ISSN 2229-5518

STUDY OF BINGHAM FLUID FOR SLIP AND NO SLIP CONDITIONS:A REVIEW

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Abstract— The Bingham Fluid flow in different geometries with different cross section is studied numerically, but less studies is being focused on circular cross section with slip and no slip condition. The study of flow parameters in curved tube of a viscous fluid constitutes a problem of fundamental interest in the field of internal fluid mechanics. Adaption of the frequent occurrence of curved tube geometries in industries, heat engine, heat exchangers, and chemical reactors. It is essential to understand the complex flow field and secondary flow. This paper is mainly focused on the flow behaviour of Bingham fluid in different cross section..

Index Terms— Bingham Fluid, Non-Newtonian Fluid, Slip and No-Slip condition

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1 INTRODUCTION

A Bingham fluid is a viscoplastic fluid that behaves as a rigid body at low stresses, while it flows as a viscous fluid at high stresses, it is used as a mathematical model of mud in drilling engineering, and it is fluids that possess a yield strength which must be increased before the fluid will flow.The Branch of physics that deals with the deformation and flow of matter, especially the non-Newtonian flow of liquids and the plastic flow of solids. Fluid rheology is used to describe the consistency of different products, normally by the two components viscosity and elasticity. By viscosity it is usually meant resistance to flow or thickness and by elasticity usually stickiness or structure. There are different types of fluid which are classified according to their properties.
But an exception in the rule of Bingham plastics, fluids which require minimum stresses to be applied before they flow, they are strictly non-Newtonian, but once the flow starts they behave as Newtonian fluid (shear stress is linear with shear rate). Considerable research efforts are directed in generalised approach for the prediction of the pressure drop for turbulent flow in pipes, mainly for purely viscous fluids.

Results obtained with drag reducing polymer solution also tend to be strongly dependent on the type of and molecular weight of the polymers, also the solvent nature on the type of experimental set up used.

Fluid Type	K	N	τ_0
Newtonian	0<	1	0
Power –law			
Shear-thinning	0<	0<N<1	0
Shear-thickening	0<	1<N<∞	0
Bingham plastic	0<	1	0<
Herschel-Berkley	0<	0<N<∞	0<

2.LITRETURE REVIEW

Study on laminar Bingham fluid flow between vertical parallel plates is done by Bayazitoglu et al (2007)[1], packer fluids for deep water oil and gas wells are developed to minimize the rate of heat transfer from the flowing production fluid to the outer casing annuli. In their study they found a yield point capable of preventing or drastically reducing natural convective fluid flow heat transfer occur from the production tubing to the production casing. In this study fluid is described in five distinct regions between the parallel plates gaps, progressing from hotter to the cooler plates, a dimensionless number are developed for the Bingham fluid in order to be available linear viscous correlation equation, this result characterize the heat transfer performance of the gel. It is concluded from the investigation that strength of gel influenced the convective heat transfer rate in oil industries is strong ,this paper help in the development of free convective heat transfer correlation equation and the pressure drop calculations for the non-Newtonian packer fluid, they also able to reduce heat transfer in economic viability of wells and longevity it is also concluded that to initiate flow temperature differential is required and can be appreciable for practical applications.
Investigation in flow of a Bingham fluid in a slightly curved

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tube is done by Bigyani Das (1992) [2]. They use the Runga-Kutta Merson Technique, in this investigation dean number region is compared with Casson fluid have the same yield value. It is concluded that the flow characteristics of a Bingham fluid through a curved tube circular cross section in the high dean number, momentum integral equation with the equation find by allowing the continuity of the secondary flow at the edge of the boundary layer, produces a system of non-linear ordinary differential equation. Flow characteristics of a Bingham fluid through a circular section of curved tube is investigated in the high Dean number region. A core formation region in central plug and boundary layer region is dominated by viscous near the wall, the corresponding equation for each region have been obtained from the modified Navier stokes equations for a Bingham fluid, momentum integral equation together with the equation acquire at the edge of the boundary layer by considering the continuity of the secondary flow, give rise to a system of non-linear ordinary differential equation.

Another investigation is done by Fusi et al (2016) [3] on Bingham fluid in a non-symmetric inclined channel and the lubrication is pressure driven. Approaching towards modelling the lubrication flow for Bingham fluid within a channel whose amplitude is non-uniform; this approach leads an integro differential equation which can be solved by iteration procedure for the pressure. The study is extended for the case of a pressure dependent viscosity in this paper, they studied the pressure driven flow of a Bingham fluid within a channel for which walls are not flat, and they used a lubrication assuming that the channel length is much larger then width. The approach lies in the motion equation of the inner rigid core which was derived by applying the momentum conservation to the whole core, body of variable mass whose boundary is not material. Method that they developed provides the classical Bingham solution when the channel walls are parallel, they predict that the rigid core expands where the channel narrows and vice versa. They proved that their approach does not lead to any paradox even if the channel width variation is not small. They provide estimate on the pressure difference ensuring that the flow does not stop.

Mukherjee et al (2016) [4] done numerical investigation in power-law on Laminar forced convection and Bingham plastic fluids inside ducts of semi-circular and other cross section. In their work the consequence of the power law and Bingham plastic viscosity on the flow and characteristics of heat transfer of laminar forced convection through the non-circular ducts were analysed. Different types of two thermal boundary condition on the duct wall implemented. Flow resistance and Nusselt number for the flow of Bingham plastic fluids and power law in non-circular duct investigated for range of power laws covering both shear thickening and shear thinning properties. They concluded by comparing the prediction of the power law model with the extended altered power law for a semi-circular duct so that the influence of the problems of power law equation in capturing the infinite and zero shear viscosities on the obtained results. Flow resistance and Nusselt number for the laminar flow of Bingham plastic fluids and power law in cores of non-circular cross section ducts including the case of a semi-circular duct have been investigated. Two velocities profile are seen to be a different in the central part of the duct, the temperature profiles are seen to overlap, inspiring confidence in the reliability of the results reported in their study.

Shelukin and Neverov (2016) [5] done investigation on thermodynamics of micro polar Bingham fluids. Bingham fluid allowing for the different concentration of polar particles, such fluids exhibit couple stresses a non-symmetrical stress tensor;microrotation and microinertia also the fluid support a yield stress, calculation is performed on a steady flow between two parallel planes prove that both the yield stress and yield couple stress reduce this tabular pinch effect. The importance of this paper is that starting from basic thermodynamics principles, they derive conservation laws and constitutive equation for micropolar Bingham fluids with variable the concentration of polar particles. This type of mathematical model is formulated for the first time such a fluid exhibit microrotational effects and micro rotational inertia, fluid can support the couple stresses do not exceed some yield stress. They prove that both the yield stress and the yield couple-stress reduce this tubular pinch effect.

Heat transfer and momentum from a semi-circular cylinder in Bingham plastic fluids is observed by Tiwari and Chhabra (2015) [6]. In this investigation heat transfer and momentum from a semi circucular cylinder immersed in Bingham plastic fluids is calculated in the laminar flow region, the governing differential equation have been solved over wide ranges of conditions for Reynolds number, Prandtl number and Bingham number. The detailed temperature field and flow in the nearness of the cylinder surface are examined in terms of the streamline and isotherm contours, the influence of the type of thermal boundary condition like constant wall temperature and constant heat flux imposed on the surface of the semi-cylinder is determined.

Rate of heat transfer for the constant wall temperature is slightly higher than that for the constant heat flux condition.

The individual and total drag co-efficients have been correlated by simple equation in terms of the modified Reynolds number and Prandtl number enabling prediction inn a new application, it denotes the free stream condition. Due to the diminishing yielded regions the velocity and temperature gradients are sharpened in Bingham plastic fluids than that in Newtonian fluids at fixed values for Re and Pr, these resulting values of the average Nusselt number are seen to be slightly higher for the CWT (constant wall temperature) conditions than that for the CHT (constant heat flux) conditions.

CONCLUSION

In the above review of the papers it is being study that there is a vast area of research in the field of Bingham Plastic and Bingham Pseudo Plastic fluid.A Bingham Plastic is a viscoplastic fluid which behaves as a rigid body in low stresses while flow as a viscous fluid at a high stress, Bhingham fluid is a type of Non-Newtonian fluid that possesses a yield strength which must be exceeded before the fluid will flow. A number of types of geometries is being studied but it is found from the review that there is less study on the behaviour of Bingham fluid in serpentine channel as the use of serpentine channel is now efficiently used in the industries of heat exchanger , heat engines etc. Slip and no slip behaviour of the Bingham fluid throughout this channel is not being focused as much more studies should be necessary in the flow behaviour of the Bingham fluid in serpentine channel with slip and no slip conditions.

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