A Review Report of Present Trend in Peristaltic Activity of MHD NON-Newtonian and Newtonian Fluids

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Abstract
This academic paper deals with reviewing theoretical studies on MHD peristaltic transport of the Non-Newtonian as well as Newtonian fluids such as Hyperbolic Tangent fluid, Carreau fluid and Bingham fluid. Here, a wide range of study subjects, concepts, points of view, and mathematical models are presented. All of these studies are focused on Non-Newtonian fluids peristaltic activity. Among numerous of the Non- Newtonian fluids flows in physiological system, blood pumping mechanics.

Keywords : Peristaltic flow ; Hyperbolic Tangent fluid; Carreau fluid; Bingham fluid

1. Introduction

Direct and individual communication among fluid dynamics experts is required for physiological fluid dynamics research. The needed collaboration should be preceded through a period of mutual education which is sufficiently long for each side to gain a thorough understanding regarding the other's language and mode of expression, along with recognition of which discipline areas have developed an especially detailed and intricate body of knowledge and skills that could be called upon whenever needed. True communication between disciplines becomes possible as a result, leading in more efficient research advancement. The peristaltic phenomena has been the subject of scientific and technical investigation recently. The name "peristalsis" is derived from Greek word "peristaltkos," that means "clasping and compressing." In the case when an area contraction or expansion wave propagates down distensible tube's length, it is referred to as peristaltic transport. Peristalsis is a physiological process where the body pushes or mixes the contents of tubes like the ureter, which transports urine from kidney to bladder, lymphatic vessels, the intestines, the heart's blood pump, vaso-motion of small vessels of blood, and several of the other glandular ducts in the living organism. The peristaltic phenomenon has piqued the curiosity of many researchers (biomechanical and biomedical engineers), with Latham [1] making the first demonstration of fluid motions in peristaltic pump. On both mechanical and biological levels, peristaltic action is crucial. Peristaltic transportation of the fluids across various vessels of human physiological systems has been recognized by physiologists as one of the natural ways for materials of pumping. Peristaltic transport is essential for moving fluids from low- to high-pressure environment, according to reports. Non-Newtonian and newtonian fluids are subjects of many theoretical peristaltic pumping investigations.

The concerns surrounding the peristaltic transport mechanism have been investigated in detail by the authors. As model equations, Fung and Yih [2] and Lozano [3] used Navier – Stokes equations for a viscous fluid. Shapiro et al.[4] indicated that pumping has been driven through a variation of time averaged flux with a pressure variation throughout one wavelength. The MHD effect on peristaltic transport is important in many disciplines, such as biology (Blood Flow) and technology (MHD Pump). Hayat *et al.* [5] investigated the impact of MHD peristaltic transport via porous medium. Peristaltic motion in Non-Newtonian and Newtonian fluids has been extensively studied theoretically. Physiological liquids (blood, food bolus fluid), geological suspensions (sedimentary liquids, Drilling Muds), industrial liquids (Greases and Oil), and peristaltic system. Pop and Ingham [6] presented the Hyperbolic tangent model as a Non-Newtonian model in 2001, whereas Nadeem and Akram [7] have studied peristaltic transport regarding Hyperbolic Tangent fluids in asymmetrical channels in 2011. Different Non-Newtonian fluid types, such as Hyperbolic tangent fluid, have been a subject of research recently. The impact of slip and wall characteristics on MHD peristaltic flow of Hyperbolic tangent fluids in Non-uniform channel were investigated by Nagachandrakala *et al*. [8] in 2013.

$$y = \pm\eta(x,t) = \pm d(x) + a\sin[\tfrac{2\pi}{\lambda}(x - ct)] \quad (1)$$

The amplitudes of waves, the mean half channel width, the wavelength, channel's dimensional non-uniformity, and time are represented by d(x)= d + m'x, a, d, m' and t. The trapped bolus's size is large on the left side regarding convergent channel, yet the opposite is true for the divergent channel. Whereas size bolus for a uniform channel is symmetric, there has been an increase in Hyperbolic tangent fluid velocity with the power law index increase, Saravana *et al*. [9] studied a comparable research work on peristaltic flow regarding the same fluid in Non-uniform channels with transfer of heat in 2017.

$$y = \pm\eta(x,t) = \pm\{d(x) + a\sin[\tfrac{2\pi}{\lambda}(x - ct)]\} \quad (2)$$

It was indicated that when there is an increased power law index, then there will be also an increase of the temperature and velocity of Hyperbolic tangent fluid, the concentration is decreased as n increases, and the size of trapped bolus is increased. Hummady and Ridha [10]

biotechnological liquids (Gels, Polymers, Food Stuffs) all have non-Newtonian properties, whereas Newtonian fluids are air, water, glycerol, alcohol, and thin motor oil. One of these is hyperbolic tangent fluid that is important in the

lately provided their research work on the impacts of magnetic field on peristaltic flows in anti-symmetric channel with porous media, and showed their results where the flow induced via peristaltic transport of the channel wall is analysed under same assumptions of Reynolds number and wave-length, and velocity and stream function are determined. The trapping phenomenon is thoroughly examined.

$$\bar{h}_1(\bar{x},\bar{t}) = d_1 + a_1\sin[\tfrac{2\pi}{\lambda}(\bar{x} - c\bar{t})] \quad (3a)$$

$$\bar{h}_2(\bar{x},\bar{t}) = -d_2 - a_2\sin[\tfrac{2\pi}{\lambda}(\bar{x} - c\bar{t}) + \Phi] \quad (3b)$$

where a_1 , a_2 , d_1 , d_2, λ , c, Φ ,t, represent wave amplitudes, channel width, wave-length, wave speed, Φ ($0 \le \Phi \le \pi$) phase difference and time.

It was discovered that as the inclination magnetic field increases, velocity at channel's central region increases, while channel wall's velocity decreases. With increasing inclination magnetic field, the size of the trapping bolus for Anti-symmetric a long the center line of the channel diminishes. Numerous research on peristaltic motion in Newtonian fluids have been published in the literature. Carreau fluid is one of those that plays an essential part in the field of peristaltic mechanism. Latham conducted research on Carreau fluid peristaltic pump motion in 1966. The impact of induced magnetic field peristaltic transportation regarding Carreau fluid in inclined channel field with porous materials was examined by Reddy *et al*. [11] in 2011. The perturbation approach with a low Weissenberg number is used to investigate the flow. The formulas for velocity, pressure rise, axial pressure gradient, and frictional forces are found over 1 wavelength cycle. Graphs are frequently utilized for showing how different developing factors affect frictional forces and pumping characteristics. Akbar *et al*. [12] after that released a work in 2014 on the numerical solution regarding peristaltic flow of Carreau nano-fluid in asymmetrical channel.

$$Y= H_1=d_1+a_1\cos[\frac{2\pi}{\lambda}(x-ct)] \quad (4a)$$

$$Y=H_2=-d_2 - a_2\cos[\frac{2\pi}{\lambda}(x-ct)+ \Phi] \quad (4b)$$

In this work, the researchers investigated at MHD peristaltic transport regarding a Carreau nanofluid in asymmetrical channel, in which flow develops in wave frame of references which moves with the wave velocity. Governing non-linear partial differential equations (PDE) have been converted to system of the nonlinear ordinary differential eqs. with the use of similarity transformations, and after that numerically solved with the use of Rang-Kutta-Fehlberg techniques of 4th and 5th order. As the Hartmann Number increased, so did the pressure, he observed. Furthermore, in 2014, Riaz *et al* [13] presented an advanced work on peristaltic transportation that is related to Carreau fluid in rectangular compliant duct. Peristaltic flow of the Newtonian or the non-Newtonian fluid in rectangular channel with the compliant walls, has yet to be investigated. Peristaltic phenomena have several applications in engineering, industry, and medical technology. Developers and researchers are particularly interested in peristaltic flows of the Non-Newtonian fluids in 3D channels. Researcher's study into peristaltic flow regarding Carreau fluids in rectangular channel with flexible walls had been prompted by the aforementioned recent peristalsis advancements. Governing equations of Carreau fluid were reduced through the use of a long wavelength approximation and low Reynolds number assumption. Homotopy perturbation and Eigen function expansions approaches were used for solving the reduced equations analytically. In 2015, Kothandapani, and Prakash [14] investigated peristaltic flow of Carreau nanofluid under an influence of magnetic fields in a tapered asymmetric channel. Maheshbabu and Sreenadh [15] then conducted tests in 2020 on peristaltic flows of the Carreau fluid in symmetrical channels with Hall impact. In the present study, they looked at effects of Hall on peristaltic transport of Carreau fluid with the use of same Reynolds number and wave-length estimations. Flow had been researched in wave frame reference which moves with frame velocity. To derive explicit forms of velocity distribution and pressure per wavelength, the perturbation approach was applied. Graphs show the effect of a number of important parameters on the pumping characteristics and pressure gradient. The magnitudes of pressure rise and pressure gradient in the pumping region increase with increasing amplitude ratio and Hartmann number, while they decrease with rising Weissenberg number. The time averaged flux falls as the Hall parameter increases, whereas increasing as Hartmann number is increased.

Narahari amd Sreenadh [16] investigated peristaltic flow regarding a Bingham fluid in the channel under low Reynolds number and long wavelength estimations in the year 2010. The flow has been analyzed in wave frame of reference that moves with wave's velocity. The yield stress is a novel parameter found in the solution for streams from different regions. The impacts of the peripheral-layer viscosity and yield stress on mechanical efficiency and time-averaged flow. It has been noticed that as the yield stress increases, time-averaged flow against the pressure rise decreases, while the viscosity ratio increases. As for pumping efficiency is higher when yield stress is lower and the viscosity ratio is higher.

$$Y= H(X,t) = a + b\,cos[\frac{2\pi}{\lambda}(X-ct)] \quad (5)$$

Here, a, b, λ and c represent waves' amplitudes, wave-length and wave speed. The consequent deformations of interface separating core and peripheral-layer has been represented by Y = $H(X,t)$.

Kumar *et al.*[17] wrote a work on the peristaltic transportation regarding a conducting Bingham fluid in contact with the Newtonian fluid in the channel in year 2013. The magnetic impact of peristaltic pumping in 2D channel walls that are filled by 2 immiscible fluids through a sinusoidal traveling wave is investigated. The channel's core contains a Bingham fluid, while the channel's periphery contains a Newtonian fluid. Flow has been investigated in reference wave frame that moves with wave's velocity. The stream function, pressure increase and velocity expressions are determined. The equation for interface between both fluids can be found. For many of the physical parameters of interest, numerical results are discussed. Low ratios of the viscosity are related to thinner peripheral layers in pump's constricted area, and lower values of and result in giving rise to bigger peripheral layers in pump's constricted region.

$$Y= H(X,t) = a + b\sin[\frac{2\pi}{\lambda}(X-ct)] \quad (6)$$

In which a, b, λ and c represent amplitudes of waves, wave-length and wave speed. In this study, the researchers discovered that as the Hartmann number and yield stress fall, the pressure rises.

The impact of the transfer of heat on peristaltic (MHD) flows regarding a Bingham fluid via porous media in the channel was investigated by Rathod and Laxmi [18] in 2014. The deformation of the wall is expressed as:

$$H(X,t) = a + b\sin[\frac{2\pi}{\lambda}(X-ct)] \quad (7)$$

Here, a, b, λ and c are amplitudes of wave, wave-length and wave speeds.

The governing equations were linearized with the use of a long wavelength approximation, in which the peristaltic wave wavelength is large in proportion to the channel radius and the Reynolds number is low. The velocity field was calculated using the Adomian decomposition method, which is suitable for blood flow since the erythrocyte and plasma areas could be classified as plug flow and non-plug flow phases, respectively. It is especially beneficial in comprehending peristaltic blood pumping in small vessels. In this research, graphics were used for explaining the effects of the emerging parameters. The rise of the pressure and gradient of the pressure increase when the amplitude ratio Φ, Hartmann number, Grashof number, and heat source parameter increase in this work. Furthermore, it is seen that when the Darcy number increases, the axial pressure falls. It's also worth noting that as the Darcy number and heat source parameter grow, the temperature field increases and decreases with the Hartmann number. The temperature field is at its maximum at y=0.

The authors then published a research in the year 2018 on peristaltic flows regarding Bingham fluid in non-uniform channel as well as its impacts upon slip conditions, heat transfer, and wall attributes. Pumping Bingham fluid through an elastic walled porous channel was used to explore heat transmission and wall slip conditions. This was done on a basis of small Reynolds numbers and a long wave-length. The impact of a variety of the physical parameters on velocity and temperature was graphically analyzed.

Eldabe et al. [19] investigated a research effort on flow regarding Non-Newtonian Bingham blood fluid via non-uniform channel in 2021. His research focused on the impact of the heat and the mass transfer on peristaltic blood flows in non-uniform environment, which affects temperature, velocity, and concentration distribution. The estimations of wave-length and Reynolds number simplify the system, which is analytically solved with the use of homotopy perturbation channel under an effect of external uniform magnetic field. The problem is mathematically modulated using a nonlinear partial differential equations approach. The impact of different emergent parameters on the acquired solutions is numerically examined and graphically demonstrated in a collection of figures. The equation for a non-uniform channel is as follows:

$$H(X,t) = b(X) = b_0 + \frac{I(x-CT)}{\lambda_1} + a\sin[\frac{2\pi}{\lambda_1}(X-ct)] \quad (8)$$

Here, a, b, λ and c represent amplitudes of waves, wave-length and wave speed.

It is observed in this work that the stream line is increased with the increase of λ_0, whereas it, D_f, λ_1 and $\lambda_0$decreases as M increase and the temperature increase with the increase of each of D_f and$\lambda_1$while it decreases as λ_0, Ec and M increases. The effect of temperature behaviour appears only for large values except that for different values of λ_1 and the horizontal velocity for different values of all parameters is shown negative and becomes grater with increasing the coordinates η.

2. Mathematical Formulation

For a Hyperbolic Tangent fluid, the constitutive equation is

$$\bar{\tau} = -\mu_0\,[1 + n\,(\Gamma\dot{\gamma} - 1)\,]\dot{\gamma} \quad (9)$$

Where $\dot{\gamma} = \sqrt{\frac{1}{2}\sum_i\sum_j \gamma_{ij}\gamma_{ij}} = \sqrt{\frac{1}{2}\Pi}$, $\bar{\tau}$, μ_0, Γ, n and Π are extra stress tensor, Zero shear rate viscosity, time constant, power-law index and 2nd invariant strain tensor.

For a Carreau fluid, the constitutive equation is

$$\frac{\eta-\eta_\infty}{\eta_0-\eta_\infty} = [1 + (\Gamma\bar{\dot{\gamma}})^2]^{\frac{n-1}{2}},$$
$$\bar{\tau}_{ij} = \eta_0[1 + \frac{n-1}{2}(\Gamma\bar{\dot{\gamma}})^2]\,\overline{\dot{\gamma}_{ij}} \quad (10)$$

Where $\dot{\gamma} = \sqrt{\frac{1}{2}\sum_i\sum_j \gamma_{ij}\gamma_{ij}} = \sqrt{\frac{1}{2}\Pi}$

, $\bar{\tau}_{ij}$, η_∞, η_0, Γ, n and Π are the extra stress tensor, infinite shear rate viscosity, 0-shear rate viscosity, time constant, index of power-law and 2nd invariant strain tensor.

For a Bingham fluid, the constitutive equation is

$$\tau = -\mu + \frac{\tau_y}{|\dot{\gamma}|}\{1 - e^{-m|\dot{\gamma}|}\}\bar{\dot{\gamma}} \quad (11)$$

Where $\bar{\dot{\gamma}} = \sqrt{\frac{1}{2}\sum_i\sum_j \overline{\dot{\gamma}_{ij}}\,\overline{\dot{\gamma}_{ij}}} = \sqrt{\frac{1}{2}\Pi}$

, μ , τ_y , m and Π are the constant viscosity, apparent yield stress, stream growth exponent and second invariant strain tensor

3. Applications:

a) Non-Newtonian fluid peristaltic transport has various applications in industry and medicine, also in mathematics because of its complexity and nonlinear equation solutions. The peristaltic phenomenon includes human reproductive system motion, food swallowing, Spermatozoa movement, and chyme motion in gastrointestinal tracts.

b) Trapping is another major peristaltic transport mechanism. Trapping is the act of using closed streamlines to form a bolus of fluid that circulates within.

c) Non-Newtonian fluids have gained a lot of interest lately because of their broad range of applications in technology and science. Gels, honey, blood, paints, lubricants with polymer additives, printer inks, toiletries, and cosmetics are examples of non-Newtonian fluid types. Tangent hyperbolic fluid model represents a type of Non-Newtonian fluids that is frequently used in research and industry.

d) A Non-Newtonian fluid known as a hyperbolic tangent fluid was frequently employed in laboratory research. Because of its multiple uses in biology and engineering, peristaltic transport regarding a Hyperbolic tangent fluid has increased curiosity of researchers and scientists. Blood flow and blood pump mechanics are examples of MHD peristaltic difficulties of a hyperbolic tangent fluid.

e) Considerations of the blood as an MHD fluid aids in blood pressure control and has therapeutical promise in blood vessel and heart diseases.

f) Bingham fluids are utilized in a variety of applications, including mud flow and shallow soil, pulmonary mucus, avalanches, waxy crude oils, and ceramics. The mass and heat transfer behavior related to the Bingham fluid flow behavior is investigated under an angled magnetic field influence, and it is used as a standard mathematical model of mud flow in drilling engineering. At low stresses, Bingham fluids, also known as Bingham plastic, have an infinite plastic viscosity, which decreases as the velocity gradient grows at increasing strains. Paints, plastics, toothpaste, and ketchup are just a few examples.

g) Due to the fact that they are providing an excellent match to tentative data in various flow cases, like flow of blood arteries and porous medium along with rheometric measurements, the Carreau fluid models are majorly utilized in a variety of the technological, industrial and biological disciplines, like engineering and bio-sciences, food processing, and reservoir engineering.

h) Seepage of water in riverbeds, filtration of fluids, limestone, underground water and oil movement, human lung, gallbladder with stones, bile duct, and small blood arteries are only a small number of the most prominent applications of Carreau fluid.

4. Concluding Remarks

a. The authors investigated the impacts of temperature, conditions of the velocity slip, wall characteristics, and boundary conditions on the MHD peristaltic transport regarding a Hyperbolic tangent fluid in Non-uniform channels and found that temperature and velocity increase in the channel's upper half as velocity slip parameter, power law index of Hyperbolic tangent fluid, and Weissenberg number increase, yet decrease in lower half.

b. The velocity at the central region regarding a peristaltic flow of Hyperbolic tangent fluid drops as the Weissenberg number We, permeability increases, according to mathematical research. There is an increase in the channel's k parameter as it approaches the channel wall's boundary. There is an increase in velocity in the central region as the Hartman number Ha and the inclination of the magnetic field B increase, but drops at the channel wall's boundary. They also discovered that as the parameters are increased, the size of the trapping bolus for anti-symmetric along the center line of the channel diminishes (k, We, B, Ha).

c. The authors indicated that the qualitative behavior regarding Power law index, amplitude ratio, Hartmann number, and Weissenberg number on pressure rise is the same in their work tests of MHD peristaltic flow of Carreau non fluid in asymmetrical channel.

d. The authors indicated that in peristaltic motions regarding Carreau fluids in symmetric channel with convective boundary condition, longitudinal velocity of Newtonian fluid is greater than that of the Carreau fluid at the channel's center, whereas the Newtonian fluid's velocity is low near the channel's walls. They also discovered that as the amplitude ratio and Hartmann number grow, the pressure gradient and rise increase, but the values of these variables fall while the Weissenberg number increases. The time averaged flux falls with the increase in Hall parameter, while Hartmann number increases.

e. The impact of peripheral-layer viscosity and yield stress on the mechanical efficiency and time-averged flux is derived in research of peristaltic transports regarding Bingham fluid which is in contact with Newtonian fluid in the channel. The time-averaged flow versus pressure grows with the rise in yield stress, whereas the viscosity ratio rises. Pumping efficiency is higher in the case when the viscosity ratio is high and yield stress is low.

f. In a research of peristaltic transports regarding a conducting Bingham fluid which is in contact with the Newtonian fluids in the channel, trapping zone's size diminishes with the increase in viscosity ratio.

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