Comments on "Effect of the surface free energy on the behaviour of surface and guided waves", by V. Vlasie Belloncle, M. Rousseau, Ultrasonics, 45 (2006) 188-195

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Short Communication

Comments on ‘‘Effect of the surface free energy on the behaviour of surface and guided waves”, by V. Vlasie Belloncle, M. Rousseau, Ultrasonics, 45 (2006) 188–195

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Abstract

In this short communication, it is demonstrated that the main results obtained by the authors of the commented paper, ‘‘Effect of the surface free energy on the behaviour of surface and guided waves ”, by V. Vlasie Belloncle, M. Rousseau, Ultrasonics, 45 (2006) 188–195, have been well-established long before publication of this paper. Therefore, the claim to novelty asserted by the authors is incorrect.

In the paper ‘‘Effect of the surface free energy on the behaviour of surface and guided waves”, by V. Vlasie Belloncle, M. Rousseau, Ultrasonics, 45 (2006) 188–195, the authors claim that they have obtained new results in their work. However, this is incorrect.

The paper aims to investigate the influence of surface properties of solids on the propagation of surface and guided acoustic modes, with a view of possible applications to ultrasonic characterisation of material surfaces and boundaries. In the Introduction, the authors say that their paper extends the existing theory of guided waves to other boundary conditions and to structures with boundaries different from the vacuum/solid interface already studied in the book [1]. They consider the following three topics in their paper: 1) Rayleigh wave at vacuum/solid interface, 2) Lamb waves in an elastic layer, 3) Guided waves in a metal/adhesive/metal structure. Note that, contrary to the above statement, the first two of these topics are clearly related to the ‘already studied’ case of the vacuum/solid interface.

The first of the above topics, to which the authors pay their main attention, concerns the effect of surface properties of solids on Rayleigh waves propagating along a vacuum/solid boundary. This and related problems have been described in detail in Chapter 15 of the book [1] (see also the review paper [2] representing the extended version of the above chapter). Although the authors recognise this fact, they nevertheless reproduce the derivations of [1] regarding the effect of surface tension on Rayleigh waves, using the same governing equations (see Eqns (10) – (14)) and the same boundary conditions (Eqn (15)). Unsurprisingly, these lead to the same dispersion equation for Rayleigh wave velocity (Eqn (16)) taking into account the effect of surface tension. There is nothing original in these authors’ derivations, apart from their doubtful use of terminology. Namely, instead of the established term ‘surface tension’ they use, incorrectly, the term ‘surface free energy’. This is in spite of the fact that, as it follows from the introductory Section 2.3 referring to the work of Shuttleworth [3] (see Page 189), they understand that for solids these terms are not the same.

The authors also repeat the approximate solution of the dispersion equation (16) in the low-frequency limit described in the book [1]. Like in [1], this solution shows that the velocity of Rayleigh wave grows linearly with frequency. Surprisingly, the authors portray this solution as their original result, without giving any reference.

Moreover, they continue and claim the prediction of the so-called critical value of frequency beyond which the Rayleigh wave velocity c_R becomes larger than the velocity of shear waves c_t and thus Rayleigh waves cease to exist. However, such a possibility, that follows from the above-mentioned approximate solution showing a linear increase of Rayleigh wave velocity with frequency, has been first noticed by Murdoch [4] and later discussed in the review paper [2]. In particular, it has been pointed out in [2] that at such extremely high frequencies, for which $c_R > c_t$, the classical phenomenological description of solids is no longer valid. At these frequencies, one has to apply discrete theories of atomic lattices or strongly non-local theories of elasticity to describe the dynamic motion of solid surfaces and to predict the frequencies at which Rayleigh waves cease to exist and become leaky. For the same reason, there is no point in numerical solution of the dispersion equation (16) in a wide frequency range, as shown by the authors in Fig. 8, since this equation is not valid at very high frequencies.

Note that taking into account surface tension only, as the authors are doing in their paper, describes only part of the real picture and thus can be of interest only for academic purposes. In particular, the dispersion equation accounting for surface tension only has been used in [1] to demonstrate a transition from Rayleigh waves in solids to capillary waves in liquids when the shear modulus of the solid tends to zero. In reality, mechanical properties of solid surfaces are characterised not only by surface tension but also by surface elastic moduli and surface mass density. The combined effect of all these surface parameters has been discussed in detail in [1] (see also [2]), dating back to the original contributions published in the 1970s. As it follows from this discussion (see e.g. Page 350 of [1]), for perfect crystal surfaces variations of Rayleigh wave velocity caused by surface elastic moduli may have the same orders of magnitude and the opposite signs to those caused by surface tension. The authors do not reflect these issues in any way, which makes their claim to practical relevance expressed in the Introduction quite unfounded.

The second of the topics considered by the authors concerns the effect of surface properties of solids on Lamb waves propagating in an elastic layer. This problem is also not new. Its brief discussion can be found in the already mentioned review paper [2] that refers back to the corresponding original contributions published in the 1980s. In particular, it has been pointed out in [2] that the influence of surface effects on Lamb wave velocities increases for thinner layers, as the ratio of the characteristic thickness of the subsurface layer to the total thickness of the elastic layer in this case becomes larger. The authors bring nothing new to the understanding of this problem via their numerical calculations of the dispersion curves shown in Fig. 11.

The third and final topic to which the authors claim novelty concerns guided waves propagating along boundaries between two different or similar solids. This topic has been considered in great detail in the review paper [5] that is not cited by the authors. The paper [5] gives a comprehensive macroscopic description of the dynamic properties of thin transition layers of various nature at the interface between two solids. It also considers, among other problems, the influence of such transition layers on the dispersion characteristics of different guided waves propagating along the interface. Thus, like in the previous two cases, the authors' results on this topic can be hardly considered as novel.

Resuming the above, in all three topics considered by the authors, the main results have been well-established long before publication of the paper ‘‘Effect of the surface free energy on the behaviour of surface and guided waves ”, by V. Vlasie Belloncle, M. Rousseau, Ultrasonics, 45 (2006) 188–195. Therefore, the claim to novelty asserted by the authors is incorrect.

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