Effect Of Porosity, Oblique Incidence And Unsteady Flow On A Fluid

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Abstract

Over the years a lot of research has been done by various researchers in this area of computational fluid dynamics. Due to its extensive applications in various industries like the aerodynamic extrusion of plastic sheets, hybrid-powered engines, manufacturing of plastic and rubber sheets, in a cooling bath cooling of a large metallic plate, which may be an electrolyte, machining etc., the area of stretching sheet in computational fluid dynamics is growing at a fast rate. The aim of the present study is to explore this enormous growing area and find out how much work has already been done in this area. In the present article, the main focus is on the stretching sheet and its various parameters like the cases when the flow is unsteady, the oblique incidence of the flow and study of the effect of porosity on various parameters of the fluid.
Keywords: Stretching sheet, porous, oblique flow, unsteady flow.

I. INTRODUCTION

The study of laminar flow of a thin liquid film over a stretching sheet is currently attracting the attention of a growing number of researchers because of its immense potential to be used as a technological tool in many engineering applications. The main applications that are applicable in various industries includes the hot rolling, wire drawing, glass– fiber production. Another application is in the manufacture of plastic and rubber sheets and cooling of a large metallic plate in the form of electrolyte etc in a bath.

Crane in 1970 has contributed as a pioneer in the field where he has calculated the effect of pressure on the stretching sheet for a viscous and incompressible fluid. Porosity is the fraction of empty space in a material to the total volume. Porosity is determined by the grain size and if we increase the distribution of grain size then there would be the decrease in the porosity. This happens due to the reason that the space between the larger is occupied by the smaller ones. A conventional porous medium is usually made up of rough and non spherical particles. The meta stable configuration comes into existence as the particle size lowers down due to the friction intervening between the particles. Ishak et al. (2006a) explained the effect of medium porosity while studying the vertical stretching sheet in a viscous fluid which was further extended by the Merrill et al. (2006) where they investigated the solution for the vertical stretching sheet with mixed convection boundary layer flow. Attia (2007) discussed the effect of velocity by the porosity parameter. The most fundamental law determining the flow of liquid is Darcy law which is analogous to other transport laws like ohm law given by Henry Darcy while experimenting on vertical water filtration through the sea beds. According to the darcy law the volumetric flow rate is inversely proportional to the viscosity. Grosan et al. (2008) investigated that in porous medium Darcy’s law model and Rosseland model for radiation are applicable and studied radiation and temperature dependent viscosity effects. Mukhopadhyay (2009) explained that as fluid viscosity parameter increases then as a result fluid velocity increases but temperature decreases.

Ziabakhsh et al. (2010) applied the Homotopy Analysis Method for the solution of non linear stretching sheet immersed in a porous medium. In the homotopy analysis method the non linear differential equations are solved by implementing the concept of homotopy from topology. Homotopy concept is related with the continuous functions from the same space where one can be deformed into the other. So by using the HAM the convergent series solution of the nonlinear fluids problem can be solved. M. Nawaz et al. (2012) studied the Dufour and Soret effects on the two-dimensional magnetohydrodynamic (MHD) steady flow of an electrically conducting viscous fluid bounded by infinite sheets. The soret effect or thermoporesis is behavior of the moving particles in a fluid to the temperature gradient which is inverse of dufour effect. Adnan Saeed Butt (2012) analysed the boundary layer flow and heat transfer analysis of a second grade fluid over a stretching sheet through a porous medium and Homotopy Analysis Method is used to calculate the effect of viscoelasticity on entropy. M. M. Nandeppanavar et al. (2013) studied the viscoelastic boundary layer flow and heat transfer over an exponentially stretching continuous sheet in the presence of a heat source/sink and concluded that with the suitable selection of the Prandtl number Pr and local Eckert number E, local viscioelastic parameter k and local heat source/ sink parameter rate of heat transfer from the stretching sheet to the fluid can be controlled. Sachin shaw et al. (2013) studied homogenous- heterogeneous reactions in a micropolar fluid flow of a permeable porous sheet in the viscous medium and calculated the effect of various parameters like stretching, permeability parameter on homogenous and hetrogenous reactions.

If instead of orthogonal flow, the fluid is incident at a certain angle to the surface then the liquid flow is said to be oblique flow. The transport phenomena are directly proportional to these oblique flows. Many researchers have immensely contributed in this area. Tilley and Weidman (1998) studied stagnation point flows of different immiscible fluids at oblique incidence. Dorrepaal

(2000) concluded while studying the oblique flow impinging on a flat rigid wall that the angle of incidence has no effect at all on the slope of the dividing streamline at the wall. Lok et al. (2006a) observed that when the fluid impinges at an angle then depending on striking angle, when stretching parameter is greater than certain critical number, a boundary layer is formed. Lok et al. (2007c) further studied that the stagnation point gets affected by the mixed convection parameter. Mahapatra et al. (2009) found the solution of the Navier–Stokes equations for two-dimensional oblique stagnation point of visco-elastic fluid towards a stretching sheet. Grosan et al. (2009) observed the impact of the magnetic parameter on the shift in the position of the stagnation point. They enumerated that the stream function bifurcates into a Hiemenz flow and a tangential component in case of heating plates. Labropulu et al. (2010) has studied the second grade fluid and explained that the boundary layer is formed only when the stretching velocity of the surface is less than the in viscid free stream velocity. He also told that as elasticity increases the velocity of the fluid increases. P. Singh et al. (2010) studied MHD oblique stagnation-point flow towards a stretching sheet with heat transfer using the Rosseland approximation and calculated that the stream function splits into a Hiemenz and a tangential component. Here they have discussed the effect of striking angle, radiation parameter, magnetic field parameter and the Prandtl number on flow and heat transfer characteristics. P.Singh et al (2011) explored the study of MHD oblique stagnation point assisting flow on vertical plate with uniform surface heat flux. P.Singh et al (2012) further probed oblique stagnation-point darcy flow towards a stretching sheet. Here the effect of porosity is also considered along with oblique incidence.

Alessandra Borrelli et al (2012) studied uniform external electromagnetic field effect on two-dimensional oblique stagnation-point of an electrically conducting micro fluid and found that the oblique stagnation-point flow exists only when the external magnetic field is parallel to the dividing streamline.

Instead of a steady flow, if we consider the unsteady flow then the inviscid flow is generated as the surface is impulsively stretched with certain velocity. On the other hand if the flow is viscous near the sheet then within a short span of time it becomes a fully developed steady flow. Pop and Na (1996) studied the unsteady flow crossing near a wall and examined that as time progresses the unsteady flow approaches steady flow. Takhar et al. (2001) calculated the unsteady MHD flow due to the impulsive motion of a stretching sheet and found that up to certain instant the surface heat transfer increases and after that it starts decreasing. Elbashbeshy and Bazid (2004) while studying the heat transfer over an unsteady stretching surface found that unsteadiness parameter affects the thermal boundary layer and momentum boundary layer in same fashion i.e. it decreases. Ishak et al. (2009b) also stressed about the time dependence layer flow over a continuously stretching permeable surface. Shateyi and Motsa (2009) while analyzing unsteady heat and mass transfer over horizontal stretching sheet found that both the local Sherwood number and Schmidt number increases. Fang et al. (2009) reported unsteady viscous flow over a continuously shrinking surface with mass suction and calculated multiple solutions for some specified range of mass suction. Elbashbeshy and Aldawody (2010) studied the effects of thermal radiation and magnetic field on unsteady boundary layer mixed convection flow from a vertical porous stretching surface and found that velocity increases as the radiation parameter increase and it decrease as magnetic parameter increases.

II. CONCLUSION

Newer and newer techniques are emerging out to solve out the various stretching sheet problems. Some of the most important techniques used to solve the differential equations in fluids are Runge- kutta method, shooting method, Finite element method, Homotopy analysis method. Now a day’s considerable research is going on employing nanotechnology in fluids which can be looked upon in the future because nanotechnology enhances the thermal conductivity and a change in other properties. In nano fluid we have the dispersal of nano scale particles like carbon nano tubes in the ordinary conventional base fluid. This computational fluid dynamics area on stretching sheet is flourishing at a fast rate. The scope for the future research could be the application of various soft computing techniques like genetic algorithm, fuzzy and neural network to solve out these physical problems which have enormous applications in the industry.

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