THE SCATTERING OF GENERAL SH PLANE WAVE BY INTERFACE CRACK BETWEEN TWO DISSIMILAR VISCOELASTIC BODIES

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ABSTRACT: The scattering of general SH plane wave by an interface crack between two dissimilar viscoelastic bodies is studied and the dynamic stress intensity factor at the crack-tip is computed. The scattering problem can be decomposed into two problems: one is the reflection and refraction problem of general SH plane waves at perfect interface (with no crack); another is the scattering problem due to the existence of crack. For the first problem, the viscoelastic wave equation, displacement and stress continuity conditions across the interface are used to obtain the shear stress distribution at the interface. For the second problem, the integral transformation method is used to reduce the scattering problem into dual integral equations. Then, the dual integral equations are transformed into the Cauchy singular integral equation of first kind by introduction of the crack dislocation density function. Finally, the singular integral equation is solved by Kurtz's piecewise continuous function method. As a consequence, the crack opening displacement and dynamic stress intensity factor are obtained. At the end of the paper, a numerical example is given. The effects of incident angle, incident frequency and viscoelastic material parameters are analyzed. It is found that there is a frequency region for viscoelastic material within which the viscoelastic effects cannot be ignored.

KEY WORDS: viscoelasticity, interface crack, general plane wave, integral transformation, singular integral equations

1 INTRODUCTION

The scattering problem of interface cracks is of importance in theoretical analysis and engineering applications. It is an important aspect of dynamic fracture mechanics of interfaces, and can provide necessary information for the techniques of nondestructive evaluation (NDE). The problem can be separated into two problems: the first is the reflection and refraction problem at a perfect interface; the second is the scattering problem due to the existence of a crack.

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For linear elastic materials, the reflection and refraction of elastic wave have been studied widely. Miklowitz\cite{1} and Achenbach\cite{2} both gave detailed discussions. The scattering problem of interface cracks was studied firstly by Srivastava\cite{3,4} on Griffith and penny-shaped cracks. Yang & Body\cite{5} considered the scattering of an elastic wave at the interface crack in a layered half-space. The scattering of SH elastic waves at the far field from a Griffith interface crack was investigated by Bostrom\cite{6}. The scatterings of P and S waves by single or multiple interface crack in layered medium were studied by Ma et al.\cite{7} and Zhang et al.\cite{8}. Qu\cite{9,10} studied the scattering at the near field and far field of a Griffith interface crack by using singular integral equation.

For viscoelastic materials, it is the viscoelastic wave that propagates. There are three important characteristics in which viscoelastic wave is different from elastic wave: 1) attenuation, 2) dispersion, and 3) movement coupling (i.e. the movement track of mass point is elliptical for P and S waves). These characteristics require the introduction of complex wave number and complex wave speed, which adds difficulties for the analysis. The studies of reflection and refraction of general plane wave dated back to the sixties when Lockett\cite{11} firstly investigated the reflection and refraction of P and S waves at free boundary and interface. It was found that reflection and refraction wave would be a fan-shaped section for compound incident waves. The investigation by Cooper\cite{12,13} on the same problem has identified the phase shift phenomena between reflection or refraction wave and incident wave. Schoenberg\cite{14} studied the reflection and refraction of SH wave and associated energy flow. Borchert\cite{15} studied the reflection and refraction of P and S wave and critical angle for incident wave. But the investigations of the scattering problem of viscoelastic wave by crack are rare. Only Georgiadis\cite{16,17} studied the dynamic response due to a sudden load for Griffith and penny-shaped cracks in homogenous viscoelastic bodies.

In this paper, the scattering problem of general SH plane wave due to an interface crack between two dissimilar viscoelastic bodies are considered, and the numerical results are obtained for the case of a Standard Linear Solid. The numerical study reveals an interesting feature: there is a frequency influence region existing for viscoelastic materials within which the viscoelastic effects cannot be ignored. In addition, the method in this paper can be used to study the scattering of P or SV waves.

2 FORMULATION OF THE PROBLEM

We consider a Griffith interface crack of length 2a between two dissimilar, homogenous, isotropic, and linear viscoelastic solids of half-spaces. A Cartesian coordinate system is assumed in such a way that the x-axis is along the crack direction and the y-axis is perpendicular to crack direction, as shown in Fig.1. The crack is infinite wide in z-direction.

\[
G_i(t) = \mu_{\infty}\left[1 + \frac{1}{\tau_i}\exp\left(-\frac{t}{\tau_i}\right)\right] (i = 1, 2)
\]  

(1)

\[\begin{array}{c}
\rho_2G_2(t) \\
\rho_1G_1(t)
\end{array}\]

\[\begin{array}{c}
2a \\
\text{SH}
\end{array}\]

Fig. 1 General SH plane incident wave on the interface crack between two dissimilar viscoelastic bodies