Appendix 1.

IDEF0 representation of support for concurrent product and mould design.

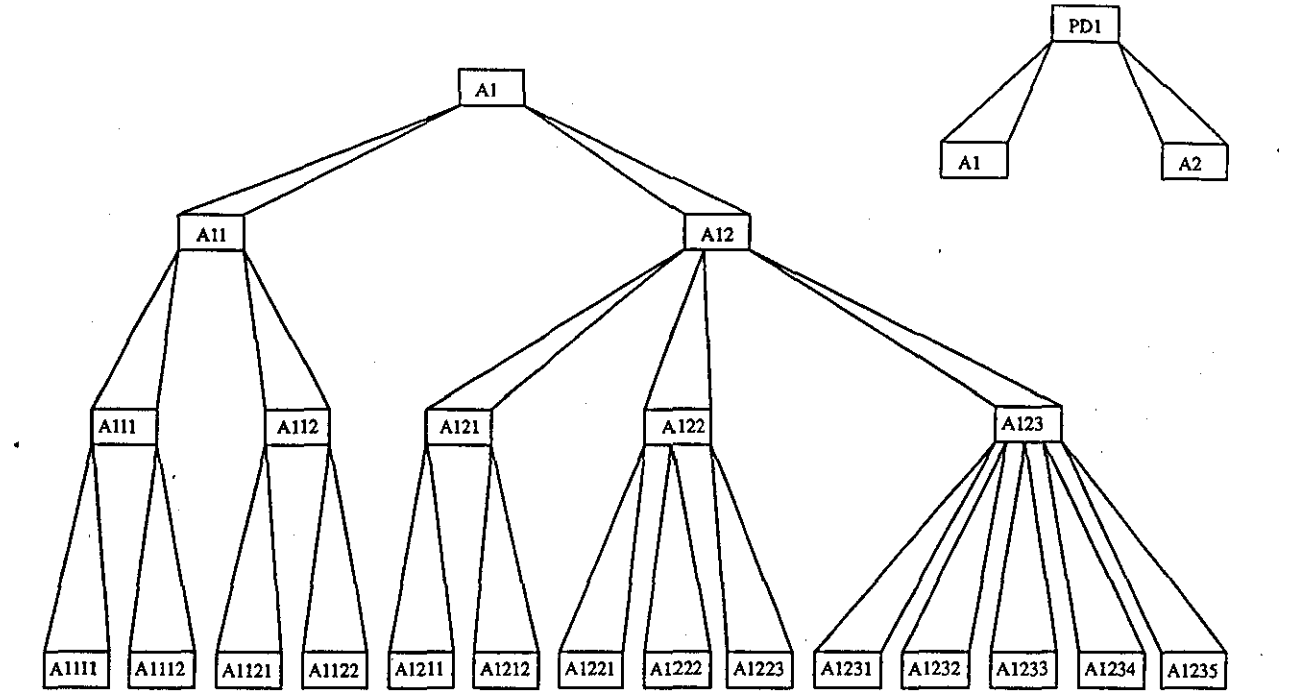


Figure A1.1 – IDEF0 model from A1 down. Support for concurrent design for function and manufacture.

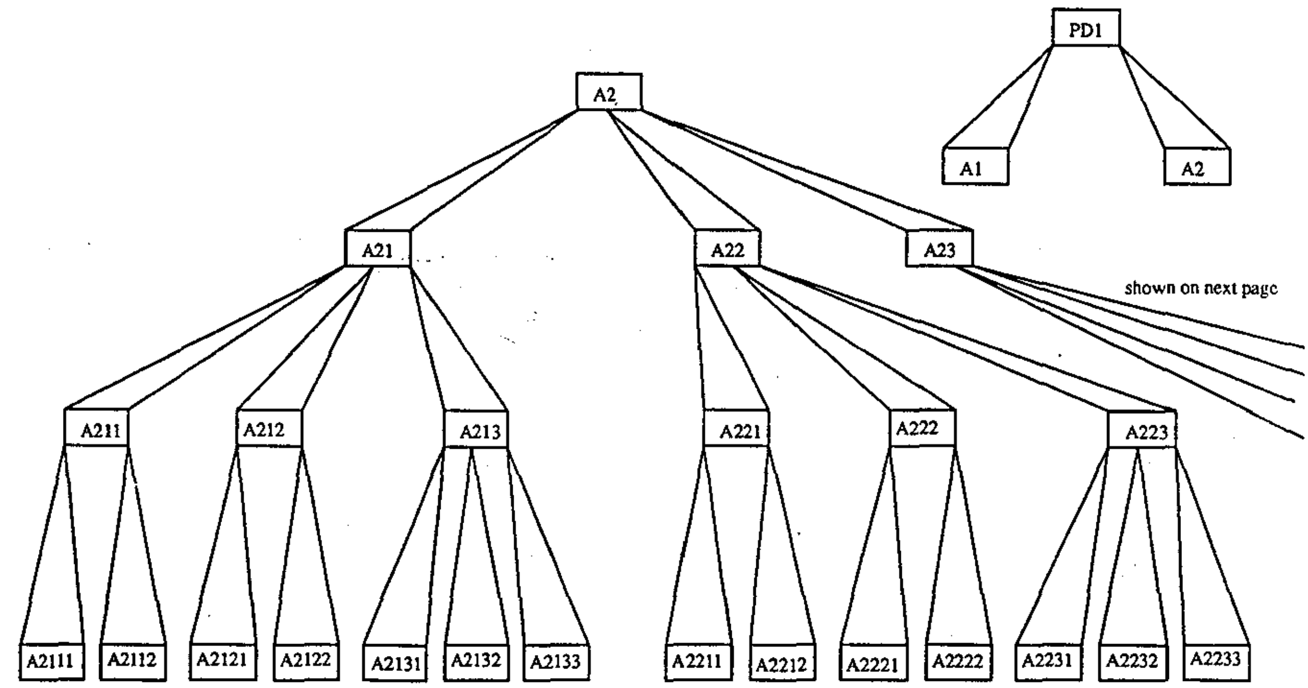


Figure A1.2 – IDEF0 model from A2 down. Support for concurrent design for function and manufacture.

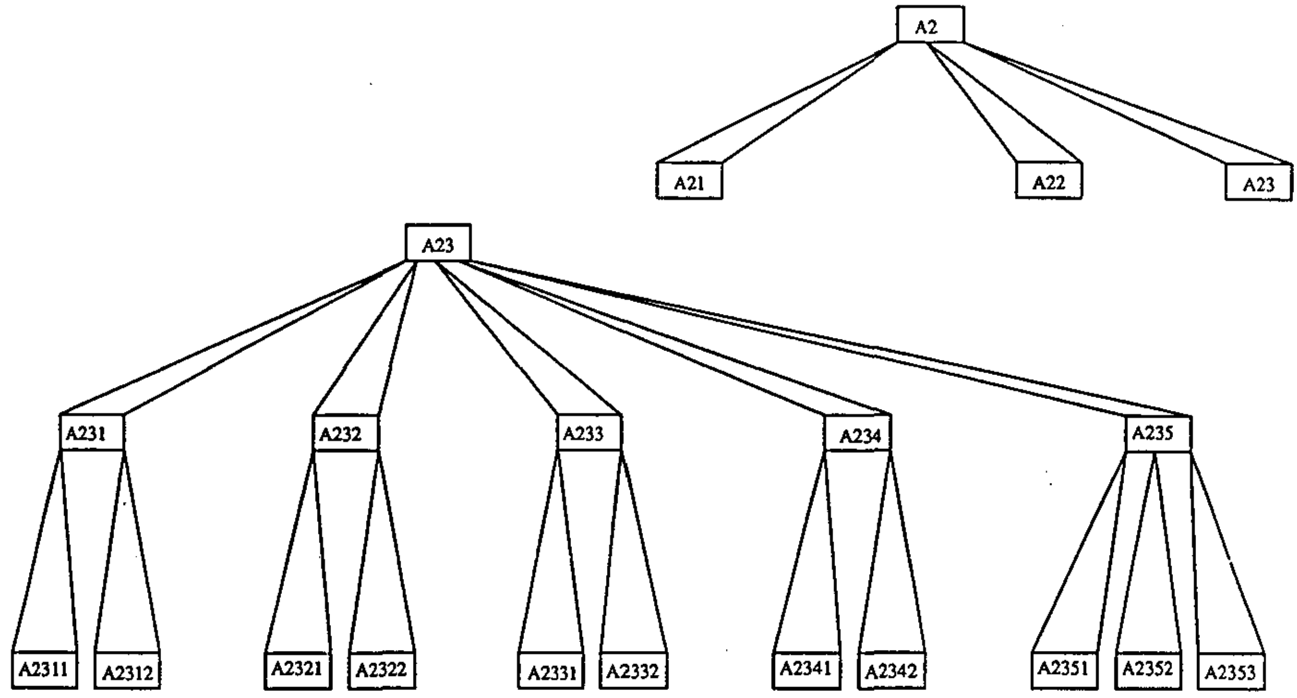


Figure A1.3 – IDEF0 model from A23 down. Support for concurrent design for function and manufacture.

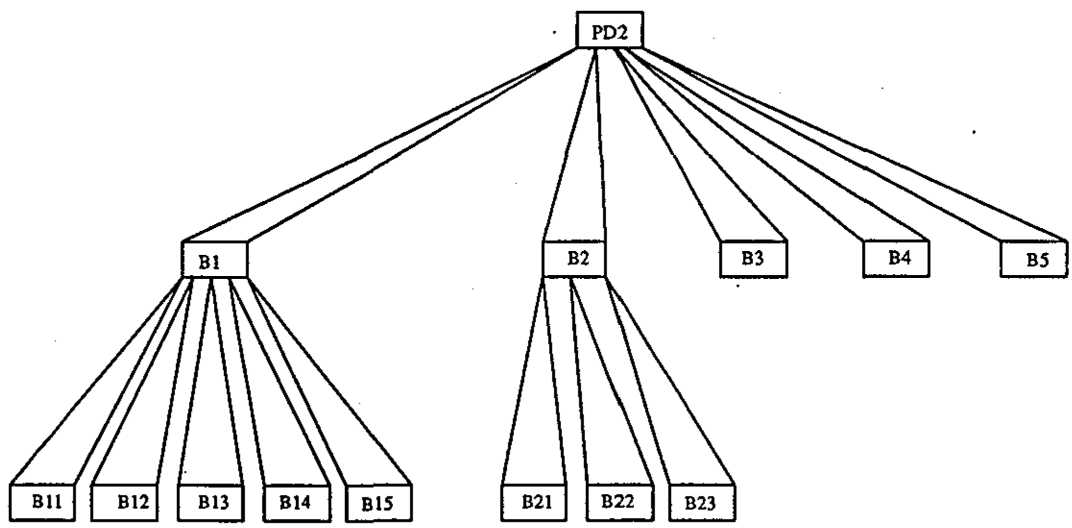
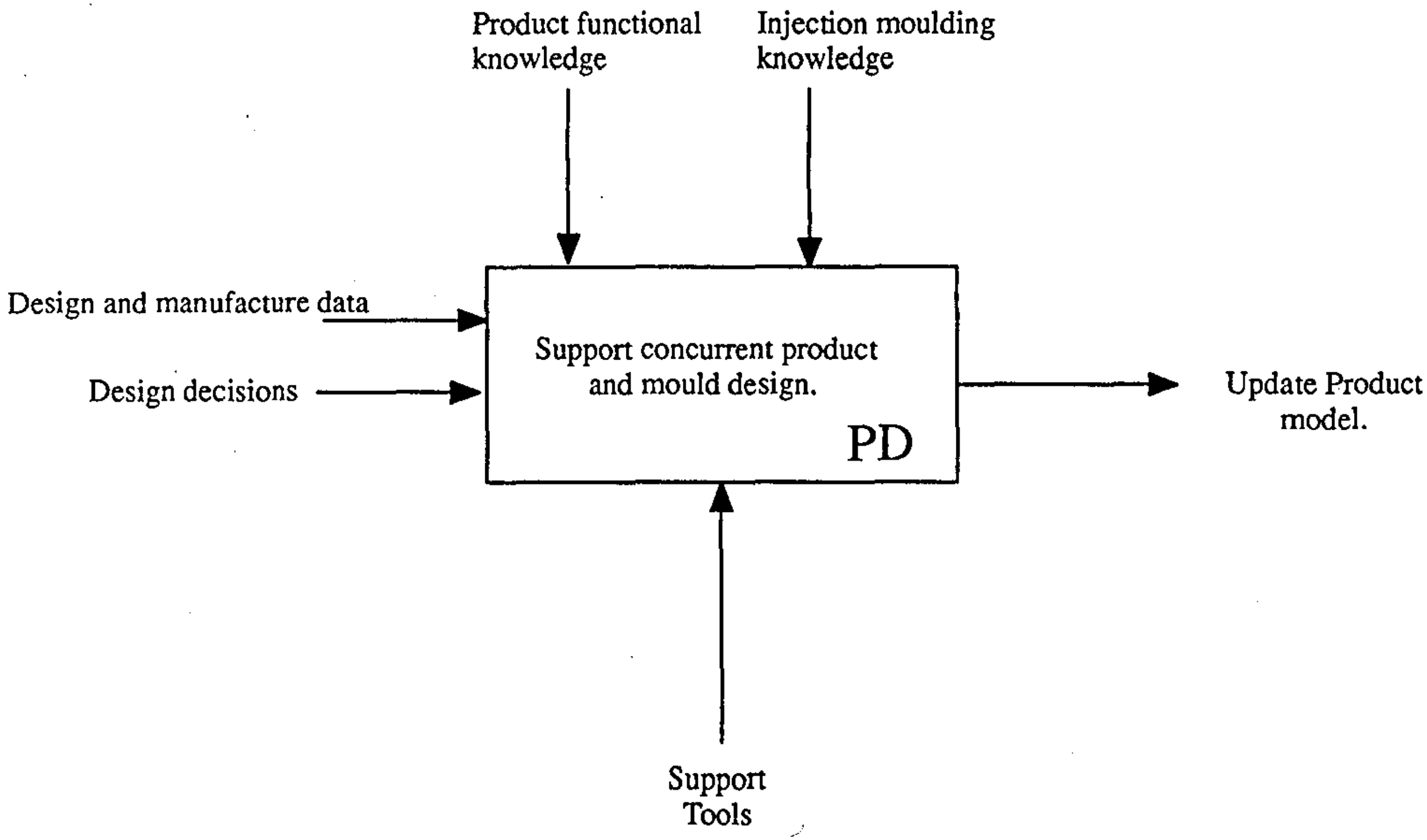


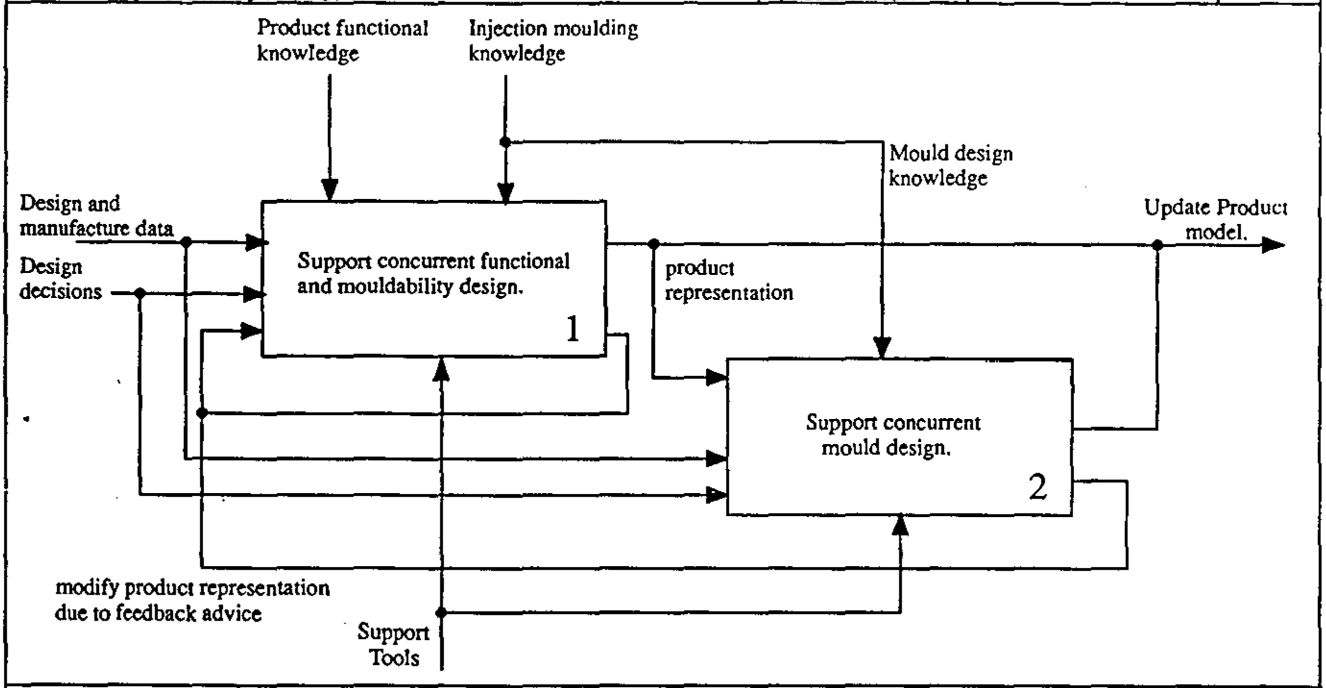
Figure A1.4 – IDEF0 model from PD2 down. Support concurrent mould design

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/01/95 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT Top



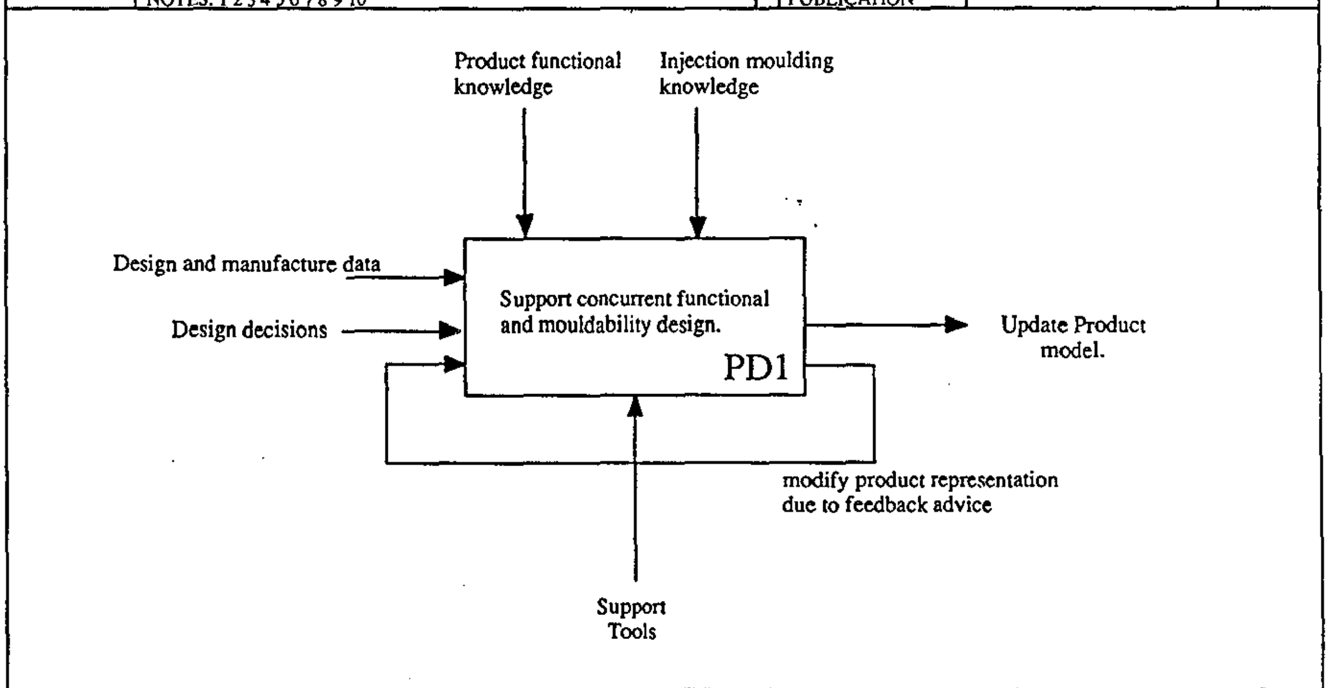
NODE: PD	TITLE: Support concurrent product and mould design.	NUMBER:

USED AT: | AUTHOR: R.J.V.Lee | PROJECT: Injection moulding strategist. | NOTES: 1 2 3 4 5 6 7 8 9 10 | DATE: 17/01/95 | REV: | X WORKING | DRAFT | RECOMMENDED | PUBLICATION | READER | DATE | CONTEXT Top

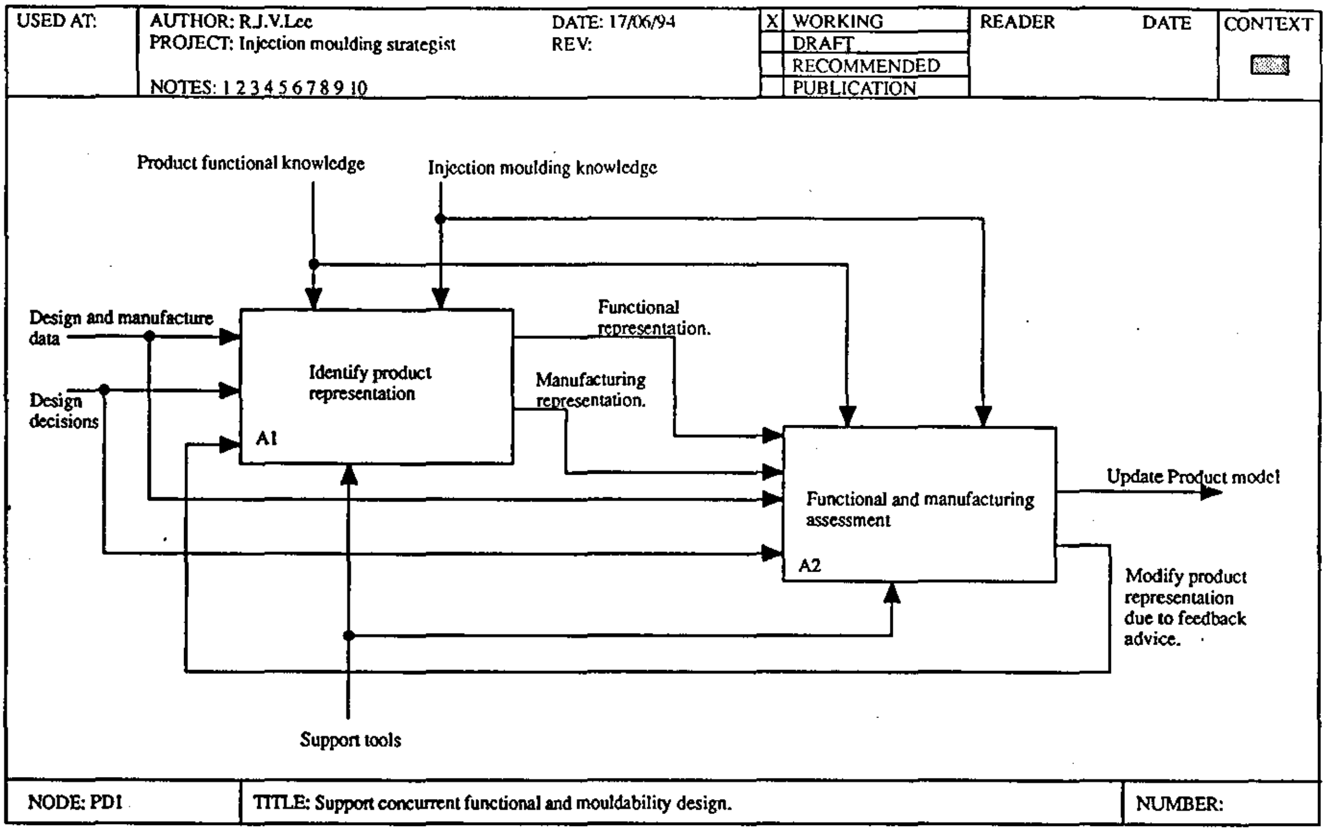


NODE: PD | TITLE: Support concurrent product and mould design. | NUMBER:

USED AT: | AUTHOR: R.J.V.Lee | PROJECT: Injection moulding strategist. | NOTES: 1 2 3 4 5 6 7 8 9 10 | DATE: 17/06/94 | REV: | X WORKING | DRAFT | RECOMMENDED | PUBLICATION | READER | DATE | CONTEXT Top



NODE: PD1 | TITLE: Support concurrent functional and mouldability design. | NUMBER: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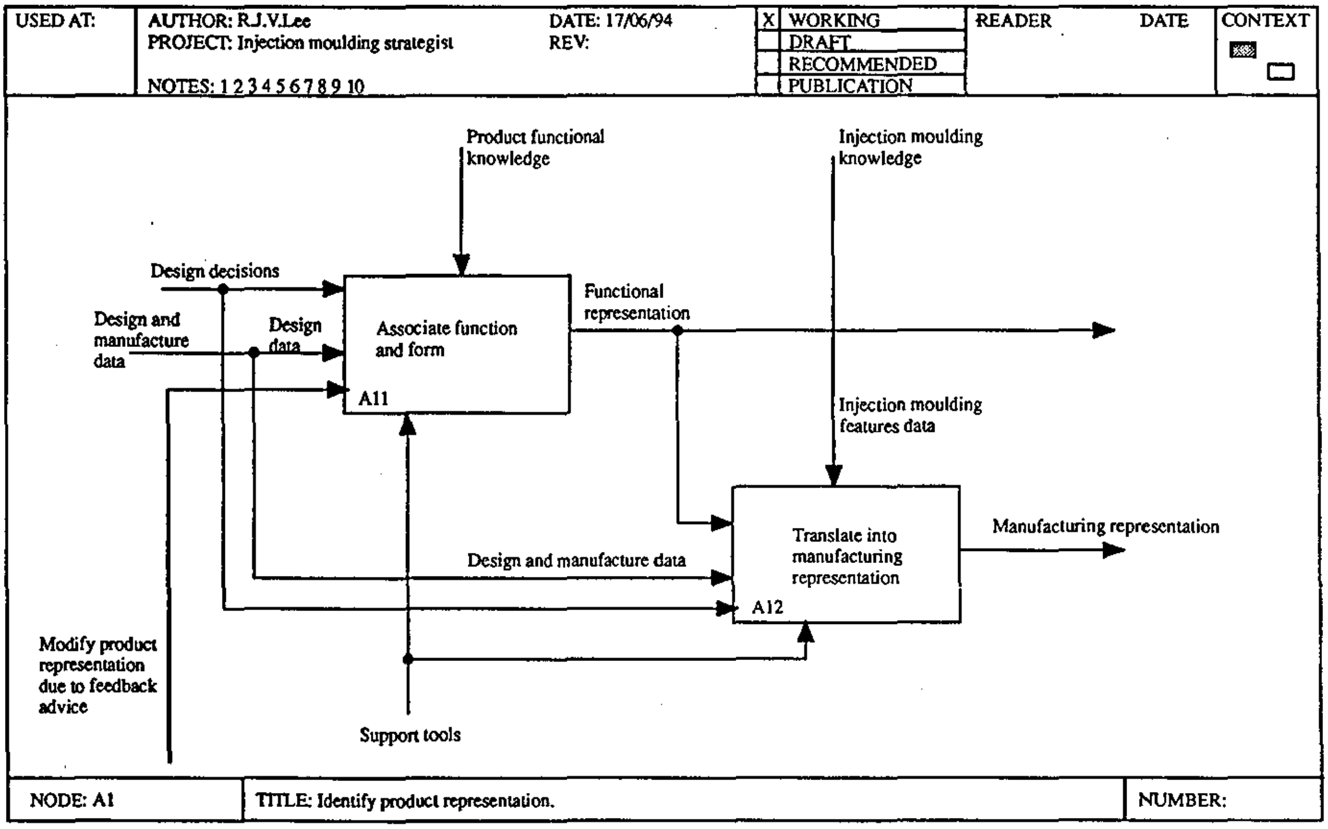
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Product functional knowledge
Injection moulding knowledge
Design and manufacture data
Design decisions
Identify product representation
A1
Functional representation.
Manufacturing representation.
Functional and manufacturing assessment
A2
Update Product model
Modify product representation due to feedback advice.
Support tools
NODE: PD1
TITLE: Support concurrent functional and mouldability design.
NUMBER: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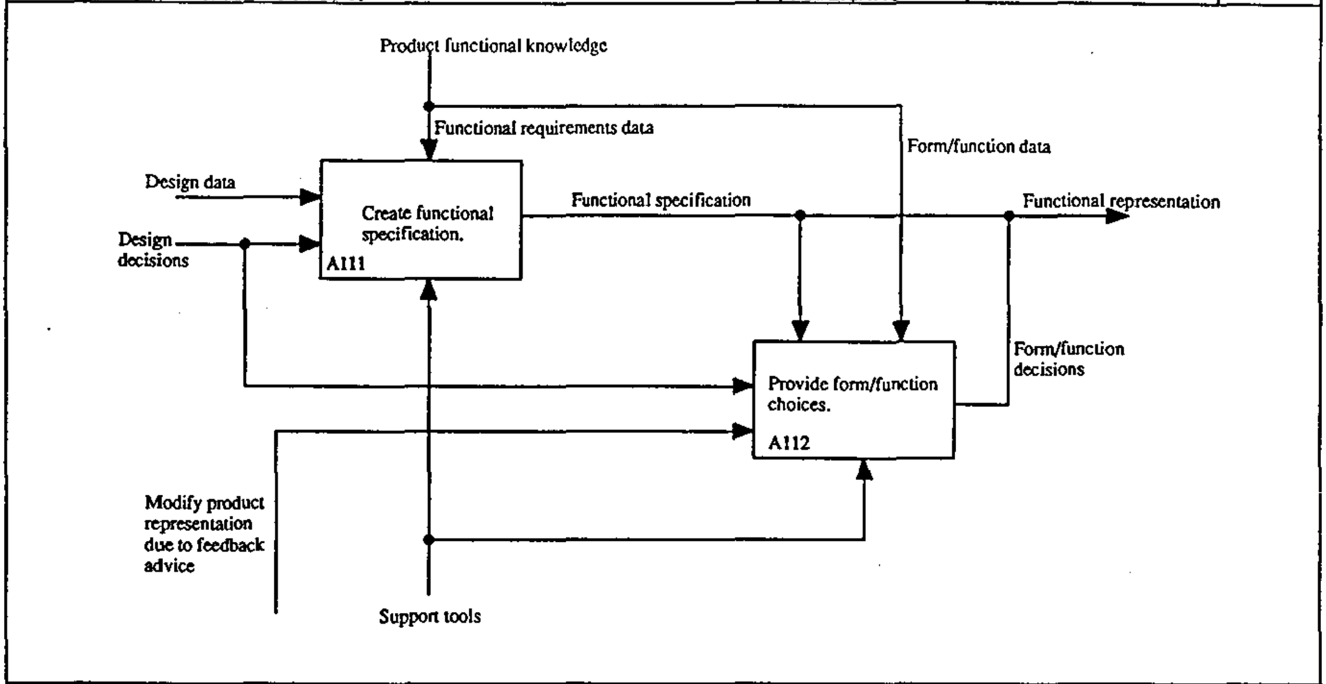
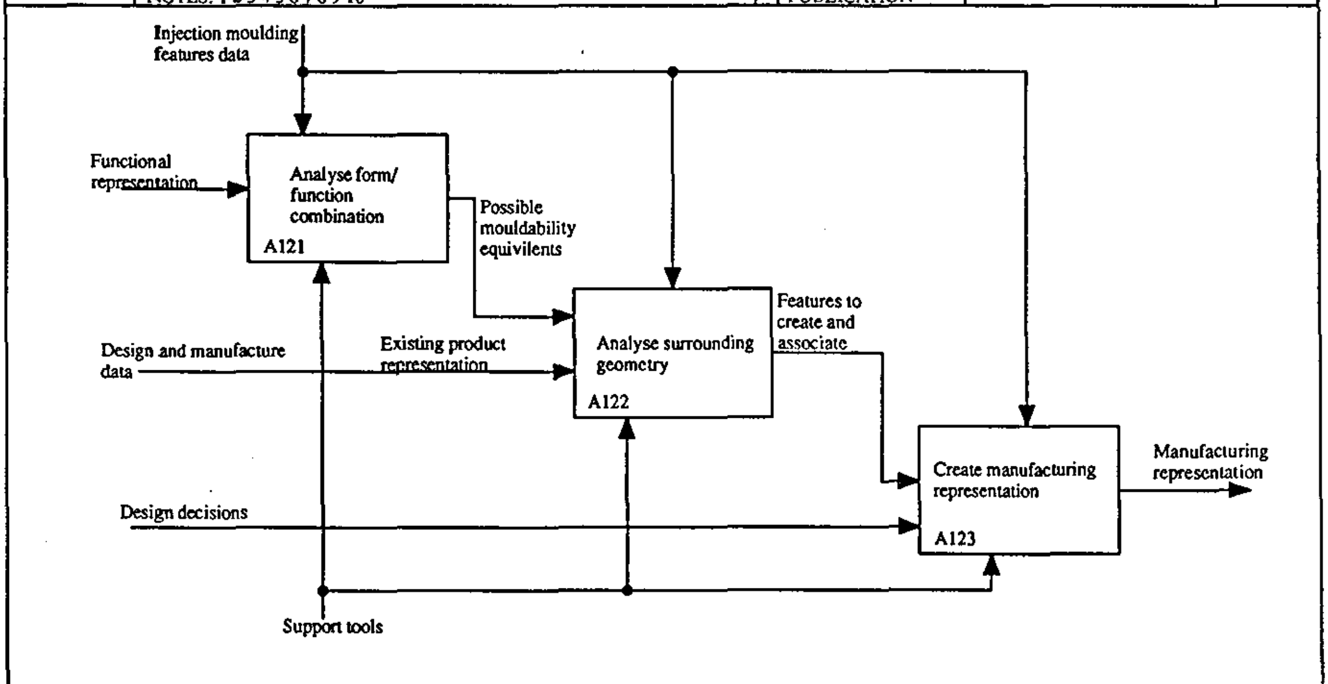
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Product functional knowledge
Injection moulding knowledge
Design decisions
Design and manufacture data
Design data
Associate function and form
A11
Functional representation
Injection moulding features data
Design and manufacture data
Translate into manufacturing representation
A12
Manufacturing representation
Modify product representation due to feedback advice
Support tools
NODE: A1
TITLE: Identify product representation.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

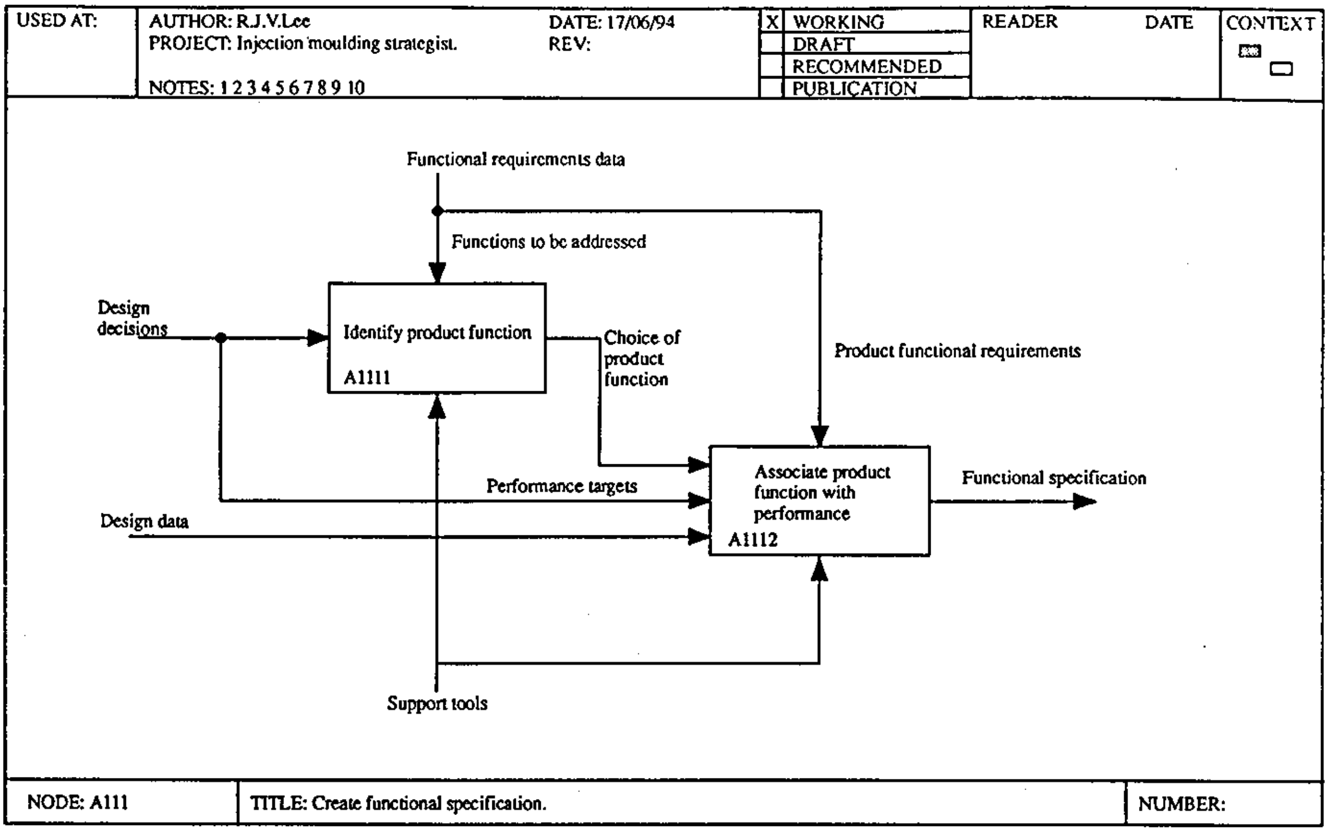


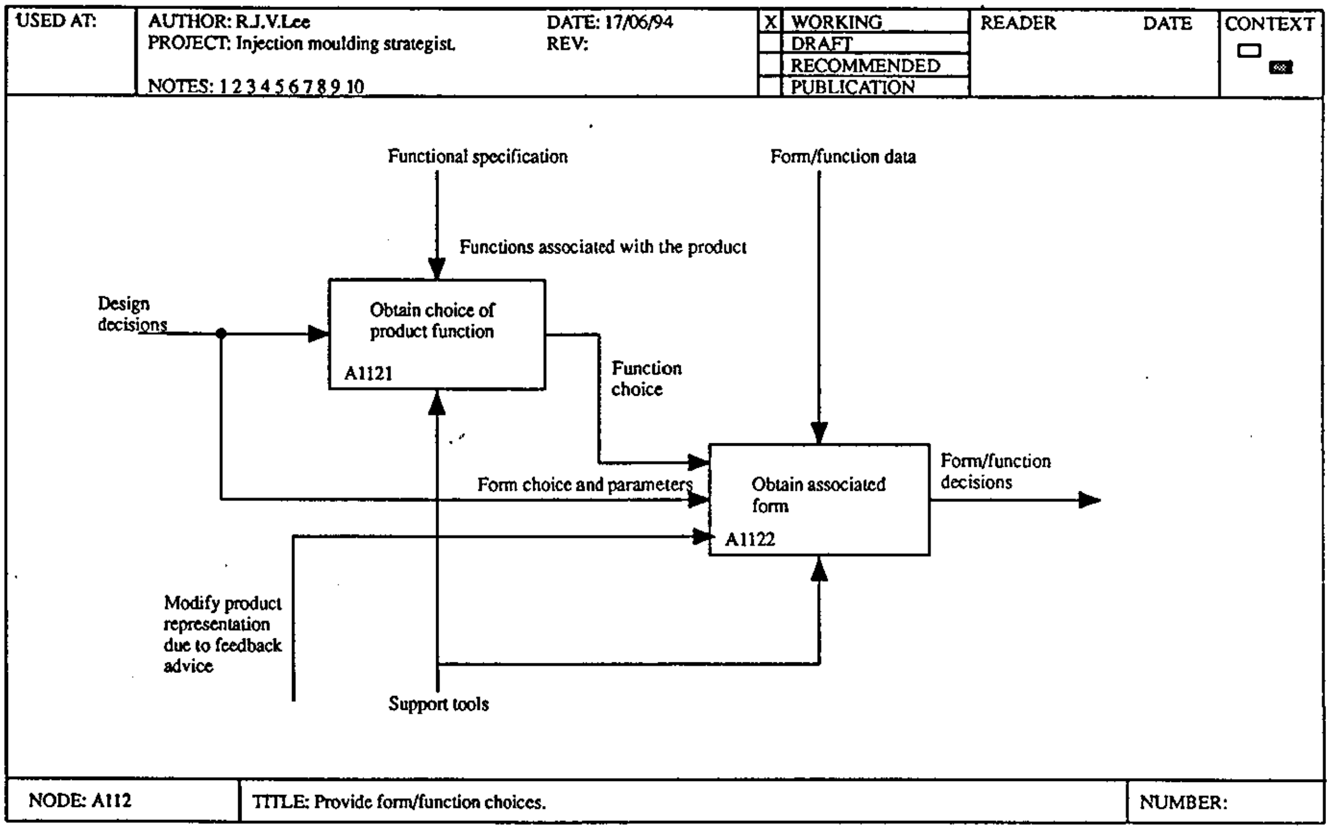
NODE: A11	TITLE: Associate function and form.	NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT



NODE: A12	TITLE: Translate into manufacturing representation.	NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional requirements data
Functions to be addressed
Design decisions
Identify product function
A1111
Choice of product function
Product functional requirements
Performance targets
Design data
Associate product function with performance
A1112
Functional specification
Support tools
NODE: A111
TITLE: Create functional specification.
NUMBER: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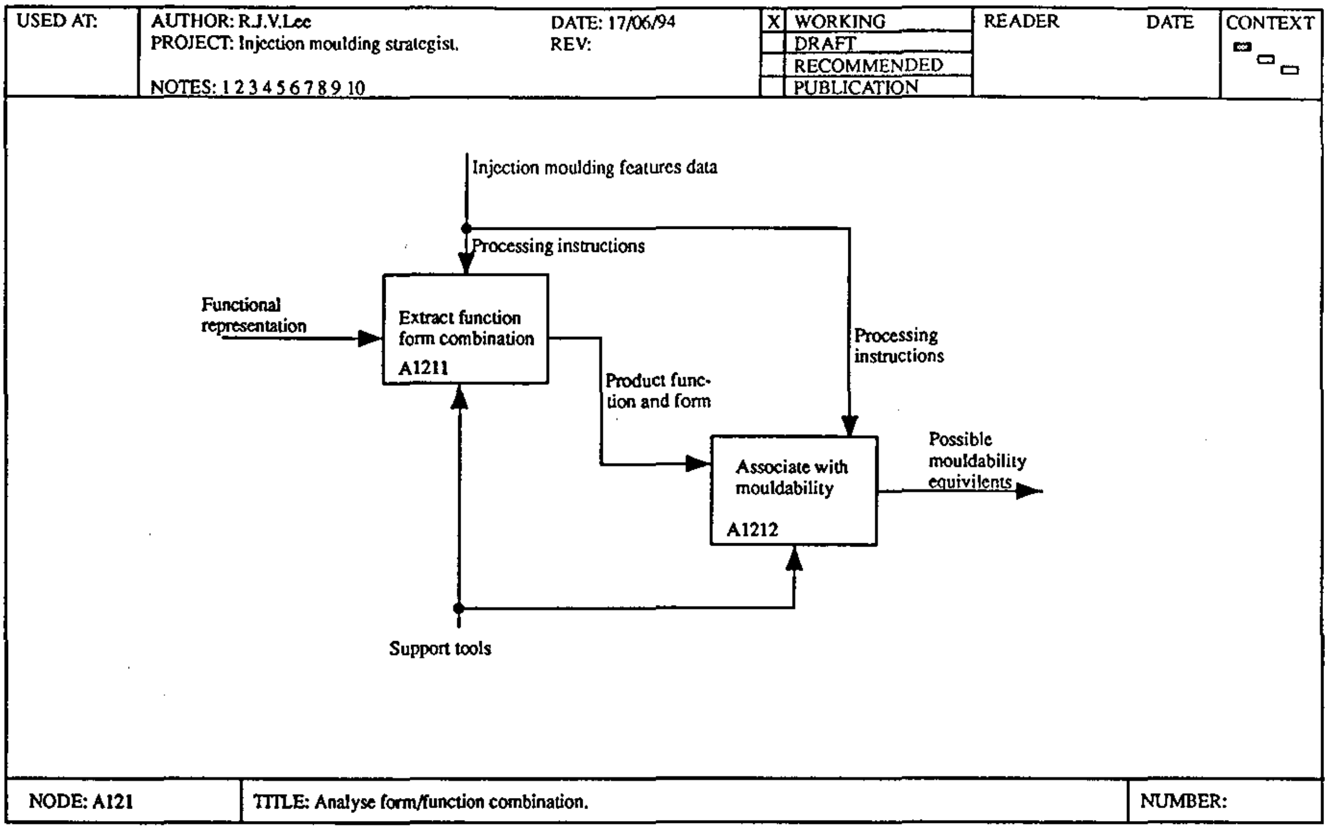
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional specification
Form/function data
Functions associated with the product
Design decisions
Obtain choice of product function
A1121
Function choice
Form choice and parameters
Obtain associated form
A1122
Form/function decisions
Modify product representation due to feedback advice
Support tools
NODE: A112
TITLE: Provide form/function choices.
NUMBER: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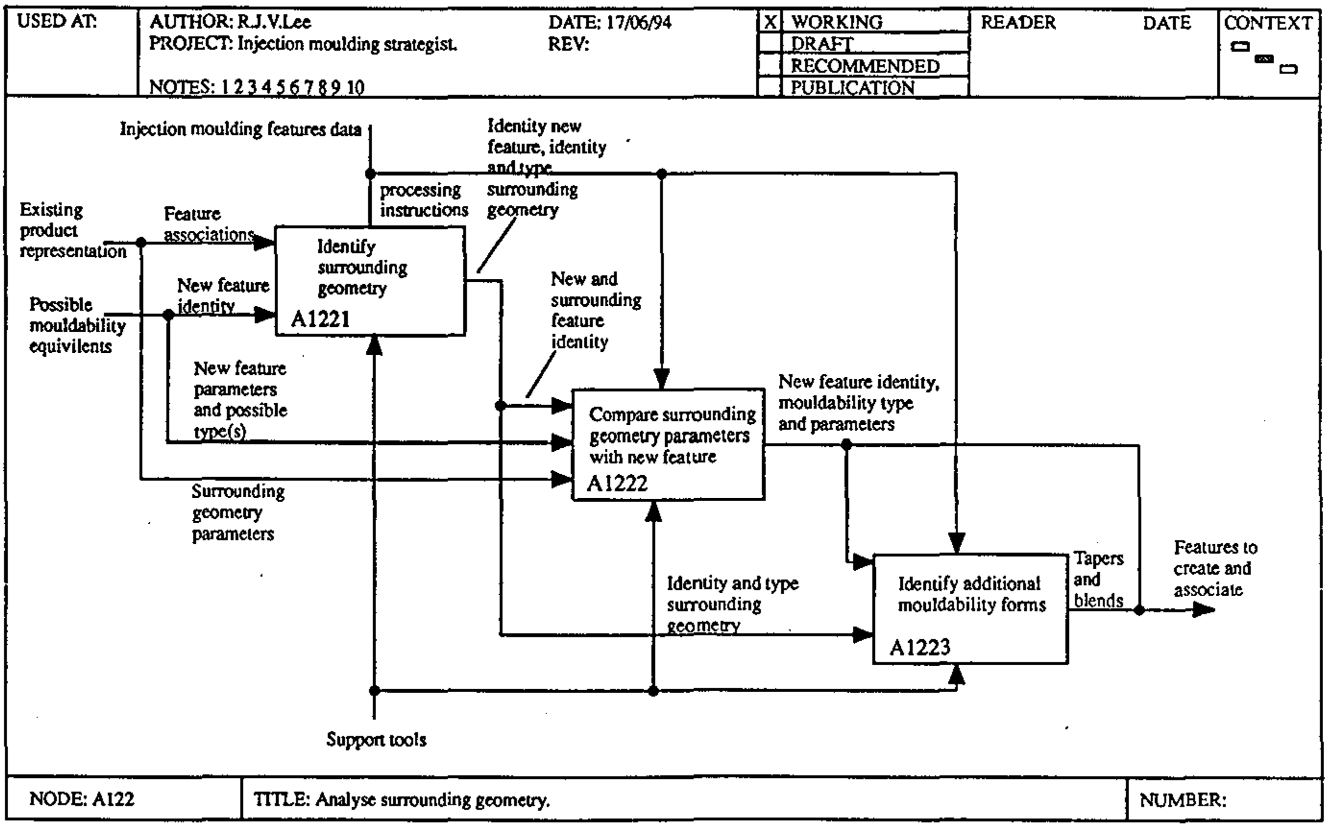
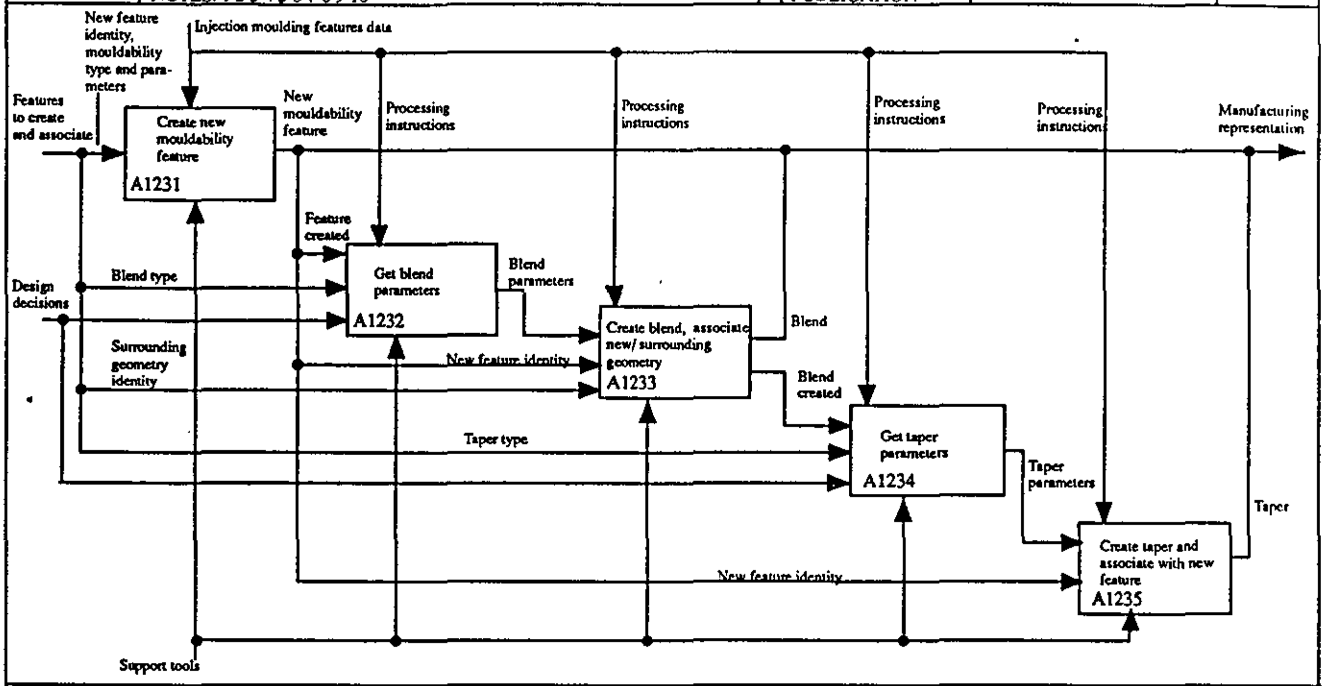
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding features data
Processing instructions
Functional representation
Extract function form combination
A1211
Processing instructions
Product function and form
Associate with mouldability
A1212
Possible mouldability equivilents
Support tools
NODE: A121
TITLE: Analyse form/function combination.
NUMBER:

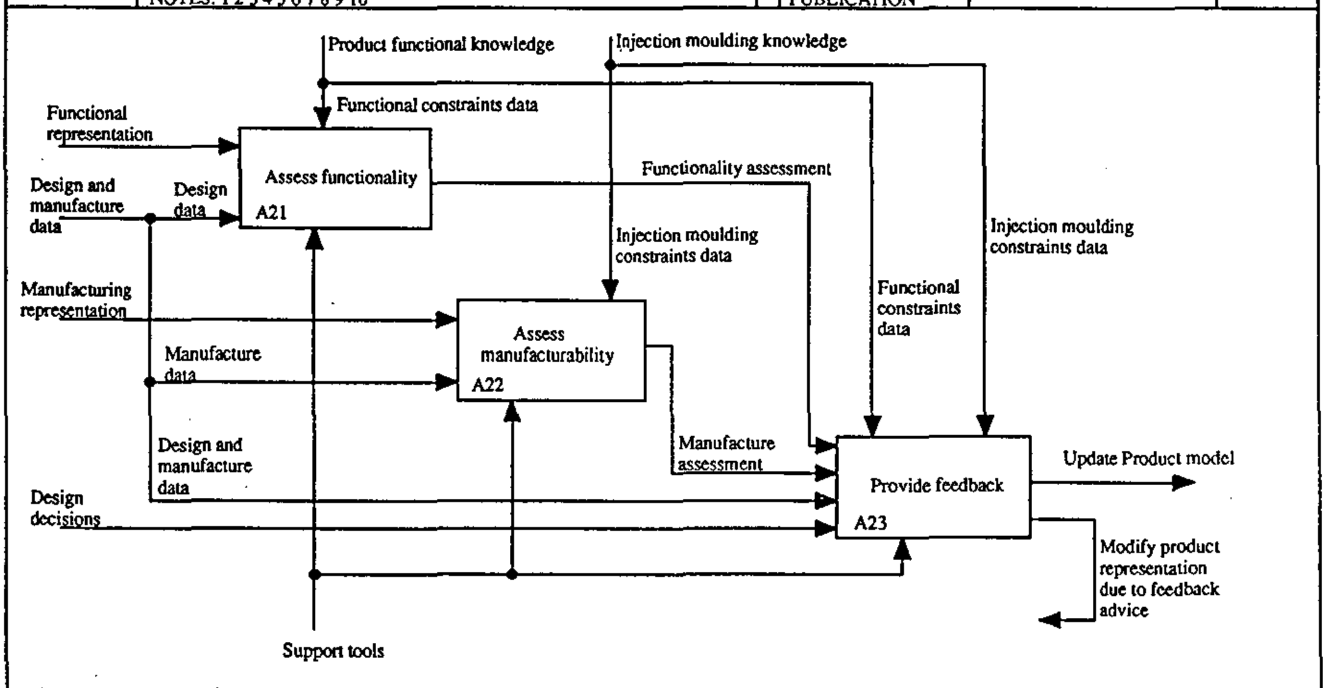

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding features data
Identity new feature, identity and type surrounding geometry
processing instructions
Existing product representation
Feature associations
Identify surrounding geometry
A1221
Possible mouldability equivilents
New feature identity
New and surrounding feature identity
New feature parameters and possible type(s)
Compare surrounding geometry parameters with new feature
A1222
New feature identity, mouldability type and parameters
Surrounding geometry parameters
Identity and type surrounding geometry
Identify additional mouldability forms
A1223
Tapers and blends
Features to create and associate
Support tools
NODE: A122
TITLE: Analyse surrounding geometry.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

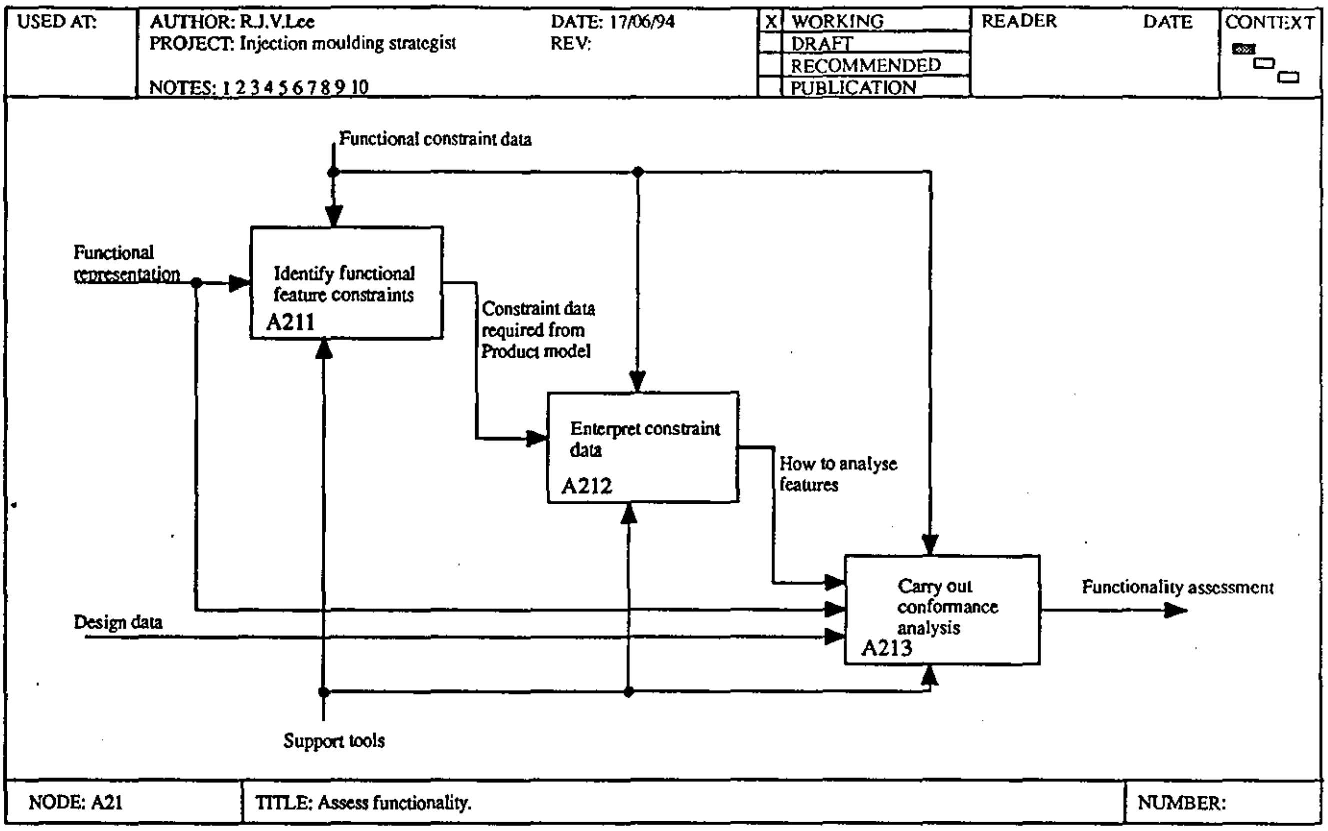


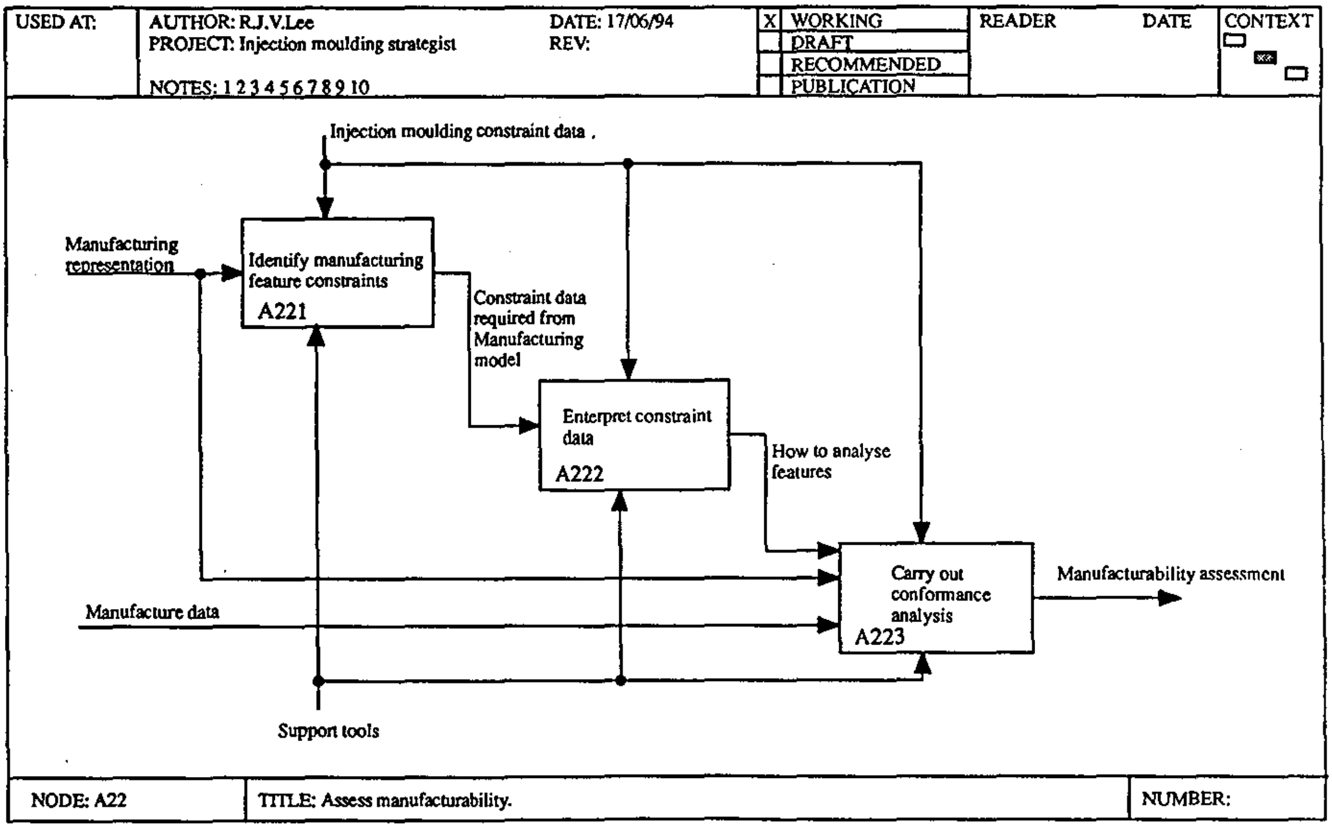
NODE: A123	TITLE: Create manufacturing representation.	NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT



NODE: A2	TITLE: Functional and manufacturability assessment.	NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Functional representation
Identify functional feature constraints
A211
Constraint data required from Product model
Enterpret constraint data
A212
How to analyse features
Carry out conformance analysis
A213
Functionality assessment
Design data
Support tools
NODE: A21
TITLE: Assess functionality.
NUMBER: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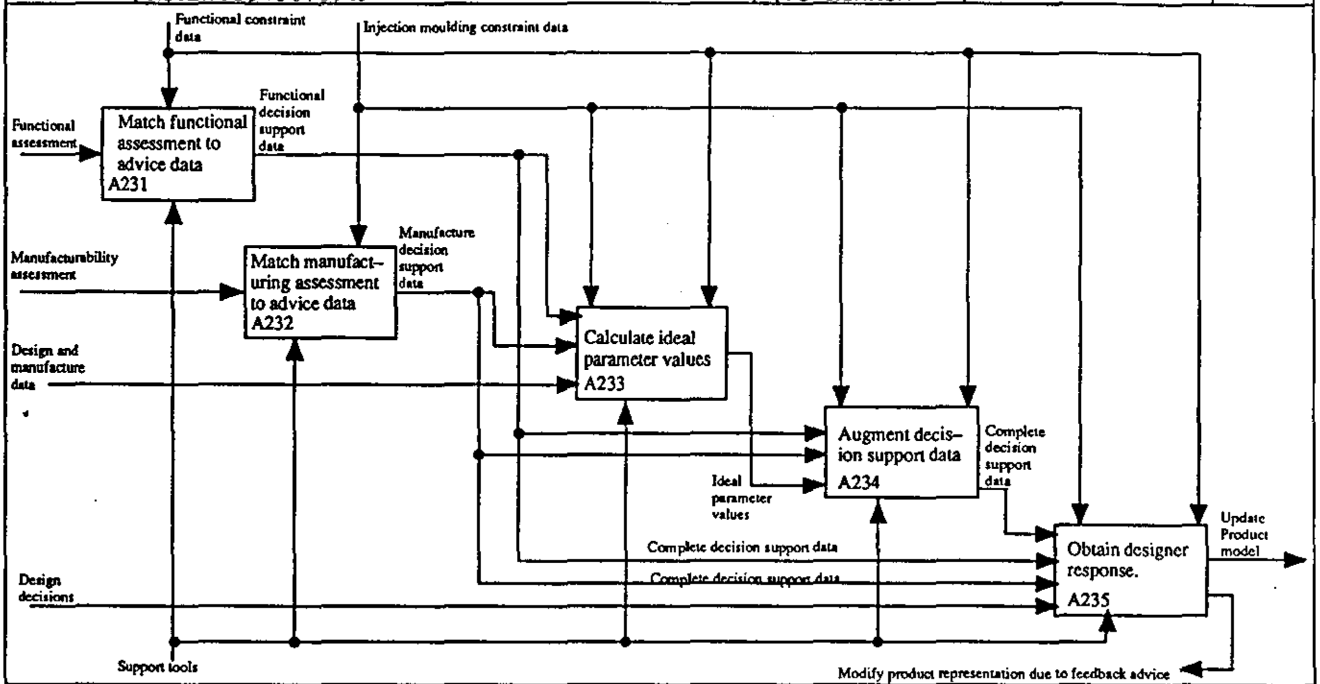
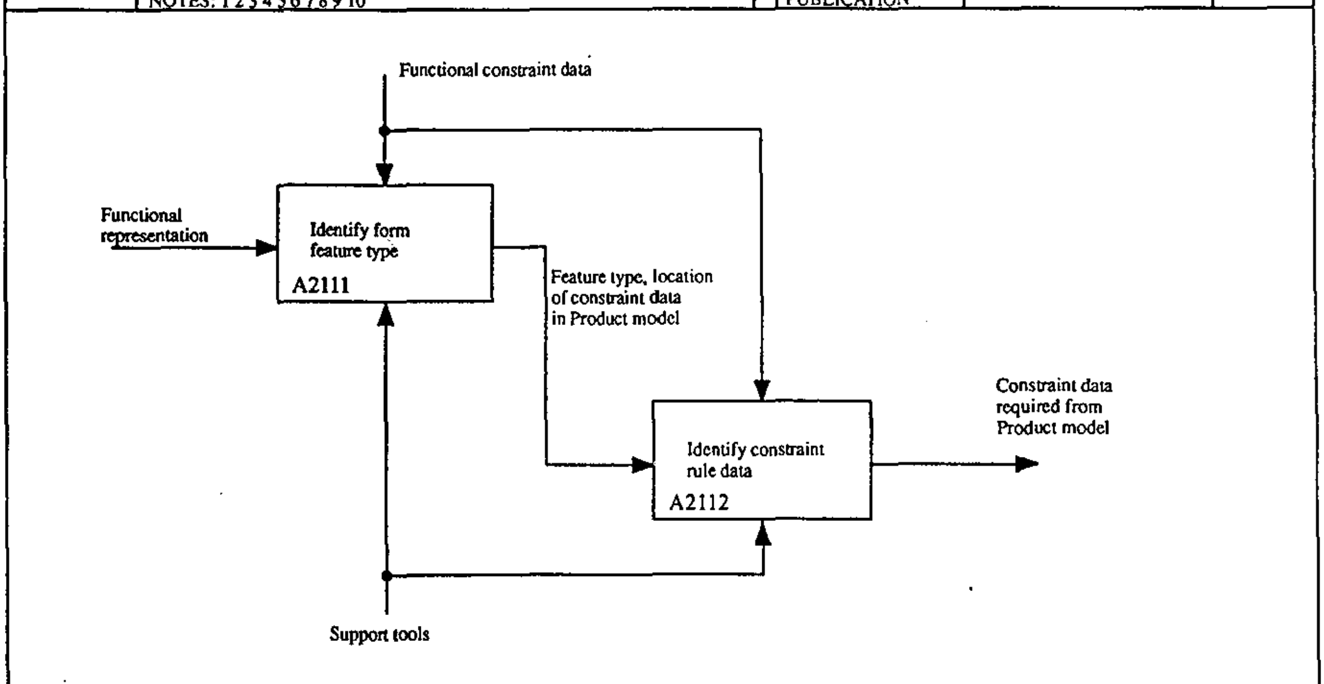
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding constraint data
Manufacturing representation
Identify manufacturing feature constraints
A221
Constraint data required from Manufacturing model
Enterpret constraint data
A222
How to analyse features
Carry out conformance analysis
A223
Manufacturability assessment
Manufacture data
Support tools
NODE: A22
TITLE: Assess manufacturability.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

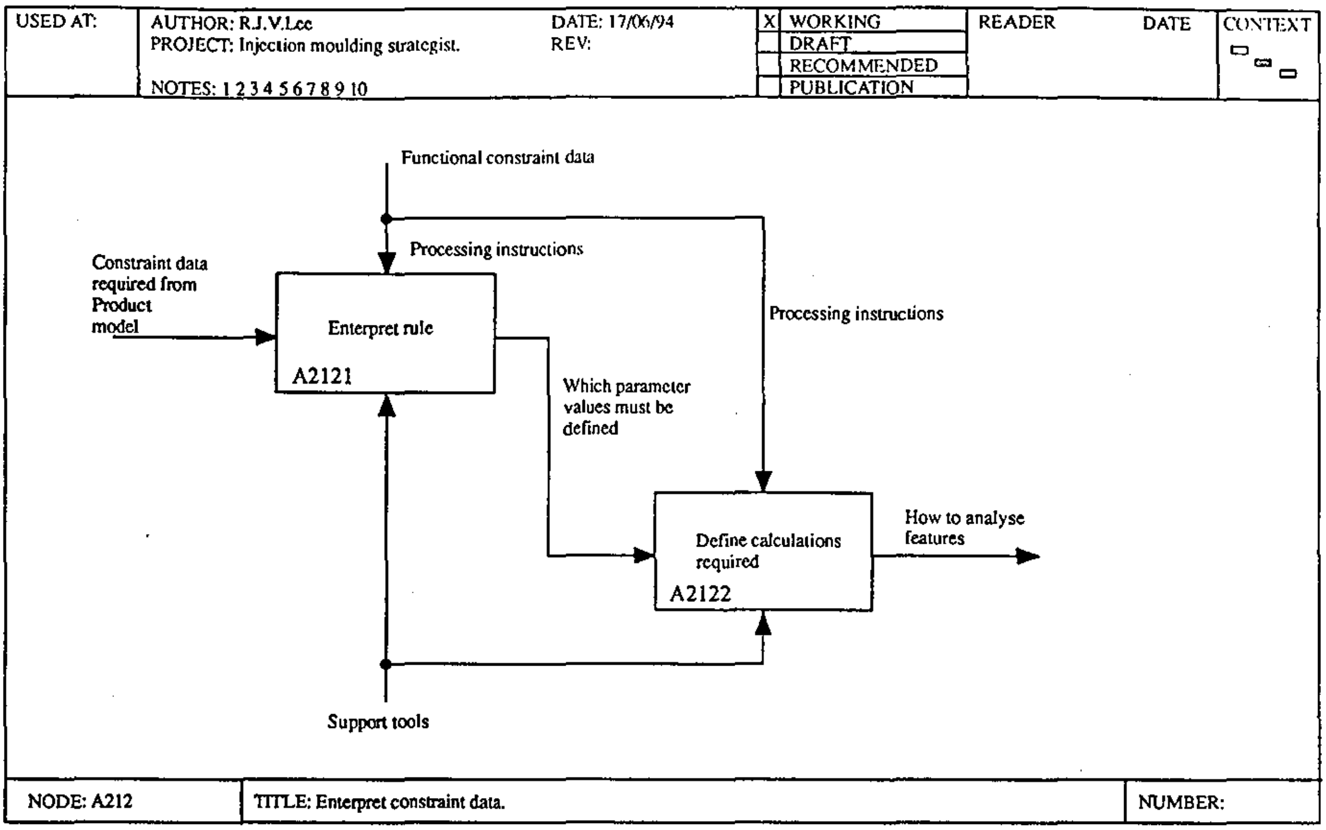


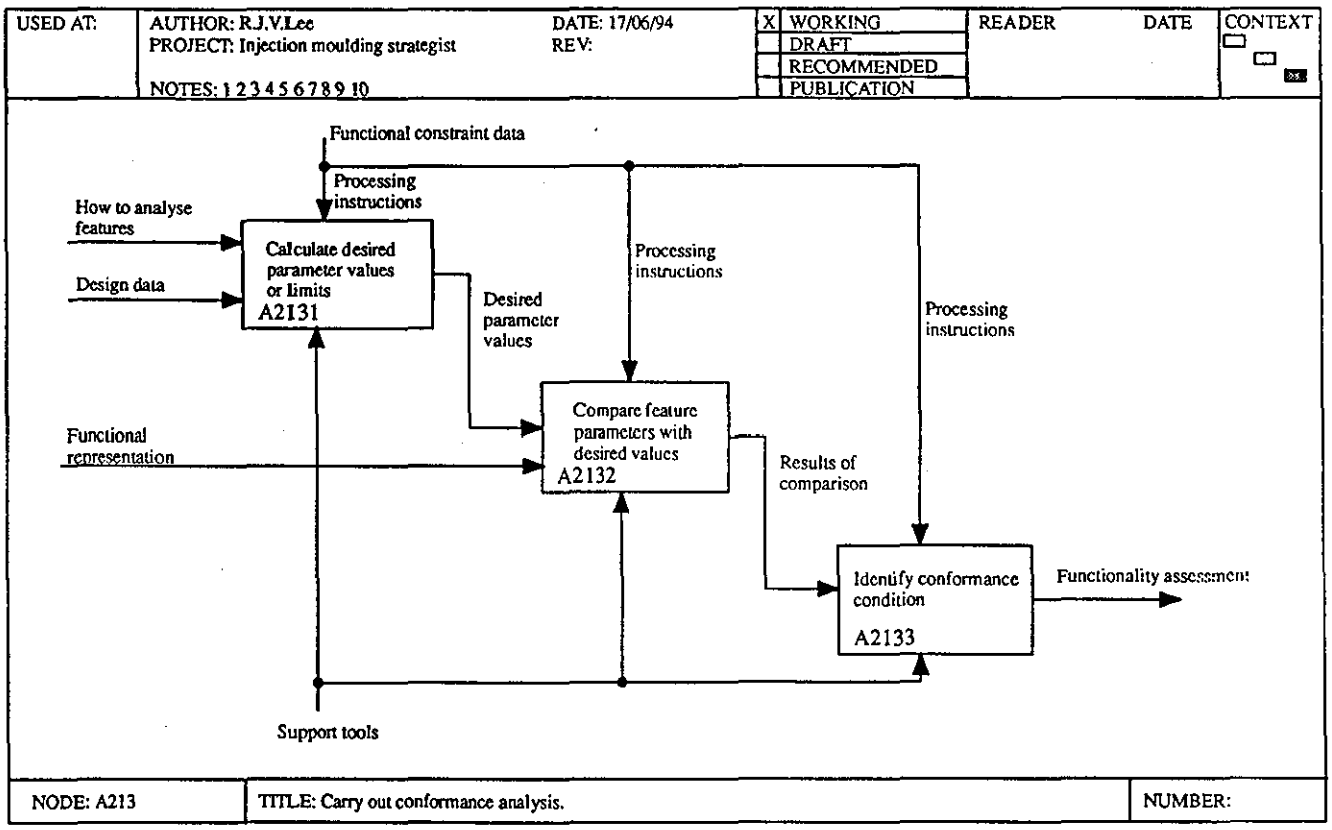
NODE: A23	TITLE: Provide feedback.	NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

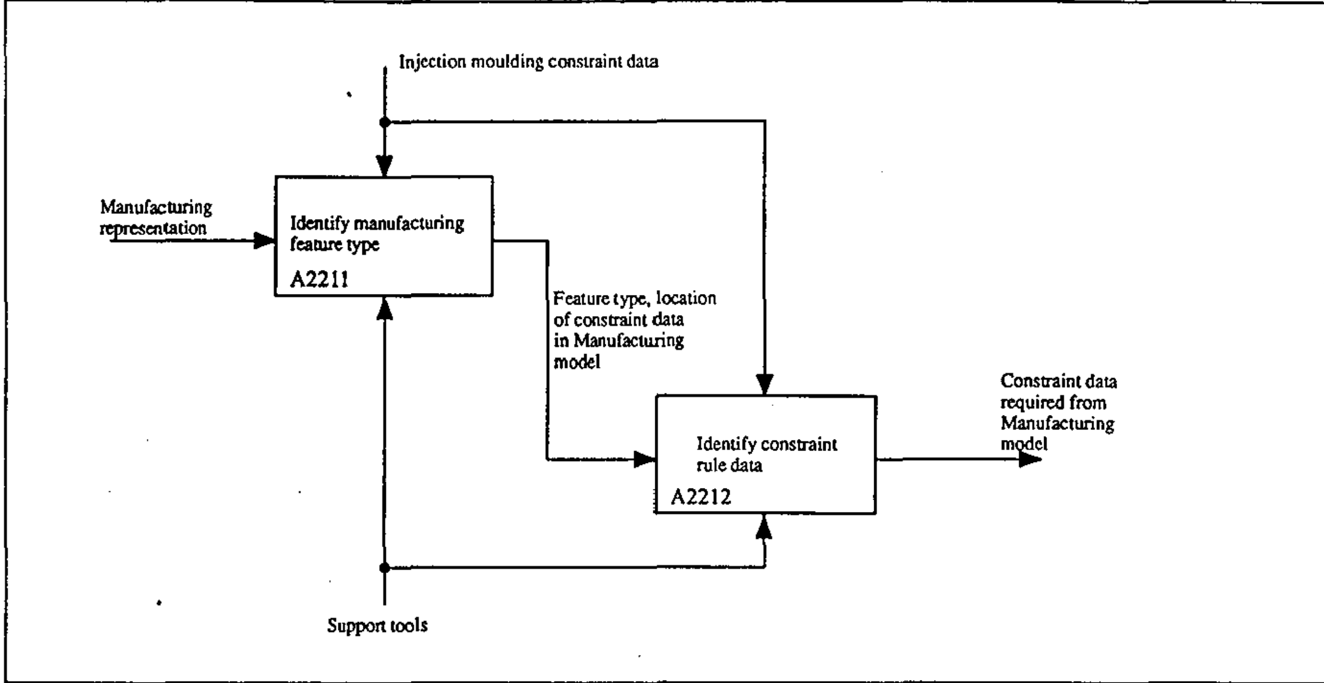


NODE: A211	TITLE: Identify functional feature constraints.	NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Processing instructions
Constraint data required from Product model
Enterpret rule
A2121
Processing instructions
Which parameter values must be defined
Define calculations required
A2122
How to analyse features
Support tools
NODE: A212
TITLE: Enterpret constraint data.
NUMBER:

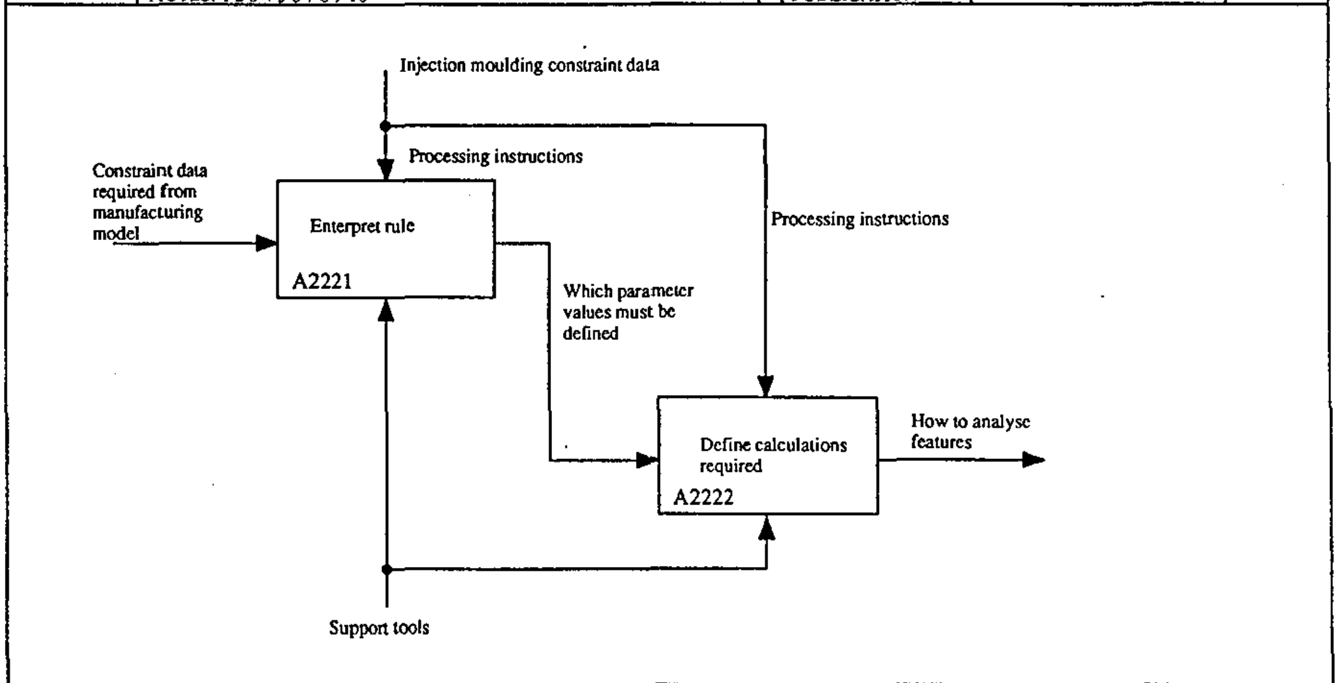

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Processing instructions
How to analyse features
Design data
Calculate desired parameter values or limits
A2131
Desired parameter values
Processing instructions
Processing instructions
Functional representation
Compare feature parameters with desired values
A2132
Results of comparison
Identify conformance condition
A2133
Functionality assessment
Support tools
NODE: A213
TITLE: Carry out conformance analysis.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

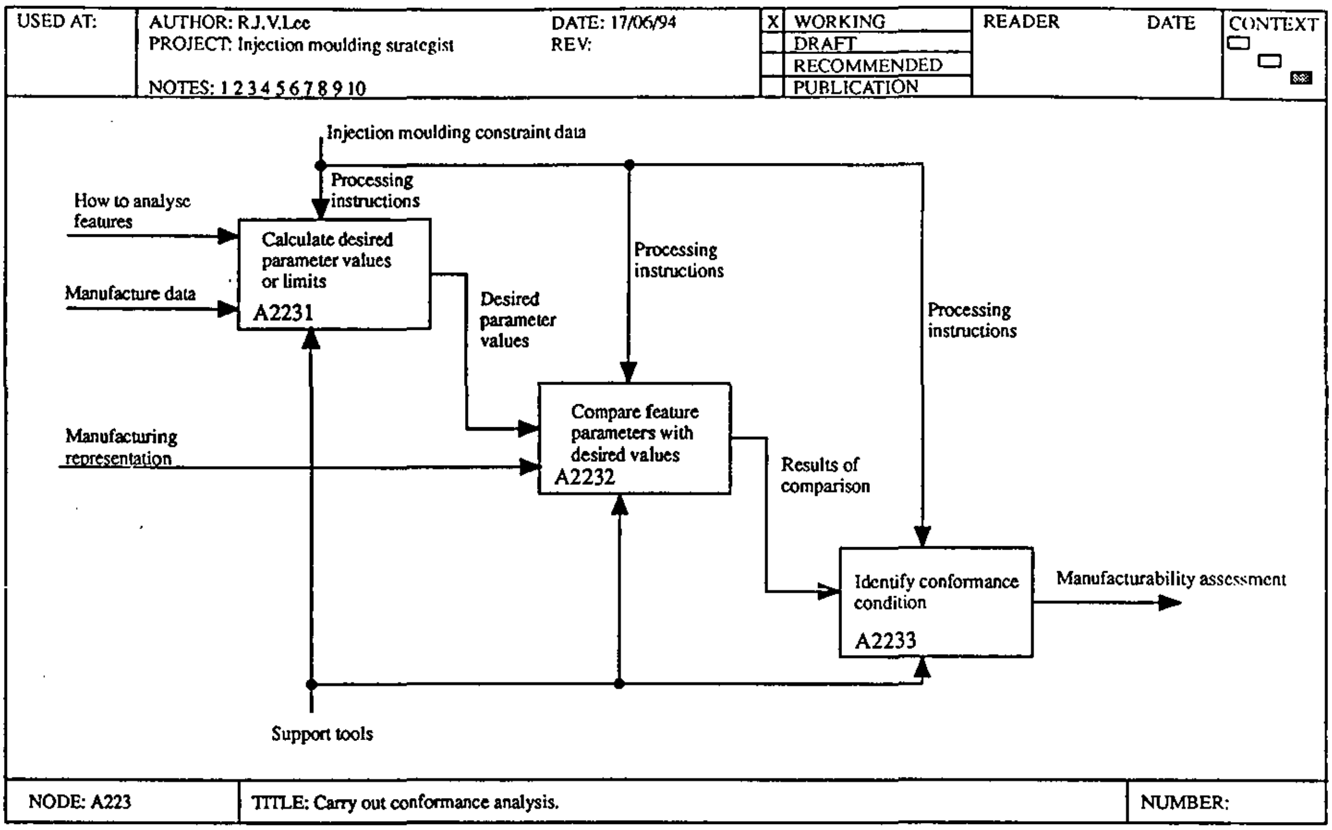


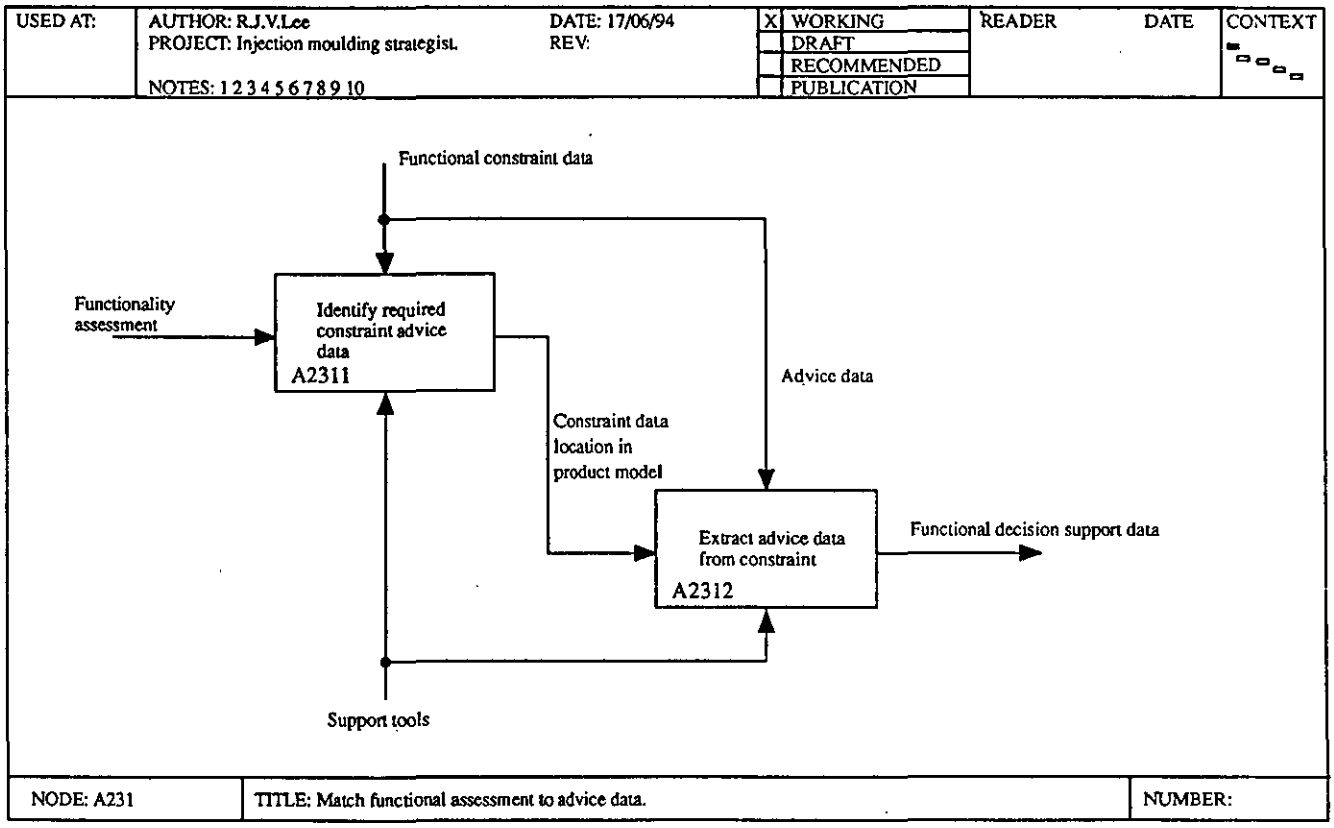
NODE: A221	TITLE: Identify manufacturing feature constraints.	NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/06/94 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT



NODE: A222	TITLE: Enterpret constraint data.	NUMBER:

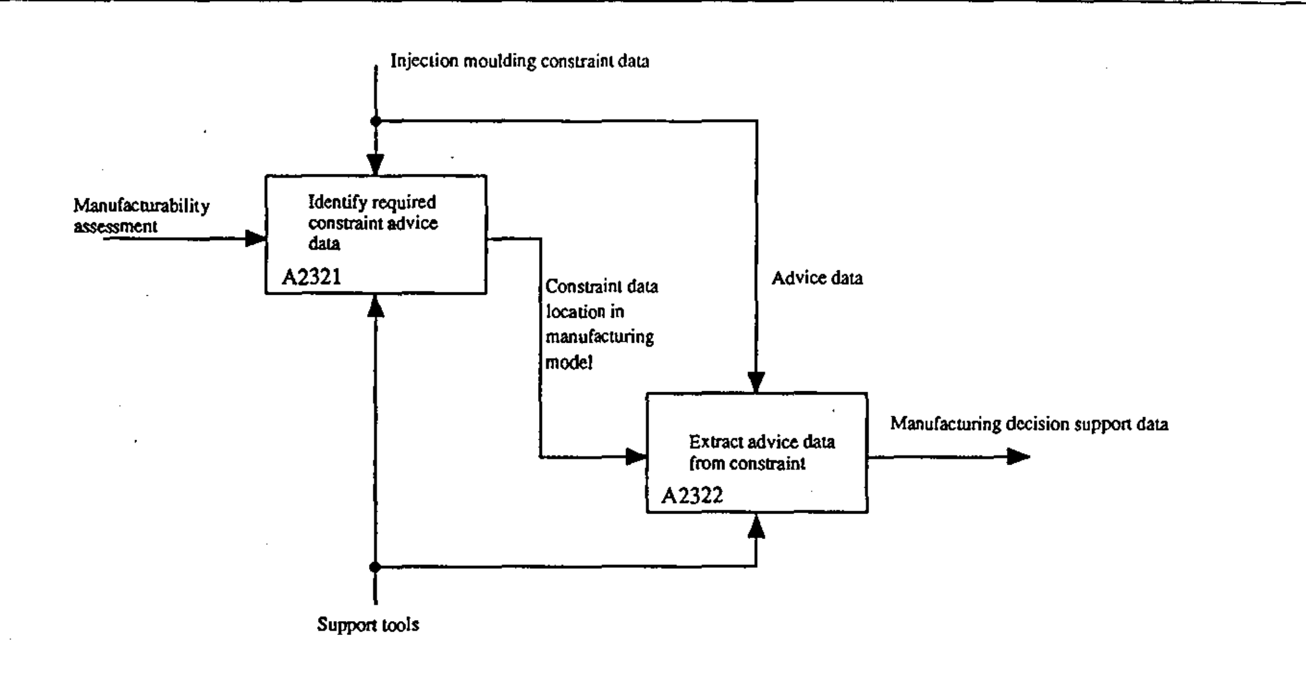

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding constraint data
Processing instructions
How to analyse features
Manufacture data
Calculate desired parameter values or limits
A2231
Processing instructions
Desired parameter values
Processing instructions
Manufacturing representation
Compare feature parameters with desired values
A2232
Results of comparison
Identify conformance condition
A2233
Manufacturability assessment
Support tools
NODE: A223
TITLE: Carry out conformance analysis.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Functionality assessment
Identify required constraint advice data
A2311
Advice data
Constraint data location in product model
Extract advice data from constraint
A2312
Functional decision support data
Support tools
NODE: A231
TITLE: Match functional assessment to advice data.
NUMBER:

USED AT: | AUTHOR: R.J.V.Lee | DATE: 17/06/94 | X WORKING | READER | DATE | CONTEXT

PROJECT: Injection moulding strategist. | REV: | DRAFT | RECOMMENDED | PUBLICATION

NOTES: 1 2 3 4 5 6 7 8 9 10

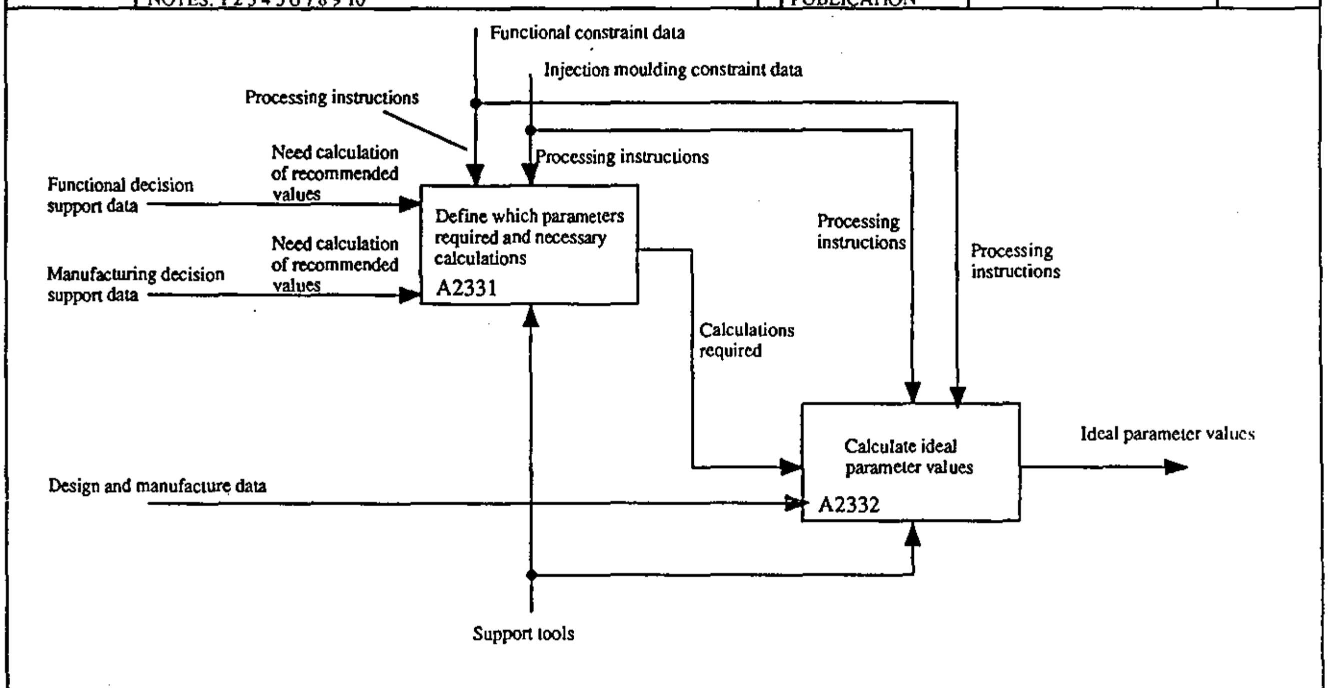


NODE: A232 | TITLE: Match manufacturing assessment to advice data. | NUMBER:

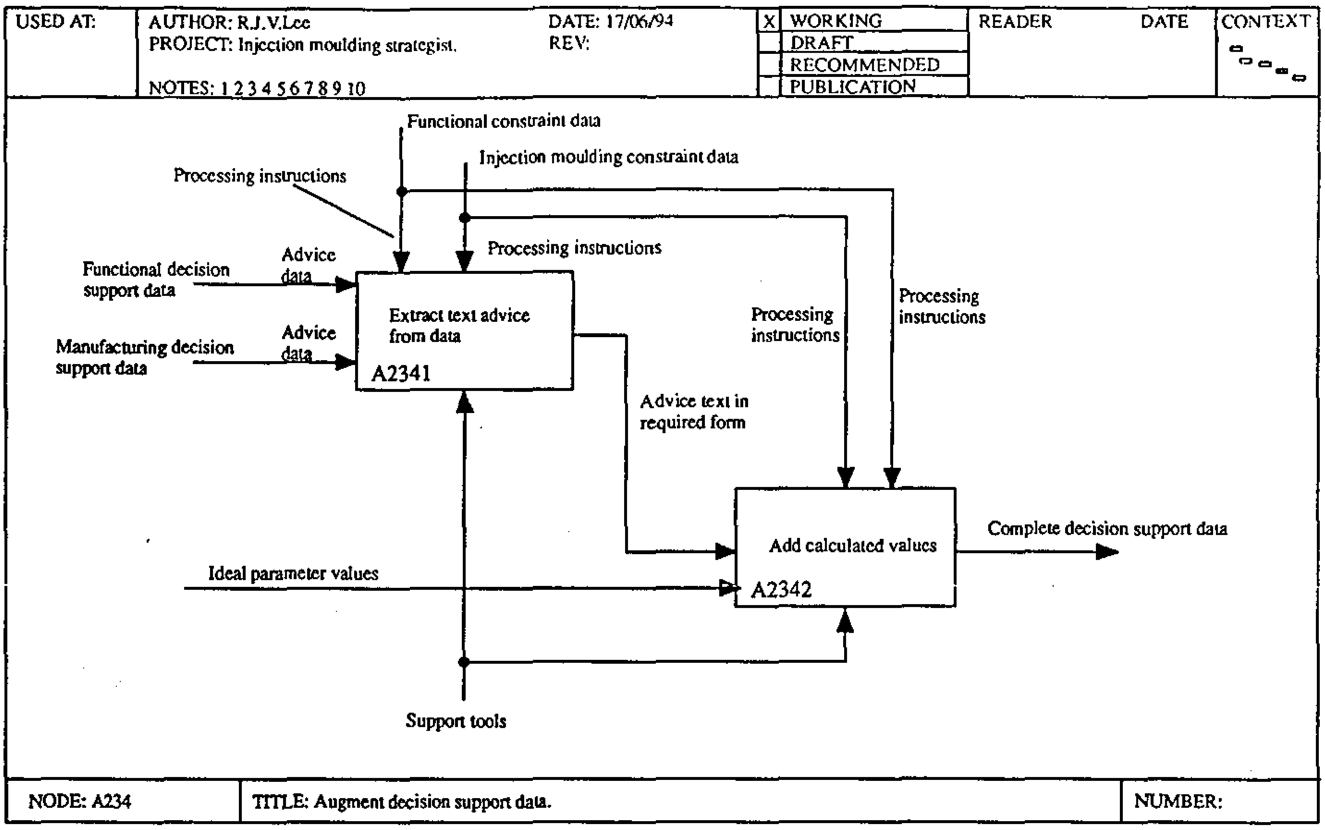
USED AT: | AUTHOR: R.J.V.Lee | DATE: 17/06/94 | X WORKING | READER | DATE | CONTEXT

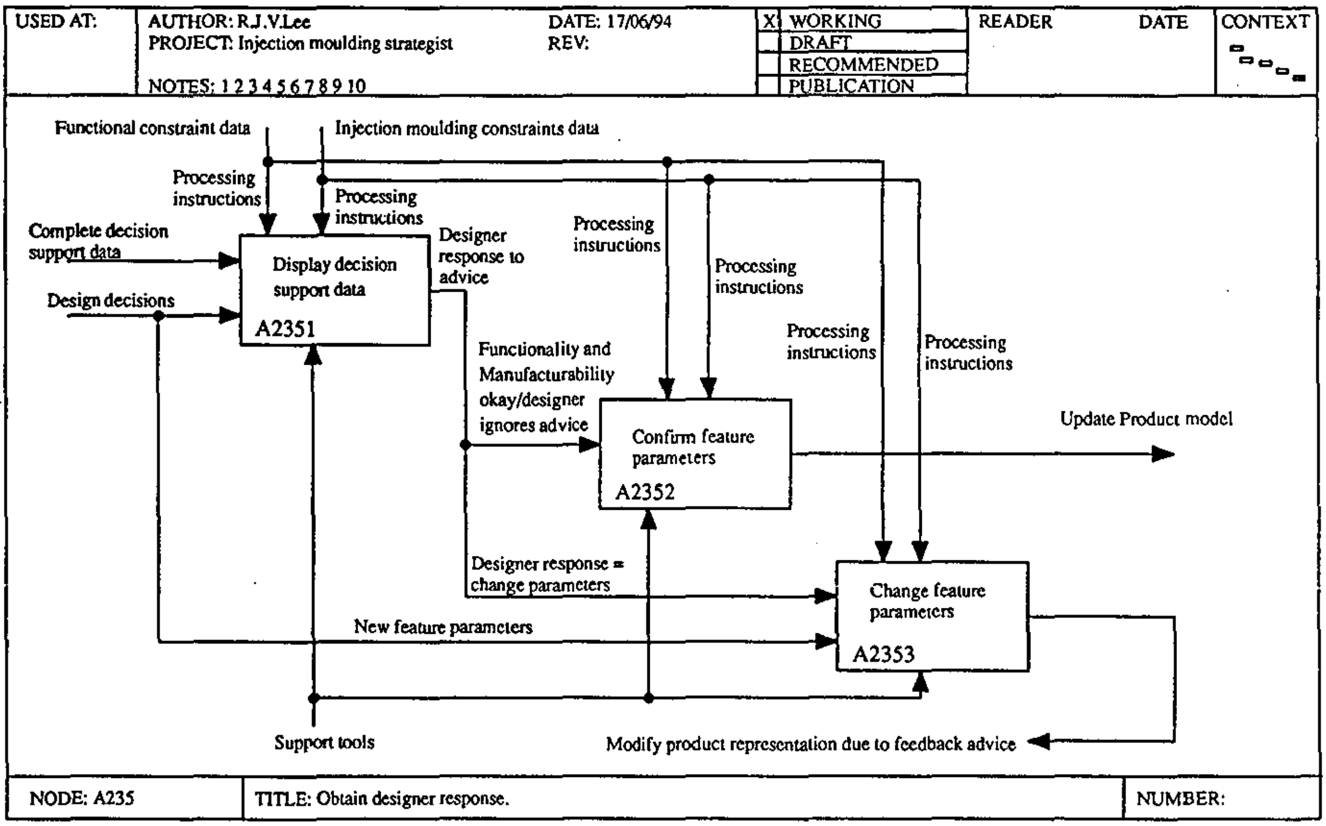
PROJECT: Injection moulding strategist. | REV: | DRAFT | RECOMMENDED | PUBLICATION

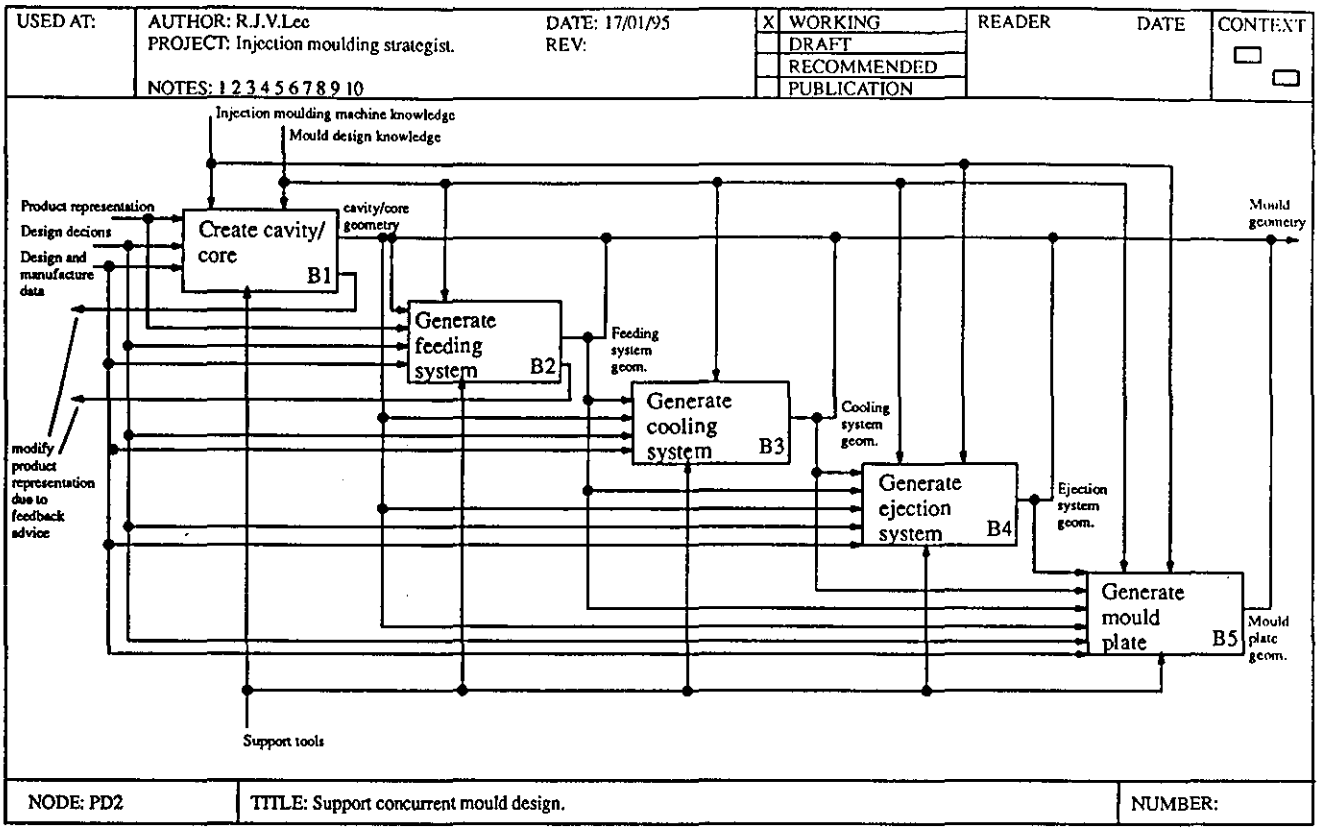
NOTES: 1 2 3 4 5 6 7 8 9 10

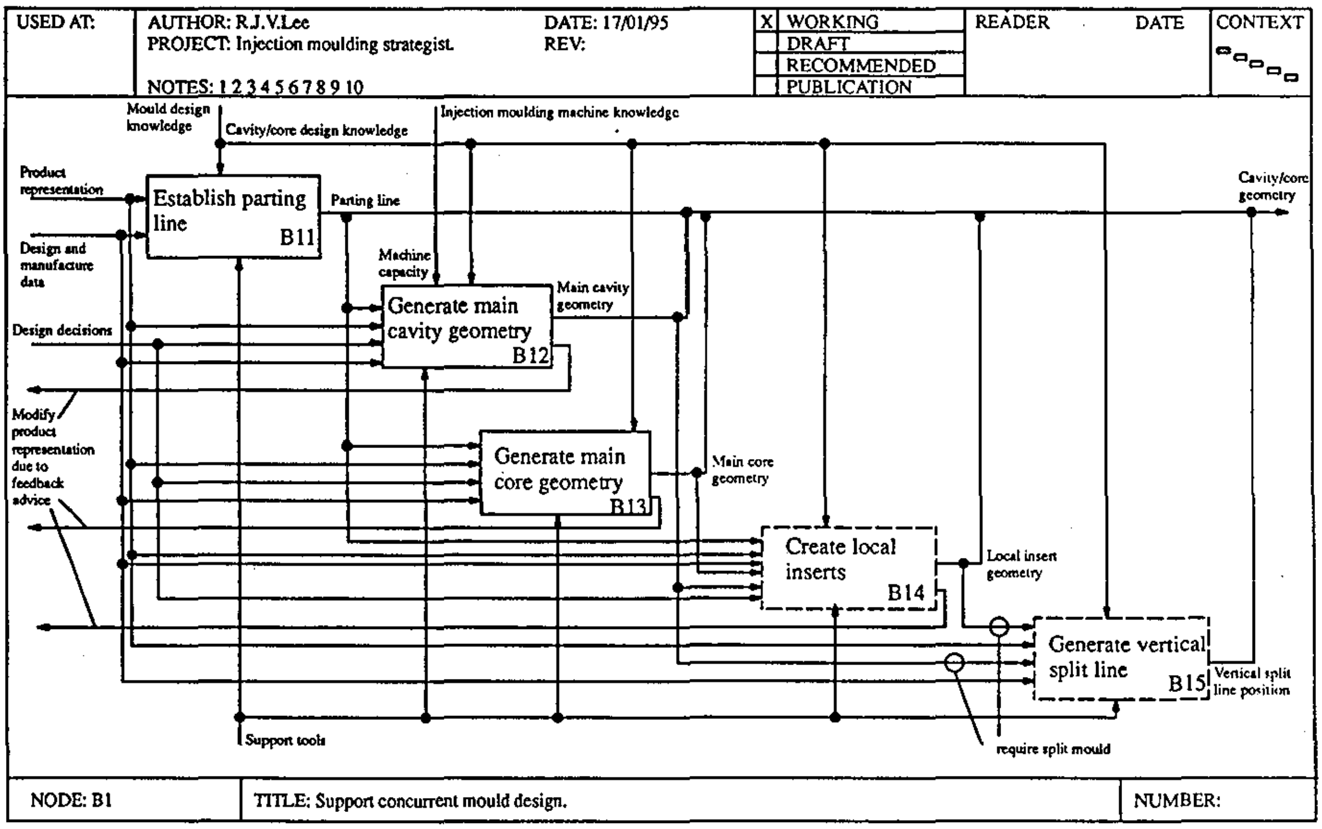


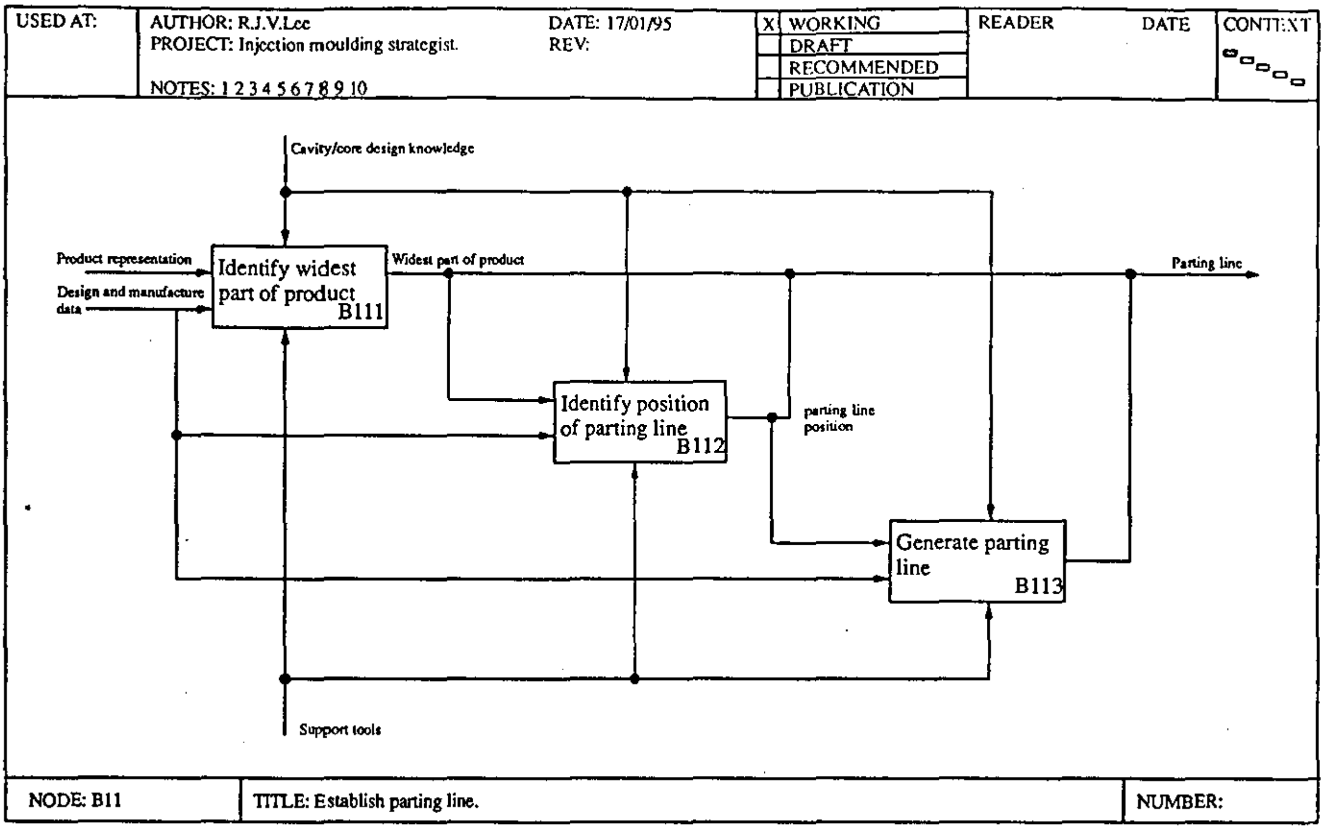
NODE: A233 | TITLE: Calculate ideal parameter values. | NUMBER:

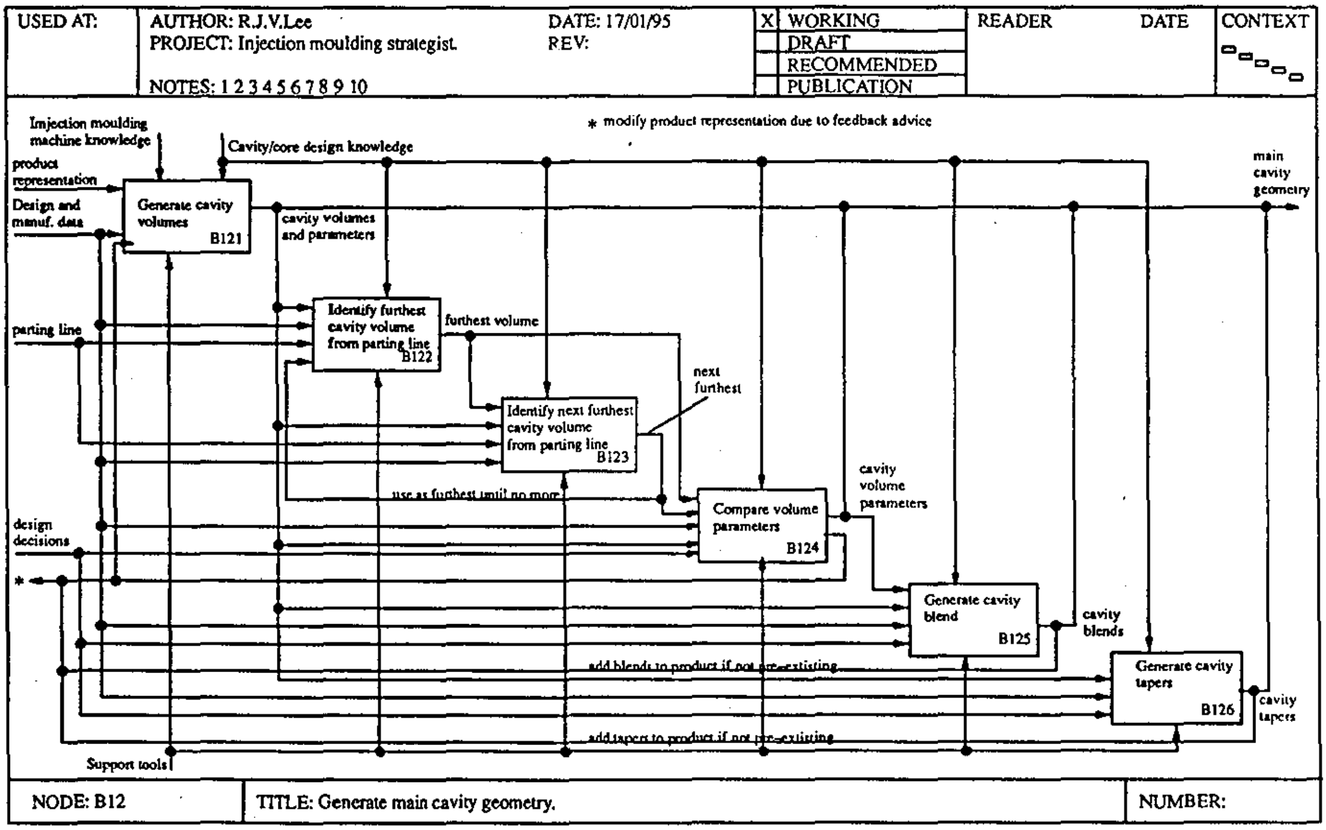

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Injection moulding constraint data
Processing instructions
Processing instructions
Functional decision support data
Advice data
Manufacturing decision support data
Advice data
Extract text advice from data
A2341
Processing instructions
Processing instructions
Advice text in required form
Add calculated values
A2342
Complete decision support data
Ideal parameter values
Support tools
NODE: A234
TITLE: Augment decision support data.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/06/94
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Functional constraint data
Injection moulding constraints data
Processing instructions
Processing instructions
Complete decision support data
Design decisions
Display decision support data
A2351
Designer response to advice
Processing instructions
Processing instructions
Processing instructions
Processing instructions
Functionality and Manufacturability okay/designer ignores advice
Confirm feature parameters
A2352
Update Product model
Designer response = change parameters
New feature parameters
Change feature parameters
A2353
Support tools
Modify product representation due to feedback advice
NODE: A235
TITLE: Obtain designer response.
NUMBER:

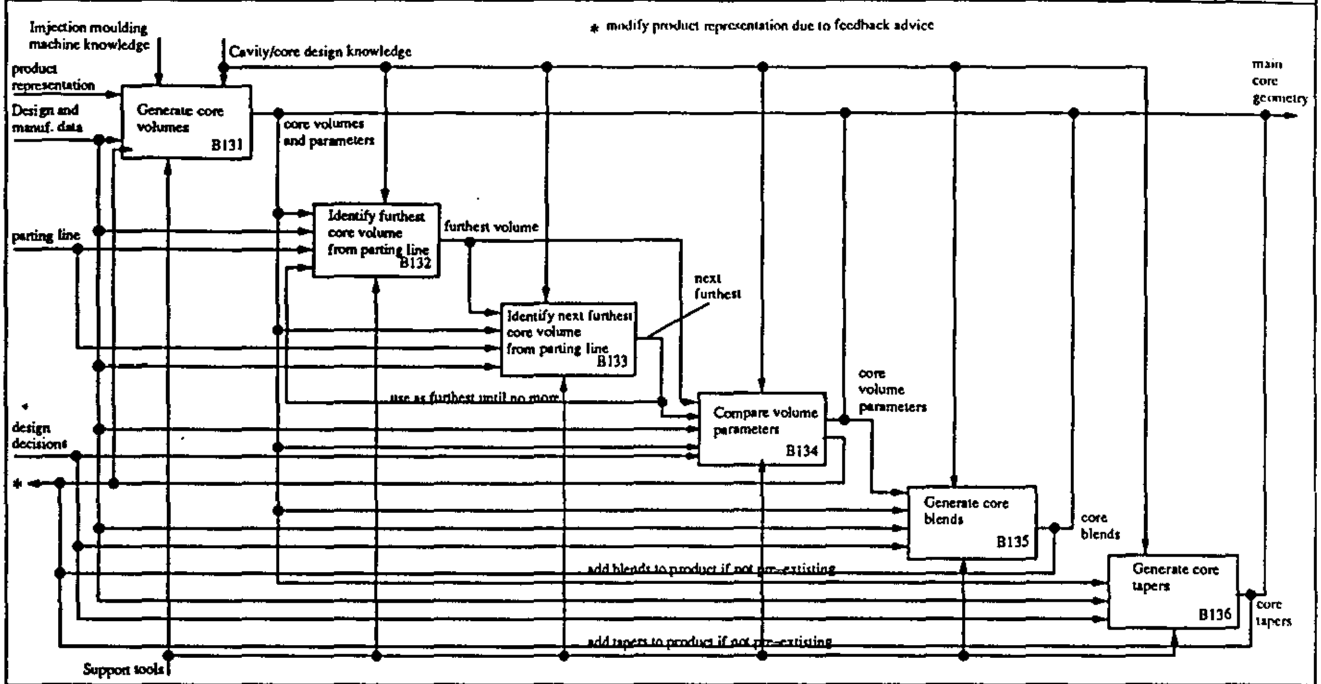

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding machine knowledge
Mould design knowledge
Product representation
Design decions
Design and manufacture data
Create cavity/ core B1
cavity/core geometry
Generate feeding system B2
Feeding system geom.
Generate cooling system B3
Cooling system geom.
Generate ejection system B4
Ejection system geom.
Generate mould plate B5
Mould plate geom.
Mould geometry
modify product representation due to feedback advice
Support tools
NODE: PD2
TITLE: Support concurrent mould design.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Mould design knowledge
Cavity/core design knowledge
Injection moulding machine knowledge
Product representation
Design and manufacture data
Design decisions
Establish parting line B11
Parting line
Machine capacity
Generate main cavity geometry B12
Main cavity geometry
Generate main core geometry B13
Main core geometry
Create local inserts B14
Local insert geometry
Generate vertical split line B15
Vertical split line position
Cavity/core geometry
Modify product representation due to feedback advice
require split mould
Support tools
NODE: B1
TITLE: Support concurrent mould design.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Cavity/core design knowledge
Product representation
Design and manufacture data
Identify widest part of product B111
Widest part of product
Identify position of parting line B112
parting line position
Generate parting line B113
Parting line
Support tools
NODE: B11
TITLE: Establish parting line.
NUMBER:

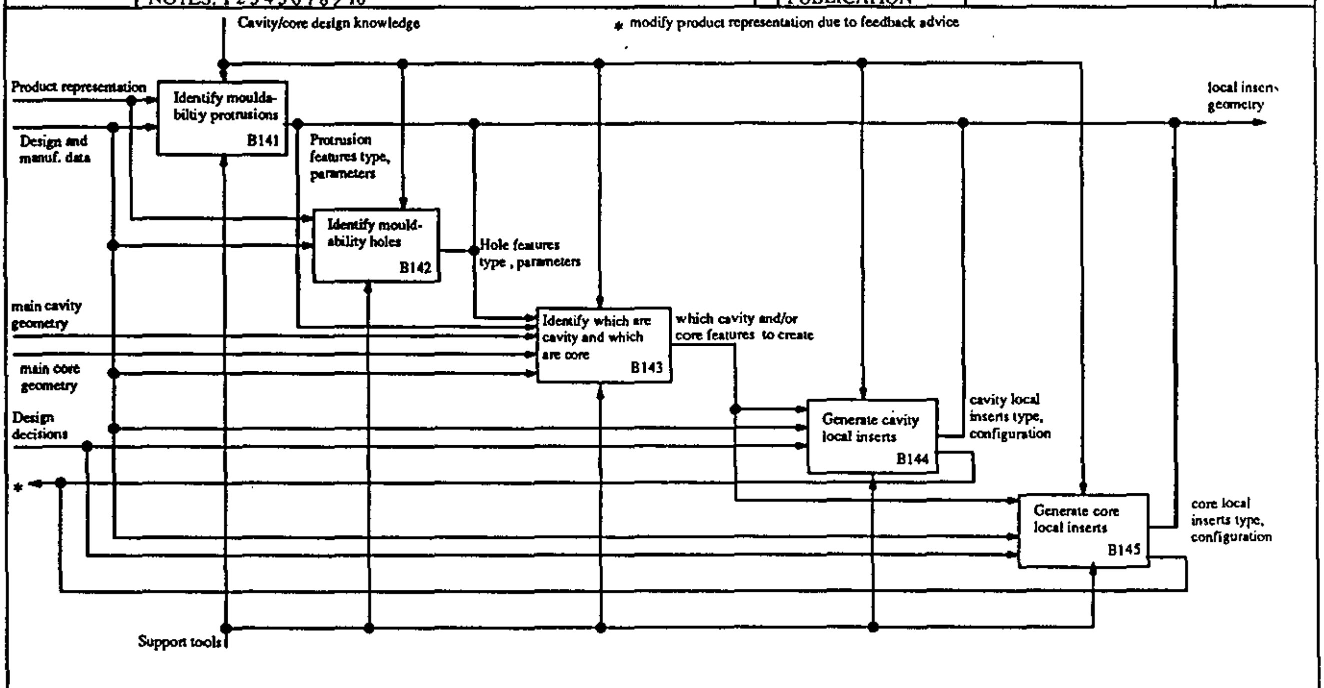

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
* modify product representation due to feedback advice
Injection moulding machine knowledge
Cavity/core design knowledge
product representation
Design and manuf. data
Generate cavity volumes B121
cavity volumes and parameters
main cavity geometry
parting line
Identify furthest cavity volume from parting line B122
furthest volume
next furthest
Identify next furthest cavity volume from parting line B123
use as furthest until no more
Compare volume parameters B124
cavity volume parameters
design decisions
*
Generate cavity blend B125
cavity blends
add blends to product if not pre-existing
Generate cavity tapers B126
cavity tapers
add tapers to product if not pre-existing
Support tools
NODE: B12
TITLE: Generate main cavity geometry.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/01/95 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

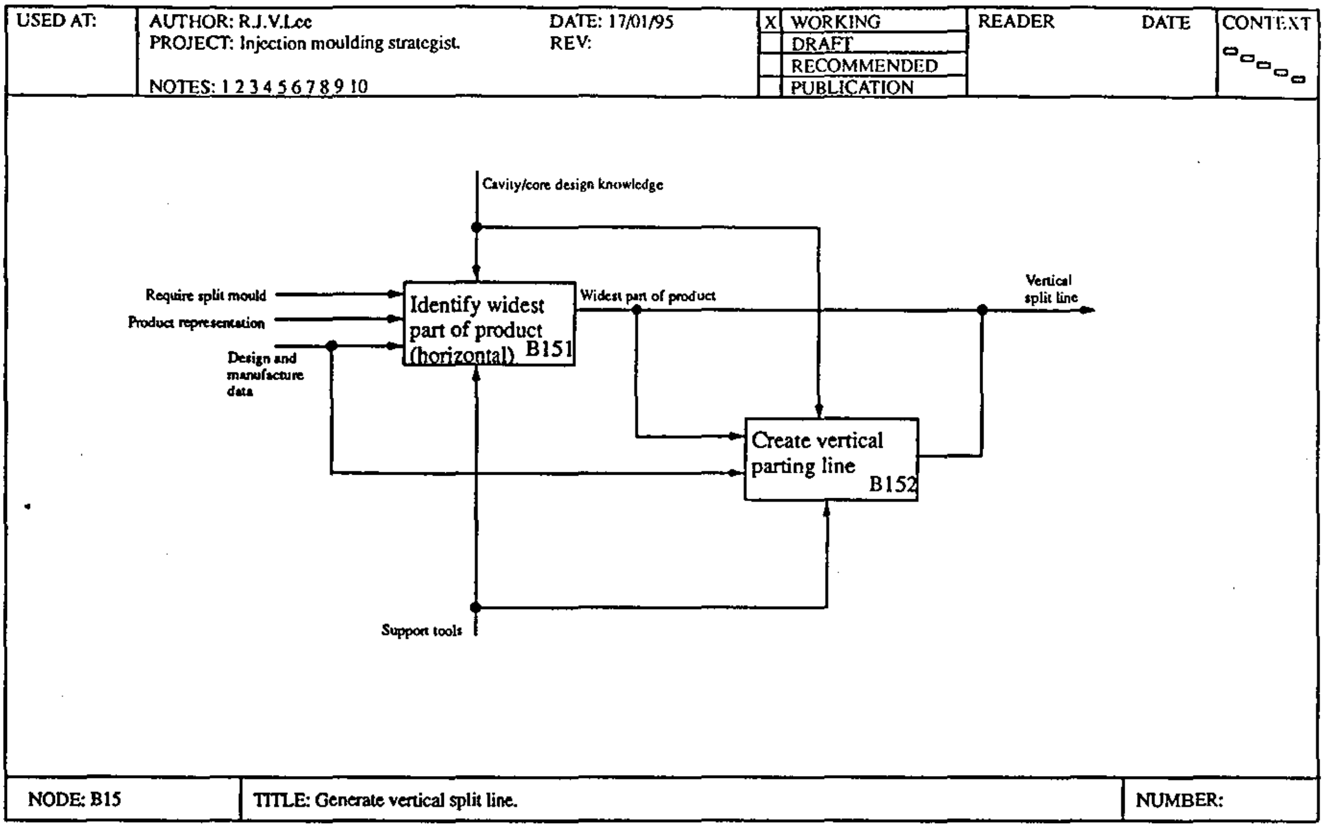


NODE: B13	TITLE: Generate main core geometry.	NUMBER:

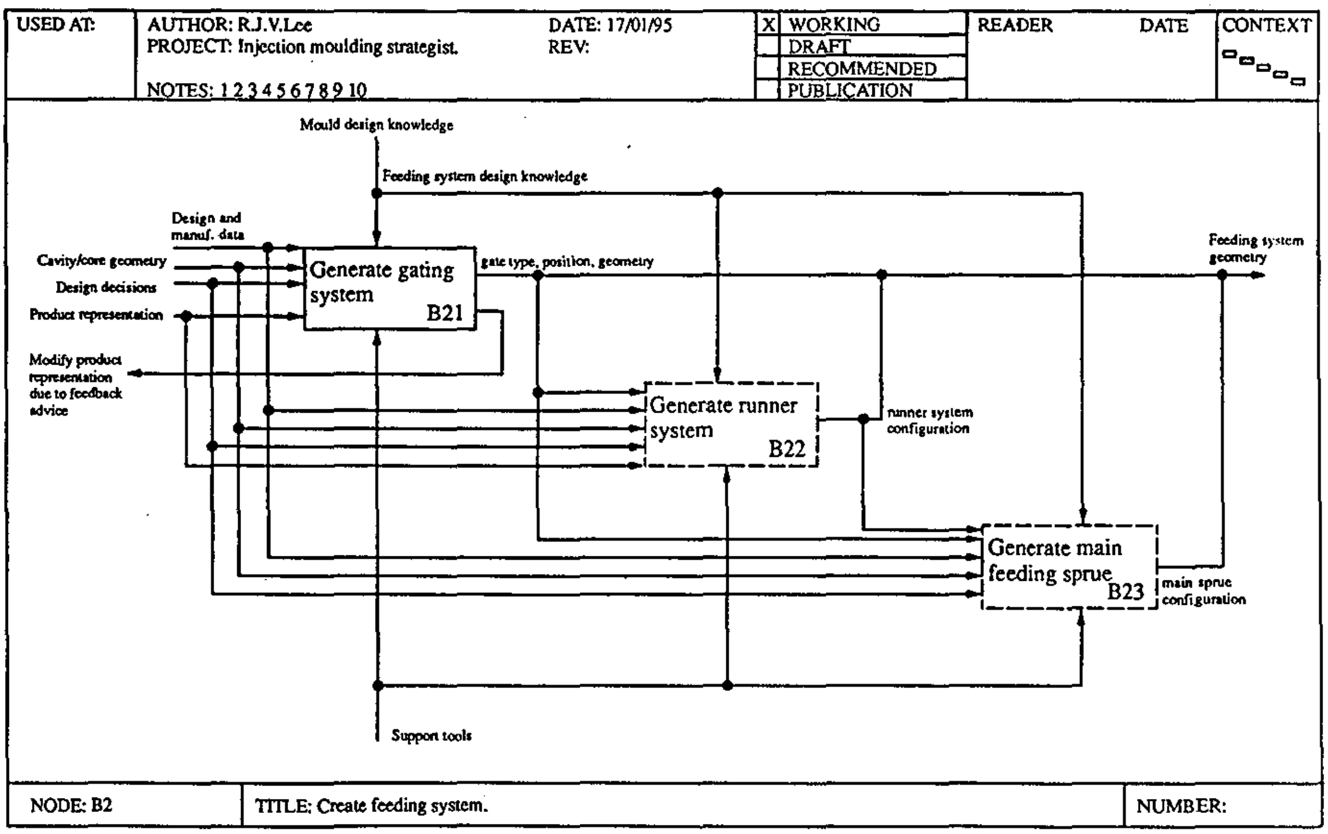
USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/01/95 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT



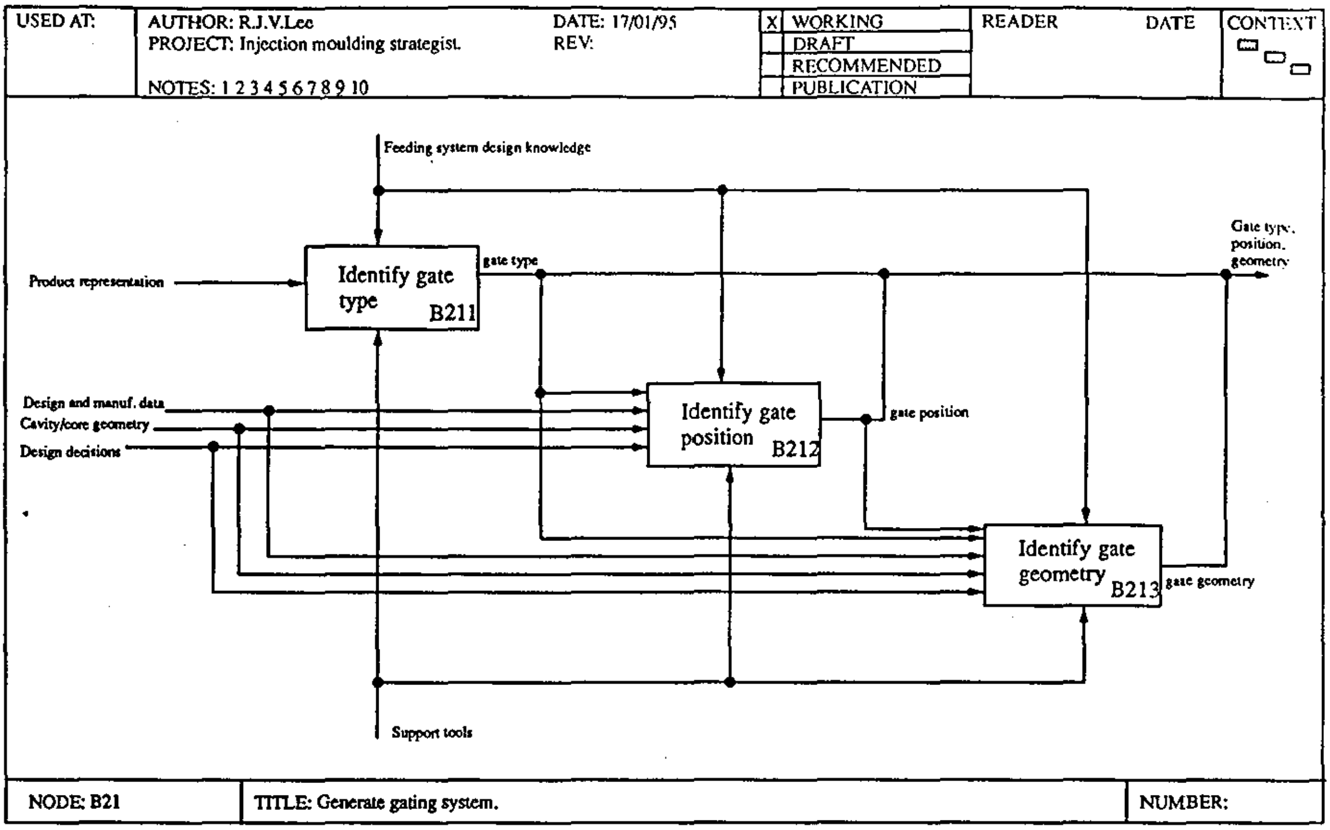
NODE: B14	TITLE: Create local inserts.	NUMBER:

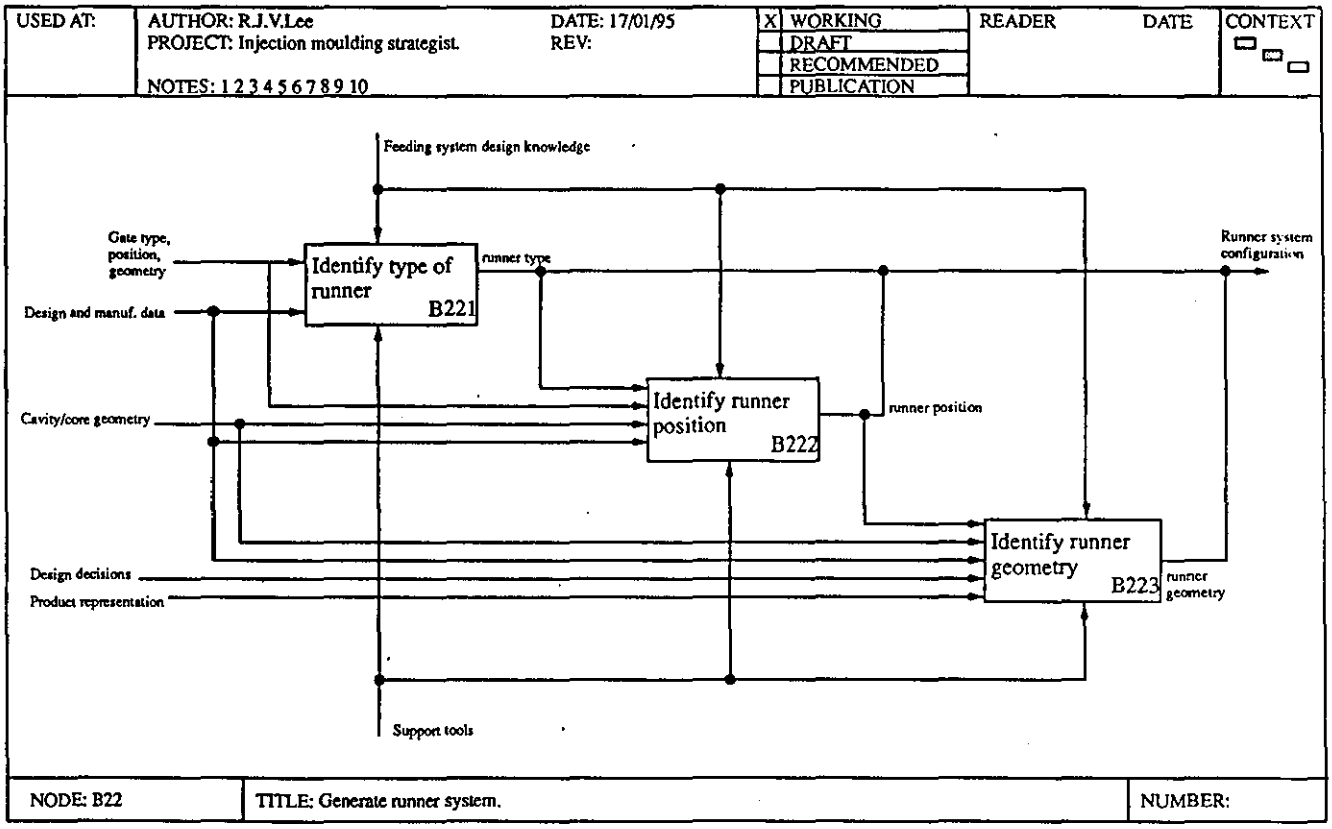


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Cavity/core design knowledge
Require split mould
Product representation
Design and manufacture data
Identify widest part of product (horizontal) B151
Widest part of product
Vertical split line
Create vertical parting line B152
Support tools
NODE: B15
TITLE: Generate vertical split line.
NUMBER:

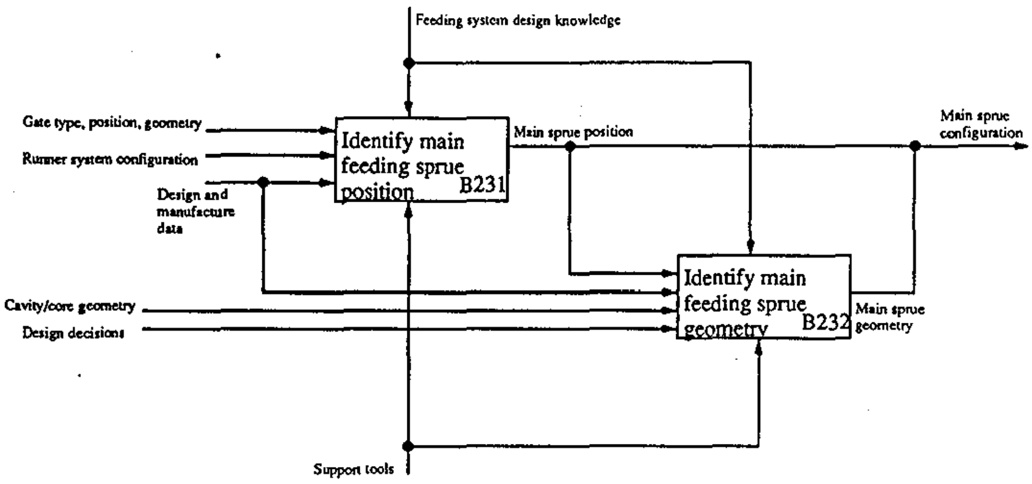


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Mould design knowledge
Feeding system design knowledge
Design and manuf. data
Cavity/core geometry
Design decisions
Product representation
Modify product representation due to feedback advice
Generate gating system B21
gate type, position, geometry
Feeding system geometry
Generate runner system B22
runner system configuration
Generate main feeding sprue B23
main sprue configuration
Support tools
NODE: B2
TITLE: Create feeding system.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Feeding system design knowledge
Product representation
Identify gate type B211
gate type
Gate type, position, geometry
Design and manuf. data
Cavity/core geometry
Design decisions
Identify gate position B212
gate position
Identify gate geometry B213
gate geometry
Support tools
NODE: B21
TITLE: Generate gating system.
NUMBER:

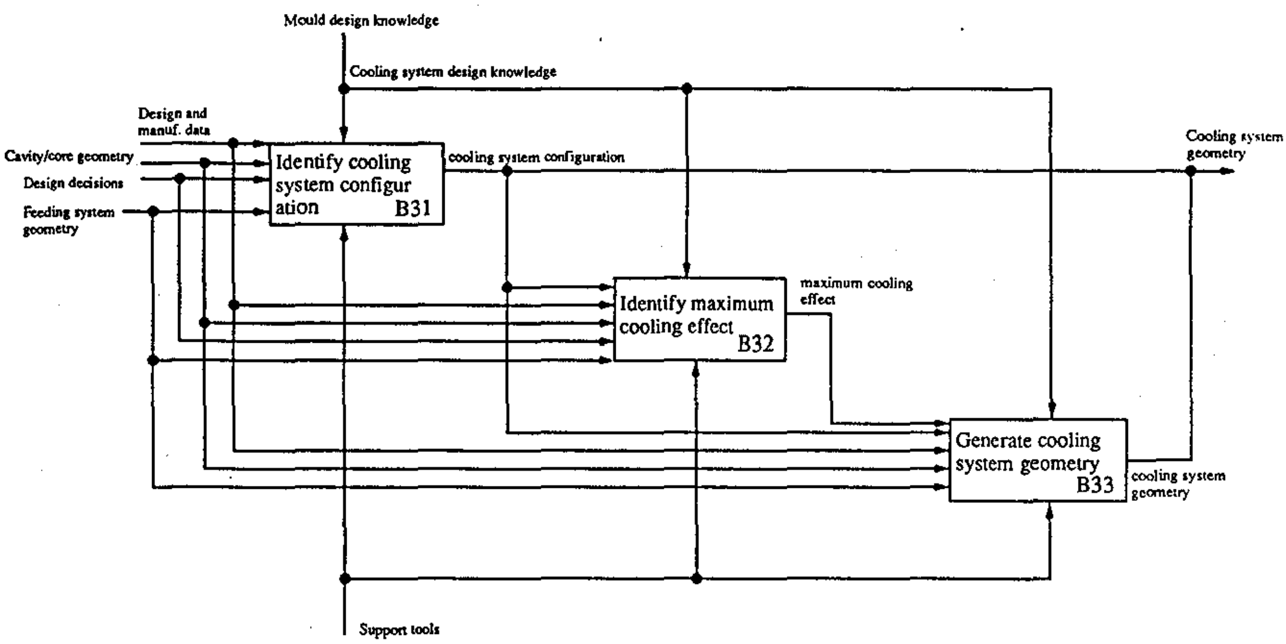

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Feeding system design knowledge
Gate type, position, geometry
Design and manuf. data
Identify type of runner B221
runner type
Runner system configuration
Cavity/core geometry
Identify runner position B222
runner position
Design decisions
Product representation
Identify runner geometry B223
runner geometry
Support tools
NODE: B22
TITLE: Generate runner system.
NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/01/95 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT

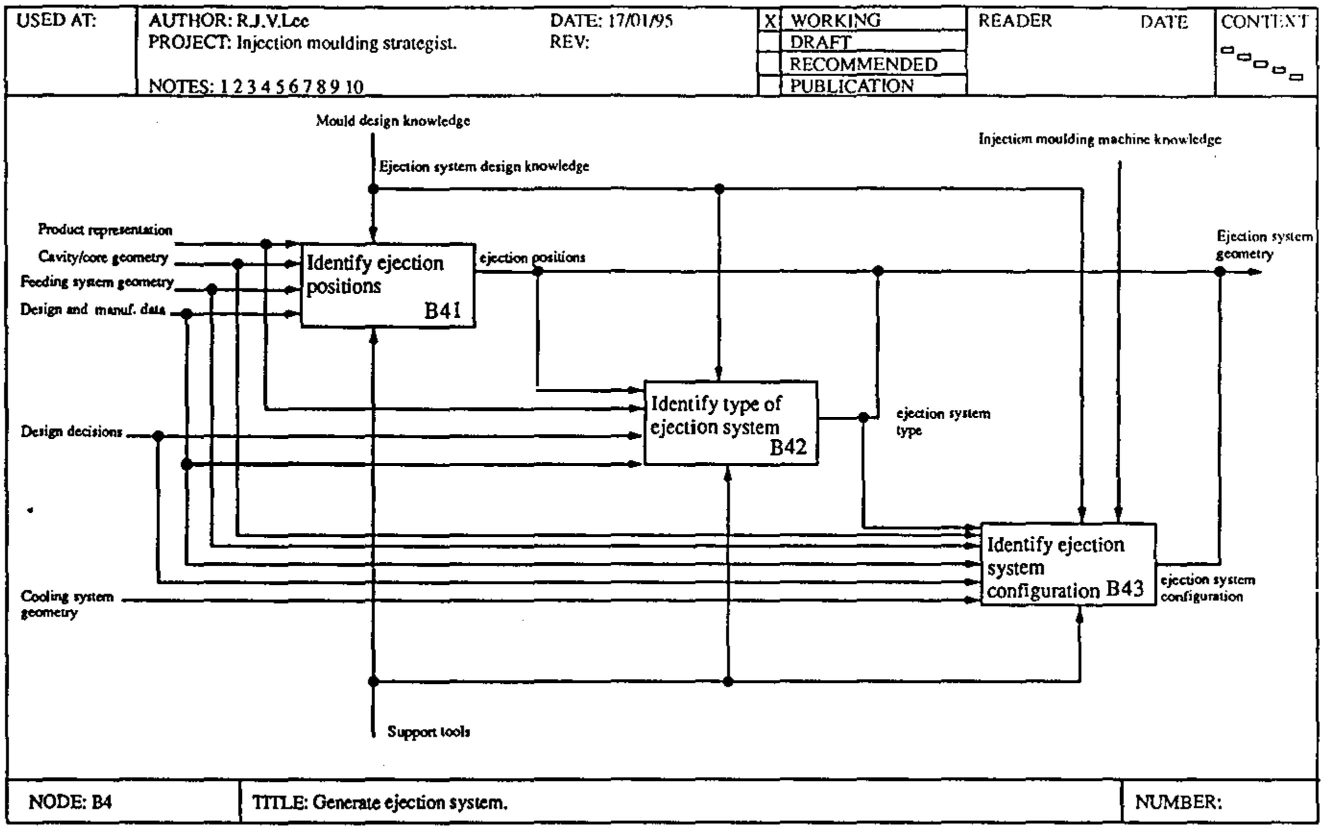


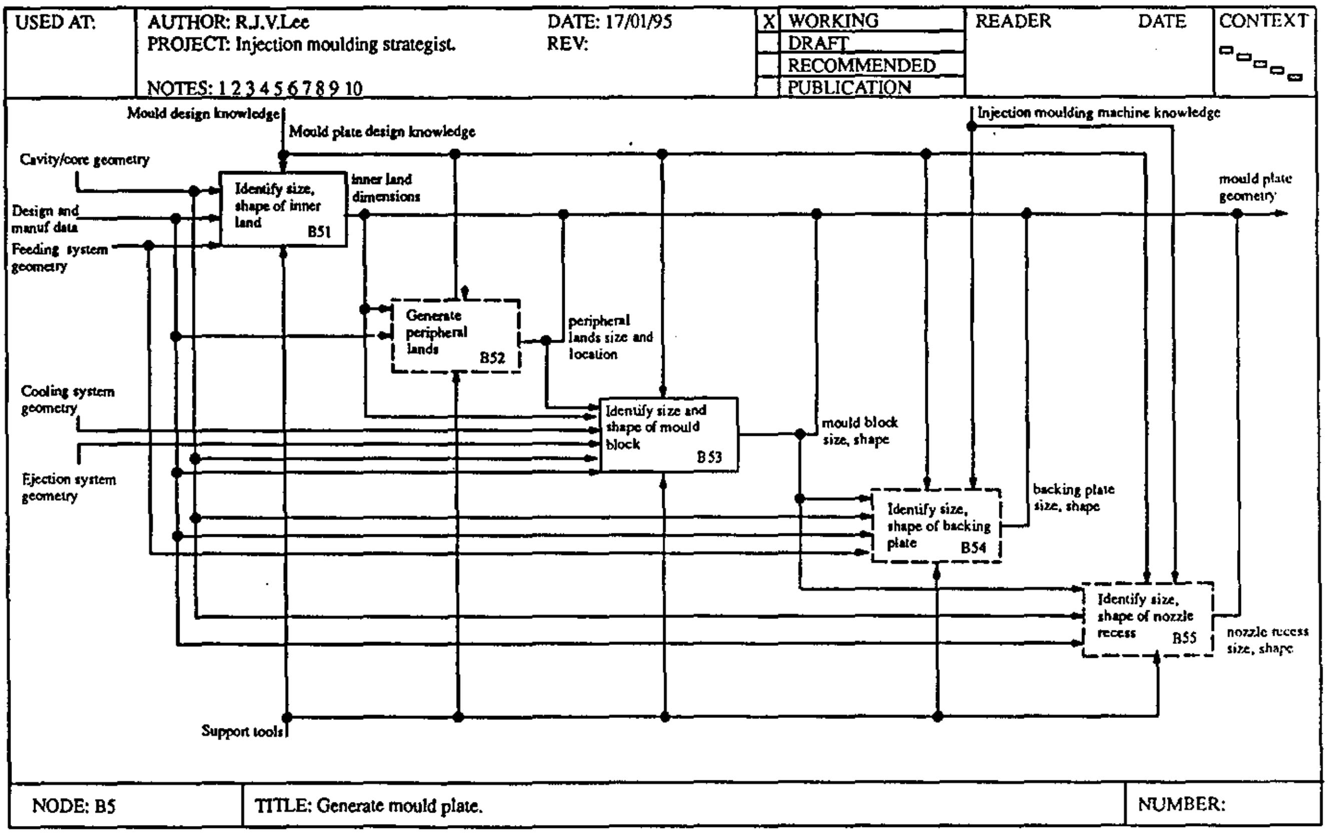
NODE: B23	TITLE: Generate main feeding sprue.	NUMBER:

USED AT:	AUTHOR: R.J.V.Lee PROJECT: Injection moulding strategist. NOTES: 1 2 3 4 5 6 7 8 9 10	DATE: 17/01/95 REV:	X WORKING DRAFT RECOMMENDED PUBLICATION	READER	DATE	CONTEXT



NODE: B3	TITLE: Generate cooling system.	NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Mould design knowledge
Ejection system design knowledge
Injection moulding machine knowledge
Product representation
Cavity/core geometry
Feeding system geometry
Design and manuf. data
Identify ejection positions B41
ejection positions
Ejection system geometry
Identify type of ejection system B42
ejection system type
Design decisions
Identify ejection system configuration B43
ejection system configuration
Cooling system geometry
Support tools
NODE: B4
TITLE: Generate ejection system.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Mould design knowledge
Mould plate design knowledge
Injection moulding machine knowledge
Cavity/core geometry
Design and manuf data
Feeding system geometry
Identify size, shape of inner land B51
inner land dimensions
mould plate geometry
Generate peripheral lands B52
peripheral lands size and location
Cooling system geometry
Identify size and shape of mould block B53
mould block size, shape
Ejection system geometry
Identify size, shape of backing plate B54
backing plate size, shape
Identify size, shape of nozzle recess B55
nozzle recess size, shape
Support tools
NODE: B5
TITLE: Generate mould plate.
NUMBER:

Drawing FD1.

Inputs.

Design and Manufacture data – Existing product representation, material performance, choice, price etc, manufacturing process performance, capabilities.

Design decisions.– Decisions on product form and function combinations plus parameters of form and mouldability features, response to advice.

Constraints.

Product functional knowledge– Functional data for a given product range, functional constraints data.

Injection moulding knowledge– Knowledge on how to create an equivalent representation of the product from the viewpoint of design for injection moulding, injection moulding constraints data.

Outputs.

Update Product model– Details of new features to be added to the product representation.

Modify product representation due to feedback advice– Change feature parameters.

Drawing A.1.

Inputs.

Design and manufacture data- Existing product representation, materials performance, choice, price, manufacturing process performance, capabilities.

Design decisions.– Decisions on product function and form combinations plus parameters of form and mouldability features.

Modify product representation due to feedback advice.– Change feature parameters.

Constraints.

Product functional knowledge.– Functional data for a given product range.

Injection moulding knowledge.– Knowledge on how to create an equivalent representation of the product from the viewpoint of design for injection moulding.

Outputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product functional specification.

Manufacturing representation.– Details of mouldability features and their association with form.

Drawing A.1.1.

Inputs.

Design decisions.– Which product to develop and which product function(s) to associate with which form(s)

Design data.– Performance of materials, choice, price etc.

Modify product representation due to feedback advice.– Change feature parameters.

Constraints.

Product type data.– How form and functions can be combined. Unique to any given product type.

Outputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product functional specification.

Drawing A.1.2.

Inputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product functional specification.

Design and manufacture data.– Existing product representation.

Design decisions.– Parameters of mouldability features.

Constraints.

Product type data.– Data specifying the type of adjacent functional features in order to achieve a new function.

Injection moulding feature data.– How to create the manufacturing representation.

Outputs.

Manufacturing representation.– Details of new mouldability features and their association with form.

Drawing A.1.1.1.

Inputs.

Design data.– Properties of materials, choices, prices etc.

Design decisions.– Product type to create and quantification of product functional objectives.

Constraints.

Functional requirements data.– Product types in the Product model and their functional objectives.

Outputs.

Functional specification.– Details of individual product functional objectives and their quantification.

Drawing A.1.1.2.

Inputs.

Design decisions.– Which product function to be associated with form, form choice and parameters.

Modification of product representation due to feedback advice.– Change feature parameters.

Constraints.

Functional specification.– Details of individual product functional objectives and their quantification.

Form?function data.– Which form(s) can be used to achieve which function(s) for the given product type.

Outputs.

Form/function decisions.– Details of functional objective(s), associated form and parameters.

Drawing A.1.2.1.

Inputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product functional specification.

Constraints.

Injection moulding features data.– Processing instructions on associating product type and function with mouldability feature types.

Outputs.

Possible mouldability equivalents.– The equivalent mouldability feature(s) for the form/function combination. There may be more than one.

Drawing A.1.2.2.

Inputs.

Possible mouldability equivalents.– The equivalent mouldability feature(s) for the form/function combination. There may be more than one.

Existing product representation.– Details of existing surrounding geometry.

Constraints.

Injection moulding features data.– How to identify new mouldability feature types.

Product type context.– In the context of the product type, what the surrounding geometry must be in terms of feature type(s).

Outputs.

Features to create and associate.– New mouldability features to create and which existing or new features to create associations with.

Drawing A.1.2.3.

Inputs.

Features to create and associate.– New mouldability features to create and which existing or new features to create associations with.

Design decisions.– Parameters of blends and tapers.

Constraints.

Injection moulding features data.– How to create new mouldability features.

Outputs.

Manufacturing representation.– Details of new mouldability features and their association with form.

Drawing A.1.1.1.1.

Inputs.

Design decisions.– Which product type to develop, eg pot type, PTPlus etc.

Constraints.

Available product types.– Product types for which form/function data is available.

Outputs.

Choice of product type.– Product type that is to be developed.

Drawing A.1.1.1.2.

Inputs.

Choice of product type.– Product type that is to be developed.

Performance targets.– Quantifying individual product functional objectives eg function 'load bearing' = 70kg.

Design data. Properties of materials, choices, prices etc.

Constraints.

Product functional requirements.– Those functional objectives for which the product is expected to be used or has to achieve.

Outputs.

Functional specification.– Details of individual product functional objectives and their quantification.

Drawing A.1.1.2.1.

Inputs.

Design decisions.– Which product function to be associated with form.

Constraints.

Functions associated with the product.– Those functional objectives to be achieved by the chosen product type and performance targets.

Outputs.

Function choice.– Which product function to be associated with form.

Drawing A.1.1.2.2.

Inputs.

Function choice.– Which product function to be associated with form.

Form choice and parameters.– Choice of form to achieve the given function, orientation, position and dimensions

Modify product representation due to feedback advice.– Change form parameters.

Constraints.

Form/function data.– Which form(s) can be used to achieve which function(s) for the given product type.

Outputs.

Form/function decisions.– Details of functional objective(s), associated form and parameters.

Drawing A.1.2.1.1.

Inputs.

Functional representation.– Combination(s) of form(s) and function(s) plus product functional specification.

Constraints.

Processing instructions.– How to extract function and form data from the functional representation.

Outputs.

Product function and form.– Identity and type of new function and form feature combination.

Drawing A.1.2.1.2.

Inputs.

Product type and function.– Combination of the product type and the product functional requirement to be fulfilled by the form.

Constraints.

Processing instructions.– How to associate mouldability features with the given product function and form combination.

Outputs.

Possible mouldability equivalents.– The equivalent mouldability feature(s) for the form/function combination. There may be more than one.

Drawing A.1.2.2.1.

Inputs.

Feature associations.– Which features are adjacent to or contained in other features.

New feature identity.– Identity of new feature to associate with surrounding geometry.

Constraints.

Product type context.– In the context of the product type, what the surrounding geometry must be in terms of feature type(s)

Outputs.

Identity new feature, identity and type surrounding geometry.– Feature identities and type in terms of mouldability.

Drawing A.1.2.2.2.

Inputs.

New and surrounding features identity.– Identity of new feature and those associated so parameters can be extracted from the Product model.

New feature parameters and possible types.– Parameters of the new feature, what it could be in terms of mouldability.

Surrounding geometry parameters.– Parameters of existing features adjacent to the new feature.

Constraints.

Injection moulding features data.– What the relative parameters of the new and adjacent old geometry mean in terms of mouldability equivalent.

Outputs.

New feature identity, mouldability type and parameters.– New feature identity, mouldability type and parameters.

Drawing A.1.2.2.3.

Inputs.

New feature identity, mouldability type and parameters.– New feature identity, mouldability type and parameters.

Identity and type of surrounding geometry.– Identity and type of surrounding geometry

Constraints.

Injection moulding features data.– What the combination of new and old features requires in terms of type of blend(s).

Outputs.

Tapers and blends.– Tapers on new features and blends between old and new.

Drawing A.1.2.3.1.

Inputs.

New feature identity, mouldability type and parameters.– Details of new mouldability feature to create.

Constraints.

Injection moulding features data.– How to create a new mouldabilty feature of the type given.

Outputs.

New mouldability feature.– Details of newly created mouldability feature.

Drawing A.1.2.3.2.

Inputs.

Feature created.– A feature has been created to which a blend may be attached.

Blend type– Type of blend to be created.

Design decisions.– The parameters of the blend.

Constraints.

Processing instructions.– How to get blend parameters from the designer.

Outputs.

Blend parameters.– Parameters of the blend.

Drawing A.1.2.3.3.

Inputs.

Blend parameters.– Parameters of the blend.

New feature identity.– Identity of the new feature to which the blend is to be attached.

Surrounding geometry identity.– Identity of the surrounding geometry to which the blend is to be attached.

Constraints.

Processing instructions.– How to create the blend type given and associate it with other features.

Outputs.

Blend.– Details of newly created blend feature.

Blend created.– A blend has been attached to the new feature and a taper can be applied.

Drawing A.1.2.3.4.

Inputs.

Blend created.– A blend has been attached to the new feature and a taper can be applied.

Taper type.– Type of taper to create.

Design decisions.– Parameters of the new taper.

Constraints.

Processing instructions.– How to get taper parameters from the designer.

Outputs.

Taper parameters.–	Parameters of the new taper to be created.

Drawing A.1.2.3.5.

Inputs.

Taper parameters.–	Parameters of the new taper to be created.
New feature identity.–	Identity of new feature to which taper is to be attached.

Constraints.

Processing instructions.–	How to create a new taper of the given type.

Outputs.

Taper.–	Details of newly created taper feature.

Drawing A.2.

Inputs.

Functional representation.–	Combination(s) of function(s) and form(s) plus product specification.
Manufacturing representation.–	Details of new mouldability features and their association with form.
Design and manufacture data.–	Existing product representation, materials data, manufacturing process data.
Design decisions.–	Designers response to advice.

Constraints.

Product functional knowledge.–	Functional constraints data.
Injection moulding knowledge.–	Injection moulding constraints data.

Outputs.

Update Product model.–	Details of new features to be added to the product representation.
Modify product representation due to feedback advice.–	Change feature parameters.

Drawing A.2.1.

Inputs.

Functional representation.–	Combination(s) of function(s) and form(s) plus product specification.
Design data.–	Materials performance, choice, price etc.

Constraints.

Functional constraint data.–	Constraint data location, processing instructions.

Outputs.

Functionality assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.

Drawing A.2.2.

Inputs.

Manufacturing representation.–	Details of new mouldability features and their association with form.
Manufacture data.–.	Manufacturing process capabilities and performance, existing mouldability features.

Constraints.

Injection moulding constraint data.–	Constraint data location, processing instructions.

Outputs.

Manufacturability assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.

Drawing A.2.3.

Inputs.

Design and manufacture data.–	Existing product representation, materials data, manufacturing process data.
Manufacturability assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.
Functionality assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.
Design decisions.–	Designers response to advice.

Constraints.

Functional constraint data.–	Advice data, processing instructions.
Injection moulding constraint data.–	Advice data, processing instructions.

Outputs.

Update Product model.– Details of new features to be added to the product representation.

Modify product representation due to feedback advice.– Change feature parameters.

Drawing A.2.1.1.

Inputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product specification.

Constraints.

Constraint data location.– Knowledge of the location of functional constraints in the Product model.

Outputs.

Constraint data required from the Product model.– The identity of the rules for conformance to constraints.

Drawing A.2.1.2.

Inputs.

Constraint data required from the Product model.– The identity of the rules for conformance to constraints.

Constraints.

Functional constraint data.– Processing instructions on how to interpret constraint data.

Outputs.

How to analyse features.– Expressions to be solved and to which feature parameter values the results must be compared.

Drawing A.2.1.3.

Inputs.

How to analyse features.– Expressions to be solved and to which feature parameter values the results must be compared.

Design data.– Materials performance, choice, price etc.

Functional representation.– Combination(s) of function(s) and form(s) plus product specification.

Constraints.

Functional constraint data.– Processing instructions on how to carry out conformance analysis.

Outputs.

Functionality assessment.– Conformance condition of new feature parameter(s) to be associated with a response.

Drawing A.2.2.1.

Inputs.

Manufacturing representation.– Details of new mouldability features and their association with form

Constraints.

Constraint data location.– Knowledge of the location of manufacturing constraints in the Manufacturing model.

Outputs.

Constraint data required from the Manufacturing model.– The identity of the rules for conformance to constraints.

Drawing A.2.2.2.

Inputs.

Constraint data required from the Manufacturing model.– The identity of the rules for conformance to constraints.

Constraints.

Injection moulding constraint data.– Processing instructions on how to interpret constraint data.

Outputs.

How to analyse features.– Expressions to be solved and to which feature parameter values the results must be compared.

Drawing A.2.2.3.

Inputs.

How to analyse features.– Expressions to be solved and to which feature parameter values the results must be compared.

Manufacture data.– Manufacturing process performance, capabilities, existing mouldability features.

Manufacturing representation.– Details of new mouldability features and their association with form

Constraints.

Manufacturability constraint data.– Processing instructions on how to carry out conformance analysis.

Outputs.

Manufacturability assessment.– Conformance condition of new feature parameter(s) to be associated with a response.

Drawing A.2.3.1.

Inputs.

Functionality assessment.– Conformance condition of new feature parameter(s) to be associated with a response.

Constraints.

Functional constraint data.– Location of functional constraint data, advice data.

Outputs.

Functional decision support data.– Textual advice, details of recommended values that must be calculated and in relation to which new feature parameters.

Drawing A.2.3.2.

Inputs.

Manufacturability assessment.– Conformance condition of new feature parameter(s) to be associated with a response.

Constraints.

Injection moulding constraint data.– Location of injection moulding constraint data, advice data.

Outputs.

Manufacturing decision support data.– Textual advice, details of recommended values that must be calculated and in relation to which new feature parameters.

Drawing A.2.3.3.

Inputs.

Functional decision support data.– Details of recommended values that must be calculated and in relation to which new feature parameters.

Manufacturing decision support data.– Details of recommended values that must be calculated and in relation to which new feature parameters.

Design and manufacture data.– Existing product representation, materials data, manufacturing process data.

Constraints.

Functional constraint data.– Processing instructions on how to calculate ideal parameter values.

Injection moulding constraint data.– Processing instructions on how to calculate ideal parameter values.

Outputs.

Ideal parameter values.– Those values ideal for functionality or manufacturability.

Drawing A.2.3.4.

Inputs.

Functional decision support data.– Details of textual advice to be given.

Manufacturing decision support data.– Details of textual advice to be given.

Ideal parameter values.– Those values ideal for functionality or manufacturability.

Constraints.

Functional constraint data.– Processing instructions on how to augment decision support data.

Injection moulding constraint data.– Processing instructions on how to augment decision support data.

Outputs.

Complete decision support data.– Textual advice ready to be given to the designer.

Drawing A.2.3.5.

Inputs.

Complete decision support data.– Textual advice ready to be given to the designer.

Design decisions.– Designer response to advice.

Constraints.

Functional constraint data.– Processing instructions on how to obtain designer response.

Injection moulding constraint data.– Processing instructions on how to obtain designer response.

Outputs.

Update Product model.– Details of new features to be added to the product representation.

Modify product representation due to feedback advice.– Change feature parameters.

Drawing A.2.1.1.1.

Inputs.

Functional representation.– Combination(s) of function(s) and form(s) plus product specification.

Constraints.

Constraint data location.– Knowledge of the location of the functional constraints in the Product model.

Outputs.

Feature type, location of constraint data in the Product model.– Type of feature, where to search for functional constraint data.

Drawing A.2.1.1.2.

Inputs.

Feature type, location of constraint data in the Product model.– Type of feature, where to search for functional constraint data.

Constraints.

Constraint data location.– Knowledge of the location of the functional constraints in the Product model.

Outputs.

Constraint data required from the product model.– The identity of rules for conformance to constraints.

Drawing A.2.1.2.1.

Inputs.

Constraint data required from the product model.– The identity of rules for conformance to constraints.

Constraints.

Processing instructions.– How to read and understand the rule(s).

Outputs.

Which parameter values must be defined.– Which parameters of the feature are to be examined for conformance to the constraint(s).

Drawing A.2.1.2.2.

Inputs.

Which parameter values must be defined.– Which parameters of the feature are to be examined for conformance to the constraint(s).

Constraints.

Processing instructions.– How to define required calculations.

Outputs.

How to analyse features.– Expressions to be solved, and to which feature parameter values they must be compared.

Drawing A.2.1.3.1.

Inputs.

How to analyse features.– Expressions to be solved, and to which feature parameter values they must be compared...

Design data.– Materials performance, choice, price etc.

Constraints.

Processing instructions.– How to carry out calculation of parameter values or limits.

Outputs.

Desired parameter values.– Values to be compared with feature parameters, and which feature parameters.

Drawing A.2.1.3.2.

Inputs.

Desired parameter values.– Values to be compared with feature parameters, and which feature parameters.

Functional representation.– Combination(s) of function(s) and form(s).

Constraints.

Processing instructions.– How to compare feature parameters with desired values.

Outputs.

Results of comparison.– Whether feature parameters are the same/within limits, too high, too low etc.

Drawing A.2.1.3.3.

Inputs.

Results of comparison.– Whether feature parameters are the same/within limits, too high, too low etc.

Constraints.

Processing instructions.– How to identify conformance condition.

Outputs.

Functionality assessment.– Conformance condition of new feature parameter(s) to be associated with a response.

Drawing A.2.2.1.1.

Inputs.

Manufacturing representation.– Details of new mouldability features and their association with form.

Constraints.

Constraint data location.– Knowledge of the location of the manufacturing constraints in the Manufacturing model.

Outputs.

Feature type, location of constraint data in the Manufacturing model.– Type of feature, where to search for manufacturing constraint data.

Drawing A.2.2.1.2.

Inputs.

Feature type, location of constraint data in the Manufacturing model.– Type of feature, where to search for manufacturing constraint data.

Constraints.

Constraint data location.– Knowledge of the location of the manufacturing constraints in the Manufacturing model.

Outputs.

Constraint data required from the Manufacturing model.– The identity of rules for conformance to constraints.

Drawing A.2.2.2.1.

Inputs.

Constraint data required from the Manufacturing model.– The identity of rules for conformance to constraints.

Constraints.

Processing instructions.– How to read and understand the rule(s).

Outputs.

Which parameter values must be defined.– Which parameters of the feature are to be examined for conformance to the constraint(s).

Drawing A.2.2.2.2.

Inputs.

Which parameter values must be defined.– Which parameters of the feature are to be examined for conformance to the constraint(s).

Constraints.

Processing instructions.– How to define required calculations.

Outputs.

How to analyse features.– Expressions to be solved, and to which feature parameters they must be compared.

Drawing A.2.2.3.1.

Inputs.

How to analyse features.– Expressions to be solved, and to which feature parameter values they must be compared..

Manufacture data.– Manufacturing process capabilities, performance, existing mouldability features.

Constraints.

Processing instructions.– How to carry out calculation of parameter values or limits.

Outputs.

Desired parameter values.–	Values to be compared with feature parameters, and which feature parameters.

Drawing A.2.2.3.2.

Inputs.

Desired parameter values.–	Values to be compared with feature parameters, and which feature parameters.
Manufacturing representation.–	Details of new mouldability features and their association with form.

Constraints.

Processing instructions.–	How to compare feature parameters with desired values.

Outputs.

Results of comparison.–	Whether feature parameters are the same/within limits, too high, too low etc.

Drawing A.2.2.3.3.

Inputs.

Results of comparison.–	Whether feature parameters are the same/within limits, too high, too low etc.

Constraints.

Processing instructions.–	How to identify conformance condition.

Outputs.

Manufacturability assessment.–	Conformance condition of new feature parameter(s) to be associated with a response

Drawing A.2.3.1.1.

Inputs.

Functionality assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.

Constraints.

Functional constraint data.–	A knowledge of the location of functional constraints data.

Outputs.

Constraint data location in Product model.–	Location of constraint advice data.

Drawing A.2.3.1.2.

Inputs.

Constraint data location in Product model.–	Location of constraint advice data.

Constraints.

Advice data.–	Details of remedial advice contained in functional constraints

Outputs.

Functional decision support data.–	Textual advice, details of recommended values that must be calculated, and in relation to which feature parameters.

Drawing A.2.3.2.1.

Inputs.

Manufacturability assessment.–	Conformance condition of new feature parameter(s) to be associated with a response.

Constraints.

Injection moulding constraint data.–	A knowledge of the location of manufacturing constraints data.

Outputs.

Constraint data location in Manufacturing model.–	Location of constraint advice data.

Drawing A.2.3.2.2.

Inputs.

Constraint data location in Manufacturing model.–	Location of constraint advice data.

Constraints.

Advice data.–	Details of remedial advice contained in manufacturing constraints

Outputs.

Manufacturing decision support data.–	Textual advice, details of recommended values that must be calculated, and in relation to which feature

parameters.

Drawing A.2.3.3.1.

Inputs.

Manufacturing decision support data.–
Need calculation of recommended values.– Details of recommended values that must be calculated

Functional decision support data.–
Need calculation of recommended values.– Details of recommended values that must be calculated

Constraints.

Functional constraint data.–
Processing instructions.– How to define the necessary calculations.

Injection moulding constraint data.–
Processing instructions.– How to define the necessary calculations.

Outputs.

Calculations required.– Expressions to be solved.

Drawing A.2.3.3.2.

Inputs.

Calculations required.– Expressions to be solved.

Design and manufacture data.– Materials performance, choice, price etc, manufacturing process performance, capabilities, details of existing functional and manufacturing representation, (ie surrounding geometry).

Constraints.

Functional constraint data.–
Processing instructions– How to carry out calculations.

Injection moulding constraint data.–
Processing instructions.– How to carry out calculations.

Outputs.

Ideal parameter values.– Those values ideal for functionality and manufacturability.

Drawing A.2.3.4.1.

Inputs.

Functional decision support data.–
Advice data.– Details of textual advice to be given.

Manufacturing decision support data.–
Advice data.– Details of textual advice to be given.

Constraints.

Functional constraint data.–
Processing instructions– How to extract text advice.

Injection moulding constraint data.–
Processing instructions.– How to extract text advice.

Outputs.

Advice text in required form.– Advice text data ready for calculated values to be added.

Drawing A.2.3.4.2.

Inputs.

Advice text in required form.– Advice text data ready for calculated values to be added.

Ideal parameter values.– Those values ideal for functionality or manufacturability.

Constraints.

Functional constraint data.–
Processing instructions– How to add calculated values.

Injection moulding constraint data.–
Processing instructions.– How to add calculated values.

Outputs.

Complete decision support data.– Textual advice ready to be given to the designer.

Drawing A.2.3.5.1.

Inputs.

Complete decision support data.– Textual advice ready to be given to the designer.

Design decisions.– Whether to act upon or ignore advice from the strategist– Whether to accept recommended values or put in new parameters/indicate to keep existing parameters.

Constraints.

Functional constraint data.–
Processing instructions– How to display decision support data and obtain designer response.

Injection moulding constraint data.–
Processing instructions.– How to display decision support data and obtain

	designer response.

Outputs.

Designer response to advice.–	Confirmation to continue by the designer if functionality and manufacturability okay, or if advice given is to be ignored. Else a desire to change feature parameters.

Drawing A.2.3.5.2.

Inputs.

Designer response to advice.– Functionality and manufacturability okay/ designer ignores advice.–	Indication to continue with feature parameters unchanged

Constraints.

Functional constraint data.– Processing instructions–	How to confirm feature parameters.
Injection moulding constraint data.– Processing instructions.–	How to confirm feature parameters.

Outputs.

Update Product model.–	Details of new features to be added to the product representation.

Drawing A.2.3.5.3.

Inputs.

Designer response to advice.– Designer response = change parameters.–	Request to change given parameters.
Design decisions.– New feature parameters.–	New parameters to replace those violating constraints.

Constraints.

Functional constraint data.– Processing instructions–	How to get new feature parameters.
Injection moulding constraint data.– Processing instructions.–	How to get new feature parameters.

Outputs.

Modify product representation due to feedback advice.	Change feature parameters.

Drawing PD2.

Inputs.

Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould design.

Constraints.

Mould design knowledge –	Knowledge on how to create a mould representation, mould design constraints data.
Injection moulding machine knowledge –	Knowledge of machine constraints.

Outputs.

Update Product model –	Details of mould features to be added to the Product model representation.
Modify product representation due to feedback advice –	Change feature parameters on product due to mould design considerations.

Drawing B.1.

Inputs.

Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould cavity/core design.

Constraints.

Mould design knowledge –	Knowledge on how to create a mould representation, mould design constraints data.
Injection moulding machine knowledge –	Knowledge of machine constraints.

Outputs.

Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.
Modify product representation due to feedback advice –	Change feature parameters on product due to cavity design considerations.

Drawing B.1.1.

Inputs.

Product representation – Product geometry.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line – Details of parting line.

Drawing B.1.2.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cavity design.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity design considerations.

Drawing B.1.3.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould core design.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Main core geometry – Details of main core features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to core design considerations.

Drawing B.1.4.

Inputs.

Parting line – Details of parting line.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cavity/core design.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Local insert geometry – Details of local insert features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity/core design considerations.

Drawing B.1.5.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Require split mould– Require split mould due to configuration of main cavity/core geometry or local inserts.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Vertical split line– Details of vertical split line.

Drawing B.1.1.1.

Inputs.

Product representation – Product geometry.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Widest part of product – Details of appropriate place(s) for parting line on the product.

Drawing B.1.1.2.

Inputs.

Widest part of product – Details of appropriate place(s) for parting line on the product.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line position– Chosen position of parting line.

Drawing B.1.1.3.

Inputs.

Parting line position– Chosen position of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line – Details of parting line.

Drawing B.1.2.1.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volume parameters – Change cavity volume parameters due to cavity design decisions.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Drawing B.1.2.2.

Inputs.

Parting line – Details of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Evalaute as furthest next– Replace furthest volume from parting line with next furthest (Repeat until no more volumes).

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Furthest volume parameters –	Identity and parameters of volume currently being considered as furthest from parting line.

Drawing B.1.2.3.

Inputs.

Furthest volume –	Identity and parameters of volume currently being considered as furthest from parting line.
Parting line –	Details of parting line.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Cavity volumes and parameters –	Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Next furthest –	Identity and parameters of volume currently being considered as next furthest from parting line.

Drawing B.1.2.4.

Inputs.

Furthest volume –	Identity and parameters of volume currently being considered as furthest from parting line.
Next furthest –	Identity and parameters of volume currently being considered as next furthest from parting line.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Cavity volumes and parameters –	Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.
Design decisions.–	Decisions on mould cavity volume parameters.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity volume parameters –	Parameters of cavity volumes after cavity design considerations.
Modify product representation due to feedback advice –	Change feature parameters on product due to cavity design considerations.

Drawing B.1.2.5.

Inputs.

Cavity volume parameters –	Parameters of cavity volumes after cavity design considerations.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Cavity volumes and parameters –	Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.
Design decisions.–	Decisions on mould cavity blend parameters.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity blends –	Parameters and identity of cavity blendss after cavity design considerations.
Modify product representation due to feedback advice –	Change feature parameters on product due to cavity design considerations.

Drawing B.1.2.6.

Inputs.

Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Cavity volumes and parameters –	Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.
Design decisions.–	Decisions on mould cavity taper parameters.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity tapers –	Parameters and identity of cavity tapers after cavity design considerations.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity design considerations.

Drawing B.1.3.1.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volume parameters – Change core volume parameters due to core design decisions.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Drawing B.1.3.2.

Inputs.

Parting line – Details of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Evaluate as furthest next – Replace furthest volume from parting line with next furthest (Repeat until no more volumes).

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Drawing B.1.3.3.

Inputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Parting line – Details of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

Drawing B.1.3.4.

Inputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Design decisions.– Decisions on mould core volume parameters.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core volume parameters – Parameters of core volumes after core design considerations.

Modify product representation due to feedback advice – Change feature parameters on product due to core design considerations.

Drawing B.1.3.5.

Inputs.

Core volume parameters –	Parameters of core volumes after core design considerations.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Core volumes and parameters –	Details of translation from mouldability to core features prior to consideration of core design constraints.
Design decisions.–	Decisions on mould core blend parameters.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core blends –	Parameters and identity of core blendss after core design considerations.
Modify product representation due to feedback advice –	Change feature parameters on product due to core design considerations.

Drawing B.1.3.6.

Inputs.

Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Core volumes and parameters –	Details of translation from mouldability to core features prior to consideration of core design constraints.
Design decisions.–	Decisions on mould core taper parameters.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core tapers –	Parameters and identity of core tapers after core design considerations.
Modify product representation due to feedback advice –	Change feature parameters on product due to core design considerations.

Drawing B.1.4.1.

Inputs.

Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Protrusion features type, parameters –	Identity of protrusions to be converted into local inserts and their parameters.

Drawing B.1.4.2.

Inputs.

Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Hole features type, parameters –	Identity of holes to be converted into local inserts and their parameters.

Drawing B.1.4.3.

Inputs.

Protrusion features type, parameters –	Identity of protrusions to be converted into local inserts and their parameters.
Hole features type, parameters –	Identity of holes to be converted into local inserts and their parameters.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Main cavity geometry –	Details of main cavity features to be added to the Product model representation.
Main core geometry –	Details of main core features to be added to the Product model representation.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Which cavity and/or core features to create –	Translation to cavity or core and type of cavity or core feature to create.

Drawing B.1.4.4.

Inputs.

Design decisions –	Decisions on local insert parameters.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Which cavity features to create –	Type of cavity local inserts to create.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity local inserts type, configuration –	Cavity local insert(s) type and parameters to be added to the Product model.
Modify product representation due to feedback advice –	Change feature parameters on product due to local insert design considerations.

Drawing B.1.4.5.

Inputs.

Design decisions –	Decisions on local insert parameters.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Which cavity features to create –	Type of core local inserts to create.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core local inserts type, configuration –	Core local insert(s) type and parameters to be added to the Product model.
Modify product representation due to feedback advice –	Change feature parameters on product due to local insert design considerations.

Drawing B.1.5.1.

Inputs.

Require split mould-	Require split mould due to configuration of main cavity/core geometry or local inserts.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Product representation –	Product geometry and mouldability representation.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Widest part of product –	Position where parting line should be created.

Drawing B.1.5.2.

Inputs.

Widest part of product – Require split mould-	Position where parting line should be created. Require split mould due to configuration of main cavity/core geometry or local inserts.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Vertical split line –	Details of vertical split line to be added to Product model representation.

Drawing B.2.

Inputs.

Product representation. –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould feeding system design.
Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Outputs.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to feeding system design considerations.

Drawing B.2.1.

Inputs.

Product representation. – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould gating system design.

Cavity/core geometry – Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Gate type, position, geometry – Details of gating system features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to gating system design considerations.

Drawing B.2.2.

Inputs.

Gate type, position, geometry – Details of gating system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould gating system design.

Cavity/core geometry – Details of cavity/core features to be added to the Product model representation.

Product representation. – Product geometry and mouldability representation.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Runner type, position, geometry – Details of runner system features to be added to the Product model representation.

Drawing B.2.3.

Inputs.

Gate type, position, geometry – Details of gating system features to be added to the Product model representation.

Runner type, position, geometry – Details of runner system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould gating system design.

Cavity/core geometry – Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Main sprue configuration – Details of main sprue features to be added to the Product model representation.

Drawing B.2.1.1.

Inputs.

Product representation. – Product geometry and mouldability representation.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Gate type – Type of gating system features to be added to the Product model representation.

Drawing B.2.1.2.

Inputs.

Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould gating system design.
Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge –	Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Gate position –	Position of gating system features to be added to the Product model representation.

Drawing B.2.1.3.

Inputs.

Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould gating system design.
Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge –	Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Gate geometry –	Geometry of gating system features to be added to the Product model representation.

Drawing B.2.2.1.

Inputs.

Gate type, position, geometry –	Details of gating system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Feeding system design knowledge –	Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Runner type –	Type of runner system features to be added to the Product model representation.

Drawing B.2.2.2.

Inputs.

Gate type, position, geometry –	Details of gating system features to be added to the Product model representation.
Runner type –	Type of runner system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge –	Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Runner position –	Position of runner system features to be added to the Product model representation.

Drawing B.2.2.3.

Inputs.

Runner type –	Type of runner system features to be added to the Product model representation.
Runner position –	Position of runner system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould gating system design.
Cavity/core geometry –	Details of cavity/core features to be added to the Product model representation.
Product representation. –	Product geometry and mouldability representation.

Constraints.

Feeding system design knowledge –	Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Runner geometry – Geometry of runner system features to be added to the Product model representation.

Drawing B.2.3.1.

Inputs.

Gate type, position, geometry – Details of gating system features to be added to the Product model representation.

Runner system configuration – Details of runner system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Main sprue position – Position of main sprue features to be added to the Product model representation.

Drawing B.2.3.2.

Inputs.

Main sprue position – Position of main sprue features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould gating system design.

Cavity/core geometry – Details of cavity/core features to be added to the Product model representation.

Constraints.

Feeding system design knowledge – Knowledge on how to create a feeding system representation, feeding system constraints data.

Outputs.

Main sprue geometry – Geometry of main sprue features to be added to the Product model representation.

Drawing B.3.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cooling system design.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Outputs.

Cooling system geometry – Details of cooling system features to be added to the Product model representation.

Drawing B.3.1.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cooling system design.

Constraints.

Cooling system design knowledge – Knowledge on how to create a cooling system representation, cooling system constraints data.

Outputs.

Cooling system configuration – Configuration of cooling system to be added to the Product model representation.

Drawing B.3.2.

Inputs.

Cooling system configuration – Configuration of cooling system to be added to the Product model representation.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cooling system design.

Constraints.

Cooling system design knowledge – Knowledge on how to create a coling system representation, cooling system constraints data.

Outputs.

Maximum cooling effect – Position and orientation of cooling system features to provide maximum, non–directional cooling.

Drawing B.3.3.

Inputs.

Cooling system configuration – Configuration of cooling system to be added to the Product model representation.

Maximum cooling effect – Position and orientation of cooling system features to provide maximum, non–directional cooling.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cooling system design knowledge – Knowledge on how to create a cooling system representation, cooling system constraints data.

Outputs.

Cooling system geometry – Details of cooling system features to be added to the Product model representation.

Drawing B.4.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Cooling system geometry – Details of cooling system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Product representation. – Product geometry and mouldability representation.

Design decisions.– Decisions on mould ejection system design.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Outputs.

Ejection system geometry – Geometry of ejection system features to be added to the Product model representation.

Drawing B.4.1.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Product representation. – Product geometry and mouldability representation.

Constraints.

Ejection system design knowledge – Knowledge on how to create an ejection system representation, ejection system constraints data.

Outputs.

Ejection positions – Position of ejection system features to be added to the Product model representation.

Drawing B.4.2.

Inputs.

Ejection positions – Position of ejection system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Product representation. – Product geometry and mouldability representation.

Design decisions.– Decisions on mould ejection system design.

Constraints.

Ejection system design knowledge – Knowledge on how to create an ejection system representation, ejection system constraints data.

Outputs.

Ejection system type – Type of ejection system to be added to the Product model representation.

Drawing B.4.3.

Inputs.

Ejection system type – Type of ejection system to be added to the Product model representation.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Cooling system geometry – Details of cooling system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould ejection system design.

Constraints.

Ejection system design knowledge – Knowledge on how to create an ejection system representation, ejection system constraints data.

Outputs.

Ejection system configuration – Configuration of ejection system to be added to the Product model representation.

Drawing B.5.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Cooling system geometry – Details of cooling system features to be added to the Product model representation.

Ejection system geometry – Details of ejection system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould plate design.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Outputs.

Mould plate geometry – Details of mould plate features to be added to the Product model representation.

Drawing B.5.1.

Inputs.

Cavity/core geometry. – Details of cavity/core features to be added to the Product model representation.

Feeding system geometry – Details of feeding system features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Mould plate design knowledge – Knowledge on how to create a mould plate representation, mould plate constraints data.

Outputs.

Inner land dimensions – Details of inner land features to be added to the Product model representation.

Drawing B.5.2.

Inputs.

Inner land dimensions – Details of inner land features to be added to the Product model representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Mould plate design knowledge – Knowledge on how to create a mould plate representation, mould plate constraints data.

Outputs.

Peripheral lands size and location – Details of peripheral land features to be added to the Product model representation.

Drawing B.5.3.

Inputs.

Inner land dimensions –	Details of inner land features to be added to the Product model representation.
Peripheral lands size and location –	Details of peripheral land features to be added to the Product model representation.
Cavity/core geometry. –	Details of cavity/core features to be added to the Product model representation.
Cooling system geometry –	Details of cooling system features to be added to the Product model representation.
Ejection system geometry –	Details of ejection system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould plate geometry.

Constraints.

Mould plate design knowledge –	Knowledge on how to create a mould plate representation, mould plate constraints data.

Outputs.

Mould block size, shape –	Details of mould block geometry to be added to the Product model representation.

Drawing B.5.4.

Inputs.

Mould block size, shape –	Details of mould block geometry to be added to the Product model representation.
Cavity/core geometry. –	Details of cavity/core features to be added to the Product model representation.
Feeding system geometry –	Details of feeding system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Mould plate design knowledge –	Knowledge on how to create a mould plate representation, mould plate constraints data.

Outputs.

Backing plate size, shape –	Details of backing plate geometry to be added to the Product model representation.

Drawing B.5.5.

Inputs.

Mould block size, shape –	Details of mould block geometry to be added to the Product model representation.
Feeding system geometry –	Details of feeding system features to be added to the Product model representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Mould plate design knowledge –	Knowledge on how to create a mould plate representation, mould plate constraints data.

Outputs.

Nozzle recess size, shape –	Details of nozzle recess geometry to be added to the Product model representation.

Appendix 2.

Modifications to IDEF0 representation due to translation requirements of concurrency.

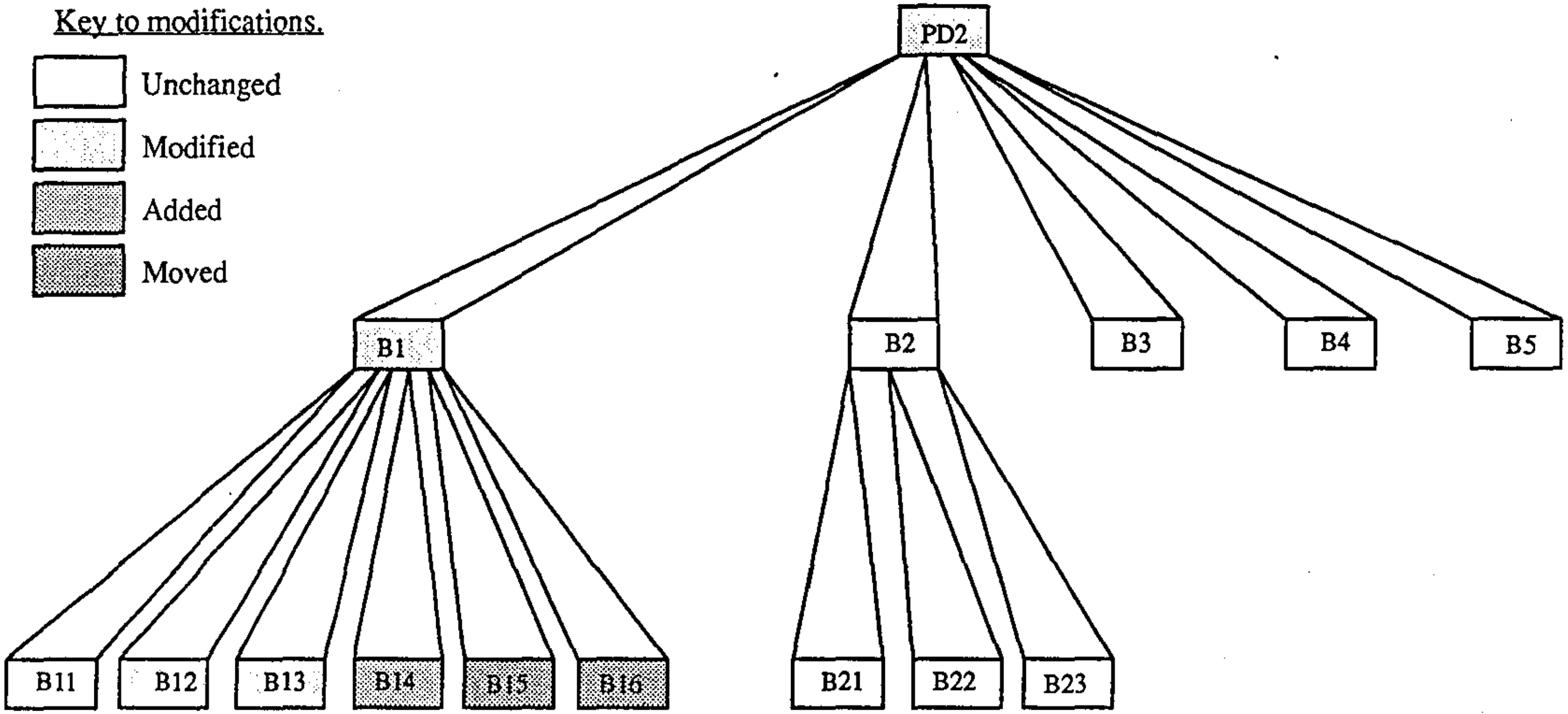
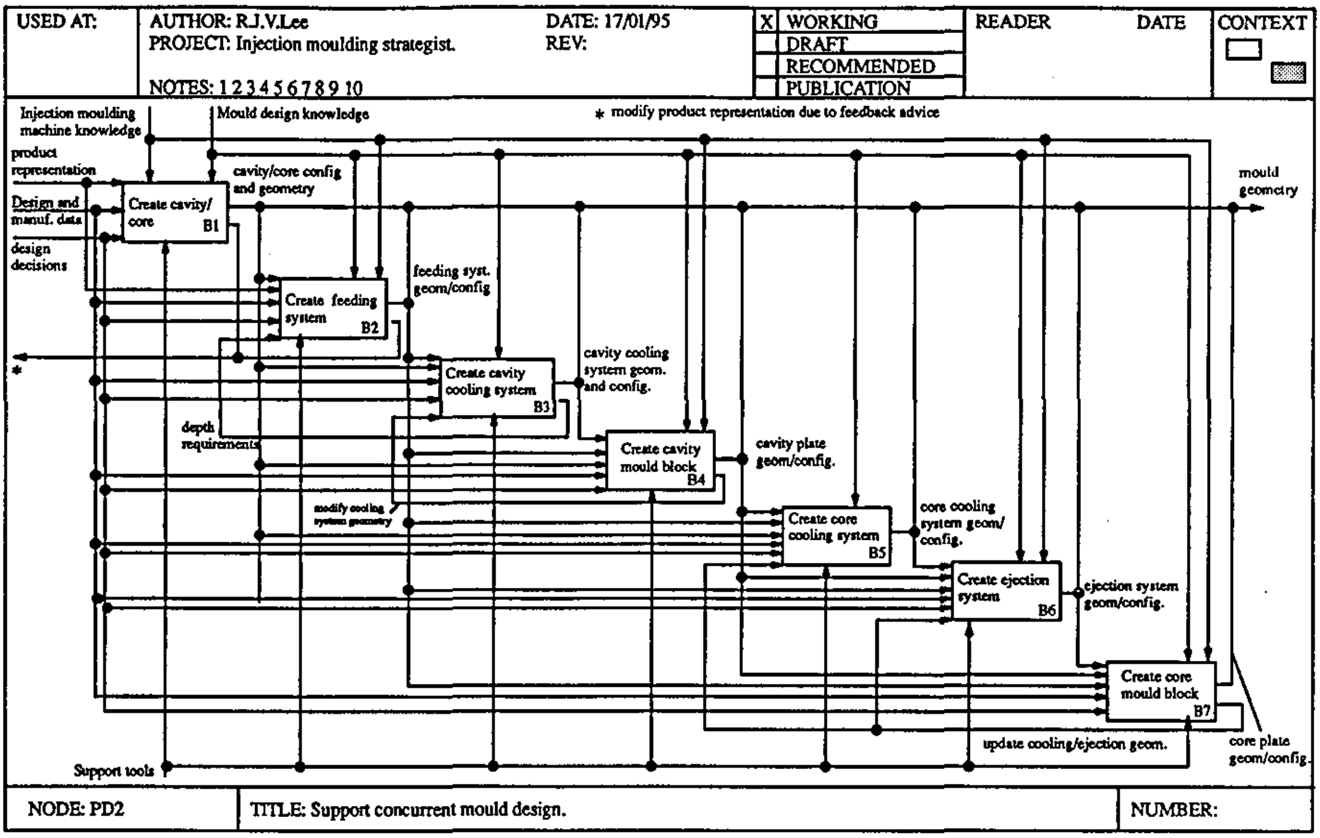
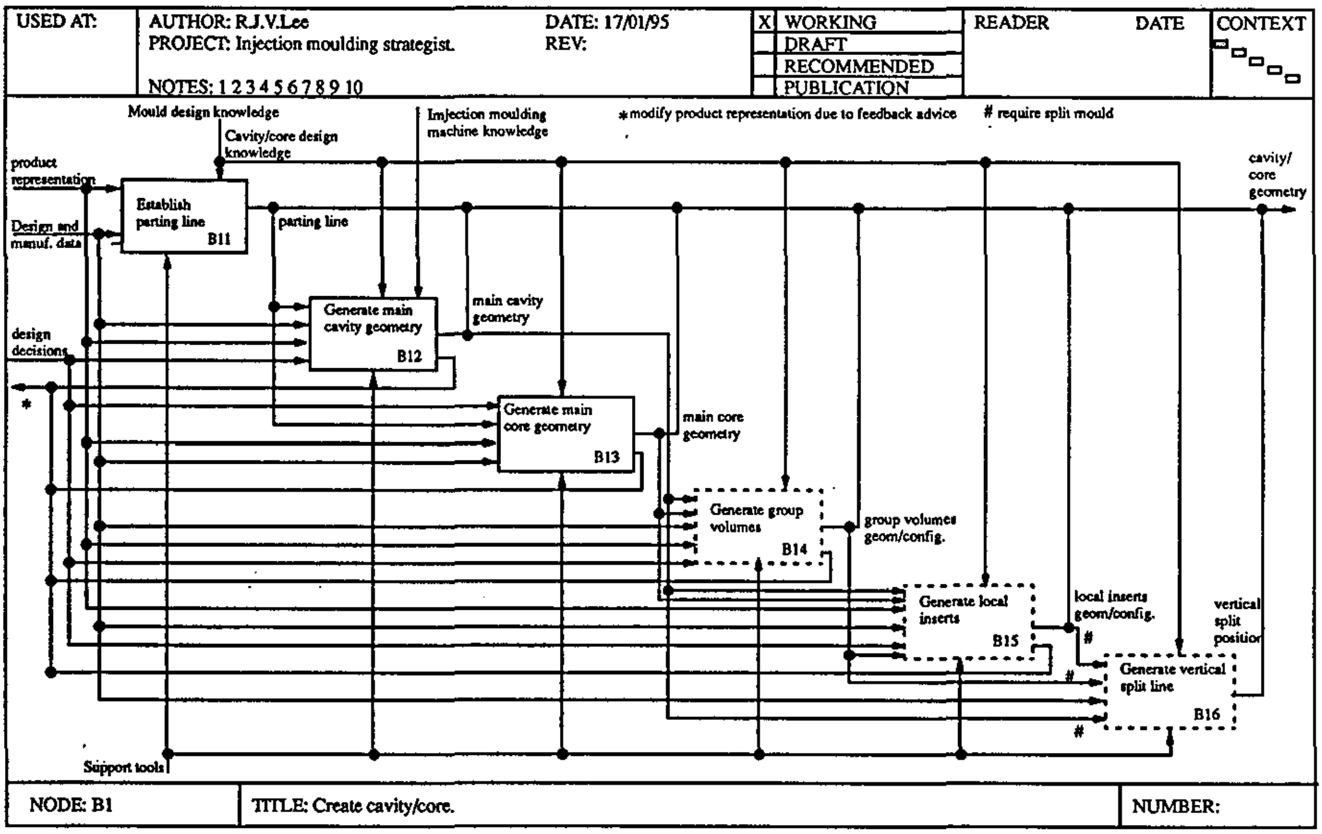
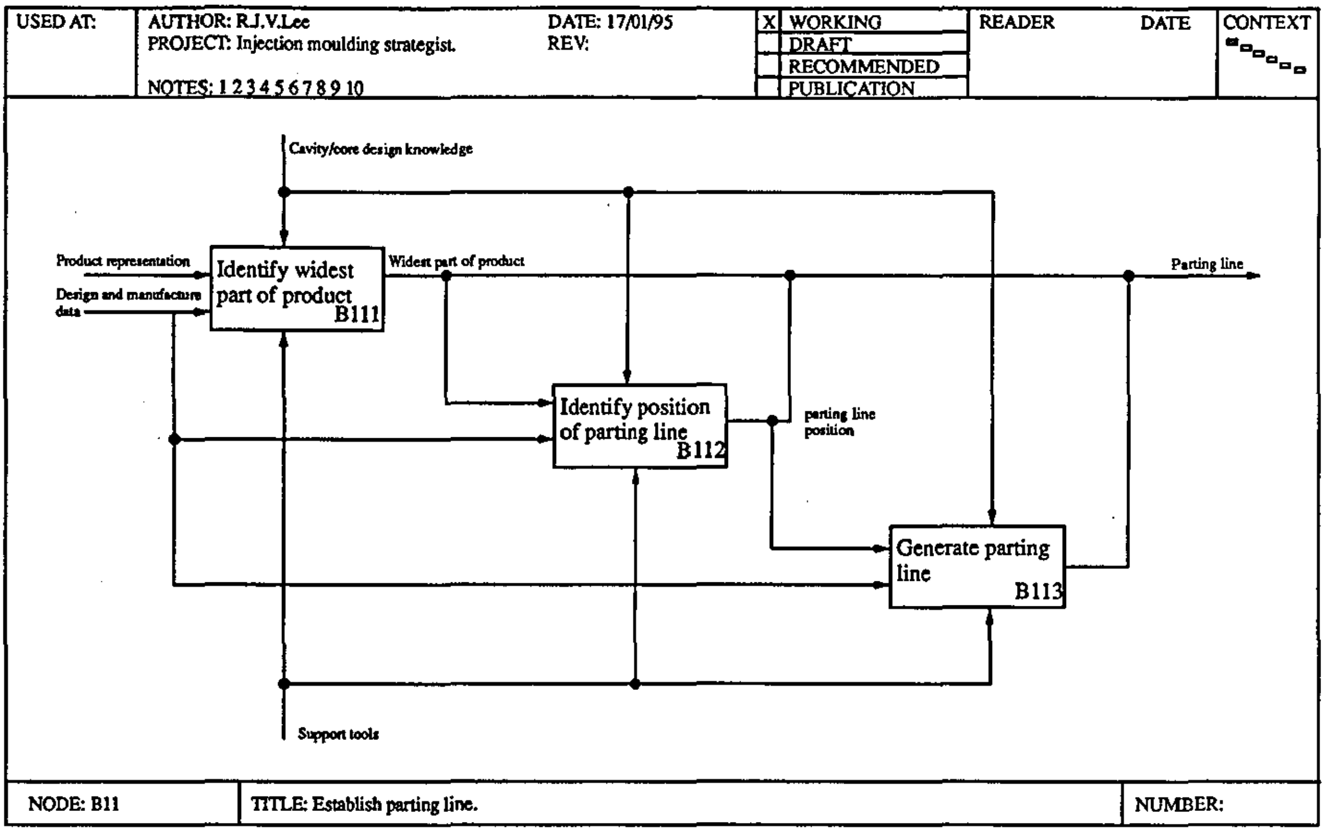
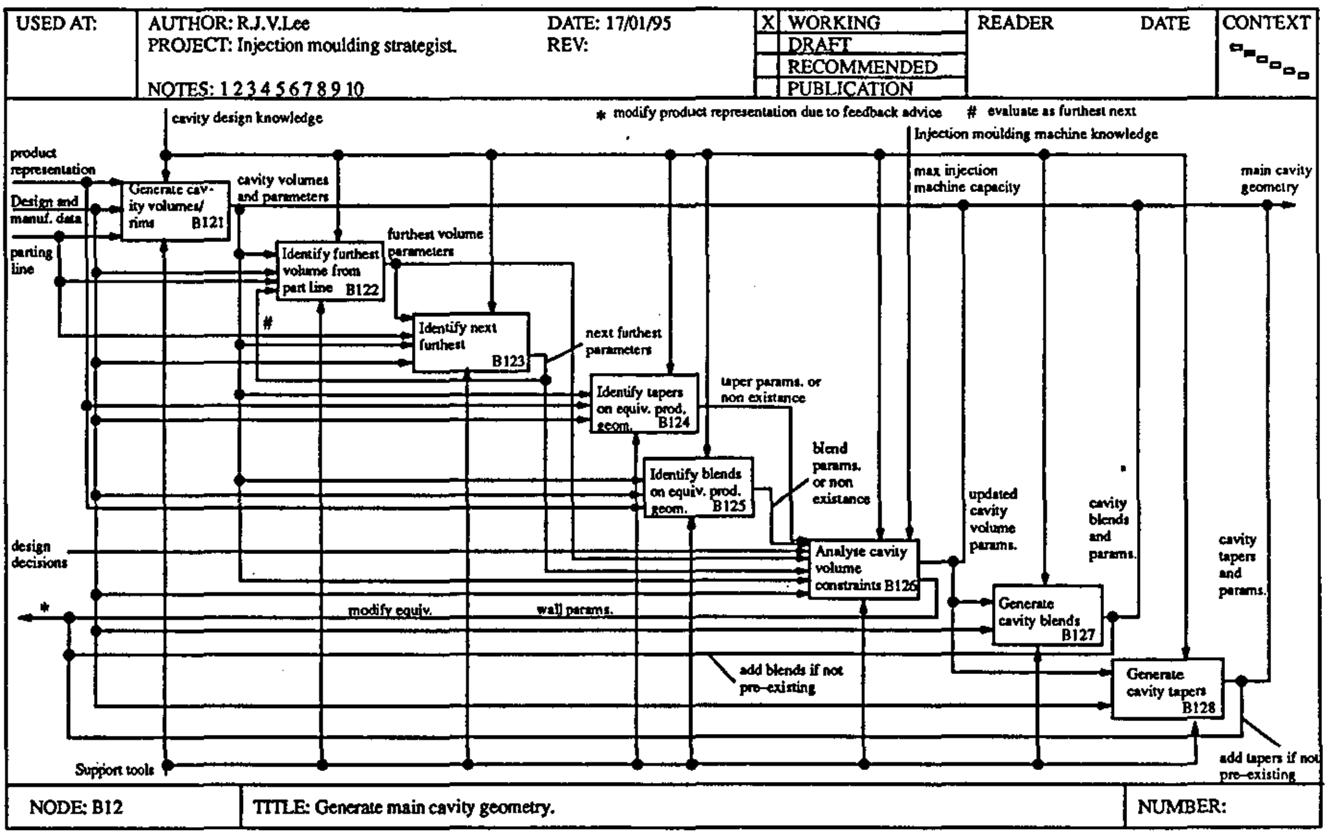


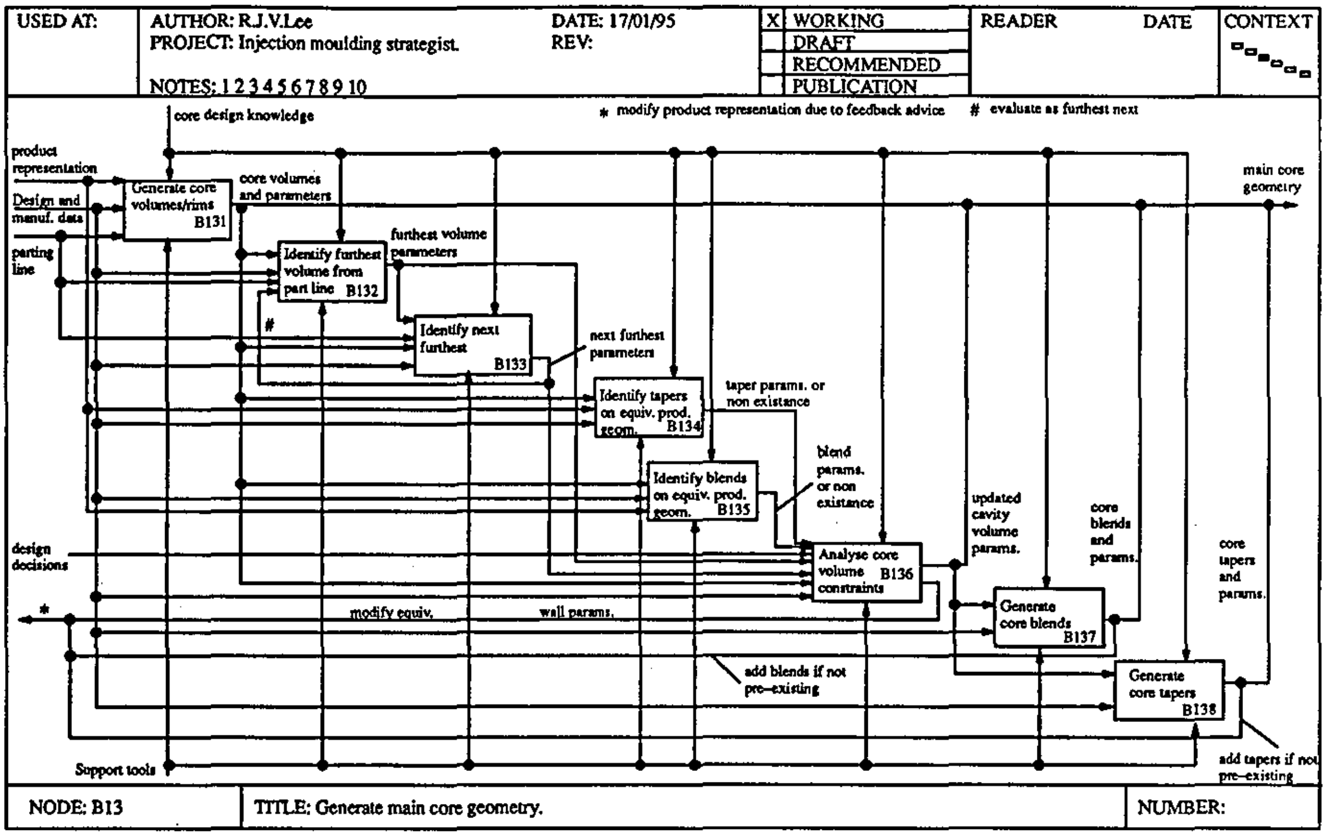
Figure A2.1 – IDEF0 model from PD2 down. Support concurrent mould design

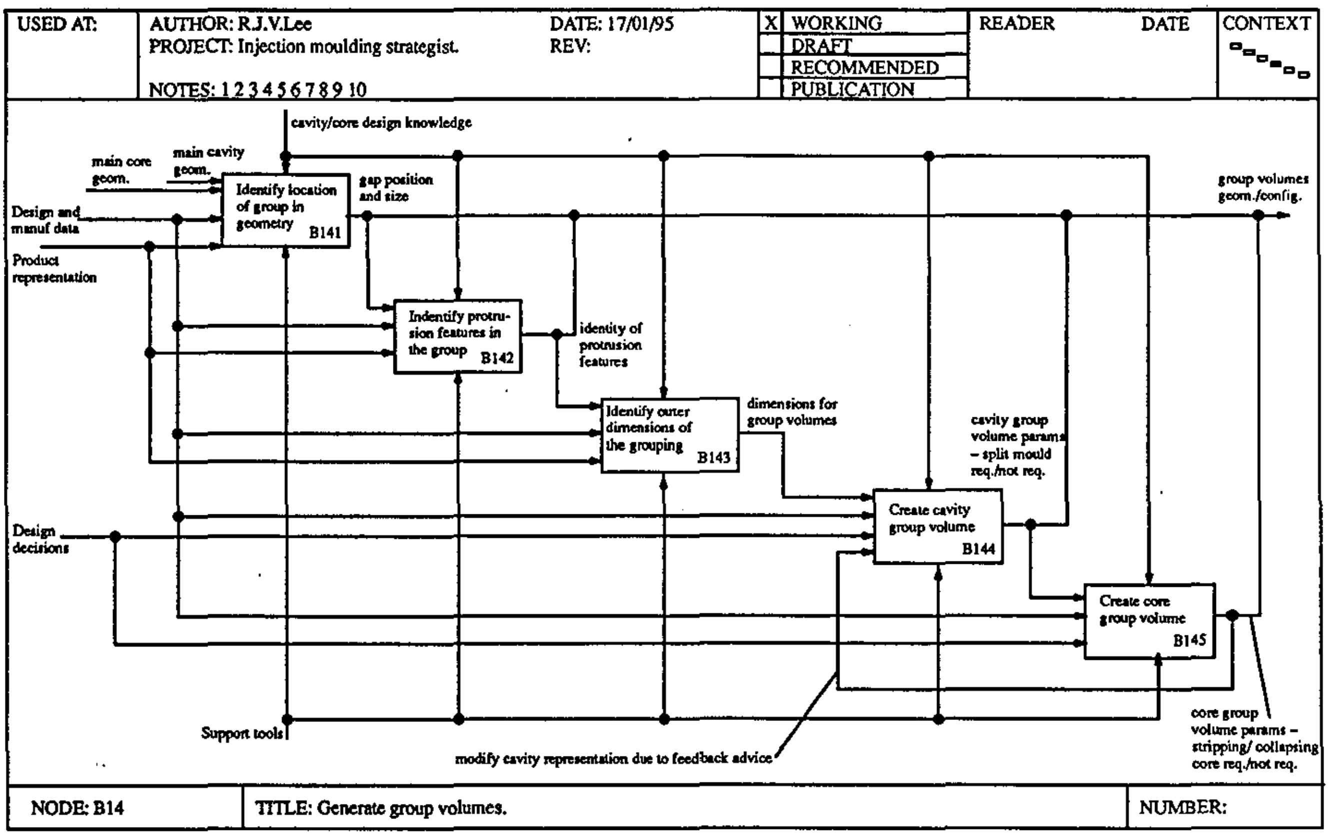

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Injection moulding machine knowledge
Mould design knowledge
* modify product representation due to feedback advice
product representation
Design and manuf. data
design decisions
cavity/core config and geometry
Create cavity/core B1
Create feeding system B2
feeding syst. geom/config
Create cavity cooling system B3
cavity cooling system geom. and config.
depth requirements
Create cavity mould block B4
cavity plate geom/config.
modify cooling system geometry
Create core cooling system B5
core cooling system geom/config.
Create ejection system B6
ejection system geom/config.
Create core mould block B7
mould geometry
update cooling/ejection geom.
core plate geom/config.
Support tools
NODE: PD2
TITLE: Support concurrent mould design.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Mould design knowledge
Cavity/core design knowledge
Injection moulding machine knowledge
* modify product representation due to feedback advice
# require split mould
product representation
Design and manuf. data
design decisions
Establish parting line B11
parting line
Generate main cavity geometry B12
main cavity geometry
Generate main core geometry B13
main core geometry
Generate group volumes B14
group volumes geom/config.
Generate local inserts B15
local inserts geom/config.
Generate vertical split line B16
vertical split position
cavity/core geometry
Support tools
NODE: B1
TITLE: Create cavity/core.
NUMBER:

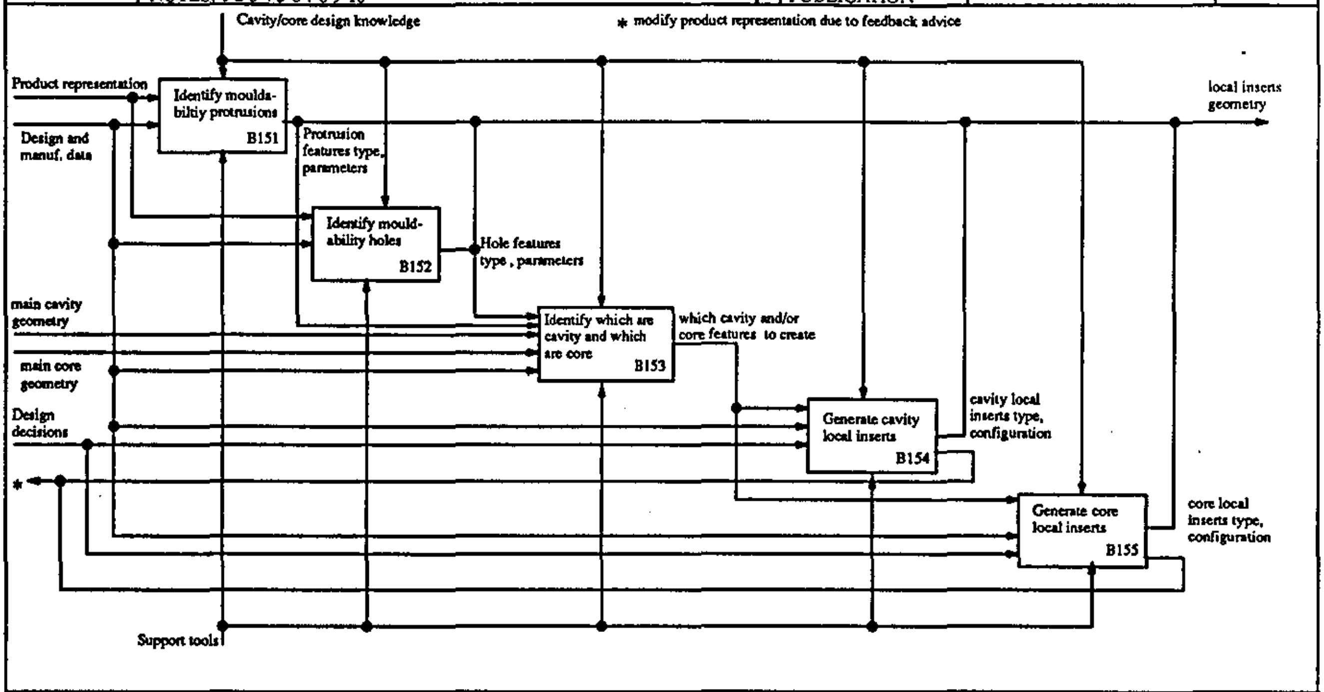

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
Cavity/core design knowledge
Product representation
Design and manufacture data
Identify widest part of product B111
Widest part of product
Parting line
Identify position of parting line B112
parting line position
Generate parting line B113
Support tools
NODE: B11
TITLE: Establish parting line.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
cavity design knowledge
* modify product representation due to feedback advice
# evaluate as furthest next
Injection moulding machine knowledge
product representation
Design and manuf. data
parting line
Generate cavity volumes/ rims B121
cavity volumes and parameters
Identify furthest volume from part line B122
furthest volume parameters
#
Identify next furthest B123
next furthest parameters
Identify tapers on equiv. prod. geom. B124
taper params. or non existance
Identify blends on equiv. prod. geom. B125
blend params. or non existance
max injection machine capacity
main cavity geometry
design decisions
Analyse cavity volume constraints B126
updated cavity volume params.
cavity blends and params.
cavity tapers and params.
*
modify equiv. wall params.
Generate cavity blends B127
add blends if not pre-existing
Generate cavity tapers B128
add tapers if not pre-existing
Support tools
NODE: B12
TITLE: Generate main cavity geometry.
NUMBER:


USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
core design knowledge
* modify product representation due to feedback advice
# evaluate as furthest next
product representation
Design and manuf. data
parting line
Generate core volumes/rims B131
core volumes and parameters
main core geometry
Identify furthest volume from part line B132
furthest volume parameters
#
Identify next furthest B133
next furthest parameters
Identify tapers on equiv. prod. geom. B134
taper params. or non existance
Identify blends on equiv. prod. geom. B135
blend params. or non existance
updated cavity volume params.
core blends and params.
core tapers and params.
design decisions
Analyse core volume constraints B136
*
modify equiv. wall params.
Generate core blends B137
add blends if not pre-existing
Generate core tapers B138
add tapers if not pre-existing
Support tools
NODE: B13
TITLE: Generate main core geometry.
NUMBER:

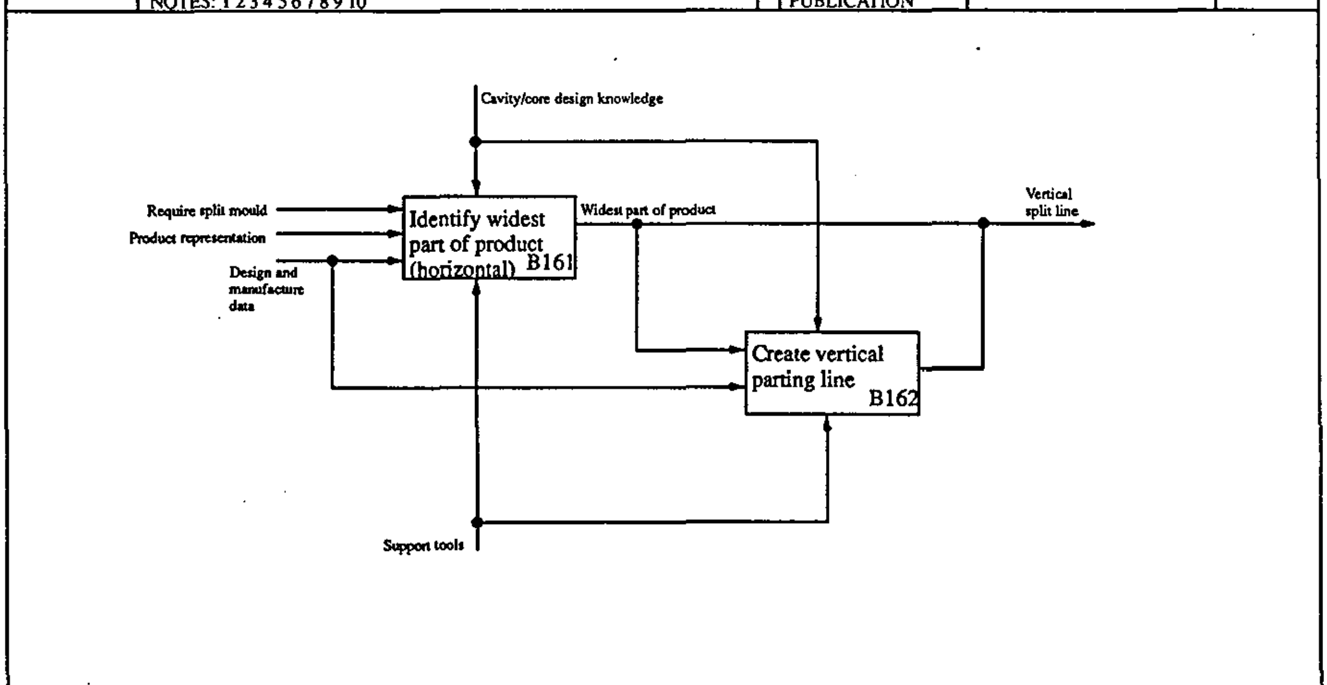

USED AT:
AUTHOR: R.J.V.Lee
PROJECT: Injection moulding strategist.
NOTES: 1 2 3 4 5 6 7 8 9 10
DATE: 17/01/95
REV:
X WORKING
DRAFT
RECOMMENDED
PUBLICATION
READER
DATE
CONTEXT
cavity/core design knowledge
main core geom.
main cavity geom.
Design and manuf data
Product representation
Identify location of group in geometry B141
gap position and size
group volumes geom./config.
Indentify protrusion features in the group B142
identity of protrusion features
Identify outer dimensions of the grouping B143
dimensions for group volumes
cavity group volume params - split mould req./not req.
Design decisions
Create cavity group volume B144
Create core group volume B145
core group volume params - stripping/ collapsing core req./not req.
Support tools
modify cavity representation due to feedback advice
NODE: B14
TITLE: Generate group volumes.
NUMBER:

USED AT: | AUTHOR: R.J.V.Lee | DATE: 17/01/95 | X WORKING | READER | DATE | CONTEXT
PROJECT: Injection moulding strategist. | REV: | DRAFT | RECOMMENDED | PUBLICATION
NOTES: 1 2 3 4 5 6 7 8 9 10



NODE: B15 | TITLE: Create local inserts. | NUMBER:

USED AT: | AUTHOR: R.J.V.Lee | DATE: 17/01/95 | X WORKING | READER | DATE | CONTEXT
PROJECT: Injection moulding strategist. | REV: | DRAFT | RECOMMENDED | PUBLICATION
NOTES: 1 2 3 4 5 6 7 8 9 10



NODE: B16 | TITLE: Generate vertical split line. | NUMBER:

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould design.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Update Product model – Details of mould features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to mould design considerations.

Drawing B.1.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cavity/core design.

Constraints.

Mould design knowledge – Knowledge on how to create a mould representation, mould design constraints data.

Outputs.

Cavity/core geometry – Details of cavity/core features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity design considerations.

Drawing B.1.1.

Inputs.

Product representation – Product geometry.

plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line – Details of parting line.

Drawing B.1.2.

Inputs:

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cavity design.

Parting line – Details of parting line.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity design considerations.

Drawing B.1.3.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould core design.

Parting line – Details of parting line.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Main core geometry – Details of main core features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to core design considerations.

Drawing B.1.4.

Inputs.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould core design.

Parting line – Details of parting line.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Group volumes geometry/config. – Details of group volume features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity/core design considerations.

Drawing B.1.5.

Inputs.

Parting line – Details of parting line.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Design decisions.– Decisions on mould cavity/core design.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Local inserts geometry/config. – Details of local insert features to be added to the Product model representation.

Modify product representation due to feedback advice – Change feature parameters on product due to cavity/core design considerations.

Drawing B.1.6.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Require split mould– Require split mould due to configuration of main cavity/core geometry or local inserts.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Vertical split line– Details of vertical split line.

Drawing B.1.1.1.

Inputs.

Product representation – Product geometry.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Widest part of product – Details of appropriate place(s) for parting line on

Drawing B.1.1.2.

Inputs.

Widest part of product – Details of appropriate place(s) for parting line on the product.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line position– Chosen position of parting line.

Drawing B.1.1.3.

Inputs.

Parting line position– Chosen position of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Parting line – Details of parting line.

Drawing B.1.2.1.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Parting line – Details of parting line.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Cavity volumes and parameters – Details of translation from mouldability to cavity

constraints.

Drawing B.1.2.2.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Evaluate as furthest next – Replace furthest volume from parting line with next furthest (Repeat until no more volumes).

Parting line – Details of parting line.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Drawing B.1.2.3.

Inputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Parting line – Details of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Parting line – Details of parting line.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

A2/10

Drawing B.1.2.4.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Product representation – Product geometry and mouldability representation.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Taper parameters or non existance – Parameters of taper associated with mouldability equivalent of cavity volume or no taper exists.

Drawing B.1.2.5.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Product representation – Product geometry and mouldability representation.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Blend parameters or non existance – Parameters of blend associated with mouldability equivalents of cavity volumes or no blend exists.

Drawing B.1.2.6.

Inputs.

Taper parameters or non existance – Parameters of taper associated with mouldability equivalent of cavity volume or no taper exists.

Blend parameters or non existance – Parameters of blend associated with mouldability equivalents of cavity volumes or no blend exists.

Furthest volume – Identity and parameters of volume currently being

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Cavity volumes and parameters – Details of translation from mouldability to cavity features prior to consideration of cavity design constraints.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Injection moulding machine knowledge – Knowledge of machine constraints.

Outputs.

Udpated cavity volume paramters– after – Parameters of volume and associated blend and taper cavity design considerations.

Drawing B.1.2.7.

Inputs.

Udpated cavity volume paramters– after – Parameters of volume and associated blend and taper cavity design considerations.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Cavity blends and parameters– Identity of new cavity blend and parameters.

Drawing B.1.2.8.

Inputs.

Udpated cavity volume paramters– after – Parameters of volume and associated blend and taper cavity design considerations.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

A2/11

Cavity design knowledge – Knowledge on how to create a cavity representation, cavity design constraints data.

Outputs.

Cavity tapers and parameters– Identity of new cavity taper and parameters.

Drawing B.1.3.1.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Parting line – Details of parting line.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Cavity volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Drawing B.1.3.2.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Evaluate as furthest next – Replace furthest volume from parting line with next furthest (Repeat until no more volumes).

Parting line – Details of parting line.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Inputs.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Parting line – Details of parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Parting line – Details of parting line.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

Drawing B.1.3.4.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Product representation – Product geometry and mouldability representation.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Taper parameters or non existance – Parameters of taper associated with mouldability equivalent of core volume or no taper exists.

Drawing B.1.3.5.

Inputs.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Product representation – Product geometry and mouldability representation.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Blend parameters or non existance – Parameters of blend associated with mouldability equivalents of core volumes or no blend exists.

Drawing B.1.3.6.

Inputs.

Taper parameters or non existance – Parameters of taper associated with mouldability equivalent of core volume or no taper exists.

Blend parameters or non existance – Parameters of blend associated with mouldability equivalents of core volumes or no blend exists.

Furthest volume – Identity and parameters of volume currently being considered as furthest from parting line.

Next furthest – Identity and parameters of volume currently being considered as next furthest from parting line.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Core volumes and parameters – Details of translation from mouldability to core features prior to consideration of core design constraints.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Udpated core volume paramters– after – Parameters of volume and associated blend and taper core design considerations.

Drawing B.1.3.7.

Inputs.

Udpated core volume paramters– after – Parameters of volume and associated blend and taper core design considerations.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Core blends and parameters– Identity of new core blend and parameters.

Drawing B.1.3.8.

Inputs.

Udpated core volume paramters– after – Parameters of volume and associated blend and taper core design considerations.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Core design knowledge – Knowledge on how to create a core representation, core design constraints data.

Outputs.

Core tapers and parameters– Identity of new core taper and parameters.

Drawing B.1.4.1.

Inputs.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Gap position and size– Location of gap and width in draw direction.

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Inputs.

Gap position and size–	Location of gap and width in draw direction.
Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Identity of protrusion features–	Protrusion features that lie within the gap.

Drawing B.1.4.3.

Inputs.

Identity of protrusion features–	Protrusion features that lie within the gap.
Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Dimensions for group volume– group of	Size of a group volume based on dimensions of a protrusions within a gap.

Drawing B.1.4.4.

Inputs.

Dimensions for group volume– group of	Size of a group volume based on dimensions of a protrusions within a gap.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould cavity/core design.
Modify cavity representation due to feedback advice –	Group volume parameters due to mould design considerations.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity group volume parameters, split mould required/not required –	Parameters of group volume after mould design considerations, eventual size does/does not require split mould.

Drawing B.1.4.5.

Inputs.

Dimensions for group volume– group of	Size of a group volume based on dimensions of a protrusions within a gap.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.
Design decisions.–	Decisions on mould cavity/core design.
Modify cavity representation due to feedback advice –	Group volume parameters due to mould design considerations.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core group volume parameters, stripping/ collapsing core required/not required –	Parameters of group volume after mould design considerations, eventual size does/does not require stripping/ collapsing core.

Drawing B.1.5.1.

Inputs.

Product representation –	Product geometry and mouldability representation.
Design and Manufacture data –	Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge –	Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

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Protrusion features type, parameters – Identity of protrusions to be converted into local inserts and their parameters.

Drawing B.1.5.2.

Inputs.

Product representation – Product geometry and mouldability representation.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Hole features type, parameters – Identity of holes to be converted into local inserts and their parameters.

Drawing B.1.5.3.

Inputs.

Protrusion features type, parameters – Identity of protrusions to be converted into local inserts and their parameters.

Hole features type, parameters – Identity of holes to be converted into local inserts and their parameters.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Main cavity geometry – Details of main cavity features to be added to the Product model representation.

Main core geometry – Details of main core features to be added to the Product model representation.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Which cavity and/or core features to create – Translation to cavity or core and type of cavity or core feature to create.

Drawing B.1.5.4.

Inputs.

Design decisions – Decisions on local insert parameters.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Which cavity features to create – Type of cavity local inserts to create.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Cavity local inserts type, configuration – Cavity local insert(s) type and parameters to be added to the Product model.

Modify product representation due to feedback advice – Change feature parameters on product due to local insert design considerations.

Drawing B.1.5.5.

Inputs.

Design decisions – Decisions on local insert parameters.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Which cavity features to create – Type of core local inserts to create.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Core local inserts type, configuration – Core local insert(s) type and parameters to be added to the Product model.

Modify product representation due to feedback advice – Change feature parameters on product due to local insert design considerations.

Drawing B.1.6.1.

Inputs.

Require split mould– Require split mould due to configuration of main cavity/core geometry or local inserts.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Product representation – Product geometry and mouldability representation.

Constraints.

representation, cavity/core design constraints data.

Outputs.

Widest part of product – Position where parting line should be created.

Drawing B.1.6.2.

Inputs.

Widest part of product – Position where parting line should be created.

Require split mould– Require split mould due to configuration of main cavity/core geometry or local inserts.

Design and Manufacture data – Manufacturing process performance, capabilities, plastic materials data.

Constraints.

Cavity/core design knowledge – Knowledge on how to create a cavity/core representation, cavity/core design constraints data.

Outputs.

Vertical split line – Details of vertical split line to be added to Product model representation.

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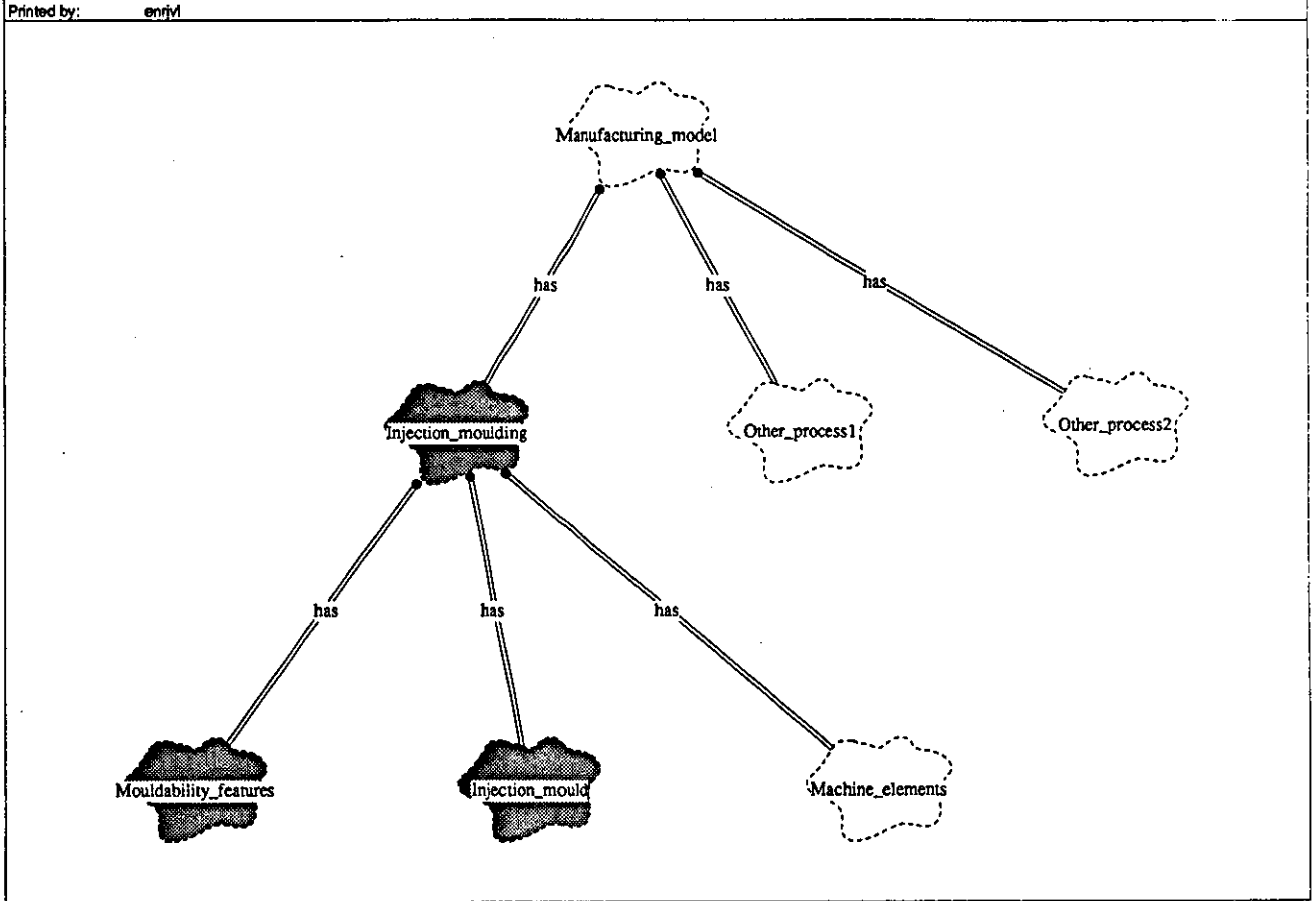
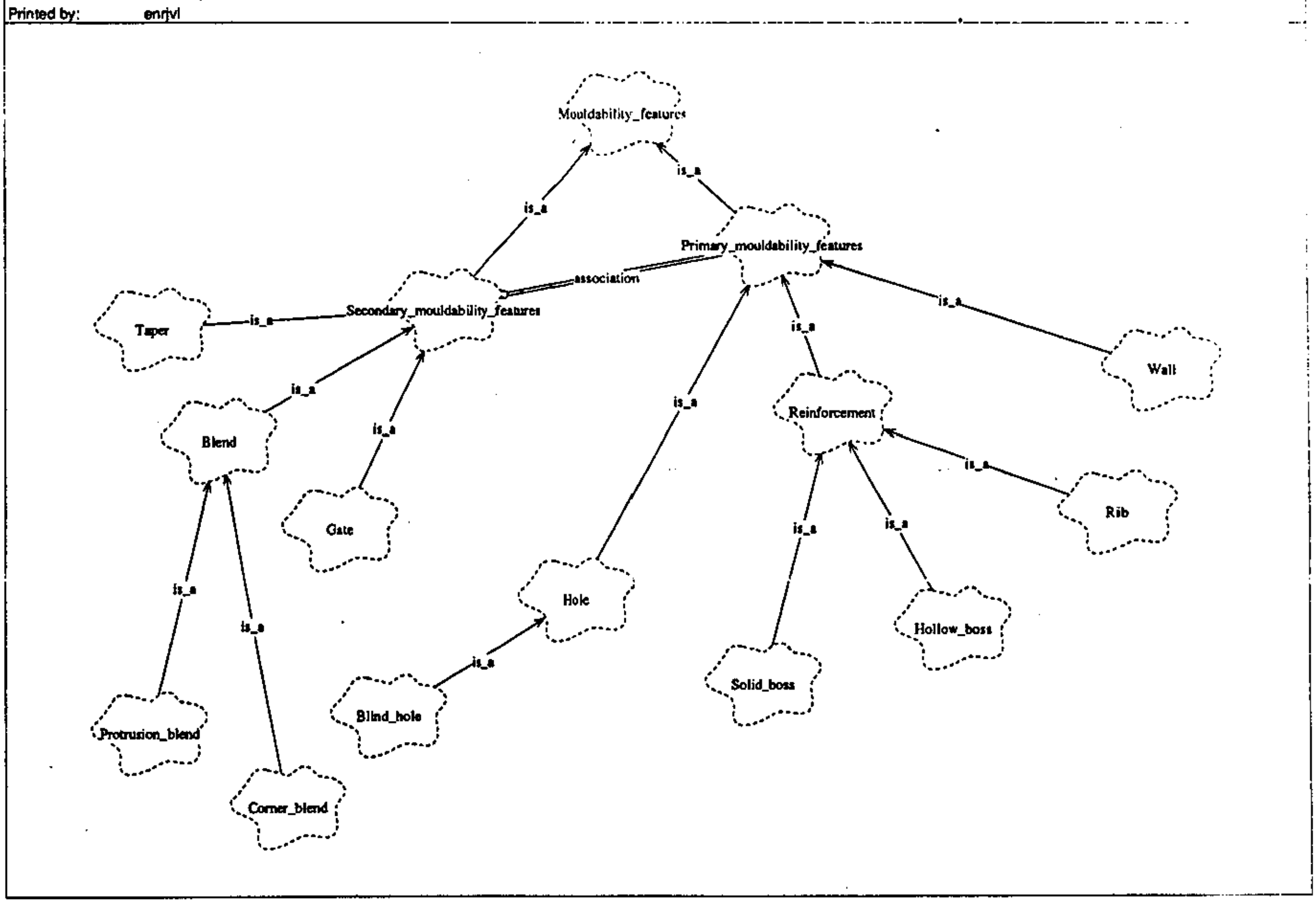
Appendix 3.

Booch representation of Manufacturing model

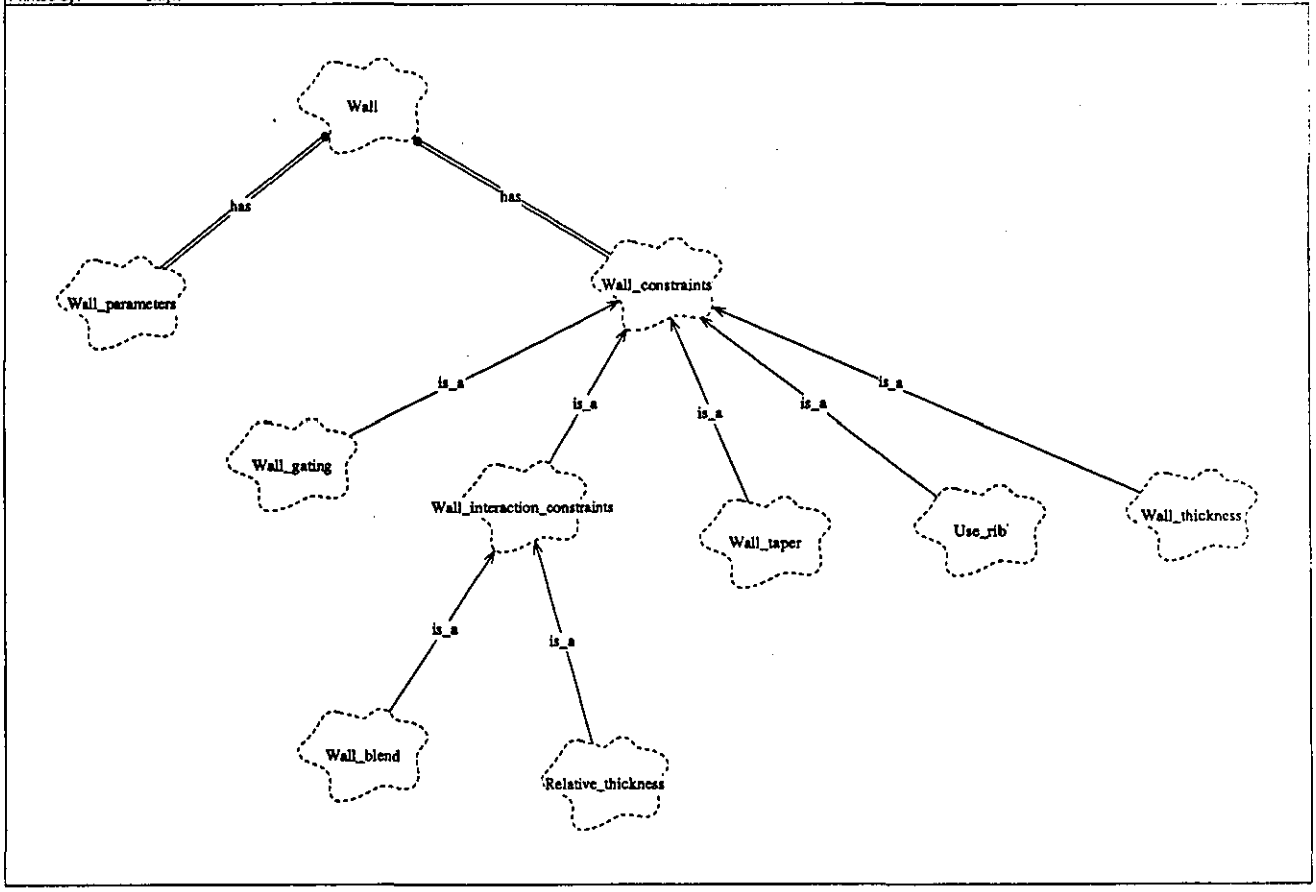
Project:	ron
Title:	Class Diagram: Manufacturing_model
Printed on:	Sunday, January 21, 1996
Printed by:	enrjvl



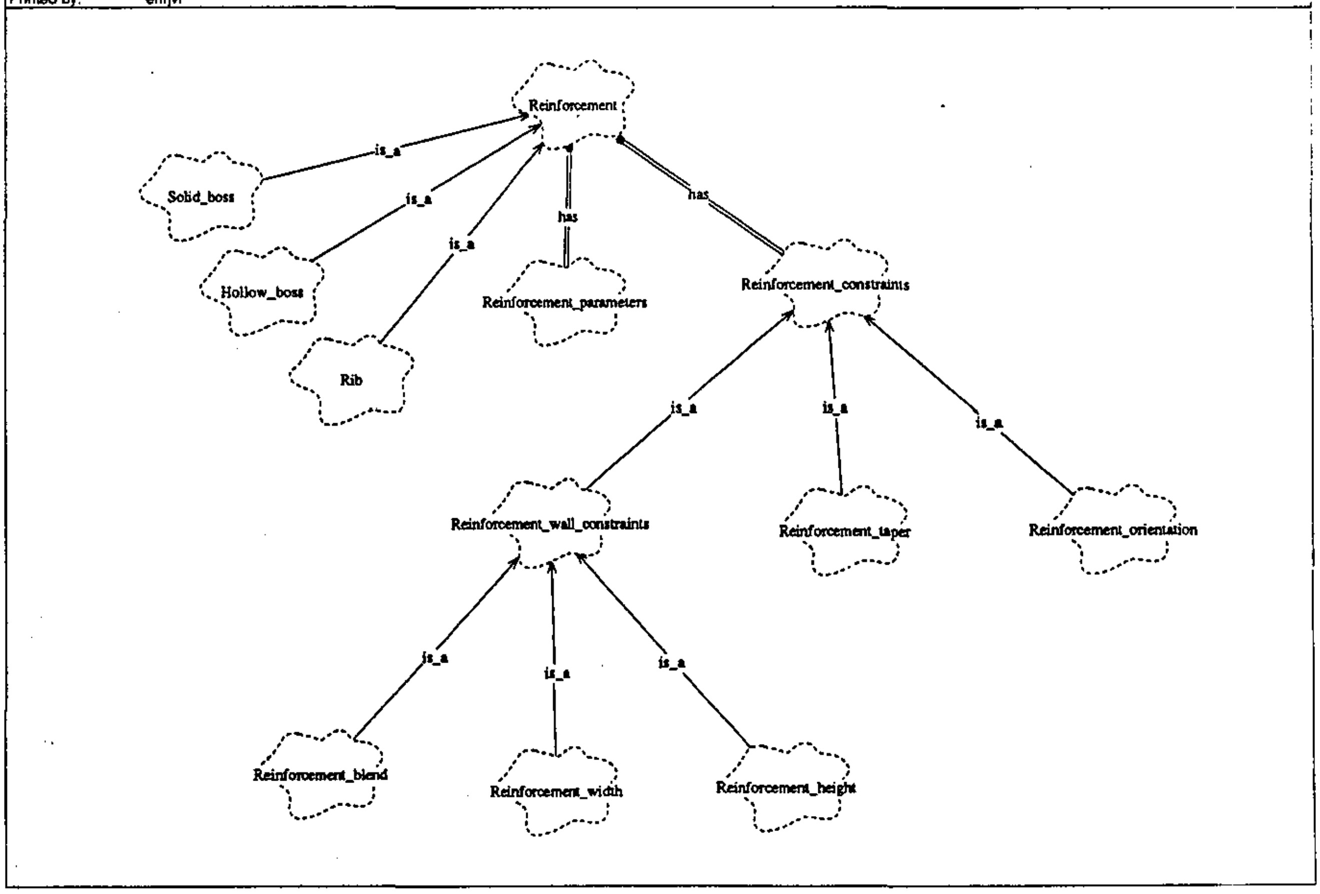
Project:	ron
Title:	Class Diagram: Mouldability_features
Printed on:	Thursday, November 30, 1995
Printed by:	enrjvl



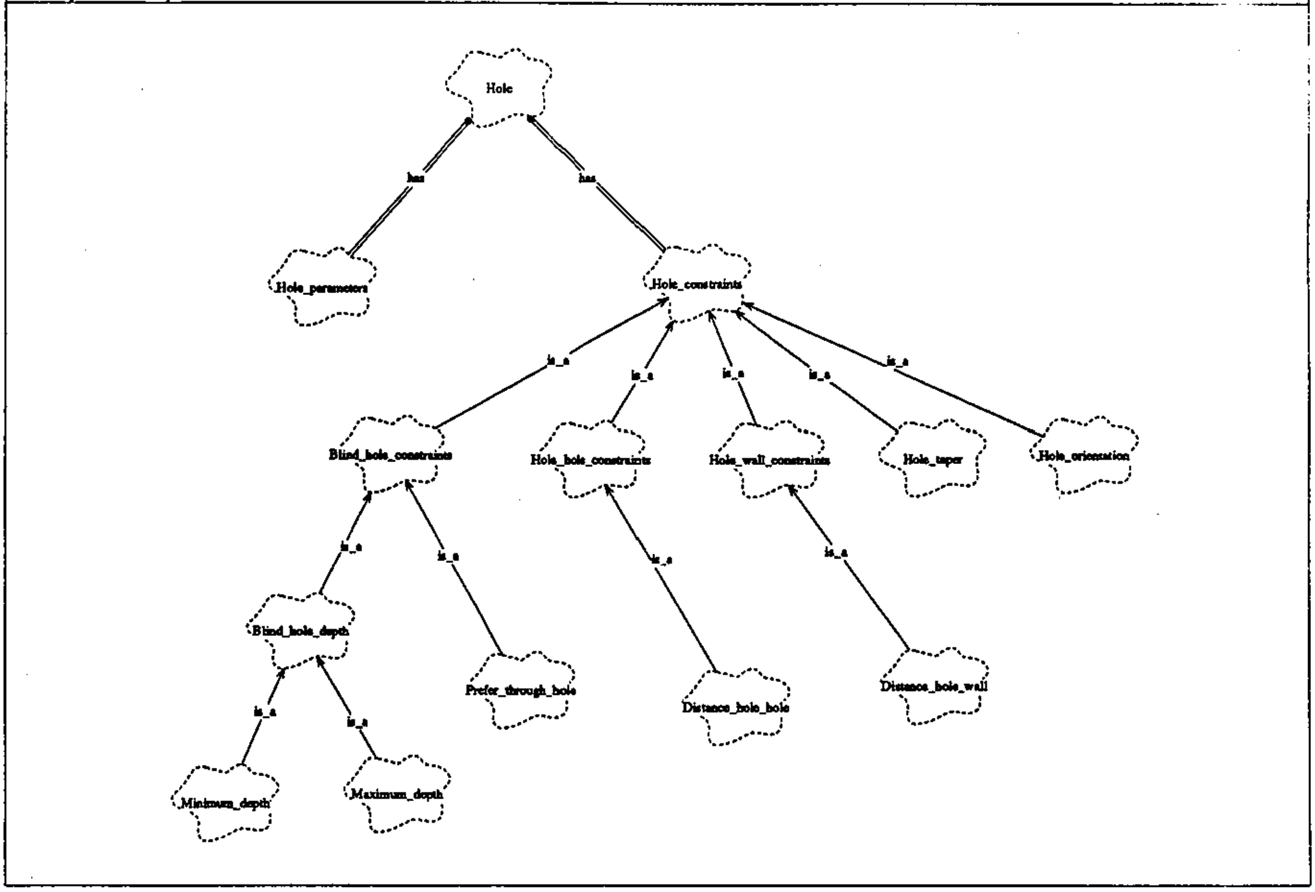
Project:	ron
Title:	Class Diagram: Wall_constraints
Printed on:	Sunday, December 17, 1995
Printed by:	enrjvl



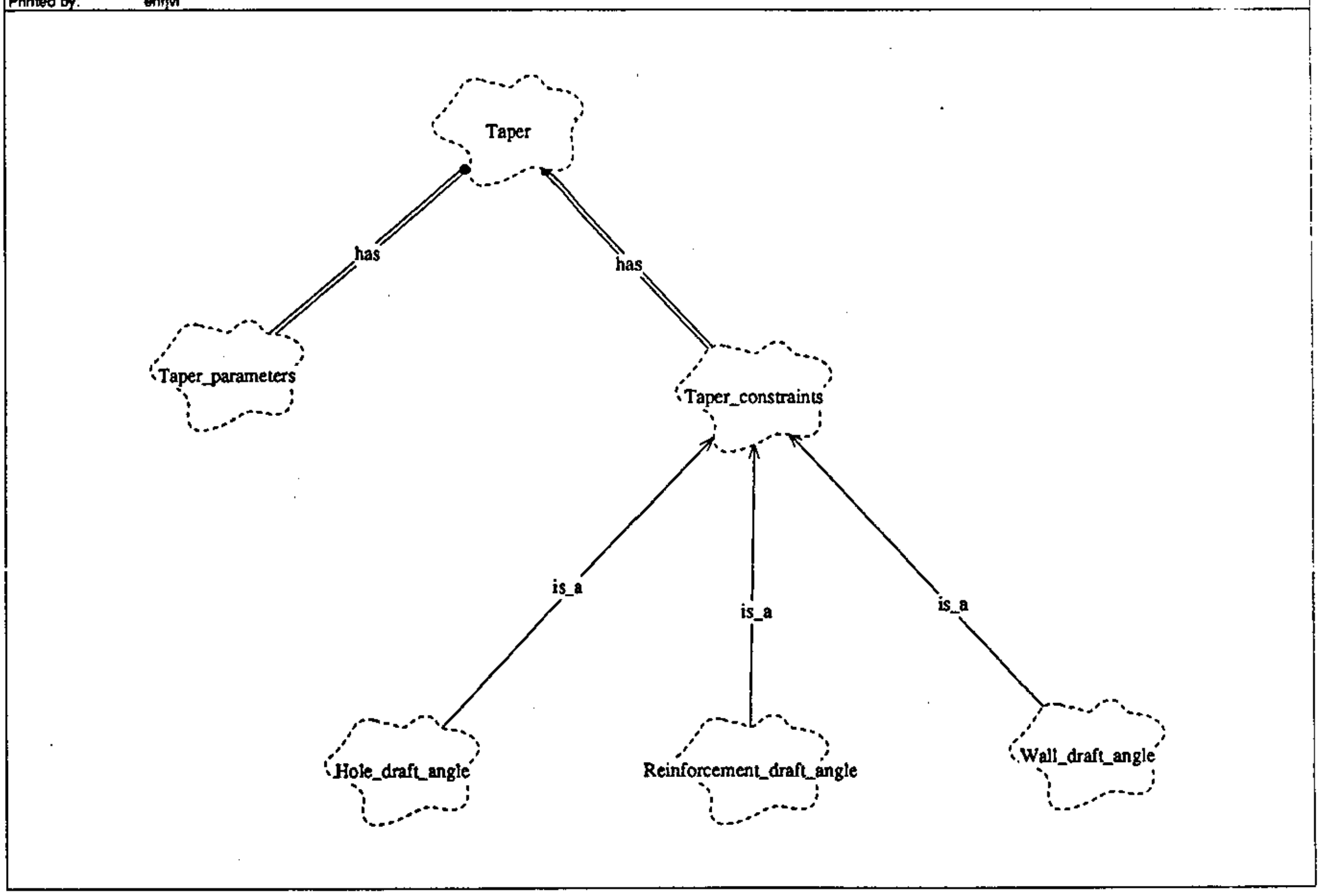
Project:	ron
Title:	Class Diagram: Reinforcement_constraints
Printed on:	Sunday, October 8, 1995
Printed by:	enrjvl



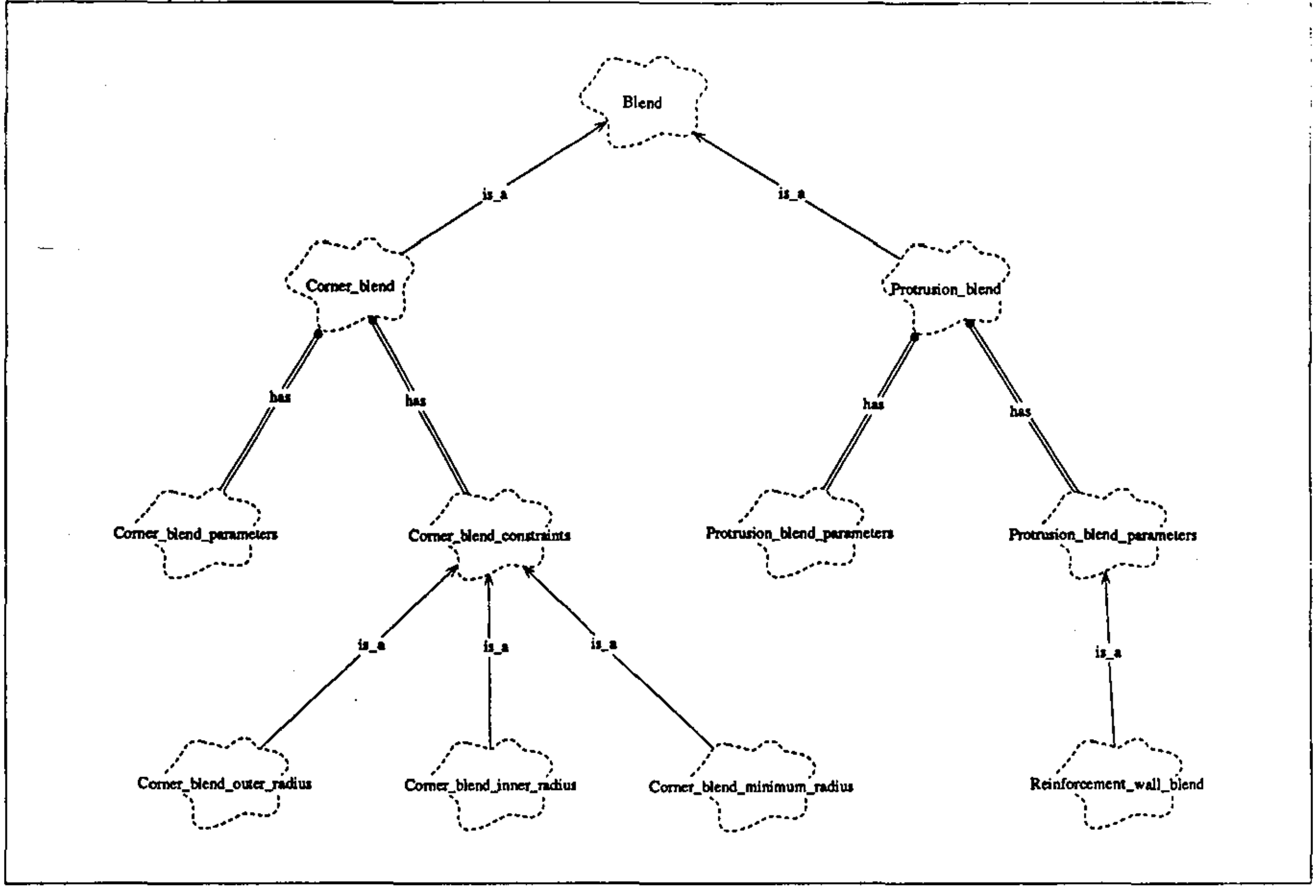
Project:	ron
Title:	Class Diagram: Hole_constraints
Printed on:	Monday, October 9, 1995
Printed by:	enrjvl



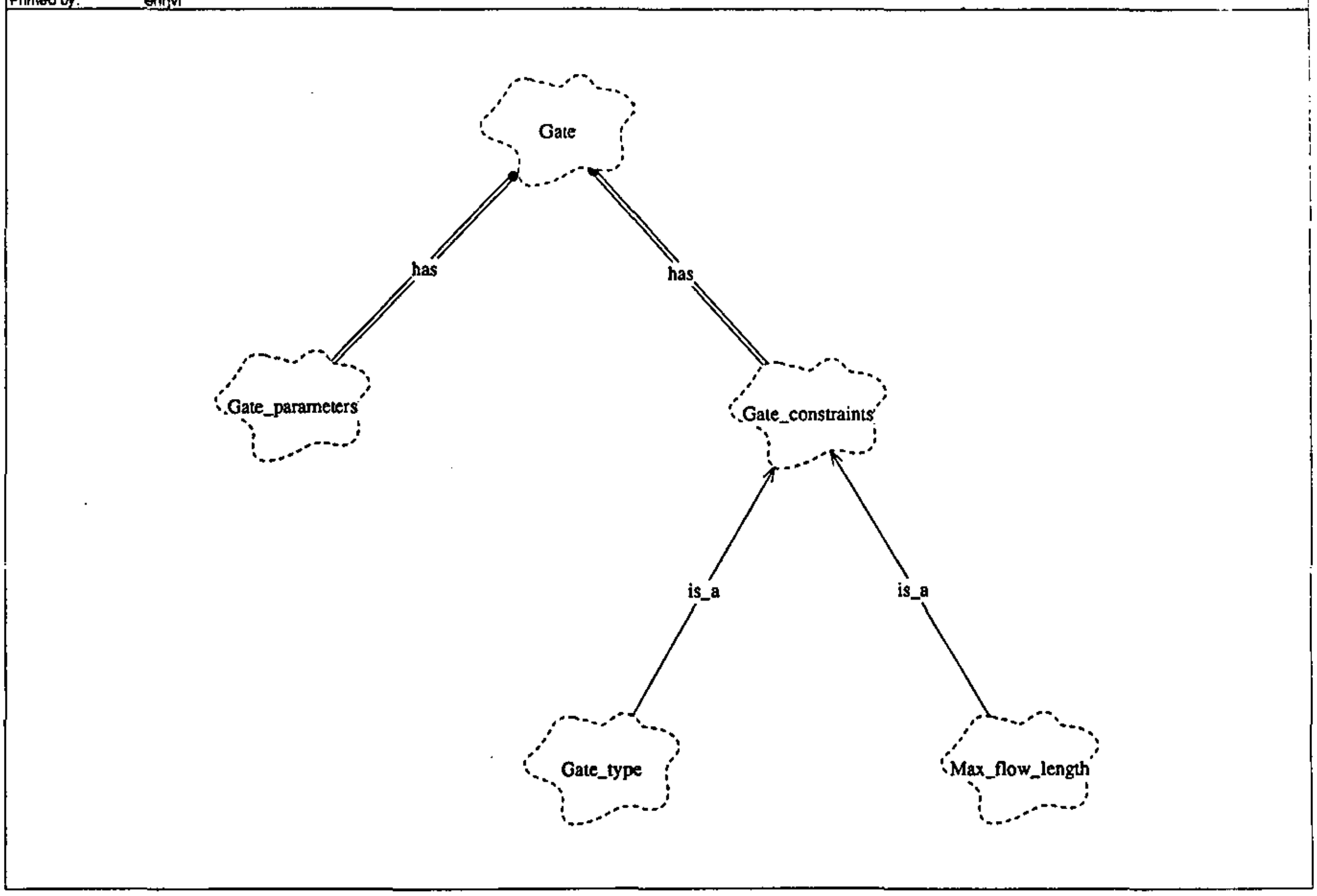
Project:	ron
Title:	Class Diagram: Taper_constraints
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



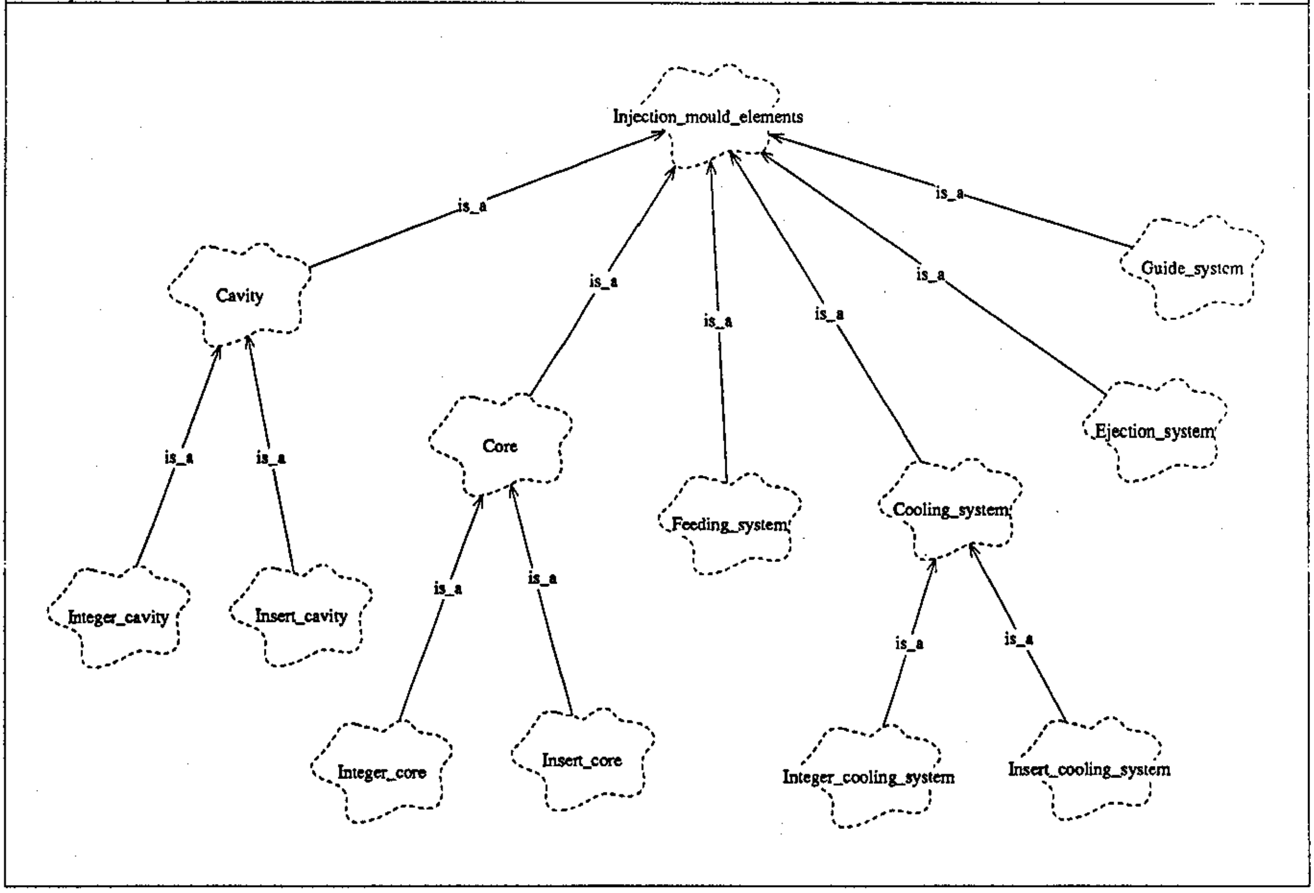
Project:	ron
Title:	Class Diagram: Blend_constraints
Printed on:	Tuesday, October 10, 1995
Printed by:	enrjvl



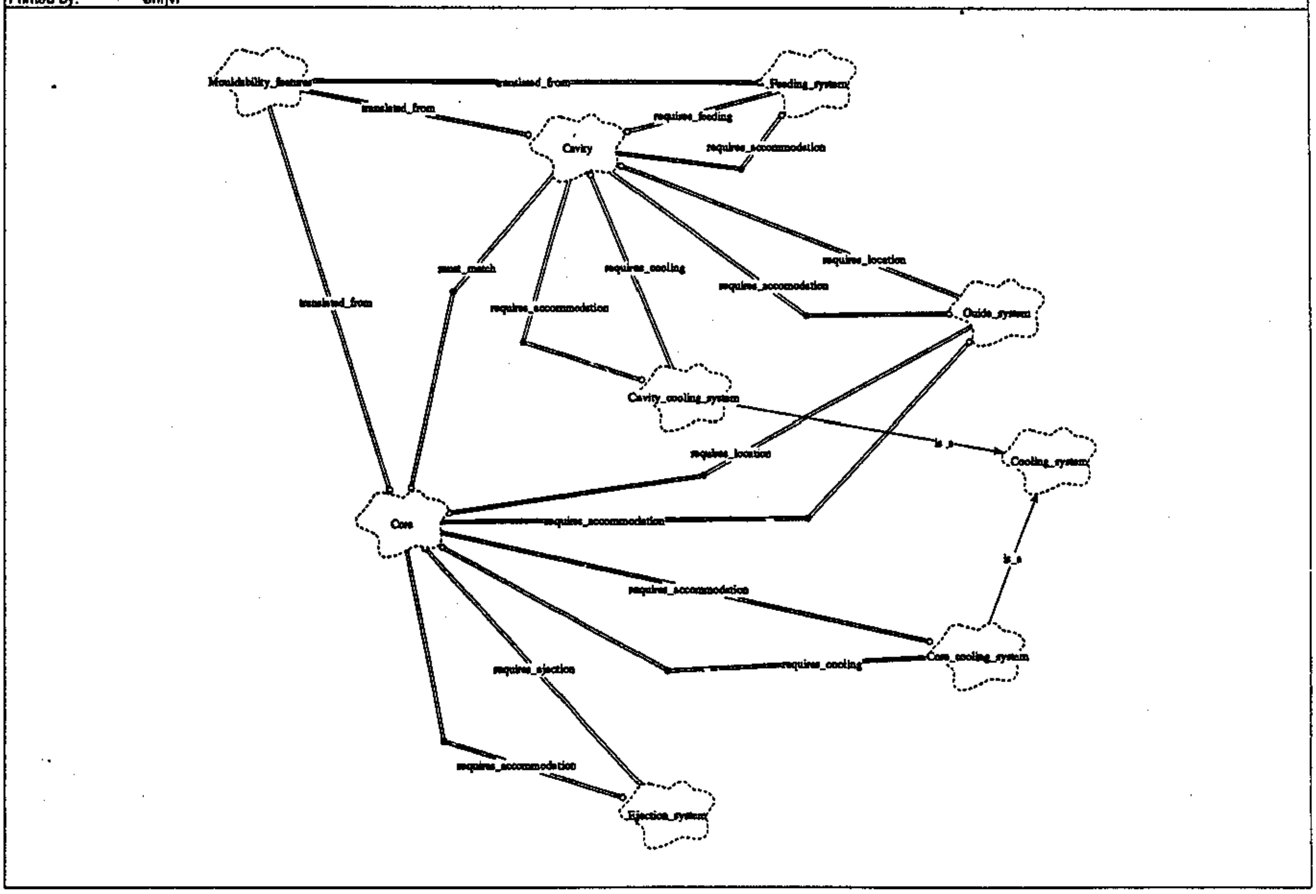
Project:	ron
Title:	Class Diagram: Gate_constraints
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



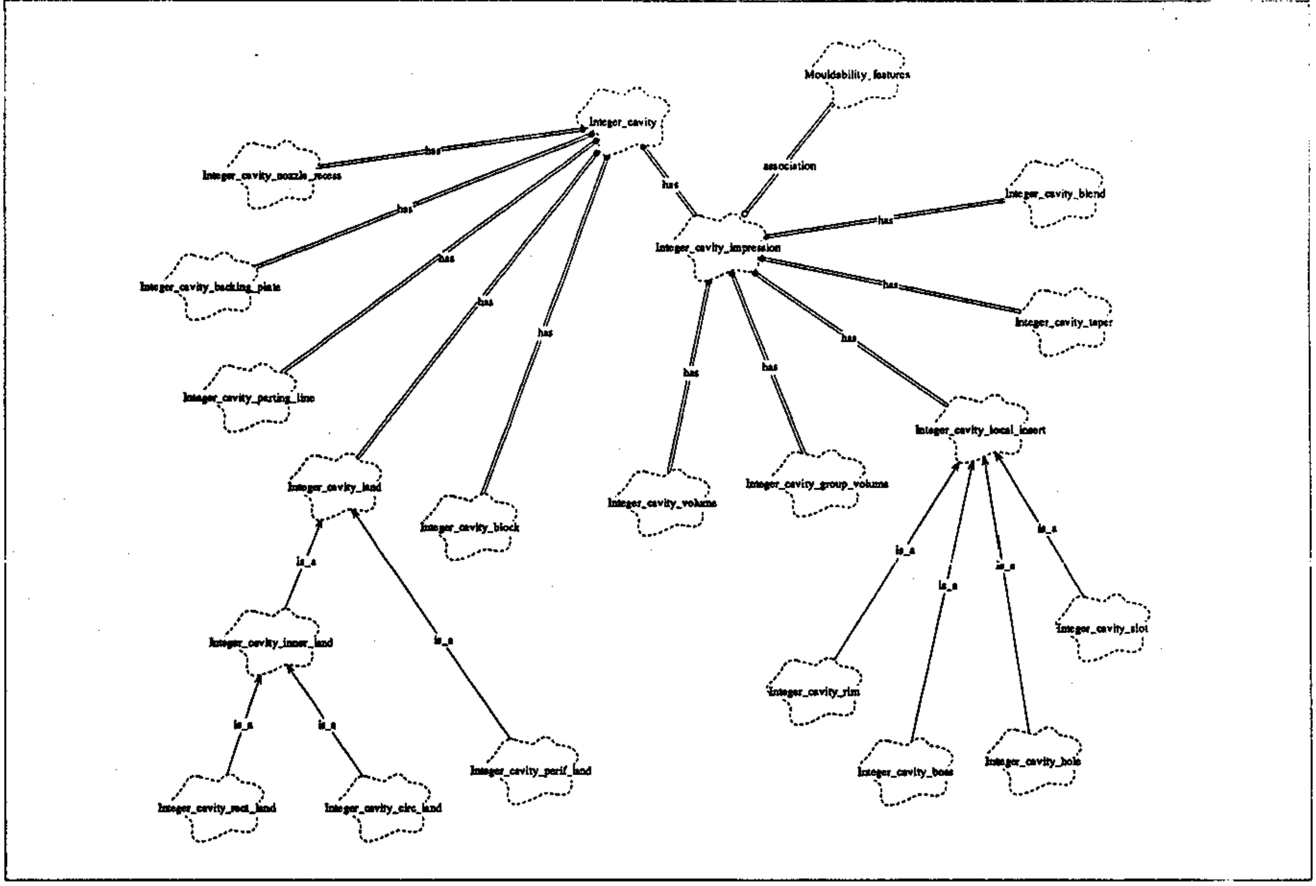
Project: ron
Title: Class Diagram: Injection_mould
Printed on: Tuesday, August 15, 1995
Printed by: enrjvl



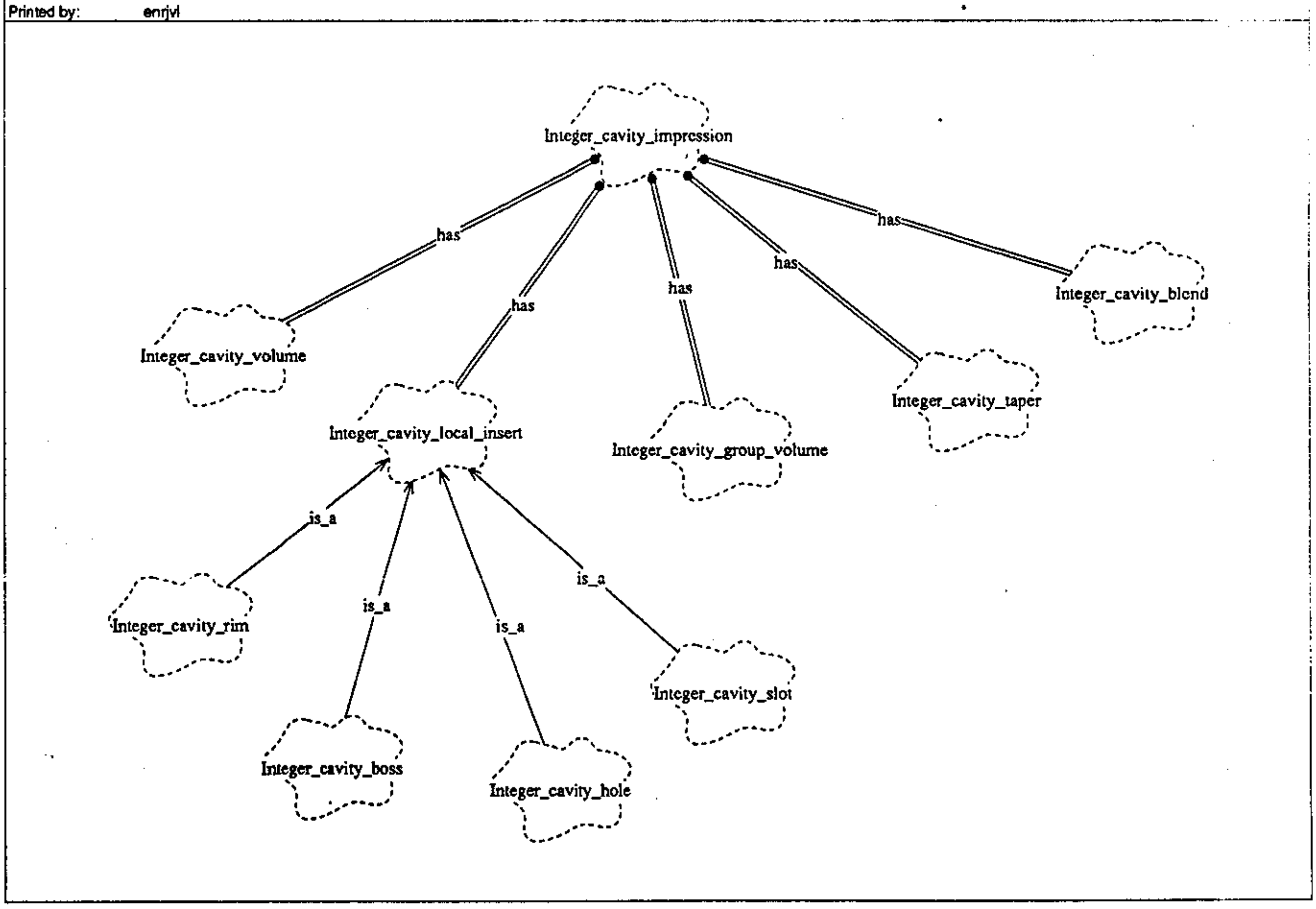
Project: ron
Title: Class Diagram: Injection_mould_relationships
Printed on: Tuesday, March 21, 1995
Printed by: enrjvl



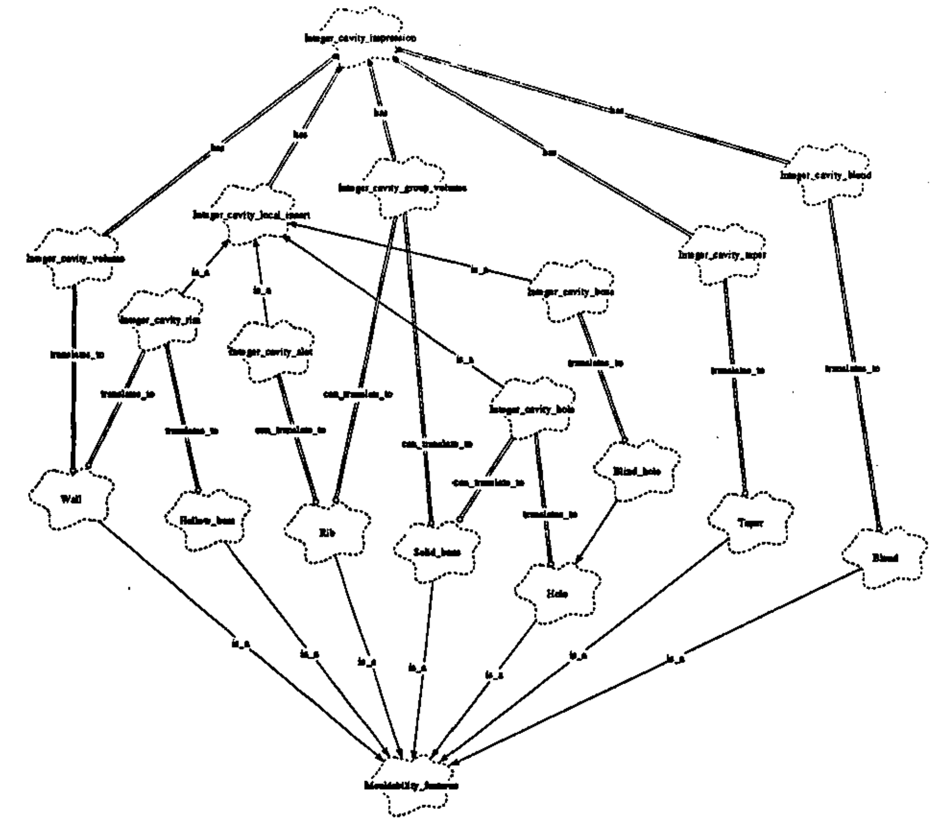
Project:	ron
Title:	Class Diagram: Integer_cavity
Printed on:	Thursday, November 30, 1995
Printed by:	enrjvl



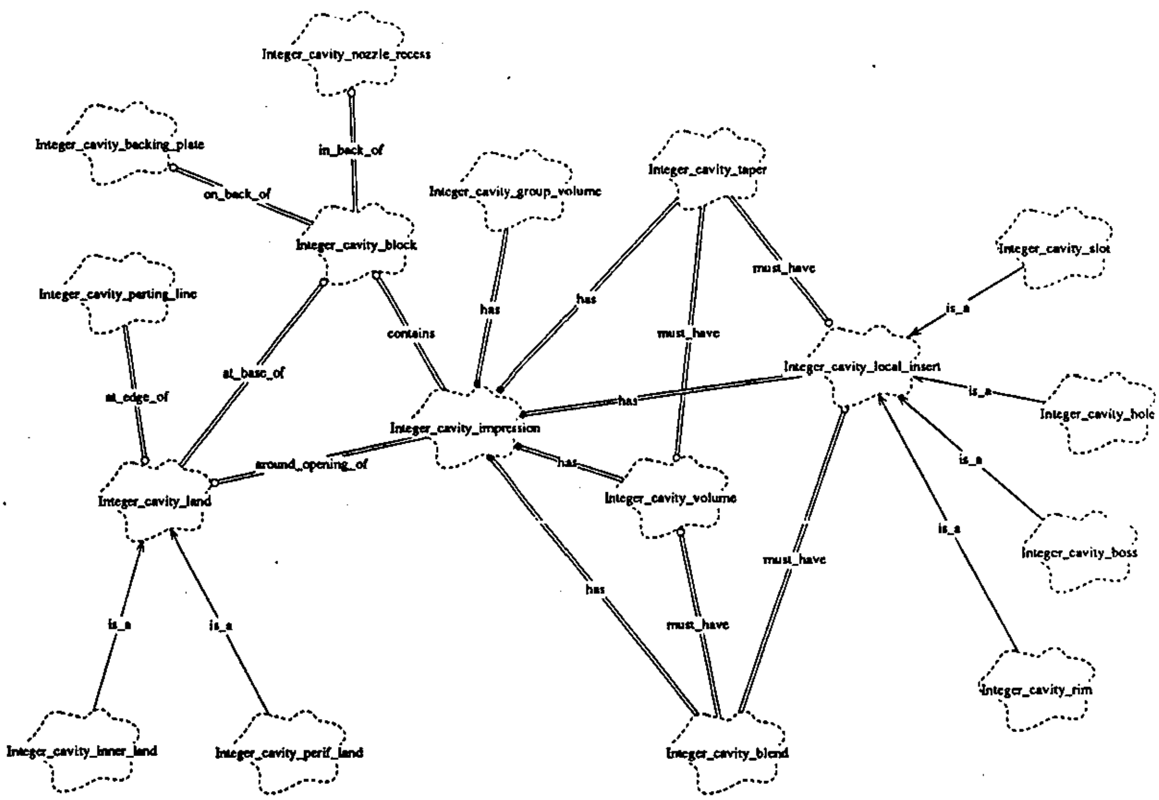
Project:	ron
Title:	Class Diagram: Integer_cavity_impression_only
Printed on:	Tuesday, October 31, 1995
Printed by:	enrjvl



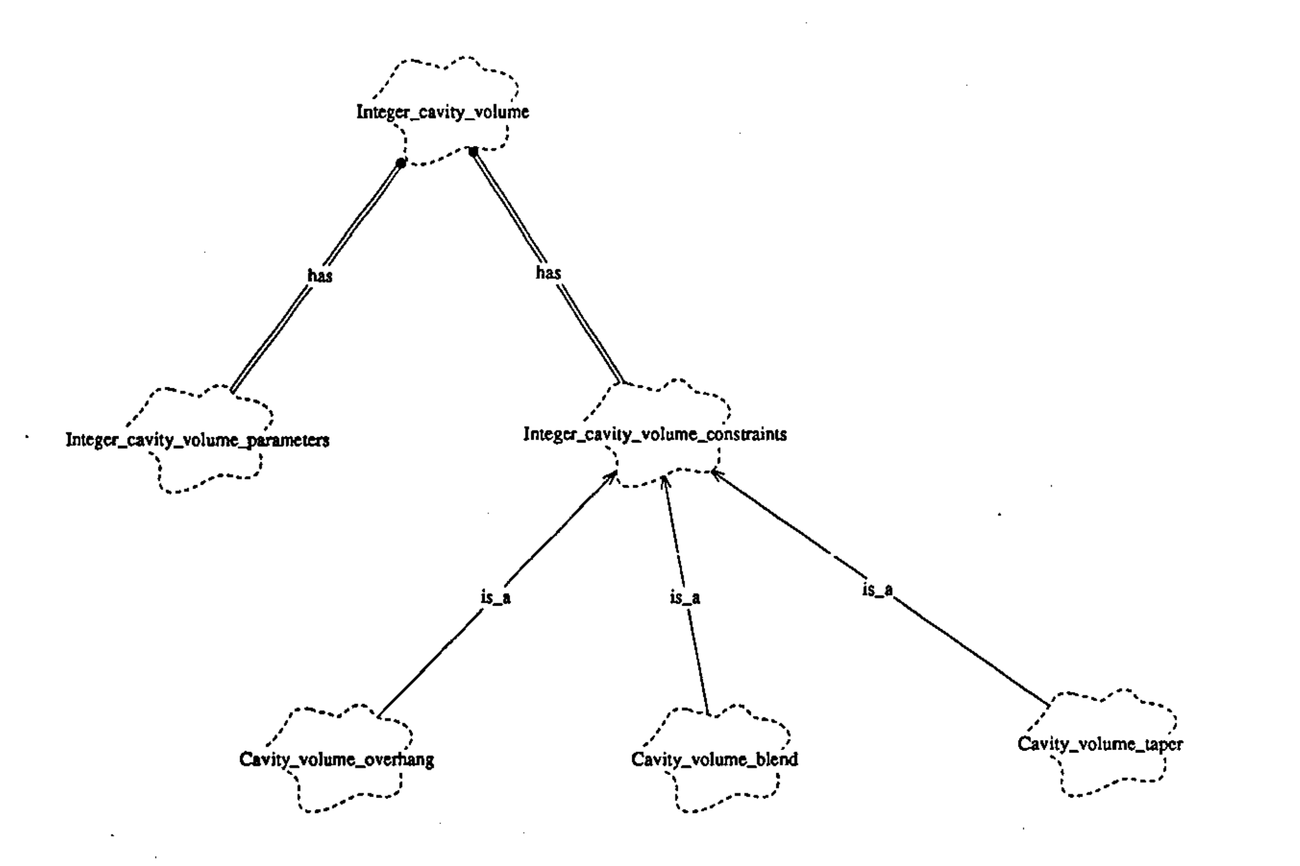
Project: ron
Title: Class Diagram: Integer_cavity_mouldability
Printed on: Tuesday, November 28, 1995
Printed by: enrjvl



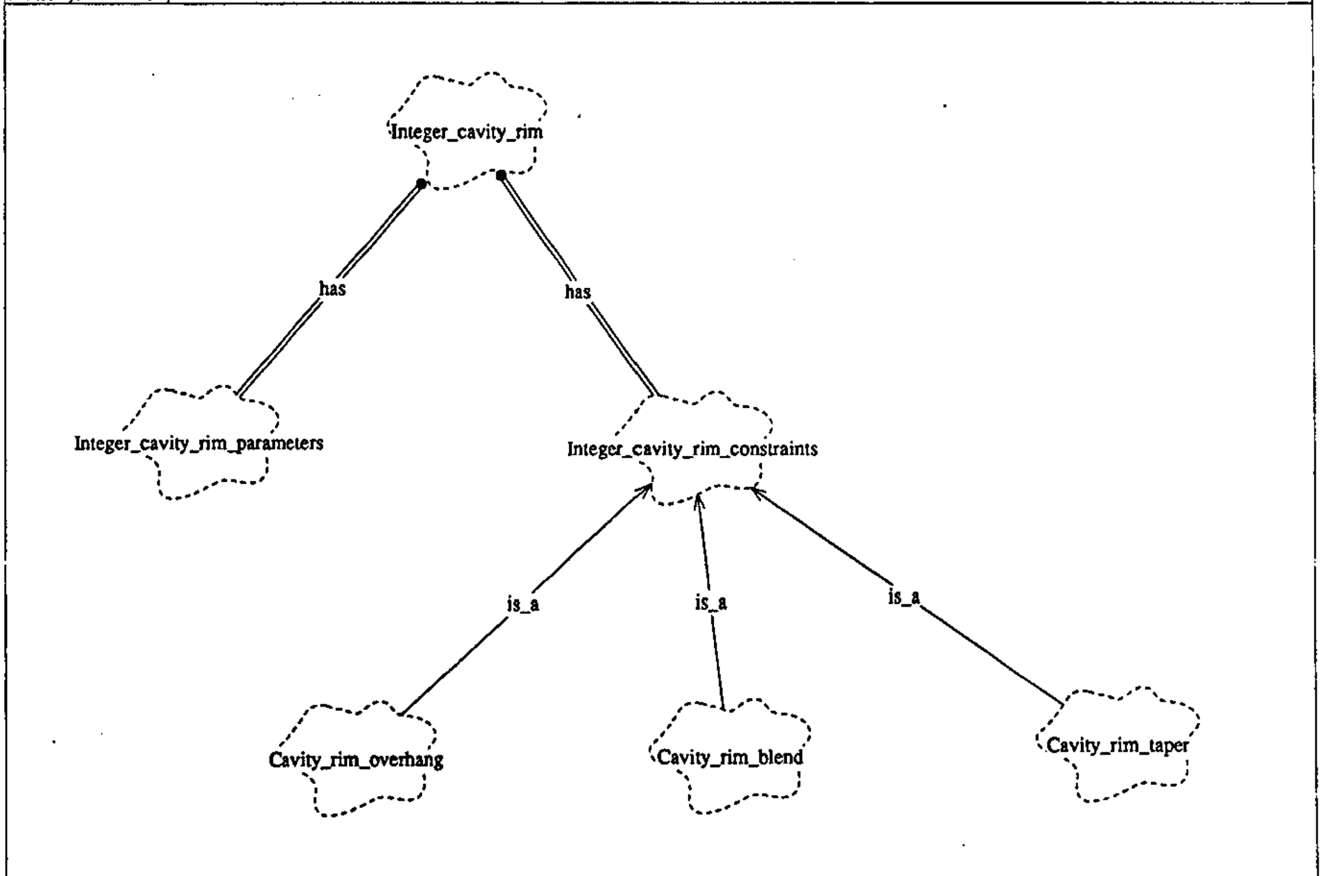
Project: ron
Title: Class Diagram: Integer_cavity_relationships
Printed on: Tuesday, October 31, 1995
Printed by: enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_volume
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_rim
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_slot
Printed on:	Tuesday, August 15, 1995
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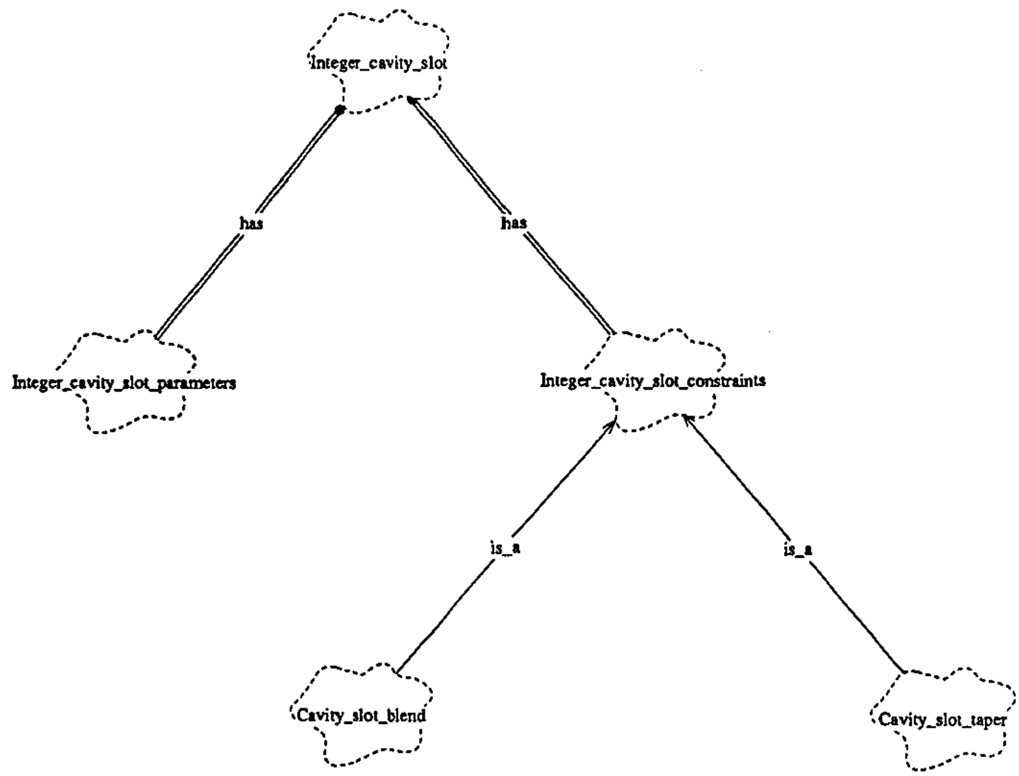

Project:	ron
Title:	Class Diagram: Integer_cavity_hole
Printed on:	Thursday, August 17, 1995
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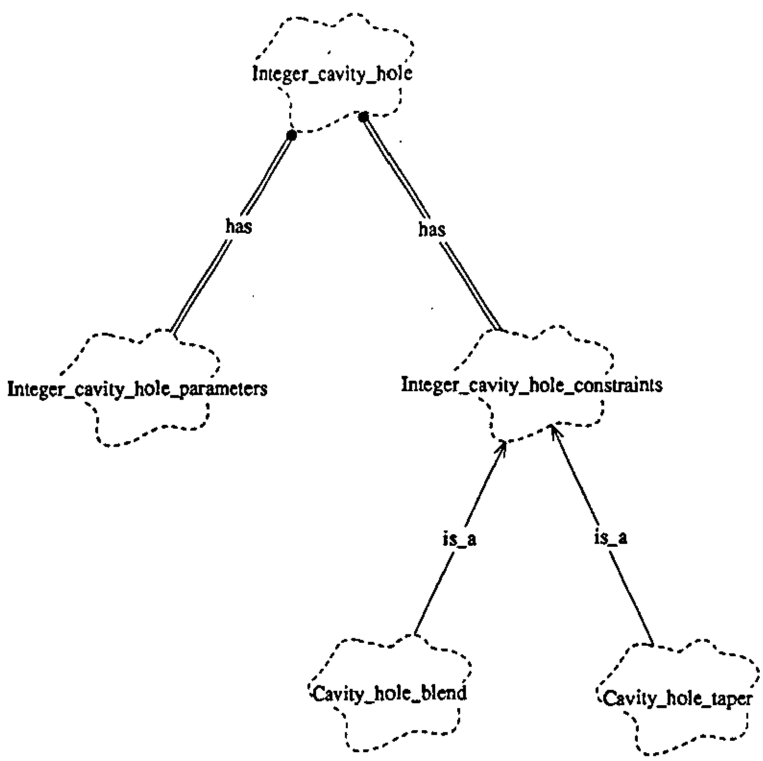
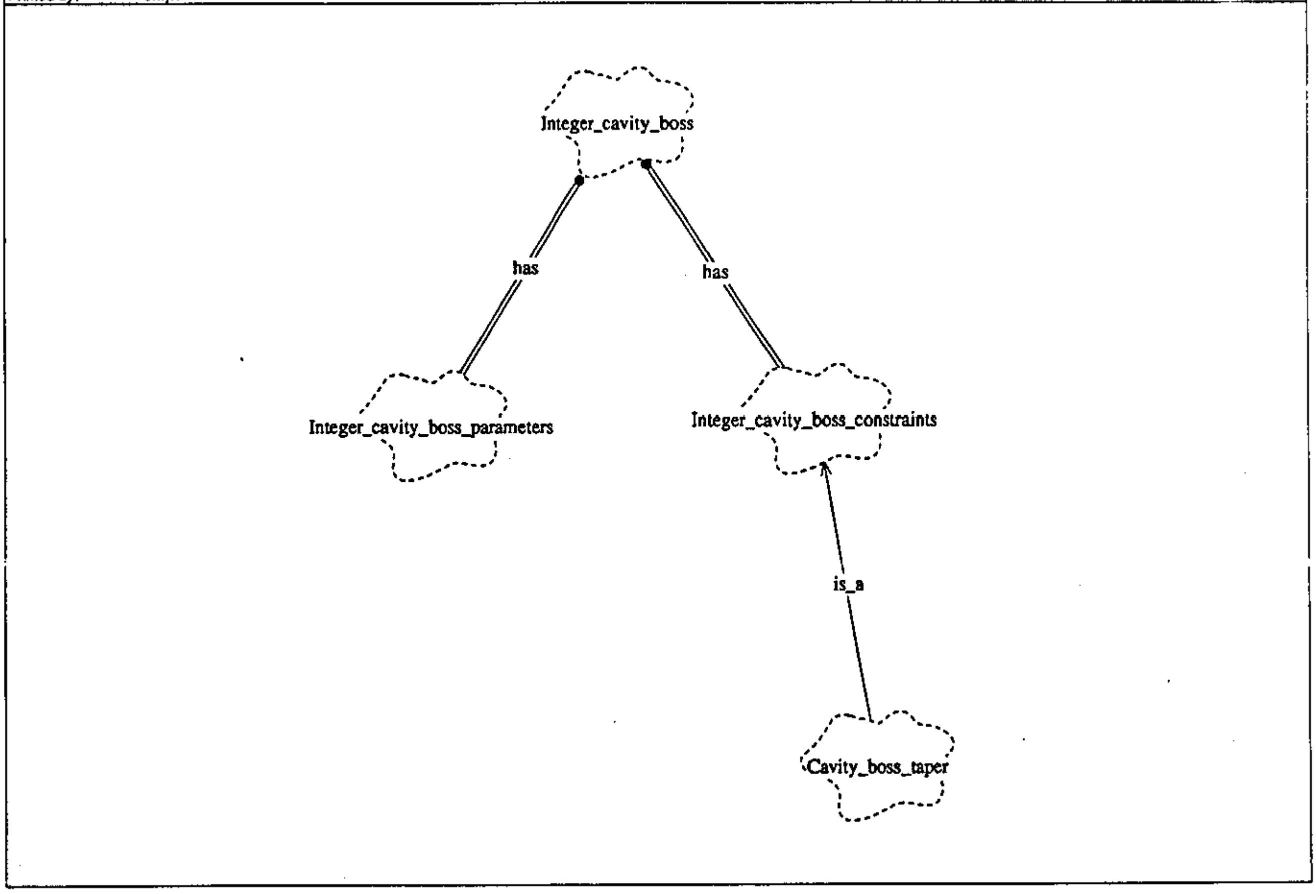


Project:	ron
Title:	Class Diagram: Integer_cavity_boss
Printed on:	Thursday, August 17, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_group_volume
Printed on:	Tuesday, August 15, 1995
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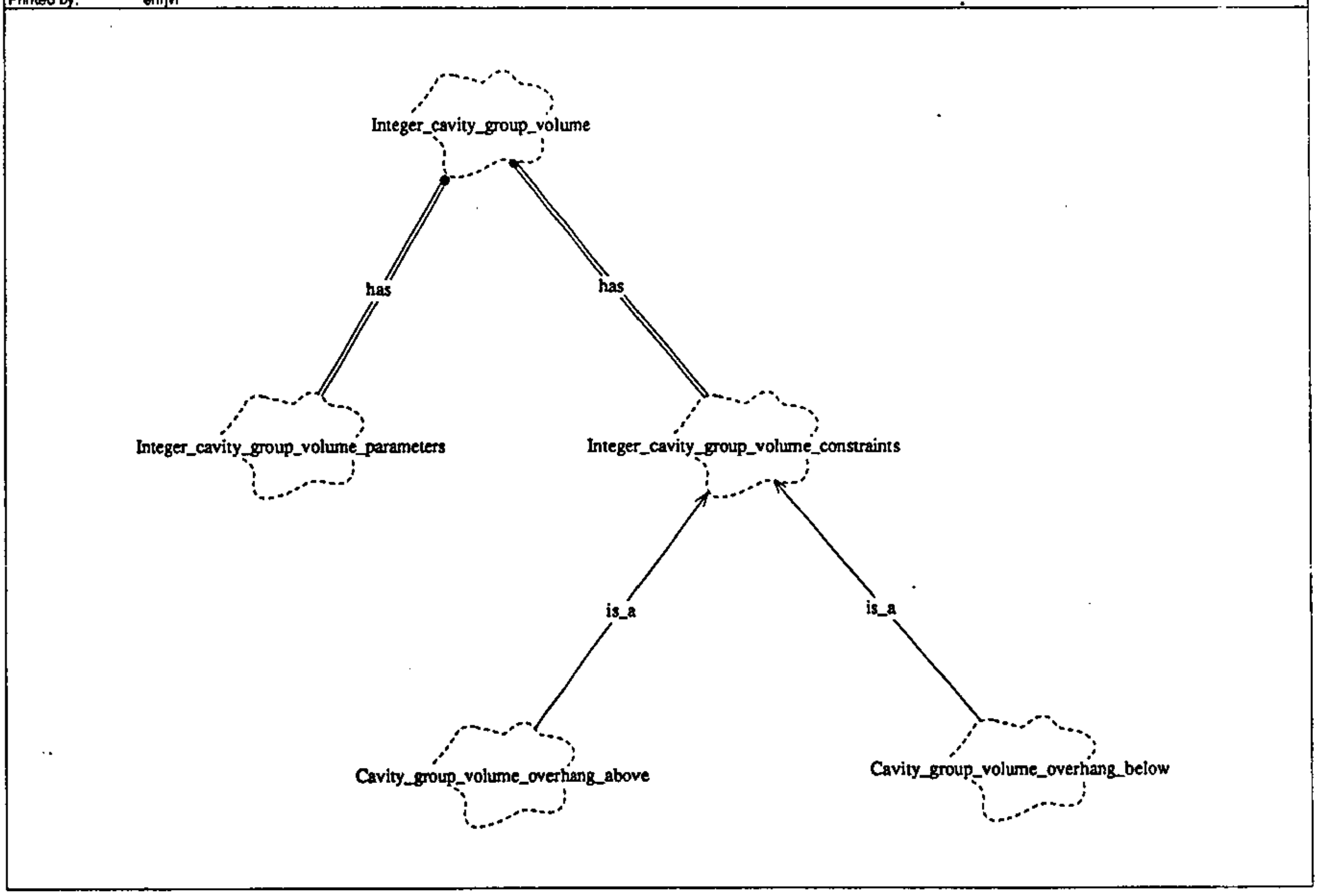

Project:	ron
Title:	Class Diagram: Integer_cavity_blend
Printed on:	Tuesday, August 15, 1995
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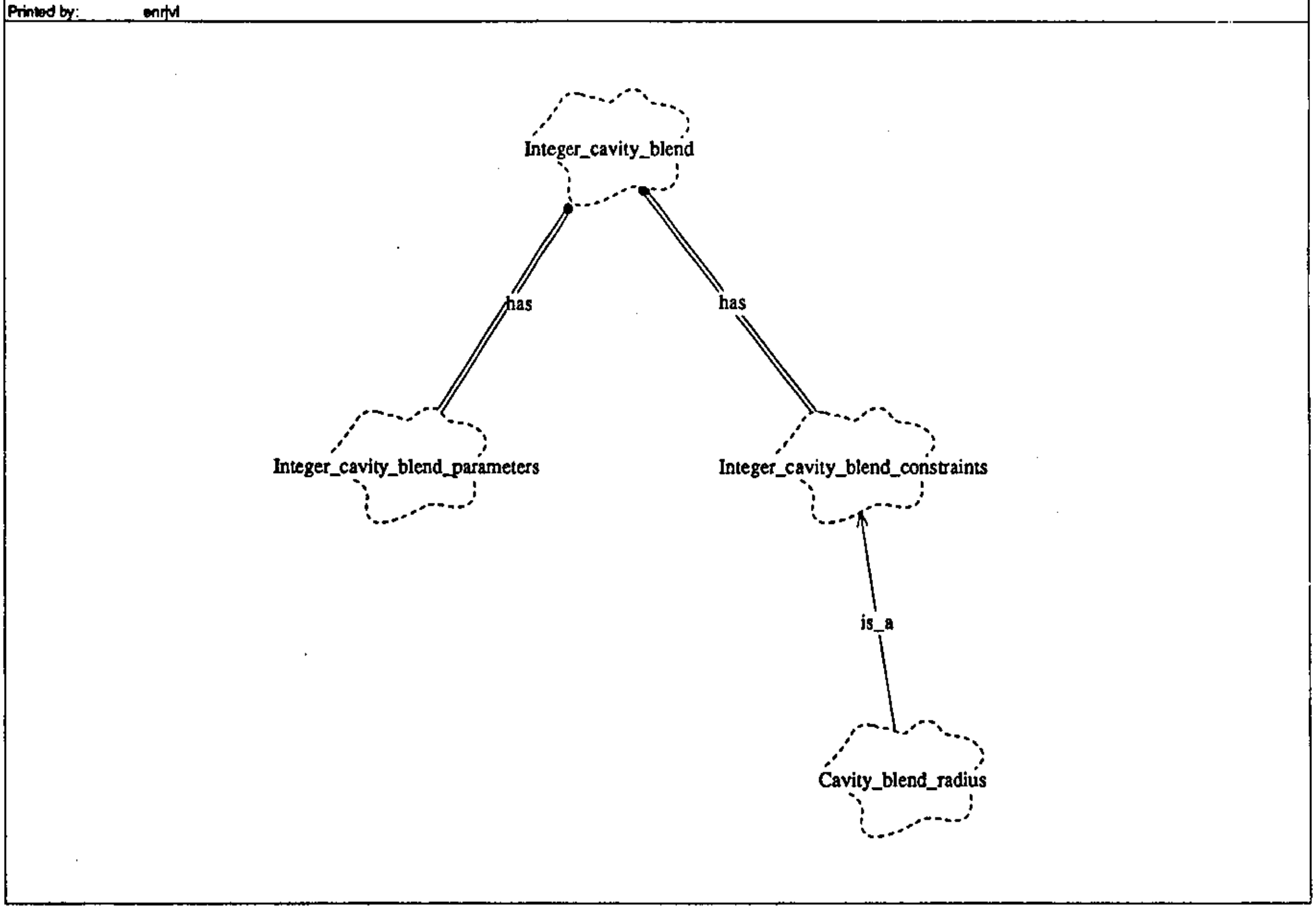
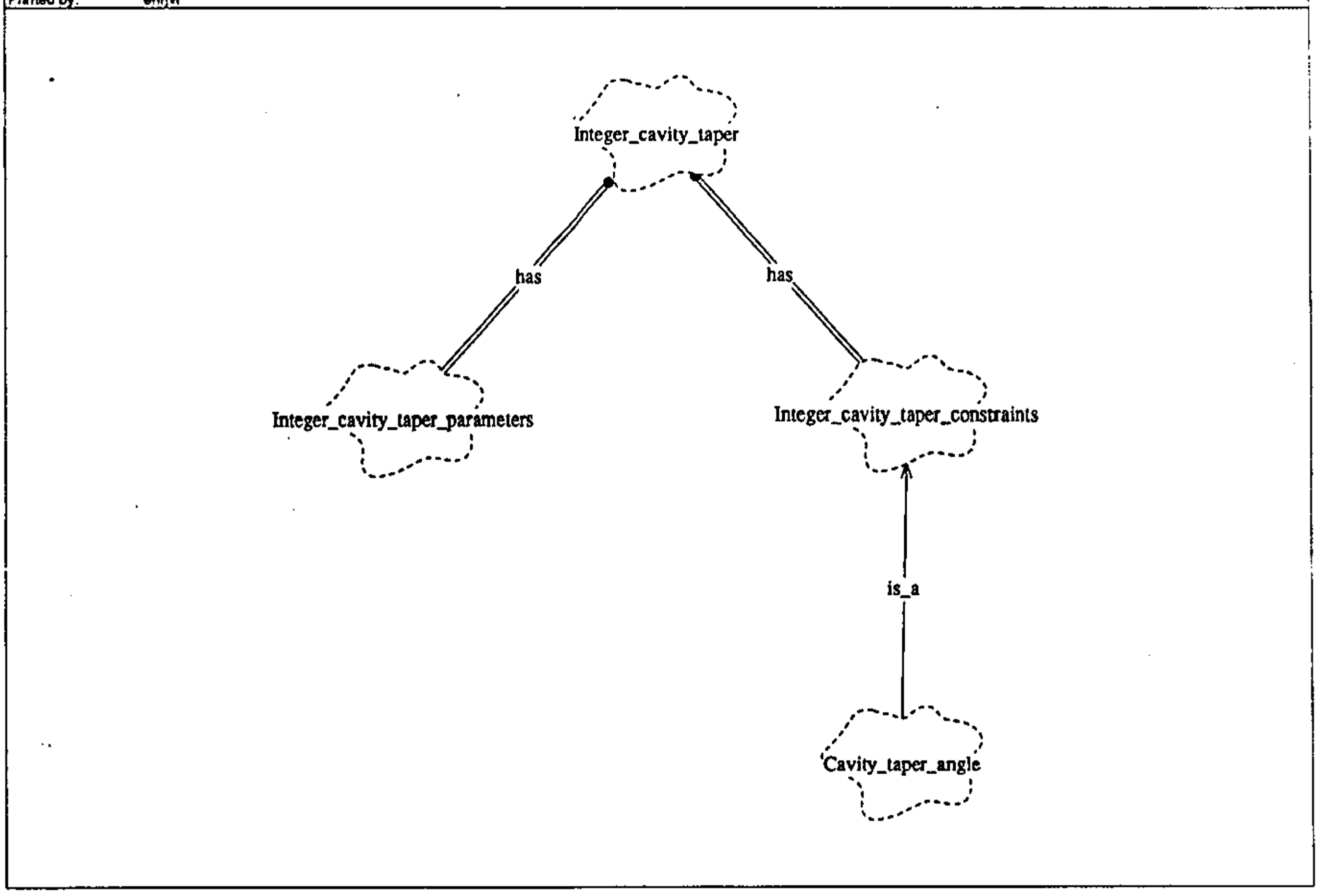
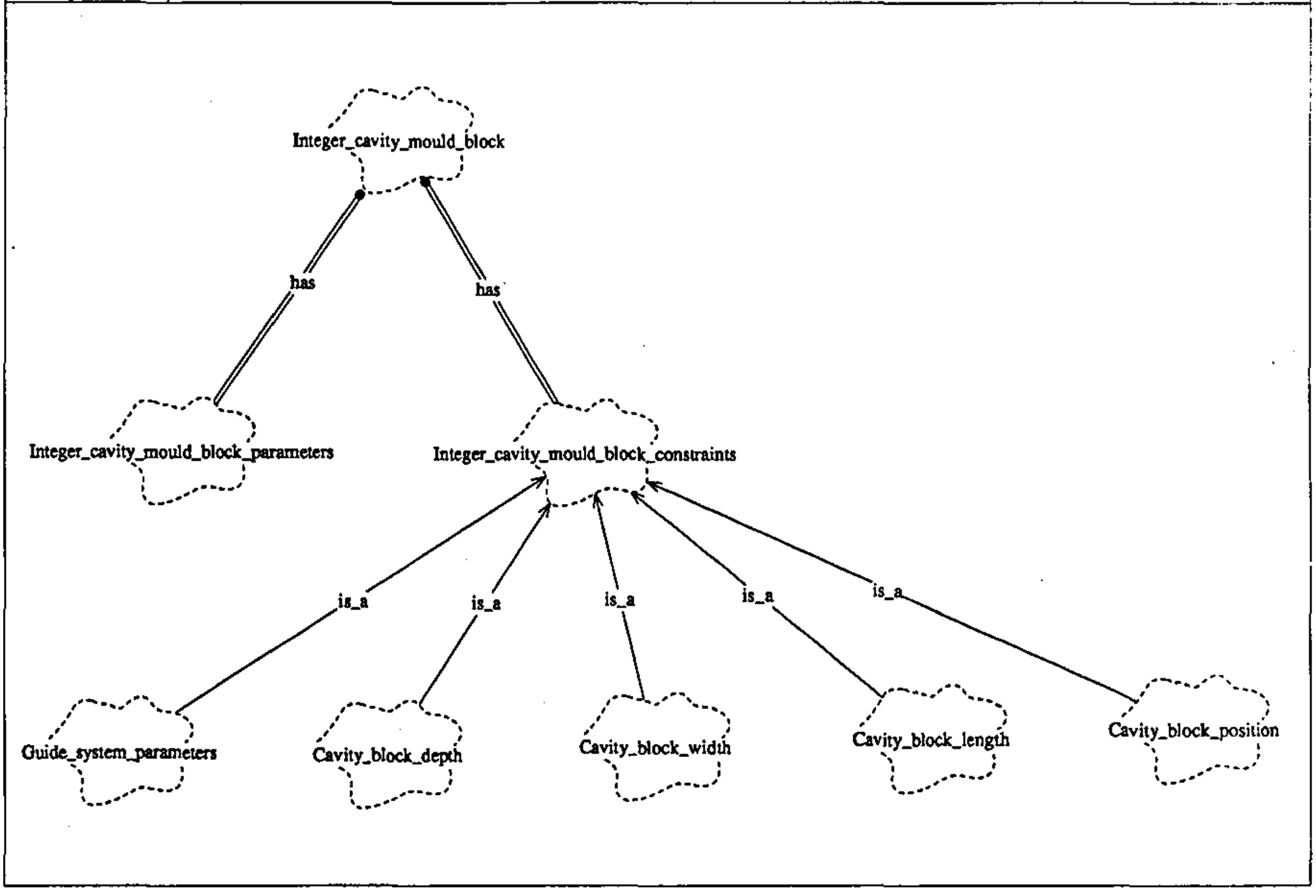


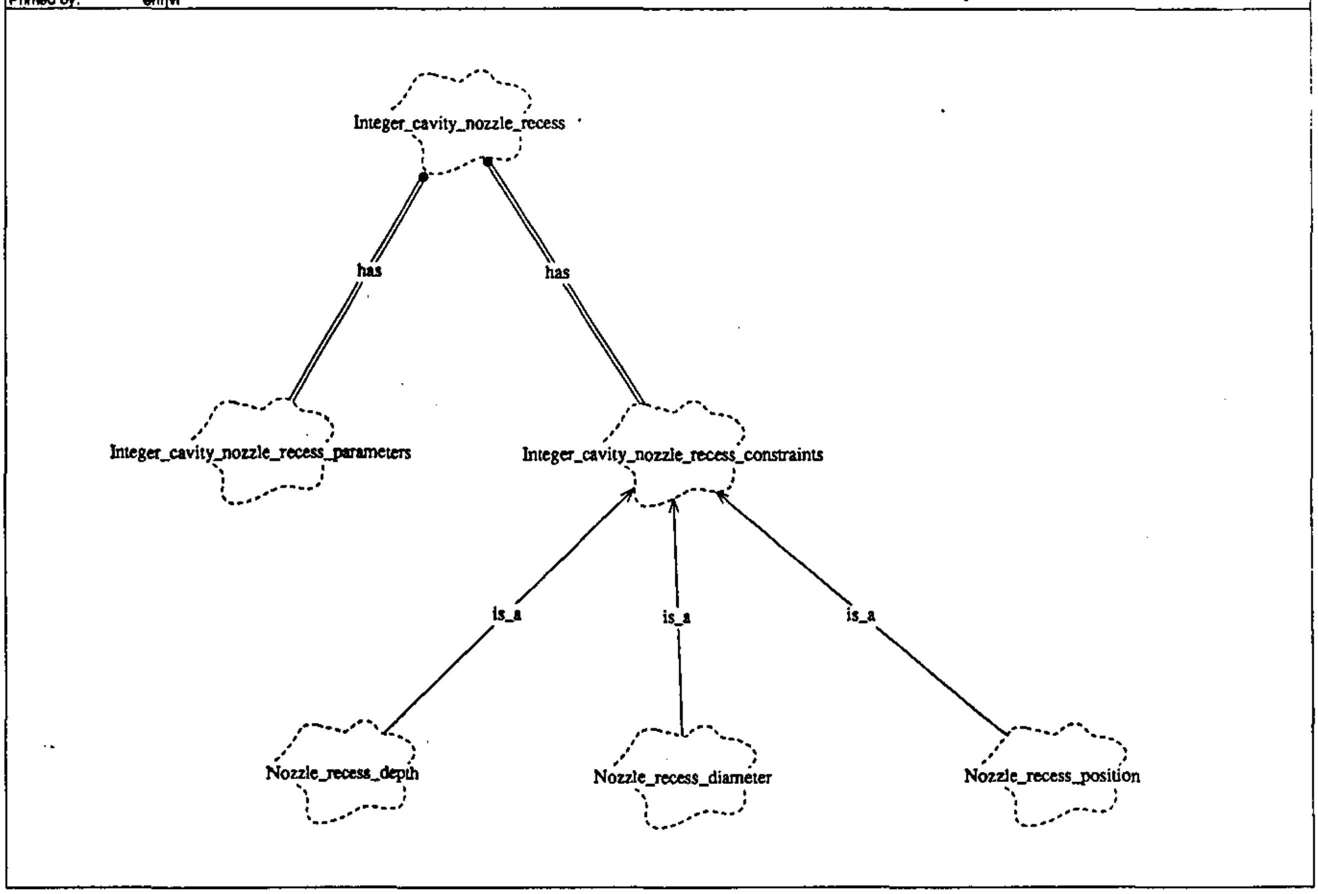
Project:	ron
Title:	Class Diagram: Integer_cavity_taper
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



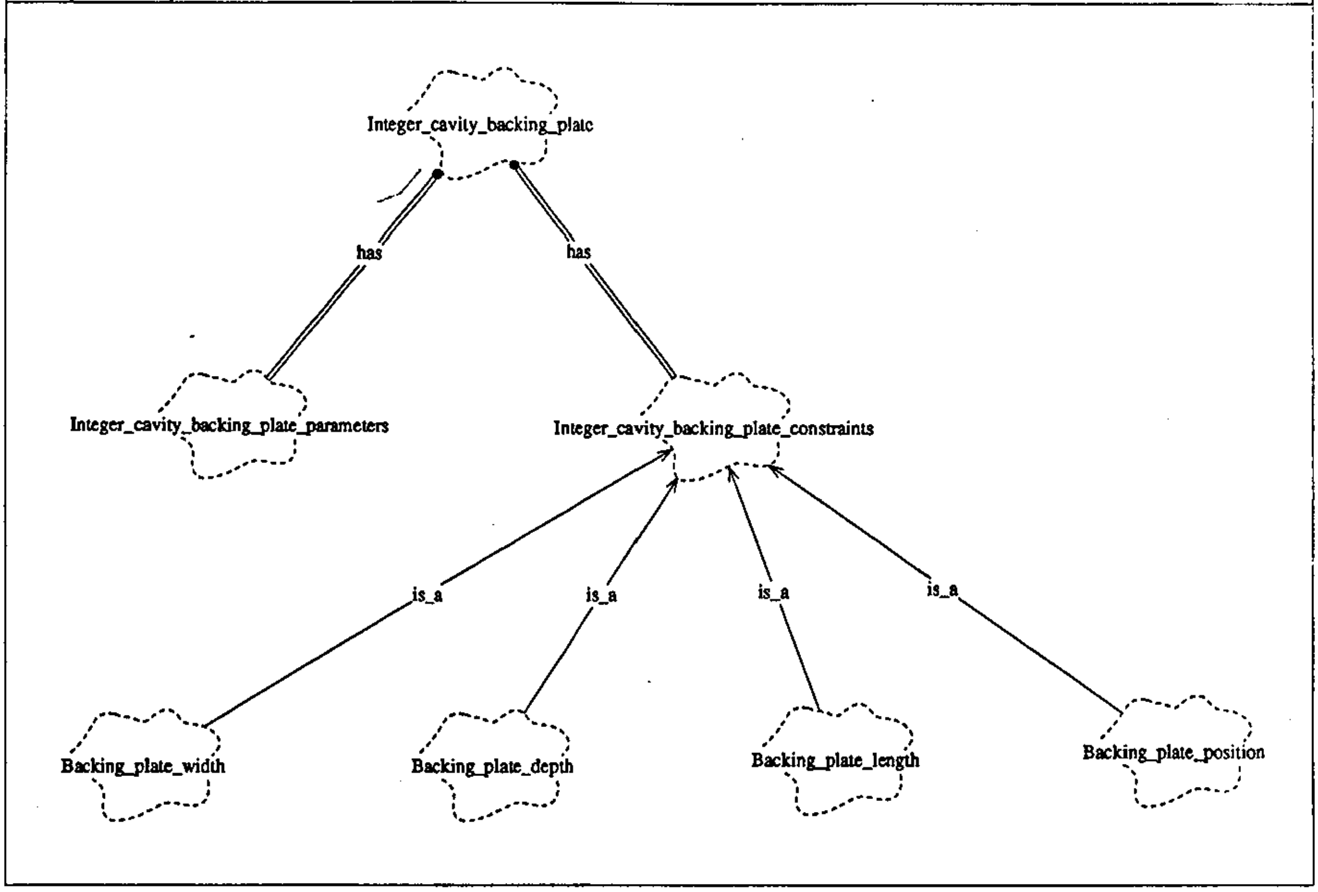
Project:	ron
Title:	Class Diagram: Integer_cavity_mould_block
Printed on:	Thursday, October 12, 1995
Printed by:	enrjvl



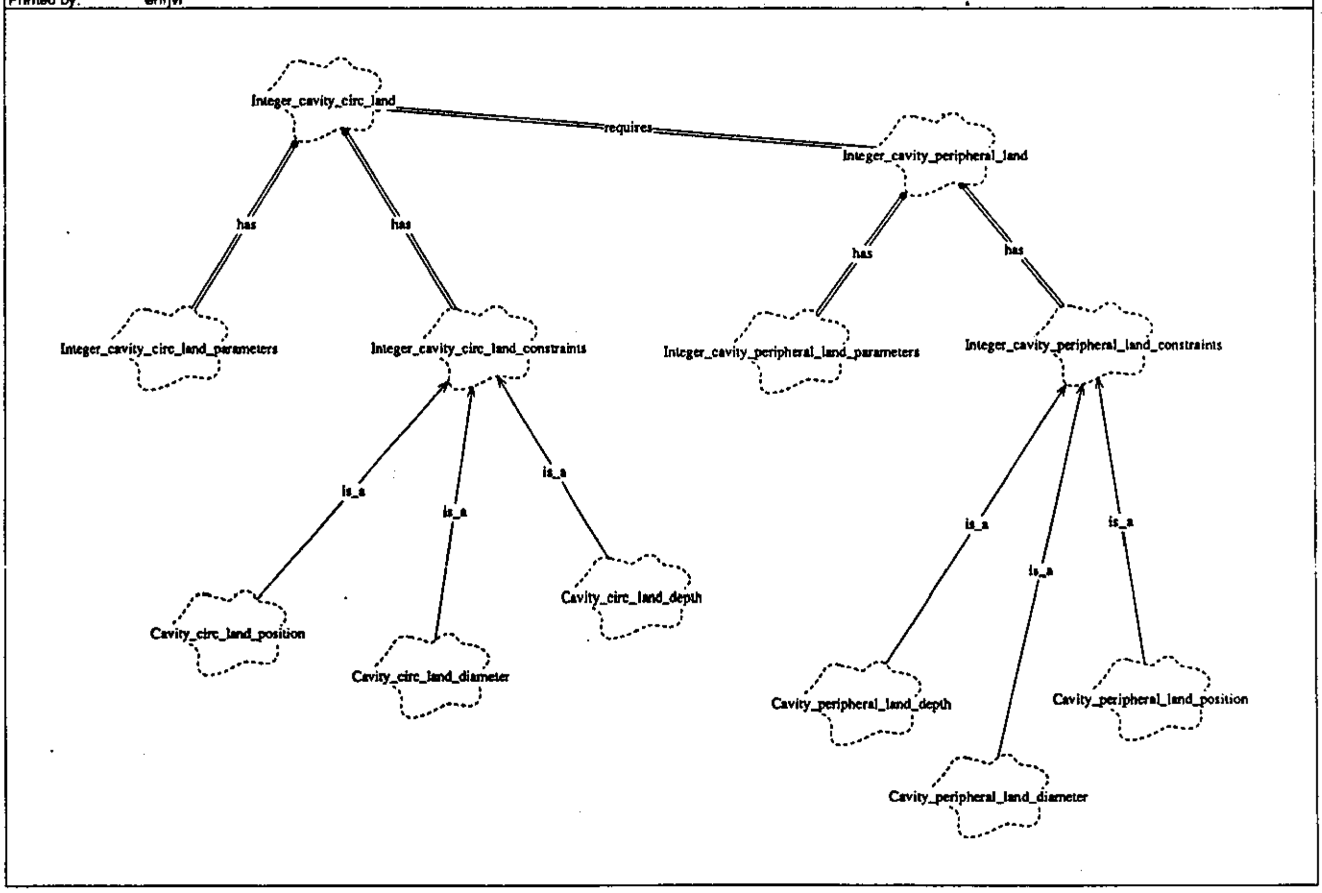
Project:	ron
Title:	Class Diagram: Integer_cavity_nozzle_recess
Printed on:	Thursday, October 12, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_backing_plate
Printed on:	Thursday, October 12, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_circ_perif_lands
Printed on:	Friday, August 18, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_cavity_rect_land
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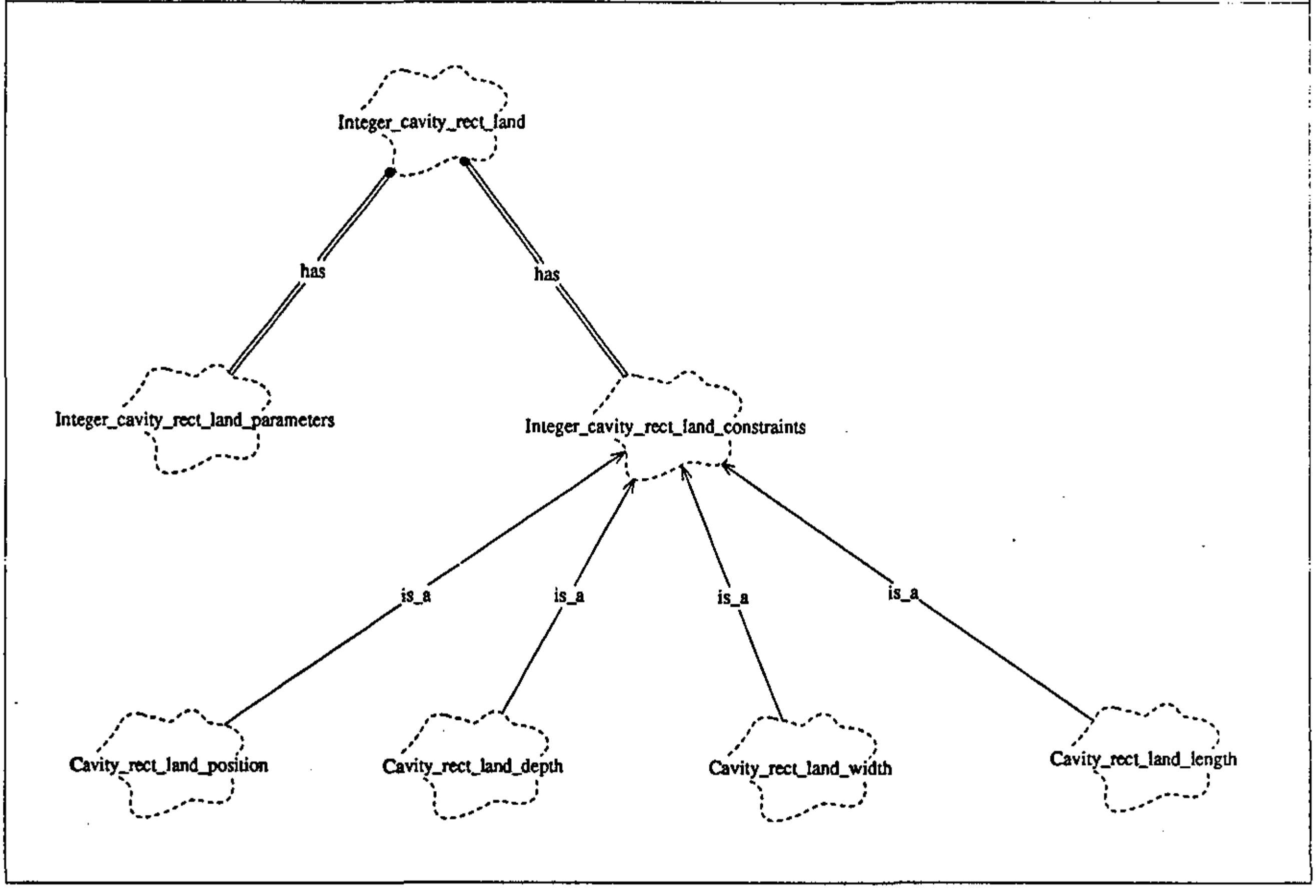

Project:	ron
Title:	Class Diagram: Integer_cavity_parting_line
Printed on:	Tuesday, August 15, 1995
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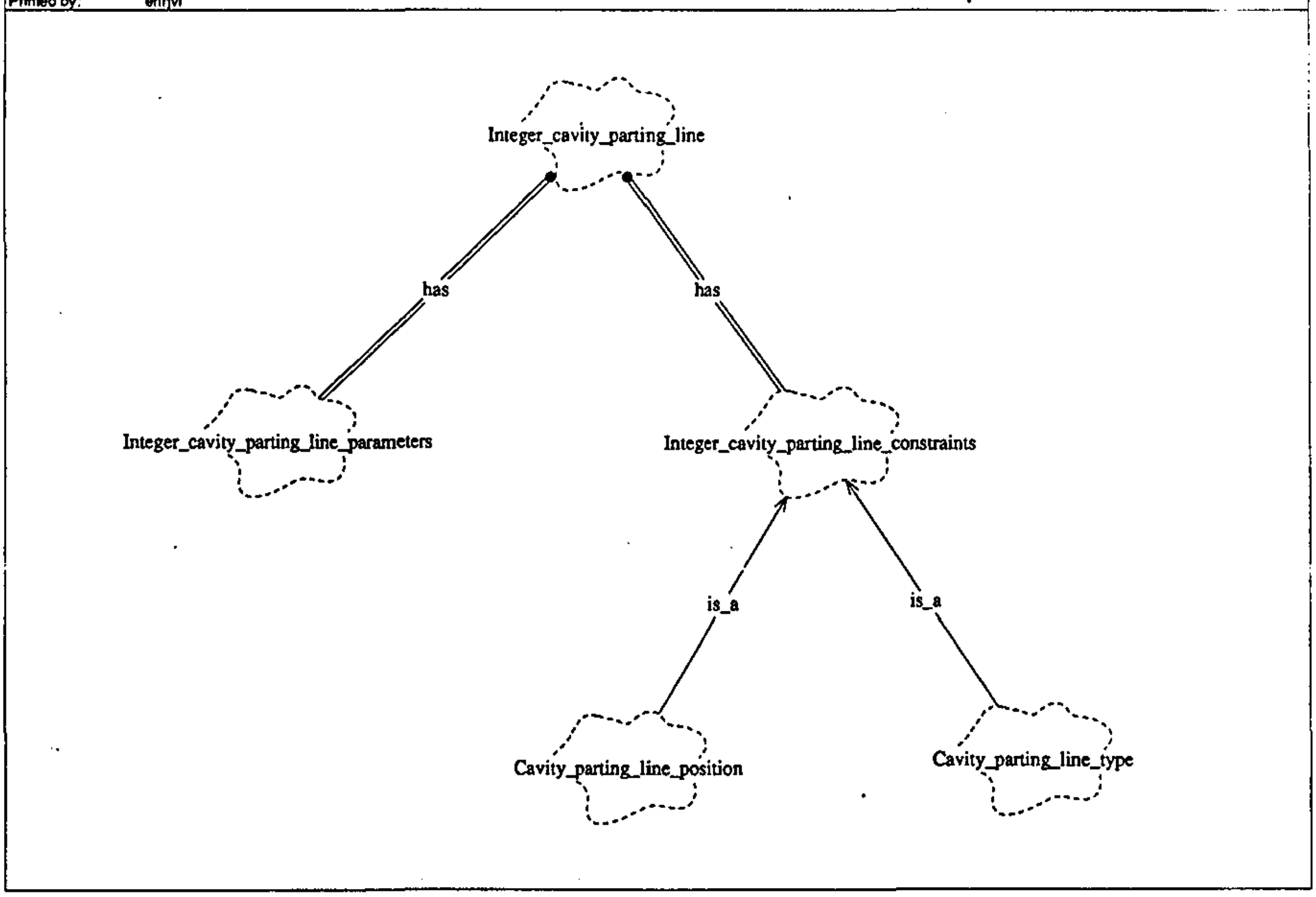

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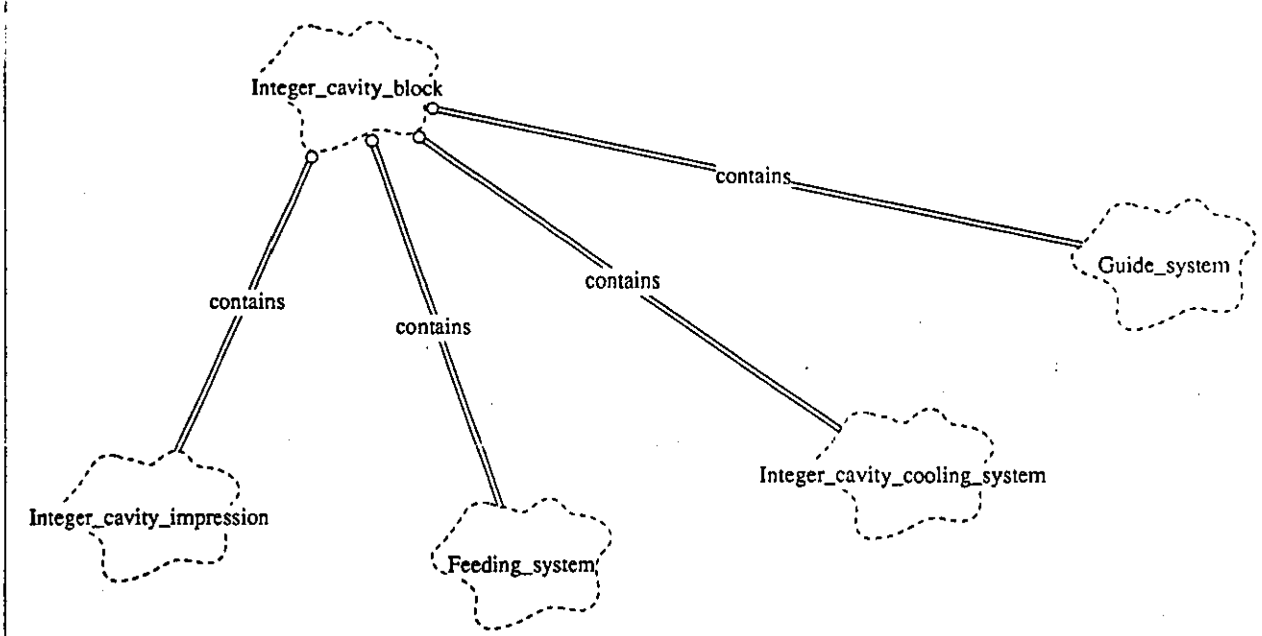
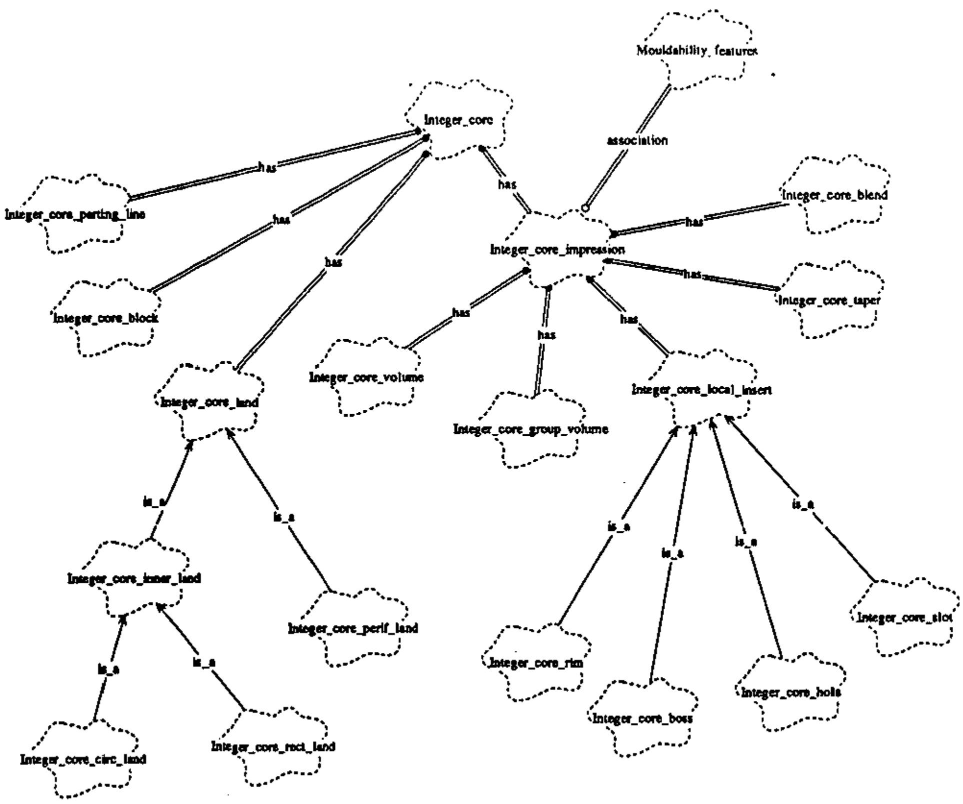
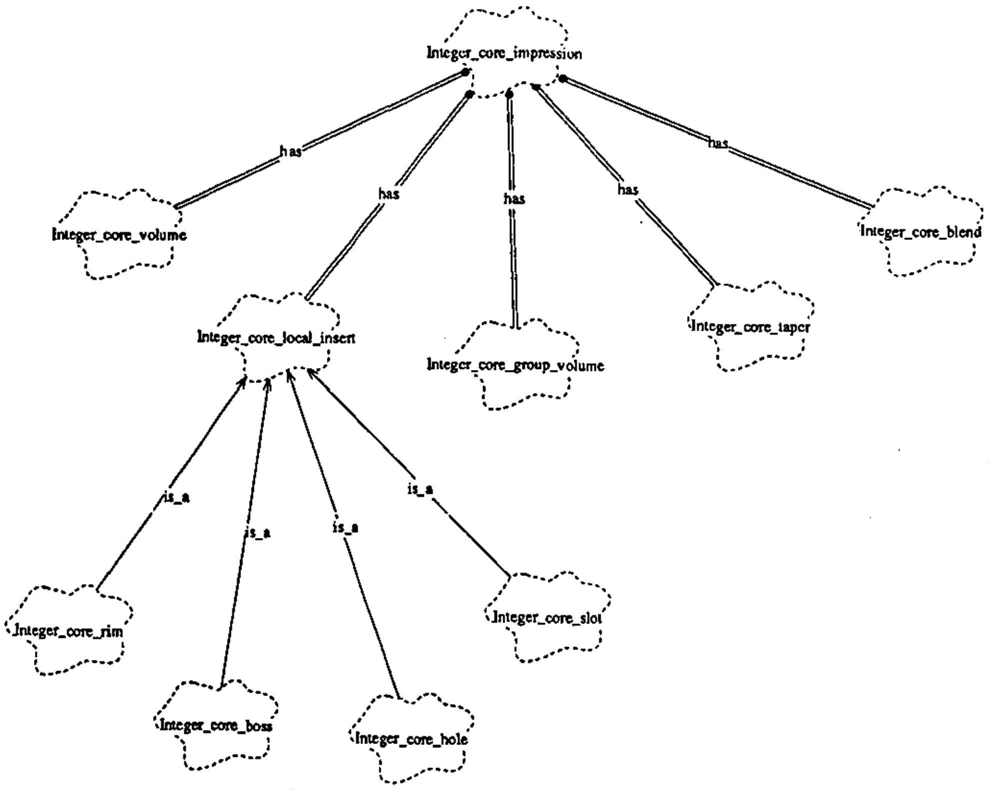
Title:	Class Diagram: Cavity_block_relationships
Printed on:	Tuesday, November 21, 1995
Printed by:	enrjvl



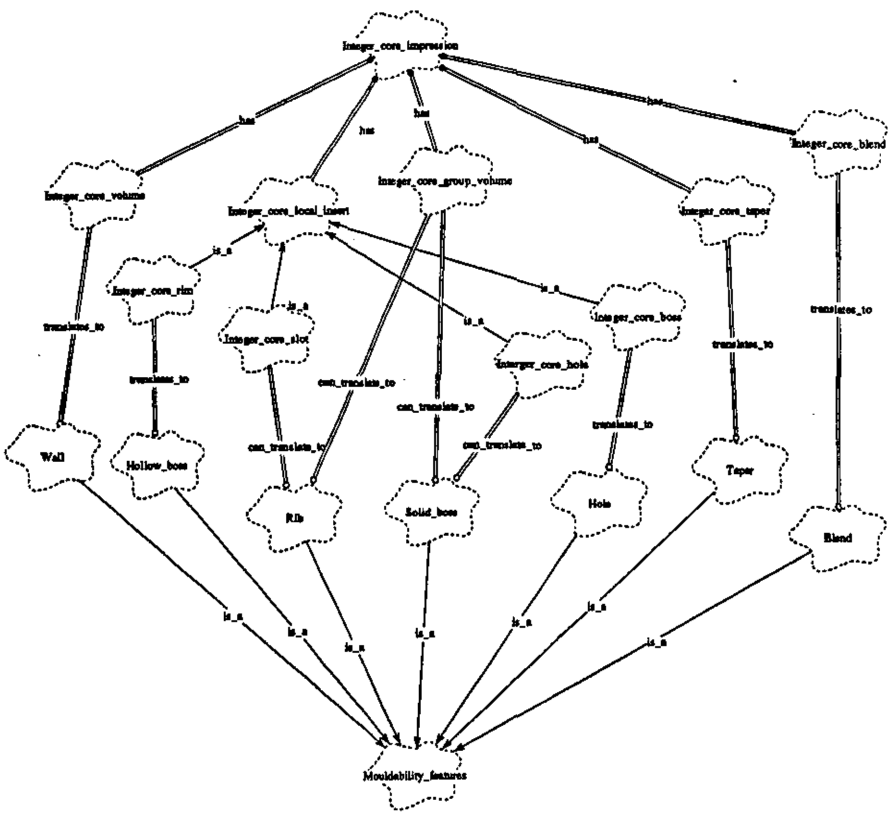
Project:	ron
Title:	Class Diagram: Integer_core
Printed on:	Thursday, November 30, 1995
Printed by:	enrjvl



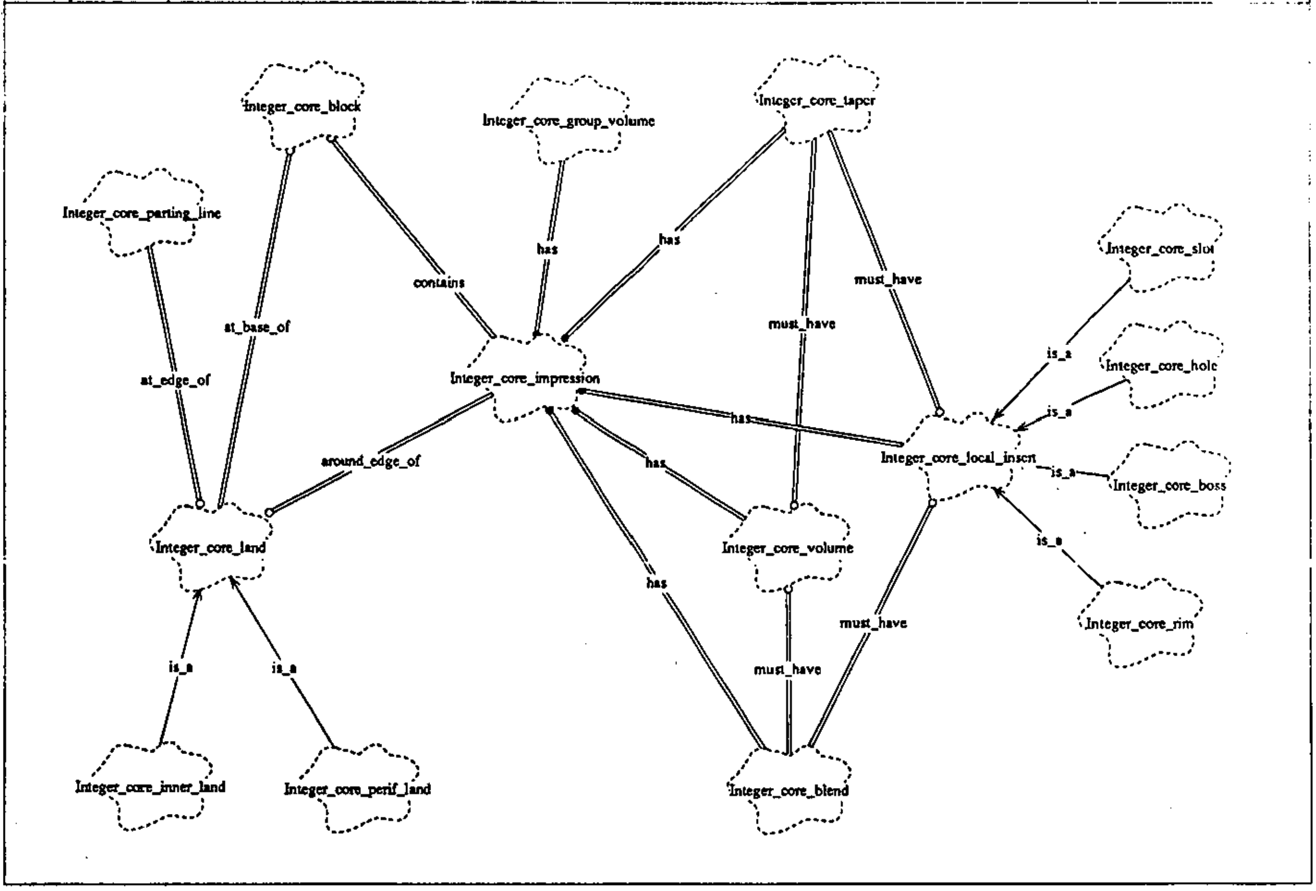
Project: ron
Title: Class Diagram: Integer_core_impression_only
Printed on: Tuesday, October 31, 1995
Printed by: enrjvl



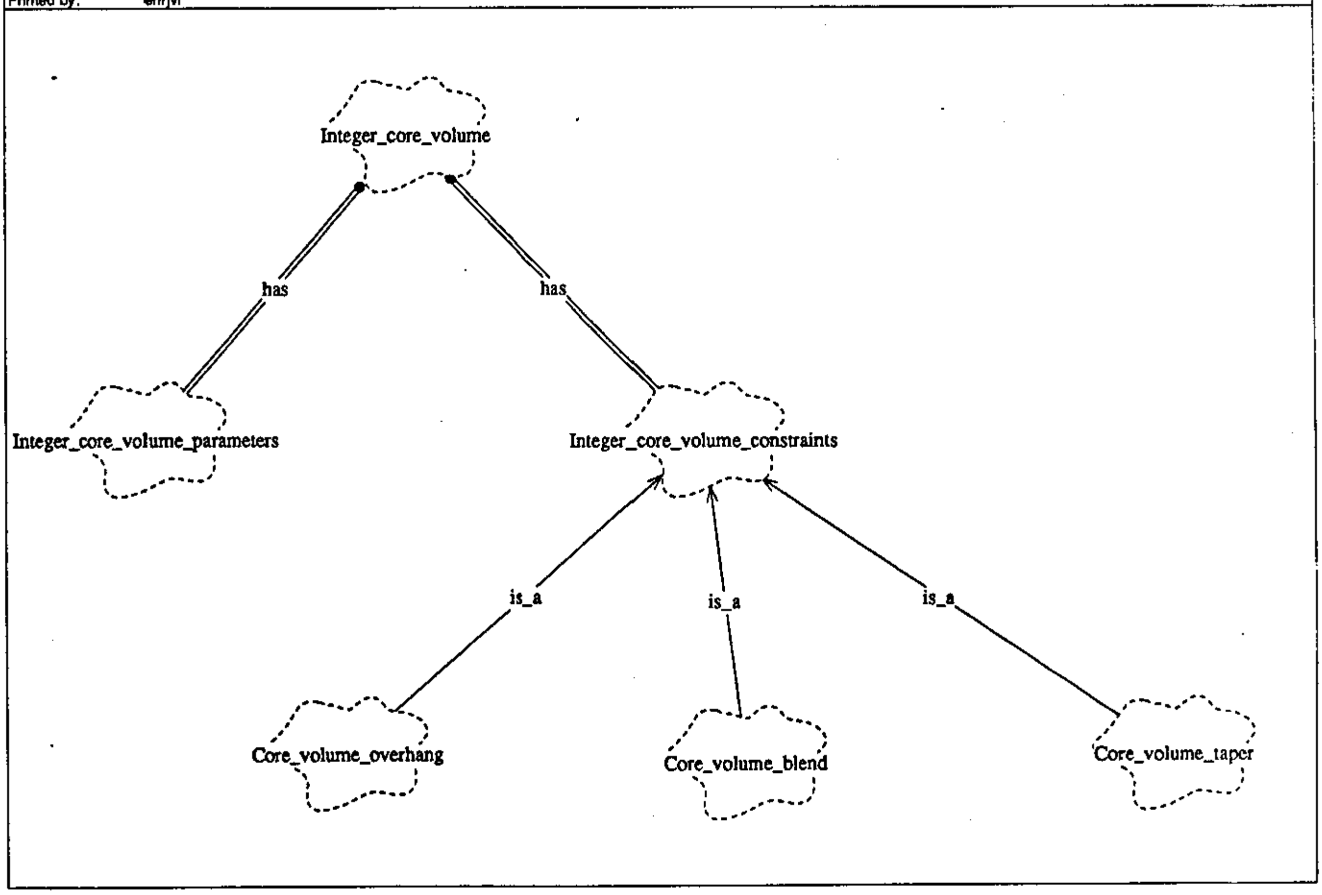
Project: ron
Title: Class Diagram: Integer_core_mouldability
Printed on: Sunday, December 17, 1995
Printed by: enrjvl



Project:	ron
Title:	Class Diagram: Integer_core_relationships
Printed on:	Tuesday, October 31, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_core_volume
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Integer_core_rim
Printed on:	Friday, August 18, 1995
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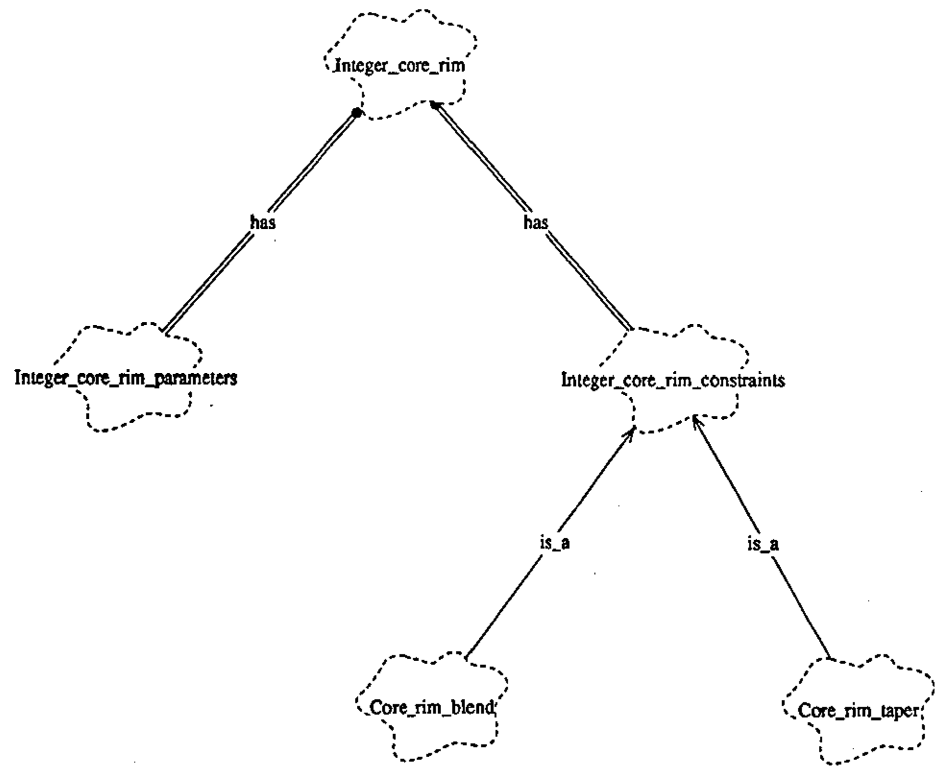

Project:	ron
Title:	Class Diagram: Integer_core_slot
Printed on:	Tuesday, August 15, 1995
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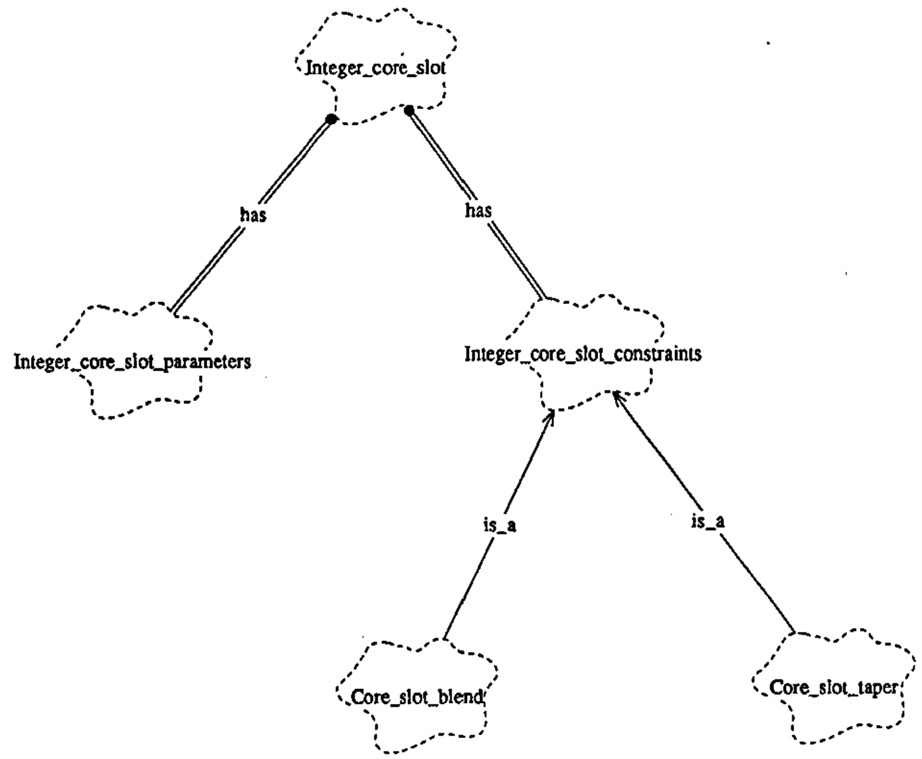

Project:	ron
Title:	Class Diagram: Integer_core_hole
Printed on:	Thursday, August 17, 1995
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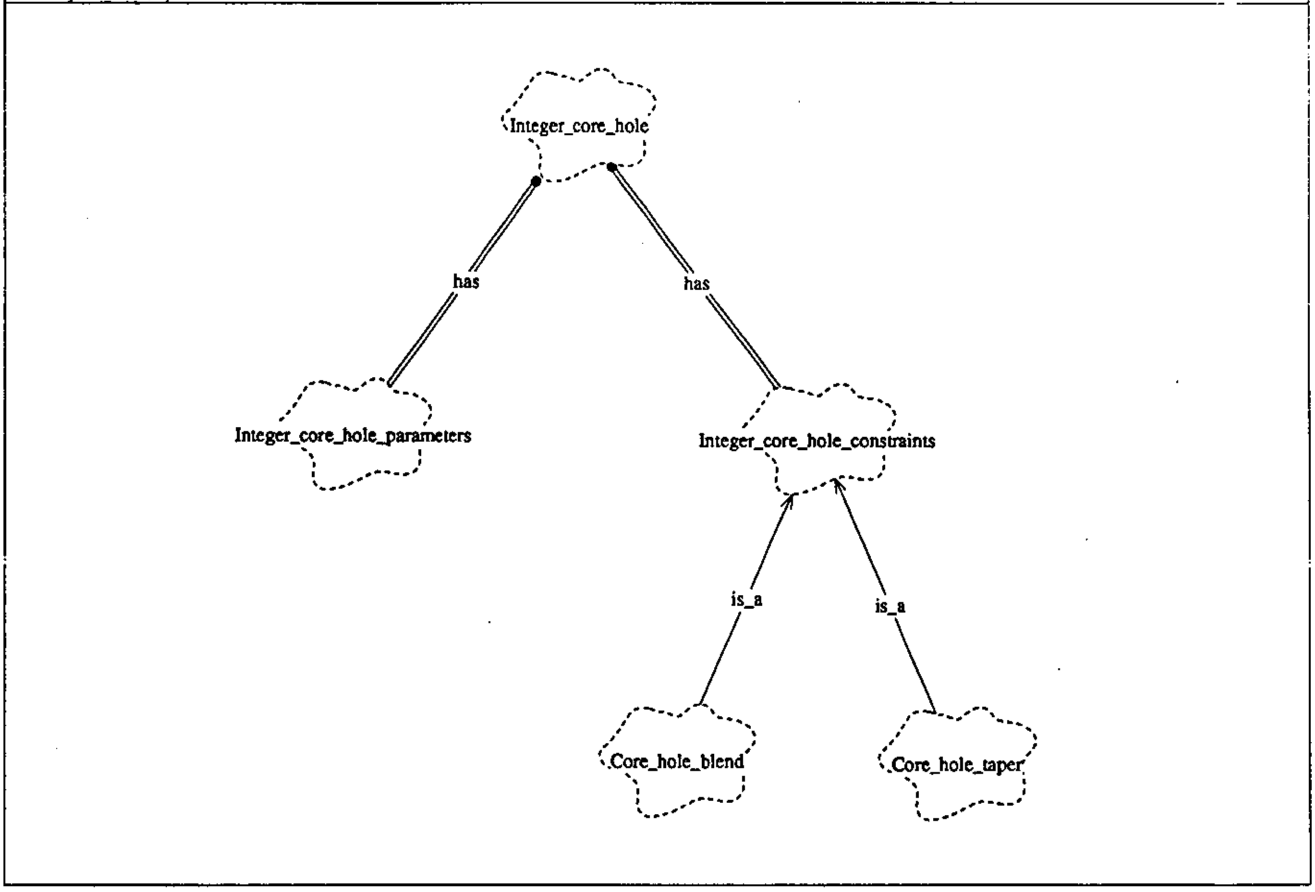

Project:	ron
Title:	Class Diagram: Integer_core_boss
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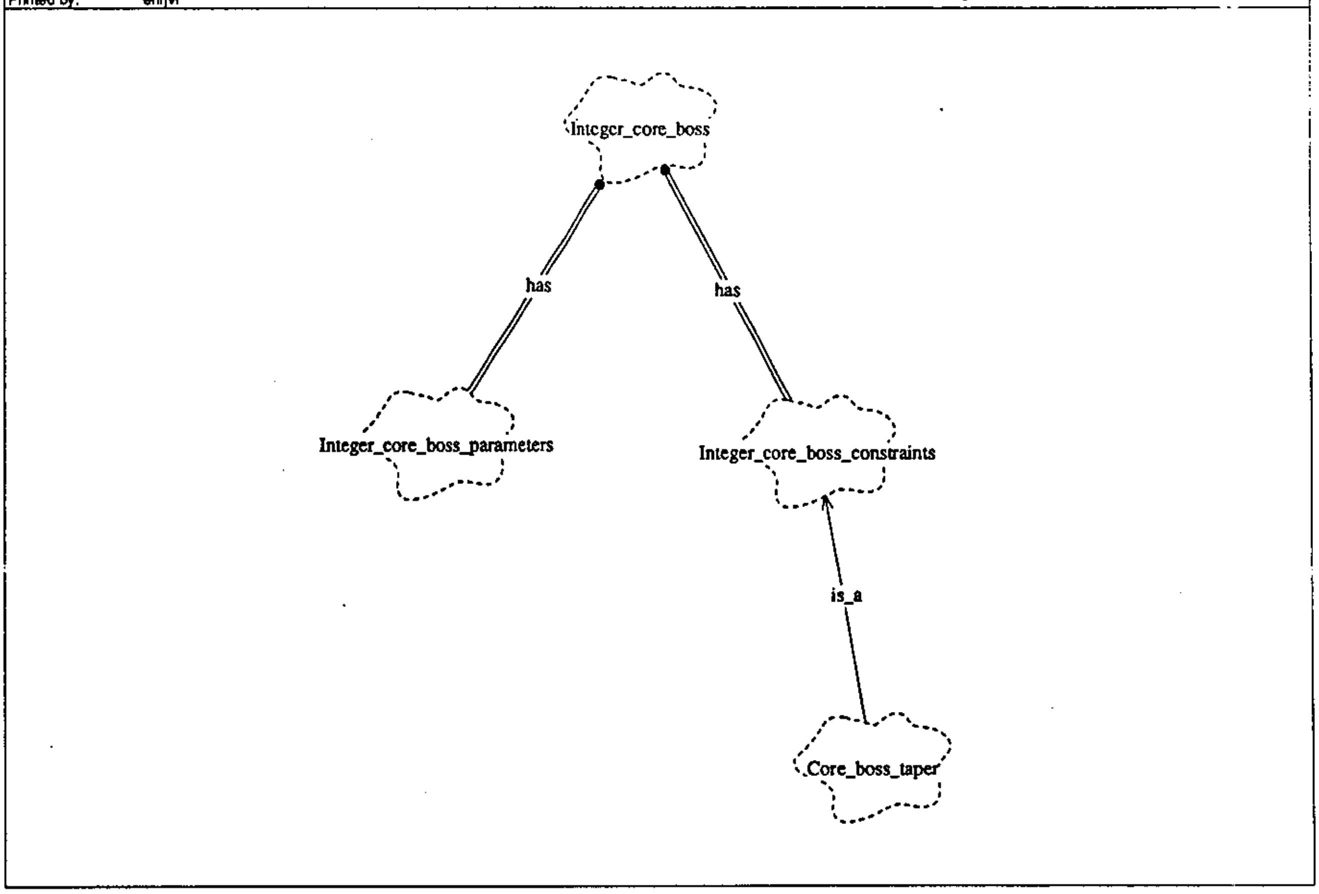
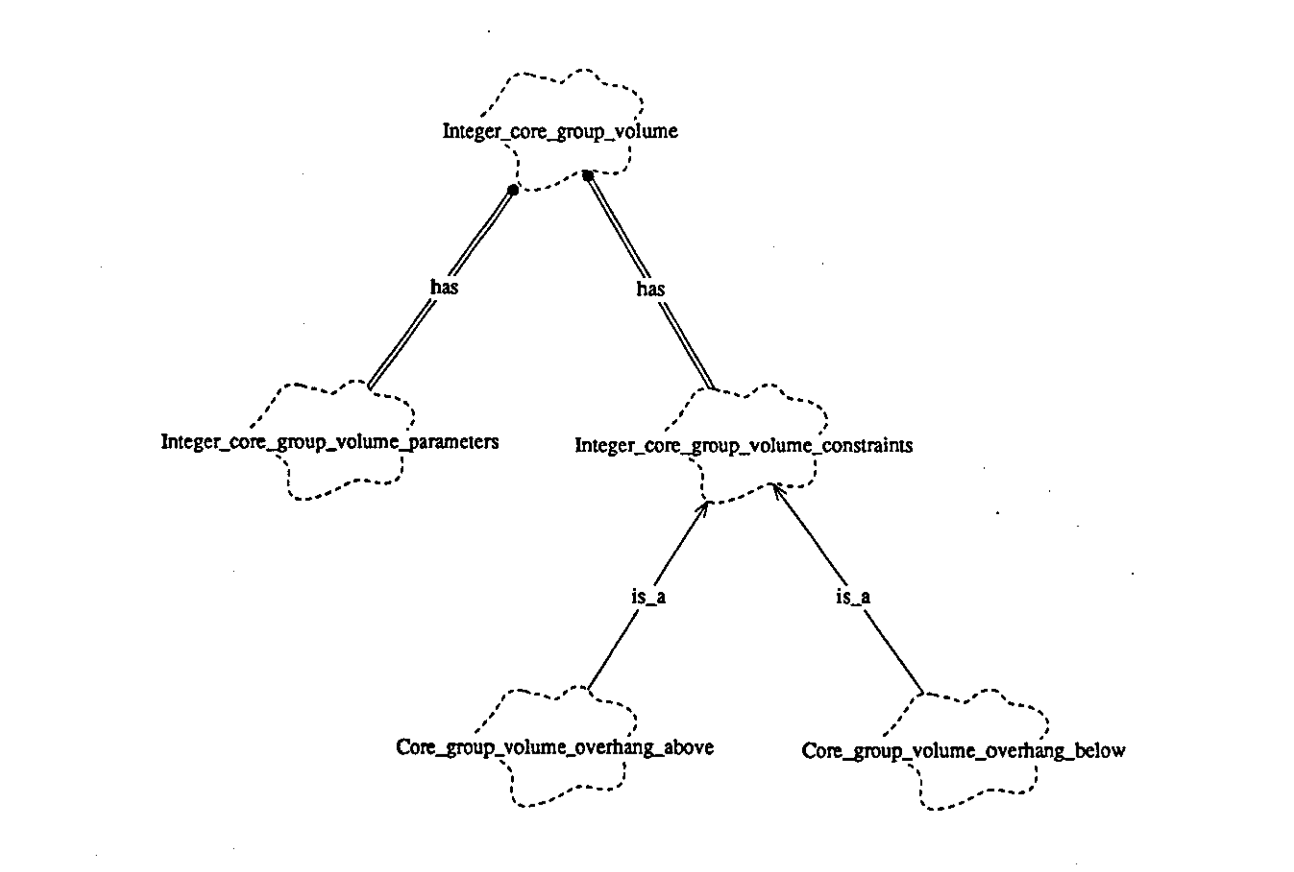
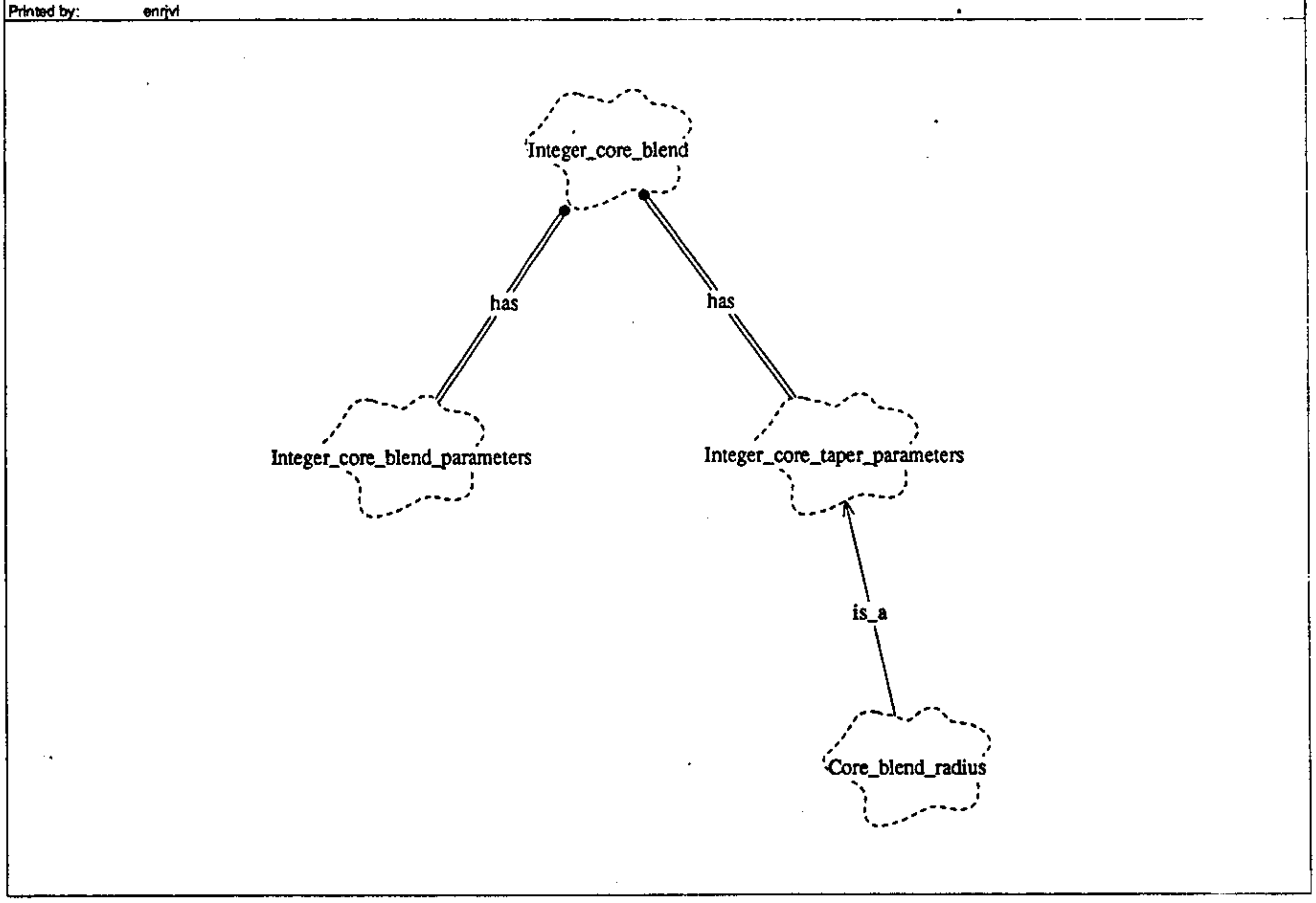


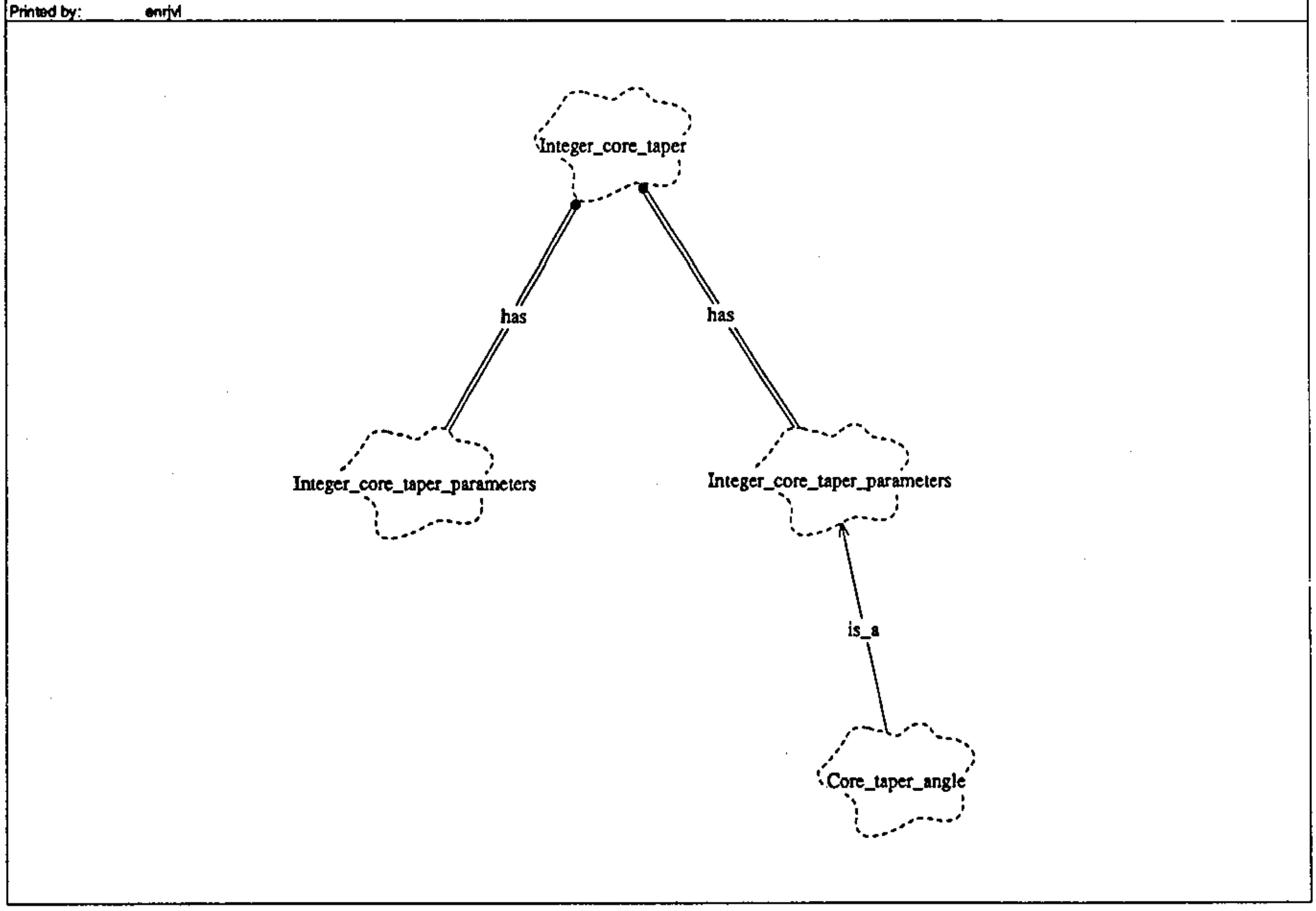
Project: ron
Title: Class Diagram: Integer_core_group_volume
Printed on: Tuesday, August 15, 1995
Printed by: enrjvl



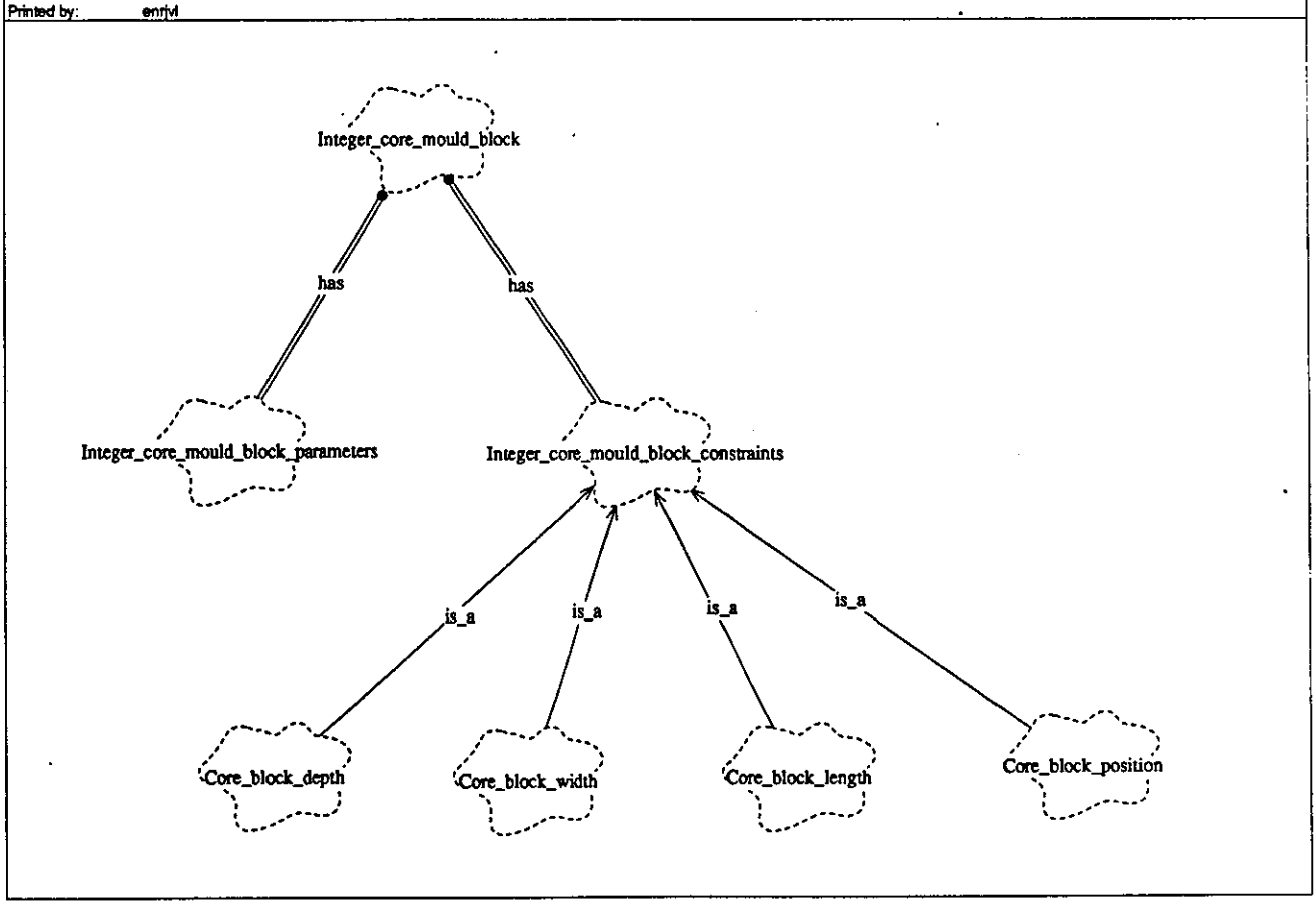
Project: ron
Title: Class Diagram: Integer_core_blend
Printed on: Tuesday, August 15, 1995
Printed by: enrjvl



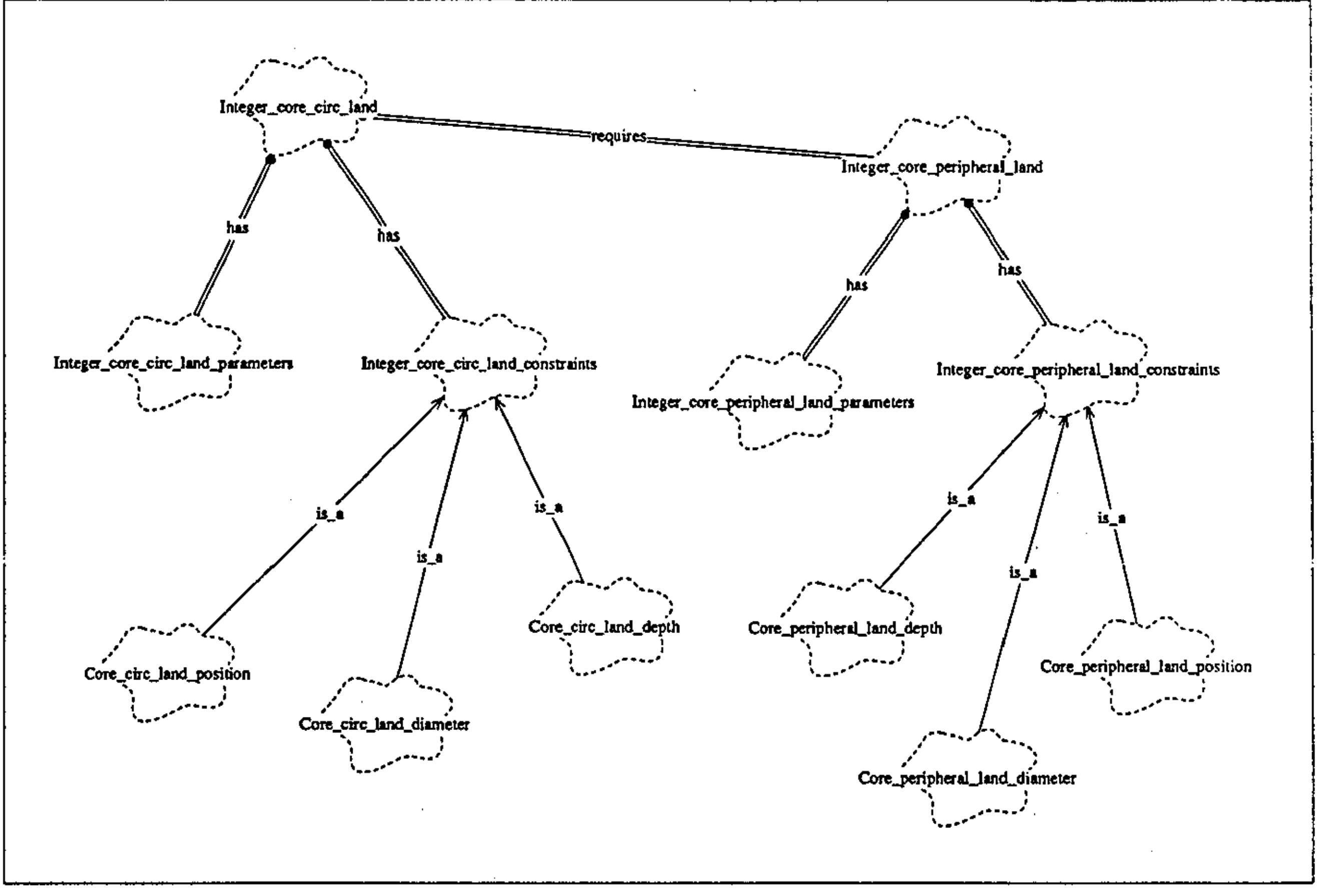
Project:	ron
Title:	Class Diagram: Integer_core_taper
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



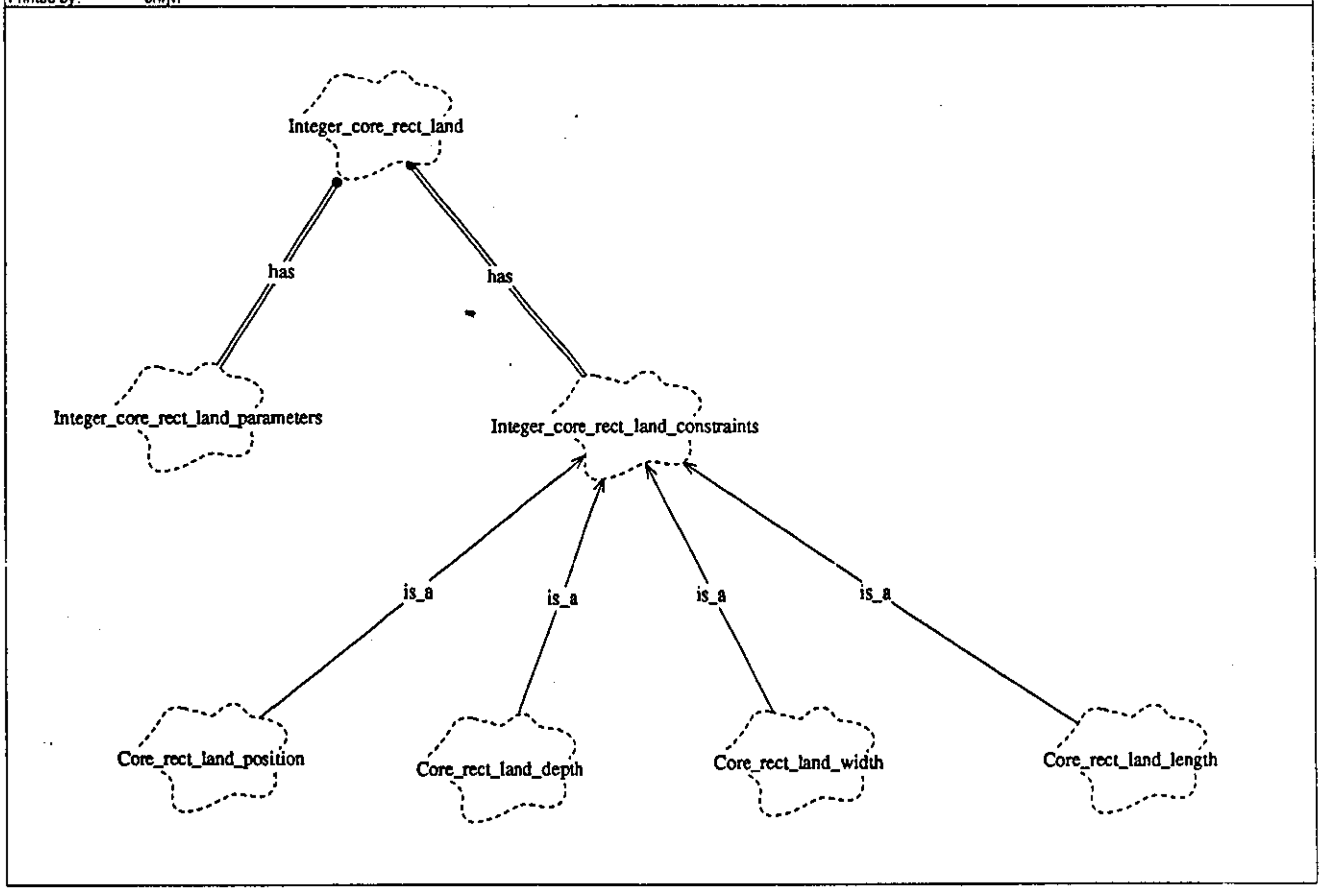
Project:	ron
Title:	Class Diagram: Integer_core_mould_block
Printed on:	Tuesday, December 19, 1995
Printed by:	enrjvl



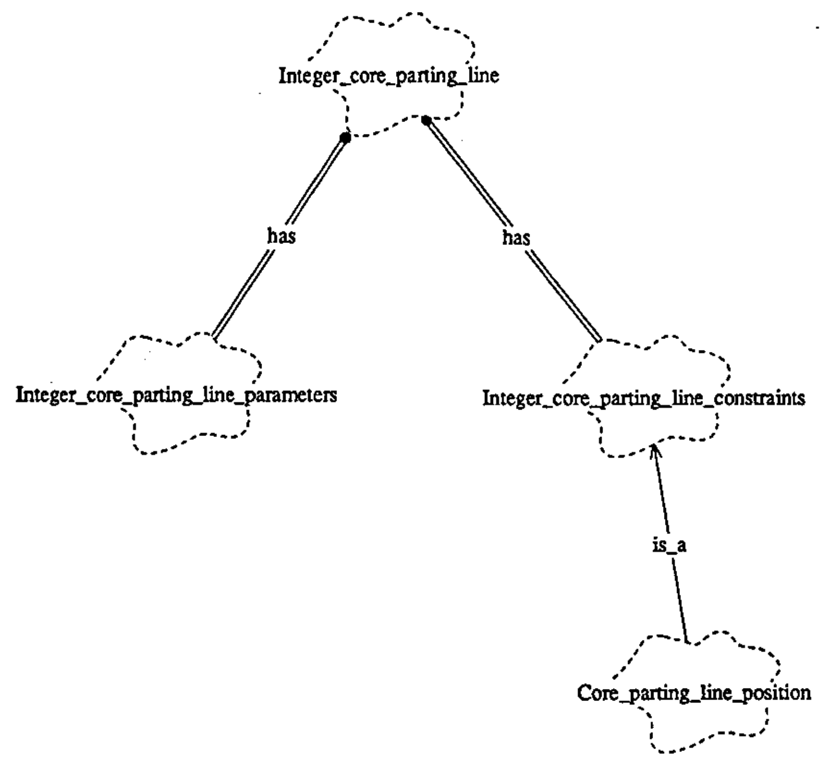
Project:	ron
Title:	Class Diagram: Integer_core_circ_perif_lands
Printed on:	Friday, August 18, 1995
Printed by:	enrjvl



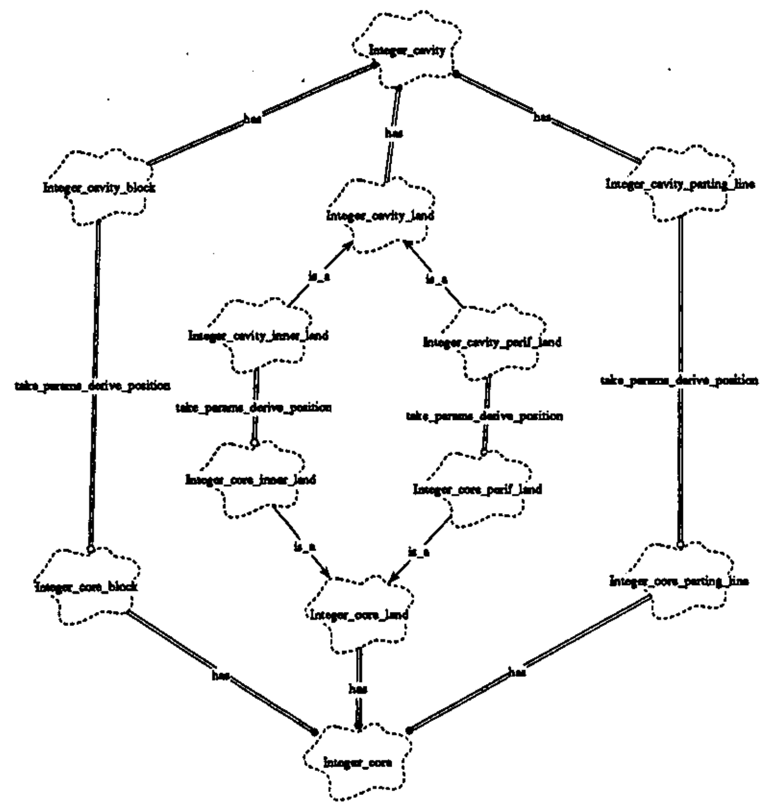
Project:	ron
Title:	Class Diagram: Integer_core_rect_land
Printed on:	Friday, August 18, 1995
Printed by:	enrjvl



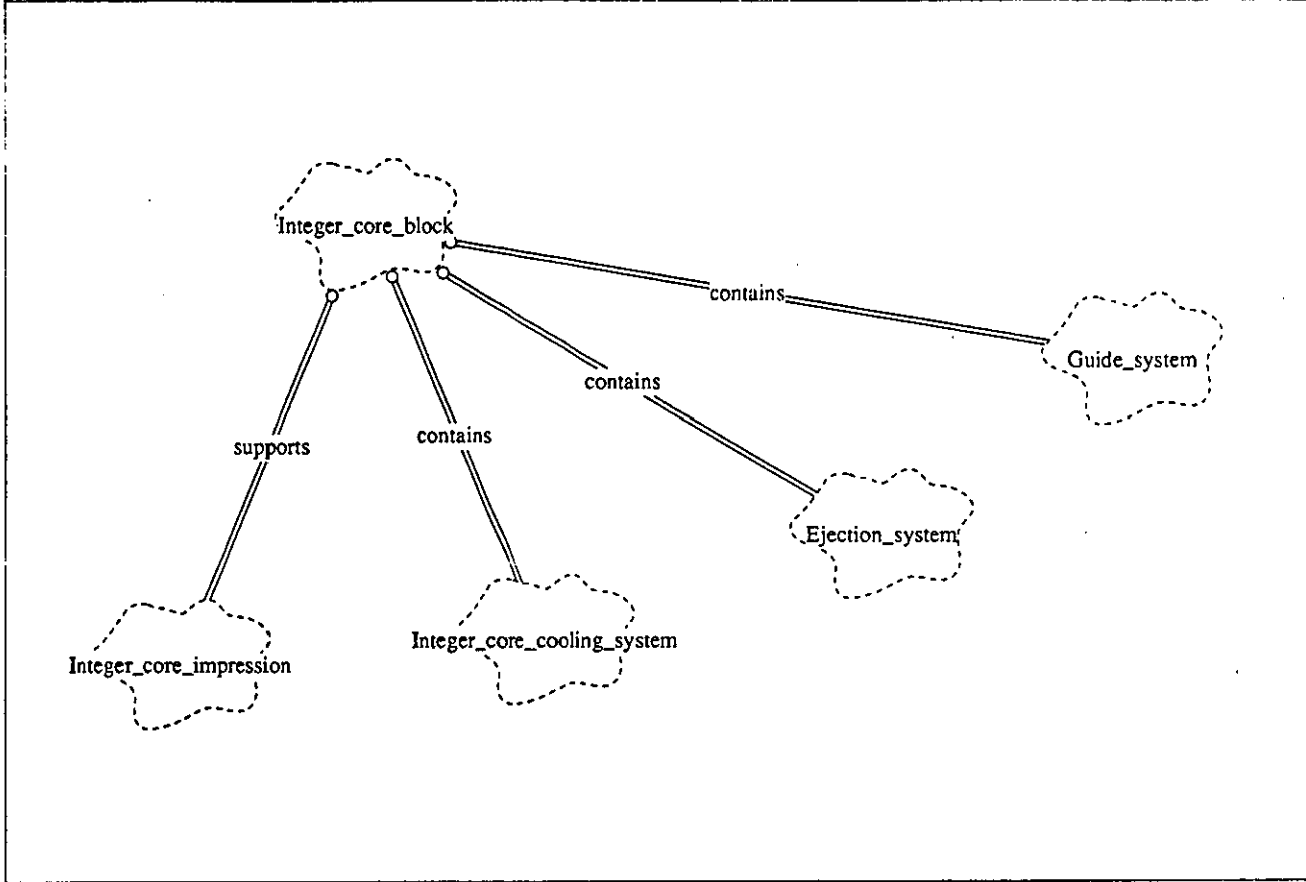
Project:	ron
Title:	Class Diagram: Integer_core_parting_line
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



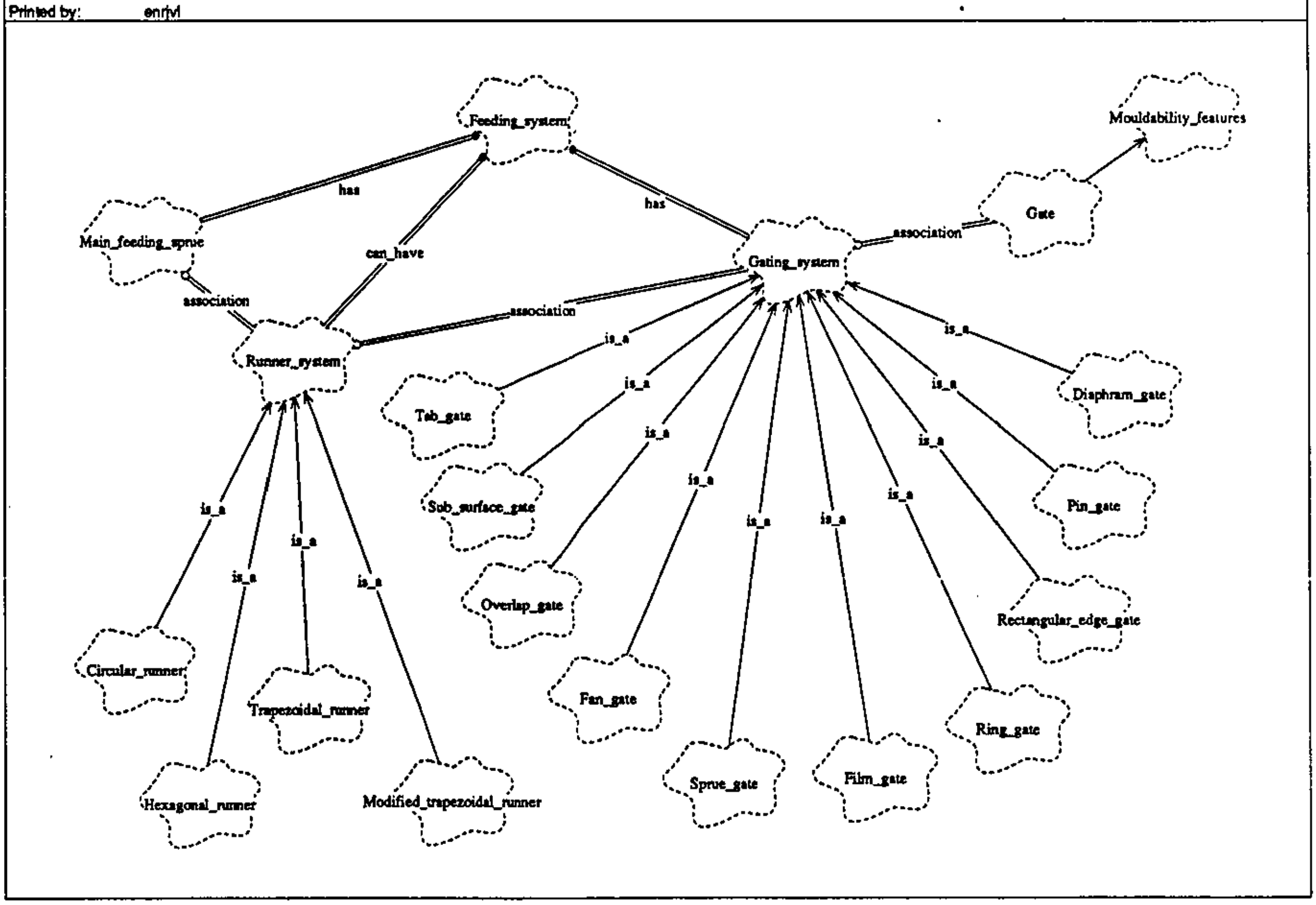
Project:	ron
Title:	Class Diagram: Cavity_core_relationships
Printed on:	Monday, March 27, 1995
Printed by:	enrjvl



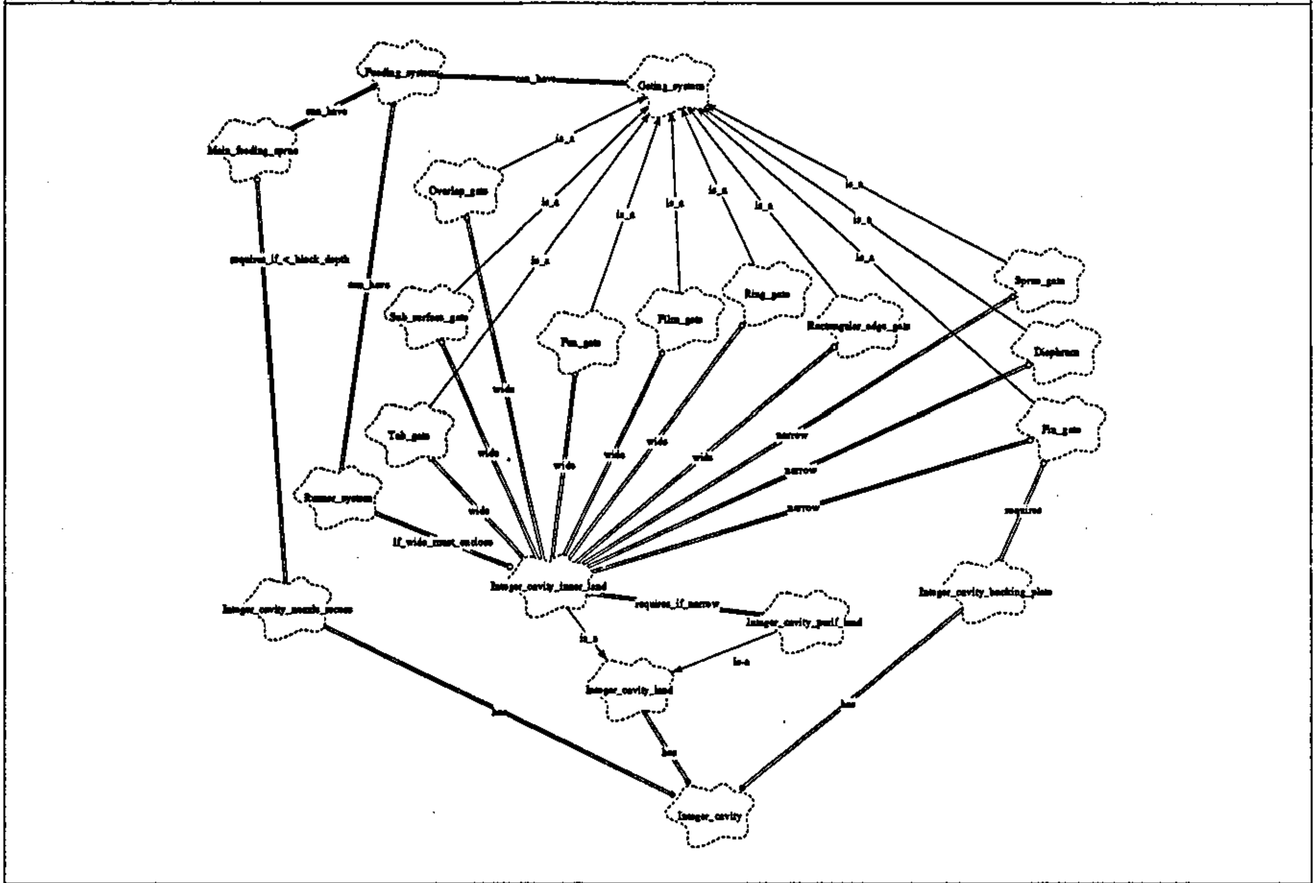
Project:	ron
Title:	Class Diagram: Core_block_relationships
Printed on:	Tuesday, November 21, 1995
Printed by:	enrjvl



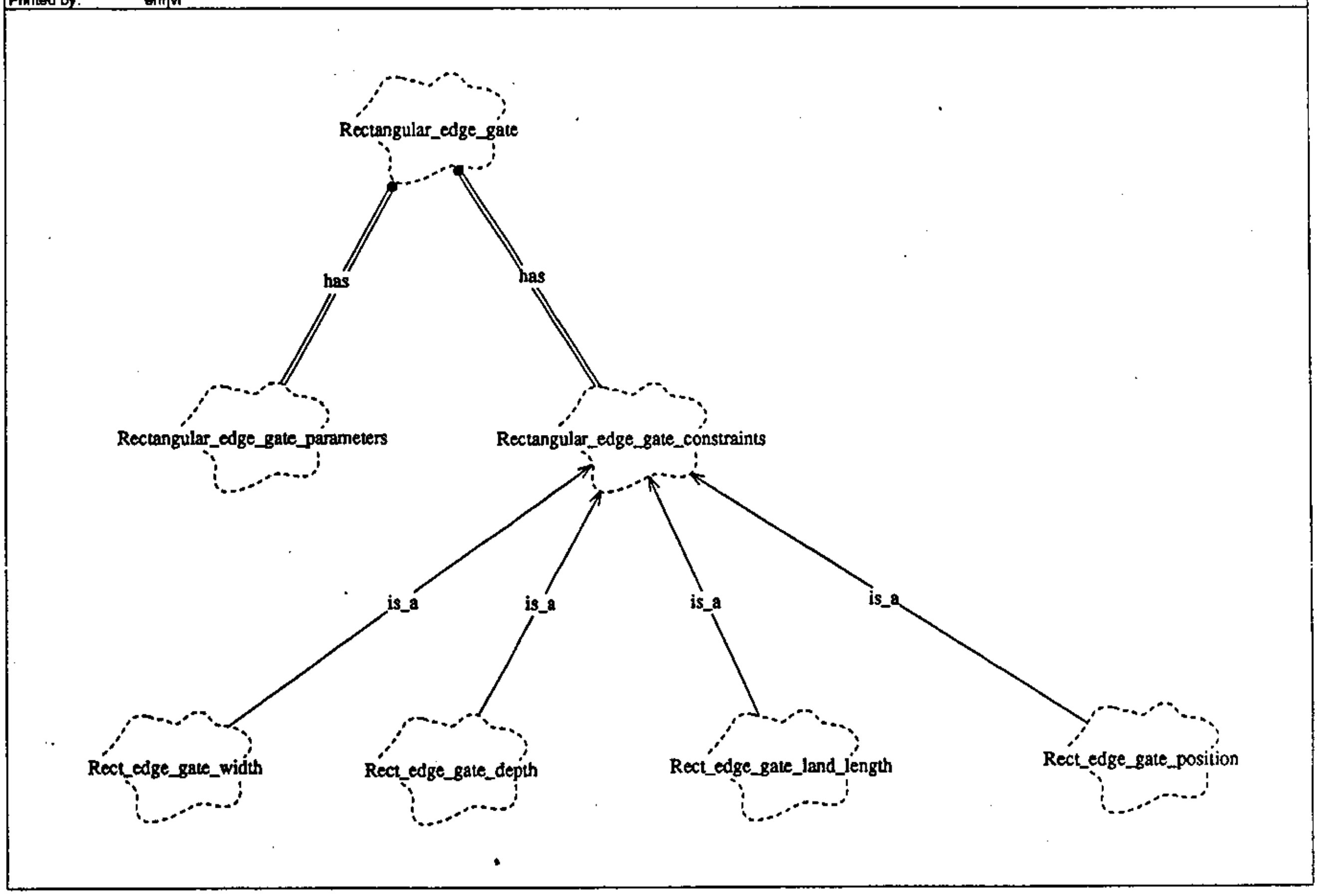
Project:	ron
Title:	Class Diagram: Feeding_system
Printed on:	Monday, March 13, 1995
Printed by:	enrjvl

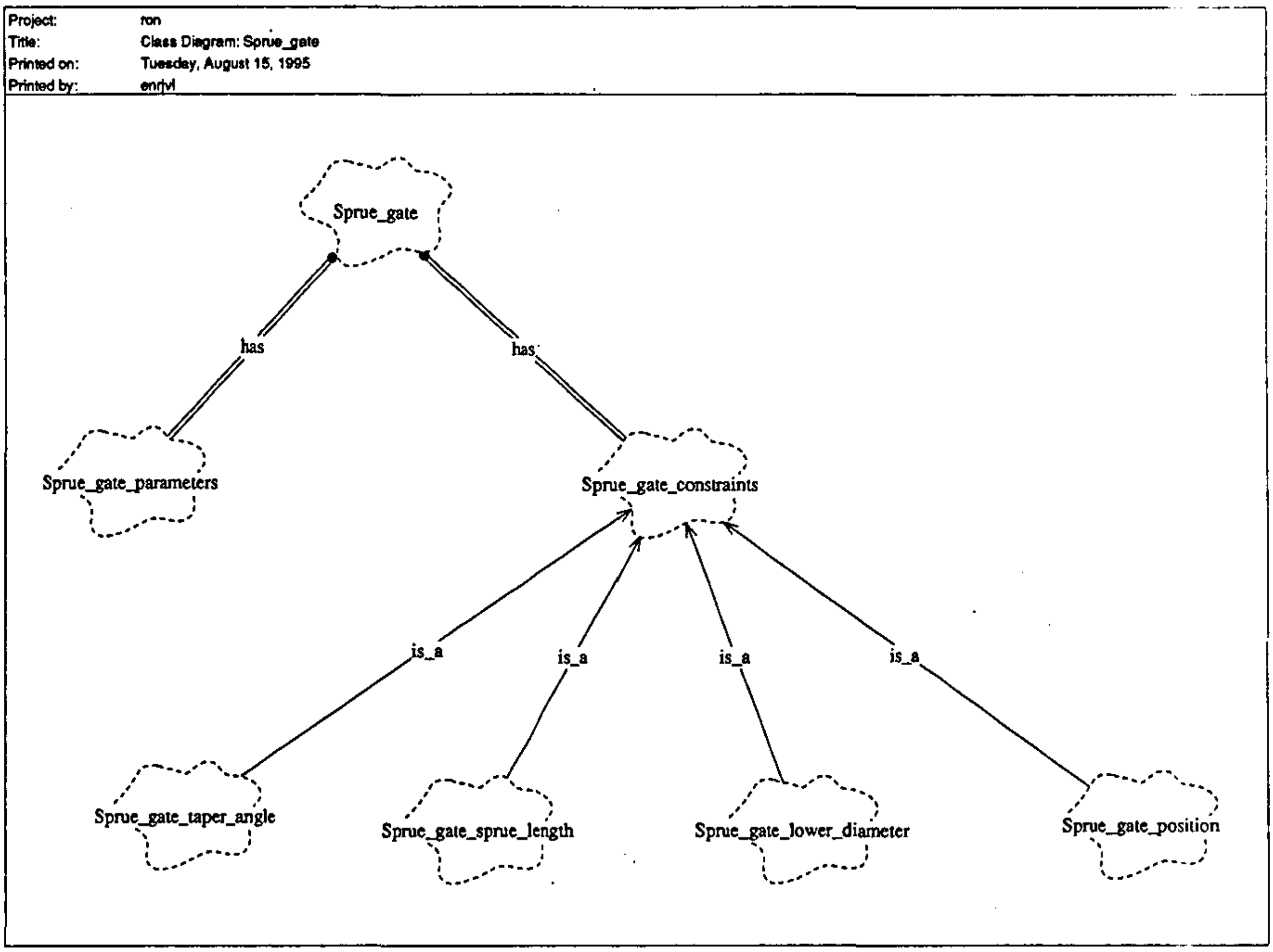


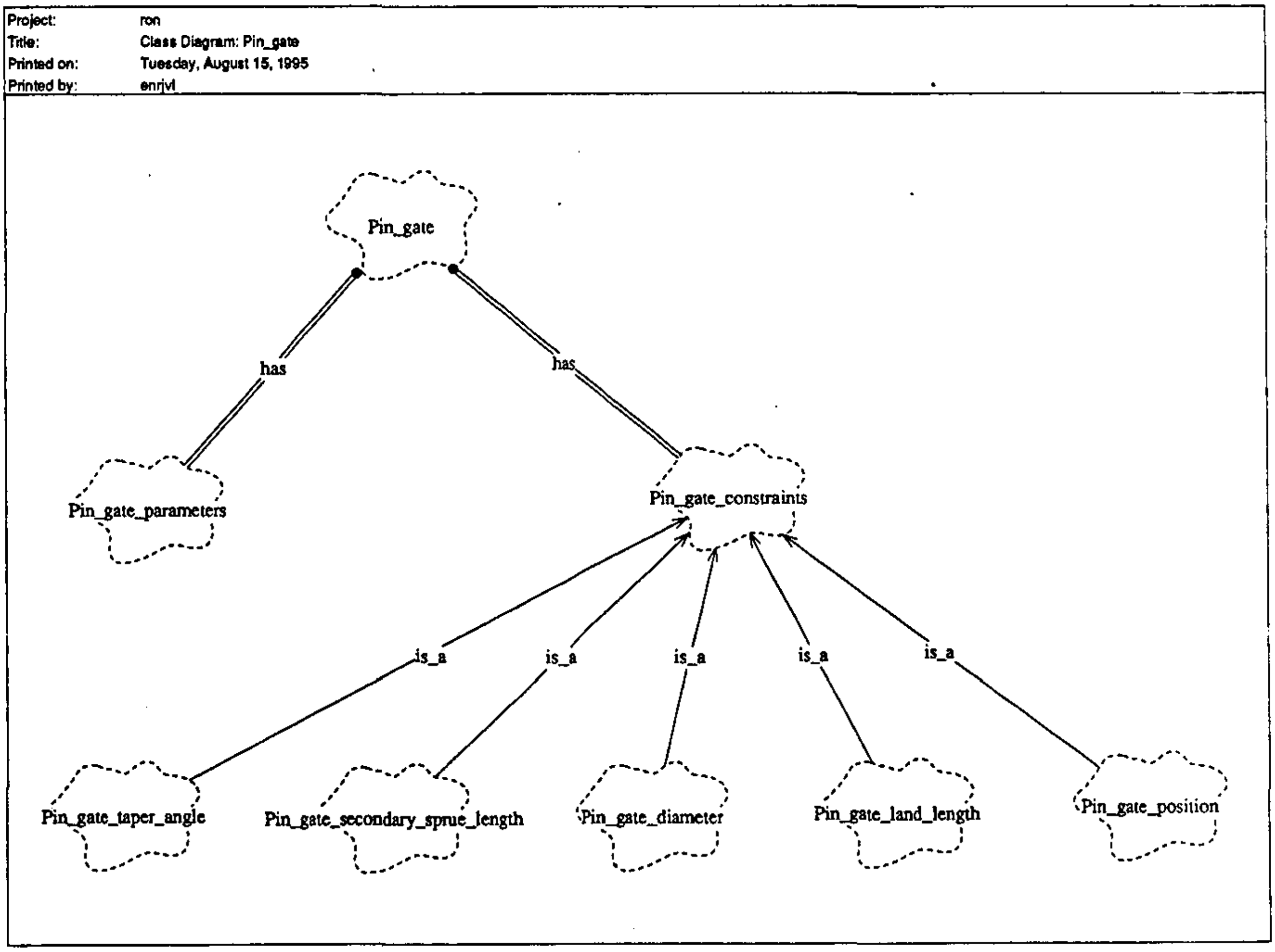
Project:	ron
Title:	Class Diagram: Gating_system_and_non_impression_cavity
Printed on:	Wednesday, March 15, 1995
Printed by:	enrjvl

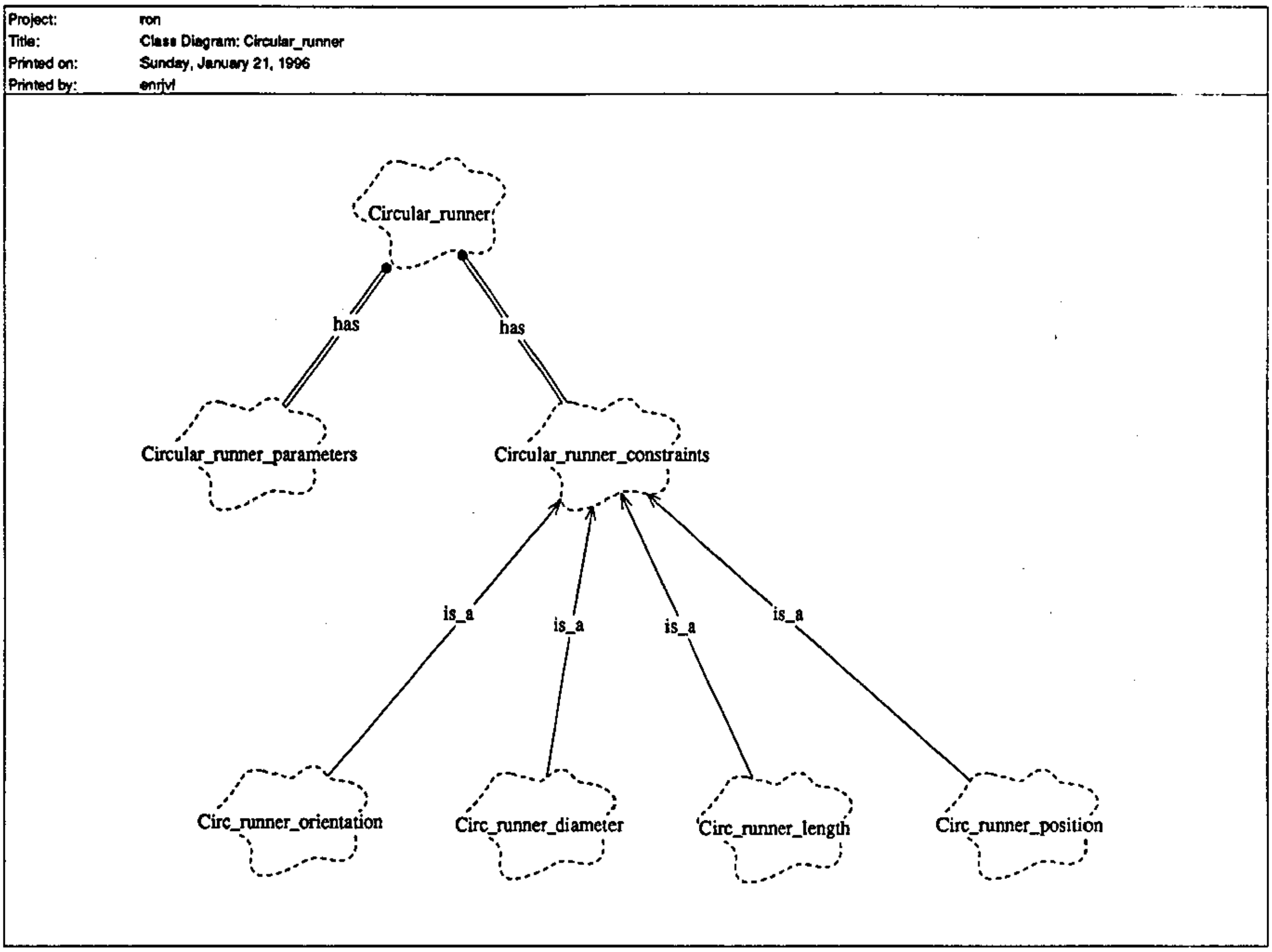


Project:	ron
Title:	Class Diagram: Rectangular_edge_gate
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl

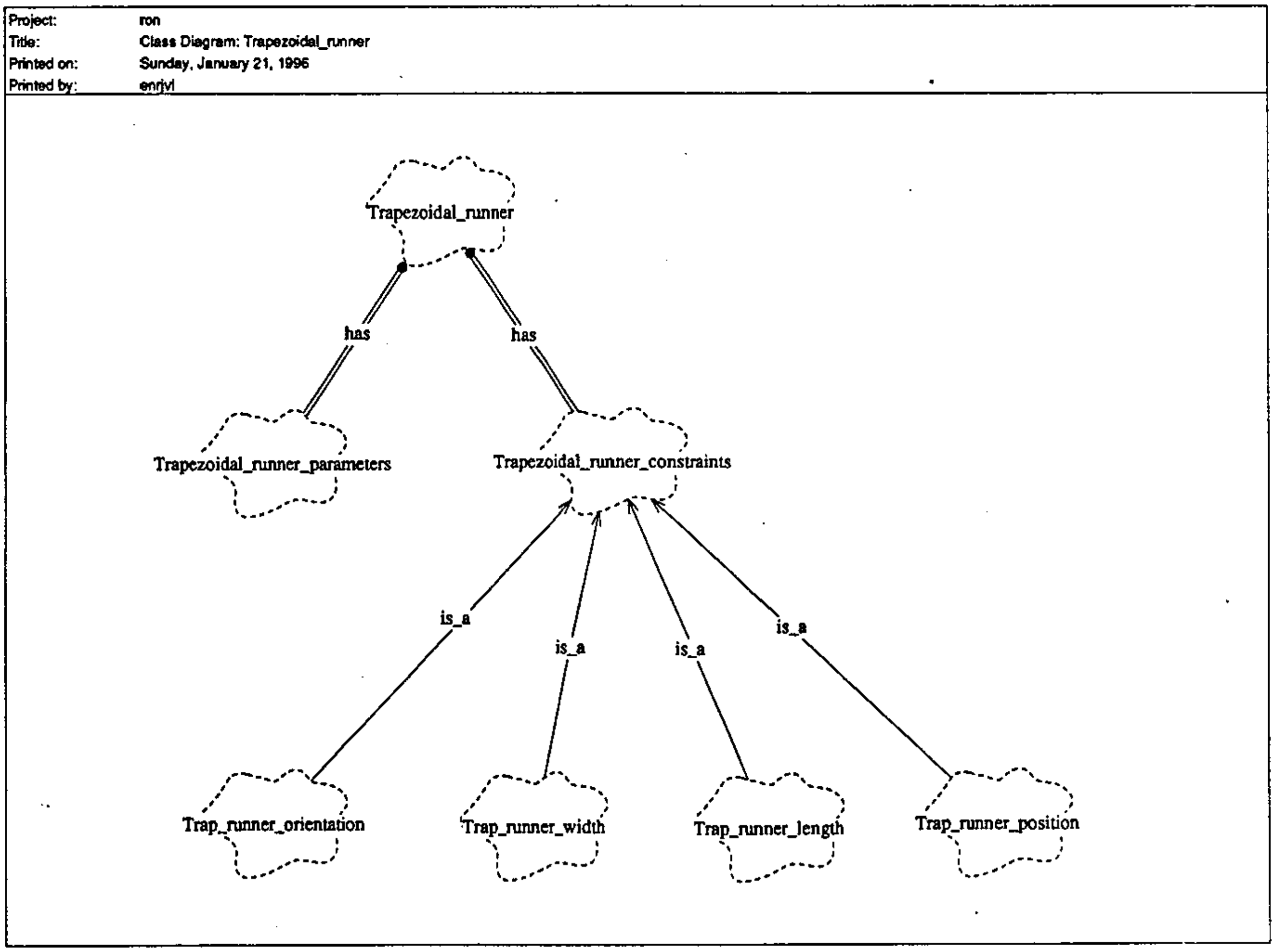



Project: ron
Title: Class Diagram: Sprue_gate
Printed on: Tuesday, August 15, 1995
Printed by: enrjvl
Sprue_gate
has
has
Sprue_gate_parameters
Sprue_gate_constraints
is_a
is_a
is_a
is_a
Sprue_gate_taper_angle
Sprue_gate_sprue_length
Sprue_gate_lower_diameter
Sprue_gate_position


Project: ron
Title: Class Diagram: Pin_gate
Printed on: Tuesday, August 15, 1995
Printed by: enrjvl
Pin_gate
has
has
Pin_gate_parameters
Pin_gate_constraints
is_a
is_a
is_a
is_a
is_a
Pin_gate_taper_angle
Pin_gate_secondary_sprue_length
Pin_gate_diameter
Pin_gate_land_length
Pin_gate_position

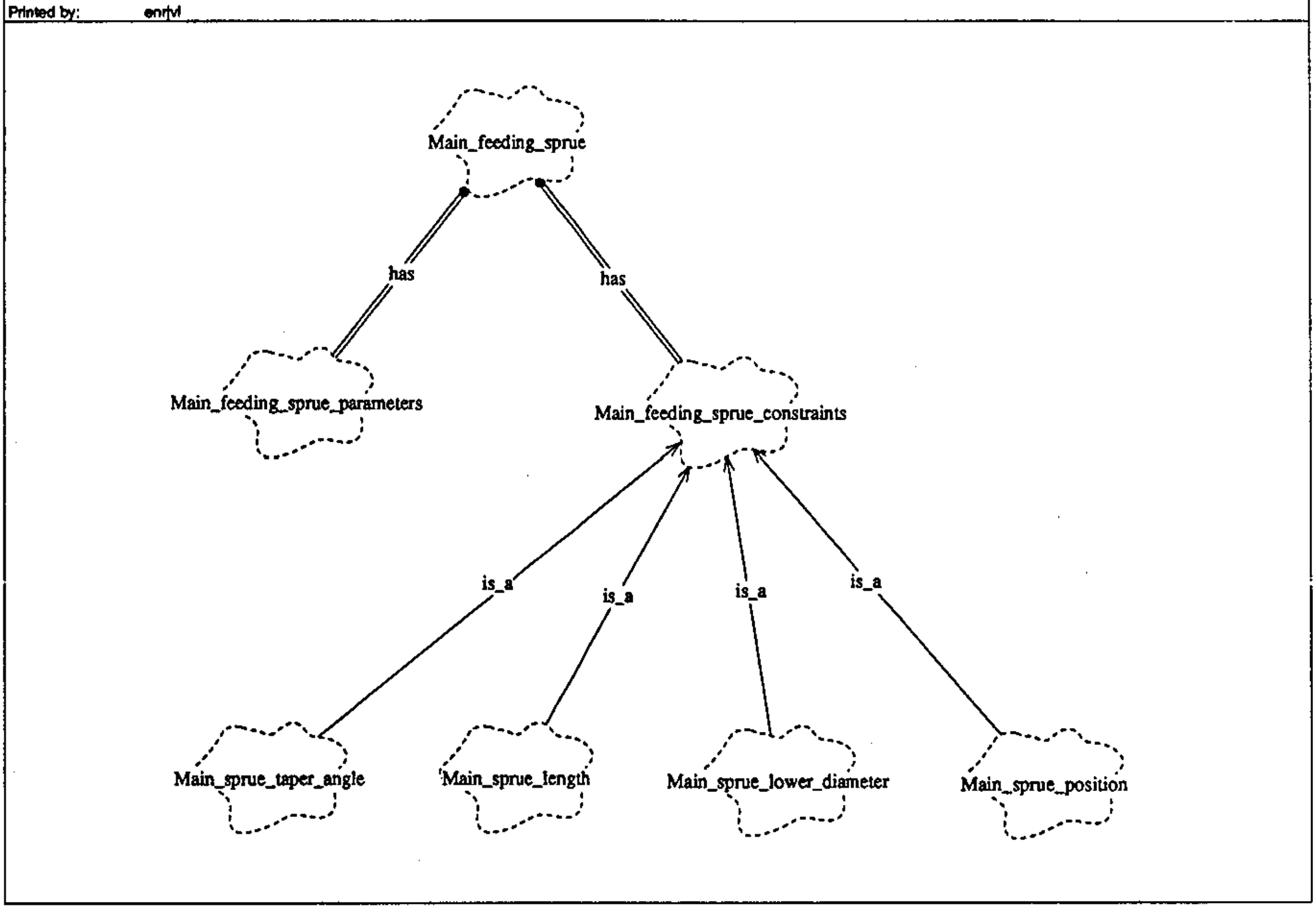


Project: ron
Title: Class Diagram: Circular_runner
Printed on: Sunday, January 21, 1996
Printed by: enrjvl
Circular_runner
has
has
Circular_runner_parameters
Circular_runner_constraints
is_a
is_a
is_a
is_a
Circ_runner_orientation
Circ_runner_diameter
Circ_runner_length
Circ_runner_position

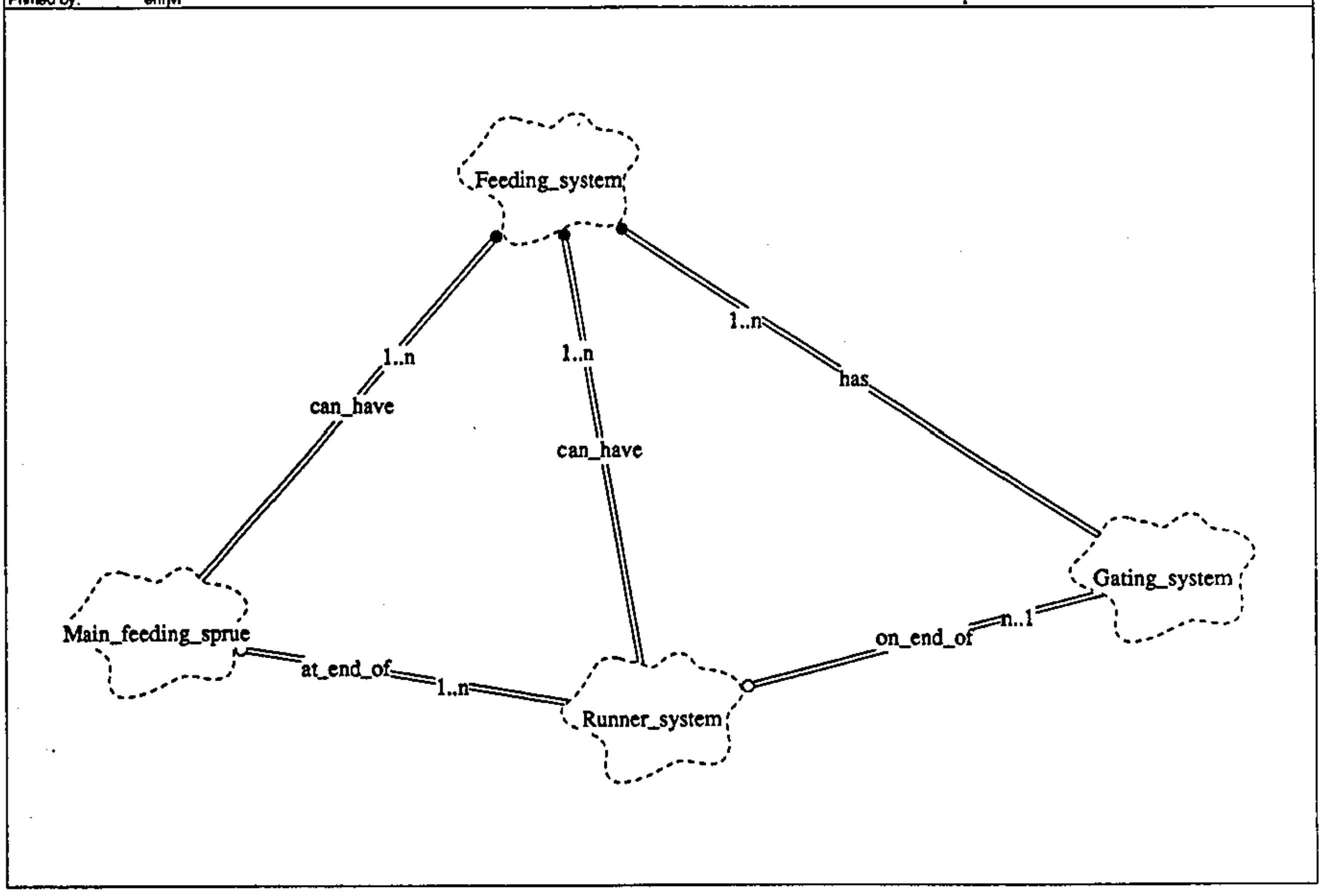


Project: ron
Title: Class Diagram: Trapezoidal_runner
Printed on: Sunday, January 21, 1996
Printed by: enrjvl
Trapezoidal_runner
has
has
Trapezoidal_runner_parameters
Trapezoidal_runner_constraints
is_a
is_a
is_a
is_a
Trap_runner_orientation
Trap_runner_width
Trap_runner_length
Trap_runner_position

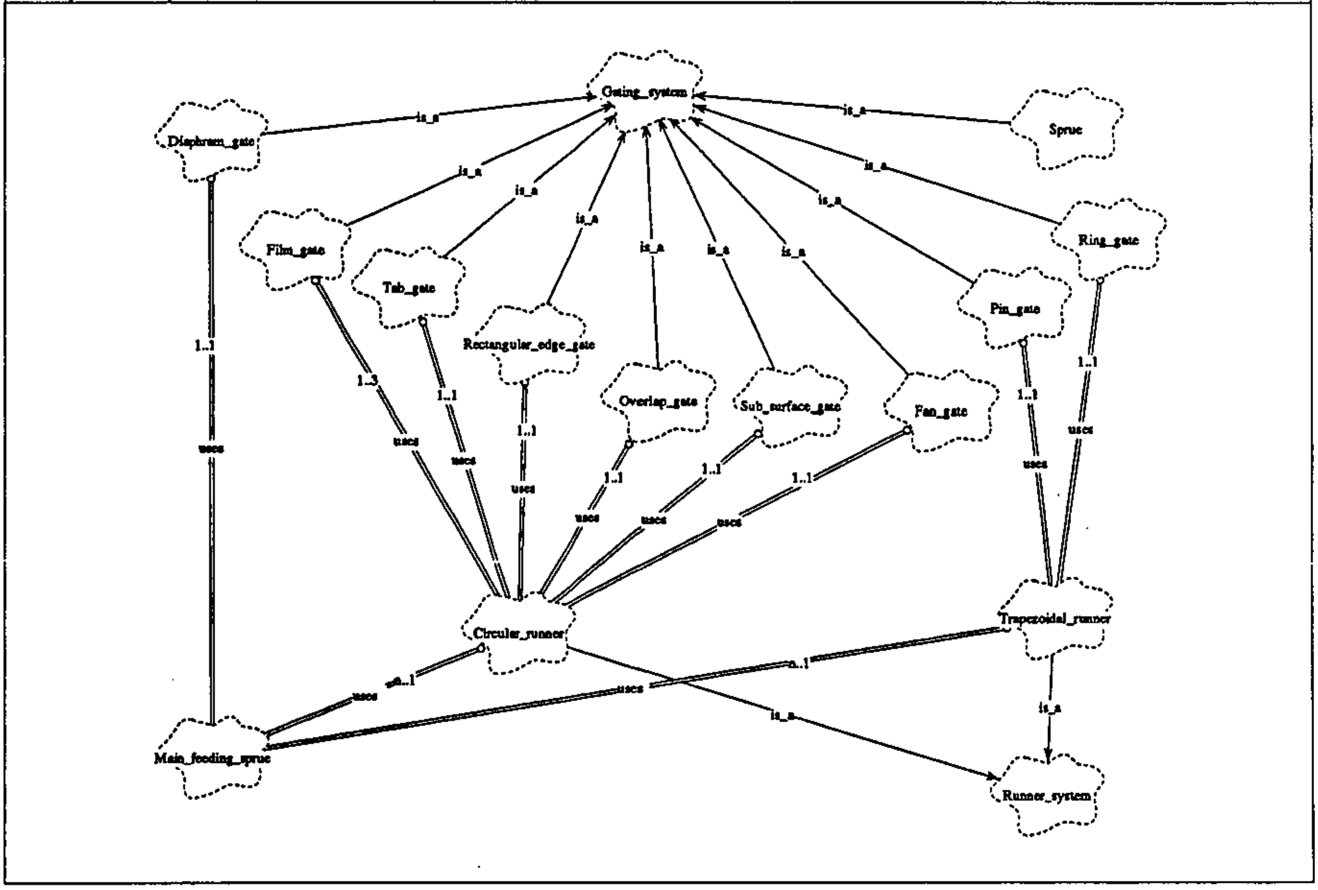
Project:	ron
Title:	Class Diagram: Main_feeding_sprue
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



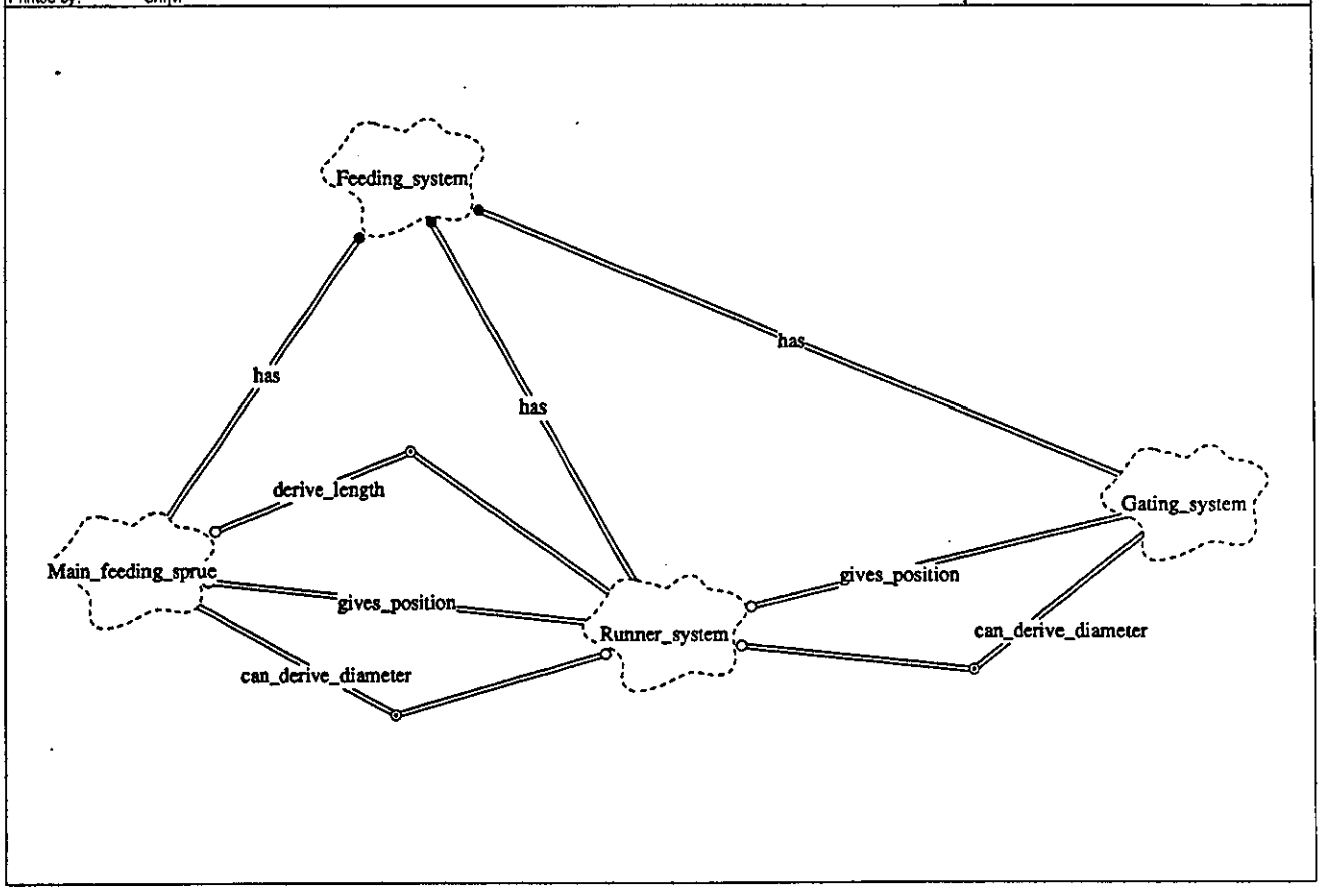
Project:	ron
Title:	Class Diagram: Feeding_system_fit_together
Printed on:	Monday, March 13, 1995
Printed by:	enrjvl



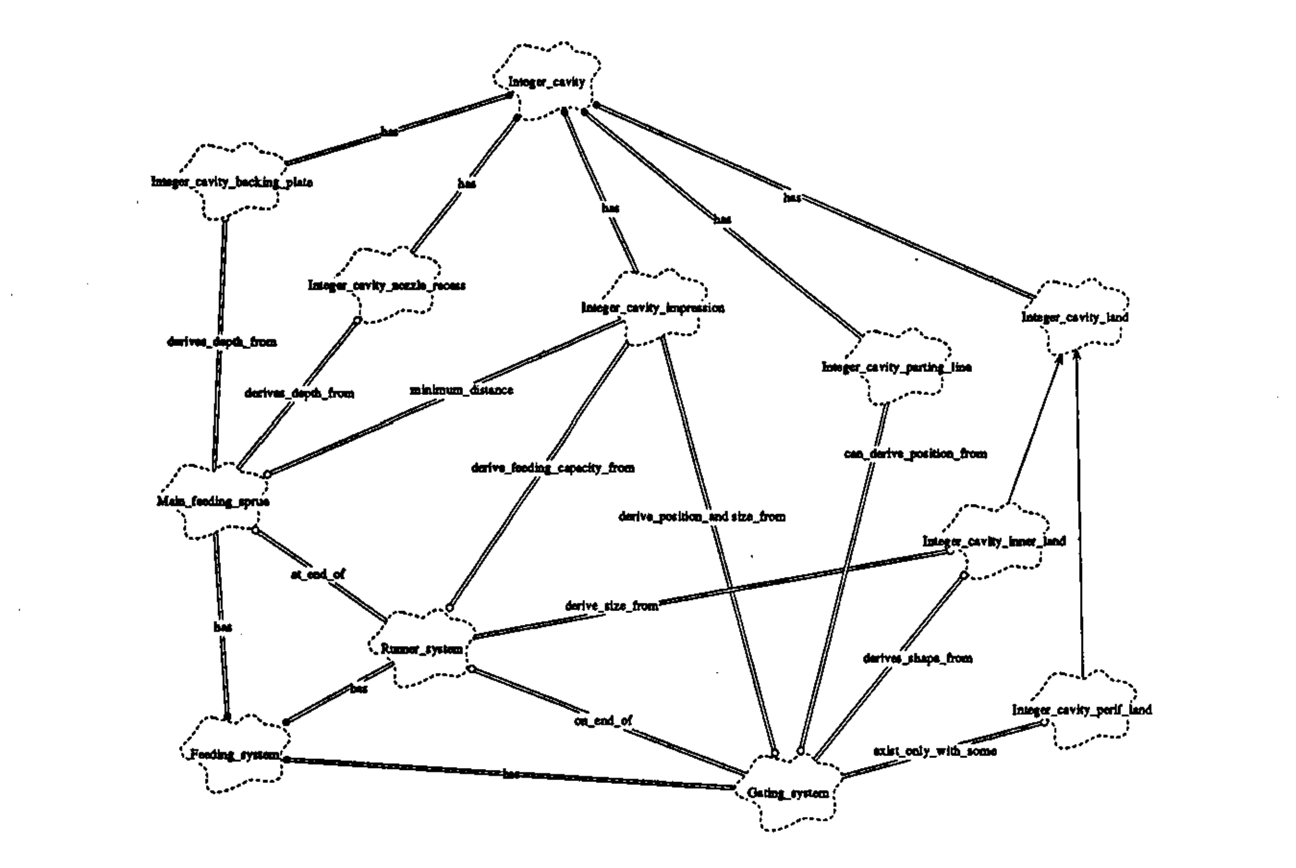
Project:	ron
Title:	Class Diagram: Gating_system_usage_of_other_elements
Printed on:	Monday, March 13, 1995
Printed by:	enrjvl



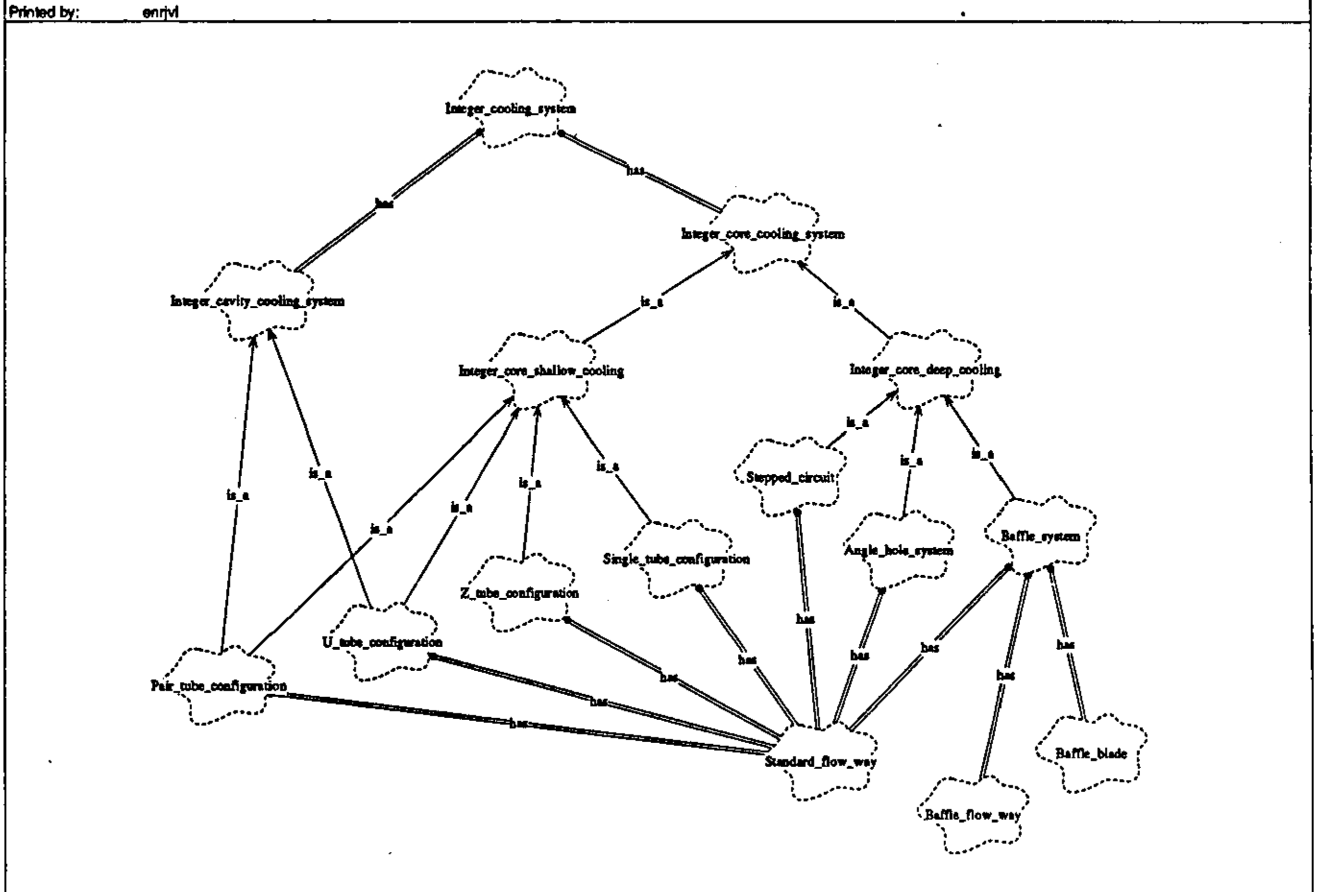
Project:	ron
Title:	Class Diagram: Feeding_system_parameter_relationships
Printed on:	Tuesday, March 14, 1995
Printed by:	enrjvl



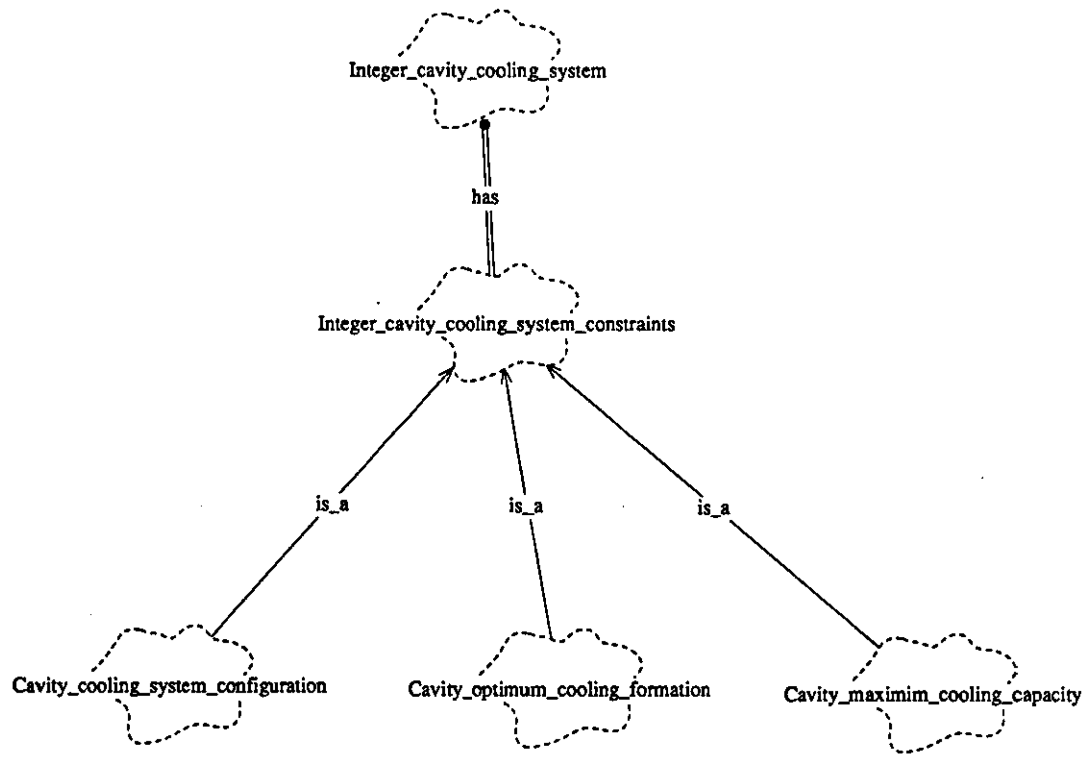
Project:	ron
Title:	Class Diagram: Integer_cavity_and_feeding_system_relations
Printed on:	Tuesday, March 14, 1995
Printed by:	enrjvl



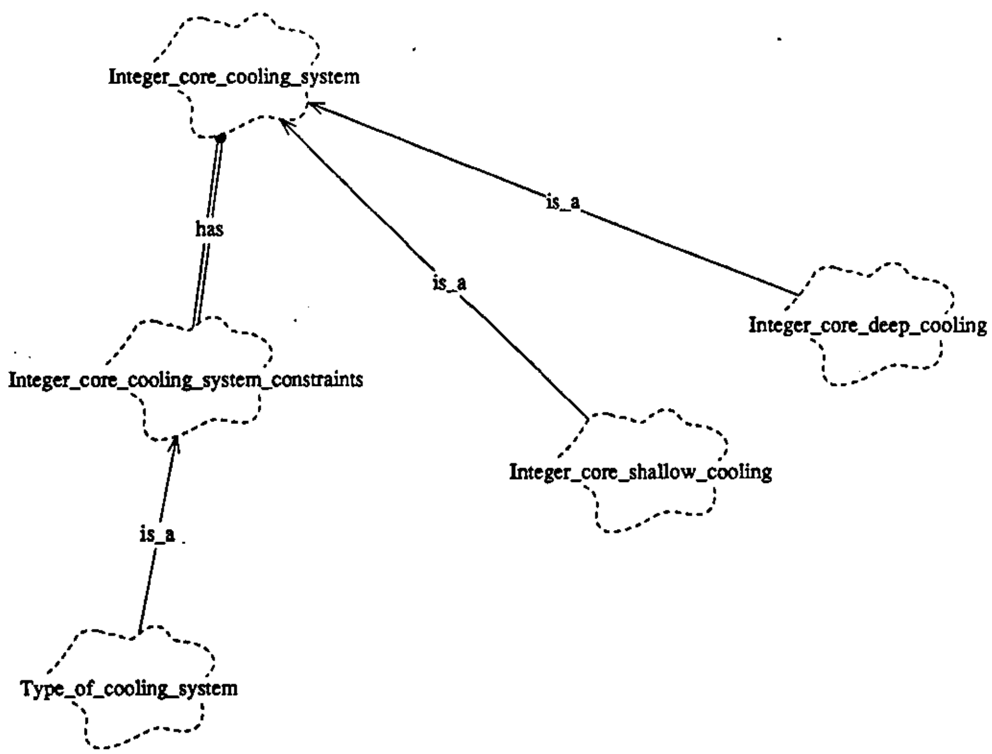
Project:	ron
Title:	Class Diagram: Cooling_system
Printed on:	Wednesday, March 1, 1995
Printed by:	enrjvl

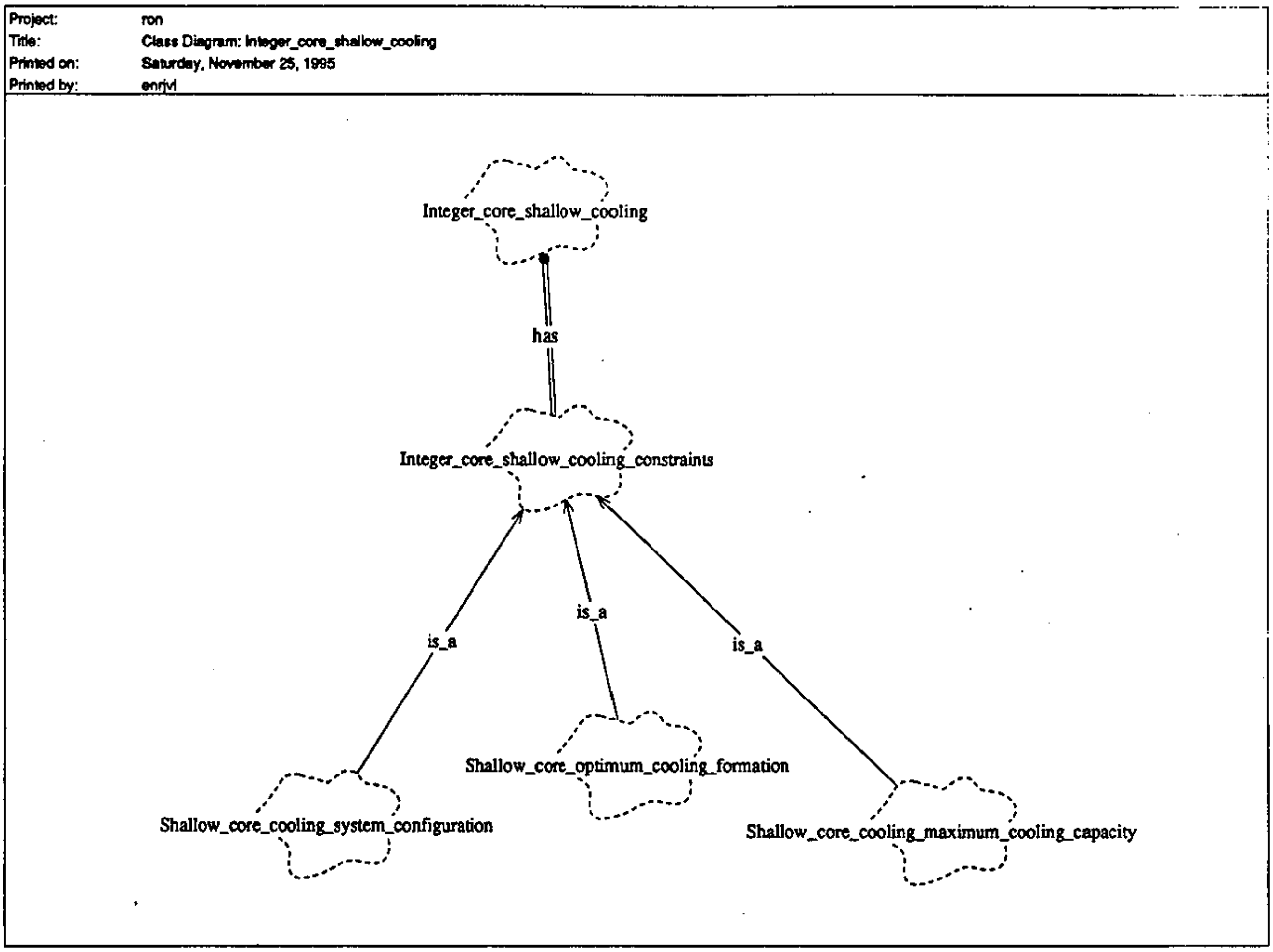


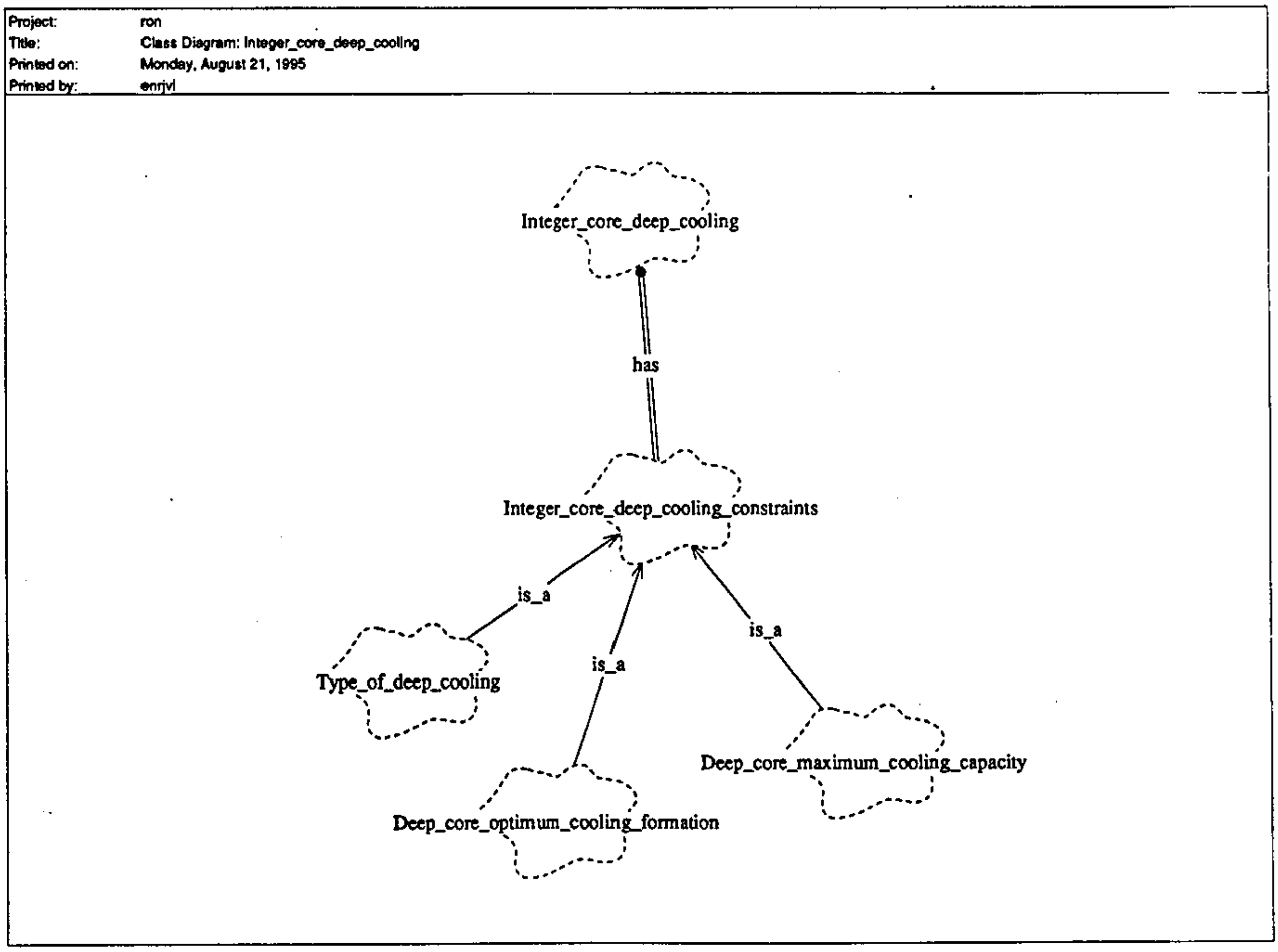
Project:	ron
Title:	Class Diagram: Integer_cavity_cooling_system
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



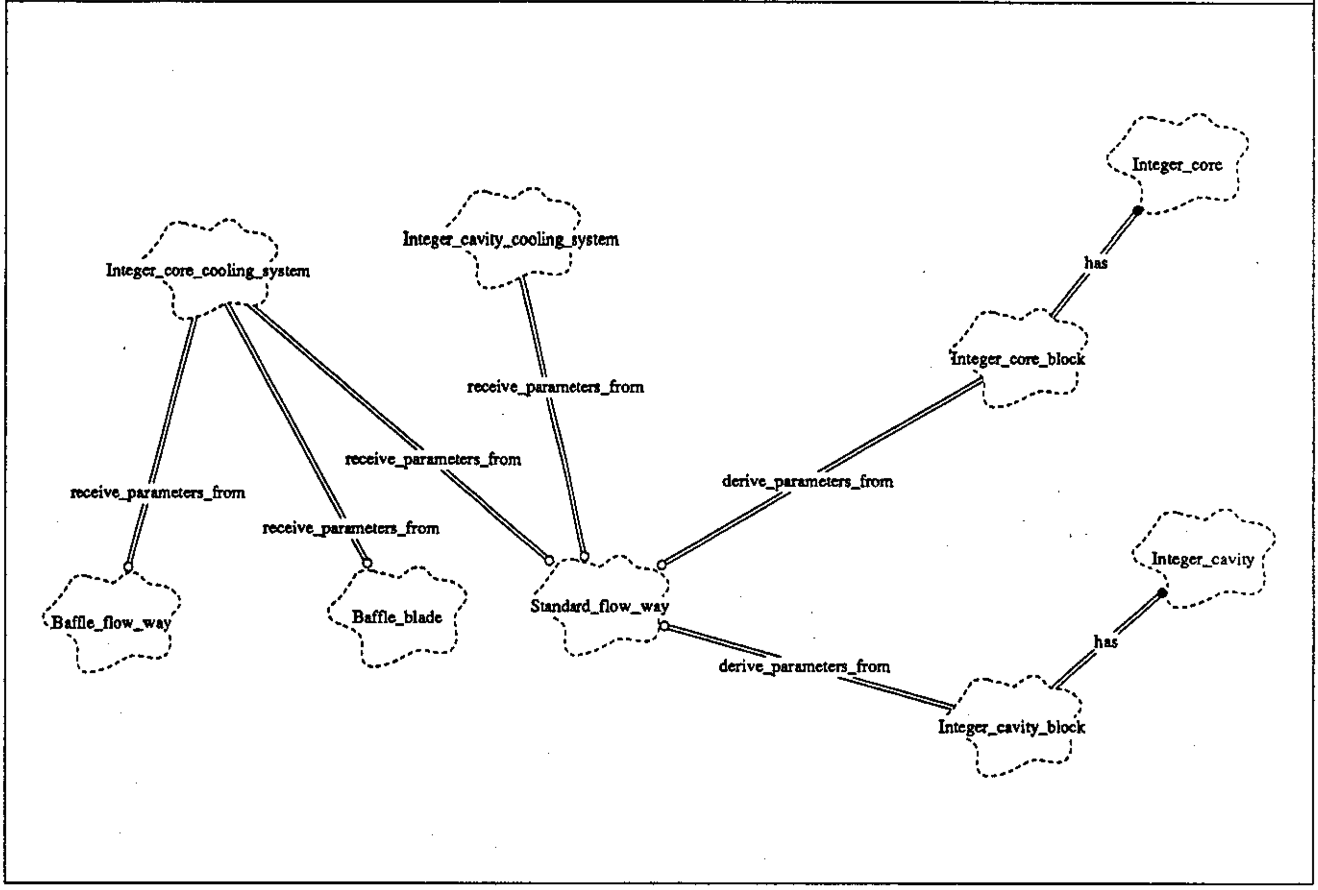
Project:	ron
Title:	Class Diagram: Integer_core_cooling_system
Printed on:	Thursday, November 23, 1995
Printed by:	enrjvl



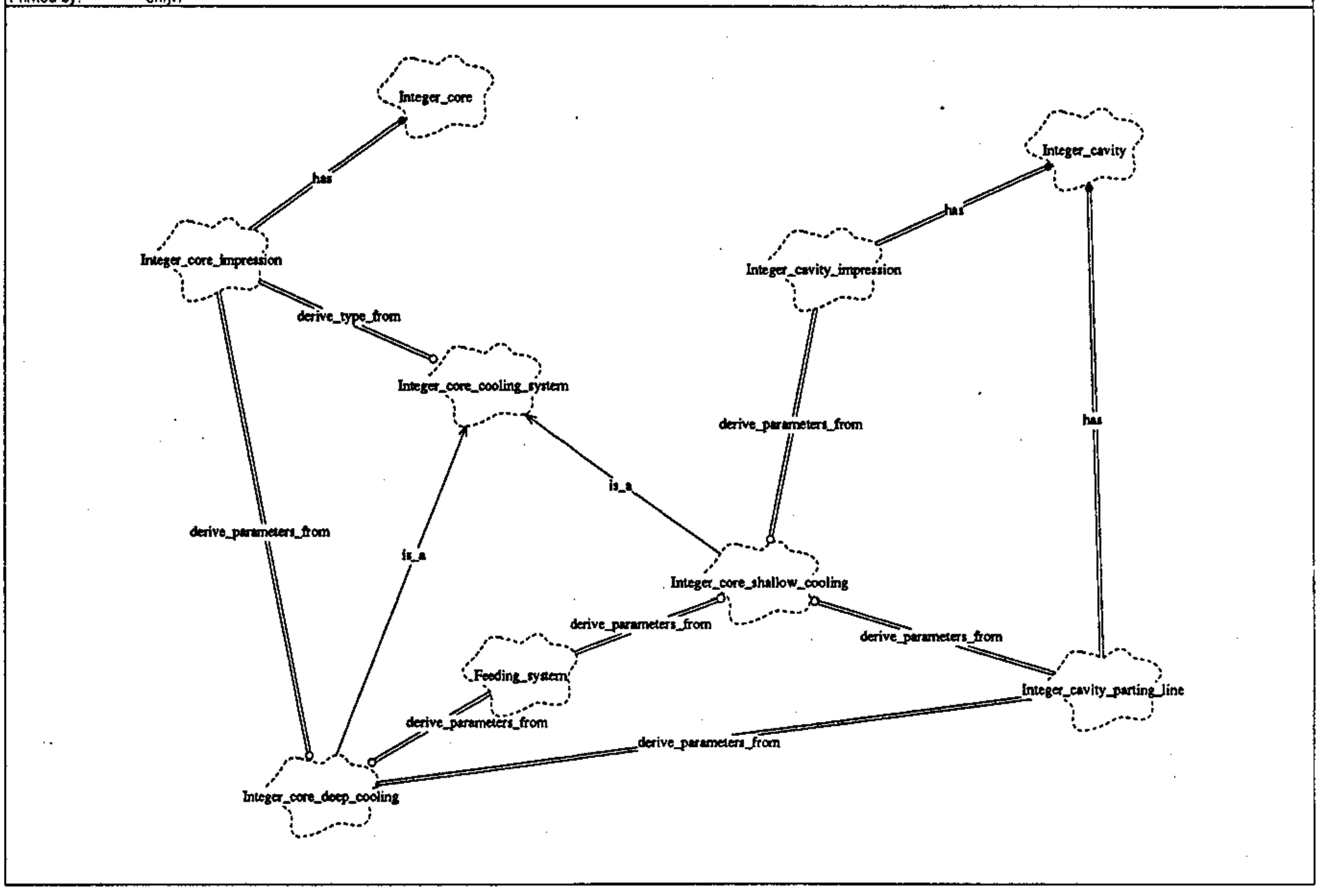

Project: ron
Title: Class Diagram: Integer_core_shallow_cooling
Printed on: Saturday, November 25, 1995
Printed by: enrjvl
Integer_core_shallow_cooling
has
Integer_core_shallow_cooling_constraints
is_a
is_a
is_a
Shallow_core_optimum_cooling_formation
Shallow_core_cooling_system_configuration
Shallow_core_cooling_maximum_cooling_capacity


Project: ron
Title: Class Diagram: Integer_core_deep_cooling
Printed on: Monday, August 21, 1995
Printed by: enrjvl
Integer_core_deep_cooling
has
Integer_core_deep_cooling_constraints
is_a
is_a
is_a
Type_of_deep_cooling
Deep_core_maximum_cooling_capacity
Deep_core_optimum_cooling_formation

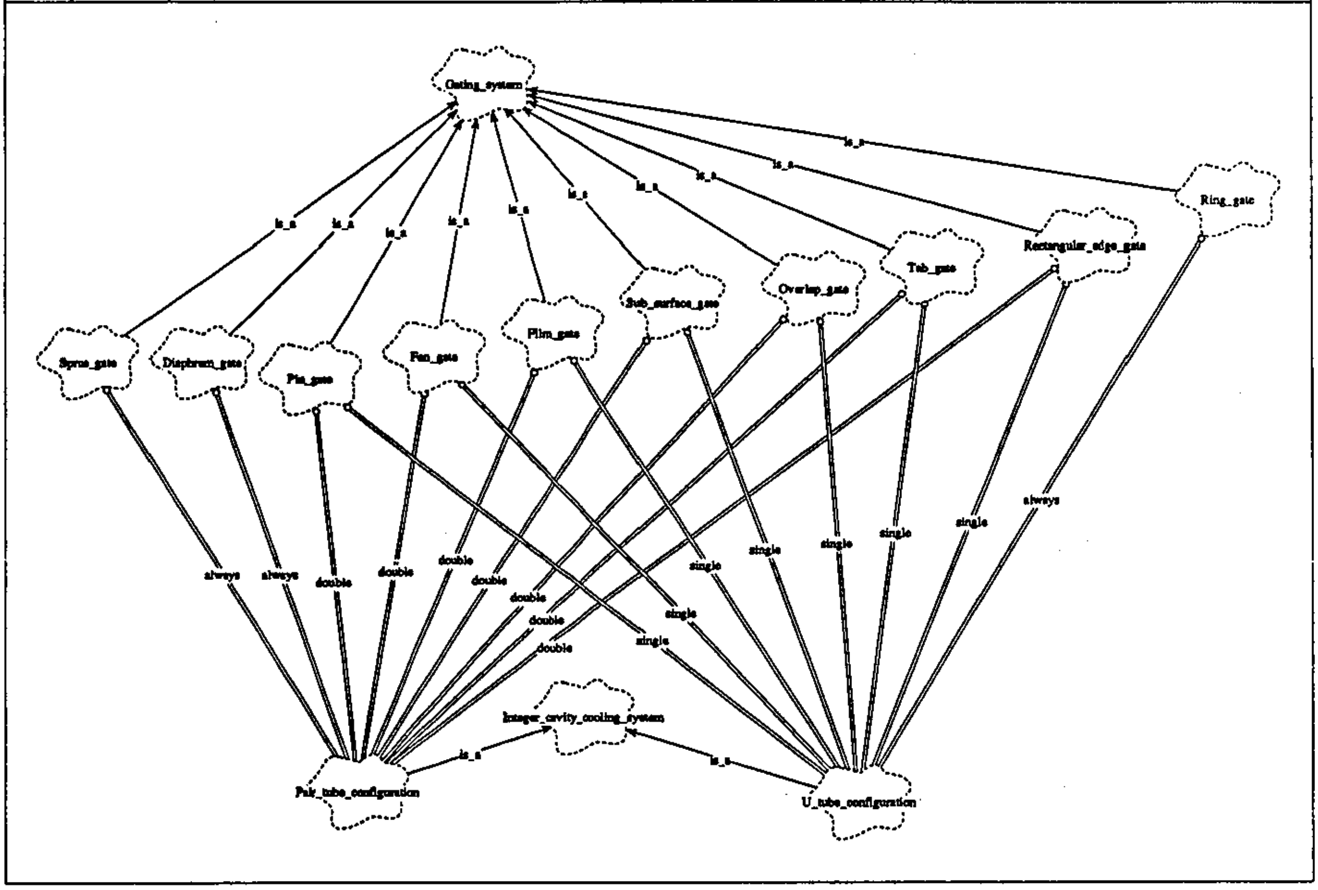
Project:	ron
Title:	Class Diagram: Cooling_element_relationships
Printed on:	Wednesday, March 15, 1995
Printed by:	enrjvl



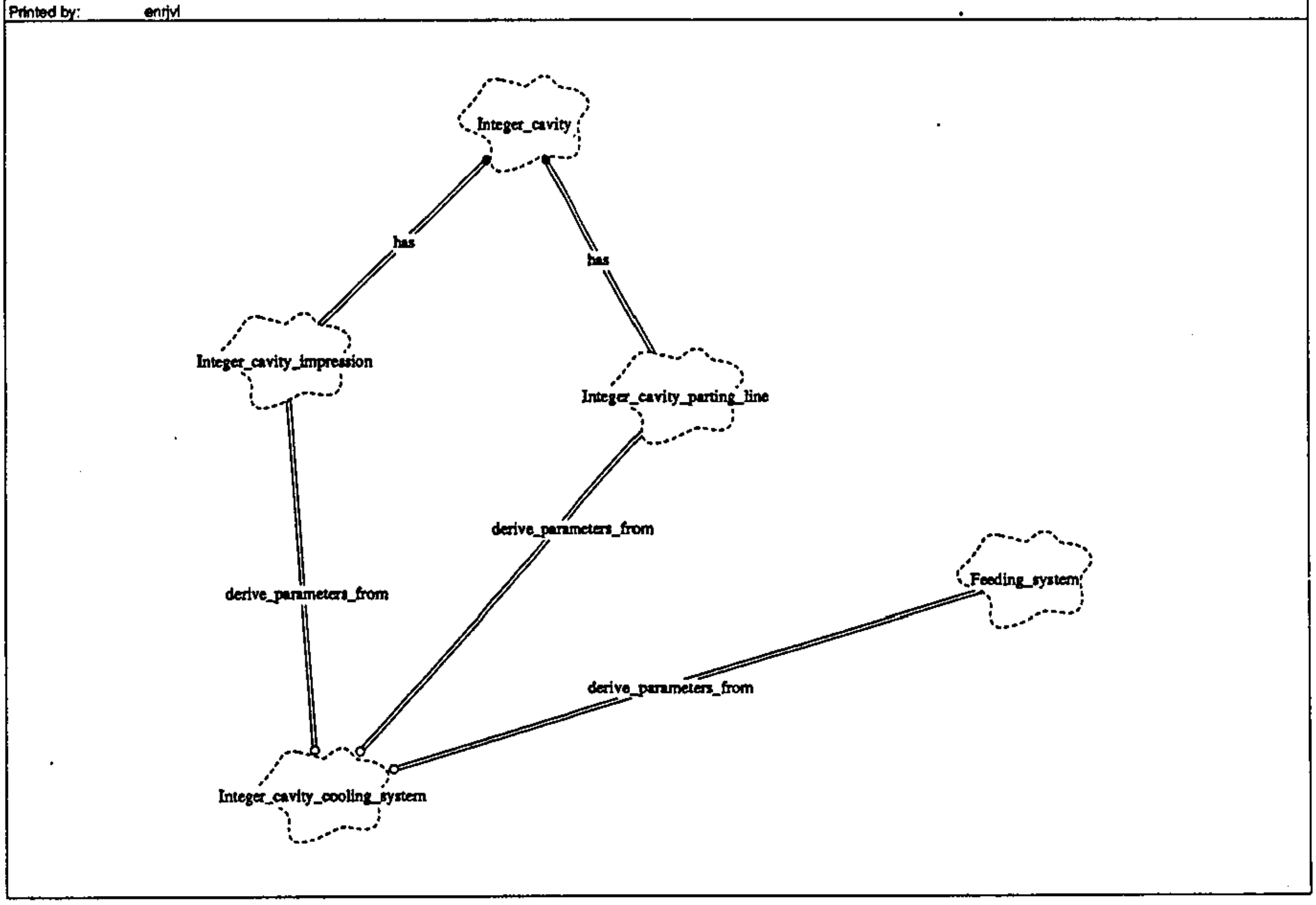
Project:	ron
Title:	Class Diagram: Core_cooling_system_relationships
Printed on:	Wednesday, March 15, 1995
Printed by:	enrjvl



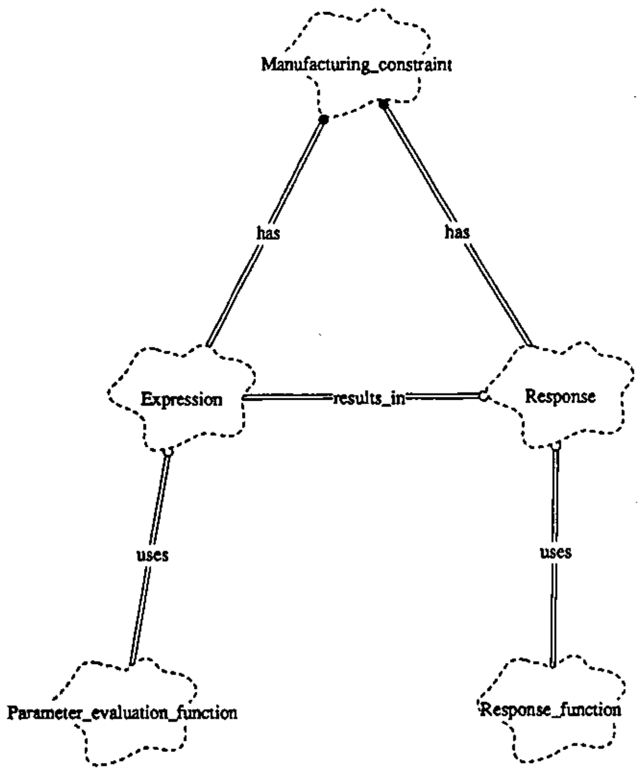
Project:	ron
Title:	Class Diagram: Gating_system_preferred_cooling_configuration
Printed on:	Wednesday, March 15, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Cavity_cooling_system_relationships
Printed on:	Thursday, March 16, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Manufacturing_constraint
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



Appendix 4.

EXPRESS representation of the Manufacturing Model.

```
SCHEMA Manufacturing_model

TYPE dimension = REAL;
WHERE
non_negative : SELF >= 0.0;
END_TYPE;

TYPE integer = INTEGER;
WHERE
non-negative : SELF >= 0;
END_TYPE;

//MOULDABILITY FEATURES

ENTITY Mouldability_features
ABSTRACT SUPERTYPE OF (ONE OF( Primary_mouldability_features,
Secondary_mouldability_features ));
END_ENTITY;

ENTITY Primary_mouldability_features
SUBTYPE OF (Mouldability_features);
ABSTRACT SUPERTYPE OF (ONE OF( Hole, Reinforcement, Wall));
END_ENTITY;

ENTITY Wall
SUBTYPE OF (Primary_mouldability_features);
Feature_name : STRING;
Feature_type : STRING;
Associated_form_name : STRING;
Associated_form_type : STRING;
thickness : dimension;
length : dimension;
height : dimension;
position : POINT3D;
orientation : POINT3D;
gated : STRING;
connect_wall : wall;
WHERE
max_thickness : thickness<=5.0;
DERIVE
thickness_difference : BOOLEAN := (thickness.NE.connect_wall.thickness);
RULE wall_thickness FOR (Wall);
IF thickness>max_thickness THEN
Possible shrinkage marks and component
warpage. Advise reduction in wall thickness
to a maximum of max_thickness.
END_RULE;
RULE Use_rib FOR (Wall);
IF thickness>max_thickness THEN
Advise the use of ribs to allow a
reduction in wall thickness.
END_RULE;
RULE Wall_taper FOR (Wall, untapered);
IF wall has no taper THEN
Problems with removal of part from
mould. Request that a Taper be created.
END_RULE;
RULE Relative thickness FOR (Wall, against adjacent wall);
IF thickness difference THEN
Possible feeding problems, component
warpage or surface finish problems,
```

stress concentrations in the component.
Advise change of thickness to
connect_wall.thickness.
END_RULE;
RULE Wall_blend FOR (Wall, against adjacent wall or reinforcement);
IF wall has no blend THEN
Stress concentrations in the component,
possible surface defects. Request that a
Blend be created.
IF adjacent mouldability type == Wall THEN
Blend type = corner.
IF adjacent mouldability type == Solid_boss OR Rib OR Hollow_boss THEN
Blend type = protrusion.
END_RULE;
RULE Wall_gating FOR (Wall, ungated);
IF wall has no gate THEN
Ask if a gate is to be created
on the wall.
END_RULE;
END_ENTITY;

ENTITY Reinforcement
SUBTYPE OF (Primary_mouldability_features);
ABSTRACT SUPERTYPE OF (ONE OF(Rib, Solid_boss, Hollow_boss));
Feature_name : STRING;
Feature_type : STRING;
Associated_form_name : STRING;
Associated_form_type : STRING;
width : dimension;
height : dimension;
orientation : dimension;
position : dimension;
connect_wall : wall;
WHERE
max_height : height <= 3.0*connect_wall.thickness + 0.85;
max_width : width <= (2.0/3.0)*connect_wall.thickness;
machine_axis : = (0.0, 0.0 , 1.0);
DERIVE
correct_orientation : BOOLEAN := (orientation == machine_axis);
RULE Reinforcement_orientation FOR (Reinforcement);
IF !correct_orientation THEN
Ejection problems, maybe moving
cores required and/or complex parting
line. Request re-orientation.
END_RULE;
RULE Reinforcement_taper FOR (Reinforcement, untapered);
IF Reinforcement has no taper THEN
Problems with removal of part from
mould. Request that a Taper be created.
END_RULE;
RULE Reinforcement_height FOR (Reinforcement, against adjacent wall);
IF height>max_height THEN
Possible sink marks opposite the
reinforcement and/or component warpage.
Advise height reduction to a maximum
of max_height.
END_RULE;
RULE Reinforcement_width FOR (Reinforcement, against adjacent wall);
IF width>max_width THEN
Possible sink marks opposite the
reinforcement and/or component warpage.
Advise width reduction to a maximum

```
of max_width.
END_RULE;
RULE Reinforcement_blend FOR (Reinforcement, against adjacent wall);
IF Reinforcement has no blend THEN
Stress concentrations in the component,
possible surface defects. Request that a
Blend be created.
END_RULE;
END_ENTITY;

ENTITY Rib
SUBTYPE OF (Reinforcement);
length : dimension;
END_ENTITY;

ENTITY Solid_boss
SUBTYPE OF (Reinforcement);
END_ENTITY;

ENTITY Hollow_boss
SUBTYPE OF (reinforcement);
inner_dia : dimension;
END_ENTITY;

ENTITY Hole
SUBTYPE OF (Primary_mouldability_features);
Feature_name : STRING;
Feature_type : STRING;
Name of associated_form : STRING;
Type_of_associated_form : STRING;
diameter : dimension;
depth : dimension;
orientation : POINT3D;
position : POINT3D;
connect_wall : wall;
WHERE
min_distance_wall : distance_hole_wall >= diameter;
min_distance_hole : distance_hole_hole >= diameter;
max_blind_depth : depth <= 2.0*diameter;
min_blind_depth : depth >= diameter;
machine_axis : = (0.0, 0.0, 1.0);
DERIVE
correct_orientation : BOOLEAN := (orientation == machine_axis);
blind_hole : BOOLEAN := (depth < connect_wall.thickness);
RULE Hole_orientation FOR (Hole);
IF !correct_orientation THEN
Ejection problems, maybe moving
cores required and/or complex parting
line. Request re-orientation.
END_RULE;
RULE Hole_taper FOR (Hole, untapered);
IF Hole has no taper THEN
Problems with removal of part from
mould. Request that a Taper be created.
END_RULE;
RULE Distance_hole_wall FOR (Hole, near to wall);
IF distance_hole_wall<min_distance_wall THEN
Possible weld line between hole and wall. Area
between hole and wall highly stressed. Advise
either move hole or reduce diameter.
END_RULE;
RULE Distance_hole_hole FOR (Hole, near to hole);
```

```
IF distance_hole_hole<min_distance_hole THEN
Possible weld line between the holes. Area between
holes highly stressed. Advise either move
hole, reduce diameter or reduce number of holes.
END_RULE;
RULE Prefer_through_hole FOR (Hole, blind);
IF blind_hole THEN
Advise that a through hole is preferred
so that the core pin can be supported at
both ends. Request change to through
hole.
END_RULE;
RULE Maximum_depth FOR (Hole, blind);
IF depth>max_blind_depth THEN
Possible poor dimensional location of hole
and/or bending or breaking of the core pin.
Advise decrease in depth to a maximum of
max_blind_depth.
END_RULE;
RULE Minimum_depth FOR (Hole, blind);
IF depth<min_blind_depth THEN
Minimum practical depth for a core pin i
n the mould is min_blind_depth. Advise
increase in depth to a minimum of
min_blind_depth.
END_RULE;
END_ENTITY;

ENTITY Taper
SUBTYPE OF (Secondary_mouldability_features);
Name of associated_form : STRING;
Type_of_associated_form : STRING;
angle : dimension;
WHERE
min_angle_wall : angle >=0.8;
min_angle_reinforcement : angle >=5.0;
min_angle_hole : angle >=5.0;
RULE Wall_draft_angle FOR (Taper, on wall);
IF angle<min_angle_wall THEN
Difficulty in removing the component from
the mould. Request an increase in taper_angle
to a minimum of min_angle_wall.
END_RULE;
RULE Reinforcement_draft_angle FOR (Taper, on reinforcement);
IF angle<min_angle_reinforcement THEN
Difficulty in removing the component from
the mould. Request an increase in taper_angle
to a minimum of min_angle_reinforcement.
END_RULE;
RULE Hole_draft_angle FOR (Taper, on hole);
IF angle<min_angle_hole THEN
Difficulty in removing the component from
the mould. Request an increase in taper_angle
to a minimum of min_angle_hole.
END_RULE;
END_ENTITY;

ENTITY Blend
SUBTYPE OF (Secondary_mouldability_features);
ABSTRACT SUPERTYPE OF (ONE OF( Corner_blend, Protrusion_blend));
Name of associated_form : STRING;
Type_of_associated_form : STRING;
```

```
Name_of_joined_form : STRING;
Type_of_joined_form : STRING;
END_ENTITY;

ENTITY Corner_blend
SUBTYPE OF (Blend);
inside_radius : dimension;
outside_radius : dimension;
connect_wall : wall;
WHERE
fixed_min : inside_radius >= 0.5;
DERIVE
best_inner : BOOLEAN := ( 0.4*connect_wall.thickness<=inside_radius<=0.6*connect_wall.thickness);
best_outer : BOOLEAN := ( outside_radius == inside_radius + connect_wall.thickness );
RULE Corner_blend_minimum_radius FOR (Corner_blend);
IF inside_radius<fixed_min THEN
Possible stress concentrations in the
component and surface defects.
Advise increase in inside_radius
to a minimum of fixed_min.
END_RULE;
RULE Corner_blend_inner_radius FOR (Corner_blend, on a wall intersection);
IF !best_inner THEN
Possible stress concentrations in the
component and surface defects.
Advise inside_radius change to
within best_inner, subject to
fixed_min.
END_RULE;
RULE Corner_blend_outer_radius FOR (Corner_blend, on a wall intersection);
IF !best_outer THEN
 IF outside_radius<best_outer THEN
 Thickening corner section – leading to
 possible shrinkage marks/surface
 depression, widening of corner angle
 and curvature of wall sections either
 side of the corner. Advise increase in
 outside_radius to best_outer.
 IF outside_radius>best_outer THEN
 Thinning corner section – leading to
 feeding problems around the corner,
 weak corner section. Advise decrease
 in outside_radius to best_outer.
END_RULE;
END_ENTITY;

ENTITY Protrusion_blend
SUBTYPE OF (Blend);
radius : dimension;
WHERE
fixed_min : radius>=0.5;
RULE Reinforcement_wall_blend FOR (Protrusion_blend)
IF radius<fixed_min THEN
Possible stress concentrations in the
component and surface defects.
Advise increase in radius
to a minimum of fixed_min.
END_RULE;
END_ENTITY;

ENTITY Gate
SUBTYPE OF (Secondary_mouldability_features);
```

```
Name of associated_form : STRING;
Type_of_associated_form : STRING;
location : STRING;
position : POINT3D_ARRAY;
gate_type : STRING;
gate_no : integer;
WHERE
min_gates : gate_no>=Ceiling(feeding_distance/800);
DERIVE
extra_gate_required : BOOLEAN := (Feeding_distance > 800);
RULE Max_flow_length FOR (Gate, on wall);
IF extra_gate_required THEN
Material will not reach the mould
extremities. Recommend a
minimum of min_gates and/or
relocation of gate position.
END_RULE;
RULE Gate_type FOR (Gate, on wall);
IF part.geometry == thin_rotn THEN
 IF gate_no==1 THEN
 Advise possible gate types : rectangular_edge_gate,
 pin_gate, sprue_gate. Advise pin_gate requires three
 plate mould.
 IF gate_no>1 THEN
 Advise possible gate types : rectangular_edge_gate,
 pin_gate. Advise pin gate requires three plate mould,
 rectangular_edge_gate requires multi nozzle manifold.
IF part.geometry == thick_rotn THEN
Advise possible gate types : rectangular_edge_gate,
sub_surface_gate, round_edge_gate.
 IF gate_no>1 THEN
 Advise multi nozzle manifold required for all
 above types.
IF part.geometry == tubular THEN
 IF gate_no==1 THEN
 Advise possible gate types: rectangular_edge_gate,
 pin_gate, diaphragm_gate, ring_gate. Advise
 pin_gate requires three plate mould.
 IF gate_no>1 THEN
 Advise possible gate types: rectangular_edge_gate,
 pin_gate. Advise pin gate requires three plate mould,
 rectangular_edge_gate requires multi nozzle manifold.
IF part.geometry == non_rotn_thin THEN
Advise possible gate types : fan_gate, film_gate.
 IF gate_no>1 THEN
 Advise multi nozzle manifold required for all
 above types.
IF part.geometry == non_rotn_thick THEN
Advise possible gate types : sub_surface_gate.
 IF gate_no>1 THEN
 Advise multi nozzle manifold required for all
 above types.
IF part.geometry == solid_block THEN
Advise possible gate types : overlap_gate,
tab_gate.
 IF gate_no>1 THEN
 Advise multi nozzle manifold required for
 overlap_gate and may be required for tab_gate.
IF part.geometry == large_area THEN
Advise possible gate types: fan_gate.
END_RULE;
END_ENTITY;
```

```
//MOULD SYSTEM ELEMENTS

ENTITY Injection_mould_elements
has_cavity : Cavity;
has_core : Core;
has_feeding : Feeding_system;
has_cooling : Cooling_system;
has_ejection : Ejection_system;
has_guidance : Guide_system;
END_ENTITY;

ENTITY Cavity
ASTRACT SUPERTYPE OF (ONE OF (Integer_cavity, Insert_cavity));
END_ENTITY;

ENTITY Integer_cavity
SUBTYPE OF (Cavity);
has_volume : Integer_cavity_volume;
has_group_volume : Integer_cavity_group_volume;
has_gate_position : Integer_cavity_gate_position;
has_rim : Integer_cavity_rim;
has_boss : Integer_cavity_boss;
has_hole : Integer_cavity_hole;
has_slot : Integer_cavity_slot;
has_taper : Integer_cavity_taper;
has_blend : Integer_cavity_blend;
has_block : Integer_cavity_block;
has_inner_land : Integer_cavity_inner_land;
has_perif_land : Integer_cavity_perif_land;
has_parting : Integer_cavity_parting_line;
has_backing : Integer_cavity_backing_plate;
has_recess : Integer_cavity_nozzle_recess;
END_ENTITY;

ENTITY Integer_cavity_volume
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
diameter : dimension;
height : dimension;
orientation : POINT3D;
connect_volume_above : Integer_cavity_volume;
connect_taper : Integer_cavity_taper;
connect_blend : Integer_cavity_blend;
WHERE
small_angle_radians : = (connect_taper.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper.angle;
larger_angle_radians : =(remaining_angle/360)*2.0*3.1416;
taper_allowance : = (height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
DERIVE
IF connect_taper.angle == 0.0 THEN
overhang_exists : BOOLEAN := (diameter > connect_volume_above.diameter);
IF connect_taper.angle !=0.0 THEN
overhang_exists : BOOLEAN := (diameter+ 2.0*taper_allowance >
connect_volume_above.diameter);
contact_exists : BOOLEAN := (position[3] + diameter >= connect_volume_above.diameter);
RULE Cavity_volume_overhang FOR (Integer_cavity_volume, in cavity);
IF overhang_exists THEN
Require split mould. If a rim
exists on the part – non
```

```
mouldable. Advise diameter
reduction to a maximum of
connect_volume_above.diameter.
If no adjustment – Create vertical split line.
END_RULE;
RULE Cavity_volume_taper FOR (Integer_cavity_volume, in cavity);
IF Taper exists on mouldability wall equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability wall equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
RULE Cavity_volume_blend FOR (Integer_cavity_volume, in cavity);
IF !contact_exists THEN
No blend required.
IF contact_exists THEN
 IF Corner_blend does not exist on mouldability wall equivalent (mouldability_feat) THEN
 Difficult to produce sharp corners
 in mould. Corners wear during
 mould operation. Request Corner_blend
 is created on mouldability_feat.
  IF external product geometry at intersection == convex THEN
  connect_blend.radius == outside_radius of Corner_blend.
  IF external product geometry at intersection == concave THEN
  connect_blend.radius == inside_radius of Corner_blend.
 IF Corner_blend exists on mouldability wall equivalent (mouldability_feat) THEN
  IF external product geometry at intersection == convex THEN
  connect_blend.radius == outside_radius of Corner_blend.
  IF external product geometry at intersection == concave THEN
  connect_blend.radius == inside_radius of Corner_blend.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_group_volume
mouldability_feat : STRING_ARRAY;
mouldability_type : STRING;
position : POINT3D;
diameter : dimension;
height : dimension;
orientation : POINT3D;
group_number : integer;
connect_volume_above : Integer_cavity_volume;
connect_volume_below : Integer_cavity_volume;
connect_taper_on_volume_below : Integer_cavity_taper
WHERE
small_angle_radians : = (connect_taper_on_volume_below.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taperon_volume_below.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume_below.height*SINE(small_angle_radians))/
              SINE(large_angle_radians);
DERIVE
overhang_exists_above : BOOLEAN := (diameter>connect_volume_above.diameter);
IF connect_taper_on_volume_below.angle == 0.0 THEN
overhang_exists_below : BOOLEAN := (diameter < connect_volume_below.diameter);
IF connect_taper_on_volume_below.angle !=0.0 THEN
overhang_exists_below : BOOLEAN := (diameter < 2.0*taper_allowance +
connect_volume_below.diameter);
RULE Cavity_group_volume_overhang_above FOR(Integer_cavity_group_volume,
in cavity);
IF overhang_exists_above THEN
```

Require split mould. If a rim
exists on the part – non
mouldable. Advise diameter
reduction to a maximum of
connect_volume_above.diameter.
If no adjustment – Create vertical split line.
END_RULE;
RULE Cavity_group_volume_overhang_below FOR (Integer_cavity_group_volume,
in cavity);
IF overhang_exists_below THEN
Require split mould. If a rim
exists on the part – non
mouldable.
IF connect_taper_on_volume_below.angle == 0.0 THEN
Advise diameter increase to a minimum of
connect_volume_below.diameter.
IF connect_taper_on_volume_below.angle != 0.0 THEN
Advise diameter increase to a minimum of
connect_volume_below.diameter + 2.0*taper_allowance.
If no adjustment – Create vertical split line.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_rim
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
inner_dia : dimension;
outer_dia : dimension;
height : dimension;
orientation : POINT3D;
connect_volume_above : Integer_cavity_volume;
connect_taper : Integer_cavity_taper;
connect_blend : Integer_cavity_blend;
WHERE
small_angle_radians : = (connect_taper.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (height*SINE(small_angle_radians))/
SINE(large_angle_radians);
DERIVE
IF connect_taper.angle ==0.0 THEN
overhang_exists : BOOLEAN := (outer_dia > connect_volume_above.diameter);
IF connect_taper.angle !=0.0 THEN
overhang_exists : BOOLEAN := (outer_dia+ 2.0*taper_allowance >
connect_volume_above.diameter);
contact_exists : BOOLEAN := (position[3] + diameter >= connect_volume_above.diameter);
RULE Cavity_rim_overhang FOR (Integer_cavity_rim, in cavity, mouldability_type==wall);
IF overhang_exists THEN
Require split mould. If a rim
exists on the part – non
mouldable. Advise outer_dia
reduction to a maximum of
connect_volume_above.diameter.
If no adjustment – Create vertical split line.
END_RULE;
RULE Cavity_rim_blend FOR (Integer_cavity_rim, in cavity, mouldability_type==wall);
IF !contact_exists THEN
No blend required.
IF contact_exists THEN
IF Corner_blend does not exist on mouldability equivalent (mouldability_feat) THEN
Difficult to produce sharp corners

```
  in mould. Corners wear during
  mould operation. Request Corner_blend
  is created on mouldability_feat.
  connect_blend.radius == inside_radius
  of Corner_blend.
  IF Corner_blend exists on mouldability equivalent (mouldability_feat) THEN
  connect_blend.radius == inside_radius of Corner_blend.
END_RULE;
RULE Cavity_rim_blend FOR (Integer_cavity_rim, in cavity, mouldability_type==hollow_boss);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN
Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Cavity_rim_taper FOR (Integer_cavity_rim, in cavity);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_boss
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
diameter : dimension;
height : dimension;
connect_taper : Integer_cavity_taper;
RULE Cavity_boss_taper FOR (Integer_cavity_boss, in cavity);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_slot
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
feature_orientation : POINT3D;
width : dimension;
length : dimension;
height : dimension;
connect_taper : Integer_cavity_taper;
connect_blend : Integer_cavity_blend;
RULE Cavity_slot_blend FOR (Integer_cavity_slot, in cavity);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN
```

Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Cavity_slot_taper FOR (Integer_cavity_slot, in cavity);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_hole
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
diameter : dimension;
depth : dimension;
connect_taper : Integer_cavity_taper;
connect_blend : Integer_cavity_blend;
RULE Cavity_hole_blend FOR (Integer_cavity_hole, in cavity);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN
Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Cavity_hole_taper FOR (Integer_cavity_hole, in cavity);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_taper
cav_vol_name : STRING;
cav_vol_type : STRING;
Mould_equiv : STRING;
angle : dimension;
connect_taper : Taper;
connect_cavity_entity: Integer_cavity_volume OR Integer_cavity_rim OR Integer_cavity_slot OR
Integer_cavity_hole OR Integer_cavity_boss;
RULE Cavity_taper_angle FOR (Integer_cavity_taper, in cavity)
angle = connect_taper.angle identified by
connect_cavity_entity.RULE Cavity_volume_taper OR

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connect_cavity_entity.RULE Cavity_rim_taper OR
connect_cavity_entity.RULE Cavity_slot_taper OR
connect_cavity_entity.RULE Cavity_hole_taper OR
connect_cavity_entity.RULE Cavity_boss_taper OR
Advise taper angle.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_blend
prim_volume_name : STRING;
prim_volume_type : STRING;
join_volume_name : STRING;
join_volume_type : STRING;
Mould_equiv :  STRING;
radius : dimension;
connect_blend : Blend;
connect_cavity_entity : Integer_cavity_volume OR Integer_cavity_rim OR Integer_cavity_hole OR
                        Integer_cavity_slot;
RULE Cavity_blend_radius FOR (Integer_cavity_blend, in cavity);
IF connect_blend == Protrusion_blend THEN
radius = connect_blend.radius identified by
connect_cavity_entity.RULE Cavity_rim_blend OR
connect_cavity_entity.RULE Cavity_slot_blend. OR
connect_cavity_entity.RULE Cavity_hole_blend.
Advise blend radius.
IF connect_blend == Corner_blend THEN
radius = connect_blend.radius identified by
connect_cavity_entity.RULE Cavity_volume_blend OR
connect_cavity_entity.RULE Cavity_rim_blend.
Advise blend radius
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_rect_block
position : POINT3D;
length : dimension;
width : dimension;
depth : dimension;
guide_pin_dia : dimension;
connect_cooling : Standard_flow_way;
connect_sprue : Main_feeding_sprue;
connect_parting : Integer_cavity_parting_line;
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_land : Integer_cavity_circ_land OR Integer_cavity_rect_land;
WHERE
depth_of_cavity: = connect_parting.position – connect_volume_lowest.position[2];
depth_of_land: = connect_land.depth;
min_land_width: = 5.0;
max_land_width: = 25.0;
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
                    min_metal_under_cavity = 6.0;
                    IF connect_volume_highest.diameter <= 38.0 THEN
                    min_metal_under_cavity = 10.0;
                    IF connect_volume_highest.diameter <= 44.0 THEN
                    min_metal_under_cavity = 14.0;
                    IF connect_volume_highest.diameter <= 50.0 THEN
                    min_metal_under_cavity = 16.0;
                    IF connect_volume_highest.diameter <= 56.0 THEN
                    min_metal_under_cavity = 18.0;
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                    IF connect_volume_highest.diameter <= 62.0 THEN
                    min_metal_under_cavity = 22.0;
                    IF connect_volume_highest.diameter <= 68.0 THEN
                    min_metal_under_cavity = 25.0;
                    IF connect_volume_highest.diameter <= 74.0 THEN
                    min_metal_under_cavity = 29.0;
                    IF connect_volume_highest.diameter <= 80.0 THEN
                    min_metal_under_cavity = 33.0;
                    IF connect_volume_highest.diameter <= 86.0 THEN
                    min_metal_under_cavity = 36.0;
                    IF connect_volume_highest.diameter <= 92.0 THEN
                    min_metal_under_cavity = 40.0;
                    IF connect_volume_highest.diameter <= 98.0 THEN
                    min_metal_under_cavity = 44.0;
                    IF connect_volume_highest.diameter <= 104.0 THEN
                    min_metal_under_cavity = 49.0;
land_size_x: IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface
OR tab THEN
                    IF connect_sprue.position[2] < 0.0 THEN
                    land_size_x = 2.0*(connect_volume_highest.position[0]-
                    connect_sprue.position[0] + min_land_width);
                    IF connect_sprue.position[2] > 0.0 THEN
                    land_size_x = 2.0*(connect_sprue.position[0]-
                    connect_volume_highest.position[0] + min_land_width);
          IF gate type == diaphragm OR pin OR ring OR sprue THEN
          land_size_x = connect_volume_highest.diameter + 2.0*min_land_width;
min_land_size_y: = connect_volume_highest.diameter + 2.0*minimum_cooling_space;
land_size_y: IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface
OR tab THEN
          land_size_y = connect_volume_highest.diameter + 2.0*min_land_width;
          IF gate type == diaphragm OR pin OR ring OR sprue THEN
          land_size_y = connect_volume_highest.diameter + 2.0*min_land_width;
                    IF land_size_y < min_land_size_y THEN
                    land_size_y = min_land_size_y;
area_of_land: 3.1416 * SQ(connect_volume_highest.diameter/2.0 + min_land_width) -
3.1416 * SQ(connect_volume_highest.diameter/2.0);
max_area_of_land:   3.1416   *   SQ(connect_volume_highest.diameter/2.0   +   max_land_width)   -

3.1416 * SQ(connect_volume_highest.diameter/2.0);
perif_land_area: (max_area_of_land - area_of_land)/4.0;
perif_land_diam: SQRT(perif_land_area/3.1416);
RULE Cavity_block_position FOR (Integer_cavity_block, enclosing mould system elements);
x position = centre of cavity base in x axis.
y position = centre of cavity base in y axis.
IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface OR tab
THEN
 IF no nozzle_recess is required THEN
 z position = connect_sprue.position[2] - connect_sprue.sprue_length.
 IF nozzle_recess is required THEN
  IF (depth_of_cavity + min_metal_condition) >= minimum_cooling_space THEN
  z position = connect_volume_lowest.position[2] - min_metal_condition.
  IF (depth_of_cavity + min_metal_condition) < minimum_cooling_space THEN
  z position = connect_parting.position - minimum_cooling_space.
IF gate type == diaphragm OR pin OR ring OR sprue THEN
 IF (depth_of_cavity + min_metal_condition) >= minimum_cooling_space THEN
 z position = connect_volume_lowest.position[2] - min_metal_condition.
 IF (depth_of_cavity + min_metal_condition) < minimum_cooling_space THEN
 z position = connect_parting.position - minimum_cooling_space.
END_RULE;
RULE Cavity_block_depth FOR (Integer_cavity_block, enclosing mould system elements);
depth = connect_parting.position - z position - connect_land.depth.
END_RULE;
```

RULE Guide_system_parameters FOR (Integer_cavity_block, enclosing mould system elements);
Advise use minimum suitable diameter to minimise mould size.
IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface OR tab THEN area in guide system = land_size_x*land_size_y.
IF gate type == diaphragm OR pin OR ring OR sprue THEN
area in guide system = (land_size_x + 2.0*perif_land_diam)*
(land_size_y +2.0*perif_land_diam).
IF area in guide system < 10000 THEN
Advise recommended guide pin diameter == 10.0.
IF area in guide system < 15000 THEN
Advise recommended guide pin diameter == 13.0.
IF area in guide system < 30000 THEN
Advise recommended guide pin diameter == 16.0.
IF area in guide system < 50000 THEN
Advise recommended guide pin diameter == 19.0.
IF area in guide system < 75000 THEN
Advise recommended guide pin diameter == 22.0.
IF area in guide system < 120000 THEN
Advise recommended guide pin diameter == 25.0.
IF area in guide system < 240000 THEN
Advise recommended guide pin diameter == 32.0.
IF area in guide system < 420000 THEN
Advise recommended guide pin diameter == 38.0.
IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface OR tab AND number of gates ==1 THEN
Unbalanced forces in mould tending to open the
mould on one side. Possible larger wall
thickness on one side than the other. Advise
use next size up than recommended to
ensure alignment.
END_RULE;
RULE Cavity_block_width FOR (Integer_cavity_block, enclosing mould system);
elements);
IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface OR tab THEN width = land_size_y + 4.0*guide pin diameter.
IF gate type == diaphragm OR pin OR ring OR sprue THEN
width = (land_size_y +2.0*perif_land_diam) + 4.0*guide pin diameter.
END_RULE;
RULE Cavity_block_length FOR (Integer_cavity_block, enclosing mould system);
elements);
IF gate type == rectangular_edge OR round_edge OR film OR fan OR overlap OR sub_surface OR tab THEN length = land_size_x + 4.0*guide pin diameter.
IF gate type == diaphragm OR pin OR ring OR sprue THEN
length = (land_size_x +2.0*perif_land_diam) + 4.0*guide pin diameter.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_inner_land
ABSTRACT SUPERTYPE OF (ONE OF(Integer_cavity_rect_land,
Integer_cavity_circ_land));
END_ENTITY;

ENTITY Integer_cavity_rect_land
SUBTYPE OF (Integer_cavity_inner_land);
position : POINT3D;
length : dimension;
width : dimension;
depth : dimension;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_parting : Integer_cavity_parting_line;
connect_taper : Integer_cavity_taper; (taper on connect_volume)

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connect_sprue : Main_feeding_sprue;
WHERE
min_land_width : = 5.0;
small_angle_radians : = (connect_taper.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
small_angle_sprue : = (connect_sprue.angle/360)*2.0*3.1416;
remaining_angle_sprue : = 90 – connect_sprue.angle;
larger_angle_sprue : = (remaining_angle_sprue/360)*2.0*3.1416;
sprue_taper_allowance : = ((connect_sprue.length – 5.0)*SINE(small_angle_sprue))/
                SINE(large_angle_sprue);
RULE Cavity_rect_land_depth FOR (Integer_cavity_rect_land, around cavity);
depth = 2.4.
END_RULE;
RULE Cavity_rect_land_position FOR (Integer_cavity_rect_land, around cavity);
x position = connect_volume.position[0];
y position = connect_volume.position[1];
z position = connect_parting.position – depth;
END_RULE;
RULE Cavity_rect_land_length FOR (Integer_cavity_rect_land, around cavity);
IF connect_sprue.position[0] < 0.0 THEN
length = 2.0*(connect_volume_highest.position[0]–
connect_sprue.position[0] + min_land_width + (connect_sprue.diameter + sprue_taper_allowance/2.0));
IF connect_sprue.position[0] > 0.0 THEN
length = 2.0*(connect_sprue.position[0]–
connect_sprue.position[0] + min_land_width + (connect_sprue.diameter + sprue_taper_allowance/2.0));
IF connect_taper.angle !=0.0 THEN
length = length + (2.0*taper_allowance).
END_RULE;
RULE Cavity_rect_land_width FOR (Integer_cavity_rect_land, around cavity);
width = connect_volume_highest.diameter + 2.0*min_land_width;
IF connect_taper.angle !=0.0 THEN
width = width + (2.0*taper_allowance).
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_circ_land
SUBTYPE OF (Integer_cavity_inner_land);
position : POINT3D;
diameter : dimension;
depth : dimension;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_parting : Integer_cavity_parting_line;
connect_taper : Integer_cavity_taper;  (taper on connect_volume)
WHERE
min_land_width : = 5.0;
small_angle_radians : = (connect_taper.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
RULE Cavity_circ_land_depth FOR (Integer_cavity_circ_land, around cavity);
depth = 2.4.
END_RULE;
RULE Cavity_circ_land_position FOR (Integer_cavity_circ_land, around cavity);
x position = connect_volume.position[0];
y position = connect_volume.position[1];
z position = connect_parting.position – depth;
END_RULE;
RULE Cavity_circ_land_diameter FOR (Integer_cavity_circ_land, around cavity);
```

```
diameter = connect_volume_highest.diameter + 2.0*min_land_width;
IF connect_taper.angle !=0.0 THEN
diameter = diameter + (2.0*taper_allowance).
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_perif_land
position : POINT3D;
diameter : dimension;
depth : dimension;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_parting : Integer_cavity_parting_line;
WHERE
min_land_width : = 5.0;
max_land_width : = 25.0;
area_of_land:   3.1416   *   SQ(connect_volume_highest.diameter/2.0   +   min_land_width)   -

3.1416 * SQ(connect_volume_highest.diameter/2.0);
max_area_of_land:   3.1416   *   SQ(connect_volume_highest.diameter/2.0   +   max_land_width)   -

3.1416 * SQ(connect_volume_highest.diameter/2.0);
perif_land_area: (max_area_of_land - area_of_land)/4.0;
RULE Cavity_peripheral_land_depth FOR (Integer_cavity_perif_land, around cavity);
depth = 2.4.
END_RULE;
RULE Cavity_peripheral_land_diameter FOR (Integer_cavity_perif_land, around cavity);
diameter = SQRT (perif_land_area/3.1416).
END_RULE;
RULE Cavity_peripheral_land_position FOR (Integer_cavity_perif_land, around cavity);
z position = connect_parting.position - depth.
IF first peripheral land of four THEN
x position = connect_volume.position[0] + (connect_volume.diameter/2.0 + min_land_width + diameter).
y position = connect_volume.position[1] + (connect_volume.diameter/2.0 + min_land_width + diameter).
IF second peripheral land of four THEN
x position = connect_volume.position[0] - (connect_volume.diameter/2.0 + min_land_width + diameter).
y position = connect_volume.position[1] + (connect_volume.diameter/2.0 + min_land_width + diameter).
IF third peripheral land of four THEN
x position = connect_volume.position[0] + connect_volume.diameter/2.0 + min_land_width + diameter.
y position = connect_volume.position[1]  - (connect_volume.diameter/2.0 + min_land_width + diameter).
IF fourth peripheral land of four THEN
x position = connect_volume.position[0] - (connect_volume.diameter/2.0 + min_land_width + diameter).
y position = connect_volume.position[1] - (connect_volume.diameter/2.0 + min_land_width + diameter).
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_nozzle_recess
position : POINT3D;
diameter : dimension;
depth : dimension;
connect_sprue : Main_feeding_sprue;
connect_block : Integer_cavity_rect_block;
WHERE
min_all_round_nozzle_clearance : = 7.0;
machine_nozzle_outer_diameter : = 12.7;
RULE Nozzle_recess_position FOR (Nozzle_recess, in block);
x position = connect_sprue.position[0].
y position = connect_sprue.position[1].
z position = connect_block.position[2].
END_RULE;
RULE Nozzle_recess_depth FOR (Nozzle_recess, in block);
depth = (connect_sprue.position[2]-connect_sprue.sprue_length) - connect_block.position[2].
END_RULE;
```

```
RULE Nozzle_recess_diameter FOR (Nozzle_recess, in block);
diameter = machine_nozzle_outer_diameter + 2.0*min_all_round_nozzle_clearance.
END_RULE;
END_ENTITY;

ENTITYInteger_cavity_backing_plate
position : POINT3D;
width : dimension;
length : dimension;
depth : dimension;
connect_block : Integer_cavity_rect_block;
connect_sprue : Main_feeding_sprue;
connect_runner : Trapezoidal_runner;
RULE Backing_plate_position FOR (Integer_cavity_backing_plate, on cavity block);
x position = connect_block.position[0].
y position = connect_block.position[1].
z position = connect_block.position[2] – (connect_sprue.length + connect_runner.width).
END_RULE;
RULE Backing_plate_depth FOR (Integer_cavity_backing_plate, on cavity block);
depth = connect_sprue.length + connect_runner.width.
END_RULE;
RULE Backing_plate_length FOR (Integer_cavity_backing_plate, on cavity block);
length = connect_block.length.
END_RULE;
RULE Backing_plate_width FOR (Integer_cavity_backing_plate, on cavity block);
width = connect_block.width.
END_RULE;
END_ENTITY;

ENTITY Integer_cavity_parting_line
position : POINT3D;
type : STRING;
on_entity : STRING;
connect_volume_widest : Integer_cavity_volume OR Integer_cavity_rim (on parting_line)
RULE Cavity_parting_line_position FOR (Integer_cavity_parting_line, on cavity);
IF type == block THEN
position = connect_volume_widest.position[2] + connect_volume_widest.height.
IF type == split THEN
position = connect_volume_widest.position[0].
END_RULE;

ENTITY Core
ABSTRACT SUPERTYPE OF (ONE OF (Integer_core, Insert_core));
END_ENTITY;

ENTITY Integer_core
SUBTYPE OF (Core);

has_volume : Integer_core_volume;
has_group_volume : Integer_core_group_volume;
has_gate_position : Integer_core_gate_position;
has_rim : Integer_core_rim;
has_boss : Integer_core_boss;
has_hole : Integer_core_hole;
has_slot : Integer_core_slot;
has_taper : Integer_core_taper;
has_blend : Integer_core_blend;
has_block : Integer_core_block;
has_inner_land : Integer_core_inner_land;
has_perif_land : Integer_core_perif_land;
has_parting : Integer_core_parting_line;
END_ENTITY;
```

```
ENTITYInteger_core_volume
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
diameter : dimension;
height : dimension;
orientation : POINT3D;
origin : dimension;
origin_d : dimension;
connect_volume_above : Integer_core_volume;
connect_taper : Integer_core_taper;
connect_blend : Integer_core_blend;
WHERE
small_angle_radians : = (connect_taper.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
DERIVE
IF connect_taper.angle == 0.0 THEN
overhang_exists : BOOLEAN := (diameter > connect_volume_above.diameter);
IF connect_taper.angle !=0.0 THEN
overhang_exists : BOOLEAN := (diameter+ 2.0*taper_allowance >
connect_volume_above.diameter);
contact_exists : BOOLEAN := (position[3] + diameter >= connect_volume_above.diameter);
RULE Core_volume_overhang FOR (Integer_core_volume, in core);
IF overhang_exists THEN
 IF overhang < 1.5 THEN
 Stripping of component from the core
 is required for removal.
 IF overhang > 1.5 THEN
 Collapsible core required for
 component removal.
Advise diameter reduction to a maximum of
connect_volume_above.diameter.
END_RULE;
RULE Core_volume_taper FOR (Integer_core_volume, in core);
IF Taper exists on mouldability wall equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability wall equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
RULE Core_volume_blend FOR (Integer_core_volume, in core);
IF !contact_exists THEN
No blend required.
IF contact_exists THEN
 IF Corner_blend does not exist on mouldability wall equivalent (mouldability_feat) THEN
 Difficult to produce sharp corners
 in mould. Corners wear during
 mould operation. Request Corner_blend
 is created on mouldability_feat.
  IF internal product geometry at intersection == convex THEN
  connect_blend.radius == inside_radius of Corner_blend.
  IF internal product geometry at intersection == concave THEN
  connect_blend.radius == outside_radius of Corner_blend.
 IF Corner_blend exists on mouldability wall equivalent (mouldability_feat) THEN
  IF internal product geometry at intersection == convex THEN
  connect_blend.radius == inside_radius of Corner_blend.
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  IF internal product geometry at intersection == concave THEN
  connect_blend.radius == outside_radius of Corner_blend.
END_RULE;
END_ENTITY;

ENTITY Integer_core_group_volume
mouldability_feat : STRING_ARRAY;
mouldability_type : STRING;
position : POINT3D;
diameter : dimension;
height : dimension;
orientation : POINT3D;
group_number : integer;
connect_volume_above : Integer_core_volume;
connect_volume_below : Integer_core_volume;
connect_taper_on_volume_below : Integer_core_taper
WHERE
small_angle_radians : = (connect_taper_on_volume_below.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_volume_below.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume_below.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
DERIVE
overhang_exists_above : BOOLEAN := (diameter > connect_volume_above.diameter);
IF connect_taper_on_volume_below.angle == 0.0 THEN
overhang_exists_below : BOOLEAN := (diameter < connect_volume_below.diameter);
IF connect_taper_on_volume_below.angle !=0.0 THEN
overhang_exists_below : BOOLEAN := (diameter < 2.0*taper_allowance +
connect_volume_below.diameter);
RULE Core_group_volume_overhang_above FOR(Integer_core_group_volume,
in core);
IF overhang_exists_above THEN
 IF overhang < 1.5 THEN
 Stripping of component from the core
 is required for removal.
 IF overhang > 1.5 THEN
 Collapsible core required for
 component removal.
Advise diameter reduction to a maximum of
connect_volume_above.diameter.
END_RULE;
RULE Core_group_volume_overhang_below FOR (Integer_core_group_volume,
in core);
IF overhang_exists_below THEN
 IF overhang < 1.5 THEN
 Stripping of component from the core
 is required for removal.
 IF overhang > 1.5 THEN
 Collapsible core required for
 component removal.
IF connect_taper_on_volume_below.angle == 0.0 THEN
Advise diameter increase to a minimum of
connect_volume_below.diameter.
IF connect_taper_on_volume_below.angle == 0.0 THEN
Advise diameter reduction to a minimum of
connect_volume_below.diameter + 2.0*taper_allowance.
END_RULE;
END_ENTITY;

ENTITY Integer_core_rim
mouldability_feat : STRING;
mouldability_type : STRING;
```

position : POINT3D;
inner_dia : dimension;
outer_dia : dimension;
height : dimension;
orientation : POINT3D;
connect_volume_above : Integer_core_volume;
connect_taper : Integer_core_taper;
connect_blend : Integer_core_blend;
RULE Core_rim_blend FOR (Integer_core_rim, in core);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN
Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Core_rim_taper FOR (Integer_core_rim, in core);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_core_boss
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
diameter : dimension;
height : dimension;
connect_taper : Integer_core_taper;
RULE Core_boss_taper FOR (Integer_core_boss, in core);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_core_slot
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
feature_orientation : POINT3D;
width : dimension;
length : dimension;
height : dimension;
connect_taper : Integer_core_taper;
connect_blend : Integer_core_blend;
RULE Core_slot_blend FOR (Integer_core_slot, in core);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN

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Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Core_slot_taper FOR (Integer_core_slot, in core);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_core_hole
mouldability_feat : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
diameter : dimension;
depth : dimension;
connect_taper : Integer_core_taper;
connect_blend : Integer_core_blend;
RULE Core_hole_blend FOR (Integer_core_hole, in core);
IF Protrusion_blend does not exist on mouldability equivalent (mouldability_feat) THEN
Difficult to produce sharp corners
in mould. Corners wear during
mould operation. Request Protrusion_blend
is created on mouldability_feat.
connect_blend.radius == radius of
Protrusion_blend.
IF Protrusion_blend does exist on mouldability equivalent (mouldability_feat) THEN
connect_blend.radius == radius of Protrusion_blend.
END_RULE;
RULE Core_hole_taper FOR (Integer_core_hole, in core);
IF Taper exists on mouldability equivalent (mouldability_feat) THEN
connect_taper.angle == angle of mouldability taper.
IF Taper does not exist on mouldability equivalent (mouldability_feat) THEN
Difficulty in removing the product
from the mould. Request Taper is
created on mouldability_feat.
connect_taper.angle == angle of mouldability taper.
END_RULE;
END_ENTITY;

ENTITY Integer_core_taper
core_vol_name : STRING;
core_vol_type : STRING;
Mould_equiv :  STRING;
angle : dimension;
connect_taper : Taper;
connect_core_entity: Integer_core_volume OR Integer_core_rim OR Integer_core_slot OR
                    Integer_core_hole OR Integer_core_boss;
RULE Core_taper_angle FOR (Integer_core_taper, in core)
angle = connect_taper.angle identified by
connect_core_entity.RULE Core_volume_taper OR
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connect_core_entity.RULE Core_rim_taper OR
connect_core_entity.RULE Core_slot_taper OR
connect_core_entity.RULE Core_hole_taper OR
connect_core_entity.RULE Core_boss_taper OR
Advise taper angle.
END_RULE;
END_ENTITY;

ENTITY Integer_core_blend
prim_volume_name : STRING;
prim_volume_type : STRING;
join_volume_name : STRING;
join_volume_type : STRING;
Mould_equiv :  STRING;
radius : dimension;
connect_blend : Blend;
connect_core_entity : Integer_core_volumeOR Integer_core_rim OR Integer_core_slot OR
                   Integer_core_hole;
RULE Core_blend_radius FOR (Integer_core_blend, in core);
IF connect_blend == Protrusion_blend THEN
radius = connect_blend.radius identified by
connect_core_entity.RULE Core_rim_blend OR
connect_core_entity.RULE Core_slot_blend. OR
connect_core_entity.RULE Core_hole_blend.
Advise blend radius.
IF connect_blend == Corner_blend THEN
radius = connect_blend.radius identified by
connect_core entity.RULE Core_volume_blend.
Advise blend radius
END_RULE;
END_ENTITY;

ENTITY Integer_core_rect_block
position : POINT3D;
length : dimension;
width : dimension;
depth : dimension;
guide_pin_dia : dimension;
connect_cooling : Standard_flow_way;
connect_parting : Integer_core_parting_line;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_land : Integer_core_circ_land OR Integer_core_rect_land;
connect_block : Integer_cavity_rect_block;
WHERE
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
                   min_metal_over_cavity = 6.0;
                   IF connect_volume_highest.diameter <= 38.0 THEN
                   min_metal_over_cavity = 10.0;
                   IF connect_volume_highest.diameter <= 44.0 THEN
                   min_metal_over_cavity = 14.0;
                   IF connect_volume_highest.diameter <= 50.0 THEN
                   min_metal_over_cavity = 16.0;
                   IF connect_volume_highest.diameter <= 56.0 THEN
                   min_metal_over_cavity = 18.0;
                   IF connect_volume_highest.diameter <= 62.0 THEN
                   min_metal_over_cavity = 22.0;
                   IF connect_volume_highest.diameter <= 68.0 THEN
                   min_metal_over_cavity = 25.0;
                   IF connect_volume_highest.diameter <= 74.0 THEN
                   min_metal_over_cavity = 29.0;
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        IF connect_volume_highest.diameter <= 80.0 THEN
        min_metal_over_cavity = 33.0;
        IF connect_volume_highest.diameter <= 86.0 THEN
        min_metal_over_cavity = 36.0;
        IF connect_volume_highest.diameter <= 92.0 THEN
        min_metal_over_cavity = 40.0;
        IF connect_volume_highest.diameter <= 98.0 THEN
        min_metal over_cavity = 44.0;
        IF connect_volume_highest.diameter <= 104.0 THEN
        min_metal_over_cavity = 49.0;
RULE Core_block_position FOR (Integer_core_block, enclosing mould system elements);
x position = x position of cavity block.
y position = y position of cavity block.
z position = connect_parting.position + connect_land.depth.
END_RULE;
RULE Core_block_depth FOR (Integer_core_block, enclosing mould system elements);
IF min_metal_condition > minimum_cooling_space THEN
depth = min_metal_condition.
IF min_metal_condition < minimum_cooling_space THEN
depth = minimum_cooling_space.
END_RULE;
RULE Core_block_width FOR (Integer_core_block, enclosing mould system);
elements);
width = connect_block.width.
END_RULE;
RULE Core_block_length FOR (Integer_core_block, enclosing mould system);
elements);
length = connect_block.length.
END_RULE;
END_ENTITY;

ENTITY Integer_core_inner_land
ABSTRACT SUPERTYPE OF (ONE OF( Integer_core_rect_land,
Integer_core_circ_land));
END_ENTITY;

ENTITY Integer_core_rect_land
SUBTYPE OF (Integer_core_inner_land);
position : POINT3D;
length : dimension;
width : dimension;
depth : dimension;
connect_parting : Integer_core_parting_line;
connect_land : Integer_cavity_rect_land;
RULE Core_rect_land_depth FOR (Integer_core_rect_land, around core);
depth = 2.4.
END_RULE;
RULE Core_rect_land_position FOR (Integer_core_rect_land, around core);
x position = connect_land.position[0].
y position = connect_land.position[1].
z position = connect_parting.position.
END_RULE;
RULE Core_rect_land_length FOR (Integer_core_rect_land, around core);
length = connect_land.length.
END_RULE;
RULE Core_rect_land_width FOR (Integer_core_rect_land, around core);
width = connect_land.width.
END_RULE;
END_ENTITY;

ENTITY Integer_core_circ_land
SUBTYPE OF (Integer_core_inner_land);
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position : POINT3D;
diameter : dimension;
depth : dimension;
connect_parting : Integer_core_parting_line;
connect_land : Integer_cavity_circ_land;
RULE Core_circ_land_depth FOR (Integer_core_circ_land, around core);
depth = 2.4.
END_RULE;
RULE Core_circ_land_position FOR (Integer_core_circ_land, around core);
x position = connect_land.position[0].
y position = connect_land.position[1].
z position = connect_parting.position.
END_RULE;
RULE Core_circ_land_diameter FOR (Integer_core_circ_land, around core);
diameter = connect_land.diameter.
END_RULE;
END_ENTITY;

ENTITY Integer_core_perif_land
position : POINT3D;
diameter : dimension;
depth : dimension;
connect_land : Integer_cavity_perif_land;
connect_parting : Integer_core_parting_line;
RULE Core_peripheral_land_depth FOR (Integer_core_perif_land, around core);
depth = 2.4.
END_RULE;
RULE Core_peripheral_land_diameter FOR (Integer_core_perif_land, around core);
diameter = connect_land.diameter.
END_RULE;
RULE Core_peripheral_land_position FOR (Integer_core_perif_land, around core);
z position = connect_parting.position.
x position = connect_land.position[0].
y position = connect_land.position[1].
END_RULE;
END_ENTITY;

ENTITY Integer_core_parting_line
position : POINT3D;
type : STRING;
on_entity : STRING;
connect_parting : Integer_cavity_parting_line;
RULE Core_parting_line_position FOR (Integer_core_parting_line, on core);
position = connect_parting.position.
END_RULE;


ENTITY Feeding_system
has_pin_gate : Pin_gate;
has_sprue_gate : Sprue_gate;
has_rect_edge : Rectangular_edge_gate;
has_circ : Circular_runner;
has_trap : Trapezoidal_runner;
has_main : Main_feeding_sprue;
END_ENTITY;

ENTITYRectangular_edge_gate
mouldability_feat : STRING;
position : POINT3D;
land_length : dimension;
depth : dimension;
width : dimension;
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connect_gate : Gate;
connect_gated_wall : Wall; (wall upon which the gate has been placed)
connect_parting : Integer_cavity_parting_line;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_taper_on_volume_highest : Integer_cavity_taper;
connect_volume_lowest : Integer_cavity_volume (furthest from parting line);
WHERE
small_angle_radians : = (connect_taper_on_volume_highest.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_volume_highest.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume_highest.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
average_cavity_dia : = ((connect_volume_highest.diameter +
                connect_volume_lowest.diameter)/2.0);
cavity_height : = connect_parting.position – connect_volume_lowest.position[2];
cavity_area : = (3.1416*average_cavity_dia*cavity_height) +
            (3.1416*SQ(average_cavity_dia/2.0));
min_land_length : = 0.5;
max_land_length : = 0.75;
RULE Rect_edge_gate_position FOR (Rectangular_edge_gate, into cavity);
IF connect_gate.position is not on edge of cavity THEN
 IF connect_gate.position is inside cavity edge THEN
 Reduced land length – weakness in
 mould construction can lead to
 wear or failure. Advise move gate
 position to edge of cavity.
 IF connect_gate.position is outside cavity edge THEN
 Gate not attached to component – No
 feeding. Advise move gate position
 to edge of cavity
 IF connect_taper_on_volume_highest.angle == 0.0 THEN
 x position = connect_volume_highest.position[0] + connect_volume_highest.diameter/2.0.
 y position = connect_volume_highest.position[1].
 IF connect_taper_on_volume_highest.angle != 0.0 THEN
 x position = connect_volume_highest.position[0] + connect_volume_highest.diameter/2.0 +
            taper_allowance.
 y position = connect_volume_highest.position[1].
IF connect_gate.position is not on parting line THEN
Gate and runner system cannot be ejected – component
non– mouldable. Gate and runner system cannot be
machined into mould block – mould non–manufacturable.
Advise move gate position to parting line.
z position = connect_parting.position
END_RULE;
RULE Rect_edge_gate_land_length FOR (Rectangular_edge_gate, into cavity);
IF land_length < min_land_length THEN
Weakness in mould construction can lead
to wear or failure. Advise increase in land
length to a minimum of min_land_length.
IF land_length > max_land_length THEN
Excessive pressure drop across gate –
inadequate filling of mould cavity.
Advise decrease in land length to a
maximum of max_land_length.
END_RULE;
RULE Rect_edge_gate_depth FOR (Rectangular_edge_gate, into cavity);
depth = 0.7*connect_gated_wall.thickness.
END_RULE;
RULE Rect_edge_gate_width FOR (Rectangular_edge_gate, into cavity);
width = 0.7*SQRT(cavity_area)/30;
END_RULE;
END_ENTITY;
```

```
ENTITY Sprue_gate
mouldability_feat : STRING;
position : POINT3D;
lower_diameter : dimension;
sprue_length : dimension;
taper_angle : dimension;
connect_gate : Gate;
connect_parting : Integer_cavity_parting_line;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_volume_lowest : Integer_cavity_volume (furthest from parting line);
connect_cooling : Standard_flow_way:
WHERE
machine_nozzle_inner_diameter: = 3.0;
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
cavity_height : = connect_parting.position - connect_volume_lowest.position[2];
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
                min_metal_over_cavity = 6.0;
                IF connect_volume_highest.diameter <= 38.0 THEN
                min_metal_over_cavity = 10.0;
                IF connect_volume_highest.diameter <= 44.0 THEN
                min_metal_over_cavity = 14.0;
                IF connect_volume_highest.diameter <= 50.0 THEN
                min_metal_over_cavity = 16.0;
                IF connect_volume_highest.diameter <= 56.0 THEN
                min_metal_over_cavity = 18.0;
                IF connect_volume_highest.diameter <= 62.0 THEN
                min_metal_over_cavity = 22.0;
                IF connect_volume_highest.diameter <= 68.0 THEN
                min_metal_over_cavity = 25.0;
                IF connect_volume_highest.diameter <= 74.0 THEN
                min_metal_over_cavity = 29.0;
                IF connect_volume_highest.diameter <= 80.0 THEN
                min_metal_over_cavity = 33.0;
                IF connect_volume_highest.diameter <= 86.0 THEN
                min_metal_over_cavity = 36.0;
                IF connect_volume_highest.diameter <= 92.0 THEN
                min_metal_over_cavity = 40.0;
                IF connect_volume_highest.diameter <= 98.0 THEN
                min_metal over_cavity = 44.0;
                IF connect_volume_highest.diameter <= 104.0 THEN
                min_metal_over_cavity = 49.0;
RULE Sprue_gate_position FOR (Sprue_gate, into cavity);
IF connect_gate.position is not in centre of part base THEN
Unbalanced gating of component can produce
uneven section thickness in the component.
Advise move gate to centre of base.
x position = connect_volume_lowest.position[0].
y position = connect_volume_lowest.position[1].
IF connect_gate.position is not on base of component THEN
 IF connect_gate.position is above component base THEN
 Reduced sprue length below cavity means a
 weakened mould block - can lead to distortion
 of mould due to injection pressure. Advise
 move gate down to base level.
 IF connect_gate.position is below component base THEN
 Gate not attached to component - No feeding.
 Advise move gate up to base level.
z position = connect_volume_lowest.position[2].
END_RULE;
RULE Sprue_gate_lower_diameter FOR (Sprue_gate, into cavity);
```

```
lower_diameter = machine_nozzle_inner_diameter + 0.1;
END_RULE;
RULE Sprue_gate_sprue_length FOR (Sprue_gate, into cavity);
IF (min_metal_condition + cavity_height) >= minimum_cooling_space THEN
sprue_length = min_metal_condition.
IF (min_metal_condition + cavity_height) < minimum_cooling_space THEN
sprue_length = minimum_cooling_space  - cavity_height.
END_RULE;
RULE Sprue_gate_taper_angle FOR (Sprue_gate, into cavity);
IF taper_angle < 4.0 THEN
Difficulty removing part and gate
from mould. Advise increase taper
angle to a minimum of 4.0.
END_RULE;
END_ENTITY;

ENTITY Pin_gate
mouldability_feat : STRING;
position : POINT3D;
land_length : dimension;
diameter : dimension;
secondary_sprue_length : dimension;
taper_angle : dimension;
connect_gate : Gate;
connect_gated_wall : Wall; (wall upon which the gate has been placed)
connect_parting : Integer_cavity_parting_line;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_taper_on_volume_lowest : Integer_cavity_taper;
connect_volume_lowest : Integer_cavity_volume (furthest from parting line);
connect_cooling : Standard_flow_way;
WHERE
small_angle_radians : = (connect_taper_on_volume_lowest.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_volume_lowest.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_volume_lowest.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
min_land_length : = 0.5;
max_land_length : = 0.75;
wall_thickness_constant : = IF connect_gated_wall.thickness <= 0.75 THEN
                        Constant = 0.178;
                        IF connect_gated_wall.thickness <= 1.0 THEN
                        Constant = 0.206;
                        IF connect_gated_wall.thickness <= 1.25 THEN
                        Constant = 0.230;
                        IF connect_gated_wall.thickness <= 1.5 THEN
                        Constant = 0.242;
                        IF connect_gated_wall.thickness <= 1.75 THEN
                        Constant = 0.272;
                        IF connect_gated_wall.thickness <= 2.0 THEN
                        Constant = 0.294;
                        IF connect_gated_wall.thickness <= 2.25 THEN
                        Constant = 0.309;
                        IF connect_gated_wall.thickness > 2.25 THEN
                        Constant = 0.326;
average_cavity_dia : = ((connect_volume_highest.diameter +
                connect_volume_lowest.diameter)/2.0);
cavity_height : = connect_parting.position – connect_volume_lowest.position[2];
cavity_area : = (3.1416*average_cavity_dia*cavity_height) +
            (3.1416*SQ(average_cavity_dia/2.0));
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
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```
                    min_metal_under_cavity = 6.0;
                    IF connect_volume_highest.diameter <= 38.0 THEN
                    min_metal_under_cavity = 10.0;
                    IF connect_volume_highest.diameter <= 44.0 THEN
                    min_metal_under_cavity = 14.0;
                    IF connect_volume_highest.diameter <= 50.0 THEN
                    min_metal_under_cavity = 16.0;
                    IF connect_volume_highest.diameter <= 56.0 THEN
                    min_metal_under_cavity = 18.0;
                    IF connect_volume_highest.diameter <= 62.0 THEN
                    min_metal_under_cavity = 22.0;
                    IF connect_volume_highest.diameter <= 68.0 THEN
                    min_metal_under_cavity = 25.0;
                    IF connect_volume_highest.diameter <= 74.0 THEN
                    min_metal_under_cavity = 29.0;
                    IF connect_volume_highest.diameter <= 80.0 THEN
                    min_metal_under_cavity = 33.0;
                    IF connect_volume_highest.diameter <= 86.0 THEN
                    min_metal_under_cavity = 36.0;
                    IF connect_volume_highest.diameter <= 92.0 THEN
                    min_metal_under_cavity = 40.0;
                    IF connect_volume_highest.diameter <= 98.0 THEN
                    min_metal under_cavity = 44.0;
                    IF connect_volume_highest.diameter <= 104.0 THEN
                    min_metal_under_cavity = 49.0;
RULE Pin_gate_position FOR (Pin_gate, into cavity);
IF connect_volume_lowest == closing off geometry THEN
 IF connect_taper_on_volume_lowest.angle != 0.0 THEN
 Gate position no longer in centre of section.
 Advise adjust gate position.
  IF connect_gate.position[0] < 0.0 THEN
  x position = connect_gate.position[0] + taper_allowance.
  y position = connect_gate.position[1].
  IF connect_gate.position[0] > 0.0 THEN
  x position = connect_gate.position[0] - taper_allowance.
  y position = connect_gate.position[1].
IF connect_gate.position is not on base of component THEN
 IF connect_gate.position is above component base THEN
 Either component attached to secondary sprue -
 cannot be ejected. OR Reduced land length
 means weakness in mould can lead to wear
 or failure. Advise move gate down to base level.
 IF connect_gate.position is below component base THEN
 Gate not attached to component - No feeding
 Advise move gate up to base level.
z position = connect_volume_lowest.position[2].
END_RULE;
RULE Pin_gate_land_length FOR ( Pin_gate, into cavity);
IF land_length < min_land_length THEN
Weakness in mould construction can lead
to wear or failure. Advise increase in land
length to a minimum of min_land_length.
IF land_length > max_land_length THEN
Excessive pressure drop across gate -
inadequate filling of mould cavity.
Advise decrease in land length to a
maximum of max_land_length.
END_RULE;
RULE Pin_gate_diameter FOR (Pin_gate, into cavity);
diameter = 0.7*wall_thickness_constant*POW(cavity_area, 0.25);
END_RULE;
RULE Pin_gate_taper_angle FOR (Pin_gate, into cavity);
```

```
IF taper_angle < 4.0 THEN
Difficulty removing part and gate
from mould. Advise increase taper
angle to a minimum of 4.0.
END_RULE;
RULE Pin_gate_secondary_sprue_length FOR (Pin_gate, into cavity);
IF (min_metal_condition + cavity_height) >= minimum_cooling_space THEN
secondary_sprue_length = min_metal_condition - land_length.
IF (min_metal_condition + cavity_height) < minimum_cooling_space THEN
secondary_sprue_length = minimum_cooling_space - cavity_height - land_length.
END_RULE;
END_ENTITY;

ENTITY Circular_runner
gate_name : STRING;
gate_type : STRING;
position : POINT3D;
runner_length : dimension;
diameter : dimension;
orientation : POINT3D;
configuration : integer;
connect_gate : Fan_gate OR Sub_surface_gate OR Overlap_gate OR Rectangular_edge_gate OR Tab_gate
OR Film_gate;
connect_gated_wall : Wall; (wall upon which the gate has been placed)
connect_parting : Integer_cavity_parting_line;
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
connect_volume_highest : Integer_cavity_volume; (on parting line)
WHERE
average_cavity_dia : = ((connect_volume_highest.diameter +
                    connect_volume_lowest.diameter)/2.0);
cavity_height : = connect_parting.position - connect_volume_lowest.position[2];
cavity_area : = (3.1416*average_cavity_dia*cavity_height) +
              (3.1416*SQ(average_cavity_dia/2.0));
material_density = 0.6/1000;
part_weight : = cavity_area*connect_gated_wall.thickness*material.density;
directional_cooling_distance: = 16.0;
maximum_sprue_diameter : = 10.0;
minimum_runner_diameter : = 2.0;
maximum_runner_diameter : = 10.0;
RULE Circ_runner_position FOR ( Circular_runner, in mould);
z position = connect_parting.position.
IF connect_gate.position[0] > 0.0 THEN
 IF connect_gate.type == Rectangular_edge OR Fan OR Overlap OR Round_edge THEN
 x position  = connect_gate.position[0] + connect_gate.land_length.
 y position = connect_gate.position[1].
 IF connect_gate.type == Film THEN
 x position = connect_gate.position[0] + connect_gate.land_length + diameter/2.0.
  IF first of three runners THEN
  y position = connect_gate.position[1].
  IF second of three runners THEN
  y position = connect_gate.position[1] - (connect_gate.width/2.0 + diameter/2.0).
  IF third of three runners THEN
  y position = connect_gate.position[1] + (connect_gate.width/2.0 + diameter/2.0).
 IF connect_gate.type == Sub_surface THEN
 x position = connect_gate.position[0] + 0.7*land_length.
 y position = connect_gate.position[1].
 IF connect_gate.type == Tab THEN
 x position = connect_gate.position[0] + diameter.
 y position = connect_gate.position[1] - diameter.
IF connect_gate.position[0] < 0.0 THEN
 IF connect_gate.type == Rectangular_edge OR Fan OR Overlap OR Round_edge THEN
 x position  = connect_gate.position[0] - connect_gate.land_length.
```

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  y position = connect_gate.position[1].
  IF connect_gate.type == Film THEN
  x position = connect_gate.position[0] – connect_gate.land_length – diameter/2.0.
    IF first of three runners THEN
    y position = connect_gate.position[1].
    IF second of three runners THEN
    y position = connect_gate.position[1] – (connect_gate.width/2.0 + diameter/2.0).
    IF third of three runners THEN
    y position = connect_gate.position[1] + (connect_gate.width/2.0 + diameter/2.0).
  IF connect_gate.type == Sub_surface THEN
  x position = connect_gate.position[0] – 0.7*land_length.
  y position = connect_gate.position[1].
  IF connect_gate.type == Tab THEN
  x position = connect_gate.position[0] – diameter.
  y position = connect_gate.position[1] – diameter.
END_RULE;
RULE Circ_runner_length  FOR ( Circular_runner, in mould);
IF connect_gate.type == Rectangular_edge OR Fan OR Overlap OR Round_edge THEN
runner_length = directional_cooling_distance + maximum_sprue_diameter/2.0 –
connect_gate.land_length.
IF connect_gate.type == Film THEN
  IF first of three runners THEN
  runner_length = directional_cooling_distance + maximum_sprue_diameter/2.0 –
  connect_gate.land_length.
  IF second of three runners THEN
  runner_length = connect_gate.width/2.0 + diameter/2.0.
  IF third of three runners THEN
  runner_length = connect_gate.width/2.0 + diameter/2.0.
IF connect_gate.type == Sub_surface THEN
runner_length = directional_cooling_distance + maximum_sprue_diameter/2.0 –
0.7*connect_gate.land_length.
IF connect_gate.type == Tab THEN
part.width/2.0 – diameter + directional_cooling_distance + maximum_sprue_diameter/2.0.
END_RULE;
RULE Circ_runner_diameter  FOR ( Circular_runner, in mould);
diameter = (SQRT(part_weight)*POW(runner_length,0.25))3.7.
IF diameter < minimum_runner_diameter THEN
Runner solidifies before cavity is filled.
Increase diameter to minimum_runner_diameter.
IF diameter > maximum_runner_diameter THEN
Large runner diameter results in cycle
time controlled by runner solidification
rate. Decrease runner diameter to
maximum_runner_diameter.
END_RULE;
RULE Circ_runner_orientation  FOR ( Circular_runner, in mould);
IF connect_gate.type == Rectangular_edge OR Fan OR Overlap OR Round_edge OR
Sub_surface THEN
  IF connect_gate.position > 0.0 THEN
  orientation = 0.0.
  IF connect_gate.position < 0.0 THEN
  orientation = 3.1416.
IF connect_gate.type == Film THEN
  IF connect_gate.position > 0.0 THEN
    IF first of three runners THEN
    orientation = 0.0.
    IF second of three runners THEN
    orientation = 3.1416/2.0.
    IF third of three runners THEN
    orientation = 2.0*3.1416/3.0.
  IF connect_gate.position < 0.0 THEN
    IF first of three runners THEN
```

```
   orientation = 3.1416.
   IF second of three runners THEN
   orientation = 3.1416/2.0.
   IF third of three runners THEN
   orientation = 2.0*3.1416/3.0.
IF connect_gate.type == Tab THEN
orientation = 2.0*3.1416/3.0.
END_RULE;
END_ENTITY;

ENTITY Trapezoidal_runner
gate_name : STRING;
gate_type : STRING;
position : POINT3D;
runner_length : dimension;
width : dimension;
orientation : dimension;
configuration : integer;
connect_gate : Ring_gate OR Pin_gate;
connect_gated_wall : Wall; (wall upon which the gate has been placed)
connect_parting : Integer_cavity_parting_line;
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
connect_volume_highest : Integer_cavity_volume; (on parting line)
connect_cooling : Standard_flow_way;
WHERE
average_cavity_dia : = ((connect_volume_highest.diameter +
                    connect_volume_lowest.diameter)/2.0);
cavity_height : = connect_parting.position - connect_volume_lowest.position[2];
cavity_area : = (3.1416*average_cavity_dia*cavity_height) +
            (3.1416*SQ(average_cavity_dia/2.0));
material_density = 0.6/1000;
part_weight : = cavity_area*connect_gated_wall.thickness*material.density;
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
                    min_metal_over_cavity = 6.0;
                    IF connect_volume_highest.diameter <= 38.0 THEN
                    min_metal_over_cavity = 10.0;
                    IF connect_volume_highest.diameter <= 44.0 THEN
                    min_metal_over_cavity = 14.0;
                    IF connect_volume_highest.diameter <= 50.0 THEN
                    min_metal_over_cavity = 16.0;
                    IF connect_volume_highest.diameter <= 56.0 THEN
                    min_metal_over_cavity = 18.0;
                    IF connect_volume_highest.diameter <= 62.0 THEN
                    min_metal_over_cavity = 22.0;
                    IF connect_volume_highest.diameter <= 68.0 THEN
                    min_metal_over_cavity = 25.0;
                    IF connect_volume_highest.diameter <= 74.0 THEN
                    min_metal_over_cavity = 29.0;
                    IF connect_volume_highest.diameter <= 80.0 THEN
                    min_metal_over_cavity = 33.0;
                    IF connect_volume_highest.diameter <= 86.0 THEN
                    min_metal_over_cavity = 36.0;
                    IF connect_volume_highest.diameter <= 92.0 THEN
                    min_metal_over_cavity = 40.0;
                    IF connect_volume_highest.diameter <= 98.0 THEN
                    min_metal over_cavity = 44.0;
                    IF connect_volume_highest.diameter <= 104.0 THEN
                    min_metal_over_cavity = 49.0;
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
minimum_runner_width : = 2.0;
maximum_runner_width : = 10.0;
```

```
max_sprue_diameter = 10.0;
IF connect_gate.type == Pin THEN
   gate_angle_radians : = ((connect_gate.taper_angle/2.0)/360)*2.0*3.1416;
   remaining_angle : = 90 – connect_gate.taper_angle/2.0;
   larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
   taper_allowance : = (connect_gate.secondary_sprue_length*SINE(gate_angle_radians))/
                 SINE(larger_angle_radians);
   sprue_junction_dia : = connect_gate.diameter + 2.0*taper_allowance;
RULE Trap_runner_position FOR (Trapezoidal_runner, in mould);
IF connect_gate.type == Ring THEN
x position = connect_volume_highest.position[0] + connect_volume_highest.diameter/2.0 +
connect_gate.land_length.
y position = connect_volume_highest.position[1].
z position = connect_parting.position.
IF connect_gate.type == Pin THEN
 IF connect_gate.position[0] > 0.0 THEN
 x position = connect_gate.position[0] + max_sprue_diameter.
 y position = connect_gate.position[1].
 IF connect_gate.position[0] < 0.0 THEN
 x position = connect_gate.position[0] – max_sprue_diameter.
 y position = connect_gate.position[1].
 IF (min_metal_condition + cavity_height) >= minimum_cooling_space THEN
 z position = connect_parting_position – (min_metal_condition + cavity_height) .
 IF (min_metal_condition + cavity_height) < minimum_cooling_space THEN
 z position = connect_parting_position – minimum_cooling_space.
END_RULE;
RULE Trap_runner_length FOR (Trapezoidal_runner, in mould);
IF connect_gate.type == Ring THEN
runner_length = directional_cooling_distance + max_sprue_diameter/2.0 + width.
IF connect_gate.type == Pin THEN
 IF connect_gate.position[0] > 0.0 THEN
 runner_length = connect_gate.position[0] – connect_volume_lowest.position[0] +
 max_sprue_diameter.
 IF connect_gate.position[0] < 0.0 THEN
 runner_length = connect_volume_lowest.position[0] – connect_gate.position[0] +
 max_sprue_diameter.
END_RULE;
RULE Trap_runner_width FOR (Trapezoidal_runner, in mould);
width = (SQRT(part_weight)*POW(runner_length,0.25))3.7.
IF connect_gate.type == Pin THEN
 IF width < sprue_junction_dia THEN
 width = sprue_junction_dia.
IF diameter < minimum_runner_diameter THEN
Runner solidifies before cavity is filled.
Increase diameter to minimum_runner_diameter.
IF diameter > maximum_runner_diameter THEN
Large runner diameter results in cycle
time controlled by runner solidification
rate. Decrease runner diameter to
maximum_runner_diameter.
END_RULE;
RULE Trap_runner_orientation FOR (Trapezoidal_runner, in mould);
IF connect_gate.type == Ring THEN
orientation = 0.0.
IF connect_gate.type == Pin THEN
 IF connect_gate.position[0] > 0.0 THEN
 orientation = 0.0.
 IF connect_gate.position[0] > 0.0 THEN
 orientation = 3.1416.
END_RULE;
END_ENTITY;
```

```
ENTITY Main_feeding_sprue
runner_name : STRING;
runner_type : STRING;
position : dimension;
sprue_length : dimension;
lower_diameter : dimension;
taper_angle : dimension;
connect_gate : Fan_gate OR Sub_surface_gate OR Overlap_gate OR Rectangular_edge_gate OR Tab_gate
OR Film_gate OR Ring_gate OR Pin_gate;
connect_runner : Circular_runner OR Trapezoidal_runner;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
WHERE
cavity_height : = connect_parting.position – connect_volume_lowest.position[2];
max_sprue_diameter = 10.0;
sprue_puller_length = 5.0;
max_sprue_dia = 10.0;
machine_nozzle_inner_diameter = 3.0;
min_metal_condition: IF connect_volume_highest.diameter <= 25.0 THEN
                min_metal_under_cavity = 6.0;
                IF connect_volume_highest.diameter <= 38.0 THEN
                min_metal_under_cavity = 10.0;
                IF connect_volume_highest.diameter <= 44.0 THEN
                min_metal_under_cavity = 14.0;
                IF connect_volume_highest.diameter <= 50.0 THEN
                min_metal_under_cavity = 16.0;
                IF connect_volume_highest.diameter <= 56.0 THEN
                min_metal_under_cavity = 18.0;
                IF connect_volume_highest.diameter <= 62.0 THEN
                min_metal_under_cavity = 22.0;
                IF connect_volume_highest.diameter <= 68.0 THEN
                min_metal_under_cavity = 25.0;
                IF connect_volume_highest.diameter <= 74.0 THEN
                min_metal_under_cavity = 29.0;
                IF connect_volume_highest.diameter <= 80.0 THEN
                min_metal_under_cavity = 33.0;
                IF connect_volume_highest.diameter <= 86.0 THEN
                min_metal_under_cavity = 36.0;
                IF connect_volume_highest.diameter <= 92.0 THEN
                min_metal_under_cavity = 40.0;
                IF connect_volume_highest.diameter <= 98.0 THEN
                min_metal under_cavity = 44.0;
                IF connect_volume_highest.diameter <= 104.0 THEN
                min_metal_under_cavity = 49.0;
directional_cooling_distance: = 16.0;
minimum_cooling_space: = connect_cooling.diameter + 2.0*directional_cooling_distance;
sprue_top_dia : sprue_angle_radians : = ((taper_angle/2.0)/360)*2.0*3.1416;
            remaining_angle : = 90 – taper_angle/2.0;
            larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
            taper_allowance : = (sprue_length*SINE(sprue_angle_radians))/
                          SINE(larger_angle_radians);
            top_dia : = lower_diameter + 2.0*taper_allowance;
length_ten_top_dia : required_allowance: = (max_sprue_diameter – lower_diameter)/2.0;
               required_sprue_length := required_allowance*SINE(sprue_angle_radians)
               /SINE(larger_angle_radians);
length_runner_dia : required_allowance2: = (connect_runner.diameter – lower_diameter)/2.0;
               required_sprue_length2 := required_allowance2*SINE(sprue_angle_radians)
               /SINE(larger_angle_radians);
length_with_trap_runn : required_allowance3: = (connect_runner.width – lower_diameter)/2.0;
                  req_trap_length := required_allowance3*SINE(sprue_angle_radians)
                  /SINE(larger_angle_radians);
RULE Main_feeding_sprue_position FOR (Main_feeding_sprue, in mould);
```

```
IF connect_runner == Circular THEN
 IF connect_gate.type == Fan OR Rectangular_edge OR Overlap OR Sub_surface OR
                    Round_edge THEN
  IF connect_runner.position[0] > 0.0 THEN
  x position = connect_runner.position[0] + connect_runner.runner_length.
  y position = connect_runner.position[1].
  z position = connect_runner.position[2] + sprue_puller_length.
  IF connect_runner.position[0] < 0.0 THEN
  x position = connect_runner.position[0] – connect_runner.runner_length.
  y position = connect_runner.position[1].
  z position = connect_runner.position[2] + sprue_puller_length.
 IF connect_gate.type == Film THEN
  IF connect_runner == First of three THEN
   IF connect_runner.position[0] > 0.0 THEN
   x position = connect_runner.position[0] + connect_runner.runner_length.
   y position = connect_runner.position[1].
   z position = connect_runner.position[2] + sprue_puller_length.
   IF connect_runner.position[0] < 0.0 THEN
   x position = connect_runner.position[0] – connect_runner.runner_length.
   y position = connect_runner.position[1].
   z position = connect_runner.position[2] + sprue_puller_length.
 IF connect_gate.type == Tab THEN
 x position = connect_runner.position[0].
 y position = connect_runner.position[1] – connect_runner.runner_length.
 z position = connect_runner.position[2] + sprue_puller_length.
IF connect_runner == Trapezoidal THEN
 IF connect_gate.type == Ring THEN
 x position = connect_runner.position[0] + connect_runner.runner_length – max_sprue_dia.
 y position = connect_runner.position[1].
 z position = connect_runner.position[2] – connect_runner.width.
 IF connect_gate.type == Pin THEN
  IF connect_runner.position[0] > 0.0 THEN
  x position = connect_runner.position[0] – max_sprue_dia.
  y position = connect_runner.position[1].
  z position = connect_runner.position[2] – connect_runner.width.
  IF connect_runner.position[0] < 0.0 THEN
  x position = connect_runner.position[0] + max_sprue_dia.
  y position = connect_runner.position[1].
  z position = connect_runner.position[2] – connect_runner.width.
END_RULE;
RULE Main_sprue_taper_angle FOR (Main_feeding_sprue, in mould);
IF taper_angle < 4.0 THEN
Difficulty removing part and gate
from mould. Advise increase taper
angle to a minimum of 4.0.
END_RULE;
RULE Main_sprue_lower_diameter FOR (Main_feeding_sprue, in mould);
lower_diameter = machine_nozzle_inner_diameter + 0.1;
END_RULE;
RULE Main_sprue_length FOR (Main_feeding_sprue, in mould);
IF connect_runner == Circular THEN
 IF (min_metal_condition + cavity_height) >= minimum_cooling_space THEN
 sprue_length = min_metal_condition + cavity_height.
 IF (min_metal_condition + cavity_height) < minimum_cooling_space THEN
 sprue_length = minimum_cooling_space.
 IF sprue_top_dia > max_sprue_diameter THEN
 Nozzle recess required.
 sprue length = length_ten_top_dia.
 IF sprue_top_dia < connect_runner.diameter THEN
 sprue_length = length_runner_dia.
sprue_length = sprue_length + sprue_puller_length.
IF connect_runner == Trapezoidal THEN
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```
  IF connect_gate.type == Pin THEN
  sprue_length = length_with_trap_runn.
   IF sprue_length < min_metal_condition
   sprue_length = min_metal_condition.
  IF connect_gate.type == Ring THEN
   IF (min_metal_condition + cavity_height) >= minimum_cooling_space THEN
   sprue_length = min_metal_condition + cavity_height - connect_runner.width.
   IF (min_metal_condition + cavity_height) < minimum_cooling_space THEN
   sprue_length = minimum_cooling_space - connect_runner.width.
   IF sprue_top_dia > max_sprue_diameter THEN
   Nozzle recess required.
   sprue length = length_ten_top_dia.
   IF sprue_top_dia < connect_runner.diameter THEN
   sprue_length = length_with_trap_runn.
END_RULE;
END_ENTITY;

ENTITY Cooling_system
has_cav_cooling : Integer_cavity_cooling_system;
has_core_cooling : Integer_core_cooling_system;
has_standard : Standard_flow_way;
has_baffle_flow : Baffle_flow_way;
has_baffle_blade : Baffle_blade;
END_ENTITY;

ENTITY Integer_cavity_cooling_system
ABSTRACT SUPERTYPE OF (ONE OF ( Pair_tube_configuration, U_tube_configuration));
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting line)
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
connect_gate : Sprue_gate OR Diaphragm_gate OR Ring_gate OR Pin_gate OR Fan_gate OR
          Sub_surface_gate OR Overlap_gate OR Rectangular_edge_gate OR Tab_gate;
connect_tube : Standard_flow_way;
connect_sprue : Main_feeding_sprue;
WHERE
max_sprue_diameter = 10.0;
cavity_height : = connect_parting.position - connect_volume_lowest.position[2];
directional_cooling_distance: = 16.0;
min_cooling_tube_diameter: = 7.0;
max_cooling_tube_diameter: = 10.0;
number_of_flow_ways: = cavity_height/(cooling_tube_diameter +
                    directional_cooling_distance);
relative_cooling_effect: = cooling_tube_diameter*3.1416*number_of_flow_ways;
RULE Cavity_maximum_cooling_capacity FOR ( Integer_cavity_cooling_system);
IF relative_cooling_effect 7.0 mm > 8.0mm THEN
Advise optimum tube diameter = 7.0mm.
IF relative_cooling_effect 7.0 mm < 8.0mm THEN
Advise optimum tube diameter = 8.0mm
IF relative_cooling_effect 8.0 mm > 9.0mm THEN
Advise optimum tube diameter = 9.0mm
IF relative_cooling_effect 9.0 mm > 10.0mm THEN
Advise optimum tube diameter = 10.0mm
END_RULE;
RULE Cavity_cooling_system_configuration FOR ( Integer_cavity_cooling_system);
IF connect_gate.type == Pin_gate OR Fan_gate OR Sub_surface_gate OR Overlap_gate OR
Rectangular_edge_gate OR Tab_gate OR Film gateTHEN
 IF number of gates == 1 THEN
 Advise use of U_tube configuration.
 Bottom of 'U' cooling gated side provides
 more even mould cooling and can reduce
 cycle time.
 IF number of gates > 1 THEN
 Advise use of paired_tube configuration
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 U_tube provides uneven cooling of mould –
 Possible differential thickness over moulding,
 differential shrinkage causing warpage.
IF connect_gate.type == Ring_gate THEN
Advise use of U_tube configuration.
Bottom of 'U' cooling gated side provides
more even mould cooling and can reduce
cycle time.
IF connect_gate.type == Diaphragm_gate OR Sprue_gate THEN
Advise use of paired_tube configuration
U_tube provides uneven cooling of mould –
Possible differential thickness over moulding,
differential shrinkage causing warpage.
END_RULE;
RULE Cavity_optimum_cooling_formation FOR ( Integer_cavity_cooling_system);
IF Configuration == Paired_tube THEN
Front tube:
connect_tube.position[1] = connect_volume_highest.position[1] –
                     (connect_volume_highest.diameter/2.0 + directional_cooling_distance +
                    connect_tube.diameter/2.0)
connect_tube.orientation = 0.0;
Back tube:
connect_tube.position[1] = connect_volume_highest.position[1] +
                     (connect_volume_highest.diameter/2.0 + directional_cooling_distance +
                    connect_tube.diameter/2.0)
connect_tube.orientation = 0.0;
IF Configuration == U_tube THEN
Front tube:
connect_tube.position[1] = connect_volume_highest.position[1] –
                     (connect_volume_highest.diameter/2.0 + directional_cooling_distance +
                    connect_tube.diameter/2.0)
connect_tube.orientation = 0.0;
Back tube:
connect_tube.position[1] = connect_volume_highest.position[1] +
                     (connect_volume_highest.diameter/2.0 + directional_cooling_distance +
                    connect_tube.diameter/2.0)
connect_tube.orientation = 0.0;
Side tube:
connect_tube.position[0] = connect_sprue.position[0] + max_sprue_diameter/2.0 +
                      directional_cooling_distance + connect_tube.diameter/2.0.
connect_tube.orientation = 3.1416/2.0;
END_RULE;
END_ENTITY;

ENTITY Integer_core_cooling_system
ABSTRACT SUPERTYPE OF (ONE OF ( Integer_core_shallow_cooling,
Integer_core_deep_cooling));
connect_parting_line : Integer_core_parting_line;
connect_volume_lowest : Integer_cavity_volume; (furthest from parting line)
connect_wall_lowest : Wall; (mouldability equivalent of connect_volume_lowest)
WHERE
cavity_height : = connect_parting.position – connect_volume_lowest.position[2];
core_depth : = cavity_height – connect_wall.thickness;
RULE Type_of_cooling_system FOR ( Integer_core_cooling_system);
IF core_depth > 25.0 THEN
Integer_core_deep_cooling.
IF core_depth <= 25.0 THEN
Integer_core_shallow_cooling.
END_RULE;
END_ENTITY;

ENTITY Integer_core_deep_cooling
```

SUBTYPE OF (Integer_core_cooling_system);
ABSTRACT SUPERTYPE OF (ONE OF (Stepped_circuit, Angled_hole_system, Baffle_system));
connect_block : Integer_core_rect_block;
connect_volume_lowest : Integer_core_volume; (furthest from parting line)
connect_parting : Integer_core_parting_line;
connect_standard_tube : Standard_flow_way;
connect_baffle_tube : Baffle_flow_way;
WHERE
directional_cooling_distance: = 16.0;
core_minimum_dia = connect_volume_lowest.diameter;
min_baffle_tube_diameter: = 12.0;
max_baffle_tube_diameter: = 16.0;
min_space_between_baffles = 9.0;
max_standard_tube_diameter = 10.0;
number_of_baffle_tubes: = ((core_minimum_dia – (2.0*directional_cooling_distance +
baffle_tube_diameter))/ (baffle_tube_diameter +
min_space_between_baffles)) + 1;
relative_cooling_effect: = baffle_tube_diameter*3.1416*number_of_baffle_tubes;
RULE Type_of_deep_cooling FOR (Integer_core_deep_cooling_system);
Choice of deep core cooling systems:
1. Angled_hole_system – Cannot be used on deeper cores. Hard to manufacture due to angled holes (fixture required). Relatively small cooling capacity. Inadequate cooling of core base periphery.
2. Stepped_circuit_system – Holes drilled into cavity space through core, require plugging, finishing and polishing. Relatively small cooling capacity.
3. Baffled_straight_hole_system – Straight holes into core, easy to manufacture. No holes into cavity. Much larger cooling capacity than the other systems.
– Use baffled_straight_hole_system.
END_RULE;
RULE Deep_core_maximum_cooling_capacity FOR (Integer_core_deep_cooling_system);
connect_standard_tube.diameter = max_standard_tube_diameter;
IF relative_cooling_effect 12.0 mm > 13.0mm THEN
Advise optimum baffle tube diameter = 12.0 mm.
IF relative_cooling_effect 12.0 mm < 13.0mm THEN
Advise optimum tube diameter = 13.0mm
IF relative_cooling_effect 13.0 mm > 14.0mm THEN
Advise optimum tube diameter = 14.0mm
IF relative_cooling_effect 14.0 mm > 15.0mm THEN
Advise optimum tube diameter = 15.0mm
IF relative_cooling_effect 15.0 mm > 16.0mm THEN
Advise optimum tube diameter = 16.0mm
END_RULE;
RULE Deep_core_optimum_cooling_formation FOR (Integer_core_deep_cooling_system);
connect_baffle_tube.position[0] = (connect_volume_lowest.position[0] –
connect_volume_lowest.diameter/2.0) +
directional_cooling_distance +
connect_baffle_tube.diameter/2.0.
connect_baffle_tube.position[1] = connect_volume_lowest.position[1].
connect_baffle_tube.position[2] = connect_block.position + connect_block.depth.
connect_baffle_tube.length = connect_baffle_tube.position[2] –
connect_volume_lowest.position[2] –
directional_cooling_distance.
spacing_between_tubes (in x direction) = connect_baffle_tube.diameter +
min_space_between_baffles.
connect_standard_tube.position[0] = connect_volume_lowest.postion[0] –

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                         connect_block.length/2.0.
connect_standard_tube.position[1] = connect_volume_lowest.position[1].
connect_standard_tube.position[2] = connect_parting.position + directional_cooling_distance +
                         connect_standard_tube.diameter/2.0.
END_RULE;
END_ENTITY;

ENTITY Integer_core_shallow_cooling
SUBTYPE OF (Integer_core_cooling_system);
ABSTRACT SUPERTYPE OF (ONE OF ( Single_tube_configuration, Pair_tube_configuration,
U_tube_configuration, Z_tube_configuration));
connect_volume_highest: Integer_cavity_volume OR Integer_cavity_rim; (on parting_line)
connect_standard_tube: Standard_flow_way;
connect_parting: Integer_core_parting_line;
connect_block: Integer_cavity+rect_block;
WHERE
directional_cooling_distance: = 16.0;
min_baffle_tube_diameter: = 7.0;
max_baffle_tube_diameter: = 10.0;
cavity_width = connect_volume_highest.diameter + 2.0*connect_land.width;
number_of_flow_ways: = cavity_width/(cooling_tube_diameter +
                    directional_cooling_distance);
relative_cooling_effect: = cooling_tube_diameter*3.1416*number_of_flow_ways;
RULE Shallow_core_maximum_cooling_capacity FOR ( Integer_core_shallow_cooling);
IF relative_cooling_effect 7.0 mm > 8.0mm THEN
Advise optimum tube diameter = 7.0mm.
IF relative_cooling_effect 7.0 mm < 8.0mm THEN
Advise optimum tube diameter = 8.0mm
IF relative_cooling_effect 8.0 mm > 9.0mm THEN
Advise optimum tube diameter = 9.0mm
IF relative_cooling_effect 9.0 mm > 10.0mm THEN
Advise optimum tube diameter = 10.0mm
END_RULE;
RULE Shallow_core_cooling_system_configuration FOR ( Integer_core_shallow_cooling);
IF number of tubes across core == 2.0 THEN
Choice of system configuration:
1. Paired_tube_configuration
2. U_tube_configuration
 IF connect_gate.type == Pin_gate OR Fan_gate OR Sub_surface_gate OR
 Overlap_gate OR Rectangular_edge_gate OR Tab_gate OR Film_gate THEN
   IF number of gates == 1 THEN
   Advise use of U tube configuration.
   Bottom of 'U' cooling gated side provides
   more even mould cooling and can reduce
   cycle time.
   IF number of gates > 1 THEN
   Advise use paired tube configuration.
   U_tube provides uneven cooling of mould -
   Possible differential thickness over moulding,
   differential shrinkage causing warpage.
 IF connect_gate.type == Ring_gate THEN
 Advise use of U tube configuration.
 Bottom of 'U' cooling gated side provides
 more even mould cooling and can reduce
 cycle time.
 IF connect_gate.type == Diaphragm_gate OR Sprue_gate THEN
 Advise use of paired tube configuration.
 U_tube provides uneven cooling of mould -
 Possible differential thickness over moulding,
 differential shrinkage causing warpage.
IF number of tubes across core == 3.0 THEN
Choice of system configuration:
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1. Z_tube_configuration
2. Single_tube_configuration
 IF connect_gate.type == Pin_gate OR Fan_gate OR Sub_surface_gate OR
 Overlap_gate OR Rectangular_edge_gate OR Tab_gate OR Film_gate THEN
  IF number of gates == 1 THEN
  Advise use of Z tube configuration.
  Cooler water entering gated side provides
  more even mould cooling and can reduce
  cycle time.
  IF number of gates > 1 THEN
  Using Z tube configuration 'cooler' water entering
  the mould at the gated end provides uneven
  cooling of the moulding. Possible differential
  thickness over moulding, differential shrinkage
  causing warpage.
  Recommendation - Use single tube configuration.
 IF connect_gate.type == Ring_gate THEN
 Advise use of Z tube configuration.
 Cooler water entering gated side provides
 more even mould cooling and can reduce
 cycle time.
 IF connect_gate.type == Diaphragm_gate OR Sprue_gate THEN
 Using Z tube configuration 'cooler' water entering
 the mould at the gated end provides uneven
 cooling of the moulding. Possible differential
 thickness over moulding, differential shrinkage
 causing warpage.
 Recommendation - Use single tube configuration.
IF number of tubes across core == 4.0 THEN
Choice of system configuration:
1. Balanced U_tube_configuration
2. Balanced Paired_tube_configuration
 IF connect_gate.type == Pin_gate OR Fan_gate OR Sub_surface_gate OR
 Overlap_gate OR Rectangular_edge_gate OR Tab_gate OR Film_gate THEN
  IF number of gates == 1 THEN
  Advise use of balanced U tube configuration.
  Bottom of 'U' cooling gated side provides
  more even mould cooling and can reduce
  cycle time.
  IF number of gates > 1 THEN
  Advise use of paired tube configuration.
  Balanced U_tube provides uneven cooling of the mould -
  Possible differential thickness over moulding,
  differential shrinkage causing warpage.
 IF connect_gate.type == Ring_gate THEN
 Advise use of balanced U tube configuration.
 Bottom of 'U' cooling gated side provides
 more even mould cooling and can reduce
 cycle time.
 IF connect_gate.type == Diaphragm_gate OR Sprue_gate THEN
 Advise use of paired tube configuration.
 Balanced U_tube provides uneven cooling of the mould -
 Possible differential thickness over moulding,
 differential shrinkage causing warpage.
END_RULE;
RULE Shallow_core_optimum_cooling_formation FOR ( Integer_core_shallow_cooling);
Spacing_between_tubes = directional_cooling_distance + connect_standard_tube.diameter.
IF system configuration == Single_tube OR Paired_tube THEN
x position:
connect_standard_tube.position[0] = connect_volume_highest.position[0] -
                                connect_block.length/2.0.
 IF number of tubes across core == 2.0 THEN
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y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
directional_cooling_distance/2.0 –
connect_standard_tube.diameter/2.0.
IF number of tubes across core == 3.0 THEN
y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
directional_cooling_distance –
connect_standard_tube.diameter.
IF number of tubes across core == 4.0 THEN
y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
1.5*directional_cooling_distance –
1.5*connect_standard_tube.diameter.
z position:
connect_standard_tube.position[2] = connect_parting.position + directional_cooling_distance +
connect_standard_tube.diameter/2.0.
connect_standard_tube.orientation = 0.0;
IF system configuration == U_tube THEN
Parallel tubes:
x position:
connect_standard_tube.position[0] = connect_volume_highest.position[0] –
connect_block.length/2.0.
IF number of tubes across core == 2.0 THEN
y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
directional_cooling_distance/2.0 –
connect_standard_tube.diameter/2.0.
IF number of tubes across core == 4.0 THEN
y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
1.5*directional_cooling_distance –
1.5*connect_standard_tube.diameter.
z position:
connect_standard_tube.position[2] = connect_parting.position – directional_cooling_distance +
connect_standard_tube.diameter/2.0.
connect_standard_tube.orientation = 0.0.
Perpendicular_tubes:
x position:
connect_standard_tube.position[0] = connect_volume_highest.position[0] +
connect_volume_highest.diameter/2.0 +
directional_cooling_distance.
y position:
connect_standard_tube.position[1] = connect_volume_highest.position[1] +
connect_block.width/2.0.
z position:
connect_standard_tube.position[2] = connect_parting.position + directional_cooling_distance +
connect_standard_tube.diameter/2.0.
orientation perpendicular tube:
connect_standard_tube.orientation = 3.1416/2.0.
IF system configuration == Z_tube THEN
Parallel tubes:
x position:
connect_standard_tube.position[0] = connect_volume_highest.position[0] –
connect_block.length/2.0.
y position front tube:
connect_standard_tube.position[1] = connect_volume_highest.position[1] –
connect_volume_highest.diameter/2.0 –
directional_cooling_distance –
connect_standard_tube.diameter/2.0.
z position:
connect_standard_tube.position[2] = connect_parting.position + directional_cooling_distance +

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                              connect_standard_tube.diameter/2.0.
connect_standard_tube.orientation = 0.0;
connect_standard_tube.length = connect_block..length/2.0 +
                           connect_volume_highest.diameter/2.0 +
                           directional_cooling_distance +
                           connect_standard_tube.diameter.
Perpendicular tubes:
x position:
connect_standard_tube.position[0] = connect_volume_highest.position[0] -
                              directional_cooling_distance -
                              connect_standard_tube.diamete/2.0.
y position:
connect_standard_tube.position[1] = connect_volume_highest.position[1] -
                              connect_block.width/2.0.
z position:
connect_standard_tube.position[2] = connect_parting.position - directional_cooling_distance +
                              connect_standard_tube.diameter/2.0.
orientation parallel tubes:
connect_standard_tube.orientation = 0.0.
orientation perpendicular tubes:
connect_standard_tube.orientation = 3.1416/2.0.
END_RULE;
END_ENTITY;

ENTITY Standard_flow_way
cav_core_name :STRING;
configuration : STRING;
position : POINT3D;
diameter : dimension;
length : dimension;
orientation : dimension;
connect_cooling : OR Integer_core_shallow_cooling OR
          Integer_core_deep_cooling;
connect_block_core : Integer_core_rect_block;
connect_block_cavity : Integer_cavity_rect_block;
connect_volume_highest : Integer_cavity_volume OR Integer_cavity_rim; (on parting_line)
connect_gate : Sprue_gate OR Diaphragm_gate OR Ring_gate OR Pin_gate OR Fan_gate OR
        Sub_surface_gate OR Overlap_gate OR Rectangular_edge_gate OR Tab_gate;
connect_sprue : Main_feeding_sprue;
WHERE
sprue_puller_length: = 5.0;
max_sprue_diameter: = 10.0;
directional_cooling_distance: = 16.0;
RULE Standard_flow_way_position FOR (Standard_flow_way, in a cooling system);
IF connect_cooling == Integer_cavity_cooling_system THEN
 IF orientation == 0.0 THEN
 Take y and z position from connect_cooling.
 position[0] = connect_volume_highest.position[0] - connect_block_cavity.length/2.0.
 IF orientation != 0.0 THEN
 Take x and z position from connect_cooling.
 position[1] = connect_volume_highest.position[1] - connect_block_cavity.width/2.0.
IF connect_cooling == Integer_core_deep_cooling THEN
Take position from connect_cooling.
 IF connect_gate.type == Fan_gate OR Sub_surface_gate OR Overlap_gate OR
            Rectangular_edge_gate OR Tab_gate THEN
 position[2] = position[2] + sprue_puller_length.
 connect_block_core.depth = connect_block.depth + sprue_puller_length.
IF connect_cooling == Integer_core_shallow_cooling THEN
 IF Single_tube OR Paired_tube THEN
 Take position from connect_cooling.
  IF number of tubes == 3 THEN
  IF connect_gate.type == Fan_gate OR Sub_surface_gate OR Overlap_gate OR
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                    Rectangular_edge_gate OR Tab_gate THEN
    position[2] = position[2] + sprue_puller_length.
    connect_block_core.depth = connect_block.depth + sprue_puller_length.
  IF U_tube THEN
   IF number of tubes == 2.0 THEN
   Take position from connect_cooling.
   IF number of tubes == 4.0 THEN
    IF first tube THEN
    Take position from connect_cooling.
    IF second tube THEN
    Take position from connect_cooling.
    position[1] = - position[1].
  IF Z_tube THEN
   IF first parallel tube THEN
   Take position from connect_cooling.
   IF second parallel tube THEN
   Take position from connect_cooling.
   position[0] = - position[0].
   position[1] = - position[1].
   IF first perpendicular tube THEN
   Take position from connect_cooling.
   IF second perpendicular tube THEN
   Take position from connect_cooling.
   position[0] = - position[0].
   position[1] = position[1] + directional_cooling_distance + diameter.
   IF third perpendicular tube THEN
   Take position from connect_cooling.
   position[0] = - position[0].
   position[1] = position[1] + 2.0*directional_cooling_distance + 2.0*diameter.
END_RULE;
RULE Standard_flow_way_orientation FOR (Standard_flow_way, in a cooling system);
IF connect_cooling == Integer_cavity_cooling_system THEN
Take orientation from connect_cooling.
IF connect_cooling == Integer_core_deep_cooling THEN
orientation = 0.0.
IF connect_cooling == Integer_core_shallow_cooling THEN
 IF system configuration == Single_tube OR Paired_tube THEN
 Take orientation from connect_cooling.
 IF system configuration == U_tube THEN
 Take orientation from connect_cooling.
  IF second perpendicular tube THEN
  orientation = orientation + 3.1416.
 IF system configuration = Z_tube THEN
 Take orientation from connect_cooling.
  IF second parallel tube THEN
  orientation = orientation + 3.1416.
  IF second perpendicular tube OR third perpendicular tubeTHEN
  orientation = orientation + 3.1416.
END_RULE;
RULE Standard_flow_way_diameter FOR (Standard_flow_way, in a cooling system);
Take diameter from connect_cooling.
END_RULE;
RULE Standard_flow_way_length FOR (Standard_flow_way, in a cooling system);
IF connect_cooling == Integer_cavity_cooling_system THEN
 IF orientation == 0.0 THEN
  IF Paired_tube THEN
  length = connect_block_cavity.length.
  IF U_tube THEN
   IF connect_gate.type == Fan_gate OR Sub_surface_gate OR Overlap_gate OR
                         Rectangular_edge_gate OR Tab_gate THEN
   length = connect_block_cavity.length/2.0 + (connect_sprue.position[0] -
          connect_volume_highest.position[0]) + max_sprue_diameter/2.0 +
```

```
        directional_cooling_distance + diameter.
    IF connect_gate.type == Pin_gate OR Ring_gate OR Diaphragm_gate THEN
    length = connect_block_cavity.length/2.0 + connect_volume_highest.diameter/2.0 +
        directional_cooling_distance + diameter.
  IF orientation != 0.0 THEN
  length = connect_block_cavity.width/2.0 + connect_volume_highest.diameter/2.0 +
  directional_cooling_distance + diameter.
IF connect_cooling == Integer_core_deep_cooling THEN
length = connect_block_cavity.length.
IF connect_cooling == Integer_core_shallow_cooling THEN
  IF Single_tube OR Paired_tube THEN
  length = connect_block_cavity.length.
  IF U_tube THEN
   IF orientation == 0.0 THEN
    IF connect_gate.type == Fan_gate OR Sub_surface_gate OR Overlap_gate OR
                    Rectangular_edge_gate OR Tab_gate THEN
    length = connect_block_cavity.length/2.0 + (connect_sprue.position[0] -
        connect_volume_highest.position[0]) + max_sprue_diameter/2.0 +
        directional_cooling_distance + diameter.
    IF connect_gate.type == Pin_gate OR Ring_gate OR Diaphragm_gate THEN
    length = connect_block_cavity.length/2.0 + connect_volume_highest.diameter/2.0 +
        directional_cooling_distance + diameter.
   IF orientation != 0.0 THEN
    IF number of tubes == 2.0 THEN
    length = connect_block_cavity.width/2.0 + connect_volume_highest.diameter/2.0 +
    directional_cooling_distance + diameter.
    IF number of tubes == 4.0 THEN
    length = connect_block_cavity.width/2.0 - directional_cooling_distance/2.0.
  IF Z_tube THEN
   IF orientation == 0.0 OR 3.1416 THEN
   length = connect_block_cavity.length/2.0
   IF orientation != 0.0 OR 3.1416 THEN
   length = connect_block_cavity.width/2.0 + connect_volume_highest.diameter/2.0 +
   directional_cooling_distance + diameter.
END_RULE;
END_ENTITY;

ENTITY Baffle_flow_way
cav_core_name : STRING;
configuration : STRING;
position : POINT3D;
diameter : dimension;
length : dimension;
connect_cooling: Integer_core_deep_cooling;
connect_land : Integer_core_rect_land OR Integer_core_circ_land.
RULE Baffle_flow_way_position FOR (Baffle_flow_way, in a cooling system);
Take position from connect_cooling.
position[0] = position[0] + connect_land.depth.
END_RULE;
RULE Baffle_flow_way_orientation FOR (Baffle_flow_way, in a cooling system);
orientation = 0.0, 0.0, -1.0.
END_RULE;
RULE Baffle_flow_way_length FOR (Baffle_flow_way, in a cooling system);
Take length from connect_cooling.
END_RULE;
RULE Baffle_flow_way_diameter FOR (Baffle_flow_way, in a cooling system);
Take diameter from connect_cooling.
END_RULE;
END_ENTITY;

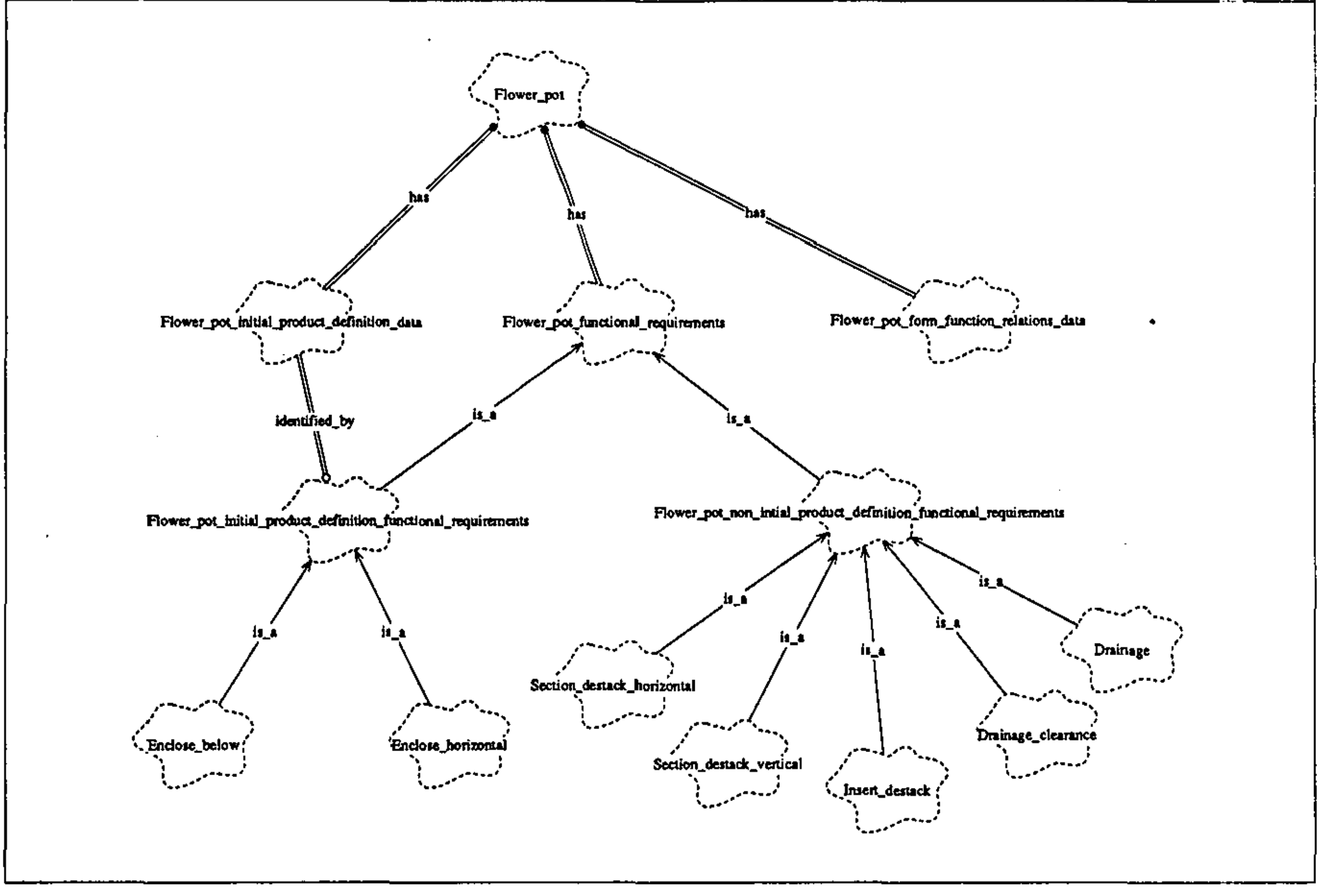
ENTITY Baffle_blade
cav_core_name : STRING;
```

```
configuration : STRING;
position : POINT3D;
width : dimension;
length : dimension;
thickness : dimension;
connect_flow_way: Baffle_flow_way;
RULE Baffle_blade_position FOR (Baffle_blade, in a cooling system);
position = connect_flow_way.position.
END_RULE;
RULE Baffle_blade_orientation FOR (Baffle_blade, in a cooling system);
orientation = downwards.
END_RULE;
RULE Baffle_blade_length FOR (Baffle_blade, in a cooling system);
length = connect_flow_way.length – connect_flow_way.diameter.
END_RULE;
RULE Baffle_blade_width FOR (Baffle_blade, in a cooling system);
width = connect_flow_way.diameter – baffle_blade_clearance.
END_RULE;
RULE Baffle_blade_thickness FOR (Baffle_blade, in a cooling system);
thickness = 2.0.
END_RULE;
END_ENTITY;
```

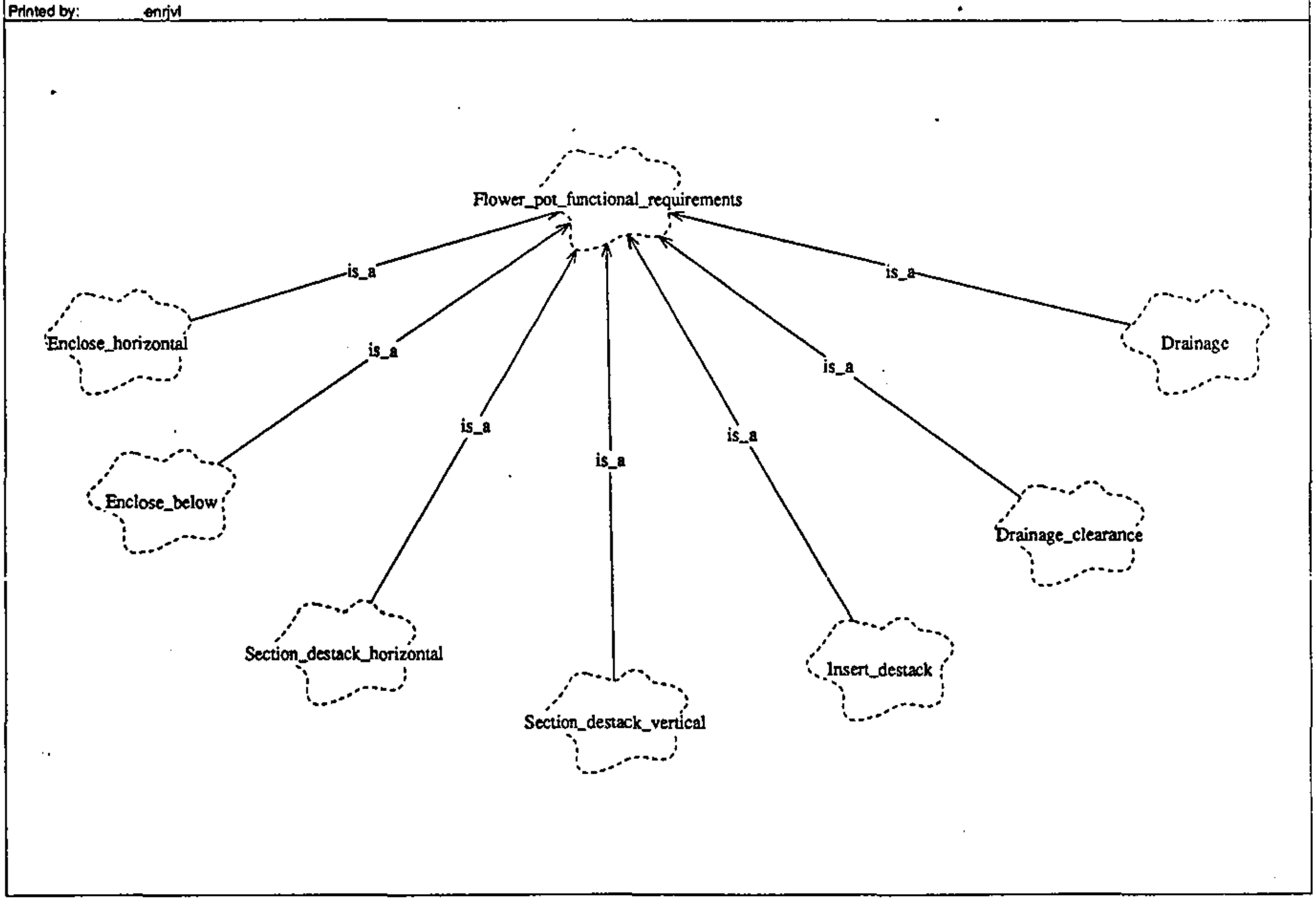
Appendix 5.

Booch representation of Product Range Model

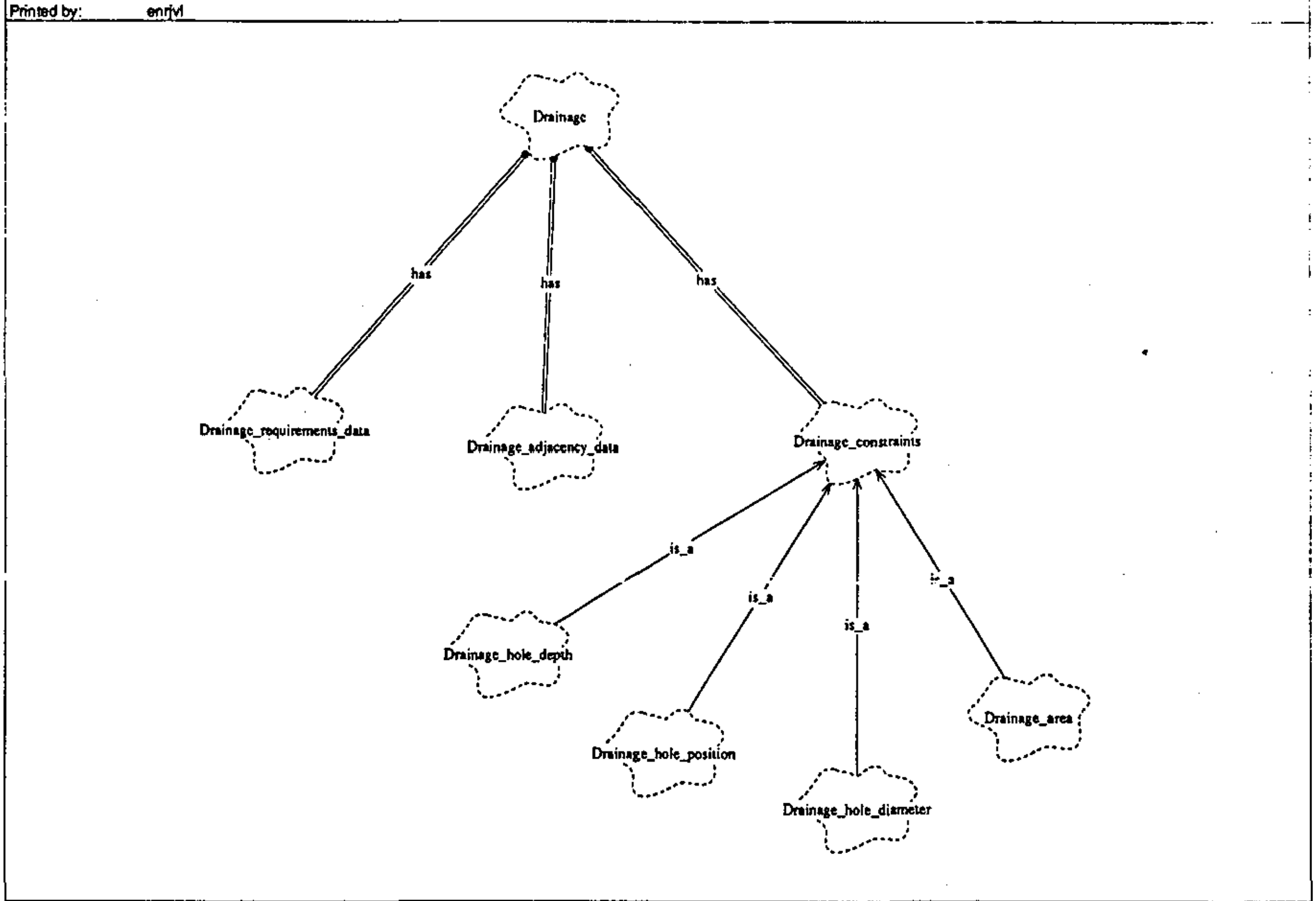
Project:	ron
Title:	Class Diagram: Flower_pot_product_range
Printed on:	Monday, January 22, 1996
Printed by:	enrjvl



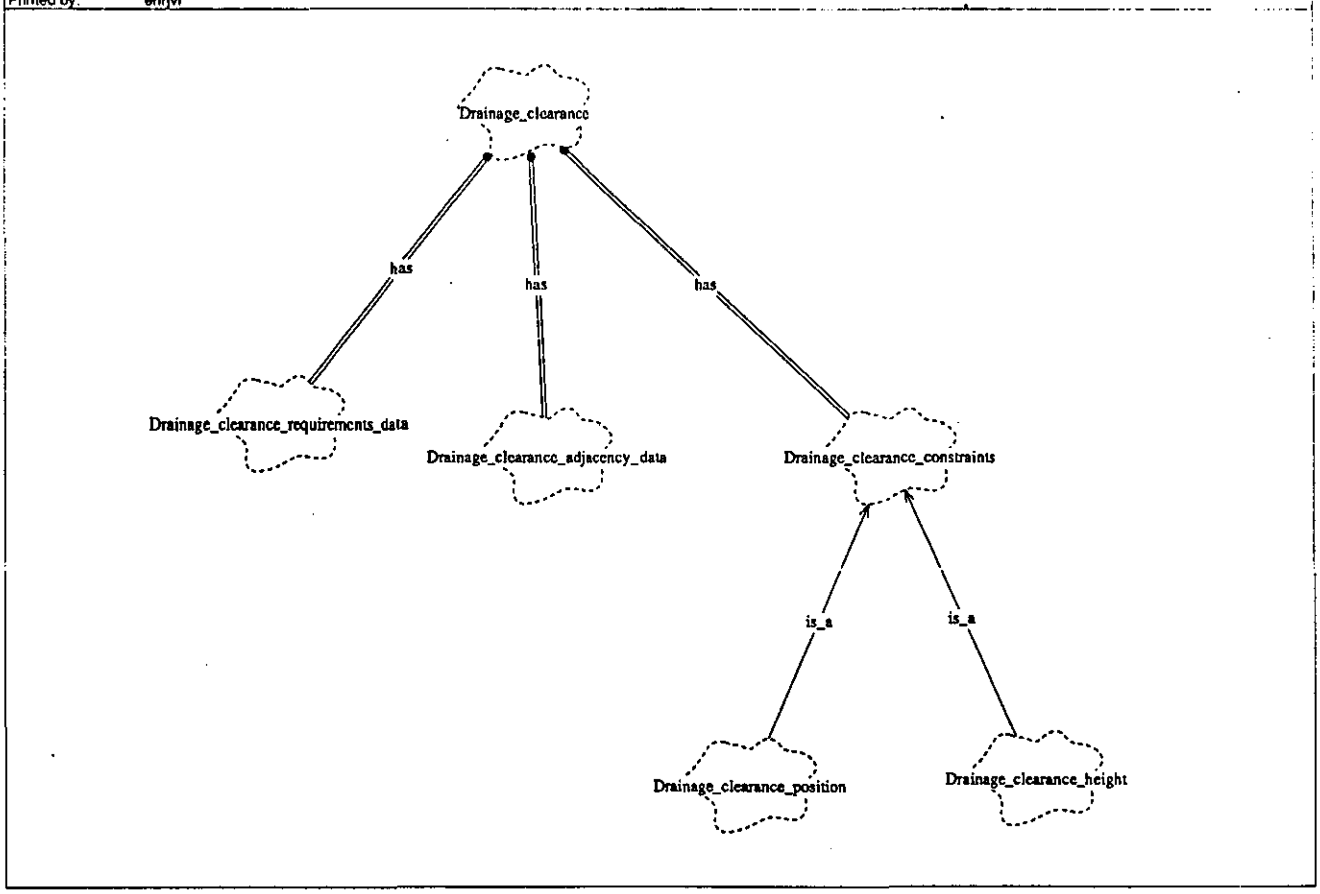
Project:	ron
Title:	Class Diagram: FP_functional_requirements
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



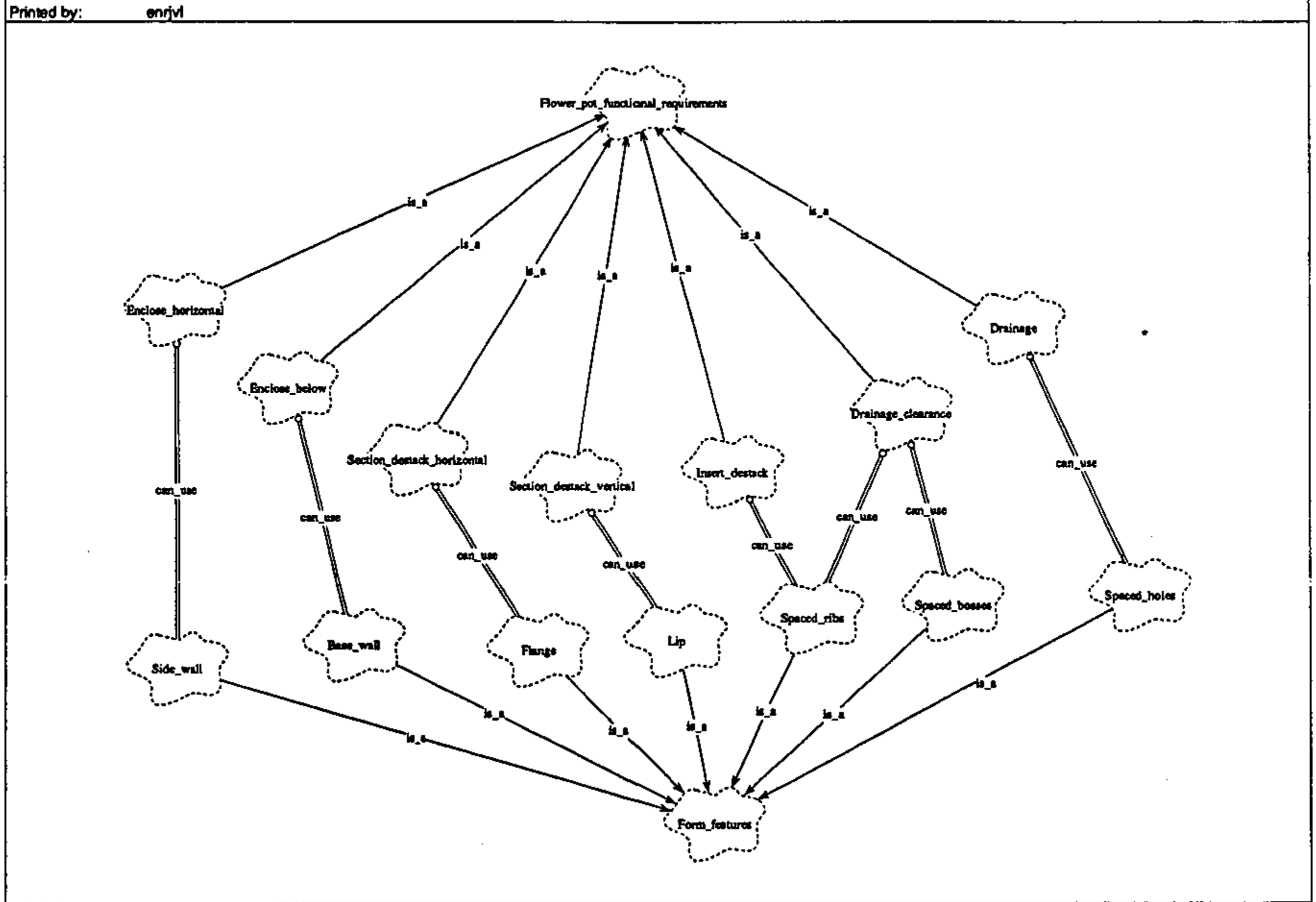
Project:	ron
Title:	Class Diagram: Drainage
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



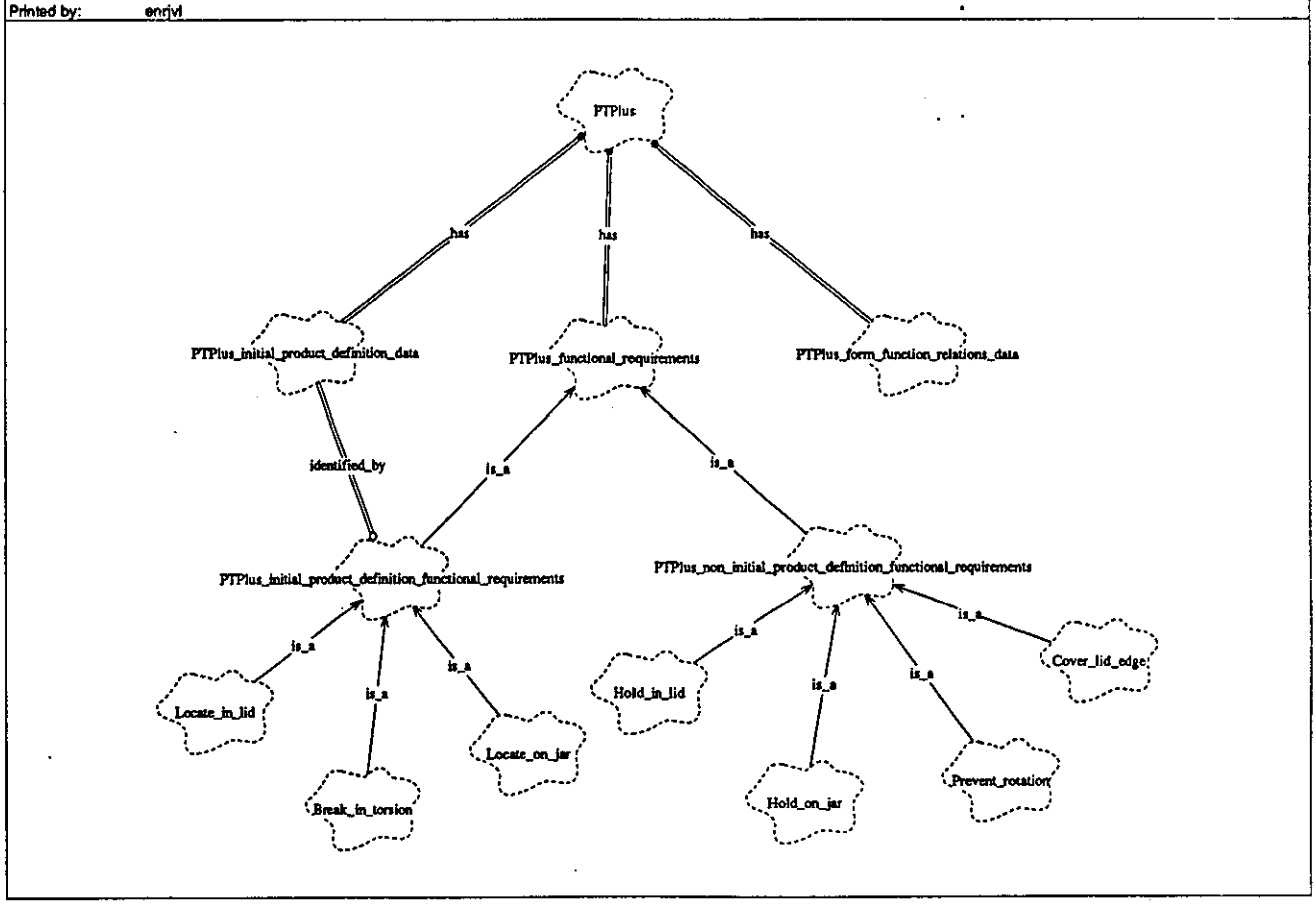
Project:	ron
Title:	Class Diagram: Draiange_clearance
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



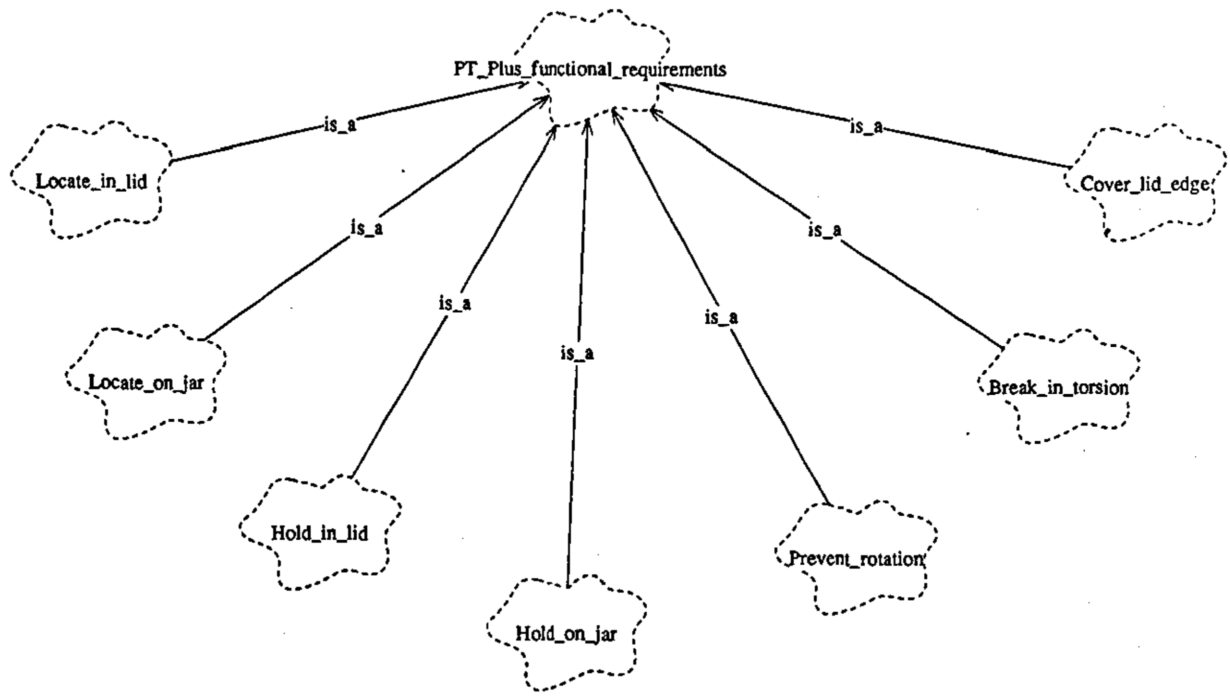
Project:	ron
Title:	Class Diagram: FP_functional_requirements_form
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



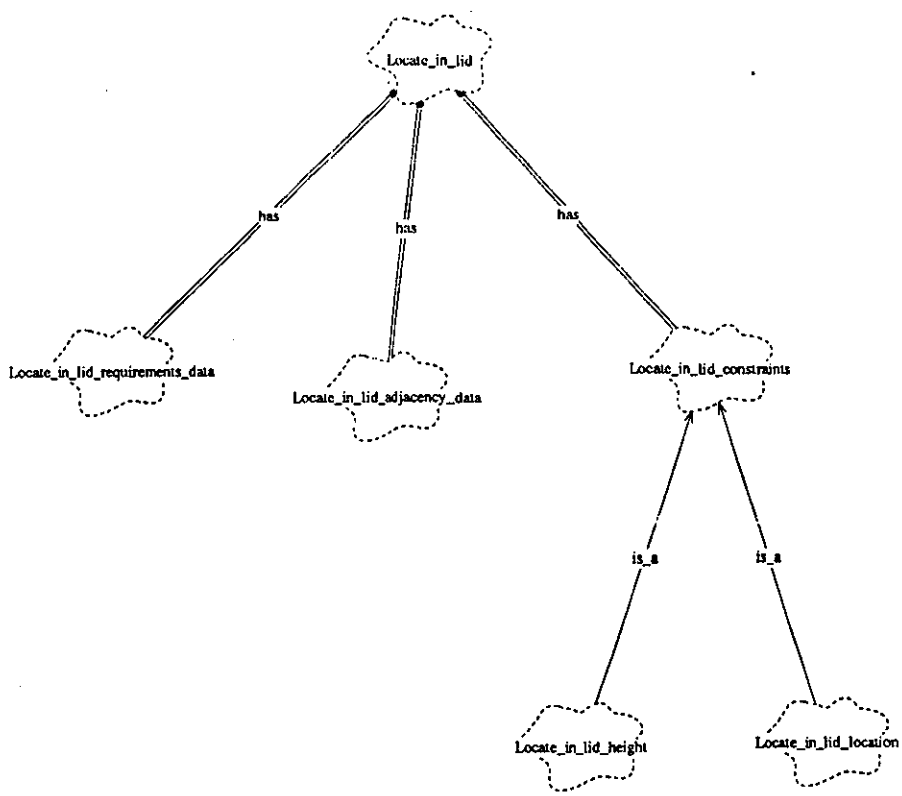
Project:	ron
Title:	Class Diagram: PTPlus_product_range
Printed on:	Monday, January 22, 1996
Printed by:	enrjvl



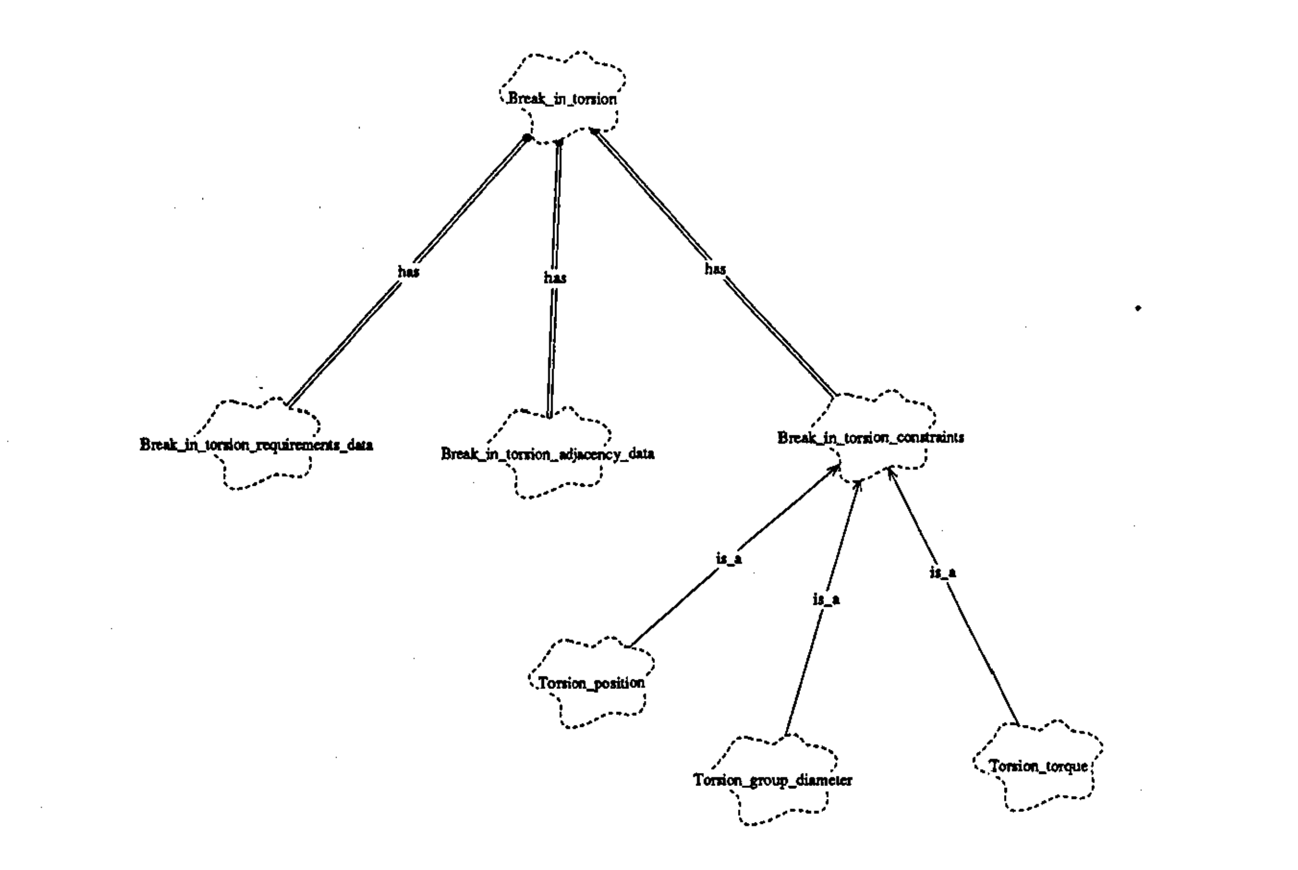
Project:	ron
Title:	Class Diagram: PT_functional_requirements
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



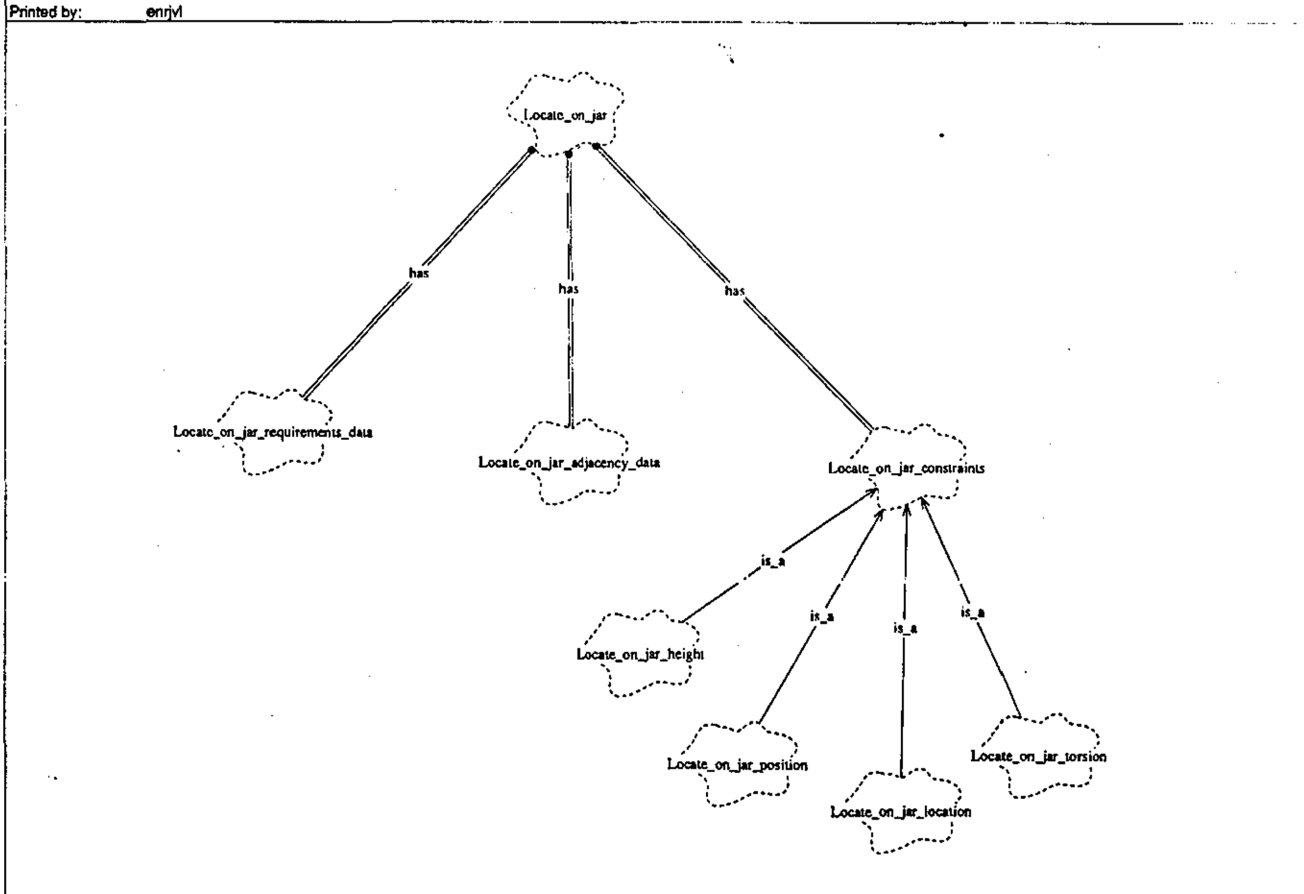
Project:	ron
Title:	Class Diagram: Locate_in_lid
Printed on:	Thursday, August 31, 1995
Printed by:	enrjvl



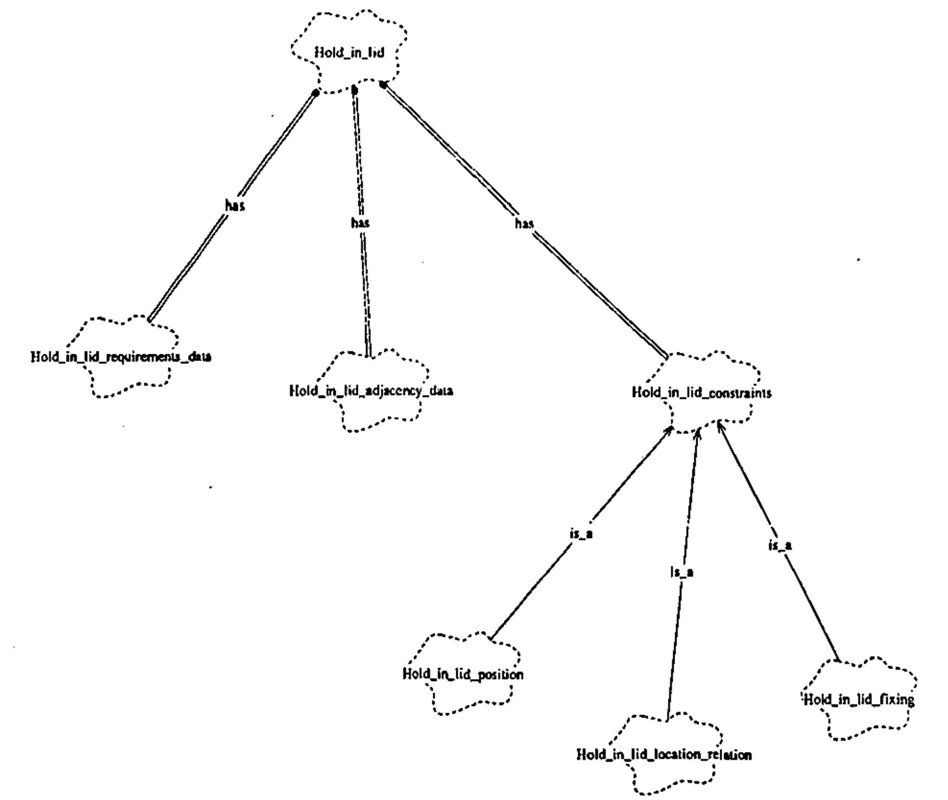
Project:	ron
Title:	Class Diagram: Break_in_torsion
Printed on:	Friday, September 1, 1995
Printed by:	enrjvl



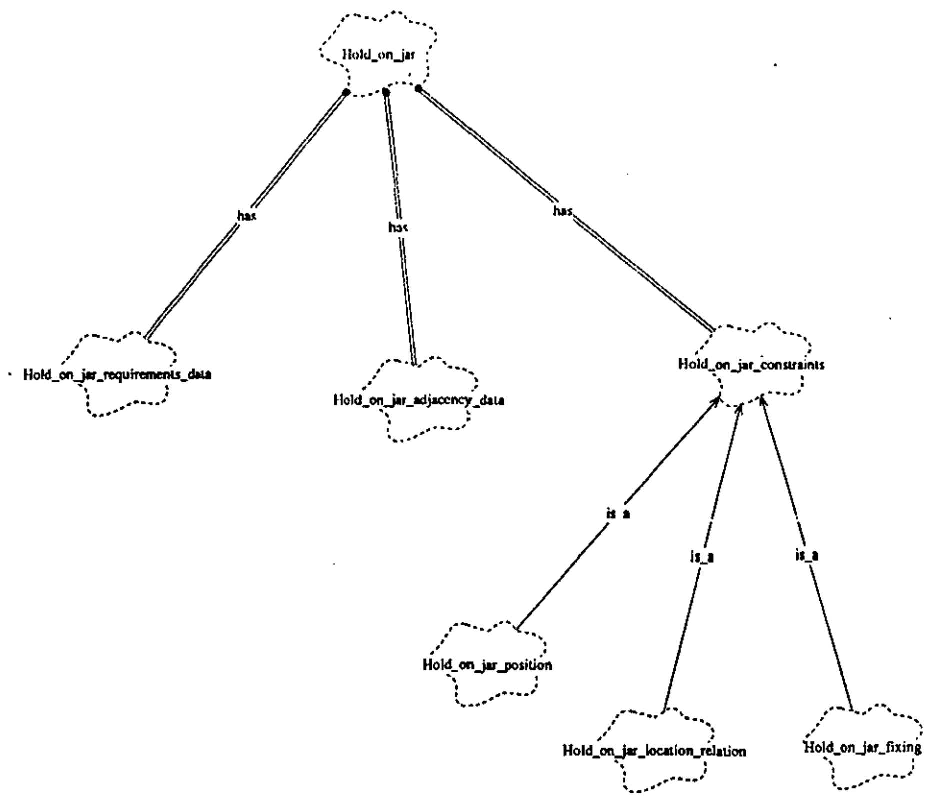
Project:	ron
Title:	Class Diagram: Locvte_on_jar
Printed on:	Thursday, August 31, 1995
Printed by:	enrjvl



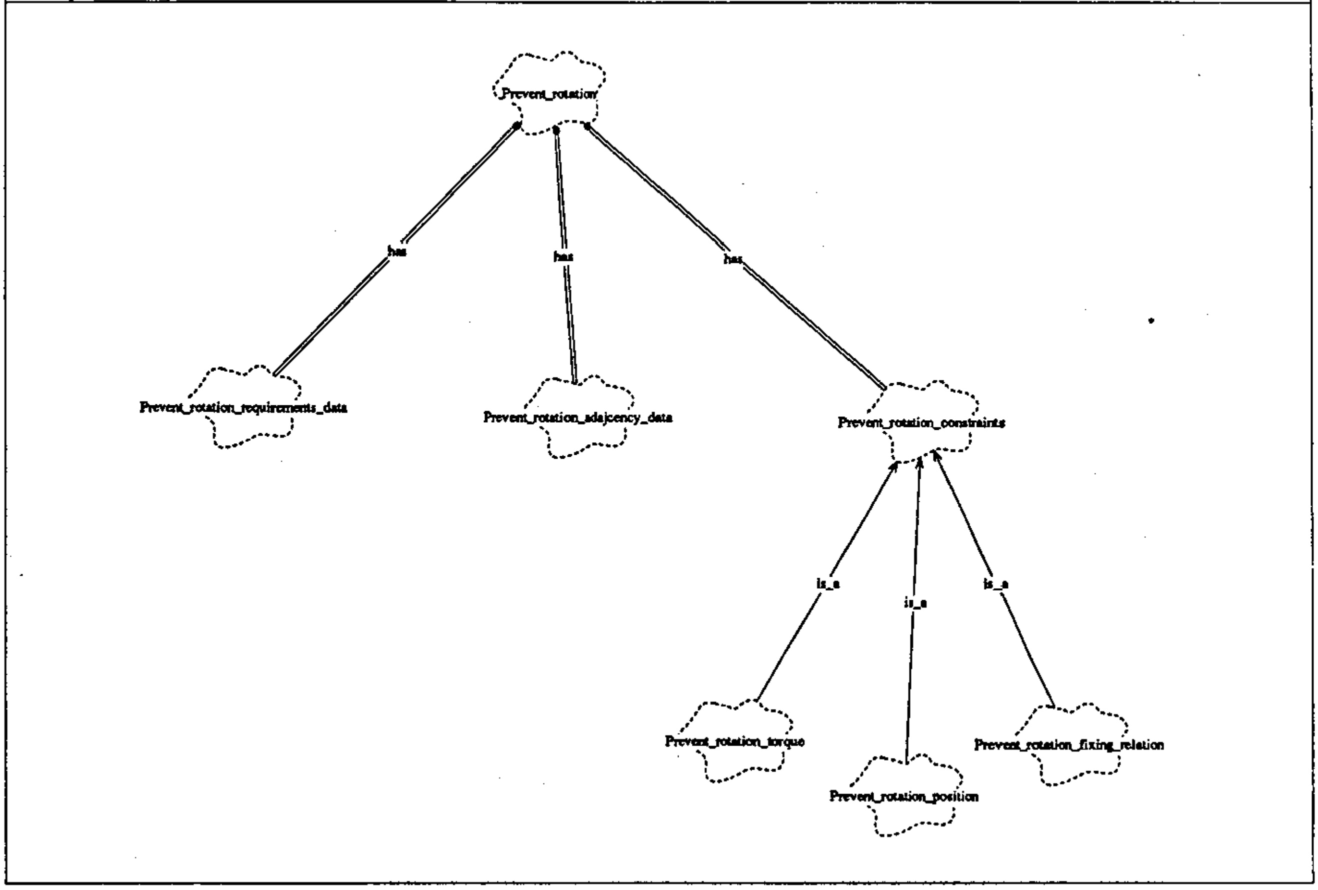
Project: ron
Title: Class Diagram: Hold_in_lid
Printed on: Thursday, August 31, 1995
Printed by: enrjvl



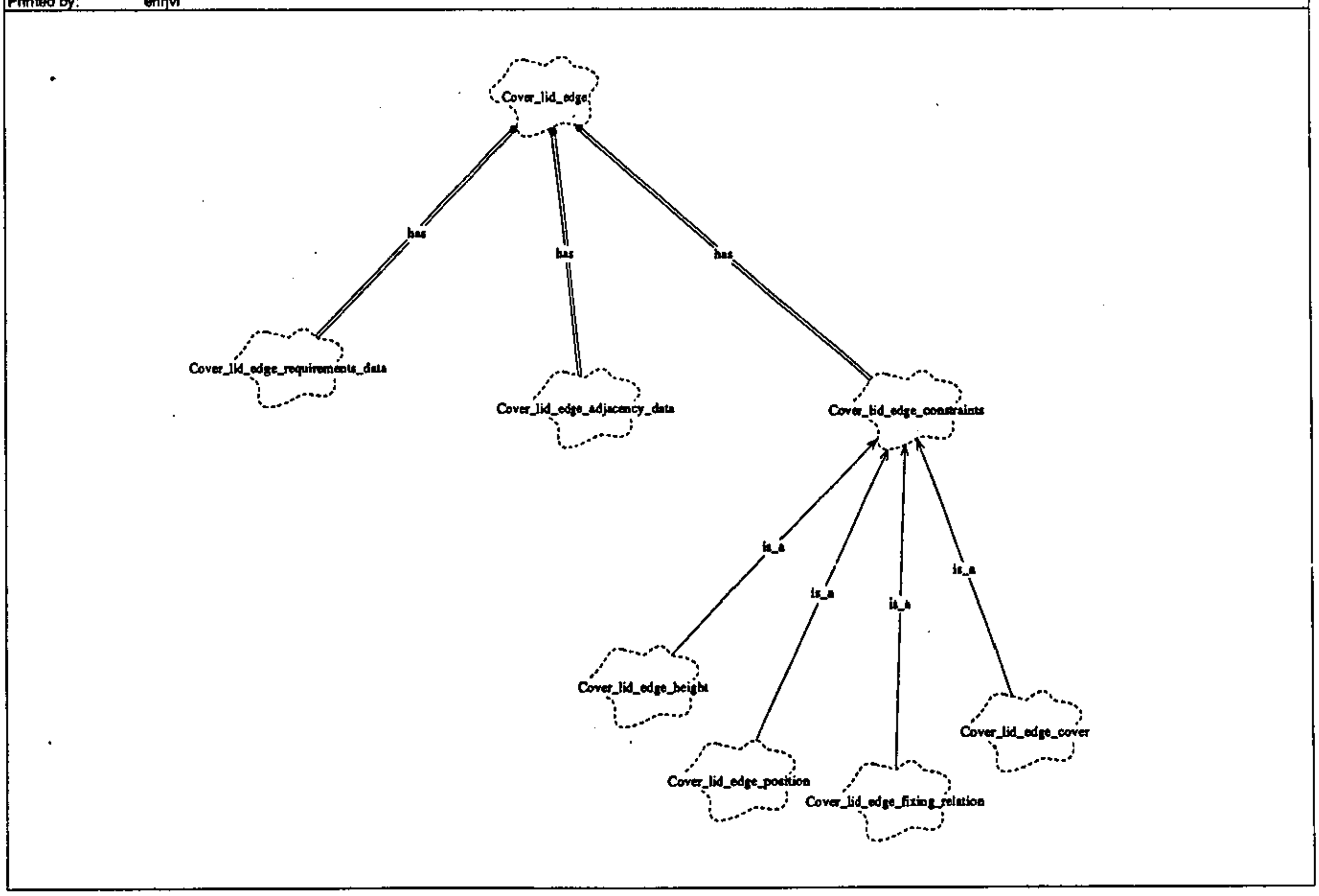
Project: ron
Title: Class Diagram: Hold_on_jar
Printed on: Thursday, August 31, 1995
Printed by: enrjvl



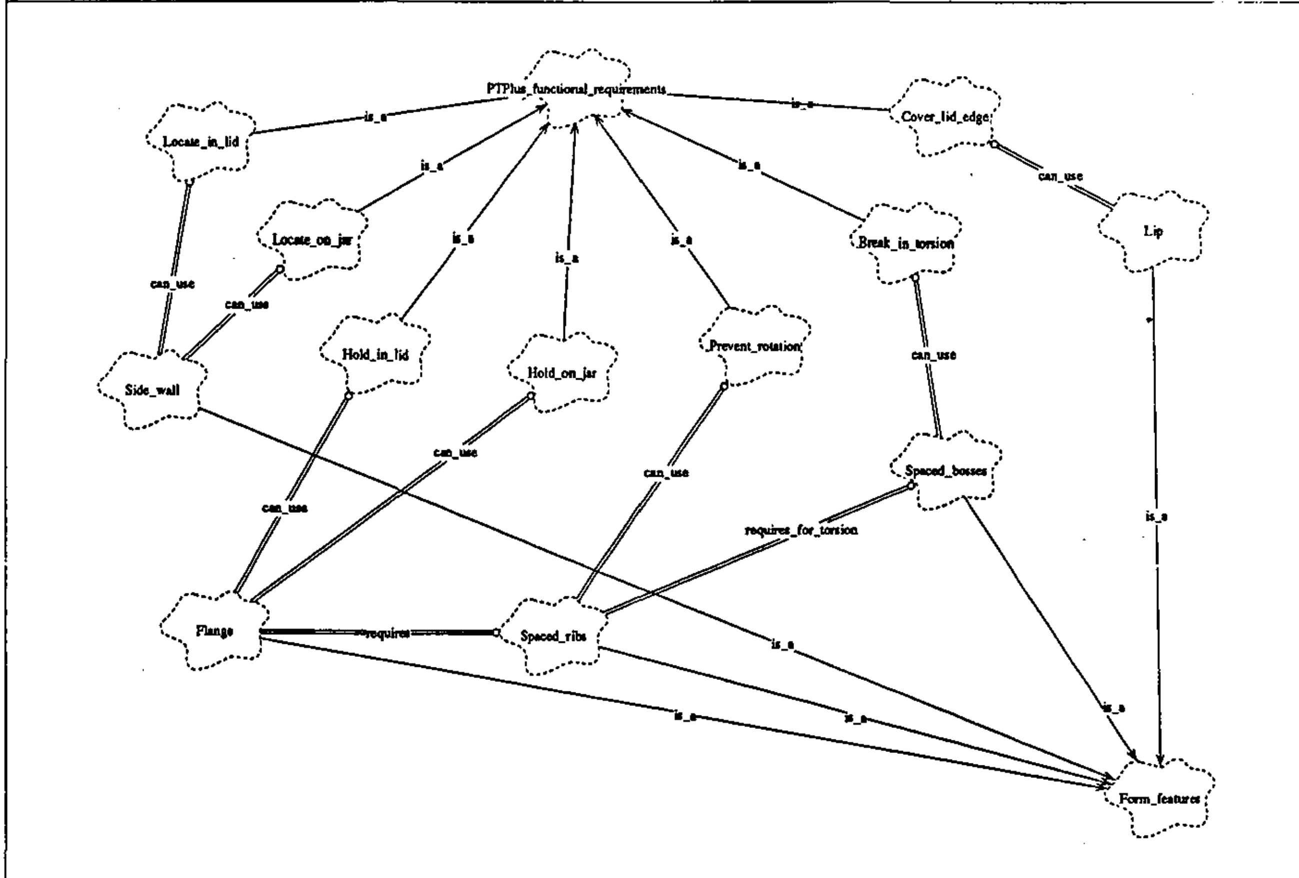
Project: ron
Title: Class Diagram: Prevent_rotation
Printed on: Sunday, September 3, 1995
Printed by: enrjvl



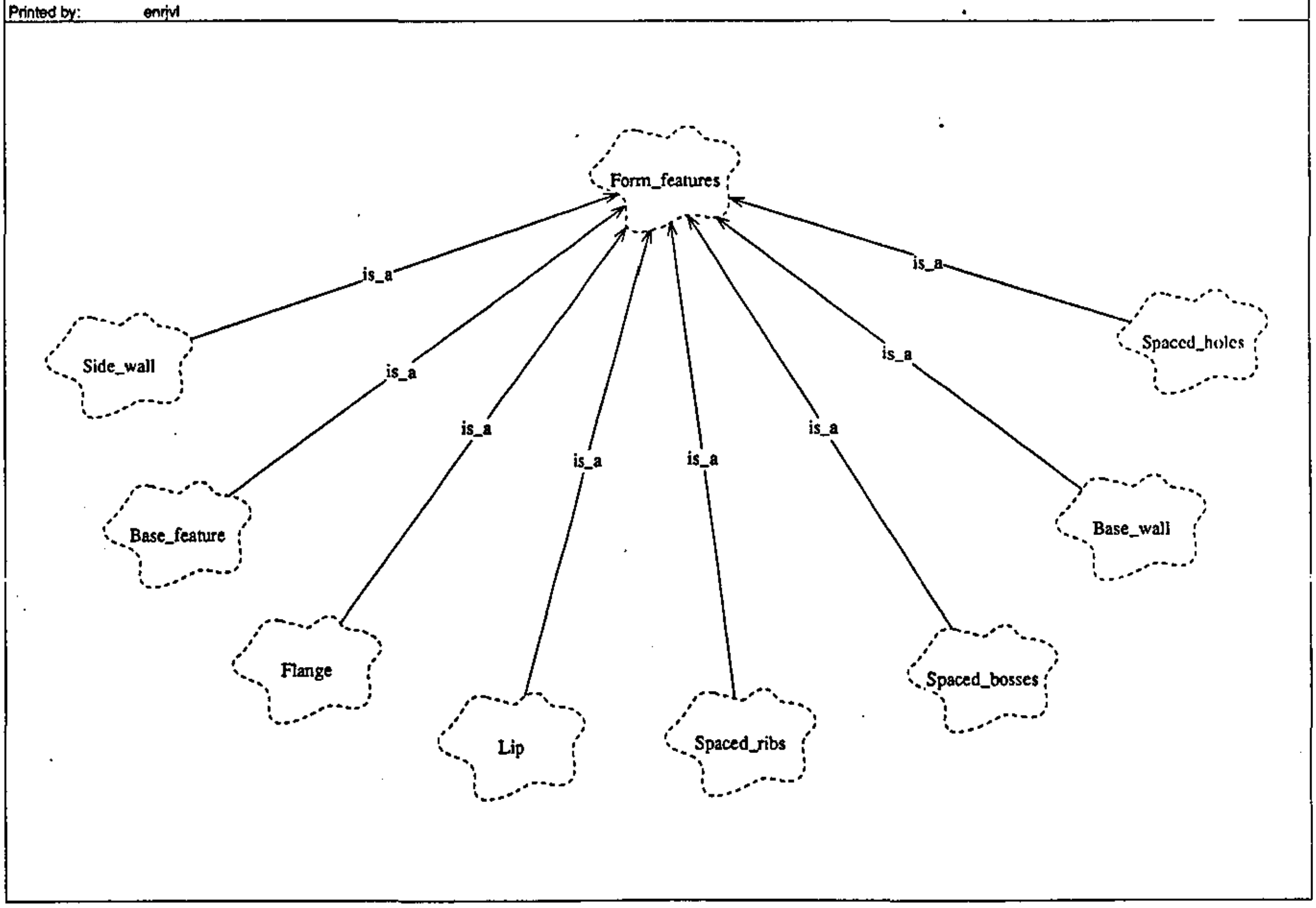
Project: ron
Title: Class Diagram: Cover_lid_edge
Printed on: Sunday, September 3, 1995
Printed by: enrjvl



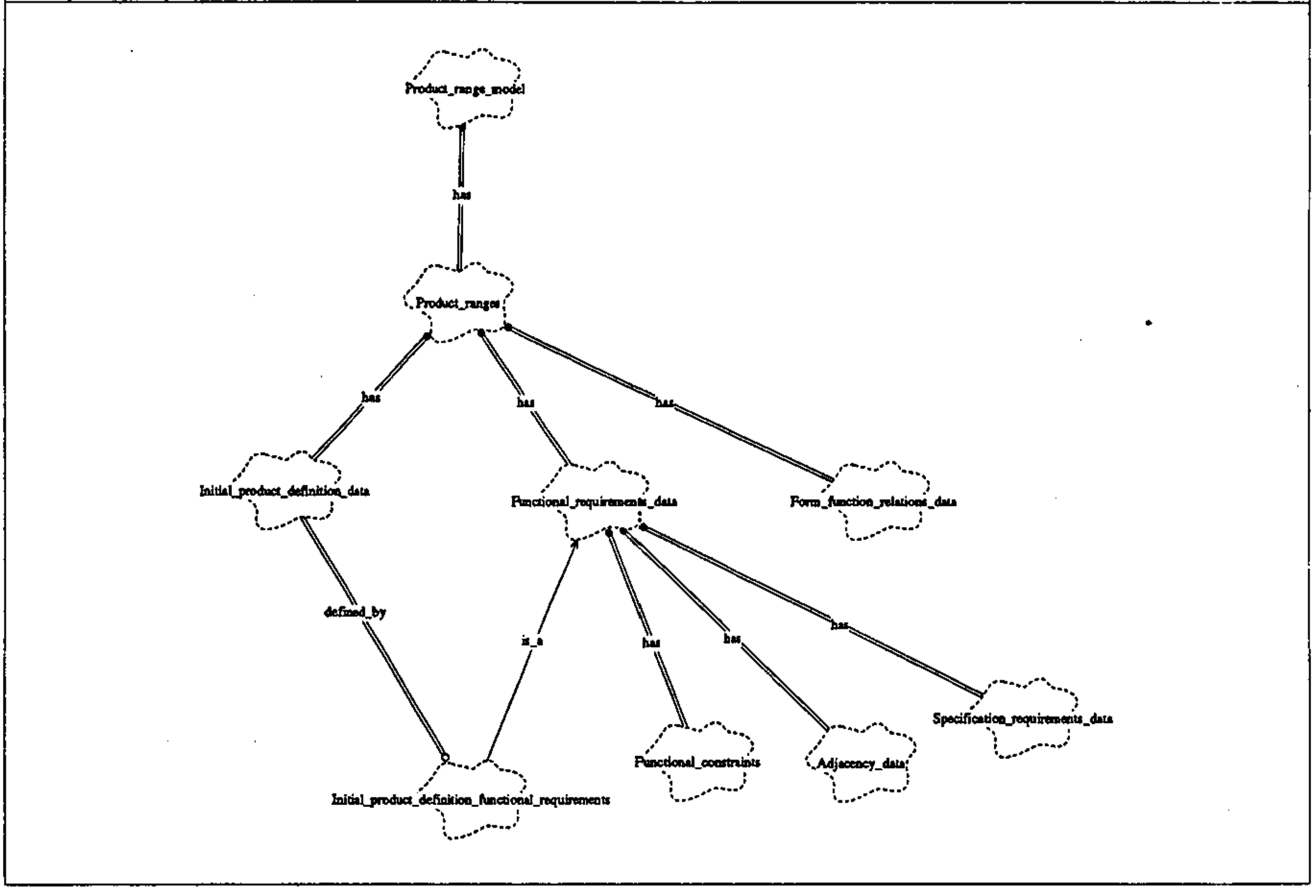
Project:	ron
Title:	Class Diagram: PT_functional_requirements_form
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



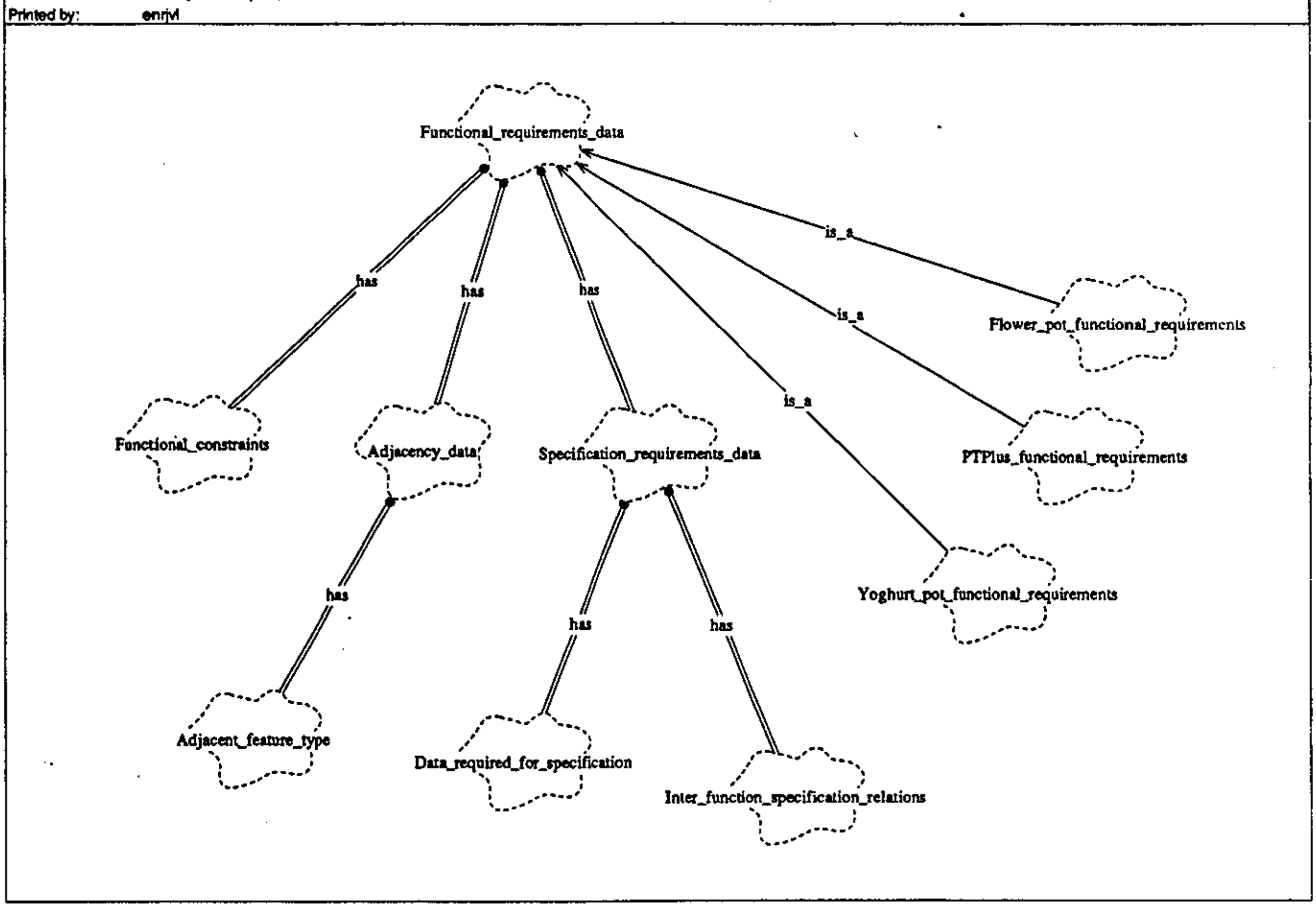
Project:	ron
Title:	Class Diagram: Form_features
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



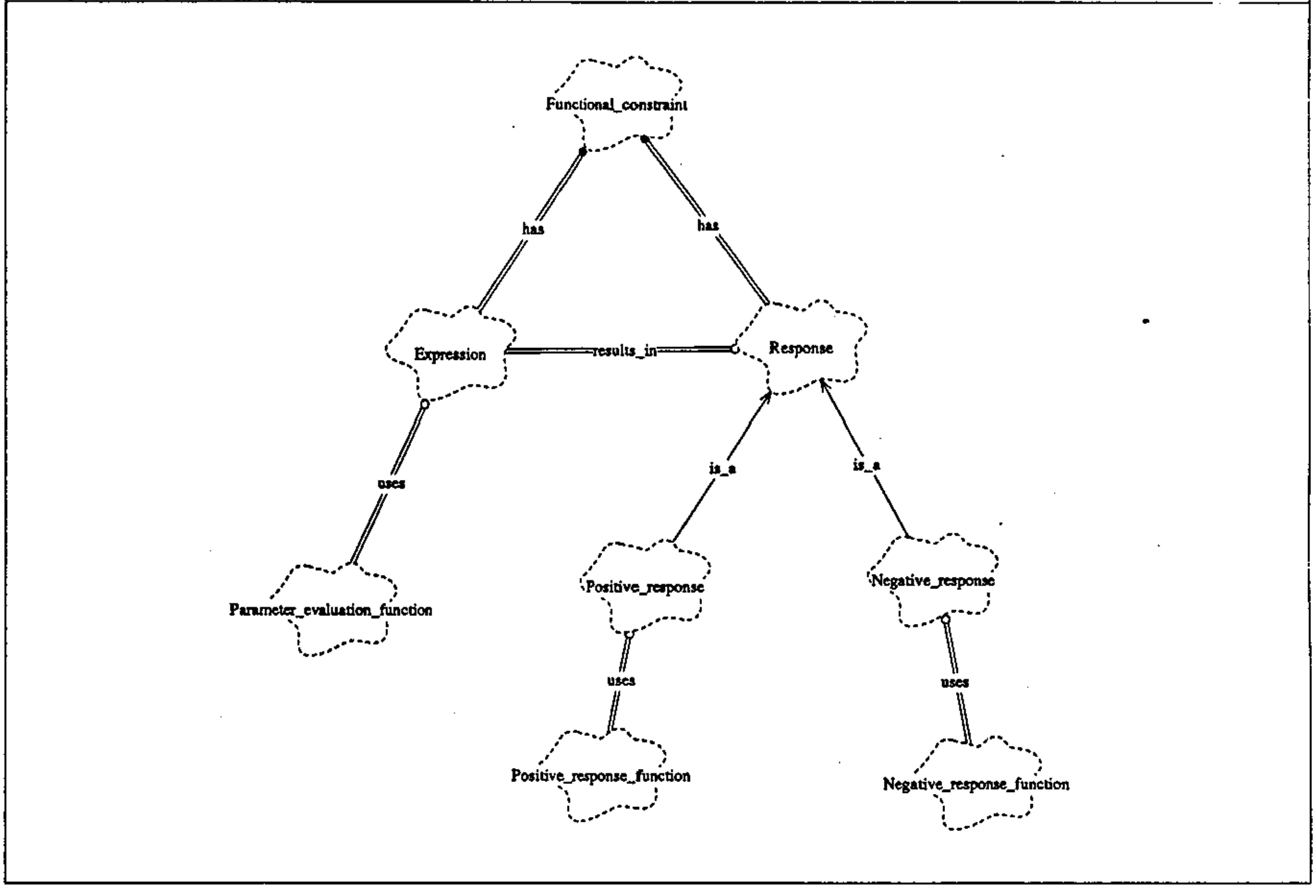
Project: ron
Title: Class Diagram: Product_range_model
Printed on: Sunday, January 21, 1996
Printed by: enrjvl



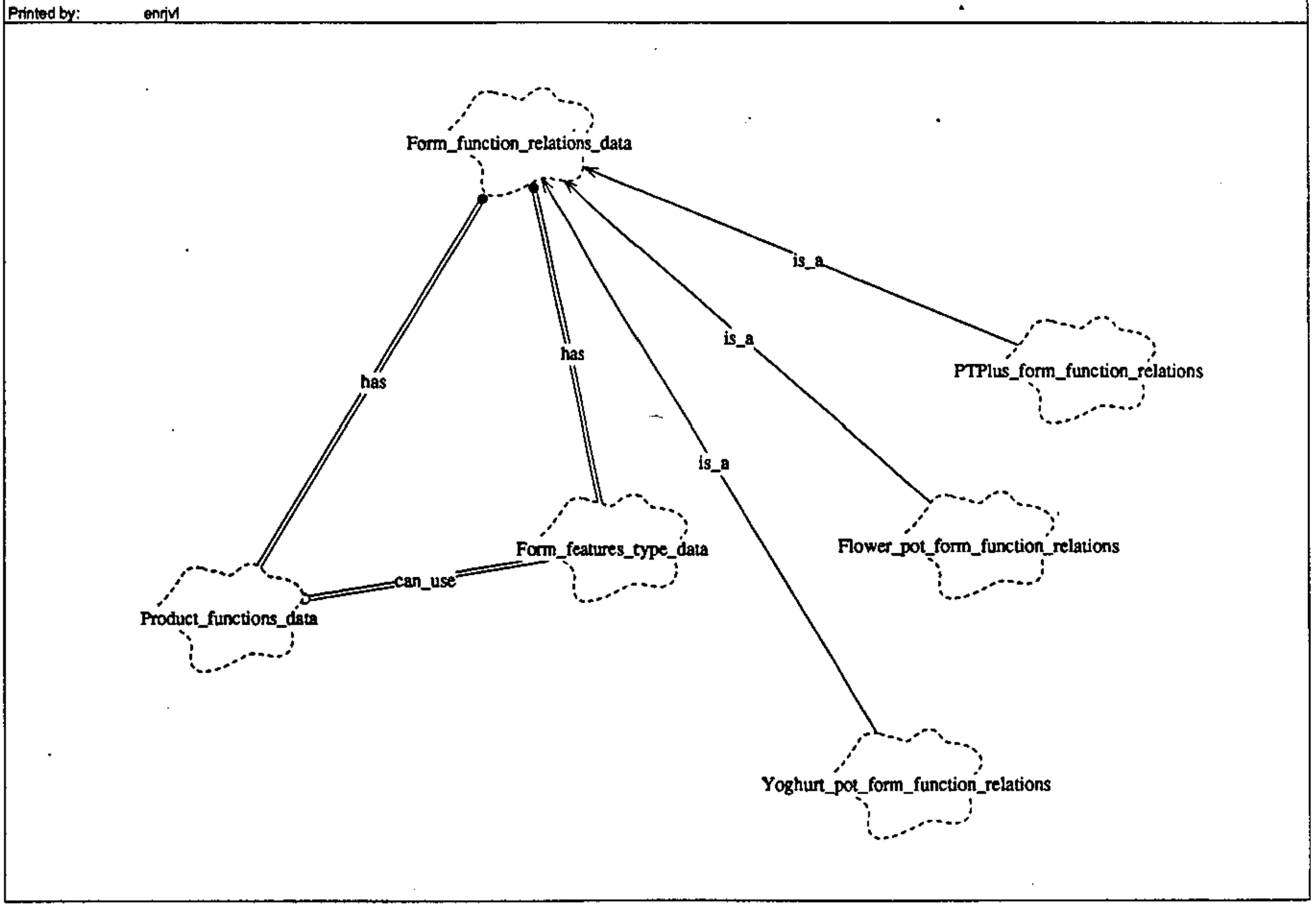
Project: ron
Title: Class Diagram: Functional_requirements
Printed on: Sunday, January 21, 1996
Printed by: enrjvl



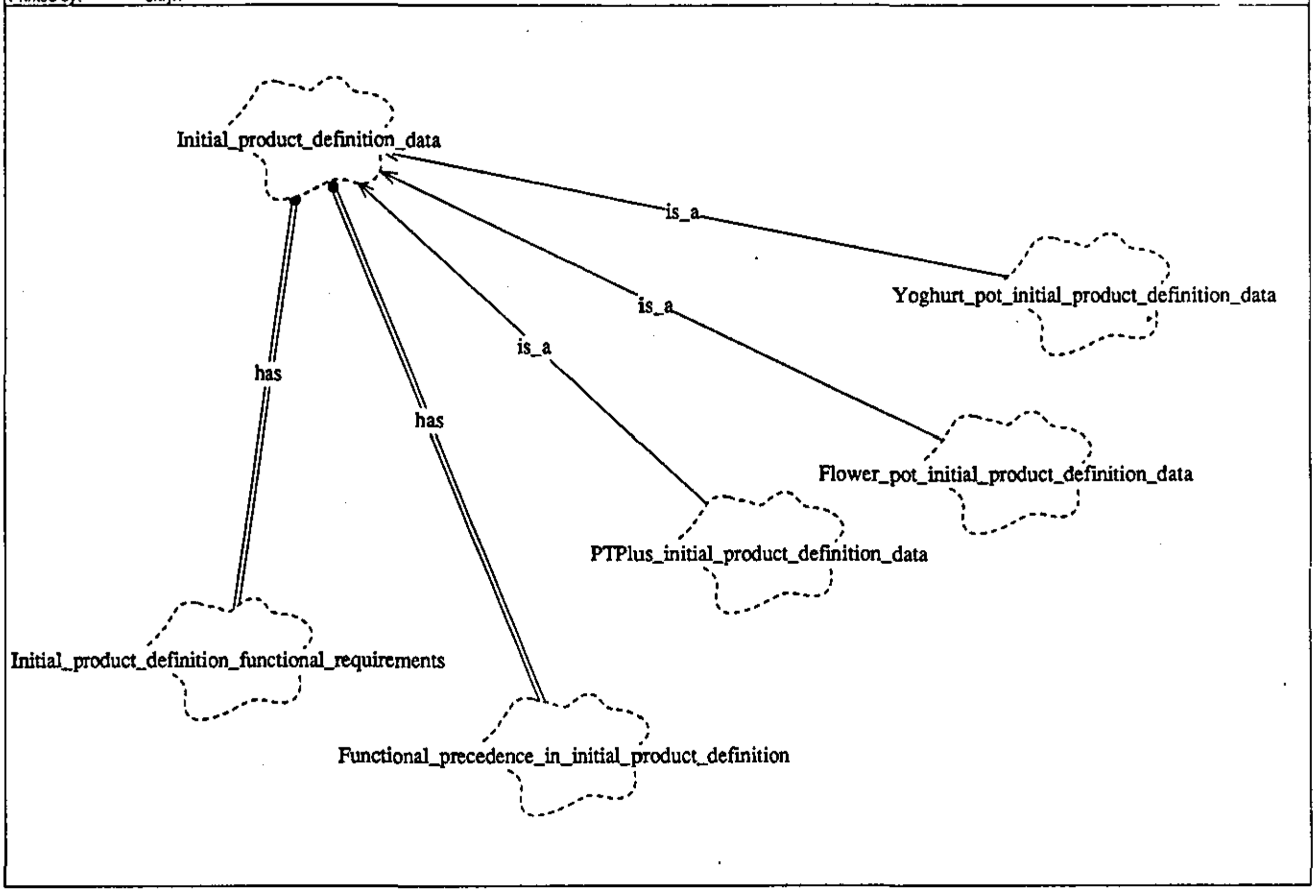
Project:	ron
Title:	Class Diagram: Functional_constraint
Printed on:	Sunday, January 21, 1996
Printed by:	enrjvl



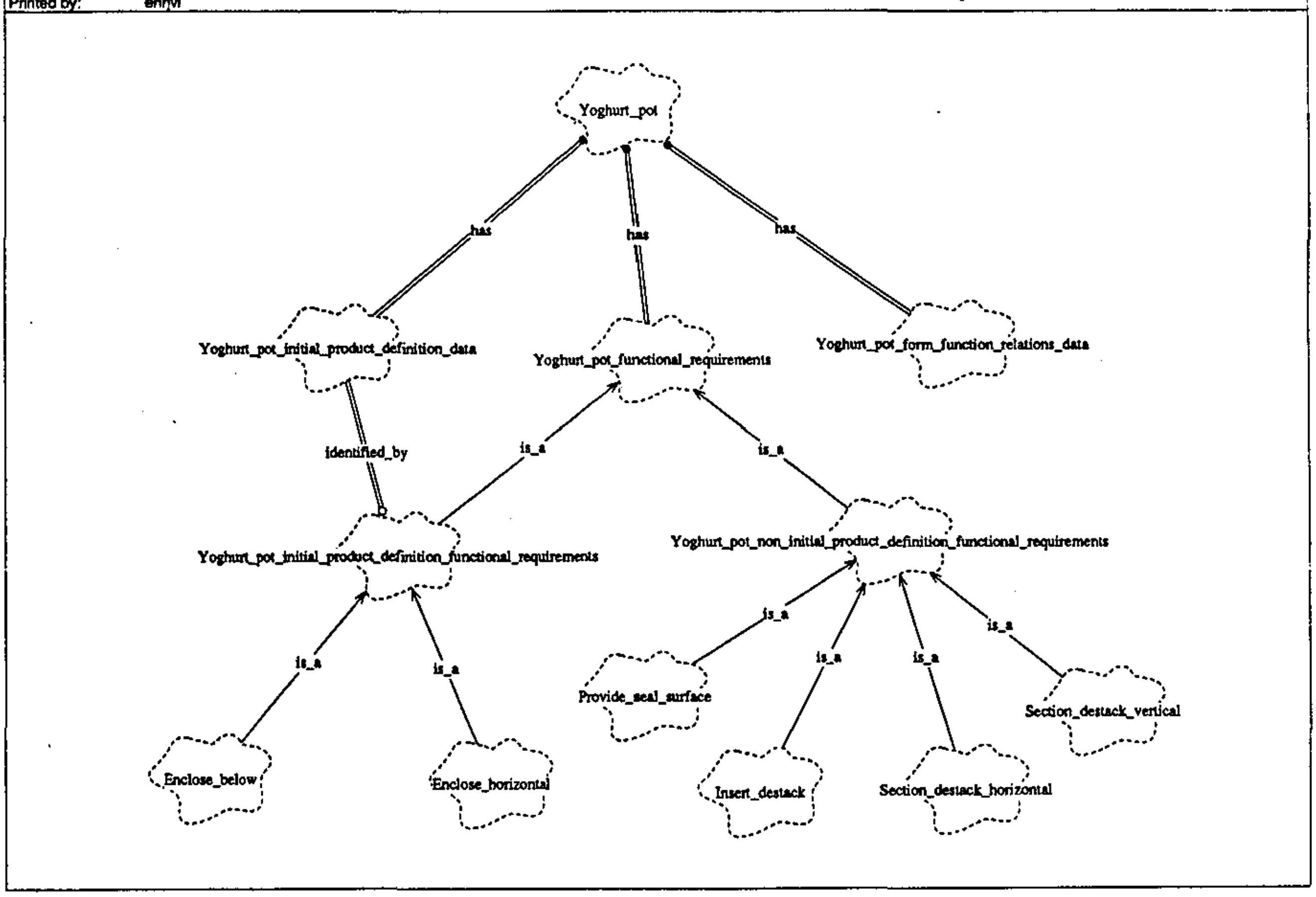
Project:	ron
Title:	Class Diagram: Form_function_relations_data
Printed on:	Sunday, January 21, 1996
Printed by:	enrjvl



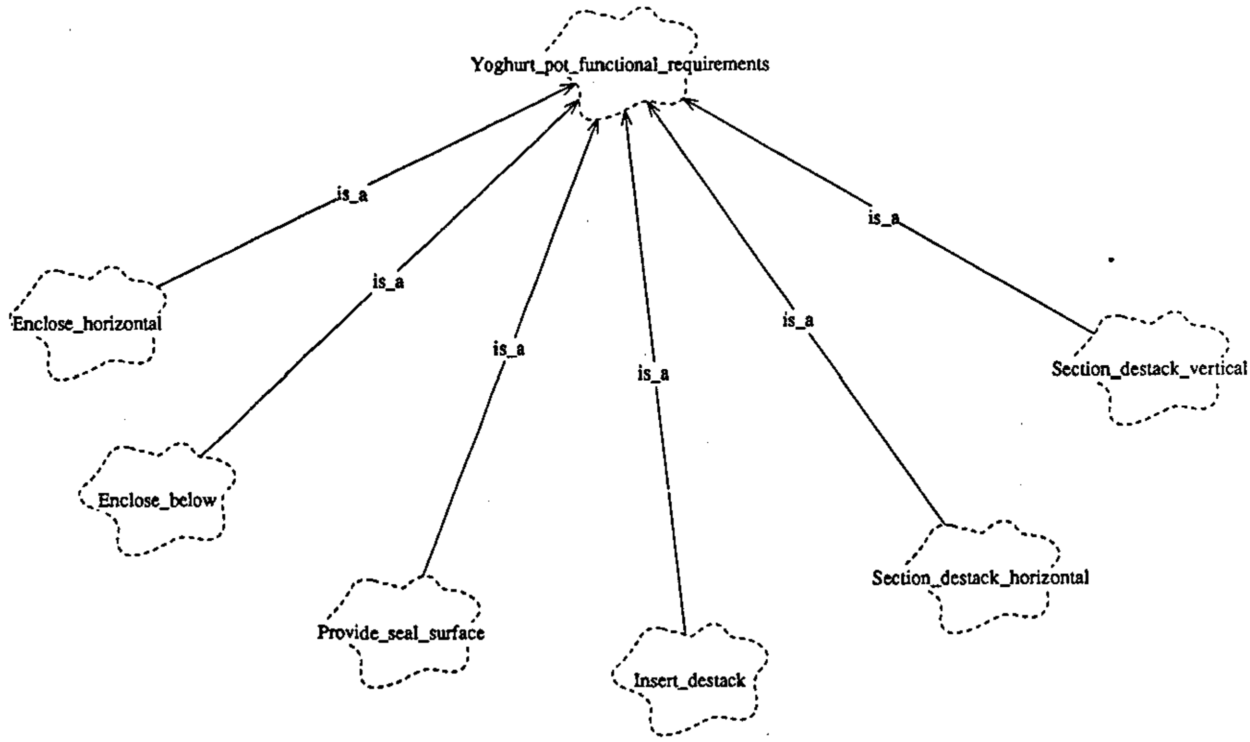
Project:	ron
Title:	Class Diagram: Initial_product_definition_data
Printed on:	Sunday, January 21, 1996
Printed by:	enrjvl



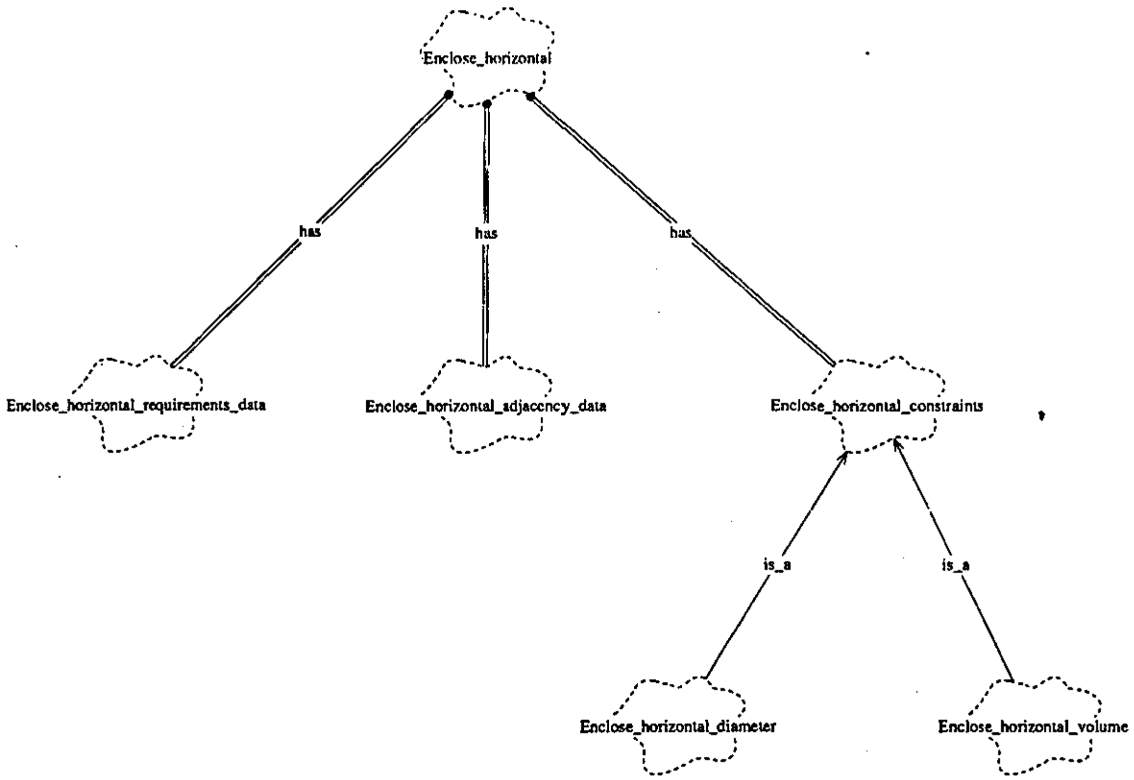
Project:	ron
Title:	Class Diagram: Yoghurt_pot_product_range
Printed on:	Monday, January 22, 1996
Printed by:	enrjvl



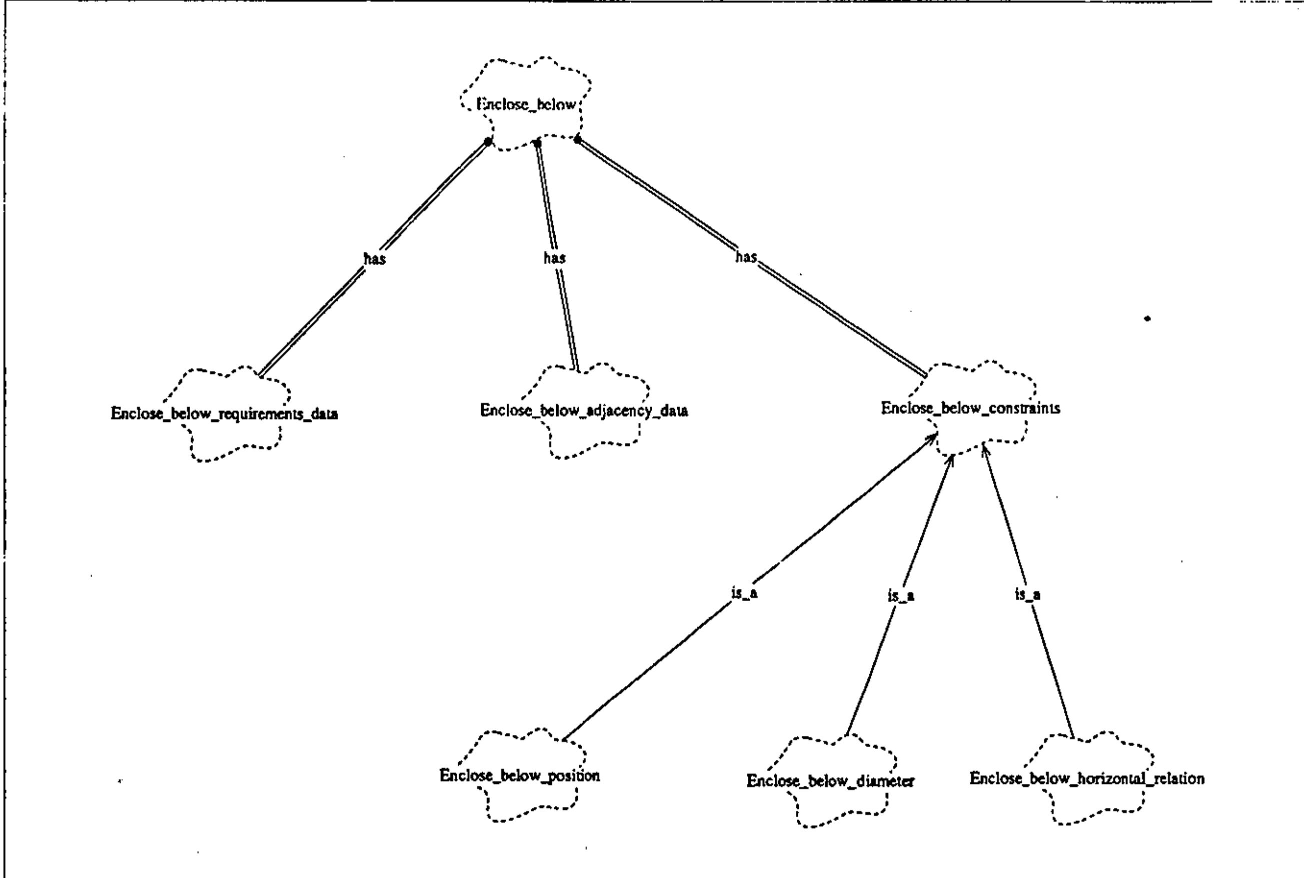
Project:	ron
Title:	Class Diagram: YP_functional_requirements
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



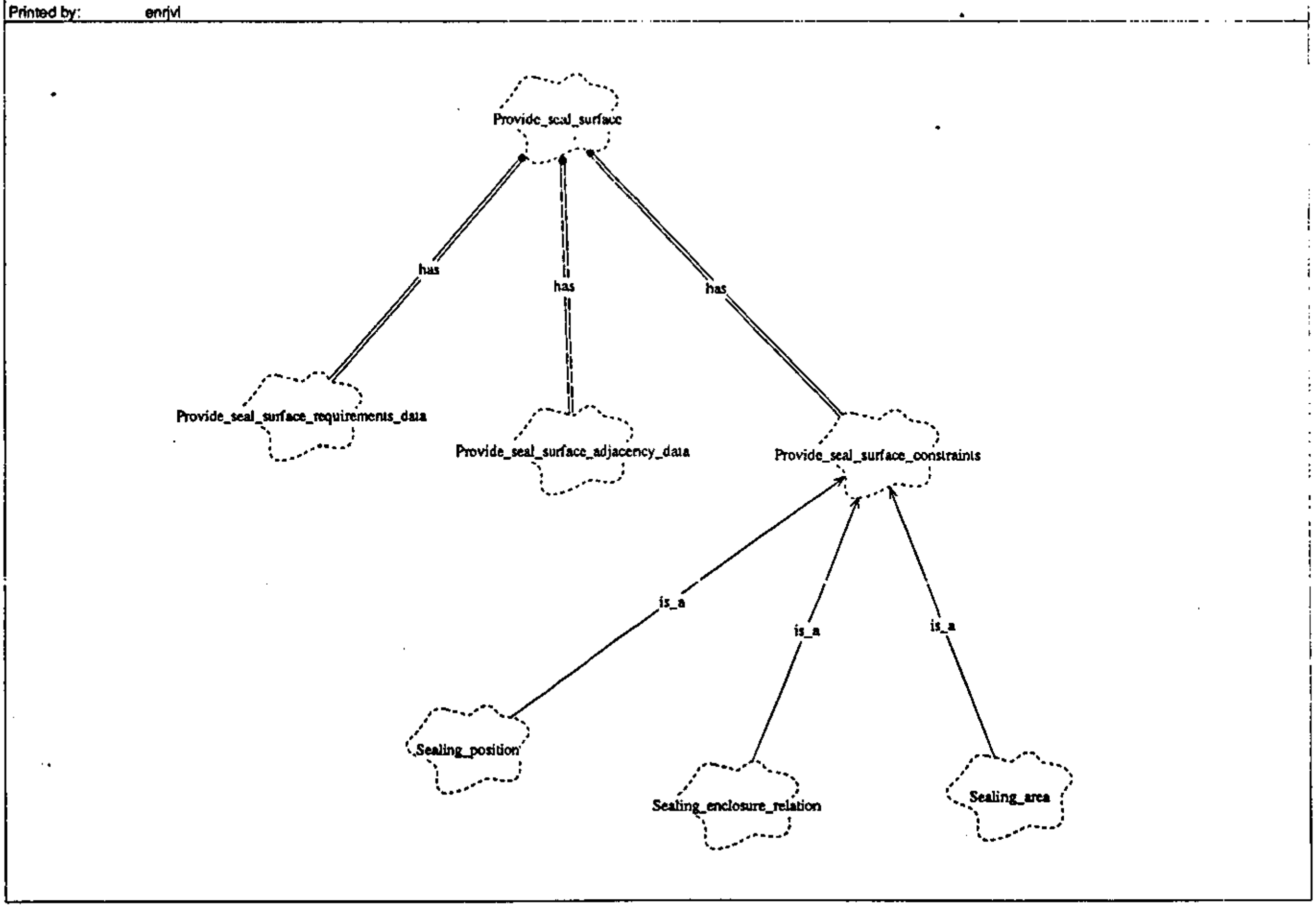
Project:	ron
Title:	Class Diagram: Enclose_horizontal
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



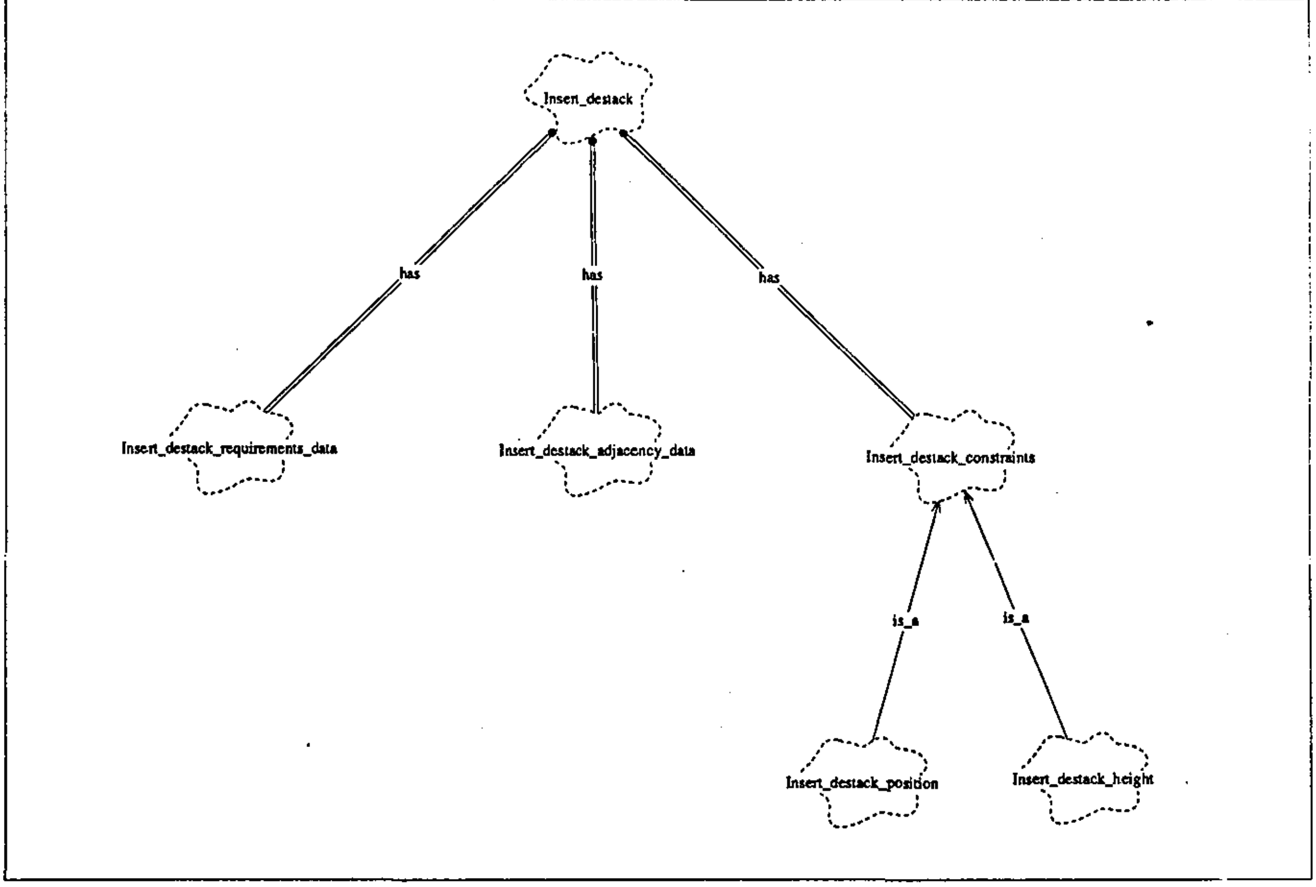
Project:	ron
Title:	Class Diagram: Enclose_below
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



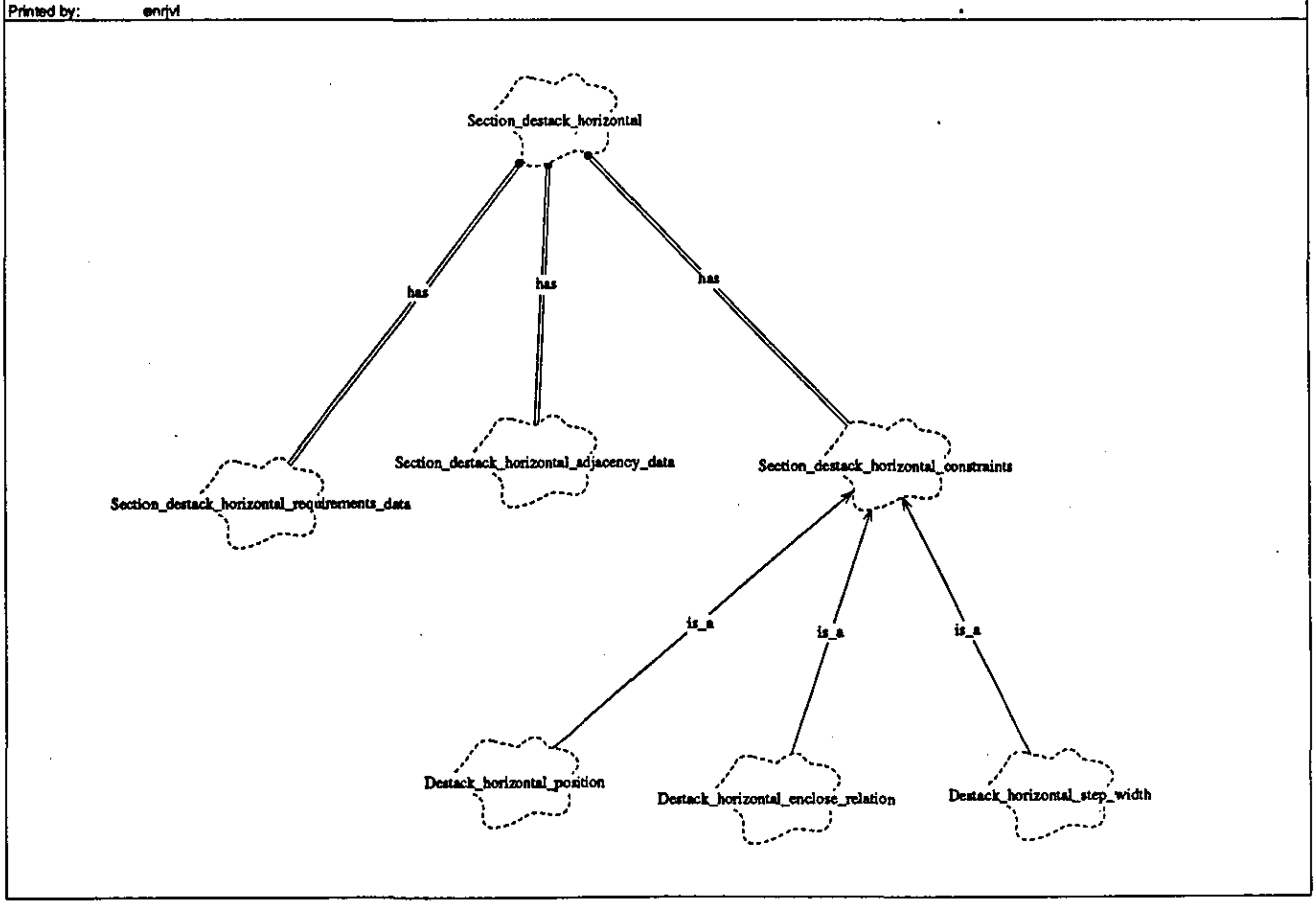
Project:	ron
Title:	Class Diagram: Provide_seal_surface
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



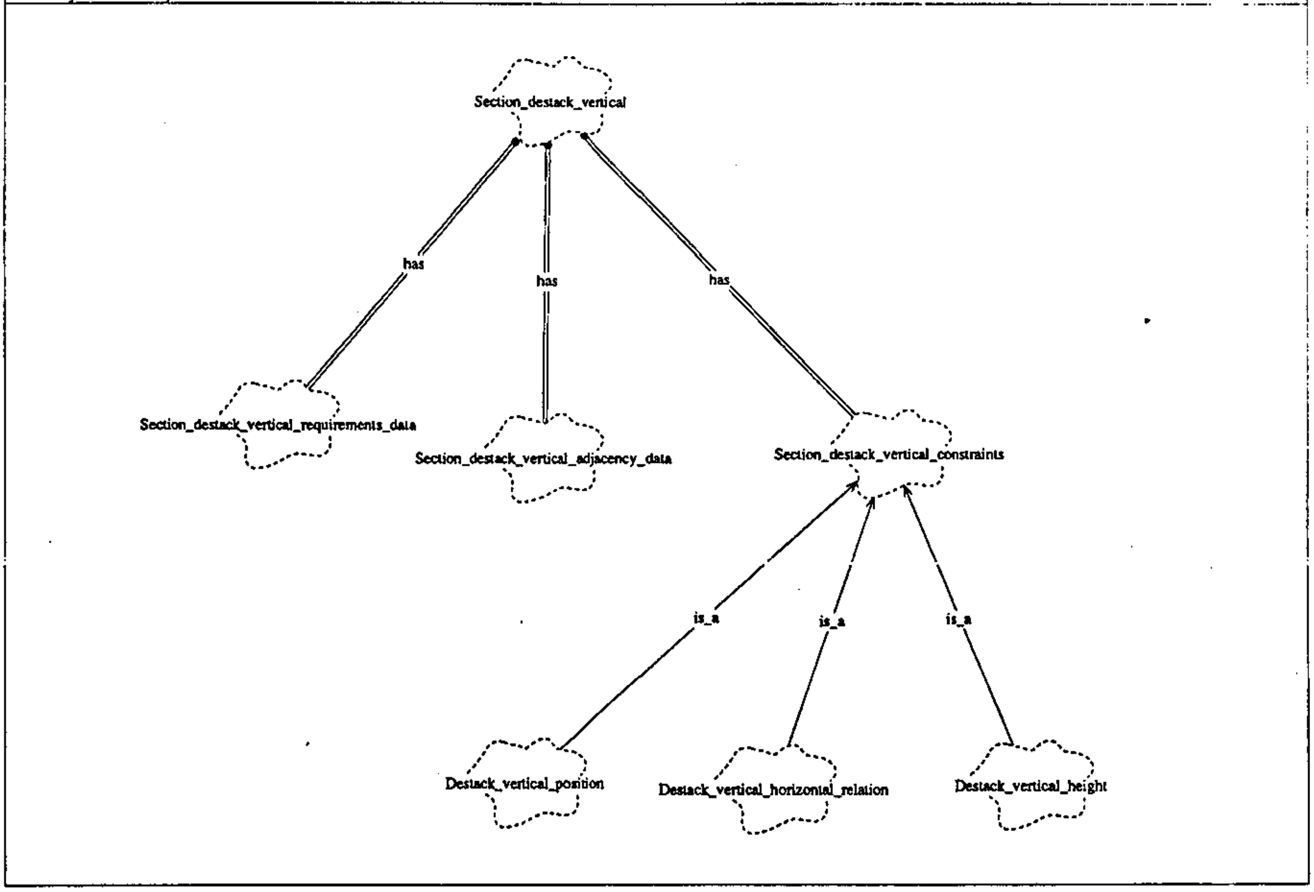
Project:	ron
Title:	Class Diagram: Insert_destack
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



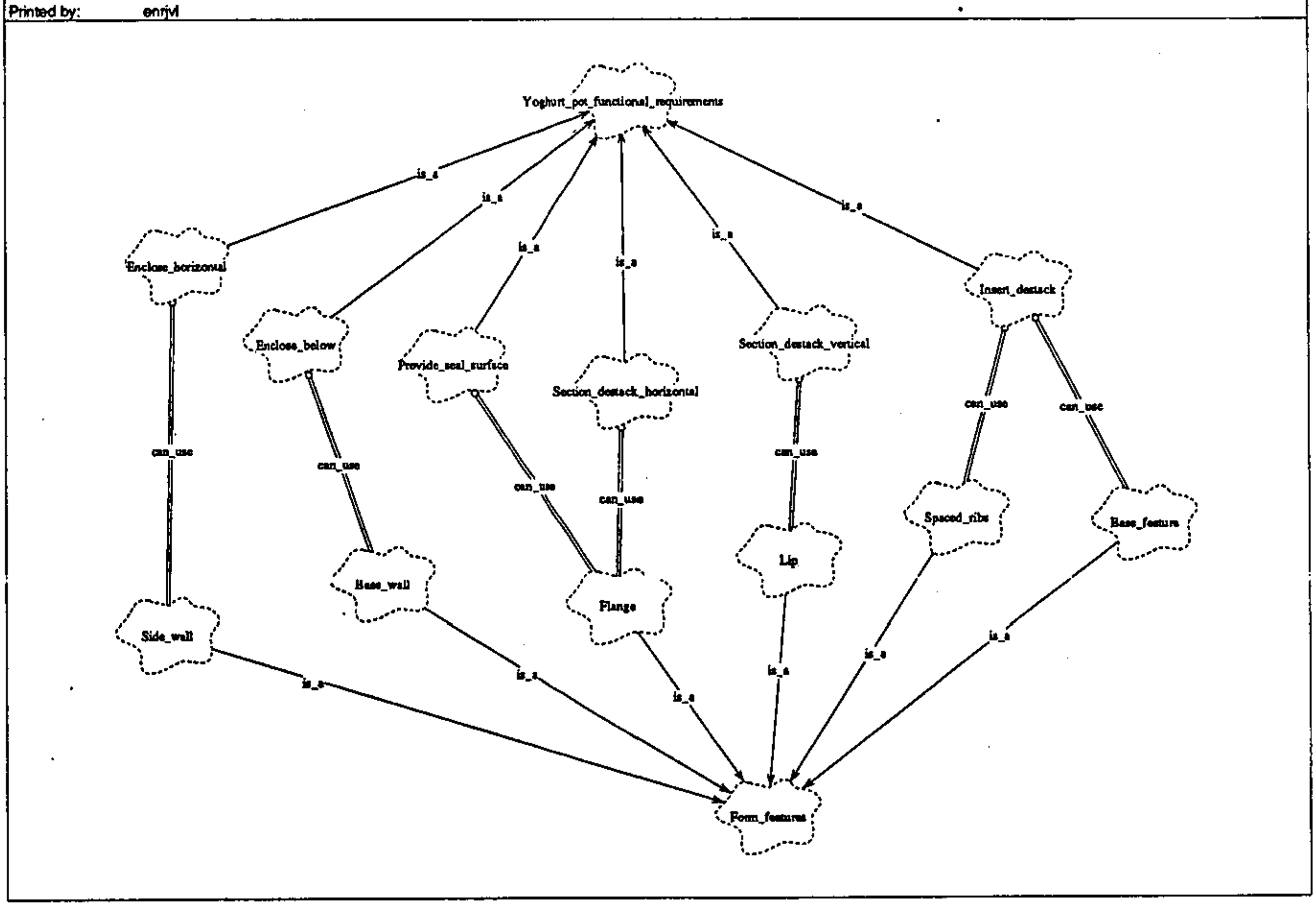
Project:	ron
Title:	Class Diagram: Section_destack_horizontal
Printed on:	Friday, September 1, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: Section_destack_vertical
Printed on:	Wednesday, August 30, 1995
Printed by:	enrjvl



Project:	ron
Title:	Class Diagram: YP_functional_requirements_form
Printed on:	Tuesday, August 15, 1995
Printed by:	enrjvl



Appendix 6.

EXPRESS representation of the Product Range Model.

```
SCHEMA Product_model

TYPE dimension = REAL;
WHERE
non_negative : SELF >= 0.0;
END_TYPE;

TYPE integer = INTEGER;
WHERE
non–negative : SELF >= 0;
END_TYPE;

//PRODUCT RANGE DESIGN MODEL.

ENTITY Product_range_design_model
has_ranges : Product_ranges;
END_ENTITY;

ENTITY Product_ranges
ABSTRACT SUPERTYPE OF ( ONE OF( PTPlus, Flower_pots, Yoghurt_pots));
has_IPD : Initial_product_definition_data;
has_requirements : Functional_requirements;
has_relations : Form_function_relations_data;
END_ENTITY;

ENTITY Yoghurt_pots
SUBTYPE OF ( Product_ranges);
END_ENTITY;

ENTITY Flower_pots
SUBTYPE OF ( Product_ranges);
END_ENTITY;

ENTITY PTPlus
SUBTYPE OF ( Product_ranges);
END_ENTITY;

ENTITY Functional_requirements_data
ABSTRACT SUPERTYPE OF (ONE OF ( Yoghurt_pot_functional_requirements,
Flower_pot_functional_requirements, PTPlus_functional_requirements,
Initial_product_definition_functional_requirements));
has_constraints : Functional_constraints;
has_adjacent : Adjacency_data;
has_require : Requirements_data;
END_ENTITY;

ENTITY Yoghurt_pot_functional_requirements_data
ABSTRACT SUPERTYPE OF (ONE OF ( Enclose_horizontal, Enclose_below,
Provide_seal_surface, Section_destack_horizontal, Section_destack_vertical, Insert_destack));
SUBTYPE OF ( Functional_requirements_data );
END_ENTITY;

ENTITY Enclose_horizontal
SUBTYPE OF (Yoghurt_pot_functional_requirements_data, Flower_pot_functional_requirements_data
Initial_product_definition_functional_requirements);
adjacent_feature_type : STRING;
volume : dimension;
diameter : dimension;
connect_wall : Side_wall;
connect_adj_wall : Base_wall;
connect_taper_on_wall: Taper;
```

```
WHERE
small_angle_radians : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle_radians : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
taper_effect_volume : = (taper_allowance*connect_wall.height/2.0)*3.1416*
                connect_wall.inner_dia;
volume_assessment : = (3.1416*SQ(connect_wall.inner_dia/2.0)*connect_wall.height) +
                taper_effect_volume;
recommended_height : = volume/(3.1416*SQ(connect_wall.inner_dia/2.0) +
                SINE(small_angle_radians)/SINE(large_angle_radians));
recommended_diameter : = 2.0*SQRT((volume–connect_wall.height*
                SINE(small_angle_radians)/SINE(large_angle_radians))/
                3.1416*connect_wall.height);
RULE Enclose_horizontal_requirements_data FOR (Enclose_horizontal);
Require enclosed volume (mm3) == volume.
Require enclosed diameter (mm) == diameter.
END_RULE;
RULE Enclose_horizontal_adjacency_data FOR (Enclose_horizontal):
adjacent_feature_type == Base_wall.
END_RULE;
RULE Enclose_horizontal_diameter FOR (Enclose_horizontal);
IF connect_wall.inner_dia < diameter THEN
Diameter less than specified for Enclose horizontal
function. Enclose horizontal function not achieved.
Advise increase connect_wall.inner_dia to diameter.
IF connect_wall.inner_dia > diameter THEN
Diameter greater than specified for Enclose horizontal
function. Enclose horizontal function not achieved.
Advise decrease connect_wall.inner_dia to diameter.
END_RULE;
RULE Enclose_horizontal_volume FOR (Enclose_horizontal);
IF volume_assessment < volume THEN
Volume enclosed less than specified. Enclose
horizontal function not achieved. Advise increase
connect_wall.height to recommended_height or
increase connect_wall.inner_dia to
recommended_diameter.
IF volume_assessment > volume THEN
Volume enclosed greater than specified. Enclose
horizontal function not achieved. Advise decrease
connect_wall.height to recommended_height or
decrease connect_wall.inner_dia to
recommended_diameter.
END_RULE;
END_ENTITY;

ENTITY Enclose_below
SUBTYPE OF (Yoghurt_pot_functional_requirements_data, Flower_pot_functional_requirements_data,
Initial_product_definition_functional_requirements);
adjacent_feature_type : STRING;
diameter : dimension;
connect_wall : Base_wall;
connect_adj_wall : Side_wall;
connect_taper_on_wall : Taper;
connect_horiz : Enclose_horizontal;
RULE Enclose_below_requirements_data FOR (Enclose_below);
Require enclosed diameter (mm) == diameter.
IF diameter < connect_horiz.diameter THEN
Diameter specification smaller than for adjacent
'Enclose_horizontal' function. If form matches
```

```
specification, enclosure not achieved, product
functionality lost. Advise increase diameter
specification to a minimum of connect_horiz.
diameter.
END_RULE;
RULE Enclose_below_adjacency_data FOR (Enclose_below):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Enclose_below_position FOR (Enclose_below);
IF (connect_wall.position[2] + connect_wall.height) < connect_adj_wall.position[2] THEN
Top of base wall not in contact with horizontal enclosure
wall. Product functionality lost. Advise relocate
connect_wall.positon[2] to (connect_adj_wall.position[2] -
connect_wall.height).
IF (connect_wall.position[2] + connect_wall.height) > connect_adj_wall.position[2] THEN
Top of base wall higher than base of horizontal enclosure
wall. Base wall encroaching on 'Enclose_horizontal' function -
Loss of functionality. Advise relocate connect_wall.positon[2]
to (connect_adj_wall.position[2] - connect_wall.height).
END_RULE;
RULE Enclose_below_diameter FOR (Enclose_below);
IF connect_wall.diameter < diameter THEN
Diameter less than specified for Enclose below
function. Enclosure not achieved, product functionality
lost. Advise increase connect_wall.diameter to a
minimum of diameter.
END_RULE;
RULE Enclose_below_horizontal_relation FOR (Enclose_below)
IF connect_wall.diameter > (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.thickness)
THEN
Unnecessary material and weight in the product -
Significant extra cost over a production run.
Unnecessary aesthetic feature. Advise decrease
connect_wall.diameter to connect_adj_wall.inner_dia
+ 2.0*connect_adj_wall.thickness.
IF connect_wall.diameter < (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.thickness)
THEN
Drastically reduced section thickness leading to
excessive structural weakness. Advise increase
connect_wall.diameter to connect_adj_wall.inner_dia +
2.0*connect_adj_wall.thickness
END_RULE;
END_ENTITY;

ENTITY Provide_seal_surface
SUBTYPE OF (Yoghurt_pot_functional_requirements_data);
adjacent_feature_type : STRING;
min_surface_area : dimension;
additional_function : STRING;
additional_spec : dimension;
connect_wall : Flange;
connect_adj_wall : Side_wall;
connect_taper_on_wall : Taper;
connect_taper_on_adjacent_wall : Taper;
connect_vert : Section_destack_vertical;
connect_horiz : Section_destack_horizontal;
WHERE
small_angle_adjacent_rads : = (connect_taper_on_adjacent_wall.angle/360)*2.0*3.1416;
remaining_angle_adjacent : = 90 - connect_taper_on_adjacent_wall.angle;
larger_angle_adjacent_rads : = (remaining_angle_adjacent/360)*2.0*3.1416;
taper_allowance_adjacent : = ((connect_wall.position[2] - connect_wall_adjacent.position[2])*
                    SINE(small_angle_adjacent_rads))/
```

SINE(large_angle_adjacent_rads);
taper_allowance_adjacent2 : =((connect_adj_wall.height*SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
min_width_spec : =((connect_vert.height_difference*SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height*SINE(small_angle_radians))/
SINE(large_angle_radians);
IF (taper_allowance == 0.0) AND (taper_allowance_adjacent != 0.0) THEN
taper_allowance_difference : = ((connect_wall_adjacent.position[2] +
connect_wall_adjacent.height – connect_wall.position[2])*
SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
IF (taper_allowance != 0.0) OR (taper_allowance_adjacent == 0.0) THEN
taper_allowance_difference : = 0.0;
sealing_area : = ((3.1416*SQ(connect_wall.inner_dia/2.0 + connect_wall.thickness +
taper_allowance)) – (3.1416*SQ(connect_adj_wall.inner_dia/2.0 +
connect_adj_wall.thickness + taper_allowance_adjacent2)));
min_seal_area : = min_surface_area – (3.1416*SQ(connect_adj_wall.inner_dia/2.0 +
connect_adj_wall.thickness + taper_allowance_adjacent2)));
min_outer_dia : = SQRT(min_seal_area/PI)*2.0;
RULE Provide_seal_surface_requirements_data FOR (Provide_seal_surface);
Require minimum sealing surface area (mm2) == min_surface_area.
'Provide_seal_surface' and 'Section_destack_horizontal' functions can
be performed using the same form.
IF Use same form for 'Section_destack_horizontal' THEN
'Section_destack_vertical' function – must also be applied.
'Insert_destack' function – no longer required.
additional_function = Section_destack_horizontal.
Require step width specification (mm) == additional_spec.
Advise min step width specification = min_width_spec.
IF Do not use same form for 'Section_destack_horizontal' THEN
Using 'Insert_destack' function:
'Section_destack_horizontal' function – no longer required.
'Section_destack_vertical' function – no longer required.
additional_function = 'none'.
END_RULE;
RULE Provide_seal_surface_adjacency_data FOR (Provide_seal_surface):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Sealing_position FOR (Provide_seal_surface);
IF (connect_wall.position[2] + connect_wall.height) < (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is below top surface of horizontal
enclosure wall. Drastic reduction in area available
for sealing. Flange area superfluous, sealing reliant
on top surface of horizontal enclosure wall. Advise
relocate flange to be flush with top of horizontal
enclosure wall, ie connect_wall.position[2] ==
connect_adj_wall.position[2] + connect_wall.height
– connect_wall.height.
IF (connect_wall.position[2] + connect_wall.height) > (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is above top surface of horizontal
enclosure wall. Drastic reduction in section thickness
leading to severe structural weakness. Drastic reduction
in area available for sealing. Advise
relocate flange to be flush with top of horizontal
enclosure wall, ie connect_wall.position[2] ==
connect_adj_wall.position[2] + connect_wall.height

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– connect_wall.height.
END_RULE;
RULE Sealing_enclosure_relation FOR (Provide_seal_surface);
IF connect_taper_on_wall.angle != 0.0 AND connect_taper_on_adjacent_wall.angle !=0.0
AND connect_taper_on_wall.angle < connect_taper_on_adjacent_wall.angle THEN
 IF (connect_wall.inner_dia – (2.0*taper_allowance_difference – 2.0*taper_allowance) <
 (connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent ) THEN
 Flange inner diameter smaller than inner diameter
 of horizontal enclosure wall. Flange encroaching on
 'Enclose_horizontal' function. Advise Increase
 connect_wall.inner_dia to a minimum of
 (connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
 + (2.0*taper_allowance_difference – 2.0*taper_allowance) ).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN
 IF (connect_wall.inner_dia – 2.0*taper_allowance_difference) <
 (connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent ) THEN
 Flange inner diameter smaller than inner diameter
 of horizontal enclosure wall. Flange encroaching on
 'Enclose_horizontal' function. Advise Increase
 connect_wall.inner_dia to a minimum of
 (connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
 + 2.0*taper_allowance_difference).
IF connect_taper_on_wall.angle > connect_taper_on_adjacent_wall.angle THEN
 IF (connect_wall.inner_dia + 2.0*taper_allowance) > (connect_wall_adjacent.inner_dia +
 2.0*connect_wall_adjacent.thickness + 2.0*taper_allowance_adjacent +
 2.0*taper_allowance_difference) THEN
 Flange inner diameter larger than corresponding
 outer diameter of horizontal enclosure wall. Drastically
 reduced section thickness leading to severe structural
 weakness or flange and horizontal enclosure wall not
 in contact – Product functionality lost. Advise decrease
 connect_wall.inner_dia to a maximum of (connect_wall_adjacent.
 inner_dia + 2.0*connect_wall_adjacent.thickness +
 2.0*taper_allowance_adjacent + 2.0*taper_allowance_difference
 – 2.0 *taper_allowance).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN
 IF connect_wall.inner_dia > (connect_wall_adjacent.inner_dia + 2.0*connect_wall_adjacent.
 thickness + 2.0*taper_allowance_adjacent – 2.0*taper_allowance_difference) THEN
 Flange inner diameter larger than corresponding
 outer diameter of horizontal enclosure wall. Drastically
 reduced section thickness leading to severe structural
 weakness or flange and horizontal enclosure wall not
 in contact – Product functionality lost. Advise decrease
 connect_wall.inner_dia to a maximum of (connect_wall_adjacent.
 inner_dia + 2.0*connect_wall_adjacent.thickness +
 2.0*taper_allowance_adjacent – 2.0*taper_allowance_difference).
END_RULE;
RULE Sealing_area FOR ( Provide_seal_surface );
IF connect_horiz.additional_function == 'Provide_seal_surface' THEN
min_sealing_area = connect_horiz.additional_spec.
IF sealing_area < min_sealing_area THEN
Flange sealing area insufficient to achieve
'Provide_seal_surface' function. Product
functionality lost. Advise increase in connect_wall
outer diameter to a minimum of min_outer_dia.
END_RULE;
END_ENTITY;

ENTITY Insert_destack
SUBTYPE OF (Yoghurt_pot_functional_requirements_data, Flower_pot_functional_requirements_data);
```

adjacent_feature_type : STRING;
height_difference : dimension;
additional_function : STRING;
additional_spec : dimension;
connect_insert : Spaced_ribs OR Base_feature;
connect_adj_wall : Base_wall;
connect_drain : Drainage_clearance;
RULE Insert_destack_requirements_data FOR (Insert_destack);
'Section_destack_horizontal' function – no longer required.
'Section_destack_vertical' function – no longer required.
Require protruding height of each (stacked) product (mm) == height_difference.
IF product range == Flower_pot THEN
'Insert_destack' and 'Drainage_clearance' functions can
be performed using the same form.
IF Use same form for 'Drainage_clearance' THEN
For 'Drainage_clearance' feature MUST be below base wall.
additional_function = Drainage_clearance.
Require drainage clearance height (mm) == additional_spec.
IF Do not use same form for 'Drainage_clearance' THEN
additional_function = none.
END_RULE;
RULE Insert_destack_adjacency_data FOR (Insert_destack):
adjacent_feature_type == Base_wall.
END_RULE;
RULE Insert_destack_position FOR (Insert_destack);
IF connect_insert.position[2] < connect_adj_wall.position[2] THEN
 IF (connect_insert.position[2] + connect_insert.height) < connect_adj_wall.position[2] THEN
 Top of connect_insert not in contact with base wall.
 Product functionality lost. Advise relocate
 connect_insert to connect_adj_wall.position[2] –
 connect_insert.height.
 IF (connect_insert.position[2] + connect_insert.height) > connect_adj_wall.position[2]
 THEN
 Top of connect_insert is higher than underside of
 base wall. Possible loss of function if insert feature
 is contained in base wall. Advise relocate
 connect_adj_wall.position[2] – connect_insert.height.
IF (connect_insert.position[2] + connect_insert.height) > (connect_adj_wall.position[2] +
connect_adj_wall.thickness) THEN
 IF connect_insert.position[2] > (connect_adj_wall.position[2] + connect_adj_wall.thickness)
 THEN
 Base of connect_insert not in contact with top
 of base wall. Product functionality lost. Advise
 relocate connect_insert to connect_adj_wall.position[2]
 + connect_adj_wall.thickness.
 IF connect_insert.position[2] < (connect_adj_wall.position[2] + connect_adj_wall.thickness)
 THEN
 Base of connect_insert is lower than topside of
 base wall. Possible loss of function if insert feature
 is contained in base wall. Advise relocate
 connect_adj_wall.position[2] + connect_adj_wall.
 thickness.
END_RULE;
RULE Insert_destack_height FOR (Insert_destack);
IF connect_drain.additional_function == 'Insert_destack' THEN
height_difference = connect_drain.additional_spec.
IF connect_insert.position[2] < connect_adj_wall.position[2] THEN
 IF (connect_adj_wall.position[2] – connect_insert.position[2]) < height_difference THEN
 Connect_insert.height insufficient to achieve
 'insert_destack' function. Product functionality
 lost.
  IF connect_insert.height < height_difference THEN

```
    Advise change connect_insert.height to height_difference
    and relocate connect_insert.position[2] to connect_adj_wall.
    position[2] – height_difference.
    IF connect_insert.height >= height_difference THEN
    Advise relocate connect_insert.position[2] to connect_adj_wall.
    position[2] – height_difference.
  IF (connect_adj_wall.position[2] – connect_insert.position[2]) > height_difference THEN
  Connect_insert.height higher than specified to achieve
  'insert_destack' function. Destack height higher than
  specified, unecessary material in the product. Advise
  relocate connect_insert.position[2] to connect_adj_wall.
  position[2] – height_difference.
IF (connect_insert.position[2] + connect_insert.height) > (connect_adj_wall.position[2] +
connect_adj_wall.thickness) THEN
  IF ((connect_insert.position[2] + connect_insert.height) – (connect_adj_wall.position[2] +
  connect_adj_wall.thickness)) < height_difference THEN
  Connect_insert height insufficent to achieve
  'insert_destack' function. Product functionality
  lost.
    IF connect_insert.height < height_difference THEN
    Advise increase connect_insert.height to height_difference
    and relocate connect_insert.position[2] to (connect_adj_wall.
    position[2] + connect_adj_wall.thickness).
    IF connect_insert.height >= height_difference THEN
    Advise relocate connect_insert.position[2] to (connect_adj_wall.
    position[2] + connect_adj_wall.thickness) –
    (connect_insert.height – height_difference).
  IF ((connect_insert.position[2] + connect_insert.height) – (connect_adj_wall.position[2] +
  connect_adj_wall.thickness)) > height_difference THEN
  Connect_insert.height higher than specified to achieve
  'insert_destack' function. Destack height higher than
  specified, unecessary material in the product. Advise
  decrease connect_insert.height to height_difference.
END_RULE;
END_ENTITY;

ENTITY Section_destack_horizontal
SUBTYPE OF (Yoghurt_pot_functional_requirements_data, Flower_pot_functional_requirements_data);
adjacent_feature_type : STRING;
min_destack_width : dimension;
additional_function : STRING;
additional_spec : dimension;
connect_wall : Flange;
connect_adj_wall : Side_wall;
connect_taper_on_wall : Taper;
connect_taper_on_adjacent_wall : Taper;
connect_vert : Section_destack_vertical;
connect_seal : Provide_seal_surface;
WHERE
small_angle_adjacent_rads : = (connect_taper_on_adjacent_wall.angle/360)*2.0*3.1416;
remaining_angle_adjacent : = 90 – connect_taper_on_adjacent_wall.angle;
larger_angle_adjacent_rads : = (remaining_angle_adjacent/360)*2.0*3.1416;
taper_allowance_adjacent : = ((connect_wall.position[2] – connect_wall_adjacent.position[2])*
                        SINE(small_angle_adjacent_rads))/
                        SINE(large_angle_adjacent_rads);
taper_allowance_adjacent2 : =((connect_adj_wall.height*SINE(small_angle_adjacent_rads))/
                        SINE(large_angle_adjacent_rads);
min_width_spec : =((connect_vert.height_difference*SINE(small_angle_adjacent_rads))/
                SINE(large_angle_adjacent_rads);
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle : = (remaining_angle/360)*2.0*3.1416;
```

taper_allowance : = (connect_wall.height*SINE(small_angle_radians))/
SINE(large_angle_radians);
IF (taper_allowance == 0.0) AND (taper_allowance_adjacent != 0.0) THEN
taper_allowance_difference : = ((connect_wall_adjacent.position[2] +
connect_wall_adjacent.height – connect_wall.position[2])*
SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
IF (taper_allowance != 0.0) OR (taper_allowance_adjacent == 0.0) THEN
taper_allowance_difference : = 0.0;
width_difference : = (connect_wall.inner_dia/2.0 + taper_allowance) –
(connect_adj_wall.inner_dia/2.0 + taper_allowance_adjacent2);
RULE Section_destack_horizontal_requirements_data FOR (Section_destack_horizontal);
'Section_destack_vertical' function – must also be applied.
'Insert_destack' function – no longer required.
Require step width specification (mm) == min_destack_width.
Advise min step width specification = min_width_spec.
IF product_range == Yoghurt_pot THEN
'Section_destack_horizontal' and 'Provide_seal_surface' functions are
performed using the same form.
additional_function = Provide_seal_surface.
Require minimum sealing surface area (mm2) == additional_spec.
END_RULE;
RULE Section_destack_horizontal_adjacency_data FOR (Section_destack_horizontal):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Destack_horizontal_position FOR (Section_destack_horizontal);
IF (connect_wall.position[2] + connect_wall.height) < (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is below top surface of horizontal
enclosure wall. Reduction in destack function.
Additional height required for "Section destack vertcial'
function – unecessary increase in product weight and
material content. Advise relocate flange to be flush with
top of horizontal enclosure wall, ie connect_wall.position[2]
== connect_adj_wall.position[2] + connect_wall.height
– connect_wall.height.
IF (connect_wall.position[2] + connect_wall.height) > (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is above top surface of horizontal
enclosure wall. Drastic reduction in section thickness
leading to severe structural weakness. Advise
relocate flange to be flush with top of horizontal
enclosure wall, ie connect_wall.position[2] ==
connect_adj_wall.position[2] + connect_wall.height
– connect_wall.height.
END_RULE;
RULE Destack_horizontal_enclose_relation FOR (Section_destack_horizontal);
IF connect_taper_on_wall.angle != 0.0 AND connect_taper_on_adjacent_wall.angle !=0.0
AND connect_taper_on_wall.angle < connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia – (2.0*taper_allowance_difference – 2.0*taper_allowance) <
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent) THEN
Flange inner diameter smaller than inner diameter
of horizontal enclosure wall. Flange encroaching on
'Enclose_horizontal' function. Advise Increase
connect_wall.inner_dia to a minimum of
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
+ (2.0*taper_allowance_difference – 2.0*taper_allowance)).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia – 2.0*taper_allowance_difference) <
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent) THEN
Flange inner diameter smaller than inner diameter

of horizontal enclosure wall. Flange encroaching on
'Enclose_horizontal' function. Advise Increase
connect_wall.inner_dia to a minimum of
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
+ 2.0*taper_allowance_difference).
IF connect_taper_on_wall.angle > connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia + 2.0*taper_allowance) > (connect_wall_adjacent.inner_dia +
2.0*connect_wall_adjacent.thickness + 2.0*taper_allowance_adjacent +
2.0*taper_allowance_difference) THEN
Flange inner diameter larger than corresponding
outer diameter of horizontal enclosure wall. Drastically
reduced section thickness leading to severe structural
weakness or flange and horizontal enclosure wall not
in contact – Product functionality lost. Advise decrease
connect_wall.inner_dia to a maximum of (connect_wall_adjacent.
inner_dia + 2.0*connect_wall_adjacent.thickness +
2.0*taper_allowance_adjacent + 2.0*taper_allowance_difference
– 2.0 *taper_allowance).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN
IF connect_wall.inner_dia > (connect_wall_adjacent.inner_dia + 2.0*connect_wall_adjacent.
thickness + 2.0*taper_allowance_adjacent – 2.0*taper_allowance_difference) THEN
Flange inner diameter larger than corresponding
outer diameter of horizontal enclosure wall. Drastically
reduced section thickness leading to severe structural
weakness or flange and horizontal enclosure wall not
in contact – Product functionality lost. Advise decrease
connect_wall.inner_dia to a maximum of (connect_wall_adjacent.
inner_dia + 2.0*connect_wall_adjacent.thickness +
2.0*taper_allowance_adjacent – 2.0*taper_allowance_difference).
END_RULE;
RULE Destack_horizontal_step_width FOR (Section_destack_horizontal);
IF product_range == Yoghurt_pot THEN
IF connect_seal.additional_function == 'Section_destack_horizontal' THEN
min_destack_width = connect_seal.additional_spec.
IF ((connect_wall.inner_dia/2.0 + connect_wall.width + taper_allowance) –
(connect_adj_wall.inner_dia/2.0 + taper_allowance_adjacent2)) < min_destack_width THEN
Step width less than minimum step width
specification. Stacked product above supported
on horizontal enclosure wall. Destack height
calculations for 'Section destack vertical' function
erroneous. Advise increase connect_wall.width to
a minimum of (min_destack_width – width_difference).
END_RULE;
END_ENTITY;

ENTITY Section_destack_vertical
SUBTYPE OF (Yoghurt_pot_functional_requirements_data, Flower_pot_functional_requirements_data);
adjacent_feature_type : STRING;
height_difference : dimension;
connect_wall : Lip;
connect_adj_wall : flange;
RULE Section_destack_vertical_requirements_data FOR (Section_destack_vertical);
Require protruding height of each (stacked) product (mm) == height_difference.
END_RULE;
RULE Section_destack_vertical_adjacency_data FOR (Section_destack_vertical):
adjacent_feature_type == Flange.
END_RULE;
RULE Destack_vertical_position FOR (Section_destack_vertical);
IF connect_wall.position[2] < connect_adj_wall.position[2] THEN
Base of lip below base of section destack
horizontal wall. Drastic reduction in section

thickness leading to severe strcutural weakness.
Possible erroneous calculation of destack
function. Advise relocate connect_wall.position[2]
to connect_adj_wall.position[2].
IF connect_wall.position[2] > connect_adj_wall.position[2] THEN
Base of lip above base of section destack
horizontal wall. Reduction in destack function.
Unecessary aesthetic feature on base of flange –
sigmificant increase in production cost due to
extra material in product over a production run.
Advise relocate connect_wall.position[2]
to connect_adj_wall.position[2].
END_RULE;
RULE Destack_vertical_horizontal_relation FOR (Section_destack_vertical);
IF connect_wall.inner_dia < (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width)
THEN
Lip inner diameter smaller than outer diameter
of section destack horizontal wall. Lip encroaching
on 'section destack horizontal' function. Advise
increase connect_wall.inner_dia to a minimum of
(connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width)
IF connect_wall.inner_dia > (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width)
THEN
Lip inner diameter greater than outer diameter
of section destack horizontal wall. Drastically reduced
section thickness leading to severe structural weakness.
Lip and section destack horizontal wall not in contact.
Advise decrease connect_wall.inner_dia to a maximum of
(connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width)
END_RULE;
RULE Destack_vertical_height FOR (Section_destack_vertical);
IF ((connect_wall.position[2] + connect_wall.height) – (connect_adj_wall.position[2] +
connect_adj_wall.thickness)) < height_difference THEN
Lip height insufficient to achieve 'destack' function.
Product functionality lost. Advise increase connect_wall.
height to (height_difference + connect_adj_wall.position[2] +
connect_adj_wall.thickness – connect_wall.position[2]).
IF ((connect_wall.position[2] + connect_wall.height) – (connect_adj_wall.position[2] +
connect_adj_wall.thickness)) > height_difference THEN
Lip height higher than specified to achieve 'destack' function.
Destack height is greater than specified – unecessary material
in product. Advise decrease connect_wall.height to
(height_difference + connect_adj_wall.position[2] +
connect_adj_wall.thickness – connect_wall.position[2]).
END_RULE;
END_ENTITY:

ENTITY Flower_pot_functional_requirements_data
ABSTRACT SUPERTYPE OF (ONE OF (Enclose_horizontal, Enclose_below,
Section_destack_horizontal, Section_destack_vertical, Insert_destack, Drainage_clearance, Drainage));
SUBTYPE OF (Functional_requirements_data);
END_ENTITY;

ENTITY Drainage
SUBTYPE OF (Flower_pot_functional_requirements_data);
adjacent_feature_type : STRING;
drain_area : dimension;
connect_hole : Spaced_holes;
connect_wall : Base_wall;
WHERE
area_for_drainage : = 3.1416*SQ(connect_hole.diameter/2.0);
total_drainage : = connect_hole.hole_numb*area_for_drainage;

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req_area_per_hole : = drain_area/connect_hole.hole_numb;
recom_diameter : = SQRT(req_area_per_hole/3.1416)*2.0;
recom_hole_no : = CEIL (drain_area/area_for_drainage);
RULE Drainage_requirements_data FOR (Drainage);
Require drainage area (mm2) == drain_area.
END_RULE;
RULE Drainage_adjacency_data FOR (Drainage):
adjacent_feature_type == Base_wall.
END_RULE;
RULE Drainage_hole depth FOR (Drainage);
IF connect_hole.depth < connect_wall.thickness THEN
Hole depth less than thickness of base wall. Blind holes -
drainage function not achieved. Advise increase hole
depth to a minimum of connect_wall.thickness.
IF (connect_hole.position[2] + connect_hole.depth) < (connect_wall.position[2] +
connect_wall.thickness) THEN
Top of hole grouping lower than topside of
base wall. Blind holes - draiange function not
achieved. Advise increase connect_hole.depth
to a minimum of (connect_wall.position[2] +
connect_wall.thickness - connect_hole.position[2]).
END_RULE;
RULE Drainage_hole_position FOR (Drainage);
IF connect_hole.position[2] > connect_wall.position[2] THEN
Base of hole grouping is above underside of
base wall. Blind holes - drainage function not
achieved. Advise relocate connect_hole.postion[2]
to below connect_wall.position[2].
END_RULE;
RULE Drainage_hole_diameter FOR (Drainage)
IF connect_hole.diameter > 14.0 THEN
Diameter of holes is too large. Excessive soil
loss from base of flower pot when soil is dry.
Advise decrease connect_hole.diameter to a
maximum of 14.0.
END_RULE;
RULE Drainage_area FOR (Drainage);
IF total_drainage < drain_area THEN
Holes area is not large enough to provide
adequate drainage. Advise increase connect_hole.
diameter (maximum 14.0) or increase connect_hole.
hole_numb. Increasing connect_hole.hole_numb
may increase the product cost by increased mould
complexity. Necessary connect_hole.diameter at
present numbers == recom_diameter. Recommeded
connect_hole.hole_numb at present diameter ==
recom_hole_no.
END_RULE;
END_ENTITY;

ENTITY Drainage_clearance
SUBTYPE OF ( Flower_pot_functional_requirements_data);
adjacent_feature_type : STRING;
drain_height : dimension;
additional_function : STRING;
additional_spec : dimension;
connect_insert : Spaced_ribs OR Spaced_bosses;
connect_adj_wall : Base_wall;
connect_dest : Insert_destack;
RULE Drainage_clearance_requirements_data FOR (Drainage_clearance);
Require drainage clearance height (mm) == drain_height.
'Drainage_clearance' and 'Insert_destack' functions can be performed
```

using the same form.
IF Use same form for 'Insert_destack' THEN
For 'Drainage_clearance' feature MUST be below base wall.
'Section_destack_horizontal' function – no longer required.
'Section_destack_vertical' function – no longer required.
additional_function = Insert_destack.
Require protruding height of each (stacked) product (mm) == additional_spec.
IF Do not use same form for 'Insert_destack' THEN
additional_function = none.
END_RULE;
RULE Drainage_clearance_adjacency_data FOR (Drainage_clearance):
adjacent_feature_type == Base_wall.
END_RULE;
RULE Drainage_clearance_position FOR (Drainage_clearance);
IF connect_insert.postion[2] > (connect_adj_wall.posiiton[2] + connect_adj_wall.thickness) THEN
Connect_insert not on underside of base wall.
Drainage clearance function not achieved.
Connect_insert MUST be on underside of
base wall. Advise relocate connect_insert.position[2]
to connect_adj_wall.position[2] – connect_insert.height.
IF (connect_insert.position[2] + connect_insert.height) < connect_adj_wall.position[2] THEN
Top of connect_insert not in contact with base wall.
Product functionality lost. Advise relocate
connect_insert to connect_adj_wall.position[2] –
connect_insert.height.
IF (connect_insert.position[2] + connect_insert.height) > connect_adj_wall.position[2]
THEN
Top of connect_insert is higher than underside of
base wall. Possible loss of function if insert feature
is contained in base wall. Advise relocate
connect_adj_wall.position[2] – connect_insert.height.
END_RULE;
RULE Drainage_clearance_height FOR (Drainage_clearance);
IF connect_dest.additional_function == 'Drainage_clearance' THEN
drain_height = connect_dest.additional_spec.
IF (connect_adj_wall.position[2] – connect_insert.position[2]) < drain_height THEN
Connect_insert.height insufficient to achieve
'drainage_clearance' function. Product functionality
lost.
 IF connect_insert.height < drain_height THEN
 Advise change connect_insert.height to drain_height
 and relocate connect_insert.position[2] to connect_adj_wall.
 position[2] – drain_height.
 IF connect_insert.height >= drain_height THEN
 Advise relocate connect_insert.position[2] to connect_adj_wall.
 position[2] – drain_height.
IF (connect_adj_wall.position[2] – connect_insert.position[2]) > drain_height THEN
Connect_insert.height higher than specified to achieve
'drainage_clearance' function. Drainage clearance higher than
specified, unecessary material in the product. Advise
relocate connect_insert.position[2] to connect_adj_wall.
position[2] – drain_height.
END_RULE;
END_ENTITY;

ENTITY PTPlus_functional_requirements_data
ABSTRACT SUPERTYPE OF (ONE OF (Locate_in_lid, Locate_on_jar, Break_in_torsion,
Hold_in_lid, Hold_on_jar, Prevent_rotation, Cover_lid_edge));
SUBTYPE OF (Functional_requirements_data);
END_ENTITY;

ENTITY Locate_in_lid

```
SUBTYPE OF ( PTPlus_functional_requirements_data,
Initial_product_definition_functional_requirements);
adjacent_feature_type : STRING;
diameter : dimension;
height : dimension;
connect_wall : Side_wall;
connect_taper_on_wall : Taper;
WHERE
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle_rads : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height/2.0*
                SINE(small_angle_adjacent_rads))/
                SINE(large_angle_adjacent_rads);
outer_dia : = connect_wall.inner_dia + 2.0*connect_wall.thickness + 2.0*taper_allowance;
RULE Locate_in_lid_requirements_data FOR (Locate_in_lid);
Require inner diameter of metal lid (mm) == diameter.
Require height of location surface (mm) == height.
Advise location surface contains flange for 'Hold in
lid' function as well as mating with inside lid surface.
END_RULE;
RULE Locate_in_lid_adjacency_data FOR (Locate_in_lid):
adjacent_feature_type == Spaced_bosses.
END_RULE;
RULE Locate_in_lid_height FOR (Locate_in_lid);
IF connect_wall.height > height THEN
Feature location height greater than lid location
surface. An overhang exists. Advise change
connect_wall.height: Location surface height
== height.
IF connect_wall.height < height THEN
Feature height smaller than lid location
surface. Location surface is under–utilised.
Possible problems with 'hold in lid'
function. Advise change connect_wall.height:
Location surface height == height.
END_RULE;
RULE Locate_in_lid_location FOR (Locate_in_lid);
IF outer_dia > diameter THEN
Connect_wall outer_diameter greater than inside
diameter of lid. This is an interference fit.
Advise change connect_wall outer_diameter:
Location diameter == diameter.
 IF connect_taper_on_wall.angle != 0.0 THEN
 outer_diameter = outer_diameter – 2.0*taper_allowance.
Connect_wall.inner_dia = outer_diameter – 2.0*connect_wall.thickness.
IF outer_dia < diameter THEN
Connect_wall outer_diameter smaller than inside
diameter of lid. An insert of some kind is required.
Advise change connect_wall outer_diameter:
Location diameter == diameter.
 IF connect_taper_on_wall.angle != 0.0 THEN
 outer_diameter = outer_diameter – 2.0*taper_allowance.
Connect_wall.inner_dia = outer_diameter – 2.0*connect_wall.thickness.
END_RULE;
END_ENTITY;

ENTITY Break_in_torsion
SUBTYPE OF ( PTPlus_functional_requirements_data,
Initial_product_definition_functional_requirements);
adjacent_feature_type : STRING;
torsion_req : dimension;
```

```
connect_boss : Spaced_bosses;
connect_wall : Side_wall;
WHERE
min_group_dia : = connect_wall.inner_dia + connect_boss.boss_dia;
max_group_dia : = connect_wall.inner_dia + connect_wall.thickness –
                connect_boss.boss_dia;
yield : = 29.0;
boss_area : = 3.1416*SQ(connect_boss.boss_dia/2.0);
total_area : = boss_area*connect_boss.boss_numb;
Force : = yield*total_area;
Torque_calculation : = Force*connect_boss.axis_dia/2.0;
Reverse_force : = Torque_calculation/(connect_boss.boss_dia/2.0);
Reverse_total_area : = Reverse_force/yield;
Reverse_boss_area : = Reverse_total_area/connect_boss.boss_numb;
recom_diameter : = SQRT(Reverse_boss_area/3.1416);
recom_boss_no : = FLOOR(Reverse_total_area/boss_area);
RULE Break_in_torsion_requirements_data FOR (Break_in_torsion);
Require breakage torsion (Nmm) == torsion_req.
END_RULE;
RULE Break_in_torsion_adjacency_data FOR (Break_in_torsion):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Torsion_position FOR (Break_in_torsion);
IF (connect_boss.position[2] + connect_boss.height) < connect_wall.position[2] THEN
Top of boss grouping not in contact with wall.
Lost product functionality. Advise reposition
connect_boss.position[2] to (connect_wall.position[2] –
connect_boss.height).
IF (connect_boss.position[2] + connect_boss.height) > connect_wall.position[2] THEN
Top of boss grouping is higher than underside of
side wall. Possible loss of function if boss grouping
is contained in side wall. Advise relocate connect_boss.
position[2] to connect_wall.position[2] – connect_insert.height.
END_RULE;
RULE Torsion_group_diameter FOR (Break_in_torsion);
IF (connect_boss.axis_dia + connect_boss.boss_dia) > ( connect_wall.inner_dia +
2.0*connect_wall.thickness) THEN
Group outer diameter greater than that of supporting
wall. Breakage torsion drastically reduced from that
intended and cannot be evaluated. Advise decrease
group diameter to be in full contact with supporting
wall ie min_group_dia <= connect_boss.axis_dia <=
max_group_dia.
IF (connect_boss.axis_dia – connect_boss.boss_dia) < connect_wall.inner_dia THEN
Group inner diameter smaller than that of supporting
wall. Breakage torsion drastically reduced from that
intended and cannot be evaluated. Advise increase
group diameter to be in full contact with supporting
wall ie min_group_dia <= connect_boss.axis_dia <=
max_group_dia.
END_RULE;
RULE Torsion_torque FOR (Break_in_torsion);
IF Torque_calculation < torsion_req THEN
Feature cross sectional area not large enough to
provide failure at the torque specified. Tampering
with the jar may be indicated erroneously. The lid
can be removed from the jar too easily. Advise
increase connect_boss.boss_numb to recom_boss_no
or increase connect_boss.boss_dia to recom_diameter.
IF Torque_calculation > torsion_req THEN
Feature cross sectional area too large to provide
failure at the torque specified. Difficulty in removing
```

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the lid from the jar. Advise decrease connect_boss.boss_numb
to recom_boss_no or decrease connect_boss.boss_dia
to recom_diameter.
END_RULE;
END_ENTITY;

ENTITY Locate_on_jar
SUBTYPE OF ( PTPlus_functional_requirements_data,
Initial_product_definition_functional_requirements);
adjacent_feature_type : STRING;
diameter : dimension;
height : dimension;
connect_wall : Side_wall;
connect_boss : Spaced_bosses;
connect_taper_on_wall : Taper;
WHERE
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle_rads : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height*
                SINE(small_angle_adjacent_rads))/
                SINE(large_angle_adjacent_rads);
min_inner_dia : = connect_boss.axis_dia + connect_boss.boss_dia –
              2.0*connect_wall.thickness – 2.0* taper_allowance;
max_inner_dia : = connect_boss.axis_dia – connect_boss.boss_dia – 2.0*taper_allowance;
min_outer_dia : = connect_boss.axis_dia + connect_boss.boss_dia – 2.0* taper_allowance;
max_outer_dia : = connect_boss.axis_dia – connect_boss.boss_dia +
              2.0*connect_wall.thickness – 2.0*taper_allowance;
outer_dia : = connect_wall.inner_dia + 2.0*connect_wall.thickness;
RULE Locate_on_jar_requirements_data FOR (Locate_on_jar);
Require outer diameter of jar neck (mm) == diameter.
Require height of location surface (mm) == height.
Advise location surface contains flange for 'Hold in
lid' function as well as mating with inside lid surface.
END_RULE;
RULE Locate_on_jar_adjacency_data FOR (Locate_on_jar):
adjacent_feature_type == Spaced_bosses.
END_RULE;
RULE Locate_on_jar_height FOR (Locate_on_jar);
IF connect_wall.height > height THEN
Feature location height greater than jar location
surface. An overhang exists. Advise change
connect_wall.height: Location surface height == height.
IF connect_wall.height < height THEN
Feature height smaller than jar location
surface. Location surface is underutilised.
Possible problems with 'hold_on_jar'
function. Advise change connect_wall.height:
Location surface height == height.
END_RULE;
RULE Locate_on_jar_position FOR (Locate_on_jar);
IF (connect_wall.position[2] + connect_wall.height) > connect_boss.position[2] THEN
Feature position too high. Shortened length of
bridges – Torque calculation no longer valid,
possible lost product functionality. Advise reposition
connect_wall.position[2] to (connect_boss.position[2] –
connect_wall.height).
IF (connect_wall.position[2] + connect_wall.height) < connect_boss.position[2] THEN
Top of location wall not in contact with boss grouping.
Lost product functionality. Advise reposition connect_wall.
position[2] to (connect_boss.position[2] –
connect_wall.height).
```

```
END_RULE;
RULE Locate_on_jar_torsion FOR (Locate_on_jar);
IF connect_wall.inner_dia > ( connect_boss.axis_dia – connect_boss.boss_dia –
2.0*taper_allowance) THEN
Wall inner diameter is greater than that
of adjacent boss grouping. Breakage torsion
drastically reduced and cannot be evaluated.
Advise decrease connect_wall.inner_dia to be
in full contact with boss grouping ie min_inner_dia
<= connect_wall.inner_dia <= max_inner_dia.
IF (connect_wall.inner_dia + 2.0*connect_wall.thickness – 2.0*taper_allowance) <
( connect_boss.axis_dia + connect_boss.boss_dia) THEN
Wall outer diameter is smaller than that
of adjacent boss grouping. Breakage torsion
drastically reduced and cannot be evaluated.
Advise increase outer_dia to be in full contact
with boss grouping ie min_outer_dia
<= outer_dia <= max_outer_dia.
connect_wall.inner_dia = outer_dia – 2.0*connect_wall.thickness.
RULE Locate_on_jar_location FOR (Locate_on_jar);
IF connect_wall.inner_dia  < diameter THEN
Connect_wall inner_dia smaller than neck
diameter of jar. This is an interference fit. Advise
change connect_wall inner_dia: Location diameter
== diameter.
IF connect_wall.inner_dia  > diameter THEN
Connect_wall outer_diameter greater than neck
diameter of jar. An insert of some kind is required.
Advise change connect_wall inner_dia: Location
diameter == diameter.
END_RULE;


ENTITY Hold_in_lid
SUBTYPE OF ( PTPlus_functional_requirements_data);
adjacent_feature_type : STRING;
fixing_diameter : dimension;
connect_wall : Flange;
connect_adj_wall : Side_wall;
connect_taper_on_wall : Taper;
connect_taper_on_adjacent_wall : Taper;
WHERE
small_angle_adjacent_rads : = (connect_taper_on_adjacent_wall.angle/360)*2.0*3.1416;
remaining_angle_adjacent : = 90 – connect_taper_on_adjacent_wall.angle;
larger_angle_adjacent_rads : = (remaining_angle_adjacent/360)*2.0*3.1416;
taper_allowance_adjacent : = ((connect_wall.position[2] – connect_wall_adjacent.position[2])*
                        SINE(small_angle_adjacent_rads))/
                        SINE(large_angle_adjacent_rads);
taper_allowance_adjacent2 : =((connect_adj_wall.height*SINE(small_angle_adjacent_rads))/
                        SINE(large_angle_adjacent_rads);
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height*SINE(small_angle_radians))/
                SINE(large_angle_radians);
IF (taper_allowance == 0.0) AND (taper_allowance_adjacent != 0.0) THEN
taper_allowance_difference : = ((connect_wall_adjacent.position[2] +
                        connect_wall_adjacent.height – connect_wall.position[2])*
                        SINE(small_angle_adjacent_rads))/
                        SINE(large_angle_adjacent_rads);
IF (taper_allowance != 0.0) OR (taper_allowance_adjacent == 0.0) THEN
taper_allowance_difference : = 0.0;
```

RULE Hold_in_lid_requirements_data FOR (Hold_in_lid);
Require maximum fixing diameter, ie diameter inside
lid (mm) == fixing_diameter.
END_RULE;
RULE Hold_in_lid_adjacency_data FOR (Hold_in_lid):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Hold_in_lid_position FOR (Hold_in_lid);
IF (connect_wall.position[2] + connect_wall.height) < (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is below top surface of location wall.
Difficulty fitting the product into the lid. Possible
sealant leakage around the edge of the lid. Advise
relocate flange to be flush with top of location wall,
ie connect_wall.position[2] == connect_adj_wall.position[2]
+ connect_wall.height - connect_wall.height.
IF (connect_wall.position[2] + connect_wall.height) > (connect_adj_wall.position[2]
+ connect_adj_wall.height) THEN
Top of flange is above top surface of location wall.
Drastic reduction in section thickness leading to severe
structural weakness. Problems fitting the product into
the lid. Advise relocate flange to be flush with top of
location wall, ie connect_wall.position[2] ==
connect_adj_wall.position[2] + connect_wall.height
- connect_wall.height.
END_RULE;
RULE Hold_in_lid_location_relation FOR (Hold_in_lid);
IF connect_taper_on_wall.angle != 0.0 AND connect_taper_on_adjacent_wall.angle !=0.0
AND connect_taper_on_wall.angle < connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia - (2.0*taper_allowance_difference - 2.0*taper_allowance) <
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent) THEN
Flange inner diameter smaller than inner diameter
of location wall. Contact with jar neck causing
increased torque for lid removal. Advise Increase
connect_wall.inner_dia to a minimum of
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
+ (2.0*taper_allowance_difference - 2.0*taper_allowance)).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia - 2.0*taper_allowance_difference) <
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent) THEN
Flange inner diameter smaller than inner diameter
of location wall. Contact with jar neck causing
increased torque for lid removal. Advise Increase
connect_wall.inner_dia to a minimum of
(connect_wall_adjacent.inner_dia + 2.0*taper_allowance_adjacent
+ 2.0*taper_allowance_difference).
IF connect_taper_on_wall.angle > connect_taper_on_adjacent_wall.angle THEN
IF (connect_wall.inner_dia + 2.0*taper_allowance) > (connect_wall_adjacent.inner_dia +
2.0*connect_wall_adjacent.thickness + 2.0*taper_allowance_adjacent +
2.0*taper_allowance_difference) THEN
Flange inner diameter larger than corresponding
outer diameter of location wall. Drastically reduced
section thickness leading to severe structural weakness
or flange and location wall not in contact - Product
functionality lost. Advise decrease connect_wall.inner_dia
to a maximum of (connect_wall_adjacent.inner_dia +
2.0*connect_wall_adjacent.thickness +
2.0*taper_allowance_adjacent + 2.0*taper_allowance_difference
- 2.0 *taper_allowance).
IF connect_taper_on_wall.angle == 0.0 OR connect_taper_on_adjacent_wall.angle == 0.0
OR connect_taper_on_wall.angle == connect_taper_on_adjacent_wall.angle THEN

```
 IF connect_wall.inner_dia > (connect_wall_adjacent.inner_dia + 2.0*connect_wall_adjacent.
 thickness + 2.0*taper_allowance_adjacent - 2.0*taper_allowance_difference) THEN
 Flange inner diameter larger than corresponding
 outer diameter of location wall. Drastically reduced
 section thickness leading to severe structural weakness
 or flange and location wall not in contact - Product
 functionality lost. Advise decrease connect_wall.inner_dia
 to a maximum of (connect_wall_adjacent.inner_dia +
 2.0*connect_wall_adjacent.thickness +
 2.0*taper_allowance_adjacent - 2.0*taper_allowance_difference).
END_RULE;
RULE Hold_in_lid_fixing FOR (Hold_in_lid);
IF (connect_wall.inner_dia + 2.0*connect_wall.width + 2.0*taper_allowance) >
fixing_diameter THEN
Feature outer diameter larger than maximum fixing
diameter. The feature cannot fit inside the lid. Advise
change feature outer diameter: Maximum fixing
diameter == fixing_diameter.
IF (connect_wall.inner_dia + 2.0*connect_wall.width + 2.0*taper_allowance) >
(connect_adjacent_wall.inner_dia + 2.0*connect_adjacent_wall.thickness +
2.0*taper_allowance_adjacent) THEN
Feature outer diameter smaller than the location
diameter. Fixing function not achieved. Advise
change feature outer diameter: Location diameter
== (connect_adjacent_wall.inner_dia +
2.0*connect_adjacent_wall.thickness +
2.0*taper_allowance_adjacent)
END_RULE;
END_ENTITY;

ENTITY Hold_on_jar
SUBTYPE OF ( PTPlus_functional_requirements_data);
adjacent_feature_type : STRING;
fixing_diameter : dimension;
connect_wall : Flange;
connect_adj_wall : Side_wall;
connect_taper_on_wall : Taper;
WHERE
small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 - connect_taper_on_wall.angle;
larger_angle : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = (connect_wall.height*SINE(small_angle_radians))/
                    SINE(large_angle_radians);
outer_dia : = connect_wall.inner_dia + 20*connect_wall.width + 2.0*taper_allowance;
RULE Hold_on_jar_requirements_data FOR (Hold_on_jar);
Require minimum fixing diameter, ie thinnest
diameter of jar neck (mm) == fixing_diameter.
END_RULE;
RULE Hold_on_jar_adjacency_data FOR (Hold_on_jar):
adjacent_feature_type == Side_wall.
END_RULE;
RULE Hold_on_jar_position FOR (Hold_on_jar);
IF (connect_wall.position[2] + connect_wall.height) < connect_adj_wall.position[2] THEN
Top of flange not in contact with location wall.
Product functionality lost. Advise relocate
connect_wall.position[2] to (connect_adj_wall.
position[2] - connect_wall.height).
IF (connect_wall.position[2] + connect_wall.height) > connect_adj_wall.position[2] THEN
Top of flange higher than base of location wall. Flange
encroaching on location surface, cannot fit product on jar -
Loss of functionality. Advise relocate connect_wall.positon[2]
to (connect_adj_wall.position[2] - connect_wall.height).
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END_RULE;
RULE Hold_on_jar_location_relation FOR (Hold_on_jar);
IF outer_dia > (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.thickness) THEN
Flange outer diameter is larger than location wall.
Unnecessary material and weight in the product -
Significant extra cost over a production run.
Unnecessary aesthetic feature. Advise decrease
outer_dia to connect_adj_wall.inner_dia
+ 2.0*connect_adj_wall.thickness.
IF outer_dia  < (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.thickness)
THEN
Flange outer diameter is smaller than location wall.
Drastically reduced section thickness leading to
excessive structural weakness. Advise increase
outer_dia to connect_adj_wall.inner_dia +
2.0*connect_adj_wall.thickness
END_RULE;
RULE Hold_on_jar_fixing FOR (Hold_on_jar);
IF connect_wall.inner_dia < fixing_diameter THEN
Connect_wall.inner_dia is smaller than minimum
fixing diameter. Feature cannot fit around the jar.
Advise change connect_wall.inner_dia: Minimum
fixing diameter == fixing_diameter.
IF connect_wall.inner_dia > connect_adj_wall.inner_dia THEN
Connect_wall.inner_dia is larger than location
diameter. Fixing function not achieved. Advise
change connect_wall.inner_dia: Location diameter
== connect_adj_wall.inner_dia.
END_RULE;
END_ENTITY;

ENTITY Prevent_rotation
SUBTYPE OF ( PTPlus_functional_requirements_data);
adjacent_feature_type : STRING;
min_torque : dimension;
connect_rib : Spaced_ribs;
connect_wall : Flange;
connect_torsion : Break_in_torsion;
WHERE
yield : = 29.0;
rib_length : = (connect_rib.outer_dia - connect_rib.inner_dia)/2.0;
torque_distance : = connect_rib.inner_dia + (rib_length/2.0);
rib_area : = rib_length*connect_rib.width;
total_area : = rib_area*connect_rib.rib_numb;
force : = yield*total_area;
torque_calculation : = force*torque_distance;
reverse_force : = min_torque/torque_distance;
reverse_total_area : = reverse_force/yield;
reverse_rib_area : = reverse_total_area/connect_rib.rib_numb;
recom_width : = reverse_rib_area/rib_height;
recom_rib_no : = FLOOR(reverse_total_area/reverse_rib_area);
RULE Prevent_rotation_requirements_data FOR (Prevent_rotation);
Require minimum torque at which rotation
can occur (Nmm) == min_torque.
IF min_torque < connect_torsion.torsion_req THEN
min_torque smaller than torque for break_in_torsion.
Rotation of component will occur - bridges will fail by
elongation. Seal can be broken without detection. Advise
specify min_torque higher than that for break_in_torsion
function, recommended safety margin is times 2 ==
(2.0*connect_torsion.torsion_req).
IF (min_torque > connect_torsion.torsion_req) && (min_torque <
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2.0*connect_torsion.torsion_req)THEN
min_torque smaller than recommended safety margin above
torque for break_in_torsion function. Possible rotation of
component – bridges will fail by elongation. Possible non
indication of broken seal. Advise specify min_torque higher
than that for break_in_torsion function, recommended safety
margin is times 2 == (2.0*connect_torsion.torsion_req).
END_RULE;
RULE Prevent_rotation_adjacency_data FOR (Prevent_rotation):
adjacent_feature_type == Flange.
END_RULE;
RULE Prevent_rotation_position FOR (Prevent_rotation);
IF (connect_rib.position[2] + connect_rib.height) < connect_wall.position[2] THEN
Top of connect_rib not in contact with flange.
Product functionality lost. Advise relocate
connect_rib to connect_wall.position[2] –
connect_rib.height.
IF (connect_rib.position[2] + connect_rib.height) > connect_wall.position[2] THEN
Top of connect_rib is higher than underside of
flange. Possible loss of function if rib grouping
is contained in flange. Advise relocate
connect_rib.position[2] to connect_wall.position[2]
– connect_rib.height.
END_RULE;
RULE Prevent_rotation_fixing_relation FOR (Prevent_rotation);
IF connect_rib.outer_dia > (connect_wall.inner_dia + 2.0*connect_wall.width) THEN
Group outer diameter greater than that of supporting
flange. Torque not applied to lid by area of ribs not
on flange. Torque significantly reduced compared to
full contact. Unable to obtain accurate torque calculation.
Advise decrease connect_rib.outer_dia to (connect_wall.
inner_dia + 2.0*connect_wall.width)
IF connect_rib.inner_dia < connect_wall.inner_dia THEN
Group inner diameter smaller than that of supporting
flange. Torque not applied to lid by area of ribs not
on flange. Torque significantly reduced compared to
full contact. Unable to obtain accurate torque calculation.
Advise increase connect_rib.inner_dia to connect_wall.
inner_dia.
END_RULE;
RULE Prevent_rotation_torque FOR (Prevent_rotation);
IF torque_calculation < min_torque THEN
Feature cross sectional area is not large enough
to provide failure at the torque specified. Rotation
of component – bridges fail by elongation. Non –
indication of a broken seal. Advise increase connect_rib.
rib_numb to recom_rib_no or increase connect_rib.width
to reom_width.
END_RULE;
END_ENTITY;

ENTITY Cover_lid_edge
SUBTYPE OF ( PTPlus_functional_requirements_data);
adjacent_feature_type : STRING;
cover_height : dimension;
cover_dia : dimension;
connect_wall : Lip;
connect_adj_wall : Flange;
connect_taper_on_wall: Taper;
connect_taper_on_adjacent_wall: Taper;
connect_hold : Hold_in_lid;
WHERE
```

small_angle_rads : = (connect_taper_on_wall.angle/360)*2.0*3.1416;
remaining_angle : = 90 – connect_taper_on_wall.angle;
larger_angle_rads : = (remaining_angle/360)*2.0*3.1416;
taper_allowance : = ((connect_adj_wall.position[2] – connect_wall.position[2])*
SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
taper_allowance2 : = (connect_wall.height*
SINE(small_angle_adjacent_rads))/
SINE(large_angle_adjacent_rads);
outer_dia : = connect_wall.inner_dia + 2.0*connect_wall.thickness + 2.0*taper_allowance2;
RULE Cover_lid_edge_requirements_data FOR (Cover_lid_edge);
Require height of covered edge (mm) == cover_height.
Require outer diameter of the covered edge (mm) == cover_dia.
END_RULE;
RULE Cover_lid_edge_adjacency_data FOR (Cover_lid_edge):
adjacent_feature_type == Flange.
END_RULE;
RULE Cover_lid_edge_height FOR (Cover_lid_edge);
IF connect_wall.height < (cover_height + connect_adj_wall.thickness) THEN
Height smaller than height of covered edge
plus adjacent flange. Edge not fully covered
or in order to cover edge drastic thinning of
corner section is necesary, leading to severe
structural weakness, or lip and flange not in
contact – loss of product functionality. Advise
increase connect_wall.height to a minimum
of (cover_height + connect_adj_wall.thickness);
END_RULE;
RULE Cover_lid_edge_position FOR (Cover_lid_edge);
IF (connect_wall.position[2] + connect_wall.height) < (connect_adj_wall.position[2] +
connect_adj_wall.height) THEN
Top of lip is lower than adjacent flange. Drastic thinning
of section leading to severe structural weakness. Advise
relocate connect_wall.position[2] to (connect_adj_wall.
position[2] + connect_adj_wall.thickness –
connect_wall.height).
IF (connect_wall.position[2] + connect_wall.height) > (connect_adj_wall.position[2] +
connect_adj_wall.height) THEN
Top of lip is higher than adjacent flange. Cannot fit
product in lid – Loss of functionality. Possible
sealing problems between product and lid. Advise
relocate connect_wall.position[2] to (connect_adj_wall.
position[2] + connect_adj_wall.thickness –
connect_wall.height).
END_RULE;
RULE Cover_lid_edge_fixing_relation FOR (Cover_lid_edge);
IF connect_wall.inner_dia > (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width +
2.0*taper_allowance) THEN
Connect_wall.inner_dia is greater than corresponding
outer diameter of flange. Drastic thinning of section
leading to severe structural weakness or lip and flange
not in contact – Loss of product functionality. Advise
reduce connect_wall.inner_dia to a maximum of
(connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width
+ 2.0*taper_allowance).
IF connect_wall.inner_dia < (connect_adj_wall.inner_dia + 2.0*connect_adj_wall.width +
2.0*taper_allowance) THEN
Connect_wall.inner_dia is smaller than corresponding
outer diameter of flange, encroaching on flange functional
surface. Insufficient space for 'hold_in_lid' function to
occur. Problems fixing product into lid. Advise increase
connect_wall.inner_dia to (connect_adj_wall.inner_dia +

```
2.0*connect_adj_wall.width + 2.0*taper_allowance2).
IF outer_dia > connect_hold.fixing_diameter THEN
Feature outer diameter larger than maximum fixing
diameter specified for hold in lid function. Feature
cannot fit inside the lid. Advise change outer_dia:
Maximun outer_dia == (connect_hold.fixing_diameter
- 2.0*taper_allowance2).
END_RULE;
RULE Cover_lid_edge_cover FOR (Cover_lid_edge)
IF connect_wall.inner_dia < cover_dia THEN
Feature inner diameter smaller than diameter of edge to
be covered. Feature cannot fit over edge. Cover function
not achieved. Advise change connect_wall.inner_dia:
Edge diameter specified is cover_dia.
END_RULE;
END_ENTITY;

ENTITY Initial_product_definition_data
ABSTRACT SUPERTYPE OF( ONE OF(Yoghurt_pot_initial_product_definition_data,
Flower_pot_initial_product_definition_data, PTPlus_initial_product_definition_data ));
END_ENTITY;

ENTITY PTPlus_initial_product_definition_data
SUBTYPE OF (Initial_product_definition_data);
RULE Initial_product_definition FOR (PTPlus);
Initial product definition =
Locate_in_lid THEN
Break_in_torsion THEN
Locate_on_jar
END_RULE;
END_ENTITY;

ENTITY Yoghurt_pot_initial_product_definition_data
SUBTYPE OF (Initial_product_definition_data);
RULE Initial_product_definition FOR (Yoghurt_pot);
Initial product definition =
Enclose_horizontal THEN
Enclose_below
END_RULE;
END_ENTITY;

ENTITY Flower_pot_initial_product_definition_data
SUBTYPE OF (Initial_product_definition_data);
RULE Initial_product_definition FOR (Yoghurt_pot);
Initial product definition =
Enclose_horizontal THEN
Enclose_below
END_RULE;
END_ENTITY;

ENTITY Form_function_relations_data
ABSTRACT SUPERTYPE OF( ONE_OF(Yoghurt_pot_form_function_relations,
Flower_pot_form_function_relations, PTPlus_form_function_relations));
END_ENTITY;

ENTITY Yoghurt_pot_form_function_relations
SUBTYPE OF (Form_function_relations_data);
RULE Yoghurt_pot_form_function_relations FOR (Yoghurt_pot_form_function_relations);
IF functional_requirement == Enclose_horizontal THEN
choice of form == Side_wall.
IF functional_requirement == Enclose_below THEN
choice of form == Base_wall.
```

```
IF functional_requirement == Provide_seal_surface THEN
choice of form == Flange.
IF functional_requirement == Insert_destack THEN
choice of form == Base_feature or Spaced_ribs.
IF functional_requirement == Section_destack_horizontal THEN
choice of form == Flange.
IF functional_requirement == Section_destack_vertical THEN
choice of form == Lip.
END_RULE;
END_ENTITY;

ENTITY Flower_pot_form_function_relations
SUBTYPE OF (Form_function_relations_data);
RULE Flower_pot_form_function_relations FOR (Flower_pot_form_function_relations);
IF functional_requirement == Enclose_horizontal THEN
choice of form == Side_wall.
IF functional_requirement == Enclose_below THEN
choice of form == Base_wall.
IF functional_requirement == Insert_destack THEN
choice of form == Spaced_ribs.
IF functional_requirement == Section_destack_horizontal THEN
choice of form == Flange.
IF functional_requirement == Section_destack_vertical THEN
choice of form == Lip.
IF functional_requirement == Drainage THEN
choice of form == Spaced_holes.
IF functional_requirement == Drainage_clearance THEN
choice of form == Spaced_ribs or Spaced_bosses.
END_RULE;
END_ENTITY;

ENTITY PTPlus_form_function_relations
SUBTYPE OF (Form_function_relations_data);
RULE PTPlus_form_function_relations FOR (PTPlus_form_function_relations);
IF functional_requirement == Locate_in_lid THEN
choice of form == Side_wall.
IF functional_requirement == Break_in_torsion THEN
choice of form == Spaced_bosses.
IF functional_requirement == Locate_on_jar THEN
choice of form == Side_wall.
IF functional_requirement == Hold_in_lid THEN
choice of form == Flange.
IF functional_requirement == Hold_on_jar THEN
choice of form == Flange.
IF functional_requirement == Prevent_rotation THEN
choice of form == Spaced_ribs.
IF functional_requirement == Cover_lid_edge THEN
choice of form == Lip.
END_RULE;
END_ENTITY;


//FORM FEATURES.

ENTITY Form_features
ABSTRACT SUPERTYPE OF (ONE OF(Side_wall, Base_feature, Flange, Lip, Spaced_ribs,
Spaced_bosses, Base_wall, Spaced_holes));
END_ENTITY;

ENTITY Side_wall
SUBTYPE OF (Form_features);
objective1 : STRING;
```

```
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
inner_dia : dimension;
thickness : dimension;
height : dimension:
END_ENTITY;

ENTITY Base_feature
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
inner_dia : dimension;
thickness : dimension;
height : dimension:
END_ENTITY;

ENTITY Lip
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
inner_dia : dimension;
thickness : dimension;
height : dimension:
END_ENTITY;

ENTITY Flange
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
inner_dia : dimension;
width : dimension;
thickness : dimension:
END_ENTITY;

ENTITY Spaced_ribs
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING_ARRAY;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
```

```
rib_numb : integer;
inner_dia : dimension;
outer_dia : dimension;
height : dimension;
width : dimension:
END_ENTITY;

ENTITY Spaced_bosses
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING_ARRAY;
mouldability_type : STRING;
alt_mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
boss_numb : integer;
boss_dia : dimension;
axis_dia : dimension;
height : dimension;
END_ENTITY;

ENTITY Spaced_holes
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING_ARRAY;
mouldability_type : STRING;
alt_mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
hole_numb : integer;
hole_dia : dimension;
axis_dia : dimension;
depth : dimension;
END_ENTITY;

ENTITY Base_wall
SUBTYPE OF (Form_features);
objective1 : STRING;
adjacent_feature_type : STRING;
function_name : STRING;
mouldability_equivalent : STRING;
mouldability_type : STRING;
position : POINT3D;
orientation : POINT3D;
dimaeter : dimension;
thickness : dimension;
END_ENTITY;
```

Appendix 7.

Example strategist support for the build up of a yogurt pot product design.

Ron> import
Enter workstation: zipporah
Product ranges where data is available in the Product Range Model are:
1. Yoghurt pot range of products
2. Flower pot range of products
3. PTPlus range of products
Enter choice.
1

1.Create a new product (Initial product definition).
2.Modify existing product (Interactive product modification).
3.Delete a product and its mould
Enter choice.
1

Enter name of new product.
Ronan

Functional requirements:

enclose_horizontal
enclose_below
provide_seal_surface
Section_destack_horizontal
Section_destack_vertical
Insert_destack

Specify functional requirements for initial product definition:

FUNCTION – Enclose horizontal

What is the enclosed volume? (mm3)500000

What is the diameter of the enclosure? (mm)80

FUNCTION – Enclose below

What is the enclosed diameter? (mm)70

This diameter specification is smaller than that for adjacent 'Enclose horizontal' function

Consequences:
1. If form matches specification, enclosure not achieved, product functionality lost

Remedial options:
1. Increase diameter specification to a minimum of 80 mm
– No further options
Change specification? y/ny

Enter new specification:80

FUNCTION:enclose_horizontal

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE– SIDE_WALL: Ronan_Fsid_w0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 10

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:80

Specify side_wall thickness:2

Specify side_wall height:70

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT – enclose_horizontal function:

Inner diameter satisfactory for enclose horizontal function

Present wall dimensions mean that the enclosed volume is lower than that specified
Specified volume: 500000 mm3

Consequences:
Enclose horizontal function specification not achieved

Remedial options:
1. Increase inner diameter to: 93 mm
NOTE: Enclose horizontal specification for inner diameter: 80 mm
2. Increase wall height to: 94.5 mm
– No further options
Change feature inner diameter? y/nn

Present diameter recorded
Change height?y/ny

New height: 94.5

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall0
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees0.8

Taper angle ok
Do you wish to create a new gate on this wall?y/nn

FUNCTION:enclose_below

Forms available for use:
1.base_wall
No more forms available.

FORM FEATURE– BASE_WALL: Ronan_Fbs_wl0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (centre of base):0 0 8

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify base_wall diameter:84

Specify base_wall thickness:3

FORM FEATURE Ronan_Fbs_wl0
FUNCTIONALITY ASSESSMENT – enclose_below function:

Top of base wall is higher than the base of horizontal enclosure wall

Consequences:
1. Base wall encroaching on 'Enclose horizontal' surface– Loss of functionality

Remedial options:
1. Lower base wall to z position 7

–No further options

Reposition the feature? y/ny

New feature position: 0 0 7
Diameter satisfactory for enclose below specification
Feature outer diameter satisfactory for enclose below function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall1
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness is not the same as adjacent wall

Possible consequences:
1. Feeding problems if a thick section is fed by a thin section
2. Stress concentrations at abrupt section changes
3. Abrupt section changes can interfere with the flow of material in the mould causing surface defects
4. Component warpage

Remedial options:
1. Make wall thickness the same or near to that of adjacent wall (2)
2. If the difference in thickness must remain make sure the change is not abrupt

–No further options

Change wall thickness? y/ny

Enter new wall thickness (mm):2.0

New thickness ok

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on wall Ronan_Mwall1
Enter inside radius:
Recommended inside radius is between 0.8 and 1.2 mm
0.5 mm is the recommended minimum radius.8

Inside blend radius ok

Enter outside radius:
Recommended outside radius is 2.8 mm2.7

This blend radius is less than 2.8 causing thickening corner section

Possible consequences:
1. Shrinkage marks or surface depressions in the corner
2. Widening of the corner angle
3. Curvature of the wall sections either side of the corner

Remedial options:
1. Increase blend radius to 2.8

–No further options

Increase the blend radius?y/ny

Enter new blend radius:2.8

New radius recorded

Do you wish to create a new gate on this wall?y/nn

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re–analysis of functional features in the given order before proceeding:

0. Ronan_Fsid_w0
1. Ronan_Fbs_wl0

Select modification/re–analysis option on main menu

ENTER 'c' to continue:c

INITIAL PRODUCT DEFINITION PHASE COMPLETE FOR PRODUCT: Ronan

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session2

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fsid_w0

Type: side_wall

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT – enclose_horizontal function:

Inner diameter satisfactory for enclose horizontal function
Enclosed volume satisfactory for enclose horizontal function

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall thickness relative to adjacent wall ok

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fbs_wl0

FORM FEATURE Ronan_Fbs_wl0
FUNCTIONALITY ASSESSMENT – enclose_below function:

Top of base wall is not in contact with base of horizontal enclosure wall

Consequences:
1. Product functionality lost

Remedial options:
1. Relocate base wall to z position 8

-No further options

Reposition the feature? y/ny

New feature position: 0 0 8
Diameter satisfactory for enclose below specification
Feature outer diameter satisfactory for enclose below function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall thickness relative to adjacent wall ok

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:4

Returning to main menu

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session5

Session terminated.Ron>

Appendix 8.

Example strategist support for the build up of a PTPlus product design.

Ron> import

Enter workstation: zipporah

Product ranges where data is available in the Product model are:
1. Yoghurt pot range of products
2. Flower pot range of products
3. PTPlus range of products
Enter choice.
3

1.Create a new product (Initial product definition).
2.Modify existing product (Interactive product modification).
3.Delete a product and its mould
Enter choice.
1

Enter name of new product.
Ronan

Functional requirements:

locate_in_lid
locate_on_jar
break_in_torsion
hold_in_lid
hold_on_jar
prevent_rotation
cover_lid_edge

Specify functional requirements for initial product definition:

FUNCTION – locate_in_lid

What is the inner diameter of the metal lid? (mm)52.44

Note: location surface contains flange for 'hold_in_lid' function as well as mating with inside lid surface
What is the height of the location surface? (mm)3

FUNCTION – break_in_torsion

What is the breakage torsion required? (Nmm)1220

FUNCTION – locate_on_jar

What is the outer diameter of the jar neck? (mm)50.08

What is the height of the location surface? (mm)3.5

FUNCTION:locate_in_lid

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE– SIDE_WALL: Ronan_Fsid_w0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 10

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

specify inner diameter:50.44

specify side_wall thickness:1.3

specify side_wall height:2

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT– locate_in_lid function:

Feature height is smaller than the height of the lid location surface
The location surface height is 3 mm.

Consequence:
The location surface is under utilised
Possible problems with 'hold_in_lid' function
Change feature height?y/ny

Enter new height:3

Feature position is currently: 0 0 10
Do you wish to adjust the position for the new location?y/nn

Feature outer diameter is greater than the inside diameter of the lid
The location diameter is 52.44 mm.

Consequence:
This is an interference fit
Change feature diameter?y/ny

New outer diameter: 52.44

To maintain constant inner diameter new thickness should be: 1
Do you wish to adjust the thickness?y/ny

New thickness: 1

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall0
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok
Do you wish to create a new gate on this wall?y/ny

Creating gate on wall Ronan_Mwall0
Feeding distance: 82.4272

Enter gate position X Y Z26.22 0 12

Feeding distance ok

This product is tubular:

Possible choices of gate type:
1. Rectangular edge gate
2. Pin gate
3. Diaphram gate
4. Ring gate

Enter choice:1

Gate type is rectangular edge gate

FUNCTION:break_in_torsion

Forms available for use:
1.spaced_bosses
No more forms available.

FORM FEATURE- SPACED_BOSSES: Ronan_Fsp_bs0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of group central axis):0 0 9.75

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify number of bosses:5

Specify boss diameters:.17

Specify diameter between boss axes:52

Specify bosses height:.25

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT- break_in_torsion function:

Torque specification: 1220
Feature position satisfactory for break in torsion function
Group diameter satisfactory for break in torsion function
Torque calculation2013.45

Feature cross sectional area is too large to provide failure
at the torque specified

Possible consequences:
1. Difficulty in removing the lid from the jar

Remedial options:
1. Decrease the number of bosses
2. Decrease the diameter of the bosses

Recommended number of bosses: 3
Necessary boss diameter at present numbers: 0.103007

-No further options

Decrease the number of bosses? y/ny

Enter number of bosses:3

Recommended boss diameter: 0.171679

Change the diameter of bosses? y/nn

Present diameter recorded
New torque = 1208.07 Nm

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos0

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos1

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos2

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

FUNCTION:locate_on_jar

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE- SIDE_WALL: Ronan_Fsid_w1

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 6.25

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:50.08

Specify side_wall thickness:1

Specify side_wall height:3.5

FORM FEATURE Ronan_Fsid_w1
FUNCTIONALITY ASSESSMENT- locate_on_jar function:

Feature height satisfactory for locate on jar function
Feature position satisfactory for locate on jar function

Wall outer diameter is less than that of adjacent boss grouping

Consequences:
1. Breakage torsion is drastically reduced from that intended and cannot be estimated

Remedial options:
1. Increase wall diameter to be in full contact with the boss grouping

Maximum outer wall diameter for full contact: 53.83
Minimum outer wall diameter for full contact: 52.17

-No further options

Increase the outer diameter? y/ny

Enter new outer diameter:52.18

To maintain constant inner diameter new thickness should be: 1.05
Do you wish to adjust the thickness? y/nn

Feature inner diameter is greater than the neck diameter of the jar
The location diameter is 50.08 mm.

Consequence:
An insert of some kind is required
Change feature diameter?y/ny

New inner diameter: 50.08

To maintain constant outer diameter new thickness should be: 1.05
Do you wish to adjust the thickness?y/ny

New thickness: 1.05

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall features require a taper

Consequences of non-inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall1
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness is not the same as adjacent wall

Possible consequences:
1. Feeding problems if a thick section is fed by a thin section
2. Stress concentrations at abrupt section changes
3. Abrupt section changes can interfere with the flow of material in the mould causing surface defects
4. Component warpage

Remedial options:
1. Make wall thickness the same or near to that of adjacent wall (1)
2. If the difference in thickness must remain make sure the change is not abrupt

-No further options

Change wall thickness? y/nn

Present thickness recorded

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

Do you wish to create a new gate on this wall?y/nn

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re-analysis of functional features in the given order before proceeding:

0. Ronan_Fsid_w0
1. Ronan_Fsp_bs0
2. Ronan_Fsid_w1

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

INITIAL PRODUCT DEFINITION PHASE COMPLETE FOR PRODUCT: Ronan

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session2

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fsid_w0

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT- locate_in_lid function:

Feature height satisfactory for locate in lid function

Feature outer diameter is greater than the inside diameter of the lid
The location diameter is 52.44 mm.

Consequence:
This is an interference fit
Change feature diameter?y/ny

New outer diameter: 52.44

To maintain constant inner diameter new thickness should be: 0.979055
Do you wish to adjust the thickness?y/nn

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall thickness relative to adjacent wall ok

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fsp_bs0

Type: spaced_bosses

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT– break_in_torsion function:

Torque specification: 1220
Feature position satisfactory for break in torsion function
Group diameter satisfactory for break in torsion function
Torque calculation1208.07
Torque at failure satisfactory for break in torsion function

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos0

Solid boss orientation ok

Solid boss height ok

Solid boss width ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos1

Solid boss orientation ok

Solid boss height ok

Solid boss width ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos2

Solid boss orientation ok

Solid boss height ok

Solid boss width ok

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fsid_w1

Type: side_wall

FORM FEATURE Ronan_Fsid_w1
FUNCTIONALITY ASSESSMENT– locate_on_jar function:

Feature height satisfactory for locate on jar function
Feature position satisfactory for locate on jar function
Feature in full contact with boss grouping – satisfactory support for break in torsion function
Feature diameter satisfactory for locate on jar function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall thickness is not the same as adjacent wall

Possible consequences:
1. Feeding problems if a thick section is fed by a thin section
2. Stress concentrations at abrupt section changes
3. Abrupt section changes can interfere with the flow of material in the mould causing surface defects
4. Component warpage

Remedial options:
1. Make wall thickness the same or near to that of adjacent wall (1)
2. If the difference in thickness must remain make sure the change is not abrupt

–No further options

Change wall thickness? y/nn

Present thickness recorded

1. Change a functional feature.
2. Re–run functional analysis.
3. Re–run mouldability analysis.
4. Return to previous menu.

Enter choice:4

Returning to main menu

1. Go on to Interactive product Modification design phase
2. Modification/re–analysis of existing forms
3. Display options
4. Go on to mould design
5. End session1

Functional requirements:
1. hold_in_lid
2. hold_on_jar
3. prevent_rotation
4. cover_lid_edge
Select a product function.1

FUNCTION – hold_in_lid

What is the maximum fixing diameter, ie diameter inside lid? (mm)54.8

FUNCTION:hold_in_lid

Forms available for use:
1.flange
No more forms available.

FORM FEATURE– FLANGE: Ronan_Fflang0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of axis of rotation):0 0 12

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:53

Specify flange width:.5

Specify flange thickness:1

FORM FEATURE Ronan_Fflang0
FUNCTIONALITY ASSESSMENT– hold_in_lid function:

Feature position satisfactory for hold in lid function

Flange inner diameter is larger than corresponding outer diameter of location wall

Possible consequences:
1. Drastically reduced section thickness leading to excessive structural weakness
2. Flange and location wall not in contact– Product functionality lost

Remedial options:
1. Decrease inner diameter to a maximum of 52.454
Note: minimum diameter to retain product functionality: 50.4819
Change feature diameter?y/ny

Enter new inner diameter:52.44

To maintain constant outer diameter new thickness should be:0.78
Do you wish to adjust the thickness?y/nn

Feature outer diameter satisfactory for hold in lid function

MOULDABILITY WALL FEATURE: Ronan_Mwall2

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall2
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness relative to adjacent wall ok

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on wall Ronan_Mwall2
Enter inside radius:
Recommended inside radius is between 0.5 and 0.6 mm
0.5 mm is the recommended minimum radius.5

Inside blend radius ok

Enter outside radius:
Recommended outside radius is 1.5 mm1.5

Outside blend radius ok

Do you wish to create a new gate on this wall?y/nn

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re-analysis of functional features in the given order before proceeding:

1. Ronan_Fflang0

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session5

Session terminated.Ron>

Appendix 9.

Example strategist support for the build up of a flower pot product design.

Product ranges where data is available in the Product model are:
1. Yoghurt pot range of products
2. Flower pot range of products
3. PTPlus range of products
Enter choice.
2

1.Create a new product (Initial product definition).
2.Modify existing product (Interactive product modification).
3.Delete a product and its mould
Enter choice.
2

Enter name of existing product.
Ronan

Functional requirements:
1. insert_destack
2. section_destack_horizontal
3. section_destack_vertical
4. drainage
5. drainage_clearance
Select a product function.5

FUNCTION – Drainage_clearance

What is the drainage clearance height (mm)1.5

SAME FORM:'Drainage_clearance' and 'Insert_destack' functions can be performed using the same form on flower pot type products:

Do you wish to use same form for 'Insert_destack' function?y/ny

NOTE: For 'Drainage_clearance' the feature MUST be below the base wall
Do you still wish to use the same form for 'Insert_destack'? y/ny

FUNCTION – Insert_destack

NOTE: Using 'insert_destack' function:
1. 'Section_destack_horizontal' function – no longer required.
2. 'Section_destack_vertical' function – no longer required.

What is the required protruding height of each (stacked) product? (mm)3

FUNCTION:drainage_clearance

Forms available for use:
1.spaced_bosses
2.spaced_ribs

Select form.1

FORM FEATURE– SPACED_BOSSES: Ronan_Fsp_bs0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of group central axis):0 0 3

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify number of bosses:3

Specify boss diameters:2

Specify diameter between boss axes:70

Specify bosses height:4

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT– drainage_clearance function:

Position of boss grouping satisfactory for 'drainage_clearance' function

Boss height is higher than specified to achieve 'drainage_clearance' function

Consequences:
1. Drainage clearance is greater than specified – unecessary material in product

Remedial options:
1. Reposition feature to z position 5.5
Change position? y/nn

Present height recorded

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT– insert_destack function:

Position of boss grouping satisfactory for insert destack function

Boss height is higher than specified to achieve 'insert_destack' function

Consequences:
1. Destack height is greater than specified – unecessary material in product

Remedial options:
1. Reposition feature to z position 4
Change position? y/ny

New position: 0 0 4

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos0

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on solid boss Ronan_Msbos0
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5.0

Taper angle ok

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos0
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos1

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on solid boss Ronan_Msbos1
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5.0

Taper angle ok

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos1
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos2

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on solid boss Ronan_Msbos2
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5.0

Taper angle ok

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos2
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re–analysis of functional features in the given order before proceeding:

1. Ronan_Fsp_bs0

Select modification/re–analysis option on main menu

ENTER 'c' to continue:c

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session

Appendix 10.

Example strategist support for the build up of a flower pot product and mould design.

Ron> import

Enter workstation: zipporah

Product ranges where data is available in the Product Range Model are:
1. Yoghurt pot range of products
2. Flower pot range of products
3. PTPlus range of products
Enter choice.
2

1.Create a new product (Initial product definition).
2.Modify existing product (Interactive product modification).
3.Delete a product and its mould
Enter choice.
1

Enter name of new product.
Ronan

Functional requirements:

enclose_horizontal
enclose_below
Section_destack_horizontal
Section_destack_vertical
Insert_destack
Drainage
Drainage_clearance

Specify functional requirements for initial product definition:

FUNCTION – Enclose horizontal

What is the enclosed volume? (mm3)77000

What is the diameter of the enclosure? (mm)70

FUNCTION – Enclose below

What is the enclosed diameter? (mm)70

FUNCTION:enclose_horizontal

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE– SIDE_WALL: Ronan_Fsid_w0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 12

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:70

Specify side_wall thickness:2

Specify side_wall height:20

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT – enclose_horizontal function:

Inner diameter satisfactory for enclose horizontal function
Enclosed volume satisfactory for enclose horizontal function

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall0
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok
Do you wish to create a new gate on this wall?y/nn

FUNCTION:enclose_below

Forms available for use:
1.base_wall
No more forms available.

FORM FEATURE– BASE_WALL: Ronan_Fbs_wl0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (centre of base):0 0 10

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify base_wall diameter:74

Specify base_wall thickness:2

FORM FEATURE Ronan_Fbs_wl0
FUNCTIONALITY ASSESSMENT – enclose_below function:

Feature position satisfactory for enclose below function
Diameter satisfactory for enclose below specification
Feature outer diameter satisfactory for enclose below function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall1
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness relative to adjacent wall ok

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on wall Ronan_Mwall1
Enter inside radius:
Recommended inside radius is between 0.8 and 1.2 mm
0.5 mm is the recommended minimum radius.8

Inside blend radius ok

Enter outside radius:
Recommended outside radius is 2.8 mm2.8

Outside blend radius ok

Do you wish to create a new gate on this wall?y/ny

Creating gate on wall Ronan_Mwall1

Enter gate position X Y Z0 0 10

Feeding distance ok

This product is thin walled (thickness < 4mm) and rotational:

Possible choices of gate type:
1. Rectangular edge gate
2. Pin gate
3. Sprue gate

Enter choice:3

Gate type is sprue gate

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re–analysis of functional features in the given order before proceeding:

0. Ronan_Fsid_w0
1. Ronan_Fbs_wl0

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

INITIAL PRODUCT DEFINITION PHASE COMPLETE FOR PRODUCT: Ronan

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 0

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session1

Functional requirements:
1. insert_destack
2. section_destack_horizontal
3. section_destack_vertical
4. drainage
5. drainage_clearance
Select a product function.4

FUNCTION – Drainage

What is the drainage area (mm2)151

FUNCTION:drainage

Forms available for use:
1.spaced_holes
No more forms available.

FORM FEATURE– SPACED_HOLES: Ronan_Fsp_hl0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of group central axis):0 0 9.75

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify number of holes:3

Specify hole diameters:8

Specify diameter between hole axes:35

Specify depth of holes:4

FORM FEATURE Ronan_Fsp_hl0
FUNCTIONALITY ASSESSMENT– drainage function:

Hole group position satisfactory for drainage function
Hole depth satisfactory for drainage function
Drainage area calculation : 150.797
Hole diameter satisfactory for drainage function

MOULDABILITY HOLE FEATURE: Ronan_Mhole0

Hole orientation ok

Hole features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on hole Ronan_Mhole0
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

hole to hole distance ok

Hole to side wall distance ok

Hole depth ok – This is a through hole

MOULDABILITY HOLE FEATURE: Ronan_Mhole1

Hole orientation ok

Hole features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on hole Ronan_Mhole1
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

hole to hole distance ok

Hole to side wall distance ok

Hole depth ok – This is a through hole

MOULDABILITY HOLE FEATURE: Ronan_Mhole2

Hole orientation ok

Hole features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on hole Ronan_Mhole2
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

hole to hole distance ok

Hole to side wall distance ok

Hole depth ok – This is a through hole

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re–analysis of functional features in the given order before proceeding:

1. Ronan_Fsp_hl0

Select modification/re–analysis option on main menu

ENTER 'c' to continue:c

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session1

Functional requirements:
1. insert_destack
2. section_destack_horizontal
3. section_destack_vertical
4. drainage
5. drainage_clearance
Select a product function.5

FUNCTION – Drainage_clearance

What is the drainage clearance height (mm)1.5

SAME FORM:'Drainage_clearance' and 'Insert_destack' functions can be performed using the same form on flower pot type products:

Do you wish to use same form for 'Insert_destack' function?y/nn

FUNCTION:drainage_clearance

Forms available for use:
1.spaced_ribs
2.spaced_bosses

Select form.2

FORM FEATURE– SPACED_BOSSES: Ronan_Fsp_bs0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of group central axis):0 0 8.5

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify number of bosses:3

Specify boss diameters:1.5

Specify diameter between boss axes:50

Specify bosses height:1.5

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT– drainage_clearance function:

Position of boss grouping satisfactory for drainage_clearance function
Height satisfactory for drainage_clearance function
Found drain clear
UPDATE

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos0

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper? y/ny

Creating taper on solid boss Ronan_Msbos0
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

Solid boss height ok

Solid boss width is too large

Possible consequences:
1. Sink marks opposite the solid boss
2. Component warpage

Remedial options:
1. Reduce solid boss width to a maximum of: 1.33333

–No further options

Change solid boss width? y/ny

Enter new solid boss width (mm):1.3

New width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos0
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos1

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on solid boss Ronan_Msbos1
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos1
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos2

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on solid boss Ronan_Msbos2
Enter taper angle:
Recommended minimum draft angle = 5.0 degrees5

Taper angle ok

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on solid boss Ronan_Msbos2
Enter blend radius:
Recommended minimum radius = 0.5 mm.5

Blend radius ok

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re-analysis of functional features in the given order before proceeding:

1. Ronan_Fsp_bs0

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 0

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session4

WARNING: Dimensional changes to cavity/core elements and application of tapers during mould design will result in dimensional changes and creation of tapers on corresponding product features

As a consequence of the above, functional relationships within the product may be invalidated

Re-analysis of all functional features in the product must be undertaken in original order of creation

Are you sure you want to go on to mould design?y/ny

Parting line is at 32 mm in the z plane
Making part_line

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl0 taper has angle 0.8

Volume diameter ok

Blend has inner 0.8 and outer 2.8

Radius for blend= 2.8
Making blend

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

Core parting line is at 32 mm in the z plane
Making part_line

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl0

taper has angle 0.8

Volume diameter ok

Blend has inner 0.8 and outer 2.8

Radius for blend= 0.8

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

No hollow boss features found for conversion to cavity/core representation

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl0

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

Creating cavity hole

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl1

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

Creating cavity hole

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl2

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

No rib features found for conversion to cavity/core representation

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs0

Blend has radius 0.5

taper has angle 5

Angle for taper= 5

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs1

Blend has radius 0.5

taper has angle 5

Angle for taper= 5

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs2

Blend has radius 0.5

taper has angle 5

Angle for taper= 5

Do you wish to change the gated wall? y/nn

CREATING FEEDING SYSTEM:

In order to design the feeding system it is necessary to first identify some parameters of the cooling system:

CAVITY COOLING SYSTEM: Ronan_CS

Number of cooling layers using 7 mm flow ways: 1

Number of cooling layers using 8 mm flow ways: 1

Number of cooling layers using 9 mm flow ways: 1

Number of cooling layers using 10 mm flow ways: 1

Choice of cooling tube diameter for cavity cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Lower than 7 mm – insufficient cooling effect – difficulty drilling deep holes

Higher than 10mm – high volume of water to be pumped around the mould for cooling

Maximum cooling effect for Ronan_CS cavity dimensions: 10 mm diameter

Enter choice (1–4):4

CREATING FEEDING SYSTEM:

FEEDING SYSTEM – SPRUE GATE:Ronan_FSsprue_g0

Gate position ok

Moulding machine nozzle inner diameter is 3mm

Gate diameter should be slightly larger then nozzle to allow for misalignment

Lower gate diameter has been calculated as 3.1 mm
Do you wish to change the diameter?y/nn

Sprue length has been calculated as 29 mm

This allows the minimum cavity block depth (below cavity) to avoid mould distorsion, and allows space for the cavity cooling system
Do you wish to change the sprue length?y/nn

Enter gate taper angle:
Recommended minimum angle = 4.0 degrees (minimum recommended)4

Taper angle ok

CREATING CAVITY COOLING SYSTEM:

CAVITY COOLING SYSTEM:Ronan_CS

Choice of cooling system configurations for mould cavity:
1. paired tube configuration
2. U tube configuration

U tube configuration is not recommended when using sprue gate:

– Cooling flow ways on three sides can cause uneven cooling of the moulding

Possible consequences:
1. Differential section thickness over the moulding
2. Differential shrinkage causing component warping

Remedial options:
1. Used paired tube configuration

–No further options

Enter choice:1

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: pair

Vertical coordinate: 11 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: pair

Vertical coordinate: 11 mm
Making standard flow way

In order to calculate remaining cavity cooling system parameters it is necessary to establish cavity block dimensions:

CREATING CAVITY BLOCK FOR: Ronan_CAV

INTEGER CAVITY RECTANGULAR MOULD BLOCK :Ronan_CAVitcv_rbl0

Cavity block position: 0 0 –19

Depth of cavity block: 48.6 mm

Choice of standard guide pin diameters:
1. 10 mm
2. 13 mm
3. 16 mm
4. 19 mm
5. 22 mm
6. 25 mm
7. 32 mm
8. 38 mm

Recommendation: Use smallest suitable guide pin diameter to minimise size and weight of mould assembly

Recommended size for current mould parameters: 3. 16 mm

Enter choice:(1–8):3

Guide pin diameter is 16 mm

Cavity block length: 178.659 mm

Cavity block width: 222 mm

INTEGER CAVITY CIRCULAR LAND:Ronan_CAVitcv_crl0

Circular land position: 0 0 29.6

Circular land depth:2.4 mm

Circular land diameter:84.5584 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf0

Periferal land position: 57.3296 57.3296 29.6

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf1

Periferal land position: –57.3296 57.3296 29.6

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf2

Periferal land position: 57.3296 –57.3296 29.6

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf3

Periferal land position: –57.3296 –57.3296 29.6

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

COMPLETING CAVITY COOLING SYSTEM:

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Standard flow way position: –89.3296 57.9999 11

Standard flow way length: 178.659 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Standard flow way position: -89.3296 -57.9999 11

Standard flow way length: 178.659 mm

CREATING CORE COOLING SYSTEM:

CORE COOLING SYSTEM:Ronan_CS

Number of standard flow ways using 7 mm flow ways: 3

Number of standard flow ways using 8 mm flow ways: 3

Number of standard flow ways using 9 mm flow ways: 3

Number of standard flow ways using 10 mm flow ways: 3

Choice of cooling tube diameter for shallow core cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Maximum cooling effect for Ronan_CS core dimensions: 10 mm diameter

Enter choice (1-4):4

Choice of cooling system configurations for shallow mould core at diameter 10 mm:

1. Z_tube configuration

2. single tube configuration

Using Z tube configuration 'Cooler' water entering the mould at the gated end provides uneven cooling of the moulding

Possible consequences:
1. Differential section thickness over the moulding
2. Differential shrinkage causing component warping

Recommendation – Use single tube configuration

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Position: -89.3296 -26 53

Length: 178.659 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: single
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w3

Position: -89.3296 0 53

Length: 178.659 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: single
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w4

Position: -89.3296 26 53

Length: 178.659 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: single
Making standard flow way

INTEGER CORE RECTANGULAR BLOCK: Ronan_CORitcr_rbl0

Core block position: 0 0 34.4

length: 178.659 mm

width: 222 mm

depth: 47 mm

guide_pin_diameter: 16 mm

INTEGER CORE CIRCULAR LAND :Ronan_CORitcr_crl0

Circular land position: 0 0 32

Circular land depth:2.4 mm

Circular land diameter:84.5584 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf0

Periferal land position: 57.3296 57.3296 32

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf1

Periferal land position: -57.3296 57.3296 32

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf2

Periferal land position: 57.3296 -57.3296 32

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf3

Periferal land position: -57.3296 -57.3296 32

Periferal land depth:2.4 mm

Periferal land diameter:15.3297 mm

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:3

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:4

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:6

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session2

WARNING:Re-analysis of features other than as advised by the strategist can invalidate functional relationships within the product :-

Re-analysis of all functional features in the product must be undertaken in the original order of creation

1. Change a functional feature.
2. Re-run functional analysis.
3. Re-run mouldability analysis.
4. Return to previous menu.

Enter choice:1

Enter feature name and type:

Name: Ronan_Fsid_w0

Type: side_wall

Do you wish to see feature dimensioning instructions?y/nn

Do you wish to change the feature position?y/nn

Do you wish to change the feature orientation?y/nn

Do you wish to change the feature inner diameter?y/ny

Specify inner diameter:56

Do you wish to change the feature thickness?y/nn

Do you wish to change the feature height?y/ny

Specify side_wall height:31

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT – enclose_horizontal function:

Present wall dimensions mean that the enclosed diameter is lower than that specified
Specified diameter: 70 mm

Consequences:
Enclose horizontal function specification not achieved

Remedial options:
1. Increase inner diameter to 70 mm– No further options
Change feature inner diameter? y/nn

Present diameter recorded
Enclosed volume satisfactory for enclose horizontal function

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall thickness relative to adjacent wall ok

1. Change a functional feature.
2. Re–run functional analysis.
3. Re–run mouldability analysis.
4. Return to previous menu.

Enter choice: 1

Enter feature name and type:

Name: Ronan_Fbs_wl0

Type: base_wall

Do you wish to see feature dimensioning instructions?y/nn

Do you wish to change the feature position?y/nn

Do you wish to change the feature orientation?y/nn

Do you wish to change the feature diameter?y/ny

Specify diameter:60

Do you wish to change the feature thickness?y/nn

FORM FEATURE Ronan_Fbs_wl0
FUNCTIONALITY ASSESSMENT – enclose_below function:

Feature position satisfactory for enclose below function
Base wall diameter is smaller than that specified for the 'Enclose below' function

Consequences:
1. Enclosure not achieved, product functionality lost

Remedial options:
1. Increase diameter to a minimum of 70 mm
– No further options
Change diameter? y/nn

Feature outer diameter satisfactory for enclose below function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall thickness relative to adjacent wall ok

1. Change a functional feature.
2. Re–run functional analysis.
3. Re–run mouldability analysis.
4. Return to previous menu.

Enter choice:4

Returning to main menu

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:6

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session4

WARNING: Dimensional changes to cavity/core elements and application of tapers during mould design will result in dimensional changes and creation of tapers on corresponding product features

As a consequence of the above, functional relationships within the product may be invalidated

Re–analysis of all functional features in the product must be undertaken in original order of creation

Are you sure you want to go on to mould design?y/ny

Parting line is at 43 mm in the z plane
Making part_line

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl0

taper has angle 0.8

Volume diameter ok

Blend has inner 0.8 and outer 2.8

Radius for blend= 2.8

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

Core parting line is at 43 mm in the z plane
Making part_line

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl0

taper has angle 0.8

Volume diameter ok

Blend has inner 0.8 and outer 2.8

Radius for blend= 0.8

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

No hollow boss features found for conversion to cavity/core representation

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl0

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

Angle for taper= 5
Making taper

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl1

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

Angle for taper= 5
Making taper

INTEGER CAVITY HOLE FEATURE: Ronan_CAVitcv_hl2

Blend has radius 0.5

taper has angle 5

Radius for blend= 0.5
Making blend

Angle for taper= 5
Making taper

No rib features found for conversion to cavity/core representation

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs0

Blend has radius 0.5

taper has angle 5

Angle for taper= 5
Making taper

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs1

Blend has radius 0.5

taper has angle 5

Angle for taper= 5
Making taper

Creating core boss and cavity hole

INTEGER CORE BOSS FEATURE: Ronan_CORitcr_bs2

Blend has radius 0.5

taper has angle 5

Angle for taper= 5
Making taper

Do you wish to change the gated wall? y/ny

Please indicate which wall you wish to gate:
0. Ronan_Mwall1
1. Ronan_Mwall0

Enter choice:1

Enter gate position X Y Z30 0 43

Feeding distance ok

This product is thin walled (thickness < 4mm) and rotational:

Possible choices of gate type:
1. Rectangular edge gate
2. Pin gate
3. Sprue gate

Enter choice:1

Gate type is rectangular edge gate

CREATING FEEDING SYSTEM:

In order to design the feeding system it is necessary to first identify some parameters of the cooling system:

CAVITY COOLING SYSTEM: Ronan_CS

Number of cooling layers using 7 mm flow ways: 1

Number of cooling layers using 8 mm flow ways: 1

Number of cooling layers using 9 mm flow ways: 1

Number of cooling layers using 10 mm flow ways: 1

Choice of cooling tube diameter for cavity cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Lower than 7 mm – insufficient cooling effect – difficulty drilling deep holes

Higher than 10mm – high volume of water to be pumped around the mould for cooling

Maximum cooling effect for Ronan_CS cavity dimensions: 10 mm diameter

Enter choice (1–4):4

CREATING FEEDING SYSTEM:

FEEDING SYSTEM – RECTANGULAR EDGE GATE:Ronan_FSrcted_g0

WARNING: Application of tapers on Ronan_Mwall0 for manufacturing reasons has increased the width of the cavity opening at the parting line by 0.865742 mm

Consequences:
1. Edge gate position no longer on edge of cavity:
– Reduced land length– weakness in mould construction can lead to wear or failure

Remedial options:
1. Adjust gate position

– No further options
Do you wish to adjust the gate position? y/ny

New gate postion: 30.4329 0 43

Gate position ok

Gate land length:

Land length should be as small as possible and in any case between 0.5 and 0.75 mm
Enter land length.5

Land length ok

Gate depth:

Gate depth has been calculated as 1.4 mm
Do you wish to change the depth?y/nn

Gate width:

Gate width has been calculated as 2.21946 mm
Do you wish to change the width?y/nn

FEEDING SYSTEM – CIRCULAR RUNNER:Ronan_FScirc_r0

Runner length:

Runner length has been calculated as 20.0671 mm

This calculation is based on minimum distance between cavity and main sprue
Do you wish to change the length?y/nn

Runner diameter:

Runner diameter has been calculated as 2 mm

This calculation is based on minimum diameter to ensure cavity is filled before plastic in runner solidifies
Do you wish to change the diameter?y/nn

FEEDING SYSTEM – MAIN FEEDING SPRUE:Ronan_FSmain_s0

Main sprue position: 50.9999 0 48
Enter main sprue taper angle:
Recommended minimum angle = 4.0 degrees (minimum recommended)4

Taper angle ok

Lower diameter of sprue = 3.1 mm to match machine nozzle diameter of 3 mm

No nozzle recess required

Sprue length has been calculated as 60 mm

This allows the minimum cavity block depth (below cavity) to avoid mould distorsion, and allows space for the cavity cooling system.
Note: 5 mm of the sprue length is to create a sprue puller in the core block
Do you wish to change the sprue length?y/nn

CREATING CAVITY COOLING SYSTEM:

CAVITY COOLING SYSTEM:Ronan_CS

Choice of cooling system configurations for mould cavity:
1. paired tube configuration
2. U tube configuration

U tube configuration recommended when using single rectangular edge gate:

Bottom of the U cooling the gated side provides more even cooling of the moulding, can reduce cycle time.

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: 22 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: 22 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Diameter: 10 mm

Orientation: 1.5708

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: 22 mm
Making standard flow way

In order to calculate remaining cavity cooling system parameters it is necessary to establish cavity block dimensions:

CREATING CAVITY BLOCK FOR: Ronan_CAV

INTEGER CAVITY RECTANGULAR MOULD BLOCK :Ronan_CAVitcv_rbl0

Cavity block position: 0 0 –12

Depth of cavity block: 52.6 mm

Choice of standard guide pin diameters:
1. 10 mm
2. 13 mm
3. 16 mm
4. 19 mm
5. 22 mm
6. 25 mm
7. 32 mm
8. 38 mm

Single rectangular edge gate causes unbalanced forces in the mould, tending to open the mould on one side

Possible consequences:
1. Larger wall section thickness one one side of the mould than on the other

Remedial options
Use guide pin size one larger than that recommended to ensure alignment of mould halves

-No further options

Recommended size for current mould parameters: 3. 16 mm

This product has a single rectangular edge gate – USE NEXT SIZE UP

Enter choice:(1–8):3

Guide pin diameter is 16 mm

Cavity block length: 186 mm

Cavity block width: 208 mm

INTEGER CAVITY RECTANGULAR LAND: Ronan_CAVitcv_rcl0

Rectangular land position: 0 0 40.6

Rectangular land depth:2.4 mm

Rectangular land length: 122.866 mm

Rectangular land width: 70.8656 mm

COMPLETING CAVITY COOLING SYSTEM:

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Standard flow way position: -92.9999 50.9999 22

Standard flow way length: 175 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Standard flow way position: -92.9999 -50.9999 22

Standard flow way length: 175 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Standard flow way position: 76.9999 -104 22

Standard flow way length: 160 mm
LOWEST DIAMETER FOR CORE =:52.9999

CREATING CORE COOLING SYSTEM:

CORE COOLING SYSTEM:Ronan_CS

Choice of cooling system configurations for deep mould core:

1. Baffled straight hole system –
Large cooling capacity, easy to manufacture.

2. Angled hole system –
Does not work for the deepest cores, hard to manufacture due to angled holes, small cooling capacity compared to baffle system.

3. Stepped circuit system –
Holes drilled through core into cavity, requiring plugging and finishing, small cooling capacity compared to baffle system.

Use baffle system for deep core:

Number of baffle flow ways using 12 mm flow ways: 1

Number of baffle flow ways using 13 mm flow ways: 1

Number of baffle flow ways using 14 mm flow ways: 1

Number of baffle flow ways using 15 mm flow ways: 1

Number of baffle flow ways using 16 mm flow ways: 1

Choice of cooling tube diameter for deep core cooling system:
1. 12mm
2. 13mm
3. 14mm
4. 15mm
5. 16mm

Maximum cooling effect for Ronan_CS core dimensions: 16 mm diameter

Enter choice (1–5):5

Number of baffle flow ways through the centre of the core : 1

Diameter of standard flow way to connect baffle flow ways has been calculated as 10 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w3

Position: -92.9999 0 69

Length: 186 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: deep
Making standard flow way

BAFFLE FLOW WAY:Ronan_CSbff_fl_w0

Baffle flow way position: -2.49993 0 92.4

Baffle flow way diameter: 16 mm

Baffle flow way length: 64.4 mm

Configuration: deep

Cavity/core name: Ronan_COR
Making baffle flow way

BAFFLE BLADE:Ronan_CSbff_bl0

Baffle blade: -2.49993 0 92.4

Baffle blade length: 48.4 mm

Baffle blade width: 15.5 mm

Baffle blade thickness: 2 mm

Configuration: deep

Cavity/core name: Ronan_COR
Making baffle blade

INTEGER CORE RECTANGULAR BLOCK: Ronan_CORitcr_rbl0

Core block position: 0 0 45.4

length: 186 mm

width: 208 mm

depth: 47 mm

guide_pin_diameter: 16 mm

INTEGER CORE RECTANGULAR LAND :Ronan_CORitcr_rcl0

Rectangular land position: 0 0 43

Rectangular land depth:2.4 mm

Rectangular land length: 122.866 mm

Rectangular land width: 70.8656 mm

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:3

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:4

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:6

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session5

Session terminated.Ron>

Appendix 11.

Example strategist support for the build up of a PTPlus product and mould design.

Ron> import

Enter workstation: zipporah

Product ranges where data is available in the Product Range Model are:
1. Yoghurt pot range of products
2. Flower pot range of products
3. PTPlus range of products
Enter choice.
3

1.Create a new product (Initial product definition).
2.Modify existing product (Interactive product modification).
3.Delete a product and its mould
Enter choice.
1

Enter name of new product.
Ronan

Functional requirements:

locate_in_lid
locate_on_jar
break_in_torsion
hold_in_lid
hold_on_jar
prevent_rotation
cover_lid_edge

Specify functional requirements for initial product definition:

FUNCTION – locate_in_lid

What is the inner diameter of the metal lid? (mm)52.44

Note: location surface contains flange for 'hold_in_lid' function as well as mating with inside lid surface
What is the height of the location surface? (mm)3.0

FUNCTION – break_in_torsion

What is the breakage torsion required? (Nmm)1220

FUNCTION – locate_on_jar

What is the outer diameter of the jar neck? (mm)50.08

What is the height of the location surface? (mm)3.5

FUNCTION:locate_in_lid

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE– SIDE_WALL: Ronan_Fsid_w0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 10

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:50.44

Specify side_wall thickness:1

Specify side_wall height:3.0

FORM FEATURE Ronan_Fsid_w0
FUNCTIONALITY ASSESSMENT- locate_in_lid function:

Feature height satisfactory for locate in lid function
Feature diameter satisfactory for locate in lid function

MOULDABILITY WALL FEATURE: Ronan_Mwall0

Wall thickness ok

Wall features require a taper

Consequences of non-inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall0
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok
Do you wish to create a new gate on this wall?y/ny

Creating gate on wall Ronan_Mwall0

Enter gate position X Y Z26.22 0 12

Feeding distance ok

This product is tubular:

Possible choices of gate type:
1. Rectangular edge gate
2. Pin gate
3. Diaphram gate
4. Ring gate

Enter choice:1

Gate type is rectangular edge gate

FUNCTION:break_in_torsion

Forms available for use:
1.spaced_bosses
No more forms available.

FORM FEATURE– SPACED_BOSSES: Ronan_Fsp_bs0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of group central axis):0 0 9.75

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify number of bosses:3

Specify boss diameters:.17

Specify diameter between boss axes:52

Specify bosses height:.25

FORM FEATURE Ronan_Fsp_bs0
FUNCTIONALITY ASSESSMENT– break_in_torsion function:

Torque specification: 1220
Feature position satisfactory for break in torsion function
Group diameter satisfactory for break in torsion function
Torque calculation1208.07
Torque at failure satisfactory for break in torsion function

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos0

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos1

Solid boss orientation ok

Solid boss features require a taper

Consequences of non–inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

MOULDABILITY SOLID BOSS FEATURE: Ronan_Msbos2

Solid boss orientation ok

Solid boss features require a taper

Consequences of non-inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/nn

Solid boss height ok

Solid boss width ok

Solid boss features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

FUNCTION:locate_on_jar

Forms available for use:
1.side_wall
No more forms available.

FORM FEATURE- SIDE_WALL: Ronan_Fsid_w1

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of central axis of rotation):0 0 6.25

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:50.08

Specify side_wall thickness:1

Specify side_wall height:3.5

FORM FEATURE Ronan_Fsid_w1
FUNCTIONALITY ASSESSMENT- locate_on_jar function:

Feature height satisfactory for locate on jar function
Feature position satisfactory for locate on jar function

Wall outer diameter is less than that of adjacent boss grouping

Consequences:
1. Breakage torsion is drastically reduced from that intended and cannot be estimated

Remedial options:
1. Increase wall diameter to be in full contact with the boss grouping
Maximum outer wall diameter for full contact: 53.83
Minimum outer wall diameter for full contact: 52.17

-No further options

Increase the outer diameter? y/ny

Enter new outer diameter:52.18

To maintain constant inner diameter new thickness should be: 1.05
Do you wish to adjust the thickness? y/ny

New thickness: 1.05
Feature diameter satisfactory for locate on jar function

MOULDABILITY WALL FEATURE: Ronan_Mwall1

Wall thickness ok

Wall features require a taper

Consequences of non-inclusion of a taper can be difficulty in
removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall1
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness is not the same as adjacent wall

Possible consequences:
1. Feeding problems if a thick section is fed by a thin section
2. Stress concentrations at abrupt section changes
3. Abrupt section changes can interfere with the flow of material in the mould causing surface defects
4. Component warpage

Remedial options:
1. Make wall thickness the same or near to that of adjacent wall (1)
2. If the difference in thickness must remain make sure the change is not abrupt

-No further options

Change wall thickness? y/nn

Present thickness recorded

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/nn

Do you wish to create a new gate on this wall?y/nn

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re-analysis of functional features in the given order before proceeding:

0. Ronan_Fsid_w0
1. Ronan_Fsp_bs0
2. Ronan_Fsid_w1

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

INITIAL PRODUCT DEFINITION PHASE COMPLETE FOR PRODUCT: Ronan

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session4

WARNING: Dimensional changes to cavity/core elements and application of tapers during mould design will result in dimensional changes and creation of tapers on corresponding product features

As a consequence of the above, functional relationships within the product may be invalidated

Re-analysis of all functional features in the product must be undertaken in original order of creation

Are you sure you want to go on to mould design?y/ny

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl0

taper has angle 0.8

Volume diameter ok

No blend required between Ronan_Mwall1 and Ronan_Mwall0
Entity boundaries do not meet

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

Core parting line is at 13 mm in the z plane

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl0

taper has angle 0.8

Volume diameter ok

No blend required between Ronan_Mwall1 and Ronan_Mwall0
Entity boundaries do not meet

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl1

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

We have a group volume
Location = 9.75

Identifying local insert features that make up group volume

INTEGER CAVITY GROUP VOLUME FEATURE: Ronan_CAVitcr_grv0

Cavity volume diameter is too small, an overhang exists

Possible consequences:
1. Split mould required
2. If there is a rim the component cannot be removed from the mould even if it is split - COMPONENT NON MOULDABLE

Remedial options:
1. Increase volume diameter to a minimum of 52.2776 mm

-No further options

Change volume diameter? y/ny

Enter new volume diameter (mm):52.28

New diameter ok

INTEGER CORE GROUP VOLUME FEATURE: Ronan_CORitcr_grv0

Core volume diameter is too large, an overhang exists

Possible consequences:
1. For an overhang of up to 1.5 mm, stripping of the component from the core is required for removal
2. If the overhang is larger than 1.5mm the component cannot be removed from the mould unless a collapsible core can be designed

Remedial options:
1. Reduce volume diameter to a minimum of 50.4399 mm

-No further options

WARNING: changing the core group volume diameter also changes the CAVITY
group volume diameter, which can result in the need for a split cavity
Maximum diameter on core to prevent split cavity requirement :52.4399
Minimum diameter on core to prevent split cavity requirement :52.2776

Change volume diameter? y/nn

Present diameter recorded – Component stripping required

INTEGER CAVITY GROUP VOLUME FEATURE: Ronan_CAVitcr_grv0

Volume diameter ok

No hollow boss features found for conversion to cavity/core representation

All solid boss features are part of a group volume in the cavity/core

No rib features found for conversion to cavity/core representation

No hole features found for conversion to cavity/core representation

Do you wish to change the gated wall? y/nn

CREATING FEEDING SYSTEM:

In order to design the feeding system it is necessary to first identify some parameters of the cooling system:

CAVITY COOLING SYSTEM: Ronan_CS

Number of cooling layers using 7 mm flow ways: 1

Number of cooling layers using 8 mm flow ways: 1

Number of cooling layers using 9 mm flow ways: 1

Number of cooling layers using 10 mm flow ways: 1

Choice of cooling tube diameter for cavity cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Lower than 7 mm – insufficient cooling effect – difficulty drilling deep holes

Higher than 10mm – high volume of water to be pumped around the mould for cooling

Maximum cooling effect for Ronan_CS cavity dimensions: 10 mm diameter

Enter choice (1–4):4

CREATING FEEDING SYSTEM:

FEEDING SYSTEM – RECTANGULAR EDGE GATE:Ronan_FSrcted_g0

WARNING: Application of tapers on Ronan_Mwall0 for manufacturing reasons has increased the width of the cavity opening at the parting line by 0.0837814 mm

Consequences:
1. Edge gate position no longer on edge of cavity:
– Reduced land length– weakness in mould construction can lead to wear or failure

Remedial options:
1. Adjust gate position

– No further options
Do you wish to adjust the gate position? y/ny

New gate postion: 26.2619 0 12

Gate position 26.2619 0 12 is not on the parting line

Consequences:
1. Component and feed system cannot be ejected– COMPONENT NON MOULDABLE
2. Gate and runner system cannot be machined into cavity block– MOULD NON MANUFACTURABLE

Remedial options:
1. Move gate to parting line

-No further options

Gate position has been recalculated to 26.2619 0 13
Do you wish to change the new position?y/ny

Enter new gate position (X Y Z):26.2619 0 13

New position recorded

Gate land length:

Land length should be as small as possible and in any case between 0.5 and 0.75 mm
Enter land length.5

Land length ok

Gate depth:

Gate depth has been calculated as 0.7 mm
Do you wish to change the depth?y/nn

Gate width:

Gate width has been calculated as 1.33192 mm
Do you wish to change the width?y/nn

FEEDING SYSTEM – CIRCULAR RUNNER:Ronan_FScirc_r0

Runner length:

Runner length has been calculated as 20.458 mm

This calculation is based on minimum distance between cavity and main sprue
Do you wish to change the length?y/nn

Runner diameter:

Runner diameter has been calculated as 2 mm

This calculation is based on minimum diameter to ensure cavity is filled before plastic in runner solidifies
Do you wish to change the diameter?y/nn

FEEDING SYSTEM – MAIN FEEDING SPRUE:Ronan_FSmain_s0

Main sprue position: 47.2199 0 18
Enter main sprue taper angle:
Recommended minimum angle = 4.0 degrees (minimum recommended)4.0

Taper angle ok

Lower diameter of sprue = 3.1 mm to match machine nozzle diameter of 3 mm

No nozzle recess required

Sprue length has been calculated as 47 mm

This allows the minimum cavity block depth (below cavity) to avoid mould distorsion, and allows space for the cavity cooling system.
Note: 5 mm of the sprue length is to create a sprue puller in the core block
Do you wish to change the sprue length?y/nn

CREATING CAVITY COOLING SYSTEM:

CAVITY COOLING SYSTEM:Ronan_CS

Choice of cooling system configurations for mould cavity:
1. paired tube configuration
2. U tube configuration

U tube configuration recommended when using single rectangular edge gate:

Bottom of the U cooling the gated side provides more even cooling of the moulding, can reduce cycle time.

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Diameter: 10 mm

Orientation: 1.5708

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

In order to calculate remaining cavity cooling system parameters it is necessary to establish cavity block dimensions:

CREATING CAVITY BLOCK FOR: Ronan_CAV

INTEGER CAVITY RECTANGULAR MOULD BLOCK :Ronan_CAVitcv_rbl0

Cavity block position: 0 0 –29

Depth of cavity block: 39.6 mm

Choice of standard guide pin diameters:
1. 10 mm
2. 13 mm
3. 16 mm
4. 19 mm
5. 22 mm
6. 25 mm
7. 32 mm
8. 38 mm

Single rectangular edge gate causes unbalanced forces in the mould, tending to open the mould on one side

Possible consequences:
1. Larger wall section thickness one one side of the mould than on the other

Remedial options
Use guide pin size one larger than that recommended to ensure alignment of mould halves

–No further options

Recommended size for current mould parameters: 3. 16 mm

This product has a single rectangular edge gate – USE NEXT SIZE UP

Enter choice:(1–8):3

Guide pin diameter is 16 mm

Cavity block length: 178.44 mm

Cavity block width: 200.44 mm
Making rblck

INTEGER CAVITY RECTANGULAR LAND: Ronan_CAVitcv_rcl0

Rectangular land position: 0 0 10.6

Rectangular land depth:2.4 mm

Rectangular land length: 114.524 mm

Rectangular land width: 62.5237 mm
Making rcld

COMPLETING CAVITY COOLING SYSTEM:

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Standard flow way position: -89.2199 47.2199 -8

Standard flow way length: 167.44 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Standard flow way position: -89.2199 -47.2199 -8

Standard flow way length: 167.44 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Standard flow way position: 73.2199 -100.22 -8

Standard flow way length: 152.44 mm

CREATING CORE COOLING SYSTEM:

CORE COOLING SYSTEM:Ronan_CS

Number of standard flow ways using 7 mm flow ways: 2

Number of standard flow ways using 8 mm flow ways: 2

Number of standard flow ways using 9 mm flow ways: 2

Number of standard flow ways using 10 mm flow ways: 2

Choice of cooling tube diameter for shallow core cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Maximum cooling effect for Ronan_CS core dimensions: 10 mm diameter

Enter choice (1-4):4

Choice of cooling system configurations for shallow mould core at diameter 10 mm:

1. paired tube configuration

2. U_tube configuration

U tube configuration recommended when using single edge gate or single pin gate:

Bottom of the U cooling the gated side provides more even cooling of the moulding, can reduce cycle time.

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w3

Position: -89.2199 -13 34

Length: 141.44 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w4

Position: -89.2199 13 34

Length: 141.44 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w5

Position: 47.2199 100.22 34

Length: 118.22 mm

Diameter: 10 mm

Orientation: 4.7124

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

INTEGER CORE RECTANGULAR BLOCK: Ronan_CORitcr_rbl0

Core block position: 0 0 15.4

length: 178.44 mm

width: 200.44 mm

depth: 42 mm

guide_pin_diameter: 16 mm

INTEGER CORE RECTANGULAR LAND :Ronan_CORitcr_rcl0

Rectangular land position: 0 0 13

Rectangular land depth:2.4 mm

Rectangular land length: 114.524 mm

Rectangular land width: 62.5237 mm

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:3

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:4

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:3

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:6

1. Go on to Interactive product Modification design phase
2. Modification/re-analysis of existing forms
3. Display options
4. Go on to mould design
5. End session1

Functional requirements:
1. hold_in_lid
2. hold_on_jar
3. prevent_rotation
4. cover_lid_edge
Select a product function.1

FUNCTION – hold_in_lid

What is the maximum fixing diameter, ie diameter inside lid? (mm)54.8

FUNCTION:hold_in_lid

Forms available for use:
1.flange
No more forms available.

FORM FEATURE– FLANGE: Ronan_Fflang0

Do you wish to see feature dimensioning instructions?y/nn

Specify feature position (base of axis of rotation):0 0 12

Specify feature orientation 1 O 0 major axis is X direction
0 1 0 major axis is Y direction, 0 0 1 major axis is Z direction:0 0 1

Specify inner diameter:52.44

Specify flange width:.5

Specify flange thickness:1.0

FORM FEATURE Ronan_Fflang0
FUNCTIONALITY ASSESSMENT- hold_in_lid function:

Feature position satisfactory for hold in lid function
Inner diameter satisfactory for hold in lid function
Feature outer diameter satisfactory for hold in lid function
Found hold_lid
UPDATE

MOULDABILITY WALL FEATURE: Ronan_Mwall2

Wall thickness ok

Wall features require a taper

Consequences of non-inclusion of a taper can be difficulty in removal of the component from the mould

Do you wish to create a taper?y/ny

Creating taper on wall Ronan_Mwall2
Enter taper angle:
Recommended minimum draft angle = 0.8 degrees.8

Taper angle ok

Wall thickness relative to adjacent wall ok

Wall features require a blend

Possible consequences of non inclusion:
1. Stress concentrations in the component
2. Turbulent flow around the corner can cause surface defects

Do you wish to create a blend?y/ny

Creating blend on wall Ronan_Mwall2
Enter inside radius:
Recommended inside radius is between 0.5 and 0.6 mm
0.5 mm is the recommended minimum radius.5

Inside blend radius ok

Enter outside radius:
Recommended outside radius is 1.5 mm1.5

Outside blend radius ok

Do you wish to create a new gate on this wall?y/nn

WARNING:Application of tapers for manufacturing objectives may invalidate the functional relationships within the product

Advise re-analysis of functional features in the given order before proceeding:

1. Ronan_Fflang0

Select modification/re-analysis option on main menu

ENTER 'c' to continue:c

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session4

WARNING: Dimensional changes to cavity/core elements and application of tapers during mould design will result in dimensional changes and creation of tapers on corresponding product features

As a consequence of the above, functional relationships within the product may be invalidated

Re-analysis of all functional features in the product must be undertaken in original order of creation

Are you sure you want to go on to mould design?y/ny

Parting line is at 13 mm in the z plane

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl0

taper has angle 0.8

Volume diameter ok

No blend required between Ronan_Mwall1 and Ronan_Mwall0
Entity boundaries do not meet

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl1

taper has angle 0.8

Volume diameter ok

Blend has inner 0.5 and outer 1.5

INTEGER CAVITY VOLUME FEATURE: Ronan_CAVitcv_vl2

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

Core parting line is at 13 mm in the z plane

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl0

taper has angle 0.8

Volume diameter ok

No blend required between Ronan_Mwall1 and Ronan_Mwall0
Entity boundaries do not meet

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl1

taper has angle 0.8

Volume diameter ok

No blend required between two core volumes of the same diameter

INTEGER CORE VOLUME FEATURE: Ronan_CORitcr_vl2

taper has angle 0.8

Volume diameter ok, evaluation completed by analysis of previous feature

Blend ok, evaluation completed by analysis of previous feature

We have a group volume
Location = 9.75

Identifying local insert features that make up group volume

INTEGER CAVITY GROUP VOLUME FEATURE: Ronan_CAVitcr_grv0

Volume diameter ok

INTEGER CORE GROUP VOLUME FEATURE: Ronan_CORitcr_grv0

Core volume diameter is too large, an overhang exists

Possible consequences:
1. For an overhang of up to 1.5 mm, stripping of the component
from the core is required for removal
2. If the overhang is larger than 1.5mm the component cannot be removed
from the mould unless a collapsible core can be designed

Remedial options:
1. Reduce volume diameter to a minimum of 50.4399 mm

-No further options

WARNING: changing the core group volume diameter also changes the CAVITY
group volume diameter, which can result in the need for a split cavity
Maximum diameter on core to prevent split cavity requirement :52.4399
Minimum diameter on core to prevent split cavity requirement :52.2776

Change volume diameter? y/nn

Present diameter recorded – Component stripping required
In Mould_manuf

INTEGER CAVITY GROUP VOLUME FEATURE: Ronan_CAVitcr_grv0

Volume diameter ok

No hollow boss features found for conversion to cavity/core representation

All solid boss features are part of a group volume in the cavity/core

No rib features found for conversion to cavity/core representation

No hole features found for conversion to cavity/core representation
LOWEST Z FOR CAVITY =:6.25

Do you wish to change the gated wall? y/ny

Please indicate which wall you wish to gate:
0. Ronan_Mwall1
1. Ronan_Mwall0
2. Ronan_Mwall2

Enter choice:0

Enter gate position X Y Z25.5 0 6.25

Feeding distance ok

This product is tubular:

Possible choices of gate type:
1. Rectangular edge gate
2. Pin gate
3. Diaphram gate
4. Ring gate

Enter choice:2

Gate type is pin gate

WARNING: Use of a pin gate requires a three plate mould.
Other possible gate types only require two plate moulds
Do you still want to specify a pin gate type?y/ny

Gate type is pin gate

-Three plate mould required

CREATING FEEDING SYSTEM:

In order to design the feeding system it is necessary to first identify some parameters of the cooling system:

CAVITY COOLING SYSTEM: Ronan_CS

Number of cooling layers using 7 mm flow ways: 1

Number of cooling layers using 8 mm flow ways: 1

Number of cooling layers using 9 mm flow ways: 1

Number of cooling layers using 10 mm flow ways: 1

Choice of cooling tube diameter for cavity cooling system:
1. 7mm

2. 8mm
3. 9mm
4. 10mm

Lower than 7 mm – insufficient cooling effect – difficulty drilling deep holes

Higher than 10mm – high volume of water to be pumped around the mould for cooling

Maximum cooling effect for Ronan_CS cavity dimensions: 10 mm diameter

Enter choice (1–4):4

CREATING FEEDING SYSTEM:

FEEDING SYSTEM – PIN GATE:Ronan_FSpin_g0

WARNING: Application of tapers on Ronan_Mwall1 for manufacturing reasons has decreased the base diameter of the cavity by 0.0279271 mm

Consequences:
1. Pin gate position no longer same distance from edge of section:

Remedial options:
1. Adjust gate position

– No further options
Do you wish to adjust the gate position? y/ny

New gate postion: 25.486 0 6.25

Gate position ok

Gate land length:

Land length should be as small as possible and in any case between 0.5 and 0.75 mm
Enter land length.5

Land length ok

Gate diameter:

Gate diameter has been calculated as 1.22121 mm
Do you wish to change the diameter?y/nn

Enter gate taper angle:
Recommended minimum angle = 4.0 degrees (minimum recommended)4.0

Taper angle ok
Min under:18

Secondary sprue length has been calculated as 34.75 mm

This allows the minimum cavity block depth (below cavity) to avoid mould distorsion, and allows space for the cavity cooling system
Do you wish to change the secondary sprue length?y/nn

FEEDING SYSTEM – TRAPESOIDAL RUNNER:Ronan_FStrap_r0

Runner length:

Runner length has been calculated as 45.486 mm

This calculation is based on minimum distance between pin gate secondary sprue and a central main sprue
Do you wish to change the length?y/nn

Secondary sprue diameter at junction with runner: 3.64821

Runner width:

Runner width has been calculated as 3.64821 mm

This calculation is based on the diameter of the secondary sprue where it joins the runner. Runner width should be at least as large as the sprue diameter up to a maximum of 10mm
Do you wish to change the width?y/nn

FEEDING SYSTEM – MAIN FEEDING SPRUE:Ronan_FSmain_s0

Main sprue position: 0 0 –32.6482
Enter main sprue taper angle:
Recommended minimum angle = 4.0 degrees (minimum recommended)4.0

Taper angle ok

Lower diameter of sprue = 3.1 mm to match machine nozzle diameter of 3 mm

Sprue length has been calculated as 18 mm

This allows the minimum backing plate depth to avoid mould distorsion
Do you wish to change the sprue length?y/nn

CREATING CAVITY COOLING SYSTEM:

CAVITY COOLING SYSTEM:Ronan_CS

Choice of cooling system configurations for mould cavity:
1. paired tube configuration
2. U tube configuration

U tube configuration recommended when using single pin gate:

Bottom of the U cooling the gated side provides more even cooling of the moulding, can reduce cycle time.

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Diameter: 10 mm

Orientation: 1.5708

Cavity/core_name: Ronan_CAV

Configuration: U_tube

Vertical coordinate: –8 mm
Making standard flow way

In order to calculate remaining cavity cooling system parameters it is necessary to establish cavity block dimensions:

CREATING CAVITY BLOCK FOR: Ronan_CAV

INTEGER CAVITY RECTANGULAR MOULD BLOCK :Ronan_CAVitcv_rbl0

Cavity block position: 0 0 –29

Depth of cavity block: 39.6 mm

Choice of standard guide pin diameters:
1. 10 mm
2. 13 mm
3. 16 mm
4. 19 mm
5. 22 mm
6. 25 mm
7. 32 mm
8. 38 mm

Recommendation: Use smallest suitable guide pin diameter to minimise size and weight of mould assembly

Recommended size for current mould parameters: 2. 13 mm

Enter choice:(1–8):2

Guide pin diameter is 13 mm

Cavity block length: 142.54 mm

Cavity block width: 189.44 mm

INTEGER CAVITY CIRCULAR LAND:Ronan_CAVitcv_crl0

Circular land position: 0 0 10.6

Circular land depth:2.4 mm

Circular land diameter:63.4678 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf0

Periferal land position: 45.2698 45.2698 10.6

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf1

Periferal land position: –45.2698 45.2698 10.6

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf2

Periferal land position: 45.2698 –45.2698 10.6

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CAVITY PERIFERAL LAND:Ronan_CAVitcv_pf3

Periferal land position: –45.2698 –45.2698 10.6

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CAVITY BACKING PLATE:Ronan_CAVitcv_bk0

Backing plate position: 0 0 –50.6482

Backing plate width: 189.44 mm

Backing plate length: 142.54 mm

Backing plate depth: 21.6482 mm
Making backing block

COMPLETING CAVITY COOLING SYSTEM:

STANDARD FLOW WAY:Ronan_CSstd_fl_w0

Standard flow way position: –71.2698 47.7199 –8

Standard flow way length: 123.99 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w1

Standard flow way position: –71.2698 –47.7199 –8

Standard flow way length: 123.99 mm

STANDARD FLOW WAY:Ronan_CSstd_fl_w2

Standard flow way position: 47.7199 –94.7199 –8

Standard flow way length: 147.44 mm
LOWEST DIAMETER FOR CORE =:50.4399

CREATING CORE COOLING SYSTEM:

CORE COOLING SYSTEM:Ronan_CS

Number of standard flow ways using 7 mm flow ways: 2

Number of standard flow ways using 8 mm flow ways: 2

Number of standard flow ways using 9 mm flow ways: 2

Number of standard flow ways using 10 mm flow ways: 2

Choice of cooling tube diameter for shallow core cooling system:
1. 7mm
2. 8mm
3. 9mm
4. 10mm

Maximum cooling effect for Ronan_CS core dimensions: 10 mm diameter

Enter choice (1–4):4

Choice of cooling system configurations for shallow mould core at diameter 10 mm:

1. paired tube configuration

2. U_tube configuration

U tube configuration recommended when using single edge gate or single pin gate:

Bottom of the U cooling the gated side provides more even cooling of the moulding, can reduce cycle time.

Enter choice:2

STANDARD FLOW WAY:Ronan_CSstd_fl_w3

Position: –71.2698 –13 34

Length: 123.99 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w4

Position: -71.2698 13 34

Length: 123.99 mm

Diameter: 10 mm

Orientation: 0

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

STANDARD FLOW WAY:Ronan_CSstd_fl_w5

Position: 47.7199 94.7199 34

Length: 112.72 mm

Diameter: 10 mm

Orientation: 4.7124

Cavity/core_name: Ronan_COR

Configuration: U_tube
Making standard flow way

INTEGER CORE RECTANGULAR BLOCK: Ronan_CORitcr_rbl0

Core block position: 0 0 15.4

length: 142.54 mm

width: 189.44 mm

depth: 42 mm

guide_pin_diameter: 13 mm

INTEGER CORE CIRCULAR LAND :Ronan_CORitcr_crl0

Circular land position: 0 0 13

Circular land depth:2.4 mm

Circular land diameter:63.4678 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf0

Periferal land position: 45.2698 45.2698 13

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf1

Periferal land position: -45.2698 45.2698 13

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf2

Periferal land position: 45.2698 -45.2698 13

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

INTEGER CORE PERIFERAL LAND :Ronan_CORitcr_pf3

Periferal land position: -45.2698 -45.2698 13

Periferal land depth:2.4 mm

Periferal land diameter:13.5499 mm

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session3

Selecting display program: 1

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:3

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block

5. Cooling system
6. Exit display options

Enter choice:4

Display options:

1. Show product only
2. Product and feeding system
3. Cavity block
4. Core block
5. Cooling system
6. Exit display options

Enter choice:6

1. Choose another product function
2. Modification/re_analysis of existing functional forms
3. Display options
4. Go on to mould design
5. End session5

Session terminated.Ron>