Advances in Applied Mathematics and Mechanics
Adv. Appl. Math. Mech., Vol. **3**, No. 2, pp. 219-238

DOI: 10.4208/aamm.10-m1016
April 2011

Viscosity and Diffusion Effects at the Boundary Surface of Viscous Fluid and Thermoelastic Diffusive Solid Medium

Rajneesh Kumar*, and Tarun Kansal

Department of Mathematics, Kurukshetra University, Kurukshetra-136 119, India

Received 10 March 2010; Accepted (in revised version) 12 November 2010
Available online 5 January 2011

Abstract. This paper concentrates on the wave motion at the interface of viscous compressible fluid half-space and homogeneous isotropic, generalized thermoelastic diffusive half-space. The wave solutions in both the fluid and thermoelastic diffusive half-spaces have been investigated; and the complex dispersion equation of leaky Rayleigh wave motion have been derived. The phase velocity and attenuation coefficient of leaky Rayleigh waves have been computed from the complex dispersion equation by using the Muller's method. The amplitudes of displacements, temperature change and concentration have been obtained. The effects of viscosity and diffusion on phase velocity and attenuation coefficient of leaky Rayleigh waves motion for different theories of thermoelastic diffusion have been depicted graphically. The magnitude of heat and mass diffusion flux vectors for different theories of thermoelastic diffusion have also been computed and represented graphically.

AMS subject classifications: 35Q80, 37D35, 74F05, 76N17, 80A17

Key words: Viscous compressible fluid, isotropic, thermoelastic diffusion, phase velocity, attenuation coefficient.

1 Introduction

The problem of fluid-structure interaction is wide and covers many types of both fluid and structural behavior. Such problems can be interesting for researching processes of vibrodisplacement and localization, decontamination of liquid medium, airing and dispersion; in bioacoustics and cardiovascular medicine (for instance, for some problems involving blood flow, where fluid and structures models are coupled); in non-destructive testing (for instance, the scattering of acoustic waves can give important information about the internal composition of solids and fluids, yielding information about internal inhomogeneities, asymmetries and defects from the scattering system);

*Corresponding author.
Email: rajneesh_kuk@rediffmail.com (R. Kumar), tarun1_kansal@yahoo.co.in (T. Kansal)

in technologies of resumption of oil production in foul wells, etc. For many years, numerous authors have been interested in dynamics of fluid-structure interaction both for unbounded domains of either fluid or structure and for delimited ones, involving both motionless and flowing fluids.

Sorokin and Terentiev [26] investigated the effects of generation and transmission of the vibro-acoustic energy in an elastic cylindrical shell filled with water. Sorokin [27] discussed the assessment of the validity of elementary models of wave propagation in an isotropic elastic layer under heavy fluid loading as well as analysis of coupling effects due to uneven fluid loading. Sorokin and Chubinskij [28] studied free wave propagation and attenuation in elastic plates loaded by a quiescent viscous compressible fluid. Ashour [6] discussed wave motion in a viscous fluid-filled fracture. Hasheminejad and Safari [12, 13] studied dynamic viscoelastic effects on sound wave diffraction by spherical and cylindrical shells submerged in and filled with viscous compressible fluids and acoustic scattering from viscoelastically coated spheres and cylinders in viscous fluids. Nayfeh and Nagy [17] investigated the problem of excess attenuation of leaky Lamb waves due to viscous fluid loading in which they also studied the propagation of leaky rayleigh waves at the interface of viscous compressible fluid half-space and homogeneous isotropic elastic half-space.

The classical theory of thermoelasticity is based on the Fourier's heat conduction theory which assumes that the thermal disturbances propagate at infinite speed. This prediction is unrealistic from the physical point of view, particularly in situations like those involving very short transient durations, sudden high heat flux exposures, and at very low temperatures near the absolute zero. In the last two decades, two different generalizations of the classical theory of thermoelasticity were developed which predict the so-called second-sound effects, that is, which predict only finite velocity of propagation for heat and displacement fields. Lord and Shulman [16] incorporated a flux rate term into the Fourier's law of heat conduction and formulated a generalized theory admitting finite speed for thermal signals. Green and Lindsay [11] have developed a temperature rate dependent thermoelasticity by including temperature rate among the constitutive variables, which does not violate the classical Fourier's law of heat conduction when the body under consideration has a center of symmetry, and this theory also predicts a finite speed of heat propagation. The Lord and Shulman [16] theory of generalized thermoelasticity was further extended to homogeneous anisotropic heat conducting materials recommended by Dhaliwal and Sherief [8]. Chanderashekhariah [7] refers to this wave like thermal disturbance as second sound. A survey article of various representative theories in the range of generalized thermoelasticity have been brought out by Hetnarski and Ignaczak [14].

The spontaneous movement of the particles from high concentration region to the low concentration region is defined as diffusion and it occurs in response to a concentration gradient expressed as the change in the concentration due to change in position. The thermodiffusion in elastic solids is due to coupling of fields of temperature, mass diffusion and that of strain in addition to heat and mass exchange with environment. Thermal diffusion utilizes the transfer of heat across a thin liquid or gas