SYNOPSIS

Gyarmati in 1969 developed a variational principle which is fairly general and can be used to describe the evolution of linear, quasi-linear and non-linear irreversible processes. Onsager's principle of least dissipation of energy, Glansdorff and Prigogine's local potential method, Biot's Lagrangian thermodynamics are particular cases of this principle called governing principle of dissipative processes and henceforth referred to as G.P.D.P.

The present thesis demonstrates the applicability of an approximate method, based on G.P.D.P., for solving non-linear transport equations of some non-equilibrium processes basic to fluid mechanics and heat conduction phenomena. The specific problems considered in this thesis are

1) Boundary layer flow and heat transfer along a flat plate.

2) Stagnation point flow in two dimensions and forced convective heat transfer near the forward stagnation point of a cylinder.
3) Free convection boundary layer flow past a semi-infinite vertical plate.
4) Heat conduction in solids.

The thesis consists of six chapters. The first chapter is introductory and gives an outline of the basic concepts and equations, and a review of the literature directly related to our work.

In Chapter II are derived the equations of thermo-hydrodynamics from the universal form of G.P.D.P. The need for such an analysis arises from the difficulty experienced in constructing suitable variational principles which yield Navier-Stokes equations as their Euler-Lagrange equations. By expressing Gyarmati's principle in energy form, it is shown that a suitable functional exists which admits Navier-Stokes and energy equations as the Euler-Lagrange equations. Following the treatment of Vincze it is further shown that the supplementary theorem of Gyarmati holds good in quasi-linear cases also.

Chapter III is devoted to the applications of Gyarmati's variational principle for obtaining solutions of boundary layer flow and heat transfer along a flat plate. The chapter is divided into two sections - A and B. Section A deals with the problem of viscous flow along a flat plate. It is found that the variational solution differs by about 4 percent from the exact numerical solution when a trial function for velocity profile is assumed to be a polynomial of third degree. The result obtained with the help of Force representation of Gyarmati's principle is identical with that obtained by Weihs and Gal-Or with the help of local potential method of Glansdorff and Prigogine. The accuracy of the solution can be improved by taking a higher degree polynomial for velocity profile. It is found that with a sixth degree polynomial the variational solution differs by only 0.65 percent from the exact result. Section B discusses the application of G.P.D.P. to the problem of thermal boundary layer along a flat plate. It is seen that the rate of heat transfer computed for various Prandtl numbers with the help of G.P.D.P. is quite close to the exact numerical values.

In Chapter IV we have developed the variational solution for flow and heat transfer near a stagnation point. In section A of this chapter, we apply the new approximate method based on the theory of non-equilibrium processes to solve viscous laminar stagnation point flow in two dimensions. The governing principle of dissipative processes is formulated for the problem and then dual field method is used to get variational solution of the problem. The boundary layer thickness and shear stress at the wall obtained with the help of universal representation of the principle are quite close to the exact values given by Howarth, the error being less than

4 percent. Results obtained are compared with the results based on local potential method of Glansdorff and Prigogine, and variational principle of Lebon and Lembermonet. In section B of this chapter, the governing principle of dissipative processes is used to study the forced convective heat transfer near the forward stagnation point of a heated cylinder when an incompressible viscous fluid flows around it.

In Chapter V we have considered the problem of free convection from a heated vertical semi-infinite plate. It is found that the rate of heat transfer computed for various Prandtl numbers using the present variational approach is quite close to the exact numerical result.

Chapter VI deals with the phenomenological theory of heat conduction in solids. A variational solution of the problem is developed. This chapter is divided into three sections A, B, and C. Section A gives the general formulation of heat conduction problem and section B establishes the equivalence of flux representation of G.P.D.P. and Biot's Lagrangian thermodynamics. In section C, we consider as particular examples the problems of linear heat conduction in semi-infinite and finite solids. We show that the results obtained with G.P.D.P. differ by about 2 percent from the exact result. We further find that the results obtained with universal form of G.P.D.P. are better than those obtained by Goodman Integral method which is widely used to study heat conduction problems.