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Journal of the Nigerian Mathematical Society 34 (2015) 318–330
Journal of the Nigerian Mathematical Society
www.elsevier.com/locate/jnnms

Temperature dependent viscosity and thermal conductivity effects on hydromagnetic flow over a slendering stretching sheet

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Received 5 June 2015; received in revised form 17 July 2015; accepted 24 July 2015
Available online 14 August 2015

Abstract

The primary focus of this work is to numerically investigate the influence of temperature dependent viscosity and thermal conductivity on hydromagnetic flow over slendering stretching sheet. In the process held at high temperature like glass blowing, the fluid properties like viscosity and thermal conductivity may gets influenced in such temperature which motivated us to analyze those kind of problem. Considering steady, two dimensional, nonlinear, laminar flow of an incompressible, viscous and electrically conducting fluid over a stretching sheet with variable thickness in the presence of variable magnetic field. Numerical computations are carried out for various values of the physical parameters and the effects over the velocity and temperature are analyzed. Numerical values of dimensionless skin friction coefficient and non-dimensional rate of heat transfer are also obtained and presented in tabulated form. It is noticed that, in additional to the magnetic field there are two more regulators which can manipulate to maintain the optimal heat for the glass blowing process to attain required shapes.

Keywords: Magnetohydrodynamics; Slendering stretching sheet; Variable viscosity; Variable thermal conductivity

1. Introduction

Research on boundary layer flow over a stretching sheet has received a striking increase in interest because of its importance in several manufacturing process in industry which include the boundary layer along the material handling conveyors, metal extrusion, continuous casting of metals, polymer extrusion, spinning of filaments, glass blowing, copper wires drawing, crystal growing, glass fiber production and paper production [1–3]. This study was initiated by Sakiadis [4] through the problem on continuous moving solid surface. Following his path, some closed form exponential solution of two-dimensional flow past a stretching plane was established by Crane [5]. Later, Banks [6] obtained the similarity solutions of the boundary layer equations for a stretching wall. Since then, research area of stretching sheet has been flooded with many research articles with multiple dimensions enriched by the innovative researchers.

During the metallurgical process, the rate of cooling can be controlled by drawing such strips into an electrically conducting fluid subjected to a magnetic field in order to get the final products of desired characteristics; as such a

Peer review under responsibility of Nigerian Mathematical Society.
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http://dx.doi.org/10.1016/j.jnnms.2015.07.002
0189-8965/

List of symbols

A	Coefficient related to stretching sheet
$\vec{B}$	Magnetic field
$\vec{B}_{in}$	Induced magnetic field
b	Physical parameter related to stretching sheet
c	Constant depending on the nature of the fluid
c_f	Skin-friction coefficient
C_p	Specific heat at constant pressure
$\vec{E}$	Electric field vector
$\vec{F}$	Lorentz force
$\vec{j}$	Induced current
k	Thermal conductivity of the fluid
k_∞	Ambient fluid thermal conductivity
M^2	Magnetic interaction parameter
m	Velocity power index parameter
Nu_x	local Nusselt number
Pr	Prandtl number
S	Thermal conductivity parameter
Re_x	Local Reynolds number
T	Fluid temperature
$T_w(x)$	Wall temperature
T_∞	Temperature far away from the sheet
u	Velocity component in the x directions
v	Velocity component in the y directions
$\vec{V}$	Velocity vector

Greek Letters

χ	Wall thickness parameter
γ	Thermal property of the fluid
η	Plate surface
μ	Fluid viscosity
μ_∞	Ambient fluid dynamic viscosity
ν_∞	Ambient kinematic viscosity
θ	Dimensionless temperature
θ_r	Viscosity parameter
ρ	Density of the fluid
σ	Electrical conductivity of the fluid
ψ	Stream function

process greatly depends on the rate of cooling. In view of this, the study has been extended to hydromagnetic flow over a stretching sheet along with heat transfer characteristics and was investigated by many researchers. Sparrow and Cess [7] reported the effect of magnetic field on the natural convection heat transfer. Chakrabarti and Gupta [8] analyzed the hydromagnetic flow and heat transfer over a stretching sheet. The hydromagnetic convective flow over the continuous moving surface was studied by Vajravelu [9].

New dimension in the field of stretching sheet has arrived that it can be stretched nonlinearly. Similarity solutions of the boundary layer equations for a nonlinearly stretching sheet was analysed by Akyildiz et al. [10]. Heat transfer over a nonlinearly stretching sheet with non-uniform heat source and variable wall temperature was studied by Nandeppanavar et al. [11]. Significance of magnetic field over stretching sheet with power law velocity was enlightened by many authors. Chiam [12] examined the hydromagnetic flow over a surface with a power-law velocity.