SURFACE WAVE IN A NON-PLANAR FGPM COMPOSITE STRUCTURE HAVING IMPERFECT INTERFACE

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Abstract

This work unfolds the propagation characteristics of Love-type wave in a corrugated functionally graded piezoelectric material (FGPM) layer imperfectly bonded to a fiber-reinforced composite half-space. Exact dispersion relation has been established analytically by employing variable separable technique for both the cases of electrically open and short conditions. Numerical computation has been performed by taking into account lithium tantalate and graphite materials for the FGPM layer and fiber-reinforced composite half-space respectively. The dependence of phase velocity of Love-type wave on wave number has been depicted graphically for specific type of corrugated boundary surfaces for both the aforementioned conditions. The emphatic impacts of imperfect bonding, corrugated boundary present in the layer and material properties of the layer on the phase velocity of Love-type wave have been remarkably traced out. It is worthwhile mentioning that imperfect bonding of the interface diminishes the phase velocity of Love-type wave profoundly. Classical Love wave equation has been recovered as the limiting case when both the medium are elastic, homogeneous and perfectly bonded with planar interfaces for both the electrical conditions.

1. Introduction

Being one of the smart materials, piezoelectric materials have become cynosure in this digital age due to their inherent property, indispensable characteristics and brilliant ability of sensing, actuating as well as controlling. Owing to this, the study of propagation of surface waves in piezoelectric structures has been a subject of investigation over the past decades. In any realistic model, the boundaries of the layer of the material medium are not perfectly plane rather irregular or corrugated in nature to a certain extent. The presence of such boundaries usually has a significant impact on the propagation of surface waves [1, 2, 3]. Moreover, there is also a prominent influence of imperfect interface on the surface waves in any structure [4]. In view of this, it becomes obligatory to consider these traced elements for the execution of a more accurate modeling procedures and a better interpretation of the results. Motivated by these pragmatic notions, an attempt has been made to get a practical insight into the problem by assuming corrugated boundary surfaces and imperfectness in the structure under investigation.

2. Basic assumptions

A corrugated FGPM stratum imperfectly bonded with a fiber-reinforced composite substrate has been considered as delineated in Figure 1. Let us assume a Cartesian co-ordinate system in such a way that y-axis is in the direction of Love-type wave propagation and x-axis is pointing vertically downwards with origin O placed at the common interface between the layer and the half-space. The piezoelectric material is polarized in z-direction and the material properties change exponentially with depth. The average thickness of layer is h. The upper corrugated boundary surface and corrugated common interface are defined by $x=\eta_1(y)-h$ and $x=\eta_2(y)$ respectively, where $\eta_1(y)$ and $\eta_2(y)$ are continuous periodic functions.

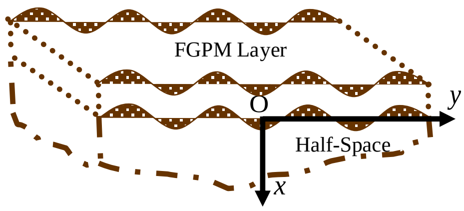

Figure 1. Geometry of the problem.

3. Conclusions

The following remarkable consequences can be drawn as major distinctive attribute of the study:

1. The phase velocity of Love-type wave starts from a certain phase which steps down with a rise in wave number and finally approaches to its minimum value for a specific wave number.
2. The imperfect bonding of the interface reduces the phase velocity of Love-type wave substantially for both the cases of electrically open and short conditions.
3. The phase velocity of Love-type wave gets decreased with an increase in the value of piezoelectric constant of FGPM layer for both the electrical conditions.
4. For both the cases of electrically open and short conditions, the gradient factor of the FGPM layer steps up the phase velocity of Love-type wave.
5. The phase velocity of Love-type wave falls off with rise in corrugation parameter of common interface between the layer and the half-space for both the electrical conditions.

In view of the above computational results of the study, it is evident that material properties of the FGPM layer, corrugated boundary present in the layer and imperfect bonding of the interface enable Love-type wave to propagate along the surface of the layer, leading to the confinement of wave for a longer duration. As the response of type of interface plays a vital role in the design of the device, therefore, these consequences can be widely utilized in the design of surface acoustic wave (SAW) devices and Love wave sensors to enhance their efficiency and achieve high performance.

4. References

[1] A.K. Singh, S. Kumar and A. Chattopadhyay (2015). Love-type wave in a piezoelectric structure with irregularity, *Int. J. Eng. Sci.*, **89**, 35-60.

[2] A.K. Singh, Z. Parween and S. Kumar (2016). Love-type wave propagation in a corrugated piezoelectric structure, *J. Intel. Mat. Syst. Str.*, doi: 10.1177/1045389X16635843.

[3] A. Chattopadhyay and A.K. Singh (2012). Propagation of magnetoelastic shear waves in an irregular self-reinforced layer, *J. Eng. Math.*, **75**, 139-155.

[4] J. Liu, Y. Wang and B. Wang (2010). Propagation of shear horizontal surface waves in a layered piezoelectric half-space with an imperfect interface, *IEEE T. Ultrason. Ferr.*, **57**, 1875-1879.