Summary of the Thesis

Thermoelasticity is a branch of applied mechanics concerned with the effect of heat on the deformation and stresses in solid bodies which are considered to be elastic. The classical uncoupled theory of thermoelasticity predicts two phenomena not compatible with physical observations. First, the equation of heat conduction of this theory does not contain elastic term; second, the heat conduction equation is of a parabolic type, predicting infinite speeds of propagation for heat waves.

The theory of coupling of thermal and strain fields gives rise to the coupled theory of thermoelasticity and was first postulated by Duhamel (1837). He derived the equations for the distribution of strains in an elastic medium subjected to temperature gradient and introduced the dilatation term in the heat conduction equation, but this equation was not on a thermodynamic basis. Neuman (1855), Voigt (1910) and Jeffreys (1930) made attempts at thermodynamical justification of equations of Duhamel’s theory and solved a number of interesting problems. The work of Biot (1956) gave a satisfactory derivation of heat conduction equation, which includes the dilatation term based on thermodynamics of irreversible process.

Lord and Shulman (1967) formulated a generalized theory of thermoelasticity with one thermal relaxation time, who obtained a wave-type equation by postulating a new law of heat conduction instead of classical Fourier’s law. Green and Lindsay (1972) developed a temperature rate-dependent thermoelasticity that includes two thermal relaxation times and does not violate the classical Fourier’s law of heat conduction. One can refer to Hetnarski and Ignaczak (1999) for a review and presentation of generalized theories of thermoelasticity.

Diffusion is defined as the spontaneous movement of the particles from a high concentration region to the low concentration region and it occurs in response to a concentration gradient expressed as the change in the concentration due to change in position. Thermal diffusion utilizes the transfer of heat across a thin liquid or gas to accomplish isotope separation. Today, thermal diffusion remains a practical process to separate isotopes of noble gases (e.g. xenon) and other light isotopes (e.g. carbon) for
research purposes. The work on the theory of thermoelastic with mass diffusion is started recently with three papers by Podstrigach (1961), Podstrigach and Pavlina (1965,1965), who gave the relationship between the deformation, temperature and concentration based upon thermodynamics of irreversible processes.


Tzou (1995) introduced two-phase lags to both the heat flux vector and the temperature gradient and considered constitutive equations to describe the lagging behavior in the heat conduction in solids. Raychoudhuri (2007) has recently introduced the three-phase-lag heat conduction equation in which the Fourier law of heat conduction is replaced by an approximation to a modification of the Fourier law with the introduction of three different phase-lags for the heat flux vector, the temperature gradient and thermal displacement gradient.

In ordinary, classical continuum mechanics the basic assumption is that the effect of microstructure of a material is not essential for describing mechanical behavior. Such an approximation has been shown in many well-known cases. Often, however discrepancies between the classical theory and experiments are observed, indicating that microstructure must be important. Voigt (1887) was the first who tried to remove the shortcomings of the classical theory of elasticity by assuming that the interaction between two parts of body through an area element is transmitted not only by the action
of a force vector but also by a moment vector. This led to the existence of couple stress.

Eringen (1966a, 1966b), introduced the theory of micropolar elasticity, in which some consideration is taken to the micro-structure. The motion is here described not only by a deformation but also by a microrotation giving six degrees of freedom. The interaction between two parts of a body is transmitted not only by a force but also by a torque, resulting in asymmetric force stresses and couple stresses. On the volume element might both body forces and body couples act. Physically, solid propellant grains, polymeric materials and fiberglass are examples for such materials.

Nowacki (1966) and Eringen (1970) extended the theory of micropolar elasticity to include the thermal effect and is known as the theory of micropolar thermoelasticity. Aouadi (2009) derived the general equations of motion and constitutive equations, based on the theory of Lord–Shulman with one relaxation time for a general homogeneous anisotropic medium with a microstructure, taking into account the effects of heat and diffusion.

**Plan of the thesis is as follows:** This thesis consists of our more chapters and a reference list in the end of the thesis.

In chapter 2, the fundamental solution and Green’ functions for two-dimensional problem in orthotropic thermoelastic diffusion media are derived. With this objective the two-dimensional general solution in orthotropic thermoelastic material is derived firstly. On the basis of general solution, the fundamental solution and Green’s functions for a steady line heat source in a semi-infinite orthotropic thermoelastic diffusion material are derived. The components of displacement, stress, temperature change and mass concentration are expressed in terms of elementary functions. The resulting quantities are computed numerically and presented graphically. Some special cases are also deduced.

Chapter 3 concerns with the propagation of plane waves in anisotropic thermoelastic with three-phase-lag model. The governing equations for homogeneous, transversely isotropic thermoelastic with three-phase-lag and two-phase-lag are
deduced as a special case. When plane waves propagate in a principle plane of transversely thermoelastic three-phase-lag model, purely transverse wave mode decouple from the rest of the motion and is not affected by the thermal variation. The different characteristics of waves like phase velocity, attenuation coefficient, specific loss and penetration depth are computed numerically and presented graphically. Some special cases are also deduced.

In chapter 4, the fundamental solution for three-dimensional problem in transversely isotropic thermoelastic diffusion medium is derived. After applying the dimensionless quantities and using the operator theory, we have derived the general expression for components of displacement, temperature change, mass concentration and stress components in Cartesian coordinate as well as in cylindrical polar coordinates. On the basis of general solution, three dimensional fundamental solutions for a steady point heat source in an infinite and semi-infinite transversely isotropic thermoelastic diffusion media are obtained by introducing four newly harmonic functions. The components of displacement, temperature change and mass concentration are computed numerically and presented graphically for the considered model. Some special cases are also deduced.

In chapter 5, the problem of reflection and transmission phenomenon due to longitudinal and transverse waves obliquely incident at a plane interface between uniform elastic solid half-space and a micropolar thermoelastic diffusion solid half space is investigated. It is noticed that reflections and transmission coefficients are functions of angle of incidence, frequency and are influenced by the micropolarity of the media. The energy ratios of different reflected and transmitted waves to that of incident wave are computed numerically and presented graphically with respect to the angle of incidence. It is verified that during transmission there is no dissipation of energy at the interface. A special case is also deduced.
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