UNIVERSITI TEKNOLOGI MARA

LOCAL SIMILARITY SOLUTIONS OF MIXED CONVECTION STAGNATION POINT FLOW IN NANOFLUID OVER A VERTICAL STRETCHING OR SHRINKING SURFACE

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ABSTRACT

The problem of mixed convection boundary-layer flow near a stagnation-point on a permeable and an impermeable stretching or shrinking vertical surfaces immersed in a nanofluid with constant wall temperature and convective boundary condition have been discussed throughout the research. The nanofluid Buongiorno model is employed with an approach of the local similarity solution where the combination of those elements have not been considered before. First, the governing nonlinear equations partial differential equations are reduced to the boundary-layer equations using the boundary-layer and Boussinesq approximations. Then, the boundary-layer equations are transformed into a set of ordinary differential equations using the local similarity transformation. Eventually, the ordinary differential equations being solved numerically using a shooting method with the help of Maple 17 software. The effects of the mixed convection parameter λ, suction or injection parameter S, stretching or shrinking parameter ε, convective heat transfer parameter γ, thermophoresis parameter Nt, Brownian motion parameter Nb, buoyancy-ratio parameter Nr and Lewis number parameter Le on the skin friction coefficient, heat and mass transfer rate at the surface as well as the velocity, temperature and concentration profiles are analyzed and discussed in details. It is observed that these parameters are significantly affected and influenced the skin friction coefficient, heat and mass transfer rate at the surface. The results indicate that dual solution exist in a case of the shrinking surface for certain range of the parameters. The results also showed that suctions tends to increase the skin friction coefficient and heat transfer rate at the surface, while injections acts in the opposite manner for both stretching and shrinking surfaces. In contrast, the mass transfer rate at the surface decreases with an increase in suction effect on both stretching or shrinking surface, while injection increases it. In addition, increasing the values of convective heat transfer parameter tends to increase the skin friction coefficient and heat transfer rate at the surface while decrease the mass transfer rate at the surface.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Boundary-layer theory is the cornerstone of modern fluid dynamics as proposed by Ludwig Prandtl in 1904 where he conceptualized a new perception that flow can be divided into two parts, namely inviscid flow in the main part and a thin layer adjacent to the surface of the body, known as the boundary-layer (Tulapurkara, 2005). In a thin layer, frictional force must be taken into account, while it is negligible outside the thin layer since it is too small to be counted (Schlichting, 1979). Moreover, Ludwig Prandtl (Tulapurkara, 2005) showed that the boundary-layer theory is valid at large Reynolds number and the Navier-Stokes equations which are elliptic equations can be simplified to parabolic equations. Based on this concept, many convective heat transfer problems can be solved theoretically. Nowadays the studies on the fluid flow, heat and mass transfer rate of a surface in a nanofluid using boundary-layer theory have increased gradually.

Heat transfer is commonly encountered in engineering systems and various aspects of life. Heat transfer is defined as the transmission of energy from one region in a medium to another as a consequence of temperature difference between them. The transfer of heat is normally from a high temperature object to a lower temperature object and the heat transfer continues until the two objects have reached thermal equilibrium (Cengel, Ghajar, & Ma, 2011). Heat transfer is accomplished by three basic methods which are conduction, convection and radiation. Conduction is the transfer of heat across a stationary medium, either solid or fluid. Convection is the transfer of heat from the surface of a moving fluid caused by the temperature difference between the two. In contrast to the mechanism of conduction and convection, heat transfer through radiation process does not require any intermediate medium. This process occurs in electromagnetic radiation between two surfaces that have different temperatures.

Mass transfer is one of several sciences which results from the interplay of conservation and transfer laws. Mass transfer occurs whenever fluid flows; that is, some mass is transferred from one place to another due to a concentration gradient in a mixture. There