



Editors-in-Chief

Mohd Fadzli Bin Abdollah – FKM, UTeM, Malaysia
Tee Boon Tuan – FKM, UTeM, Malaysia
Mohd Azli Salim – FKM, UTeM, Malaysia
Mohd Zaid Akop – FKM, UTeM, Malaysia
Rainah Ismail – FKM, UTeM, Malaysia
Haslinda Musa – FPTT, UTeM, Malaysia

First published 2017

Copyright © 2017 by Centre for Advanced Research on Energy (CARE)

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, electronic, mechanical photocopying, recording or otherwise, without the prior permission of the Publisher.

ISBN: 978-967-0257-88-4 (online)

Published and Printed in Malaysia by:

Centre for Advanced Research on Energy,
Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, MALAYSIA.
Tel: +606 234 6891 | Fax: +606 234 6884 | E-mail: care@utem.edu.my
www.utem.edu.my/care

TABLE OF CONTENTS

FOREWORD BY THE EDITORS-IN-CHIEF	ii
EDITORIAL BOARD	iii
REVIEWERS	iv
TABLE OF CONTENTS	vi

No.	Title	Authors	Page
Theme 1: Automotive and Aeronautics			
001	Tribological behavioural of bio-oil extracted from peel waste of musa aluminata balbisiana	<i>H.A. Hamid, N.A.B. Masripan, R. Hasan, G. Omar, M.F.B. Abdollah</i>	1
002	Pre-charge pressure effects on isothermal and adiabatic energy storage capacity for dual hybrid hydro-pneumatic passenger car driveline	<i>F. Wasbari, R.A. Bakar, L.M. Gan, M.M. Tahir, A.A. Yusof</i>	3
003	Influence of iron oxide on the mechanical and tribological behaviors of brake friction materials	<i>R.J. Talib, M.A. Selamat, M. Hisyam Basri, Koay Mei Hyie, N.I. Ismail</i>	5
199	Boundary layer flow of Jeffrey fluid over a stretching sheet with convective boundary conditions: Application in polymer processing	<i>S.M. Zokri, N.S. Arifin, L.A. Aziz, M.K.A. Mohamed, M.Z. Salleh, A.R.M. Kasim, N.F. Mohammad</i>	437
200	Mathematical modelling on convective boundary layer of non-Newtonian micropolar viscoelastic fluid	<i>L.A. Aziz, N.S. Arifin, S.M. Zokri, A.R.M. Kasim, M.Z. Salleh, I. Waini, S. Shafie</i>	440
201	Mathematical modeling on aligned magnetic field of two-phase dusty Casson fluid	<i>N.S. Arifin, S.M. Zokri, L.A. Aziz, A.R.M. Kasim, M.Z. Salleh, N.F. Mohammad</i>	442

Mathematical modelling on convective boundary layer of non-Newtonian micropolar viscoelastic fluid

L.A. Aziz^{1,*}, N.S. Arifin¹, S.M. Zokri¹, A.R.M. Kasim¹, M.Z. Salleh¹, I. Waini², S. Shafie³

¹) Applied & Industrial Mathematics Research Group, Faculty of Industrial Sciences & Technology, **Universiti Malaysia Pahang**, 26300 Kuantan, **Pahang, Malaysia**

²) Faculty of Engineering Technology, **Universiti Teknikal Malaysia Melaka**, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, **Malaysia**

³) Faculty of Science, **Universiti Teknologi Malaysia**, 81310 Johor, **Malaysia**

*Corresponding e-mail: laila@ump.edu.my

Keywords: Viscoelastic micropolar; circular cylinder; mixed convection

ABSTRACT – This article presents the mixed convection boundary layer flow over a circular cylinder placed in a viscoelastic micropolar fluid with surface heat flux. The governing boundary layer equations are transformed into non-dimensional form by using appropriate dimensionless variables. Then, the resulting equations are transformed into similarity equations and solved using an implicit finite difference scheme known as the Keller box method. For validation purpose, the current results are compared to previous study. With congruent results from both study, authors are convinced that the proposed model is reliable.

1. INTRODUCTION

Viscoelastic is a renowned type of fluid in industrial-manufacturing processes and engineering field with practicality in petroleum drilling, manufacturing of foods and paper, as well as reducing frictional drag on the hulls of ships and submarines. The study of the flow of viscoelastic fluid has sparked interests in many researchers due to its special ability to deform semi-permanently. However, in the existing models of viscoelastic fluids (refer [1-3]), the presence of rigid, randomly oriented suspended particles are neglected. Considering that the presence of the particles in the fluid might affect the behavior of the flow and heat transfer, therefore, this article will propose a new model of viscoelastic micropolar fluid.

According to the model proposed by Eringen in [4], micropolar fluids is a type of fluid consisting of rigid, randomly oriented (or spherical) particles suspended in a viscous medium which is particularly useful to model fluids with presence of dust and smoke, especially in gas. Hence, viscoelastic micropolar fluid can be defined as fluid with suspended particles that displays viscous and elastic characteristics.

In this study, the outcomes of the numerical solutions of the fluid flow of viscoelastic micropolar model on the outer of a circular cylinder will be presented.

2. METHODOLOGY

2.1 Mathematical formulation

Figure 1 illustrates the physical geometry of the problem and the corresponding coordinate system.

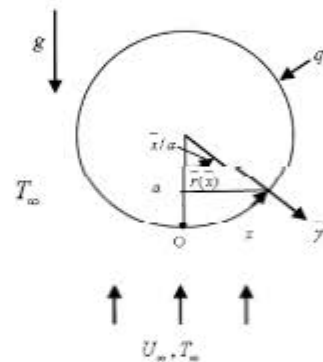


Figure 1 Physical model and coordinate system.

Under the assumptions that the Boussinesq and boundary layer approximations are valid, the dimensional equations governing the mixed convection boundary layer flow are

Continuity equation:

$$\frac{\partial \bar{u}}{\partial \bar{x}} + \frac{\partial \bar{v}}{\partial \bar{y}} = 0 \quad (1)$$

Momentum equation:

$$\bar{u} \frac{\partial \bar{u}}{\partial \bar{x}} + \bar{v} \frac{\partial \bar{u}}{\partial \bar{y}} = \bar{u}_e \frac{\partial \bar{u}_e}{\partial \bar{x}} - \left(\frac{\mu + \kappa}{\rho} \right) \frac{\partial^2 \bar{u}}{\partial \bar{y}^2} + K_0 \left(\frac{\partial}{\partial \bar{x}} \left(\bar{u} \frac{\partial^2 \bar{u}}{\partial \bar{y}^2} \right) + \bar{v} \frac{\partial^3 \bar{u}}{\partial \bar{y}^3} - \frac{\partial \bar{u}}{\partial \bar{y}} \frac{\partial \bar{u}}{\partial \bar{x}} \frac{\partial^2 \bar{u}}{\partial \bar{y}^2} \right) - g \beta (T - T_\infty) \sin \left(\frac{\pi}{a} \bar{y} \right) + \frac{\kappa}{\rho} \frac{\partial \bar{H}}{\partial \bar{y}} \quad (2)$$

Energy equation:

$$\bar{u} \frac{\partial T}{\partial \bar{x}} + \bar{v} \frac{\partial T}{\partial \bar{y}} = \alpha \frac{\partial^2 T}{\partial \bar{y}^2} \quad (3)$$