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Method Article

Mutual effects of stratification and mixed convection on Williamson fluid flow under stagnation region towards an inclined cylindrical surface

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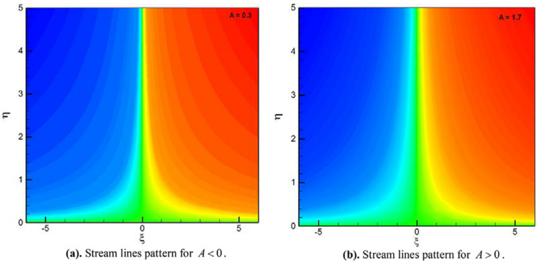
GRAPHICAL ABSTRACT



(a). Stream lines pattern for $A < 0$. (b). Stream lines pattern for $A > 0$.

ABSTRACT

We have found that few attempts are reported on Williamson fluid flow yields by an inclined cylindrical surface. To be more specific, Williamson fluid flow regime characteristics under stagnation point region especially when it is manifested with mutual interaction of double stratification and mixed convection effects are not proposed as yet. Therefore, we have considered stagnation point mixed convection Williamson fluid flow brought by an inclined cylinder in the presence of temperature and concentration stratification phenomena. Further, the fluid flow is entertained through no slip condition i-e the velocity of particles is directly related to velocity of cylindrical surface due to stretching. The physical situation within the real concerned constraints is translated in terms of differential equations as a boundary value problem. To make implementation of computational algorithm possible, following steps are taken into account

- The PDE's are transformed into ODE's by using suitable transformation.
- The resulting boundary value problem is converted into an initial value problem.

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- These constructed ordinary differential equations are solved computationally by shooting technique charted with Runge-Kutta scheme.
- The effect logs of an involved physical flow parameters are explored by way of graphical outcomes and tabular values.

ARTICLE INFO
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Method details

The study of non-Newtonian fluids flow brought by stretching surfaces is always remains a topic of great interest and has received outstanding attention by the researchers due to their numerous applications in an industrial and engineering process. To be more specific, pulps, sugar solutions, tomato ketchup, and shampoos are the well-known examples of non-Newtonian fluids. In non-Newtonian fluids, there exists non-linear bond between deformation rate and shear stresses so, it is difficult to narrate the accurate salient features of non-Newtonian fluid models. To clip out the complete description of non-Newtonian fluids flow different model are proposed by scientists like Maxwell fluid model (1867), Barus fluid model (1893), Bingham Herschel-Bulkly (1922), Ostwald-de Waele power law model (1923), Williamson fluid model (1929), Eyring fluid model (1936), Burgers fluid model (1939), Generalized Burgers (1939), Reiner-Rivlin fluid model (1945), Oldroyd-A (1950), Oldroyd-B fluid model (1950), Oldroyd-8 constants (1950), Glen fluid model (1955), Rivlin-Ericksen (1955), Criminale-Ericksen-Filbey (1957), Sisko fluid model (1958), Kaye-Bernstein-Kearsley-Zapas (K-BKZ, 1963), Seely fluid model (1964), Cross fluid model (1965), FENE-P (1966), Carreau fluid model (1972), Carreau-Yasuda fluid model (1972), Johnson-Segalman fluid model (1977), Johnson-Tevaarwerk (1977), Phan-Thien-Tanner fluid model (1978), Giesekus fluid model (1982), FENE-CR (1988), Ellis fluid model, Blatter fluid model (1995), and White-Metzner, Rolie-Poly. In short, the interest of researchers and scientists immensely increased towards rheological features of non-Newtonian fluids like Abel et al. [1] discussed non-Newtonian fluid flow characteristics in the presence of magnetic field, heat and mass transfer effects. Tan and Masuoka [2] identified Stokes first problem by an incorporating second grade fluid by means of heated boundary. The mutual properties of heat and mass subject to viscoelastic fluid model was taken by Sanjayanand and Khan [3]. Ishak et al. [4] presented variable heat flux characteristics for micropolar fluid model. Whereas, the impact of magnetic field on power law fluid flow an induced by stretching flat surface was studied by Chen [5]. The combined properties of heat and mass transfer regarding peristaltic movement for a Jeffrey fluid was discussed by Nadeem and Akbar [6]. Ashorynejad et al. [7] probed nanofluid flow yields by stretching cylindrical surface in the presence of heat transfer phenomena along with magnetic field effect. The influence of thermal radiation on MHD nanofluid flow with heat transfer was given by Sheikholeslami et al. [8]. Recently, the non-Newtonian fluid flow with heat and mass transfer manifested with bio-convection was taken by Raju et al. [9]. More recently, Salahuddin et al. [10] deliberated non-Newtonian fluid flow characteristics by means of stretching cylindrical surface.

To be more specific, out of these non-Newtonian fluid models, Williamson model is quoted as fluid with pseudo-plastic features. In addition, Williamson fluid model admits shear thinning properties. The industrial and biological liquids that obey the Williamson fluid are polymers, melts/solution, ketchup blood, paint, and whipped cream to mention just a few. Williamson [11] exposed this model to express pseudo-plastic physiognomies with both characteristics of minimum and maximum viscosity effects. Then rest of motivated researchers explore more heads for this non-Newtonian fluid category like Aksoy et al. [12] derived first boundary layer equations subject to Williamson fluid model and offered symmetry analysis. Akbar et al. [13] found numerical solution of Williamson nanofluid flow by using both fourth and fifth order RK–Fehlberg method in an irregular channel. Nadeem et al. [14] examined Williamson fluid