ISSN: 0975-766X
CODEN: IJPTFI
Available through Online
www.ijptonline.com
Review Article

A REVIEW REPORT OF RECENT DEVELOPMENTS IN PERISTALTIC TRANSPORT OF PHYSIOLOGICAL FLUIDS

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Received on 20-05-2016 *Accepted on 15-06-2016*

Abstract

This paper deals with the review of the literature on Peristaltic transport of physiological fluids like Carreau, Casson and Jeffrey fluids. Here, it is discussed extensive research topics, concepts, different views and the respective mathematical models. All these investigations deal with peristaltic pumping of biofluid. Among several biofluid flows in physiological systems, blood flow in small blood vessels is reported to flow under the mechanism of peristalsis.

Keywords: Peristaltic flow; Carreau fluid; Casson fluid; Jeffrey fluid; Porous medium.

Definition and Motivation

Peristaltic pumping has been the object of scientific and engineering research in recent years. The word peristaltic comes from a Greek word "Peristaltikos" which means clasping and compressing. The phenomenon of peristalsis is defined as expansion and contraction of an extensible tube in a fluid generate progressive waves which propagate along the length of the tube, mixing and transporting the fluid in the direction of wave propagation. Peristaltic pumping is a form of fluid transport that occurs when a progressive wave of area contraction or expansion propagates along the length of a distensible tube containing the fluid. It is an inherent property of many tubular Organs of the human body. It plays an indispensable role in transporting many physiological fluids in the body in various situations such as urine transport from the kidney to the bladder through the ureter, vasomotion of small blood vessels, as well as mixing and transporting the contents of the gastrointestinal passage, the transport of the spermatozoa in cervical canal, transport of bile in the bile duct, transport of cilia. Peristalsis plays an indispensable role in transporting physiological fluids inside living bodies and many biomechanical and engineering devices have been designed on the basis of the principle of peristaltic pumping to transport fluids without internal moving parts. The need for peristaltic pumping also arises in circumstances where it is desirable to avoid using any internal moving parts such as pistons, in pumping process. Peristalsis mechanism has attracted the attention of many researchers' since the first investigation of fluid motion in peristaltic pump by Latham [1] in 1966. After that a number of exact, analytical, and numerical studies of peristaltic transport for Newtonian and non-Newtonian fluids have been investigated by so many researchers.

Introduction

Work in physiological fluid dynamics needs very close and intimate collaboration between specialists in physiological science and specialists in the dynamics of fluids. The necessary collaboration has to preceded by a process of mutual education sufficiently prolonged to bring about on each side an adequate understanding of the other side's language and modes of expression, as well as recognition of which are the main areas where the discipline has developed a particularly extensive and intricate body of knowledge and skills which can be called upon when required. After this, real communication between the different specialism becomes possible, and can lead to effective research progress.

Peristaltic flows are generated by the propagation of waves along the flexible walls of channel. Because there are no internal moving parts, peristaltic transport provides an efficient, clean, and safe means for fluid transport and is widely used in industrial peristaltic pumping. In physiological and medical applications, peristaltic transport is used for the transport of blood within small blood vessels or artificial blood services.

The mathematical work on peristaltic transport was initiated by Fung and Yih and Shapiro, Jaffrin, and Weinberg using the Navier-Stokes equations for a viscous fluid as model equations. Humankind has borrowed the idea and used it in applications where the material being pumped must not be contaminated (e.g. blood) or is corrosive and should not be in contact with the moving parts of ordinary pumping machinery. Also, peristaltic motion has even been found to play a role in never regeneration. In addition peristaltic pumping occurs in many practical applications involving bio-mechanical systems. For example, the heart lung machine and other pump instruments.

In recent years so much of research work done on the different physiological fluids like for example Casson fluid, in the year 2002, A.V.Meronone [2] done the study of peristaltic transport of a Casson fluid modeled by non-Newtonian fluid by using a zeroth and first order Perturbation method.

$$G(x,t) = A\cos\frac{2\pi}{\lambda}(x-ct) \text{ ----------------- (1)}$$

G is the vertical displacement; A is amplitude of the sinusoidal wave, λ is the wavelength, x is the direction of the wave and t is the time. It is found that in the zeroth -order approximation in stream function that there is a dependence on the Casson coefficient of viscosity, yield stress, the density of the fluid, the wave speed, and the dimension of the channel. After that in the year 2004, P.Nagarani et.al. [3] done the work on Peristaltic transport of a Casson fluid in an asymmetric channel by assuming long-wavelength and low-Reynolds number by discussing the phenomena of trapping and reflux in the asymmetric channel. The yield stress of the fluid tends to form two yield planes in the plug core region. When the channel is symmetric the yield plans are found to be located symmetrically on either side of the centerline y = 0 and in an asymmetric channel the plug region is skewed towards the boundary wall with higher amplitude.

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

$$Y = H_2 = -d_2 - b_1 \cos\left(\frac{2\pi}{\lambda}(x - ct) + \phi\right) \quad \text{---------------(2b),}$$

where a_1, b_1 are the amplitude of the waves, λ is the wavelength, $d_1 + d_2$ is the width of the channel, ϕ is the phase difference.

It is noticed that the trapping of fluid occurs and the trapping zone extends for an increase in the time average flux. It is found that reflux occurs for higher values of amplitude of the peristaltic wave and the reflux zone extends for increased amplitudes. This model can further be redefined by considering the effects of the elasticity of the walls, which will affect the yield plane location and flow characteristics. After that in the year 2010 Nagarani [4] presented research work on peristaltic transport of a Casson fluid in an inclined channel, and shown her results as the flow induced by peristaltic motion of the channel wall of a Casson fluid is analyzed under long wavelength and low Reynolds number assumptions.

$$Y = S(X, t) = a + b \sin\frac{2\pi}{\lambda}(X - ct) \quad \text{-------------- (3),}$$

where (X, Y) is the rectangular coordinate system, b is the amplitude of the wave and λ is the wavelength.

The problem investigated in a wave frame of reference moving with the velocity of the wave. It is observed that the angle of inclination and yield stress of the fluid are the parameters that affect the pressure rise, frictional force and formation of trapped bolus quantitatively.

It is observed that the pressure flow rate curves are linear in presence and absence of plug with and angle of inclination and the results are discussed for the variation of different parameters. Formation of trapping bolus is analyzed with the variation of different parameters that are occurred in the problem. It is observed that the volume of the trapped bolus increases with an increase in angle of inclination and phase difference and decrease with plug width.

Later J.C. Misra et al. [5] shown his research work in 2008 on peristaltic transport of a physiological fluid in an asymmetric porous channel in the presence of an external magnetic field, the stream function, pressure gradient, and axial velocity are studied by using appropriate analytical and numerical techniques. In this work he investigated effects of different physical parameters such as permeability, phase difference, amplitude and magnetic parameter on the velocity, pumping characteristics, streamline pattern, and trapping are investigated with particular emphasis. The computational results are presented in the graphical form.

The results are found to be in perfect agreement with those of previous study carried out for a non-porous channel in the absence of magnetic field. On the basis of this work again in the year 2011 he developed the peristaltic flow of fluid in a porous channel with the flow of bile within ducts in a pathological state. In the year 2009, K.Vajravelu et al. [6] Studied the peristaltic transport of a casson fluid in contact with Newtonian fluid in a circular tube with permeable wall and showed their results as the motion is caused by the movement of peristaltic waves on the flexible walls of the channel.

The equation of interface is obtained and its variation with yield stress is discussed. The effects yield stress and permeability on the pumping characteristics are studied. They conclude that when the limit of the permeability parameter and yield stress tends to zero , they obtained the results for the flow characteristics reveal many interesting behavior that warrant further study of the peristaltic transport models with physiological fluids especially the shear-thinning fluids, shear thinning reduces the wall shear stress.

In the year 2013, N.Naga Jyothi et.al. [7] done the research work on the effect of porous lining on the peristaltic transport of a Casson fluid in an inclined channel and developed analytical solutions for velocity distribution, stream function, pressure rise and frictional force.

$$H(X,t) = a + b\sin\frac{2\pi}{\lambda}(X - ct) \quad \text{-----------} (4)$$

where b is the amplitude , λ is the wavelength and c is the wave speed.

In this work they showed that trapped bolus increases with increase in permeability parameter and decrease with increase in thickness of the porous lining, also increase in permeability results in increase of velocity distribution, velocity decreases as yield stress increases, velocity decreases with decrease in the angle of inclination, velocity increases with increase in amplitude ratio.

After that in the year 2014, A.N.S. Srinivas et al. [8] studied the peristaltic transport of a Casson fluid in a channel with permeable walls. In this work he investigated the exact analytical solution of the flow quantities are developed under long wavelength and low Reynolds number assumptions.

$$H = a + b\sin\frac{2\pi}{\lambda}(X - ct) \text{ --------- (5)}$$

Where b is the amplitude , λ is the wavelength and c is the wave speed.

The effects of Darcy number yield stress on the pumping characteristics are discussed. It is observed that for a given pressure raise the flux decreases with increasing Darcy number, and he noticed that for a given pressure raise the flux decreases with increasing yield stress. This will occur due to the yield stress behavior of the casson fluid. Also he analyzed the trapping phenomena for different wave forms.

In the literature, numerous studies regarding peristaltic motion have been done for Newtonian fluids. Among that Carreau fluid plays an important role in the field of peristaltic mechanism. In the year 1966 T.W. Latham has done his research on carreau fluid motion in a peristaltic pump. After that so many researchers like A.El.Hakeem, S.Nadeem, S.Srinivas, M.Kodhandapani, Y.Wang, etc., done their research work on Carreau fluid in peristaltic motion. S.Nadeem et al. [9] in the year 2010 done his research work on effect of heat and mass transfer on peristaltic flow of Carreau fluid in a vertical annulus by considering of long wavelength.

$$\bar{R}_1 = a_1 ,\ \bar{R}_2 = a_2 + b\sin\frac{2\pi}{\lambda}\left(\bar{Z} - c\bar{t}\right) \text{------------ (6)}$$

where a_1, a_2 are the inner and outer radius of the tube, where b is the amplitude, λ is the wavelength and c is the wave speed and $\bar{t}$ is the time.

He investigated the flow in a wave frame of reference moving with the velocity. Exact solutions have been evaluated for temperature and concentration field. Also he approximated analytical and numerical solutions are found for the velocity field using the perturbation method and shooting method. Also he investigated the effects of various emerging parameters graphically.

In the year 2011, R.Hemadri Reddy et al [10] studied the effect of induced magnetic field on peristaltic transport of a carreau fluid in an inclined channel field with porous material under the assumption of long wavelength and low Reynolds number. The flow is analyzed using a perturbation expansion in terms of small Weissenberg number. The expressions for the velocity, axial pressure gradient, pressure rise and frictional force over one cycle of wavelength are obtained. Also the effects of various emerging parameters on pumping characteristics and frictional forces are discussed through graphs.

In the year 2012, R. Hemadri Reddy et al. [11] studied the peristaltic transport of a Carreu fluid in a porous channel with suction and injection .They used the perturbation technique in terms of small Deborah number is employed to determine the expression for the velocity, stream function, the pressure raise and friction force under long wavelength and low Reynolds number assumptions. They discussed the effects of different parameters on the pumping characteristics and frictional forces through graphically.

In the year 2012, R.Ellahi et al. [12] done his research work on peristaltic flow of a Carreau fluid in a rectangular duct through a porous medium and he simplified the governing equations of motion by applying the long wavelength and low Reynolds number approximations.

$$Z = H(X,t) = \pm a \pm b\cos\frac{2\pi}{\lambda}(X - ct) \quad \text{----------} \; (7),$$

Where a, b are the amplitudes, λ is the wavelength and c is the wave speed.

He solved the highly nonlinear partial differential equations are solved jointly by homotopy perturbation and Eigen function expansion methods and solution given through plotting the graphs for velocity, pressure gradient, pressure rise, and stream lines. After that in the year 2013, Noreen et al. [13] has done his research work on numerical solution of peristaltic flow of a Carreau nanofluid in an asymmetric channel.

$$Y = H_1 = d_1 + a_1\cos\frac{2\pi}{\lambda}(x - ct) \;,$$

$$Y = H_2 = -d_2 - b_1 \cos\left(\frac{2\pi}{\lambda}(x-ct)+\phi\right), \text{---------------} (8)$$

In this work he studied MHD peristaltic flow of a Carreau nano fluid in an asymmetric channel, the flow development is carried out in a wave frame of reference moving with velocity of the wave. The governing nonlinear partial differential equations are transformed into a system of coupled nonlinear ordinary differential equations using similarity transformations and then tackled numerically using the fourth and fifth order Runge-kutta-Fehlberg. He found that the pressure rise increases with increase in Hartmann Number and thermophoresis parameter. In the year 2014, T.Hayat et al. [14] investigates the peristaltic motion of Carreau fluid in an asymmetric channel with convective boundary conditions. A mathematical model subject to long wavelength and low Reynolds number approximations is presented in order to study the effects of convective boundary conditions on peristaltic transport of carreau fluid in an asymmetric channel. Series expressions of stream function, longitudinal velocity and pressure gradient are developed. Finally he concluded that at the center of channel, the longitudinal velocity for Newtonian fluid is greater than the carreau fluid, also the fluid temperature for a Newtonian fluid is higher than carreau fluid.

In the same year 2014 the research has taken an advanced study on peristaltic transport of carreau fluid in a compliant rectangular duct by Arshid Riaz et al. [15].However, the peristaltic flow of Newtonian or non-Newtonian fluid in a rectangular channel with compliant walls is not discussed so far. Due to large number of applications of peristaltic phenomenon in industry, clinical equipment and engineering, the researchers and developers are keen to concentrate on the peristaltic flows of non-Newtonian fluids in three dimensional channels. Motivated from above recent development in the field of peristalsis, his study presented to evaluate the peristaltic flow of carreau fluid in a rectangular channel having flexible walls. The governing equations of a carreau fluid are simplified by using assumption of low Reynolds number and long wavelength approximation. The reduced equations finally solved by analytically by homotopy perturbation and Eigen function expansion methods. Also he discussed the trapping phenomena. After that B.Swaroopa et al. [16] done their research work on slip effects on the flow of Carreau fluid through a porous medium in a planner channel under the effect of a magnetic field with peristalsis in the year 2015.

In this work they shown the effects slip on the peristaltic flow of carreau fluid through a porous medium in to a dimensional channel under the assumptions of low Reynolds number and long wavelength is investigated. The flow is investigated in a wave frame of reference moving with the velocity of the wave. The perturbation series in the Weissenberg number was used to obtain explicit forms for velocity field, pressure gradient per one wavelength. The effects of various pertinent parameters on the pressure gradient and pumping characteristics are discussed though graphs. It is observed that the axial pressure gradient and time averaged flux in the pumping region increases with increasing power law index, Hartmann number and amplitude ratio where as they decreases with increasing Weissenberg number, slip parameter and Darcy number.

Recently, Kothandapani in 2009 have discussed the peristaltic flow of Jeffrey fluid in an asymmetric channel in the presence of a transverse magnetic field. Using Jeffrey fluid a linear model was developed using time derivatives instead of convective derivatives. In their work they observed that the size of trapped bolus in the Jeffrey fluid is much smaller than the Newtonian fluid. Due to the large number of applications, the peristaltic flows for different fluids and different geometries have been discussed by so many researchers like A.H. Shapiro in the year 1969, A.H. Abd El-Naby in the year 2002, T. Hayat in the year 2006 etc. but only limited attention has been focused on the study of peristaltic flows in the presence of hear transfer analysis. But recently new research work has been done on Influence of heat transfer and magnetic field on a peristaltic transport of a Jeffrey fluid in an asymmetric channel with partial slip in the year 2009.In this work the exact and closed form of Adomian solutions are obtained under the assumptions of long wavelength and low Reynolds number. Here the influence of physical parameters on the pressure rise, temperature and stream function have been studied for five types of wave forms namely sinusoidal, multisensorial, square, trapezoidal , and triangular.

In the year 2011, R. Saravana et al. [17] studied the influence of slip conditions, wall properties and heat transfer on MHD peristaltic transport of a Jeffrey fluid in a non-uniform porous channel under the assumptions of long wavelength and low Reynolds number. They obtained the analytical expressions for the stream function, velocity and temperature. Also noticed that the velocity and temperature decrease with increasing Jeffrey parameter λ1, Further it is observed that the size of the trapped bolus decreases with increasing λ_1.

After that in the year 2012, A.Kavitha et al. [18] Studied the peristaltic transport of a Jeffrey fluid in a porous channel with suction and injection discussed in the wave frame moving with constant velocity of the wave under the consideration of long wavelength and low Reynolds number. They obtained the analytical solution for the fluid velocity field, pressure gradient and the frictional force. The effect of suction/ injection parameter k, amplitude ratio ϕ and the permeability parameter including slip α on the flow quantities are discussed graphically. Also noticed that for pressure rise is positive (pumping region), the rate of pumping decreases with increasing Jeffrey parameter λ1 whereas for pressure rise is negative (co-pumping region) the behaviour is quite opposite for pressure rise ΔP= 0 (free pumping region) no variation is observed in the pumping rate. After that K. Kavitha et al. [19] in the year 2012, studied the influence of heat transfer on MHD oscillatory of Jeffrey fluid in a channel and shown the expressions for the velocity and temperature analytically. Also they found that velocity increases with increasing the ratio of relaxation to retardation times, radiation parameter, Grashof number, Peclet number. Also they found that the velocity is more for Jeffrey fluid than that of Newtonian fluid.In the year 2013, S. Nadeem et al. [20] done his research on the peristaltic flow of a Jeffrey fluid in a rectangular duct having compliant walls. The governing equations were simplified by employing the long wavelength and low Reynolds number approximations. The resulting equations were then solved by using the method of Eigen function expansion.In the same year 2013, S. Navaneeswara Reddy et al. [21] has done his research on slip effects on the peristaltic pumping of a Jeffrey fluid through a porous medium in an inclined asymmetric channel under the assumption of long wavelength and low Reynolds number. In his work he shown that the expressions for the velocity field and pressure gradient are obtained analytically. Also observed that, the pressure gradient and time averaged flux increases with increasing angle, Reynolds number, amplitude ratios. While they decreases with increasing slip parameter, ration of the relaxation time to retardation time, Darcy number.

In the year 2015, P. Hariprabakaran et al. [22] done their advance research work in influence of elasticity on MHD peristaltic transport of a Jeffrey fluid through porous medium channel with heat and mass transfer under the assumptions of long wavelength and low Reynolds number. They obtained the analytical expressions for the stream function, velocity and temperature. Also noticed that the velocity and temperature decrease with increasing Jeffrey parameter λ1, Further it is observed that the size of the trapped bolus decreases with increasing λ1.

After that in the year 2015, Santhosh et al. [23] has done his research work on Jeffrey fluid flow through narrow tubes in the presence of a Magnetic field. In this work he investigated the effect of magnetic field on a two fluid model for the flow of Jeffrey fluid in tubes of small diameters. It is assumed that the core region consists of Jeffrey fluid and the peripheral region consists of Newtonian fluid.

He followed the equations of motion have been linearized and analytical solution for the velocity, flow, flux, effective viscosity, core hematocrit and mean hematocrit have been obtained. The expressions for the above relevant quantities have been numerically solved by mathematica software. Also he observed that the effective viscosity decreases with Jeffery parameter but increases with tube radius. Finally the core hematocrit decreases with Jeffrey parameter and tube radius. According the above data and research work, we want to carry out research work by using finite element method.

Also in the same year 2015, A. Kavitha et al. [24] done the research work on the peristaltic transport of a Jeffrey fluid in contact with a Newtonian fluid in an inclined channel is analyzed under the assumptions of long wavelength and low Reynolds number. The channel is inclined at an angle β with the horizontal. This model is useful to understand the two fluid flow behaviours in physiological systems.

The velocity field, stream function, interface shape, pressure rise and frictional force at the wall over one cycle of wavelength are obtained and the results are shown graphically. Also observed that the variation of the interface shape gives rise to thinner peripheral region with increasing Jeffrey parameter $\lambda 1$.

Mathematical Formulations

The constitutive equation for an incompressible Jeffrey fluid is

$$S = \frac{\mu}{I+\lambda_1}\left[\dot{\gamma} + \lambda_2 \ddot{\gamma}\right]$$ Where S = Extra stress tensor, I is identity tensor,

λ_1 is the ratio of retardation to retardation times, λ_2 is the retardation time, $\dot{\gamma}$ is the dynamic viscosity, $\ddot{\gamma}$ is the shear rate and dots over the quantities indicate differentiation with respect to time.

The constitutive equation for casson fluid is

$$\tau^{1/2} = \tau_y^{1/2} + \left(-\mu\frac{\partial u}{\partial y}\right)^{1/2}, if\ \tau \geq \tau_y\ \ and$$

$$\frac{\partial u}{\partial y} = 0\ , \qquad if\ \tau \leq \tau_y$$

Where τ_y is yield stress, μ is the viscosity coefficient of the fluid, u is axial velocity, τ is shear stress.

The constitutive equations for Carreau fluid is

$$\left(\frac{\eta-\eta_{\infty}}{\eta_0-\eta_{\infty}}\right)=\left[1+(\Gamma\bar{\dot{\gamma}})^2\right]^{\frac{n-1}{2}},$$

$$\overline{\tau_{ij}}=\eta_0\left[1+\left(\frac{n-1}{2}\right)(\Gamma\bar{\dot{\gamma}})^2\right]\overline{\dot{\gamma}_{ij}} \quad \text{Where } \bar{\dot{\gamma}}=\sqrt{\frac{1}{2}\sum_i\sum_j\overline{\dot{\gamma}_{ij}}\,\overline{\dot{\gamma}_{ij}}}=\sqrt{\frac{1}{2}\Pi} \quad \text{and}$$

$\overline{\tau_{ij}}$ is extra stress tensor, η_{∞} is the infinite shear rate viscosity, η_0 is the Zero shear rate viscosity

Γ is the time constant, n is the power law index, Π is the second invariant strain tensor.

Applications:

1. Study of peristaltic flow of a Jeffrey fluid is quite useful in physiology and industry because of its large number of applications and in mathematics due to its complicated geometries and solutions of nonlinear equations. In physiology, it is used by many systems in the living body to propel or to mix the contents of a tube. The peristaltic mechanism usually occurs in urine transport from the kidney to the bladder, swallowing food through the esophagus, chyme motion in the gastrointestinal tracts, vasomotion of small blood vessels, movement of Spermatozoa and the human reproductive tract.
2. Applications of Jeffrey fluid in science and engineering including thermal oil recovery, food and slurry transportation, polymer and food processing, etc.
3. Recently, researchers have diverted their attention to the boundary layer flow of Nano fluids. A liquid suspension containing ultrafine particles with a diameter less than 50 nm, these ultrafine particles play a vital role in the heat transfer rate. Such particles greatly enhance the thermal conductivity, which also increases the heat transfer rate of the base fluid. This phenomenon is useful in many industrial, cooling, and biomedical applications, nuclear reactor, transportation industry, and micro-electromechanical systems
4. The Casson fluid model describes the flow characteristics of blood more accurately at low shear rates and when it flows through small blood vessels. Casson fluids are found to be applicable in developing models for blood oxygenator and haemodialysers.
5. The study of laminar flow and heat transfer of a cason fluid over a stretching sheet is an essential research field in fluid mechanics, due to its extensive applications in many manufacturing processes in industry, such as glassfiber

production, extraction of polymer sheet, hot rolling, wire drawing, solidification of liquid crystals, paper production, drawing of plastic films, petroleum production, exotic lubricants and suspension solutions, continuous cooling and fibers spinning.

6. Casson was the first who introduced the model for the prediction of the flow behavior of pigment oil suspensions used for preparation of printing inks. The examples of Casson fluid are jelly, tomato sauce, honey, soup, concentrated fruit juices, etc. Human blood can also be treated as Casson fluid of several substances like, protein, fibrinogen, and globulin in aqueous base plasma, human red blood cells can form a chain like structure, known as aggregates or rouleaux.
7. The carreau fluid widely used models provide good match to the experimental data in many flow situations, such as the flow in the blood arteries and through porous media as well as rheometric measurements, and hence they are popular in various biological, technological and industrial disciplines, such as biosciences and engineering, reservoir engineering and food processing.
8. The most important application of Carreau fluid in which flow through a porous medium is mostly prominent are filtration of fluids, seepage of water in river beds, movement of underground water and oils, limestone, rye bread, wood, the human lung, bile duct, gallbladder with stones, and small blood vessels.

Conclusions:

1. Here authors studied the effect of heat transfer on MHD oscillatory flow of Jeffrey fluid in a channel, the expressions for the velocity and temperature are obtained analytically and they found that the velocity increasing with Peclet number, Grashof number, Radiation parameter while it decreasing with increasing Hartmann number, Reynolds number, further it is found that the velocity is more for Jeffrey fluid that of Newtonian fluid.
2. In the study of peristaltic flow of Jeffrey fluid in a compliant rectangular duct , they found the profile velocity is decreasing function of the parameters. Also authors conclude that fluid flows more rapidly at the central part of the channel, also the size of the bolus changes randomly with the variation of all the physical parameters.
3. In the study of the effects of magnetic field and slip on the peristaltic flow of a Jeffrey fluid through porous medium in an asymmetric channel under the assumptions of long wavelength and low Reynolds number, the expressions for

the velocity field and pressure gradient are obtained analytically. Finally they conclude that the pressure gradient and time averaged flux increases with increasing angle, Reynolds number.

4. In the study of the effect of magnetic field on a two-fluid model for the flow of Jeffrey fluid in tubes of small diameters has been investigated. They conclude that the effective viscosity decreases with Jeffrey parameter but increases with tube radius further the core hematocrit decreases with Jeffrey parameter and tube radius.
5. In the mathematical study of peristaltic transport of casson fluid, authors found that in the zeroth-order approximation in stream function that there is a dependence on the casson coefficient of viscosity, yield stress, the density of the fluid, the wave speed, and the dimensions of the channel.
6. In the study of peristaltic transport of a casson fluid in asymmetric channel is studied in the wave frame under long wavelength and low Reynolds number. The presence of yield stress found to enhance the time average flux, also noticed that the trapping of fluid flows occur and the trapping zone extends for an increase in the time average flux.
7. In the study of the peristaltic transport of casson fluid in inclined channel, the problem is investigated in a wave frame of reference moving with the velocity of the wave .It is observed that the angle of inclination and yield stress of the fluid are the parameters that affect the pressure rise, frictional force and formation of trapped bolus quantitatively and qualitatively.
8. In the study of the effect of heat and mass transfer on peristaltic flow of carreau fluid in a vertical annulus, found that the pressure rise increases with the increase in Weissenberg number, while the pressure rise decreases with increase in power law index. They conclude that square wave has the best pumping characteristics while triangular wave has the worst pumping characteristics.
9. In the study of MHD peristaltic flow of a carreau nanofluid in an asymmetric channel, the qualitative behavior of Hartmann number, Power law index, Weisenberg number, Grashof number and amplitude ration on the pressure rise are same. Also concluded that the size of trapping bolus increases with the decrease in the upper and lower parts of the channel.
10. In peristaltic motion of a carreau fluid in a channel with convective boundary conditions, authors concluded that at the center of the channel the longitudinal velocity for Newtonian fluid is greater that that of carreau fluid while near the walls of the channel the velocity for Newtonian fluid is lower than that of a carreau fluid.

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