World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:11, No:04, 2017

Thermomagnetic Convection of a Ferrofluid in a Non-Uniform Magnetic Field Induced a Current Carrying Wire

Authors : Ashkan Vatani, Peter Woodfield, Nam-Trung Nguyen, Dzung Dao

Abstract : Thermomagnetic convection of a ferrofluid flow induced by the non-uniform magnetic field around a current-carrying wire was theoretically analyzed and experimentally tested. To show this phenomenon, the temperature rise of a hot wire, immersed in DIW and Ferrofluid, as a result of joule heating has been measured using a transient hot-wire technique. When current is applied to the wire, a temperature gradient is imposed on the magnetic fluid resulting in non-uniform magnetic susceptibility of the ferrofluid that results in a non-uniform magnetic body force which makes the ferrofluid flow as a bulk suspension. For the case of the wire immersed in DIW, free convection is the only means of cooling, while for the case of ferrofluid a combination of both free convection and thermomagnetic convection is expected to enhance the heat transfer from the wire beyond that of DIW. Experimental results at different temperatures and for a range of constant currents applied to the wire show that thermomagnetic convection becomes effective for the currents higher than 1.5A at all temperatures. It is observed that the onset of thermomagnetic convection is directly proportional to the current applied to the wire and that the thermomagnetic convection happens much faster than the free convection. Calculations show that a 35% enhancement in heat transfer can be expected for the ferrofluid compared to DIW, for a 3A current applied to the wire.

Keywords : cooling, ferrofluid, thermomagnetic convection, magnetic field
Conference Title : ICFMHTT 2017 : International Conference on Fluid Mechanics, Heat Transfer and Thermodynamics
Conference Location : Boston, United States
Conference Dates : April 24-25, 2017