INTERNATIONAL JOURNAL FOR COMPUTATIONAL METHODS IN ENGINEERING SCIENCE AND MECHANICS
2018, VOL. 19, NO. 3, 185–193
https://doi.org/10.1080/15502287.2018.1444681

Impacts of nonuniform heat source or sink on MHD mixed convection along an exponentially stretching surface

Prabhugouda Patil, Geeta Hadimani, and A. Shashikant

Department of Mathematics, Karnatak University, Pavate Nagar, Dharwad, Karnataka, India

ABSTRACT

This paper investigates steady MHD mixed convection flow over an exponentially stretching surface in presence of nonuniform heat source or sink. The dimensional nonlinear partial differential equations governing the flow and temperature fields are expressed in nondimensional form using suitable nonsimilar transformations. Then, numerical solutions are obtained by solving these nondimensional equations using implicit finite difference scheme in combination with Quasilinearization technique. Effects of various physical parameters on velocity and temperature profiles are analyzed numerically. Further, numerical results in terms of the skin-friction coefficient and local Nusselt number are presented graphically and also in tabular form.

KEYWORDS

Exponentially stretching surface; implicit finite difference scheme; nonuniform heat source or sink; magneto-hydrodynamics (MHD); mixed convection; quasilinearization technique

1. Introduction

The study of magnetohydrodynamic (MHD) flow has experienced vigorous growth in recent years. The heat and mass transfer of a steady flow of an incompressible, electrically conducting fluid due to a stretching sheet under the influence of an applied magnetic field has several industrial and engineering applications such as metal spinning and spinning fibers [1], drawing of plastic films [2], the aerodynamic extrusion of plastic sheets [3], metal extrusion [4], cooling of continuous strips [5], chemical and petroleum industries [6], spinning and drawing sheets [7], glass fiber [8], etc. The research on MHD is currently undergoing a period of great enlargement and differentiation of subject matter. For instance, Mukhopadhyay [9] investigated heat transfer by considering MHD and uniform heat source or sink. Dessie et al. [10] studied the MHD effects on heat transfer over stretching sheet embedded in porous medium with variable viscosity, viscous dissipation, and heat source/sink. The effects of MHD over a stretching sheet in presence of viscous dissipation and chemical reaction was studied by Yirga and Shankar [11].

Many researchers have carried research over uniform heat source/sink. For example, Chamkha [12] investigated the heat transfer by considering a uniform heat source or sink. Hayat et al. [13] have shown the effects Soret and Dufour effects on three-dimensional flow over an exponentially stretching surface through a porous medium in presence of chemical reaction and heat source or sink. Patil and Chamkha [14] have analyzed uniform heat source/sink with chemical reaction. However, imposing the nonuniform heat source/sink effects to the considered problem may lead to a new set of results. The effect of nonuniform heat source or sink has a vital role in varying the thermal properties of the fluid. Applications of nonuniform heat source or sink parameter are crucial in controlling the heat transfer. Its relevance is seen in the manufacture of plastic and rubber sheets, food stuffs storage, heat removal from the nuclear fuel debris and several others. Further, the nonuniform heat source/sink plays an important role in the industrial and engineering fields. For instance, the nonuniform heat source or sink may change the heat distribution in the fluid which consequently affects the particle deposition rate in the system such as semiconductors, electronic devices, and nuclear reactors [15]. Mabood et al. [16] presented the numerical analysis on the effects of Soret and nonuniform heat source on MHD non-Darcian flow over a stretching sheet. Pal [17] has worked on the convective boundary layer flow and heat transfer over a stretching surface with nonuniform heat source/sink and thermal radiation.

The study of laminar flow and heat transfer over a stretching sheet in a viscous fluid is of considerable interest because of its ever increasing industrial applications and important bearings on several technological processes. Shateyi et al. [18] studied the problem of MHD

CONTACT Dr. Prabhugouda Patil pmpmath@gmail.com Department of Mathematics, Karnatak University, Pavate Nagar, Dharwad, 580003, Karnataka, India.

FF
10

324

ived 6 October 2017
sed 27 November 2017
epted 29 November 2017

Influence of partial slip flow and thermal jump on mixed convection from an exponentially stretching surface

Prabhugouda Mallanagouda Patil,
Geeta Hadimani and Shashikant A.
Department of Mathematics, Karnatak University, Dharwad, India

P.S. Kulkarni
Department of Aerospace Engineering,
Indian Institute of Science, Bangalore, India, and

Mukesh Kumar
School of Physics and Institute for Collider Particle Physics,
University of the-Witwatersrand, Johannesburg, South Africa

Abstract

Purpose – This paper aims to provide a detailed study on the influence of slip flow and thermal jump over mixed convection flow along an exponentially stretching surface. Also, impacts of suction/blowing, volumetric heat source/sink and velocity ratio parameter will be studied in this analysis.

Design/methodology/approach – The modeled governing equations for the assumed problem are dimensional nonlinear partial differential equations in nature. To reduce these equations, non-similar transformations are used to get the dimensionless nonlinear partial differential equations. Then, quasi-linearization technique is used to linearize these non-dimensional nonlinear partial differential equations. Finally, an implicit finite difference scheme is used to discretize the resulting equations.

Findings – The physical explanations are provided for the variations of various non-dimensional governing parameters over the velocity and temperature profiles. Also, the effects of these dimensionless parameters on skin friction coefficient and heat transfer rate are scrutinized in a manner which highlights their physical interpretation. The detailed discussion exhibits the fact that the streamwise co-ordinate velocity ratio parameter, partial slip parameter and the thermal jump parameter have significant influence over the flow and thermal fields.

Originality/value – This work has not been reported in the literature to the authors' best of knowledge.

Keywords Mixed convection, Non-similar solution, Exponentially stretching sheet, Suction/injection, Thermal jump, Partial slip flow

Paper type Research paper

Nomenclature

C_f = local skin friction coefficient;
C_p = specific heat at constant pressure;

rnational Journal of Numerical
thods for Heat & Fluid Flow
. 28 No. 10, 2018
2324-2341
merald Publishing Limited
51-5539
I 10.1108/HFF-10-2017-0396

P.M. Patil and Shashikant thank the University Grants Commission (UGC), New Delhi, 110 002, India, for the financial assistance under the grant: F. No. 43-413/2014 (SR) dated: 30-10-2015.