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Shear horizontal wave in multilayered piezoelectric structures: Effect of frequency, incidence angle and constructive parameters

R. Rodríguez-Ramos [a,*], H. Calás [b], J.A. Otero [c], V. Guerra [c], A. Ramos [b], Y.S. Wang [d]

[a] Facultad de Matemática y Computación, Universidad de La Habana, San Lázaro y L, Vedado, Habana 10400, Cuba
[b] Grupo. Señales, Sistemas y Tecnologías Ultrasónicas (CAEND-CSIC), Serrano 144, 28006 Madrid, Spain
[c] Instituto de Cibernética, Matemática y Física, Calle 15, No. 551, Vedado, Habana 10400, Cuba
[d] Institute of Engineering Mechanics, School of Civil Engineering, Beijing Jiaotong University, Beijing 100044, China

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ABSTRACT

In this paper, the global matrix method is applied to find the behavior of transmission coefficients for shear horizontal (SH) wave propagation with oblique incidence in piezocomposite layered systems. The elemental periodic cells of these piezocomposites are formed by two types of components: a piezoelectric PZT material and an Araldite polymer. The behavior of the transmission coefficient with respect to the frequency, incidence angle and piezoelectric volume fraction is studied. Some numerical calculations for different configurations of the composite are shown. The influence of the bonding films made of polymeric material is also studied. These results could be used to versatile transducers design.

1. Introduction

The interest in the application of piezoelectric material devices has attracted attention to the reflection and refraction between solids and piezo-composite. For instance, see the works of Shuvalov and Lothe (1997) and Burkov et al. (2005). Recently, reflection and transmission coefficients of plane waves with oblique incidence to a multilayered system of piezomagnetic and/or piezoelectric materials have been investigated by many other authors, such as, Shuvalov and Gorkunova (1999), Alvarez-Mesquida et al. (2001), Li and Wang (2005), Yu et al. (2008), and Chen et al. (2008).

This work is related to the numerical modeling of the SH-wave scattering in layered structures formed by a piezoelectric crystal with 6 mm symmetric and isotropic polymers. We are interested in analyzing numerically the influence of the materials and the layer thickness on the reflection and transmission of the waves. In particular, we consider the effect of the thin polymer film that usually bonds the piezoelectric structures in the transmission spectrum.

This study is based on the analysis of the transmission and reflection coefficients when the frequency and the incidence angle are varied. The numerical calculation of the coefficients is performed by using the global matrix technique (Knopoff, 1964; Lowe, 1995) combined with a scaling technique to improve the conditioning of the linear system involved into the method (Calás et al., 2010).

The main contribution of this work is the design and analysis of a numerical simulation that shows the strong relation between the interference effects within the layers and the existence of values of the incidence angle where the transmission is maximum. The numerical experiments suggest that the polymer films that bond the laminated piezocomposite act as spatial filters whereby the reflection is only present for some values of the incidence angle of the wave. These results can have an impact at the design stage of transducers.

The rest of the paper is organized as follows: Section 2 introduces basic definitions and gives a brief presentation of the general SH wave solution. In Section 3, we present the global matrix technique as an alternative method for calculating the transmission and reflection coefficients that is particularly useful when the number of layers is large. The numerical simulation is proposed and discussed in Section 4. The paper closes with the conclusions suggested by the numerical study.

2. Statement of the problem and general SH wave solution

The scattering that occurs when a SH wave impinges with angle θ upon a laminated piezoelectric composite is analyzed. We assume that the SH wave propagates in the *XY* plane and that it is polarized along the *OZ* axis. We will consider a finite multilayered composite embedded between two semi-infinite piezoelectric media, see Fig. 1. The composite is made of η cells, which consist

* Corresponding author. Tel.: +53 7 832 2466; fax: +53 763 7480.
E-mail address: reinaldo@matcom.uh.cu (R. Rodríguez-Ramos).

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