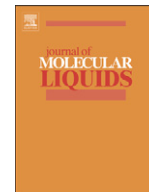




Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq



Convection heat transfer in micropolar nanofluids with oxide nanoparticles in water, kerosene and engine oil



Abid Hussanan ^a, Mohd Zuki Salleh ^a, Ilyas Khan ^{b,*}, Sharidan Shafie ^c

^a Applied & Industrial Mathematics Research Group, Faculty of Industrial Science & Technology, Universiti Malaysia Pahang, Pahang, Malaysia

^b Basic Engineering Sciences Department, College of Engineering, Majmaah University, Majmaah, Saudi Arabia

^c Department of Mathematical Sciences, Faculty of Science, Universiti Teknologi Malaysia (UTM), 81310 Skudai, Malaysia

ARTICLE INFO

Article history:

Received 9 October 2016

Received in revised form 24 November 2016

Accepted 5 December 2016

Available online 13 December 2016

Keywords:

Oxide nanoparticles

Micropolar nanofluids

Convection flow

Transient exact solutions

ABSTRACT

The basic idea of nanofluid was to enhance the thermal conductivity of base fluid. However, the classical nanofluid models have some drastic limitations, i.e. they cannot describe a class of fluids that have certain microscopic characters arising from the microrotation and local structure of the fluid elements. Therefore, the present work is one of the infrequent contributions that describes the microrotation and microinertia characteristics of nanofluids. More exactly, in this work, the unsteady free convection flow of micropolar nanofluids is investigated over a vertical plate. Five types of oxide nanoparticles namely copper oxide, titanium oxide, alumina oxide, iron oxide and graphene oxide are suspended in three different types of fluids such as water, kerosene and engine oil. Exact solutions of the governing problem are obtained by the Laplace transform method. Solutions for conventional or regular nanofluid is also recovered as a special case. Temperature of graphene oxide suspended micropolar nanofluid is higher than other oxide nanoparticles based nanofluids.