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Convective slip flow of rarefied fluids over a wedge with thermal jump and variable transport properties

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A B S T R A C T

Convective slip flow of slightly rarefied fluids over a wedge with thermal jump and temperature dependent transport properties such as fluid viscosity and thermal conductivity is studied numerically. Due to the appearance of a slip condition at the surface of the boundary no self similar solution can be found. Locally similar solutions are obtained numerically by using the widely used and very robust computer algebra software Maple. The nondimensional velocity, temperature, Prandtl number, hydrodynamic boundary layer thickness, displacement thickness, momentum thickness, and thermal boundary layer thickness are displayed graphically for various values of the pertinent parameters. The results show that strong rarefaction and increased angle of wedge significantly controls the growth of the hydrodynamic and thermal boundary layers thickness, which are found to be lower for the flow of constant fluid properties than for the flow of variable fluid properties.

1. Introduction

Due to many engineering applications in aerodynamics, geothermal systems, crude oil extractions, ground water pollution, thermal insulation, heat exchanger, storage of nuclear waste etc, convective flows over wedge shaped bodies have been extensively studied since the early formulation of the problem in 1931 by Falkner and Skan [1]. They first studied two-dimensional flow of a viscous incompressible fluid over a wedge. Similarity transformation technique was developed which reduced the governing partial differential boundary layer equation to an ordinary differential equation which could then be solved numerically. Na [2] introduced a group of transformations which reduced the Falkner–Skan equation to a pair of initial value problems which are solved by means of forward integration scheme. Rajagopal [3] studied the Falkner–Skan boundary layer flow of second grade fluid over a wedge. Steady two dimensional laminar forced flows and heat transfer from a wedge was considered in great detail by Lin and Lin [4]. They proposed a similarity solution for an isothermal surface for a wide range of Prandtl numbers. Asaithambi [5] presented a finite difference method for solving Falkner–Skan equation. Yih [6] presented an analysis of forced convection boundary layer flow over a wedge with uniform suction and injection. Watanabe [7] investigated the behavior of the boundary layer over a wedge with suction (or injection) in forced flow. Laminar boundary layer flow over a wedge with suction (or injection) has been discussed by Kafoussias and Nanousis [8] while Anjali Devi and Kandasamy [9] analyzed the effects of thermal stratification on the laminar boundary layer flow over a wedge with suction (or injection). Kuo [10] analyzed the heat transfer for the Falkner–Skan wedge flow by the differential transformation method. Kandasamy et al. [11] studied effects of chemical reaction, heat and mass transfer along a wedge with heat source and concentration in the presence of suction or injection. Recently, Rashad and Bakier [12] studied numerically the effects of a magnetic field on non-Darcy forced convection boundary layer flow along a permeable wedge in a porous medium with uniform heat flux.

Rarefied flows at low Mach numbers have practical applications in the field of aerosol science, subsonic flight in extraterrestrial atmospheres, and micro and nano air vehicles. Due to these applications many researchers have studied and reported results on slip flows over various geometries. Martin and Boyd [13] investigated the effect of slip flow on the hydrodynamic boundary layer over a stationary flat plate employing Maxwell slip conditions while Fang and Lee [14] studied the same problem for a moving plate. Later Vedantam [15] extended the work of Martin and Boyd [13] with three different models for the slip flow. Martin and Boyd [16] further studied the

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