Abstract

This thesis presents a numerical study on fluid flow and heat transfer of nanofluid in an enclosure as well as in microchannels. The main objectives is to analyze the heat transfer augmentation using nanofluid in several flow configurations. The mathematical model is based on conservation principles of fluid and heat transport, which leads to the equations governing the flow and thermal filed are the Navier-Stokes equations coupled with the energy equation. A control volume based algorithm is used for the numerical solution of the transport equations. **Chapter 1** of the thesis is introductory, which is followed by five main chapters and a chapter providing the overall conclusions and future scope.

In **Chapter 2**, we numerically investigate the mixed convection due to a Cu–water (copper-water) nanofluid in a square enclosure. The fluid flow and heat transfer characteristics are studied for a wide range of Reynolds number and Grashof number so as to achieve the Richardson number greater or less than 1. Heat flow patterns are analyzed through the energy flux vector. The rate of enhancement in heat transfer due to the addition of nanoparticles is analyzed. The entropy generation is analyzed to demonstrate the thermodynamic optimization of the mixed convection.

The effect of skew angle on the heat transfer, temperature uniformity and entropy generation of a Cu-water nanofluid is studied in **Chapter 3**. Our computed result shows that the flow field, heat transfer rate, entropy generation rate, are sensible to the skew angle and nanoparticle volume fraction. The heat transfer rate and entropy generation rate increases with an increase of the nanoparticles volume fraction. We obtained maximum heat transfer rate and minimum entropy generation rate when the skew angle is at 90^0. Further, a higher rate of enhancement in heat transfer compared to the augmentation rate in entropy generation can be achieved for higher value of the skew angle.

In **Chapter 4**, we numerically investigate the effect of the inclination angle and the skewed angle on the heat transfer performance and entropy generation of Cu-water nanofluid in an inclined skewed enclosure. The critical inclination angle for optimum heat transfer is determined in the present configuration. We find that the heat transfer rate and entropy generation rate are sensible to the inclination angle, skew angle and nanoparticles volume fraction. However, the average Nusselt number and the total entropy generation rate are independent of the inclination angle when the buoyancy effect is negligible (lower value of the Richardson number). The heat transfer rate and entropy generation rate increases with the increase of the nanoparticles volume fraction.

Subsequently, the effect of nanoparticles size, temperature difference on the mixed convection of a Cu-water nanofluid in a differentially heated skewed enclosure is studied in **Chapter 5**. We consider both the homogeneous and non-homogeneous model. Our computed results show that the average rate of heat transfer based on

the non-homogeneous model overestimate by a slight mergin the result based on the homogeneous model. Further, the effect of Brownian motion and thermophoresis on the mixed convection of a Cu-water nanofluid is found to be negligible.

In **Chapter 6**, the thermal-hydraulic performance of a Cu-water nanofluid in a microchannel with patterned hydrophobic or superhydrophobic patches aligned on the channel wall is investigated. We have considered that there may exist an arbitrary shift between the patterns at the top and the bottom wall. We determined the optimal position of the hydrophobic or superhydrophobic patches for enhanced heat transfer and reduced pressure drop. The effects of the slip length and the temperature jump on the heat transfer and entropygeneration is analyzed. Our computed results show that the heat transfer rate and entropy generation rate increases with the increase of the nanoparticle volume fraction and Reynolds number. The heat transfer and the entropy generation rate increases with the increase of the slip length. In addition to that, with the increase of the slip length the friction factor reduces.

Keywords : Nanofluids; Mixed convection; Forced convection; Entropy generation; Hydrophobic; Superhydrophobic; Nusselt number; Numerical solution.