Synopsis of Ph.D. Programme

Title of the Research:

Numerical Study of Heat and Mass Transfer in a Thin Liquid Film of Nanofluids on an Unsteady Stretching Sheet

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Nanofluids are a relatively new class of fluids which consist of a base fluid with nano-sized particles (1-100 nm) suspended within them. The term “Nanofluid” was first proposed by Choi (1995), referring to the dispersion of the nanoparticles in the base fluids such as water, ethylene glycol, propylene glycol. These particles are generally a metal or metal oxide which may increase conduction and convection coefficients for allowing more heat transfer out of the coolant. The main advantages of nanofluidsare that they are more stable and have acceptable viscosity and better wetting, spreading and dispersion properties on solid surface. In particular, nanofluids are suspensions of nanoparticles in the base fluids that show significant enhancement of their properties at modest nanoparticle concentrations. In this new age of energy awareness, the research on heat transfer in nanofluids has been receiving increased attention worldwide. Many researchers have found unexpected thermal properties of nanofluids, and are proposing new mechanisms behind the enhanced thermal properties of nanofluids.In many industrial applications such as power generation, microelectronics, heating processes, cooling processes and chemical processes; water, mineral oil and ethylene glycol are used as heat transfer fluid. Effectiveness and high compactness of heat exchangers are obstructed by the lower heat transfer properties of these common fluids as compared to most solids. It is obvious that solid particles having thermal conductivities several hundred times higher than these conventional fluids must be used in the heat transfer applications. To improve thermal conductivity of a fluid, suspension of ultrafine solid particles in the fluid can be acreative idea. Different types of particles (metallic, non-metallic and polymeric) can be added into fluids to form slurries.

In the literature, the experimental results usually show that theflow velocity and volume fraction affected the convective heattransfer coefficient of the nanofluids as well as being higher thanthe base fluid at the same conditions. The Nusselt number of thenanofluidwith 2% volume fraction of Cu particles can be 60%higher as compared to water.Nanofluid is considered more like a fluid rather than a liquid-solid mixture by some researchers. There are few articles treating thenanofluid as to have the multiphase feature. According to earlier researches, thermal conductivity has come into the limelightas most studied transport properties of the nanofluid. It was evident from the obtained result that when the nanoparticles were added to the base fluid, heattransfer characteristics were significantly enhanced.The convectiveheat transfer of nanofluids has comparatively been less acclaimedin literature therefore the number of the publications dealingwith the convective heat transfer of nanofluids is limited.They used three different primary nanofluid of CuO, Al_2O_3, and TiO_2.

The study of boundary layer flow and heat transfer due to stretching surface has numerous applications in industry and technology, such as aerodynamic extrusionof plastic sheets and continuous casting, rolling, annealing and thinning of copper wires, artificial fibers, paper production wire drawing, glass fiber, metal extrusion and metal spinning, wire and fiber coating, cooling of metallic plates and continuous stretching of plastic films. In the extrusion process this understanding is crucial for maintenance of the surface quality of the extrudate.Crane(1970) first studied the boundary layer flow due to linearly stretching sheet and gave an exact solution for the problem of steady two-dimensional boundary layer flow caused by the stretching of a sheet which moves in its own plane with velocity varying linearly with distance from a fixed point. The problem of flow,heat and mass transfer over a stretching sheet in the presence of suction or blowing was examined by Gupta and Gupta(1977).The hydrodynamics of a flow in a thin liquid film driven by an unsteady stretching surface was first investigated by Wang(1990).His work was subsequently extended by Dandapat et al.(2000). The boundary layer flow over a semi infinite unsteady stretching sheet was done by El-Aziz (2010) and analyzed the effect of Hall currents on the flow and heat transfer of an electrically conducting fluid over an unsteady stretching surface in presence of a strong magnetic field.Abel et al. (2009)investigated the heat transfer in a liquid film on an unsteady stretching surface with viscous dissipation in presence of external magnetic field. Liu and Megahed (2012)considered numerical study for the flow and heat transfer in a thin liquid film over an unsteady stretching sheet with variable fluid properties in the presence of thermal radiation. Noor and Hashim (2010) analyzed the thermocapillarity and magnetic field effects in a thin liquid film on an unsteady stretching surface.

The boundary layer flow of nanofluid past a linearly stretching sheet was first studied by Khan and Pop (2010). The boundary layer flow induced in a nanofluid due to a linearly stretching sheet with convective boundary condition was described by Makinde and Aziz (2011). Kandasamy et al. (2011) investigated the MHD boundary layer flow of a nanofluid past a vertical stretching permeable surface with suction/injection. Rana and Bhargava (2012) illustrated the steady, laminar boundary layer flow due to the nonlinear stretching of a flat surface in a nanofluid. Hady et al. (2012) studied the radiation effect on viscous flow of a nanofluid and heat transfer over a nonlinearly stretching sheet. Recently, Bhattacharyya andLayek (2014) studied on magnetohydrodynamic boundary layer flow of nanofluid over an exponentially stretching permeable sheet. Gul et al. (2014) considered the thin film flow in MHD third grade fluid on a vertical belt with temperature dependent viscosity.

The study of convective flow heat transfer in the presence of magnetic field and thermal radiation has been an active field of research as it plays a crucial role in diverse applications, such as thermal insulation, and chemical catalytic reactors etc. The analysis of convective transport in liquid thin film with the inclusion of MHD and thermal radiation effects would also been a matter of the present research work. Due to its important applications in many fields as mentioned above, a full understanding of heat transfer in thin liquid film under various constraints is meaningful. Thus during my Ph.D. work I shall be doing various problems to study the effects of thermal radiation, magnetic field, viscous dissipation and Ohmicdissipation, uniform and non-uniform heat generation/absorptions, and suction/injections effects on free and mixed convection along a vertical plate in a thin liquid filmover an unsteady stretching sheet consideringnanofluids. The physical problems would be modeled using non-linear differential equations. The resultant ordinary differential equations obtained by similarity transformations will be solved numerically using shooting technique with fifth-order Runge-Kutta-Fehlberg Method. The computed results will be discussed with the help of graphs and tables.

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