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Effects of Viscous Dissipation on Free Convection Boundary Layer Flow towards a Horizontal Circular Cylinder

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Abstract

In this study, the numerical investigation of viscous dissipation on convective boundary layer flow towards a horizontal circular cylinder with constant wall temperature is considered. It is known that [Merkin, 1976] became the first one who got the exact solution for the problem of free convection boundary layer on an isothermal horizontal cylinder. Next, [Merkin and Pop, 1988] studied free convection boundary layer on a horizontal circular cylinder with constant heat flux. [Nazar et al., 2002] extended [Merkin, 1976] and [Merkin and Pop, 1988] in micropolar fluid. Recently, [Salleh and Nazar, 2010] and [Sarif et al., 2014] updated [Nazar et al., 2002] with Newtonian heating and convective boundary conditions, respectively. Both problems are solved numerically by using the Keller-box method. It is worth to mention that the viscous dissipations effect is important to study in order to understand the behaviour of temperature distributions when the internal friction is not negligible. Therefore, the purpose of the present study is to investigate the effects of viscous dissipation on free convection boundary layer flow towards a horizontal circular cylinder. The governing partial differential equations are solved numerically and the variation of pertinent physical parameters are analyzed and discussed in detail with the aid of tables and profiles. The results in this paper is original and important for the researchers working in the area of boundary layer flow and this can be used as reference and also as complement comparison purpose in future.

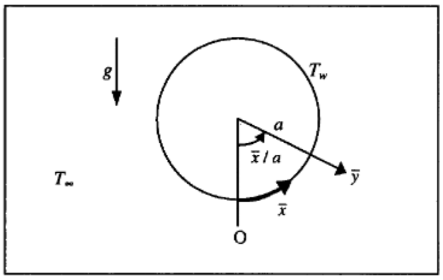

Figure 1: Physical model of the coordinate system

This study started with the introduction of physical model and the coordinate system for the problem as in Figure 1. It is considered the horizontal circular cylinder of radius a, which is heated to a constant temperature T_w embedded in a viscous fluid with ambient temperature T_∞. The orthogonal coordinates of $\bar{x}$ and $\bar{y}$ are measured along the cylinder surface, starting with the lower stagnation point $\bar{x}=0$, and normal to it, respectively. By using the non-dimensional variables, the boundary layer equations in the form of dimensional non linear partial differential equations are transformed to the dimensionless partial differential equations as follows: