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|  | Timespan | Content | Speaker |
| 1 | 0:00.0 - 2:12.9 | Nice to meet you and thank you very much for being here today...  I would like to ask you about your general experience in designing for additive roughly how many products or components have you designed for additive manufacturing? | Interviewer A |
| 2 | 2:12.8 - 2:14.8 | Up to now | ID16 |
| 3 | 2:14.8 - 2:23.8 | Well over fifty, less than a hundred I’d guess, or somewhere around that mark. | ID17 |
| 4 | 2:23.8 - 2:28.5 | How often do they come up? | Interviewer A |
| 5 | 2:28.5 - 2:33.2 | Monthly pretty well I would guess | ID16 |
| 6 | 2:33.2 - 3:19.1 | What proportion of your projects with additive manufacturing are series production - If one hundred percent is the total proportion of projects you designed how much is the percentage of products you designed specifically for additive as opposed as the projects you do use additive for tooling prototyping or one-off. How much is the percentage of projects you use additive for production, the projects that are using additive for tooling and the projects that are using additive for prototypes; and the projects you are using additive for one-off? | Interviewer A |
| 7 | 3:17.1 - 3:55.3 | Okay, so very rarely we make tooling using additive. Most products I would say are designed ten or fifteen percent of them are printed as prototype, I’d guess before we go straight to manufacture and then the final bit of that printing element of it we print straight off and they are usually in low numbers between one and thirty. | ID16 |
| 8 | 3:55.3 - 3:57.4 | Thirty is probably the biggest batch we have done. | ID17 |
| 9 | 3:57.3 - 3:59.8 | As a proportion of the total projects that we do here less than five percent. It is five percent, three percent, two percent something like that. Because we are not designing for additive manufacturing, we are designing for our client and so we have to design whichever is the most appropriate technology to solve their particular challenge. | ID16 |
| 10 | 4:29.7 - 4:35.4 | Do you think that is percentage is changing? | Interviewer A |
| 11 | 4:35.3 - 4:37.0 | Yes | ID16 |
| 12 | 4:37.0 - 4:44.0 | May I ask you in which way? | Interviewer A |
| 13 | 4:43.9 - 5:11.9 | Well, I would say as the years progress we will print more and more but there would be changes due to economic requirements, due to what the clients demand or who are working for at the time. So just at the moment we’ve got projects on, which would have manufacturing in it because they are not fit for that environment. | ID16 |
| 14 | 5:11.9 - 5:30.2 | In my email I ask you if you could identify some components or products you have designed which have been then produced using additive. Which products or components have you chosen? | Interviewer A |
| 15 | 5:30.2 - 5:47.5 | Okay we’ve chosen two products here both have gone through being designed and manufactured and dispatched. ID17 did one and ID18 has done the other. So can I hand to them to describe which one | ID16 |
| 16 | 5:47.5 - 5:51.7 | I will do the Cardioplegia Clamp first | ID17 |
| 17 | 5:51.7 - 6:03.4 | ID18 did the Cardioplegia which is the process you photograph on the board. So it is relevant to her first. | ID16 |
| 18 | 6:03.4 - 6:34.8 | It is that one there. the client approached us. He wanted to develop a better product for holding this here, which are heat exchangers they called. And do you want to go through the process or just? | ID18 |
| 19 | 6:34.8 - 6:46.2 | Well if you can show me some material about - that you used in your design process... but if there is something that you want to say right now | Interviewer A |
| 20 | 7:03.2 - 7:26.4 | There is a difference between the two projects. This one is for the medical industry and we have designed projects, additive manufacturing products for that kind. And the other one there is one that ID17 did. | ID18 |
| 21 | 7:26.4 - 9:30.8 | That is for the same industry but it is for a different client which again, we have already supplied them with a previous product we designed to both clients actually use. That's part of a product, which, that’s a sheet just under your folder there which I can explain more detail. The image on the top left that was just an initial sketch when we were looking at the idea of gathering all the information from the client what they were looking for and just exploring ideas there. We did look at that being completely additively manufactured with no assembly requirements so it is all printed in one. We then discussed it as a group and ID18 came up with the slightly different concept which is the top right and then actually having a solution there. Afterwards which provided a rendered image to what we were supplying the client. The top half is actually printed, the bottom half isn't and then specification is changed a little bit more and the request came in after seeing the initial concept and then we actually had the final design completed and then approved and there is at the back there. A number of the top half that was printed. However, the one that you actually got there is the one we rejected for the quality. This one down here was the final product and the binder is there, it is actually - they were rejected as a quality. We rejected them. We requested in a certain orientation for print and we also requested them to be sealed. The one you have there in you hand now that was actually a finished and that was accepted. You want to compare them, you will see the orientation and quality of print that is different. | ID17 |
| 22 | 9:30.8 - 9:43.6 | Did you try different orientations in printing and then one of them survived and the rest of them | Interviewer B |
| 23 | 9:43.6 - 10:02.3 | We ordered ten in total and we asked them to print them in a certain orientation. When we actually received them, they haven't followed that instruction and printed them differently, which therefore affected the cosmetic of it. So we very quickly rejected that | ID17 |
| 24 | 10:02.3 - 10:05.2 | Why did it affect the cosmetic of it? | Interviewer A |
| 25 | 10:05.2 - 10:26.2 | Just if you look at the lines of which occurs from the layers they are actually very slightly they are all very different. There is one in particular. One of them has a quite of a bulge in the outside. | ID17 |
| 26 | 10:26.2 - 11:45.3 | We are also quite specific about the build orientation, so that holes remain circular or cylindrical. That's a huge challenge with 3D additive manufacturing, is integrity in shape of the part. And the other huge challenge with it, is tolerance stacks and how one part, one part and one part [joint together] maybe plus and minus point three. At any point on a product two interlocking parts may or may not work. So a good example was this joint here on ID18's. To get that right we ended up having to hand finish the parts to make sure they fit together. So that wasn't intended but we couldn't get the quality of fit. So it felt smother, ran nicely and also didn't wobble around without having to do some hand finishing. | ID16 |
| 27 | 11:45.3 - 11:51.2 | How did you decide the part orientation? How to orient your component? | Interviewer A |
| 28 | 11:51.1 - 12:31.9 | Well after the last two to three years using additive manufacturing, we understand the XYZ print platform. We had a number of parts printed, different thickness layers so we see the quality and I know different materials and different technologies provide different finishes or standard finishes. This one we’ve used several times. The Z axis is slightly weaker on the bond between the layers so we decided to print in an orientation for the actual strength but also the cosmetics and the Z (()). So it is actually for the concetricity of the holes. | ID17 |
| 29 | 12:31.9 - 12:34.7 | Which is better for the Z axis. | Interviewer A |
| 30 | 12:34.7 - 12:36.1 | Yeah | ID17 |
| 31 | 12:36.1 - 12:50.5 | But even that part, that you have in your hands Interviewer A you can see that we had to do some - if you pull the bolt out - push the bolt out we had to do some | ID16 |
| 32 | 12:50.5 - 12:53.5 | Here inside you mean | Interviewer A |
| 33 | 12:53.5 - 12:54.6 | Yeah just (()) | ID17 |
| 34 | 12:54.6 - 13:35.5 | Which is not what we want to do ideally, for us, for 3D printing, because the all point is getting the product without doing any finishing it just goes straight out. As soon as we have to start cutting it, we may as well put a bolt, a lump of metal and cut it from one lump. But they are learning points for us. They are not areas where you can easily read a book and find out how to do that. It is just something you have to learn as you go along I think. | ID16 |
| 35 | 13:35.5 - 14:19.4 | I mean there are options offered where we can reduce the tolerance but there seems to be a number of different areas of supplies saying where they put it in the print area. Potential temperatures, but there is not really a sort of, an exact given number which we then find really hard to work with. And again is all the extra requests, which obviously they push price up as well and potential lead times. So again all these different areas we have to consider to get the best printed outcome to then if we need to do a, say, further post machine process. | ID17 |
| 36 | 14:19.3 - 15:03.6 | Unfortunately, we have picked good and bad projects but I would say that this one here was realistically as ID17 described earlier the base part we ended up manufacturing - machining from solid and possibly we should have machined these in solid as well, just so we had better control over the surfaces, I think it was not the best use of 3D printing because of the need for post printing processing costs a lot of time. | ID16 |
| 37 | 15:03.6 - 15:06.9 | Do you that part would be more expensive made in machining? | Interviewer A |
| 38 | 15:06.9 - 15:31.7 | We have not done sums on that, but if you had the time it look to mess around and do it and get an outcome which was not as good as, I don’t think, we could have achieved machining, we probably should have gone straight to machining, we didn't for all sorts of good reasons, but possibly. It is one of those in the balance jobs. | ID16 |
| 39 | 15:31.6 - 15:39.4 | If there is no post finishing required then I think the additive manufacturing would be more cost effective | ID17 |
| 40 | 15:39.4 - 15:39.5 | Yeah | ID16 |
| 41 | 15:39.6 - 15:53.4 | And that was the all point of doing that in the first place and again the quality issues and then the hole issue as well, suddenly, maybe machining in the first time would have been | ID17 |
| 42 | 15:53.4 - 16:20.4 | And I think that is an important point for people trying to learn about designing for additive manufacture, the outcome you get isn't always as it looks like on CAD. If you machine something it would pretty always look like your CAD model. If you print it, it will look something like it, but it won’t be as your CAD model so you may end up having to post printing processing. | ID16 |
| 43 | 16:20.4 - 16:47.1 | You have also got to understand the different technologies and the benefits and the disadvantages of each technology to choose which one is suitable for the product you are looking to print. I mean obviously this one here is the powder form, it is actually Alumide, but we have printed other materials and we also used other technologies. Again it is a case by case bases. | ID17 |
| 44 | 16:47.1 - 16:53.1 | But we do not tend to use FDM. We have never printed anything with FDM | ID16 |
| 45 | 16:53.0 - 17:06.2 | We tend to find the advantages of that and the quality is actually quite - it is one of the lower grade ones and therefore we have never actually printed anything with the FDM. | ID17 |
| 46 | 17:06.2 - 17:18.0 | How did you decide to produce in series this component? Why did you decide to print it in additive? | Interviewer A |
| 47 | 17:17.9 - 17:50.5 | Start initially due to the complex geometry and that's - because the printing gives you, as we like to say, a lot more freedom of the design, whereas machining sometimes on complex geometry can become very costly or isn't easy possible. So therefore just the freedom of design gives us the flexibility which also sometimes adds that better feel cosmetic as well. | ID17 |
| 48 | 17:50.5 - 17:55.0 | And you are saying for this one. | Interviewer A |
| 49 | 17:55.0 - 18:01.7 | I think the case for that one was far stronger for the additive manufacturing, don't you ID18? | ID16 |
| 50 | 18:01.7 - 18:19.9 | Well, it was actually a request from the client, we supplied this one. He wanted the same method for the attachment to do post… | ID18 |
| 51 | 18:19.8 - 19:21.2 | Just some history on the gauge holder there. There was some supply previously before additive manufacturing was used, that was quite time consuming to actually attach to a mast and looked very industrial looking; therefore, when we were given the task again to produce them, for another batch we then considered additive manufacturing now knowing a lot more about and feeling more comfortable, the cost benefits and lead time became so rocketing down as well as cosmetically they look a lot more pleasing then the previous version, but also you can tell there is often a matter of seconds rather than minutes. So therefore, I think just about every single point was a benefit using additive manufacturing there. Again there was an initial learning curve just on the tolerance we needed on the diameter of the hole. We found a batch where they would not fit. | ID17 |
| 52 | 19:21.2 - 19:25.6 | Because that gauge fits into that. | ID16 |
| 53 | 19:25.6 - 20:10.3 | We actually had a batch which first will work well, then when we actually had it sealed, that caused the part to swallowed a little bit which then caused an issue. We then actually had a part delivered to us in winter and when (I get sat on top of your hands you can get tweet). So again just learning about the thermo-properties of the material. And we do have that very well controlled now. And then from a very, very successful batch delivered to clients, they get to really like the product itself and the principle. When the Cardioplegia came, that was requested, very early on in the brief, to follow the same principles. | ID17 |
| 54 | 20:10.4 - 20:16.9 | You told us you used SLS, right, to make all the components? | Interviewer A |
| 55 | 20:16.8 - 20:17.7 | Pretty well | ID17 |
| 56 | 20:17.6 - 20:25.7 | Yeah, I think there is only one thing that we have not, which is this clip part here, which was in Stereolithography. | ID16 |
| 57 | 20:25.7 - 20:32.3 | We have done two technologies in that one. | ID17 |
| 58 | 20:32.3 - 20:38.7 | What would you call it? I mean the technical name of | Interviewer B |
| 59 | 20:38.6 - 20:42.3 | Of what? Of that thing is? I cannot remember how we called it now | ID16 |
| 60 | 20:42.3 - 20:48.8 | (()) something like that | ID18 |
| 61 | 20:48.8 - 21:08.2 | Yeah, was it the lower chamber or - I cannot remember now. It is for a demonstration rig for - looking at the flow for a micro valve or metro valve so it is for a research project | ID16 |
| 62 | 21:08.3 - 21:51.7 | There is another product we actually use which is not in medical. Using the same technology, we actually had it polished and painted and that was to hold electronics equipment. The reason for that then is obviously there is no metal around it, so there is no conductivity, we also had very, very short lead time and we only had to have one of them. So again that was used. And the cost was obviously quite high in comparison but then was again right. And there is actually a case study on the website, unfortunately I do not have the product to show you. | ID17 |
| 63 | 21:51.7 - 22:14.5 | Well if it’s in the website. And for all these products did you consider also conventional processes? You told me before about milling, did you consider any other conventional processes? | Interviewer A |
| 64 | 22:14.5 - 23:19.2 | Well, yes that is always an option, isn't it? You know, you always have to keep your options open on any design, which way is the best to go. I would say both of the projects we’ve shown, certainly the second one, which is ID18's Cardioplegia Clamp. To machine that from solid would have been really quite time consuming and expensive and the surface texture probably wouldn't have been particularly good unless you spend a lot of time post machining, removing machining marks. So this is the cast aluminium look works well. It fits, it works, you know the all project allowed us to build-in features which would have been very hard to introduce to machining. Like what… | ID16 |
| 65 | 23:19.2 - 23:22.0 | The finger taps | ID17 |
| 66 | 23:22.0 - 23:24.7 | The clip | ID18 |
| 67 | 23:24.7 - 24:02.0 | This part here, I’ll demonstrate it, so that’s got an (over centric) clip. That comes off. And the heat exchanger comes out of there. So the idea is if during surgery the need to change those things quickly, they can do that. They just clip that one back in and then, I can't see what I’m doing, it is secured and there is a little (crup) screw here. So they can set the angle. So in terms of developing that, how many attempts did we have to go to get that right? | ID16 |
| 68 | 24:02.0 - 25:23.1 | We have few attempts. Those are the concepts that we have sent to the client. The first one is very different design. So he requested the same (bun) arrangement for the mast. But then the specifications changed and he said that need to be fifty millimetres apart from the mast so we needed to change the design. Then we came out with the idea of the clip, the (upper sant) clip, which is that one. And we printed the prototype which is this one. We printed that type and that type from the print of clip to try which one is the best. And then with the prototype, we tried a part, made some refinements, close that a little bit so the clip is better. We changed slightly that one. | ID18 |
| 69 | 25:23.1 - 25:47.8 | So it is more secure. That was just not clipping correctly, so we altered the geometry slightly of that. What else did we do at that stage? The (yog) remain pretty standard throughout, didn't it? | ID16 |
| 70 | 25:47.7 - 25:53.9 | You can see here different concepts. | ID18 |
| 71 | 25:53.9 - 25:58.7 | So this one is very close to the final solution, okay. | Interviewer B |
| 72 | 25:58.7 - 26:08.9 | Yeah, but it started out the models, so that was a progress of the model. That's the route through for both parts. | ID16 |
| 73 | 26:08.8 - 26:18.3 | So ID18 said the major changes from this step to that is due to the customers’ requirements? | Interviewer B |
| 74 | 26:18.3 - 26:44.3 | Yeah, yes he wanted to move. We did this because it was the smallest volume to get away with, but he said no, we needed further away from the mast, so that meant, just the idea is changed. | ID16 |
| 75 | 26:44.3 - 26:48.8 | So in which stage did you decide to use additive manufacturing? | Interviewer B |
| 76 | 26:48.8 - 27:37.4 | Pretty well straight off. because we knew for what was going to be and how we wanted to attach it onto to the mast using these O-rings that is very difficult to produce. You can see a common DNA in all these designs is that shape there and start machining that is quite a big task. It is just complicated and slow and we don't need the accuracy that machining can give for what that is. It does not need to be accurate; it just needs to be the right shape to hold effectively a rubber band. | ID16 |
| 77 | 27:37.4 - 27:44.7 | If you were going to machine those components what material would you choose? | Interviewer B |
| 78 | 27:44.7 - 27:47.0 | I would probably choose | ID16 |
| 79 | 27:47.0 - 27:48.8 | Stainless | ID18 |
| 80 | 27:48.7 - 28:08.6 | If we would have machined it in metal, we would you stainless, one of the stainless grades, and if we were going to machine in plastic, it would probably be acetyl or maybe one of the Nylons or something like that. | ID16 |
| 81 | 28:08.5 - 28:16.7 | So the material properties do not actually take a big part of the consideration? | Interviewer B |
| 82 | 28:16.6 - 28:17.3 | No | ID16 |
| 83 | 28:17.2 - 28:23.3 | It does for these products, because it is going to medical industries so we do have to take some consideration there. | ID17 |
| 84 | 28:23.3 - 28:24.6 | Which ones? | Interviewer A |
| 85 | 28:24.6 - 28:48.5 | Such as - for the medical obviously we have to think about sterilization, the cleanness. Which obviously the Alumide gives us a nice - we got an option to seal it. Whereas, if we were using anything like a standard mild steel we potentially got corrosion to consider, which is not acceptable; therefore, stainless steel as a metal it is the only option there. | ID17 |
| 86 | 28:48.5 - 29:22.4 | But you are right. In terms of the material, we have only chosen Alumide because it just looks nice - you know that's aesthetics as oppose to functionality and we can design it with the sufficient thickness, that we know that is not going to fail, so we are not having to stress these parts and rely on them. | ID16 |
| 87 | 29:22.4 - 29:36.8 | In the prototype, the white one, that's not Alumide, that's polyamide. We chose to print that in polyamide because is cheaper, so for a prototype we don’t need to use Alumide. | ID18 |
| 88 | 29:36.7 - 29:46.5 | In the Alumide, that you saw in that, that's pretty much the natural finish when it comes out of the print, which (they said) it looked very pleasing. | ID17 |
| 89 | 29:46.5 - 29:54.7 | And you asked your suppliers to print it in this direction? | Interviewer A |
| 90 | 29:54.7 - 29:55.9 | Yes | ID18 |
| 91 | 29:55.9 - 29:59.2 | I can’t remember now | ID16 |
| 92 | 29:59.2 - 30:00.1 | I am looking at the layers | Interviewer A |
| 93 | 30:00.1 - 30:07.6 | Should be in that orientation | ID18 |
| 94 | 30:07.6 - 30:08.5 | Ah okay | Interviewer A |
| 95 | 30:08.5 - 30:18.6 | Because you need tolerance there. So you do not want that hole to (damp) in the top so you need to print that way | ID18 |
| 96 | 30:18.6 - 30:22.8 | So that hole is the most important functional feature of the | Interviewer B |
| 97 | 30:22.7 - 31:15.4 | Yeah, because it needed to fit with - there is a screw there I cannot take it out. It had to work with those two parts and normally - it seems logical to print it that way up, but it didn't matter if the two legs spread apart or closed up because of the way they mount on to the mast. | ID16 |
| 98 | 31:15.4 - 31:56.4 | Okay so now I am going to use a metaphor ... Oh did you come to this shape? | Interviewer A |
| 99 | 31:56.4 - 32:42.4 | These features were a must to have. We needed to use that feature there which is the one that we used in the gauge holder. Having just one is going to drop we needed two and at a certain distance apart also we needed - we were specified that distance as well so I guess structurally that triangle would be the best shape and this is just refine that to have the less amount of material. | ID18 |
| 100 | 32:42.4 - 33:49.4 | Another specification was to have no pooling areas where fluids could get stuck and sit on surfaces so that's why the shape is - potentially we could have taken more material out of here, but if you have turned it upside down you would get a big pool area and vice versa it would have taken out of the top, we would have possibly end up with the pool area there which would have been okay. So we wouldn’t want to make it so someone had to think which way does it go, it just goes on and then it will work either way up. We talked about this quite a lot about how the process - because you can see we didn't go from the initial design to the final design straight off, we talked about what the process is, you are asking about how did it work on a video? | ID16 |
| 101 | 33:49.4 - 34:12.7 | It is just to introduce the question. When you were at the concept stage, which were you main considerations? | Interviewer A |
| 102 | 34:12.7 - 34:58.6 | I think the main consideration was simplicity, wouldn't they? How can we produce a really simple design, which is obvious how is going to be used and it is clear and simple to use. I think they were the drivers, weren't they? I think this underpins all our design, how can we make this is as simplest as we possibly can. Although, the shape looks relatively complicated, in additive manufacturing complication does not cost anything, does it? It is just volume that costs. | ID16 |
| 103 | 34:58.6 - 35:08.8 | So you didn't actually worry to much about the complexity of the geometry? | Interviewer B |
| 104 | 35:08.8 - 36:02.7 | No, we don't. The only thing we are worried about when we are doing design is how do things interface with each other, so how do I make fits reliable, that's a real challenge. Whereas just complexity and - complexity is simple, we can do that, but if we need specific geometry - say we needed a hole through something that had to be of a certain size and maybe we couldn't drill it, maybe had to be a curved hole or something like that. That would be a real worry to me, to be able to guarantee that that hole was say cylindric or circular and follow the correct path. Those are the areas that we really talk through and think about and again if we could make it straight holes so that we could drill it. | ID16 |
| 105 | 36:02.7 - 36:05.6 | To ensure the right tolerance? | Interviewer A |
| 106 | 36:05.5 - 36:06.7 | Yeah. | ID16 |
| 107 | 36:06.7 - 36:47.6 | There is a thing just out there. There is a very different perception from a enthusiast or sales oriented person on additive manufacturing compared to actually technical prospective. There seems to be a lot of great achievement that can be sold on a new user or someone looking to going to additive manufacturing compared to what we have learned, which there is always a hidden challenge or unknown challenge or something to actually finish to the product and then realize that the benefits are not all as it seems. | ID17 |
| 108 | 36:49.2 - 36:52.3 | How do you face the unknown challenges? | Interviewer A |
| 109 | 36:52.3 - 37:24.0 | It was one were we had to then - unfortunately the supplier we used had to - the sales department and it actually had a technical department willing to work with us. So we were happy to ask the questions that we were facing to get their knowledge. There is a lot to learn and we learned a lot over the last three years. And again we are still learning with the different materials, different technologies as it changes, as well as our knowledge changes. | ID17 |
| 110 | 37:24.0 - 37:31.6 | You might have mentioned that before. What's the production volume for this part? How many of them? | Interviewer B |
| 111 | 37:31.5 - 37:36.7 | This one here, we have actually produced, I think it was about twelve - fifteen, wasn't it? | ID17 |
| 112 | 37:36.6 - 37:37.8 | Yeah, fifteen I think it was. | ID18 |
| 113 | 37:37.7 - 37:39.6 | One five | Interviewer B |
| 114 | 37:39.5 - 37:41.9 | And the smaller ones (we discuss that) is actually (a reason) there has been ten. | ID17 |
| 115 | 37:41.8 - 37:45.7 | Which one? | Interviewer B |
| 116 | 37:45.7 - 38:03.9 | These ones here. Our first product that we have done the gauge holders, I think today there must be over fifty of those being printed and supplied as well, which they are actually in the industry now being used. | ID17 |
| 117 | 38:03.8 - 38:05.0 | Fifty | Interviewer A |
| 118 | 38:04.9 - 38:10.3 | Yeah, over fifty of those supplied and used. | ID17 |
| 119 | 38:10.4 - 38:42.1 | So are there any considerations you go towards production, so when you are preparing your design for production, do you change anything? | Interviewer A |
| 120 | 38:42.0 - 39:19.9 | We may then just review again the printing orientation. Does that need to be considered or not? Is that one of the, I suppose, main points to consider when additive manufacturing. We pretty much probably decided on the material well in advance of that, but then maybe there is a further consideration of finish potentially. But I would say the print orientation is more important close to manufacture and we might actually start doing any geometry within the design such as holes or. | ID17 |
| 121 | 39:19.9 - 40:48.2 | Although I would say, because additive manufacturing is a relatively small part of our work, I think it is important to point out that other designs do exist out there and I am just working on one at the moment where I tend to block out things, make the overall design work, it won’t have a lot of detail there and then will start having more detail to make sure that everything will fit together, how will it be manufactured? At that stage we would probably making decisions like does this surface need to be machined or what accuracy do we need between these components how they will fit together. And sometimes out of that it might be that we will decide actually this component we won’t machine it, we might print it or something that may have been in the back of our mind to print, we will switch over and say no, it will be machined. So we need to remain flexible all the way through the process. It is just that this example we started out with additive manufacturing in mind and it remained there not because other system were not considered, they were just not considered as being practical. | ID16 |
| 122 | 40:52.2 - 41:01.8 | When you are designing a product or component for additive, did you follow any design guidelines or rules? | Interviewer A |
| 123 | 41:01.8 - 42:01.2 | Again we will think about orientation, when we have any features we got to consider that. We do try to minimize the overall volume XYZ, because obviously we know that has an impact on time and cost. I suppose as well, it’s what the product environment would be at the end, what is required such as - One of the products we have done we obviously had to have nice, smooth and painted and quite robust therefore we went with a slightly different technology and material than Alumide. Other times Alumide is suitable. Sometimes we got to consider any water ingress, which then again might have to, uh, material selection. | ID17 |
| 124 | 42:01.2 - 42:14.4 | There is also - depending on the technology we use, for example if we are using this sintering, we may need to think about how the powder is gonna to come out. | ID18 |
| 125 | 42:14.4 - 42:15.2 | Yeah it is a good point. Will it come out? Or will come out all over our clients. But I mean on the design rules we did attend a seminar which specified how you go about justifying 3D additive manufacture and there were some design rules there like: are they gonna be less than a thousand. The set out certain parameters you could feed these into one of their programmes (and have to be said) yes or no whether it was additive manufacturing or not and I guess we just have learned those. We do not follow as a rigid form, a list of rules, you didn't get to there, so you cannot carry on. | ID16 |
| 126 | 43:15.2 - 43:21.2 | I think it is one of those natural things that come to us now. After a number of designs of products | ID17 |
| 127 | 43:21.2 - 44:06.4 | But having said we haven't printed anything in metal yet, because all our metal components will tend to be relatively highly stressed so we need to know how they will perform. Whereas, we still treat additive manufacturing as having weakness planes and although you can design around the weakest weakness plane, you still, I still don't feel the process is sufficiently under control for them to be absolutely sure that the weakest weakness plane is (stiff) enough; whereas, we can buy the same certified material for specific jobs so we know we are getting what we ask for. | ID16 |
| 128 | 44:06.4 - 45:06.5 | I mean we have been given data sheets on materials and expectations from many different suppliers, but also just to validate our design validation process, we actually got printed samples in different orientations in two different types of materials which were used quite often, which we have done a FEA simulation on to give us results on the CAD using the material specifications and we are actually going to do a physical test of them as well, so we can validate that. Because again with steel we are very, there is a lot of knowledge and there is a lot of - has been validated a number of times, so we are quite comfortable. A lot of materials are still very new, are still very, sort of force down through the roof, so sales based with very little technical experts and knowledge in easy reach. | ID17 |
| 129 | 45:06.5 - 45:11.4 | And this physical samples, are they from metals, right? | Interviewer A |
| 130 | 45:11.4 - 45:14.7 | No, at the moment is actually plastics | ID17 |
| 131 | 45:14.7 - 45:22.5 | So you are running your own tests to see what are the material properties of the materials. | Interviewer A |
| 132 | 45:22.5 - 46:05.4 | The other thing with the metals, is a lot of - there has been, the component we have considered, but we got to keep cost in mind and we will actually have some very high tolerance or very critical post-machining areas, suddenly the benefits of additive manufacturing are not longer there. The cost (a due) spiral and therefore machining from solid is a much better option. Possibly if weight is a very critical element then there may be benefits there, but again there are other cost implications of topology to consider | ID17 |
| 133 | 46:05.4 - 46:19.7 | How did you learn these rules? How did learn how to design for additive? | Interviewer A |
| 134 | 46:19.7 - 46:26.5 | Practice, trial and error unfortunately. | ID16 |
| 135 | 46:26.5 - 47:27.9 | And speaking with the supplier who is happy to speak with a number of different companies on what they are actually looking to print, what are the products they are dealing with. We actually had one of their technical experts visit us and basically show them all range of designs we do and products every shape and form to get their expert advice on, how many of those you make, one, okay, I wouldn't print that at all. Or I would. Oh that's quite good, but how big is it? Oh that is far too big to consider. So we actually then proved that round about 95% of what we were actually already considering for additive manufacturing are what they would say are suitable to consider. Again some of the others were potential considerations but then there were cost implications there that we were not able to accept. So I think from working with them we get a very good balance. | ID17 |
| 136 | 47:27.9 - 48:46.1 | Yeah, but I would still say that a lot of it has been trial and error. You know we’ve printed something and it’s gone wrong or that the outcome was not what we expected and you are holding a piece there. That's now three years down the line and we are still getting surprises, because we expect one thing and it comes in slightly differently, it swollen slightly during the sealing process we didn't make allowances for that, you know, so it is a matter of just immersing yourself in the outcome of these things. Initially I found personally the move to additive manufacturing really quite difficult, because I’ve spent a lot of a life designing in a more traditional world of, is it going to be a casting, is it going to be a fabrication, it going to be machined from solid or bent metal. And then suddenly to have the (roof left off that) doesn't matter you can have it any shape you like, don't even need to think about the manufacturing process, just design the function and shape you want. I found that quite challenging for start, but once you sort of get a couple under your belt all then a sudden it becomes easier to do. How do you find that? | ID16 |
| 137 | 48:46.1 - 49:36.9 | I find it a lot easier than that but the challenges I for sometimes found is when is the side should I make this radius or make it that radius, should I add this bit in or I might put this curve in. You can actually spend a lot longer making a product look a little bit more personal or pleasant to the eye that is the sort of practicality of it, it is actually very easy simple quick stage, which sometime when tight deadlines or something is there you’ve got to get that equal balance. Whereas using sort of spot sections steels, you generally only have an angle or a side to choose from. It is a different process, but as I said I haven't found it too challenging on this apart from (this). | ID17 |
| 138 | 49:36.9 - 49:51.9 | So what you are saying is that because you have much more freedom and flexibility and therefore you can work more on the details then you can lose more time that you will do with a traditional manufacturing process and that you see this as a challenge. | Interviewer A |
| 139 | 49:51.8 - 50:26.4 | Yeah, because when we are machining metals there are generally a certain amount of options you can choose from and knowing the cost implications by making too complicated, additive manufacturing suddenly you’ve got, you are open to whatever you like to do, a lot of freedom without actually almost knowing what you want before you start, suddenly you can spend a lot of time on detail to what benefit is always an open book really. | ID17 |
| 140 | 50:26.4 - 50:55.9 | Let’s come back to something ID16 said previous about the - you said you need to remain flexible in terms of the production method during the design process so for the example for that one you always consider all the way through the entire design process, you always keep your eyes open to different manufacturing methods? | Interviewer B |
| 141 | 51:00.7 - 51:06.7 | Less so on that one, but you probably picked the worst one for manufacturable. | ID16 |
| 142 | 51:06.7 - 51:11.8 | But this one here is a better example. The (rabbit). | ID17 |
| 143 | 51:11.8 - 52:12.1 | Because, as ID17 said, initially we were looking at printing the whole thing as a single printed product. But we soon realised that you can't get good quality feel between two parts that are printed like that. It was fine as a concept but it wasn't gonna fly. And then, quite a long way down the line, we moved this product away from being printed into being machined because we needed to have certain features which had to be machined. We needed threads in it and needed to hide screws into (counter ports). So immediately we made those decisions that those features needed to be there. That's quite a long way down the line, wasn't it? You know, there were several iterations before we've ever got to it looking like this. All of the sudden, it became obvious that, well, let's just machine this then. Does that answer your question? | ID16 |
| 144 | 52:12.1 - 52:13.6 | It does, yeah. | Interviewer B |
| 145 | 52:13.6 - 52:36.8 | There is also just on the batch size. I mean, for the gauge holders, we do print. There was a very large order, say, for example, tens of thousands came in, suddenly additive manufacturing would not be an option. And again, we always keep that in mind if it's...There is no rule or use, it's how we would produce these and what for batch size. | ID17 |
| 146 | 52:36.8 - 53:49.2 | Actually, I think, another interesting point you bring out from that, ID17, it's the, I don't know if the bit is still kicking around here for (Carl) [a client's name]. One of our clients wants some small parts, it's gonna have injection moulded. And he wanted to have samples printed and we said no, don't print them because you cannot get the quality of the shape you want. In a printed part, it would be representative for what you've received and when you get them moulded. So we've suggested that he has those parts actually machined from solid. So then he can keep one copy for himself, give one to his client (who) always is mould, to say let's what I want and these two are identical. So the certain time when additive manufacture, although it seems like the right thing to do, only need one of each of those, can you produce a model? We can, but it won't give you what you want because the () [feature name] won't be representative, or holes won't be. True. | ID16 |
| 147 | 53:49.2 - 54:59.7 | There is also, just (jump into) that first. Printing any from (first), there is obviously software now and a (couple) can do it for you. But then again, it's thinking, well, you know, do I go the low end of the tolerance, do I go the up end of the tolerance, of the threads standards, then you've also got to think about production quality standards of the material and the technology (about to) manufacturing. So now you suddenly potentially have three tolerances to consider, what is the best answer? Then, going further into detail, depending on where it's being printed on the bed, because sometimes the centre is a lot warmer than it's on the outside on the laser sintered powder. That can have an effect. So suddenly there is a lot of uncertainty on (knowns) that, that you might sort of post-machine that. Suddenly then you might sort of just stick to machine from solid. I think there is a lot of this hasn't, it isn't explained very early on or sold to people when they talk about the additive manufacturing benefits and general technology around it. | ID17 |
| 148 | 54:59.7 - 55:16.3 | Can I come back a little bit on that and ask you: what are the drawbacks and limitations in these two examples, as a result of these being designed for additive manufacturing? | Interviewer A |
| 149 | 55:16.3 - 55:30.0 | In both cases, I'd say the unexpected outcomes of having to do post-printing processing in order to the two parts functioned. That was one. | ID16 |
| 150 | 55:30.0 - 55:32.3 | Yeah, the (shoulder board), that's the thing. | ID18 |
| 151 | 55:32.3 - 55:58.1 | There's never always been 100%, there's always been almost (100%). Whereas, getting something machined from the supplier with technical drawings, it would generally come in very finished, at (almost) finished where to go immediately. When we ask for () inserts, they haven't always had the right () inserts. | ID17 |
| 152 | 55:58.1 - 56:10.0 | We've got these because they are...Are they brass? I think it's brass. We asked for stainless steel and they put brass. It doesn't matter, sorry...that's not what we want. | ID16 |
| 153 | 56:10.0 - 56:45.5 | Then we also had items where we asked for (inserts for insert pitch) which is the one that (pitch) is included. Yes, I could still have the machined items but again, being followed through an online instruction or email quotation or something, whereas it's a technical drawing, it isn't always () to ask for additive manufacturing because in one sense, it's not always needed. Whereas, a technical drawing from a machined item, it generally always has, that tends to be specification requirements and that's contract. | ID17 |
| 154 | 56:45.5 - 56:47.5 | What was the question again? Just to... | ID16 |
| 155 | 56:47.5 - 56:49.7 | About drawbacks and limitations. | Interviewer A |
| 156 | 56:49.8 - 56:58.7 | I think there are (concurrent) drawbacks, tolerances, cylinderical of the hole, integrity of the shape. | ID16 |
| 157 | 56:58.6 - 57:28.1 | Cost for finishing is one, 'cause we seem to find from a number of suppliers that, very much in general, the cost of finishing is doubled the price of the additive manufactured part. And that, I'm presuming it's just labour intensive, it's polishing, smoothing, sanding, painting, priming, whatever the case might be. | ID17 |
| 158 | 57:28.1 - 58:00.3 | Drawbacks on some jobs, this one, you can see the layers, but they are not a disadvantage. There is a job we did for somebody, the layers turned out to be almost like contour, they conplained about it, actually it was ok in the end but it did look (). Wouldn't necessary to guess that from our model, but that's how it's gonna come out. | ID16 |
| 159 | 58:00.3 - 58:32.3 | So how about orientation? Because you mentioned orientation a lot about printing that part, you need to keep that uh, the hole, so you had to print this direction. So did orientation take you extra time to do the design or something as a drawback? Because in machining, you don't need to consider too much about it, you just design it and machine it. But you spent some time deciding orientation or something to... | Interviewer B |
| 160 | 58:32.3 - 58:55.3 | It's pretty quick to decide I think. For specifying that, we don't usually do technical drawings for 3D printed part. But if we are deciding on one printing orientation or we have thread insert, we do our drawing and state in those, those, basically. [ID18 means stating the orientation this way or that way] | ID18 |
| 161 | 58:55.3 - 59:14.6 | Do you change the design of the component. I mean, this process, when you define the orientation and then do you change the design? | Interviewer A |
| 162 | 59:14.3 - 59:49.7 | It varies depending on the features. Every early on, maybe orientation is not considered until you've actually got some concepts or some features. Then you want to get your features right, like I've got holes in this plane, which is a more critical hole, this one, so I will print it in this orientation. Or it could be, I've now got all these holes that are all critical, how can I now change the design to be more (possible) for one, for considered orientation. Sometimes it's again, the design brief changes, the design changes again, we might have to reconsider the orientation of the print. | ID17 |
| 163 | 59:49.7 - 59:54.0 | First you change the design, and then you find the orientation? | Interviewer A |
| 164 | 59:54.2 - 1:00:37.3 | Sometimes, and sometimes the other way round. It's the one that you've always got to keep it back in mind as you progress. And that's very very right towards the end, you've always got to review before you actually have them printed. I'm actually happy with this (does tick) quality of the boxes. Because sometimes you can very easily forget to consider that for the process, just the time and the number of changes. Again, (getting back) going too much into detail, I will put this curve on, put that curve on, you don't forget the impact that might have on the orientation of printing. | ID17 |
| 165 | 1:00:37.3 - 1:00:48.3 | How did you specify the orientation in the CAD or drawings, when you sent the CAD file or the drawing to the [AM bureau]? | Interviewer B |
| 166 | 1:00:48.3 - 1:01:20.8 | Sometimes you'll have to check with the supplier what is their X, Y and Z compared to the software we use. But the supplier we acutally ask for a lot of additive manufacturing, we actually just state, we highlight a face, we state this face is X plane or Y plane or something. And we do try and get a confirmation from...they understand that and accept it. Becuase at sometimes, people have different in-house rules for sort of X, Y, Z planes and how to (modelling) space. | ID17 |
| 167 | 1:01:20.8 - 1:02:14.1 | This is an example of, this is a prototype [ID16 means the handler] because we weren't sure how the thing would feel in a hand, which is quite important. It didn't end up with this geometry but one thing we did decide was we needed it a little bit thinner here. If you hold it, you can feel it's just too wide across that area. So we thinned the model down and gave it a little bit more...so it became just more rounder than...just fitted your hand better. When we printed it, it was printed laid down, wasn't it, this side? We printed it, those curves, becuase they were very (suttle) curves, all of the sudden, that's where the countours showed up and they were quite impressively contoured. | ID16 |
| 168 | 1:02:14.1 - 1:02:53.1 | If we would've made it a little bit more, it could've looked like, we didn't intend it to be like that. But again, this is a really good example, this was designed to remove the need to machine it. Originally, this was a machined item. Because it was relatively complex and we wanted to get cable routes through () attached and all sorts of other things, we ended up printing them. They are much much better products, cheaper, look better. | ID16 |
| 169 | 1:02:53.1 - 1:03:01.8 | She's also done a job test on the material chosen as well to see how performing there in the field. | ID17 |
| 170 | 1:03:01.8 - 1:03:09.7 | That's one example where we did the prototyping. This is another prototype part. | ID16 |
| 171 | 1:03:09.6 - 1:03:29.2 | I suppose that's a different reason for that prototype. It wasn't actually to see any fits or the product, that was actually used for tool path. | ID17 |
| 172 | 1:03:29.6 - 1:04:39.4 | That part that you've got in your hand is actually, you can see, is not designed for additive manufacture, it's actually assembly of various different components, () cylinders there, various sort of parts. What we wanted to do is prove whether the tool path onto...this is a part of suspension of a vehile, we didn't print it, it was printed for us, but the tool path and the rest of the tool was...did we print that? | ID16 |
| 173 | 1:04:39.5 - 1:04:41.8 | No, we didn't. We did initially and we changed it. | ID17 |
| 174 | 1:04:41.8 - 1:06:04.7 | So this is an important bit and what we had to prove was this is used in final inspection of vehicles, so we had to prove whether there was a sensible path to get passed the suspension feature here. There are tool path software that you can get hold of. There is nothing like actually getting in the (pick) and checking whether that is a feasible path or not. And you can see from that, it is. And also it's used whether, how design of these contact points, which were critical for alignment of the tool, whether they would actually fit onto the component correctly or not. And the actual fact, it flushed out there was a problem in the design they'd given us. So printed this from there, it wasn't the same as the CAD they provided us. () We designed to this, and then when we got the CAD data to back it up, the two didn't (match) out, so it flushed out a problem for us. And ultimately, that's a perfect example of additive manufacture for prototyping, so just proved that the metal bit was printed in...you know, if you want, we can give you a picture of the final bit. | ID16 |
| 175 | 1:06:04.7 - 1:06:18.1 | So Can I? It's used for concept proving? | Interviewer B |
| 176 | 1:06:18.1 - 1:07:03.4 | Yeah, we've already produced a 3D model of the part that we...that's what we thought, it would sort of look like. And then we just wanted to prove that without cutting metal, we could prove all the shapes were correct, just still get the tool path onto that. And this is, you see this (), that's the bit we will really concern about not heating with the tool. It was really critical that we didn't damage that, so we were sure there was a proper tool path and we weren't gonna damage that. And printing that was much easier than making the whole thing. There was a metal () machined from solid. There was quite a lot of complexity in that. | ID16 |
| 177 | 1:07:03.4 - 1:07:10.2 | And then within a couple of days we got that. | ID17 |
| 178 | 1:07:10.2 - 1:07:33.9 | Did the introduction of additive change the way you design products or components? | Interviewer A |
| 179 | 1:07:33.8 - 1:07:44.6 | Yes, it's definitely impacted how I design. | ID17 |
| 180 | 1:07:44.6 - 1:08:42.1 | This is a good example of actually being able to test out something before you actually cut metal or commit to tooling. It gives you a chance to be more adventure in a way in your design, best conservative, because you can try and push the boundary really how things might be manufactured without huge risks. I mean, let's say, that cost 100 pounds to make like that. If we would've machined that part and all the associated bits, I don't know, a couple of thousands, three thousands [pounds] maybe? So for 100 pounds investment, we've proved the concept works and it's enabled us to thin down bits that we weren't sure whether we can do in the past. | ID16 |
| 181 | 1:08:42.1 - 1:09:11.6 | This is more about the products, the example you showed us. Did the component that you made in additive change the design of other components you did not make in additive? For instance, because with additive, you can do more complex components, so the components in additive may be more complex, so the other components could be simplified [or 'simplier']? | Interviewer A |
| 182 | 1:09:11.4 - 1:11:00.6 | Yes, absolutely. Just an example of that. This is actually a (mic) switch cover. The original one came from, just machined from a piece of Nylon. Then we actually ended up having to produce it even smaller, as we needed more internal space. Suddenly it became, wall thickness that any chatter during machining became an issue, just the (paths and the walls) were. So when we then considered additive manufacturing which was more cost effective and gave us some flexibility of design, that influenced onto another, some of products where we actually had to include a (position) to cover the (mic) switch, we then also had to mount an energy chain for cable management. There was also a cylindrical surface, we also needed to think about assembly. So we came up with this mount here, which allowed the terminal to be mounted to the energy chain and be fixed permanantly. We then used a cover, which we were able to give a nice of aerodynamic look to it as there is an airflow going over it. Very simply mount of two fastners, but also another benefit, we were able to add branding in, and the branding cost was almost zero. You can't really calculate how much that would cost to add to your part. So, to our client, that was a very very (hardly) welcome. But also in this scenario, it allowed all the components around it to be much much more simple, well, the complexity was (purely) into these two components. | ID17 |
| 183 | 1:11:00.6 - 1:11:07.4 | You would never machine that, look, you know, you wouldn't () my machine that, would you? | ID16 |
| 184 | 1:11:07.4 - 1:11:11.1 | I'm an expect in machining, but I think it would be... | Interviewer A |
| 185 | 1:11:11.1 - 1:11:13.3 | It would be challenging. | ID16 |
| 186 | 1:11:13.3 - 1:11:20.9 | Whereas we can have whatever shape we wanted, and that's it, that's what it would look like. | ID17 |
| 187 | 1:11:20.9 - 1:11:22.9 | I'm thinking, probably kind of casting. | Interviewer A |
| 188 | 1:11:22.9 - 1:11:33.7 | Yes, you could cast it but then you've got the tooling cost. It could be investment cast. The one of those have been made... | ID16 |
| 189 | 1:11:33.7 - 1:11:49.8 | Two, plus this one. We've actually never had to change the design on that. That worked the first time. | ID17 |
| 190 | 1:11:49.8 - 1:12:03.6 | What are your views on additive manufacturing as a production process for end user components? | Interviewer A |
| 191 | 1:12:03.6 - 1:12:38.8 | I think it's very still open, it's not...I don't think the overall impact would be as great as sometimes advertised. But I think it definitely ends another form of process or technology to consider when in general manufacturing, it's still a very young technology, it's still a lot of aspiration and research to come and benefits to be discovered. But it's definitely something that's gonna grow, () it will. | ID17 |
| 192 | 1:12:38.8 - 1:13:30.2 | But for clients' point of view, most of our designs, as they are in the interview, would be from one to maybe ten or twenty-off. So it's very low production rate, and lots of these for () equipment where they are selling between one to twenty of these items a year. So it's a huge advantage to our clients, his name is on there [ID16 means the part which has a branding on], to be able to have something that looks really, like being injection moulded, looks like someone's invested a lot of money in it but actually it didn't cost much at all. So for a lot of our clients, it's really a good way of finishing off their design. | ID16 |
| 193 | 1:13:30.1 - 1:13:42.3 | What do you think designers need to know when they have to design effective parts for additive? | Interviewer A |
| 194 | 1:13:42.3 - 1:14:40.1 | I think more importantly at this stage is how the technology is. I think it's more keep an open mind and ask as many questions as there are many different types of people experiences from people actually do the printing to technical experts to people who have actually printed items for themselves and I suppose, use clients' views, 'cause every different type of persons experience on different areas of the actual part or technology or process has a different view. I think there is a lot of different specs out there and then again, importantly, I think invest some time to try and explore yourself. But definitely can speak to experts who are on the technical side of spec... | ID17 |
| 195 | 1:14:40.1 - 1:15:35.1 | I think the change for, I guess this is ended young engineers or young product designers (), isn't it? I'd say the huge challenge is, if you are gonna cut metal, there are only certain ways that you are gonna cut metal really, if you are gonna design for additive manufacturing, what are you designing, are you designing parts for human beings that are gonna grow skeletal metal around or are you designing stuff like we do which is the other end of market. If you are gonna be designing, say, human tissue, that's a totally different set of skills to what we are doing. That's where just putting a blanket over additive manfuacturing and saying how do you design for that, I don't know, you can do that, I think you have to... | ID16 |
| 196 | 1:15:35.1 - 1:16:13.4 | Every single product, case by case, industry, every single one is, there is almost no boundary in the way, so you've got no (where) to actually look for the right part and quite keeping a open eye on and then actually closing the options down. When it comes to experience and speaking to people, I think that will become a lot more ready to handle or knowleagable to people as it develops. But at the same time, as the industry develops, I think more and more options become available as well. | ID17 |
| 197 | 1:16:13.3 - 1:16:54.4 | But I want to say, as a technology, obviously the car manufacturers are all using it, but they need unit cost to be minimum, and obviously turnaround time's to be...so it will be helpful to them to certain extent but it'll have a limit how far it can go. Whereas biomedical, because of the value you are doing, the (intervention) is extremly high, I can see that actually printing stuff for say biomedical (intervention) is going to be where the massive growth is in the process. | ID16 |
| 198 | 1:16:54.4 - 1:17:19.7 | As well as in aerospace, they are very keen on weight as the weight reduction (overlight) on an aircraft is quite important so where additive manufacturing can be used there, that's () will be very keen. However, safety critical components, I think it will still be, unless heavily proven and certified, is another area. | ID17 |
| 199 | 1:17:19.7 - 1:18:09.9 | I think probably another barrier to learning about how to design for additive manufacturing is, I've already identified it need to be almost industry specific. There is also, one of these works being done by large companies that aren't going to spread the information rapidly. They will be developing their own solutions whatever they see it's been the most lucrative for the future. I don't know what those areas are. Whereas in the past, when I was being trained, a lathe was a lathe, you can only do certain things on them, whereas now, we don't know what the next generation of printers are gonna be printing, might be electronics, might be anything. So that won't be in the general domain until it's out there. | ID16 |
| 200 | 1:18:09.9 - 1:19:50.7 | Just add onto that as well. So there was an application where we used parts and I wanted to know what the impact was going to be from the temperature 25 degrees roughly to how it will affect -40. That was always came up to another sort of barrier based in what we don't know. And there was no sort of information or I'll actually go away and look at that for you and find information, there was always: no, we don't knowm, and it was just bottom. Because it wasn't a high demand on it, anything that is plus 80, that'll be a lot of research on, so they can tell you that. We did find a company who were willing to say that would be suitable at the temperature for the application. However, they would not give us any technical details on it, so suddenly how can I then trust the verbal word, how can I be confident that it will or other than it's just a yes from a salesman. So again, that's the area where you've really got to think about the application of the product and think about the manufacturing. I mean, no doubt there is () for people, but again it's something which, I think some industries are still very secretive because there is a lot of new research (whereas there is minimum years ago) steel still may be the same, because it's very open, we can go and find out just about anything we want about steel, no one really has a secret about it anymore. As for additive manufacturing, there are a lot of suppliers, material suppliers still may be very, protect a lot of information that they've got. | ID17 |
| 201 | 1:19:50.7 - 1:20:41.1 | I'm thinking in terms of learning how to design for additive manufacturing. I think it's really hard because you say you've got freedom of design, you can do everything you want, but each technology is different and it has its rules, and each technology has different rules. Also it's a relatively new process, and it keeps developing, and new technologies and new forms of printing, it's hard to keep up-to-date, and it'll everything, or technology, for us, we need laser sintering, we know stereolithography, but there are some other technologies that we don't know about because there is some () for us. | ID18 |
| 202 | 1:20:41.0 - 1:21:20.7 | I think, just going on that as well to include that point, is the boundaries are constantly moving by own knowledge, by our suppliers' development and by research discovery development as well. So trying to design for something which is constantly moving, their boundaries keep moving, you gotta keep up-to-date with it, you gotta keep chasing it. Until those slow down or stop, I think the challenges aren't gonna get greater, like going back to steels, the boundaries pretty much been there for a number of years, and they won't, you design for that, you know what they are. | ID17 |
| 203 | 1:21:20.7 - 1:21:26.3 | Did you come up with your own rules for design for additive? | Interviewer A |
| 204 | 1:21:26.3 - 1:21:30.9 | We've got certain in house. | ID16 |
| 205 | 1:21:30.9 - 1:21:40.9 | But always reverse back to each other and say what do you think? Do you think this is viable or not? Just to get a second opinion 'cause you can be quite biased on your own idea. | ID17 |
| 206 | 1:21:40.9 - 1:22:13.1 | We haven't formalised them, have we? The certain ones...() but the certain things now we say we will never do that again, we will do it a different way because the problems we had when we tried to...it looked like a good idea at the time and looked to work well and all my experience in designing, I still felt it's a trap, and now we won't do it that way anymore. | ID16 |
| 207 | 1:22:13.0 - 1:22:23.9 | The certian thing is to try and keep it simple, which is generally how we would like to approach anything that we do. | ID17 |
| 208 | 1:22:23.9 - 1:22:30.7 | Did you prove your design rules? Did you test your design rules? | Interviewer A |
| 209 | 1:22:30.7 - 1:23:07.3 | For some, we do. These things here [ID16 means the gauge holder] are so strong and tough, I don't think we bother doing a FEA on that. But we did do a FEA on the clear part there [ID16 means the SLA part, the transparent one] and the rest of the part, because we knew that was gonna be under pressure. So we do prove them to that extent. Did that answer the question? | ID16 |
| 210 | 1:23:07.3 - 1:23:09.1 | Yes. | Interviewer A |
| 211 | 1:23:09.0 - 1:23:15.3 | After the FEA, did you do any experiments on the [design rules]? | Interviewer B |
| 212 | 1:23:15.3 - 1:23:17.4 | Did we do any experiments? | ID16 |
| 213 | 1:23:17.3 - 1:24:40.2 | We haven't down, say, full scale of experiments and developments or research or projects on that. But we have spoken to different people within different industries, saying based on (), can you just double check, do you know about that, what can you learn from that? Again it's validating, it's something in there we don't know about? Is it what we've been told? But also just to some of them we don't know about, these materials and these technologies, what are () it is? It's just getting that sort of non-biased opinion. And then I suppose other times, it's getting feedback. One of the things we do do actually, the Alymide (to seal it), so you don't get water (progress). So we try to find the, that's the secret of these suppliers so they won't tell us what they are actually doing...so we do our own experiments to find out what we think it could be and we believe we found very close to what it is and therefore we would do ourselves. There is a bit of time consuming there but there is much much cost effect than get someone to do it when it's not necessary all the time or doesn't have to be, I suppose you want to call it 'certified'. | ID17 |
| 214 | 1:24:40.2 - 1:24:53.9 | Ok, well, this is the last question, in the next 5 to 10 years, how do you think additive manufaturing as a production process will influence design? | Interviewer A |
| 215 | 1:24:53.0 - 1:25:05.3 | I think that could be a great influence, for example, in metal printing, if the cost of printing reduces and it will by the time. | ID18 |
| 216 | 1:25:05.3 - 1:26:23.5 | I think I might have a slightly different view. I think the influence on design, I think it depends on the person designing it and the knowledge and experience. I think initially young designers, I think, yes, there is a lot of influence there. Then when you've done your first design, first print, I think then you'll realise that the views of perception that's been given out now is not necessary a full story. Also I think sometimes the technology's been advanced in such a way, such I know some of the technologies now will do a 14 micron layer which I think well that's fantastic, but is that actually what's needed and in most cases, the answer is no. What is needed is better accuracy and the quality on the outcomes, so that's repeatability and consistency, and actually lead times and I mean that's cost. As additive manufacturing metals, it sounds fantastic, but those are very high costs there and there is a lot of learning yet to be done, and that's why it's still in very early stages. No doubt I think it will come and they'll be a viable option in some cases but I don't think it will ever completely (replicate) machining. | ID17 |
| 217 | 1:26:23.4 - 1:28:03.5 | From my point of view, I think, one of the barriers to taking additive manufacturing forward is dinosaurs like themselves who sometimes find it difficult to think about different sorts of structures. I mean, one of good examples when you gave the tour at Loughborough University, there was some materials that had been printed as...looked like chain mail, you remember that? A little squares of material and this material just drape over pretty well in shape. Now I can't think of an application for us for that, but maybe in the future we might come across a...need to design a structure that has to have any (absorption) time, it may have spring back and it may not, it might be just one-off crash protection device or that's perfect for additive manufacturing because you can build all that complexity within the model, but it's thinking outside the box, it's just...say ok, we'll go down that way and then understanding how to analyse the whole structure to give the profile that you want. As human being, you are almost self limiting to some extent to where it goes next and that's where the university's playing a part role to keep looking to see what's over the horizon and feed that back to students because it's expanded massively, hasn't it, in all directions? | ID16 |
| 218 | 1:28:03.5 - 1:29:26.9 | I think the options to printing, we've all seen many videos and ideas, they are all there and they are possible I'm sure, but I think the key thing is still say is that actually practical? Because I think that the suppliers we use, they will not say well, it's actually...uh we print for fashion industry, print dresses, well looking at the material selections out there now, one is, ok, you wanna go and buy () clothing, keep you warm and comfort, as reusable as possible, so it's practical. Is that additive manufactured () clothing, is that practical? Or for the walking down, maybe the () the (photo shoe), yes, probably yes, but would you see that's on the high street everyday, can you reuse it, can you repair it, can you wash it, can you...suddenly all that coming five to ten years, well, until you can start taking maybe more than 25% of the high street stores, I don't think that's going to come. But maybe other agents may say (they are). Again that's all down to that word I've taken, is it actually practical? It cannot beat all what we already have, and until that happens, I think there's...uh, the influence on, as we explore it, I don't think people have realised... | ID17 |
| 219 | 1:29:26.9 - 1:29:37.3 | You live in a practical world. There is the other world of art and design where people are producing all sorts of complicated shapes which... | ID16 |
| 220 | 1:29:37.3 - 1:29:39.2 | I suppose that's practical for them. | ID17 |
| 221 | 1:29:39.2 - 1:30:37.3 | Yes, exactly. You know and also there is an awful lot of work being done in medical work, printing organs and replicates of organs dragged from ultrasound scans so that you can practice operations or something like that, tremendous exciting stuff. Is that practical? It is for them, it is determined by what the outcome needs to be, isn't it? I think people will remain, there will be people out there looking to do all sorts of interesting and clever things with the printing. For me, that's really exciting is that it wasn't that many years ago where rapid prototyping, is it called then, you know, you pick a part and, you know, you can just sort of snap it off like that, it's representative whereas now we are producing parts straight from the printer, which is phenomenal. | ID16 |
| 222 | 1:30:37.3 - 1:30:57.1 | Generally with the prototype, I mean, the only difference is we...or we can really point it as a prototype is it is white, it is generally a prototype because it's a cheaper material, whereas the grey one here, well, that's more than likely a finished item, or yeah, the quality issue. | ID17 |
| 223 | 1:30:57.1 - 1:31:00.5 | Right, anything else? | ID16 |
| 224 | 1:31:00.5 - 1:31:02.2 | No, we are done. | Interviewer A |
| 225 | 1:31:02.2 - 1:31:04.0 | Good, ok, do you need me to sign this? | ID16 |
| 226 | 1:31:04.0 - 1:31:11.9 | Please. Just about your educational background. Very quickly. If you can tell me your educational background? | Interviewer A |
| 227 | 1:31:11.9 - 1:31:27.3 | Studying Structural Engineering in Spain and then I did a Master in Manufacturing Engineering here in Derby. | ID18 |
| 228 | 1:31:27.3 - 1:31:39.3 | I initially started with the (med) sport technology, later moved to Mechanical Engineering. | ID17 |
| 229 | 1:31:39.3 - 1:31:56.9 | I did many many years ago a apprenticeship, did a HND, that's about it really. Carried on from there. | ID16 |
| 230 | 1:31:56.9 - 1:31:59.8 | How long have you been working as professional designers? | Interviewer A |
| 231 | 1:31:59.8 - 1:32:05.5 | That's two and a half years for me. | ID18 |
| 232 | 1:32:05.5 - 1:32:15.0 | Five and a half, almost six years now. | ID17 |
| 233 | 1:32:15.0 - 1:32:20.1 | 45 years. | ID16 |
| 234 | 1:32:20.1 - 1:32:35.7 | Ok, can you confirm it is ok for me to take some pictures and to have some copies of drawings? | Interviewer A |
| 235 | 1:32:35.7 - 1:32:46.3 | Yeah, I'd say the only one just, might be more cautious on there [ID17 means the transparent SLA part], anything else it's all our design products, so no problems at all. | ID17 |
| 236 | 1:32:46.3 - 1:32:49.6 | Are these projects in the public domain? | Interviewer A |
| 237 | 1:32:49.6 - 1:32:50.3 | Yes, mainly. | ID16 |
| 238 | 1:32:50.3 - 1:32:52.6 | Can we use it? | Interviewer A |
| 239 | 1:32:52.6 - 1:33:06.6 | We won't show you anything that was secret. I mean, there is anything (Stratasys) are going be doing, that could... | ID16 |
| 240 | 1:33:06.6 - 1:33:08.2 | (research water) | ID18 |
| 241 | 1:33:08.2 - 1:33:26.4 | [ID17] That doesn't give us the...[ID16 starts talking] It's just really this one, no, that one there, that's not doing anything just yet. Because that's gonna be coming out as an article and they get asked about it, not being brand new and brand new. | ID16 |
| 242 | 1:33:26.4 - 1:33:28.7 | Anything else can we use as case studies? | Interviewer A |
| 243 | 1:33:29.1 - 1:33:44.1 | Yes. There is also additive manfacturing and 3D printing section on our website with case studies, I think we've actually uploaded another one the other day, so there are eight there at the moment. If you've gone through any of those, some of these are actually on there already. | ID17 |
| 244 | 1:33:44.1 - 1:33:47.3 | There is also a news article as well, the Cardioplegia. | ID18 |
| 245 | 1:33:47.3 - 1:34:07.9 | And then, there is actually case study for these ones will be out in January as well. The smaller one, that's this one here. We are happy to give you the images as well, there is no problem at all. So the case study, I haven't officially finished writing it yet so that will be open there in January. | ID17 |
| 246 | 1:34:07.9 - 1:34:38.5 | Ok, so, generally speaking, the following weeks we will transcribe the interview and then we will send a copy to you. It will take a couple of weeks. And then you will be able to check the interview transcript, change anything you want, and eliminate or whatever. Then after that, we will probably publish the results. Do you prefer to be named or anonymised? | Interviewer A |
| 247 | 1:34:38.5 - 1:34:40.9 | We are happy to be named. | ID16, ID17 and ID18 |
| 248 | 1:34:40.9 - 1:34:43.4 | Generally speaking, we will try to anonymise everything. | Interviewer A |
| 249 | 1:34:43.4 - 1:35:06.5 | I don't mind. If you want to keep us anonymised, because that helps you, that's fine with us. From my point of view, we've invested a reasonable amount of time in this, are we allowed to say somewhere in our newsletters that we've been interviewed this. If you can give us a few words for that's about, that would be... | ID16 |
| 250 | 1:35:06.5 - 1:35:13.2 | I can send you...definitely () version of that. | Interviewer A |
| 251 | 1:35:13.1 - 1:35:23.3 | I suppose if that's possible, if you could just state why you wanted to interview us, if that's possible. | ID17 |
| 252 | 1:35:23.3 - 1:35:48.6 | It's helpful for us for our newsletters to have a...why did you come to us, what did you get out of working with us as a post of...let's wave a flag saying some people from well-known universities came and interviewed us. | ID16 |
| 253 | 1:35:48.6 - 1:36:23.8 | It will also be of help as well to read your research and the notes. In our news page as well, there is a few on there. I can email and give you a link directly but there is actually a video of myself about the additive manufacturing event we attended, giving our point of view. There are other events we have also attended in terms of metal printing, plastics, what are the benefits of them, if that's of any use there as well. | ID17 |
| 254 | 1:36:23.8 - 1:43:22.5 | [introduction of Company L and the D4AM project] | All |