ABSTRACT

The Study of Coupled Fluid Flows and Heat Transfer in Permeable Boundaries

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This thesis examines heat transfer of steady, coupled fluid flow involving Newtonian, incompressible fluids past porous media. In the problems that follow, the porous substrate is modelled using a transition Brinkman region overlying a Darcy layer, combined within rectangular, cylindrical and spherical configurations.

In the first problem, laminar flows of two immiscible fluids past a channel with a lower permeable wall are considered. The cases of Plane Couette, Generalized Couette and Poiseuille flow are examined. Each case is developed and solved analytically, with investigations of various parameters on the Nusselt number, velocity and temperature profiles. Applications of this model include the use of thermal barrier coatings on airplanes, treatment of heating systems, and heat extraction within geothermal systems.

Secondly, flow and heat transfer is considered for the case of fluid between a rotating solid and a stationary permeable disk. A two step analytical and numerical process is employed to solve the problem. Series expansions are first utilized to yield analytical approximations, while a Runge-Kutta algorithm is subsequently implemented to numerically evaluate relevant profiles and streamlines. These are discussed in reference to parameters including Reynolds number and permeability. One may apply this model in the context of oil extraction techniques and suction design in vacuum cleaners.

In the third study, the creeping flow past a porous approximate shell is investigated. The shell consists of fluid and porous substrate with a Darcy region sandwiched between two Brinkman layers. Analytical solutions for both the flow and heat transfer are constructed with the use of relevant expansions, after which graphs of streamlines and isotherms are presented. This problem may be applied to insulation design within buildings, as well as heat extraction within volcanic terrain.

Keywords: Dayle Chandan Jogie; Porous; Brinkman; Darcy; Hill and Straughan; Coupled Fluid Flow; Disk; Channel; Spherical Shell