Abstract

The experimental study on natural convection cavity with nanofluids (<2% of total studies of nanofluid use in natural convection cavity) is very less as it is a challenging domain of heat transfer investigation. The power consumption is very small and that is only for the rotary electromagnetic field. This field is not used before for this type of study and it is done to make the nanoparticles in suspension for longer duration in the cavity. This investigation involves the use of two distinct nanofluids, namely ferromagnetic (Iron Oxides (II, III), average particle size (APS) = 50 - 100 nm) and non-magnetic (Alumina, APS = 13 nm), within a square cavity that facilitates the natural convection. There are five concentrations associated with each nanofluid. The electromagnet assembly is used to investigate the impact of the rotational magnetic field on the process of heat transfer. The magnetic strength can be manipulated by regulating the magnetic power and direct current (DC) power. The magnetic field forms a hysteresis loop in the DC power vs magnetic flux plot. The optimal heat transfer performance is observed at a nanoparticle concentration of 0.1% by volume (ϕ) for alumina nanofluids at Rayleigh number (Ra_H) ~ 2.5 x 10^8 and 0.05% by volume for iron oxide nanofluids at Ra_H ~ 2 x 10^8. In the absence of a rotating magnetic field, the ferromagnetic nanofluid exhibited superior performance. When Ra_H is one order smaller than the critical Ra value, the heat transfer performance is often superior with nanofluid compared to demineralized water. The rotational electromagnetic field enhances the heat transfer for non-magnetic nanofluids in the presence of magnetic beads in the cavity. The flow visualization study reveals that there is sluggish thermal movement of nanoparticles or thermophoresis due to the temperature gradient between the walls. There is a vortex formation in the center of the cavity but it shifts to a corner opposite to the tilting side for a tilted cavity. If there is a combination of rotary magnetic field and temperature difference then there is a three-dimensional vortex formation in the cavity. A numerical study has shown an optimum concentration of ϕ =0.05% for Alumina nanoparticles and only water case performs best for iron oxide nanoparticles. This numerical study has considered only the thermo-physical properties of the nanofluids from the experiments. However, it is clear that nanoparticle movement takes a major role in the natural convection cavity and has made a difference in the results.

Keywords: Nanofluid, Natural convection cavity, Rotary electromagnetic field, Nanomaterials characterization, Thermo-physical properties