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BRIEF NOTES AND DISCUSSIONS

Flow and heat transfer of a slightly rarefied gas over a stretching surface

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1 Introduction

The laminar boundary layer flow of an incompressible fluid past a stretching surface was first studied by Crane [1]. Subsequently; various aspects of the flow and heat transfer over a stretching surface have been examined by several investigators [2–11].

In all the above studies, the no-slip boundary conditions are used. In many applications, such as the biological system [12], the cooling of the electronic equipment and Micro-Electro-Mechanical systems (MEM) the fluid behavior might be treated as a rarefied gas [13]. Flow in a rarefied gas is characterized by the value of the Knudsen number K_n. When $K_n = 0$, the no-slip condition is valid and the continuum flow assumption works well for small Knudsen number $K_n < 0.001$. When $0.01 < K_n < 0.1$, it is the slip flow regime for which the Navier-Stokes equations with slip boundary conditions are still applicable. For larger values of K_n ($K_n > 10$) the Navier-Stokes equations is not applicable and the kinetic theory of gases must be employed.

The boundary layer flow past a surface in slip flow regime has been studied by many authors under different situations [14–22]. The aim of this study is to discuss the effect of slip conditions on the boundary layer flow and heat transfer of a slightly rarefied gas over a stretching surface in the presence of suction/blowing.

2 Mathematical model

Consider the steady, two-dimensional, incompressible, laminar flow of a slightly rarefied gas on a stretching porous surface which coincides with the plane $y = 0$, the flow being in the region $y > 0$. Two equal and opposing forces are applied along the x-axis so that the surface is stretched with linear velocity cx keeping the origin fixed. Furthermore, we confine our attention to the flow region, $x \geq 0$ and $y > 0$.

Under the boundary layer approximations, the governing equations are given by:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \tag{1}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \frac{\mu}{\rho}\frac{\partial^2 u}{\partial y^2}, \tag{2}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{\kappa}{\rho c_p}\frac{\partial^2 T}{\partial y^2}, \tag{3}$$

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