Abstract

A numerical investigation on the effects of wall modulation on enhanced electroosmotic flow through a modulated micro-channel is considered in this thesis. Subsequently, heat transfer characteristics of nanofluids based on homogeneous as well as non-homogeneous models in thin channels and enclosures is made. The governing equations are solved numerically on a staggered grid arrangement in a coupled manner through the finite volume method. **Chapter 1** of the thesis is introductory, which contains the basic principles of fluid flow, electroosmotic flow and the heat transfer of nanofluids along with an outline on mathematical formulations and numerical methods.

In **Chapter 2**, we consider the electroosmotic flow of an electrolyte through a nano-channel in which the channel walls are modulated with a periodic array of curved hydrophobic patches. The aim of this study is to obtain an enhanced electroosmotic flow through the wall modulation compared to a slit nano-channel under the same electrostatic conditions. Our computed results show that the electroosmotic flow is enhanced in the patterned channel and the enhancement depends on the amplitude of the modulated wall and the planform length of the hydrophobic region.

The forced convection of a Cu-water nanofluid in a channel with wall mounted blunt ribs is studied numerically in **Chapter 3**. The fluid flow and the thermal fields are analyzed for an wide range of Reynolds number and nanoparticle volume fractions. The increment in heat transfer rate due to the addition of nanofluid and the thermal performance of a ribbed channel under the same pumping power are analyzed. The entropy generation is analyzed to demonstrate the thermodynamic optimization of the forced convection.

The conjugate heat transfer due to the mixed convection of a Cu-water nanofluid inside a square enclosure with thick wavy lower wall is studied numerically in **Chapter 4**. A homogeneous model for nanofluid is adopted for this study. The aim of this study is to analyze the effects of the wall waviness and wall conductivity on the flow field, thermal field and heat transfer rate. The entropy generation due to heat transfer irreversibility and fluid friction irreversibility is obtained to measure the loss of energy in the process. Our computed results show that the flow field, thermal field, heat transfer, and entropy generation are sensible on the wall waviness as well as the conductivity of the wall. It is found that the heat transfer and entropy generation increases with the increase of nanoparticle volume fraction, wave amplitude and wave length of the wavy solid-fluid interface. The Bejan number is calculated to measure the relative contribution of heat

transfer irreversibility and the fluid friction irreversibility on the total entropy generation.

In **Chapter 5** an analysis based on the homogeneous and non-homogeneous model is made on the mixed convection of Cu-water nanofluid inside an enclosure with a thick wavy left wall. The effects of the wall modulation, wall conductivity, nanoparticle size and nanoparticle bulk volume fraction on the flow and thermal field are analyzed. Entropy generation and the Bejan number are determined for optimal heat transfer analysis. Our computed results show that the non-homogeneous model predicts a higher heat transfer rate compared to the homogeneous model. Conductivity of the solid wall has a significant impact on the Brownian motion and thermophoretic diffusion.

In **Chapter 6**, the mixed convection of Al_2O_3-water nanofluid is investigated in an enclosure with corrugated left wall for different inclination angle of the enclosure using the non-homogeneous model. Our results show that the heat transfer and entropy generation are sensitive to the inclination angle for higher values of the Richardson number. Heat transfer and entropy generation are maximum when the inclination angle is 30^0 and further increases with the increase of the wave amplitude and the wave number of the modulated wall. Heat transfer and entropy generation increases with the increase of the bulk nanoparticle volume fraction whereas, both decreases with the increase of the nanoparticle diameter. We have also studied the impact of nanoparticle dispersion on heat transfer characteristics.

Chapter 7 provides the concluding remarks and an outline on the future scope.

Keywords : Wall modulation; Electroosmosis; Nernst-Planck equations; Hydrophobic; Superhydrophobic; Nanofluid; Mixed convection; Nusselt number; Numerical solution.