



Scientific
Research
Publishing

Heat and Mass Transfer Phenomena in MHD Flow : Modelling with Applications

Dr. Sanjib Sengupta

Heat and Mass Transfer Phenomena in MHD Flow: Modelling with Applications

Dr. Sanjib Sengupta

Heat and Mass Transfer Phenomena in MHD Flow: Modelling with Applications

Published by
Scientific Research Publishing, Inc.
ISBN: 978-1-61896-066-5
<http://www.scirp.org>

Copyright © 2014 by Scientific Research Publishing, Inc., USA.
All rights reserved.

This work may not be translated or copied in whole or in part without the written permission of the publisher (Scientific Research Publishing, Inc., USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

Requests to the Publisher for permission should be addressed to the SRP Copyrights Manager, Scientific Research Publishing, Inc., USA, E-mail: service@scirp.org.

PREFACE

Fluid dynamics, which is a sub-division of fluid mechanics, is one of the rapidly growing basic sciences, whose principles find applications even in daily life. The flight of a bird in air and the motion of fish in water are governed by the fluid dynamic rules. The design of various types of aircrafts and ships for water transportation are based on the principles of fluid dynamics. Natural phenomena like tornadoes and hurricanes can be explained by the science of fluid dynamics. Since the earth is surrounded by an environment of air and water to a very large extent, almost everything that is happening on earth and its atmosphere is some way or the other associated with the science of fluid dynamics. It introduced new fields of interest such as hypersonic flow and magneto-fluid dynamics and has become essential to accumulate the combine knowledge of thermo-dynamics, heat transfer, mass transfer, and electromagnetic theory for complete understanding of the physical phenomenon involved in any flow process.

The primary objective of the book is to provide basic idea on fluid dynamics and its related properties and help to understand research work in the field of transport phenomena in MHD flow. This book introduces the students of mathematical, physical as well as engineering sciences to the fundamental physical principals suitable to analyze the transport phenomena in MHD fluid flow. The book will focus on the fundamental principles associated in the formulation, solution and numerical simulation of heat and mass transfer analogy in single phased electrically conducting domain. The fluid model describing various aspects of boundary layer flow past a vertical flat surface embedded in Darcian porous media have been studied. An asymptotic periodic transformation is used to solve the dynamical equations. The influence of various physical effects like thermal radiation, chemical reaction, magnetic field, radiation absorption, heat sink etc. have been considered on the fluid properties. In this study some influential engineering quantities of interest such as skin-friction, Nusselt number and Sherwood number are also calculated and analyzed

through graphs and tables. It is expected that, the governed exact closed form of solutions corresponding to different problems can be used for validating numerical treatment of certain critical flows with heat and mass transfer phenomena.

It is rightly said that, every good work is associated with the attachment of certain people who directly or indirectly involved for the successful completion of the work. I am thankful to Prof. N. Ahmed (Gauhati University) and Prof. Prashanta Chatterjee (Viswa-Bharati University) for their constructive suggestion for the completion of this book. My special thanks go to Prof. Vasudevan Murthy (IISc, Bangalore), Prof. B.C. Tripathi (IASST, Guwahati), Prof. Saroa (Retd. Prof. Dibrugarh University) and Prof. G.C. Hazarika (Dibrugarh University). I am grateful to our Honourable Vice-Chancellor Prof. Somnath Dasgupta for providing me the right platform to undergo this work. I am also grateful to my cousin Prof. Ashokendu Mozumder (Emeritus Prof. Notre Dame University) for his significant suggestion on many physical aspects especially in the basic theory of Radiation.

I am ever grateful to my parents Late Sankar Sengupta and Late Uma Sengupta and would like to thank my School and College level Maths teachers Sri S. Mukherjee, Late K.S. Dubey, Sri Mahendr Nath Saikia and Late Bhaben Gogoi.

Last but not the least, I want to thank my family members, my wife Mausumi, daughter Sumedha and my son Shreyom for supporting me throughout this work and life. I can't resist myself to give a special thanks to Dr. Mausumi Sen, Dept. of Mathematics, N.I.T, Silchar for providing me with valuable suggestion for the preparation of the book.

The book consists of four chapters. It begins with chapter1, which provides an introduction and an overview on the theory of fluids and heat and mass transfer phenomena with basic idea on the theory of magnetohydrodynamics.

In **Chapter 2**, an exact analysis is made to study theoretically the influence of thermal radiation and first order chemical reaction on free convective heat and mass transfer flow of a Newtonian viscous incompressible electrically conducting fluid past a suddenly accelerated semi-infinite vertical permeable plate embedded in Darcian absorption media.

Chapter 3 exhibits an investigation on the effect of heat and mass transfer phenomena on two-dimensional laminar flow of an electrically conducting viscous absorbing fluid

past a vertical porous plate immersed in Darcy heat absorbing (thermal sink) media with first order chemical reaction. The exact closed form of expressions for velocity, temperature and concentration functions are obtained and presented graphically and in tabular form for various physical parameters involved in the study.

An overall conclusion on the problems stated in *Chapters 2 and 3* is outlined in *Chapter 4*. Finally a complete list of references has been highlighted as a *Bibliographic* section and at the end a set of *Test problems* have been supplied for the readers.

Sanjib Sengupta
Assam University, silchar
Assam, India

CONTENT

PREFACE

Chapter 1: Introduction

1.1 A Historical Review	1
1.2 Viscosity, Viscous Fluid, and Newtonian Fluid	4
1.3 Compressibility and Incompressible Fluid	5
1.4 Laminar Flow	6
1.5 Steady and Unsteady Flows	6
1.6 Nature of Transport Processes	6
1.7 Theory of boundary Layers	12
1.8 Magnetohydrodynamics	17
1.9 Porous Medium	19
1.10 Thermal Diffusion (or Soret Effect)	22
1.11 Chemical Reaction	23
1.12 Basic Equations	24
1.13 Nature of Boundary Conditions	26
1.14 Some Non-Dimensional Parameters	27
1.15 An Outline of the Study	30

Chapter 2: MHD Free Convective Radiative Flow with Chemical Reaction

2.1 Introduction	33
2.2 Mathematical Formulation of the Problem	35
2.3 Method of Solution	38
2.4 Results and discussion	40
2.5 Conclusions	42
Appendix I	51

Chapter 3: MHD Free Convective Flow of Chemically Absorbing Fluid with Heat Sink

3.1 Introduction	55
3.2 Mathematical Formulation of the Problem	57
3.3 Method of Solution	59
3.4 Results and Discussion	60
3.5 Conclusion	62
Appendix II	68

Chapter 4: Conclusion and Future Work

4.1 Concluding Remarks	71
4.2 Future Work	72

Bibliography

TEST PROBLEMS

APPENDIX

