Exploration of thermal transport for Sisko fluid model under peristaltic phenomenon

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Abstract
The present analysis focuses on the thermal radiation and slips effects on the peristaltic movement of Sisko fluid with the symmetric compliant channel with rheological properties, enhancing damping tools, protection apparatus individuals and in various distinct mechanical procedures. Keeping in mind the considered problem assumptions (Non-Newtonian Sisko fluid model, power-law model, Prandtl number, wall properties, porous space, etc) it is found that the modeled equations are coupled and non-linear. Using low Reynold’s number and long wavelength assumptions, the governing system of a nonlinear coupled system of equations with appropriate boundary constraints is solved with the perturbation technique. Due to convectively heated surface fluid between the walls having a small temperature. Sherwood and Nusselt numbers both deduce for fixed radiation values and different Sisko fluid model quantity. Skin friction is maximum in the case of Newtonian, while minimum in case of dilatant model and pseudoplastic models. The influence of numerous parameters associated with flow problems such as Hartman number, Prandtl number, and slip parameters are also explored in detail and plotted for concentration profile, thermal distribution, and momentum distribution profile. From this analysis, it is concluded that velocity escalates for the larger slip. Also, skin friction is found similar for Newtonian and pseudoplastic models where in case of dilatant model it is little different but it increases for these three cases when Schmidt number is increased. Moreover, the shear-thinning and shear-thickening behavior of the fluid model is also explained in detail. Industrial applications of the Sisko model include minimum friction, reduction in oil-pipeline friction, uses as a surfactant for comprehensive scales cooling and heating systems, scale-up, flow tracers, and in several others.

Nomenclature

| Description (SI units) | Symbol |
|------------------------|--------|
| Cartesian coordinates  | (X, Y) |
| Velocity components (m s⁻¹) | (U*, V*) |
| Rivlín-Ericksen tensor | A₁ |
| Sisko fluid parameter  | (A) |
| Temperature (K)        | (T) |
| Thermal slip           | (β₂) |
| Extra stress tensor of fluid (N m⁻²) | (S) |
| Material constants     | (A) |
| Chemical reaction parameter | (Re) |
the mechanism occurs because of continuous symmetrical and asymmetrical propulsion of smooth channel walls. Physiological, industrial, and biomedical processes and is experimented by many researchers. This Any exchange on drug intricacies must pay courtesy to serval type of motion during biological functions. 1. Introduction

Any exchange on drug intricacies must pay courtesy to serval type of motion during biological functions. Amongst these biotic flow mechanisms, the peristaltic mechanism is one of them. Peristalsis is used in several physiological, industrial, and biomedical processes and is experimented by many researchers. This flow mechanism occurs because of continuous symmetrical and asymmetrical propulsion of smooth channel walls. Peristalsis is a very significant mechanism for carrying the drug and other materials during sensitive diseases treatments (e.g. cancer, tumor, heart surgery, etc) and also in several engineering and industrial processes because in peristalsis movement of walls fluid material does not stick with channel walls. In the Peristaltic flow, the fluid move by way of relaxation/ shrinking of liberal waves. Physiologically it studies the evacuation from the kidney to sac, spermatozoa motion, food consuming, gastrointestinal chyme activity and moving of ovum, etc are due to peristalsis mechanism. Peristaltic pumps are used in many industrial and engineering processes especially in chemical-pharmaceutical industries. In the biomedical field, it helps in pumping blood through the arteries. Peristaltic flow has many applications in industries as well, such as the motion of corrosive fluids, movement of sanitary liquid, transport of toxic liquid. Many biotic systems also invoke peristalsis mechanisms like the esophagus, small intestine, large intestine. Peristalsis is used in several physiological, industrial, and biomedical processes and is experimented by many researchers. Bhatti et al [1] elucidated the fundamental procured and principal evidently impacts of innumerable physical factors that govern the fluid flow. Bhatti et al [2] investigated the thermal radiation effect for electro-hydrodynamic through the Riga plate. They solved the fluid flow expressions with numerical shooting techniques. They also incorporated the in this study, the effect of Nusselt and Sherwood numbers. The main outcomes of this analysis are that, temperature profile boots up for higher values of thermal radiation effect and observed opposite nature for Prandtl number. Riaz et al [3] investigated the entropy generation impact on the peristaltic transport of the Non-Newtonian Williamson fluid model in an asymmetric complaint channel. They employed perturbation techniques for the solution of governing expressions of fluid transport. Form this study they obtained that the thermal profile id enhancing for Biot and Brinkman numbers. Latham [4] and Shapiro et al [5] gives the idea of low Reynolds number and long wavelength analysis. They analyzed the attributes of fluid movement in the peristaltic pump. Fung [6] explained the concept of ureteral muscles through peristalsis. The mathematical model of peristaltic transport of blood with the magnetic field is presented by Mishra et al [7]. Transportation of peristalsis in a porous annulus with heat transfer has been analyzed by Vajravelu et al [8]. Srinivas and Kothandapani [9] explored the heat transfer study of peristaltic flow in an asymmetric path. Hayat et al [10] explored the MHD peristaltic flow of Newtonian fluid in porous space under the consequence of heat transfer. Aly and Ebaid [11] derived the precise methodical solution of nanofluid under the effects of a slip in an asymmetric channel in presence of peristalsis. Carreau fluid in porous space under convective conditions in presence of peristalsis is examined by Hayat et al [12]. The viscous Newtonian fluid that depends on radial and axial components in the presence of peristalsis was analyzed by Lachiheb [13]. A precise solution of Jeffery nano-fluid in peristalsis was derived by Ebaid et al [14]. Recent exploration in this regard and some references therein can be mentioned in [15–19].

The study of MHD channel transport is of countless contemplation due to its real-world applications in industrial and biomedical processes, such as magneto-hydrodynamic pumps, tumor treatment, petroleum industry, bleeding reduction during surgeries, aerodynamics heating and cancer therapy. MHD is used in several physiological, industrial, and biomedical processes and is experimented by many researchers. Hina et al [20] investigated the Laminar flow of the MHD Oldroyd-B fluid model with a non-Fourier flux effect. Abbashandy et al [21] discussed the transport of non-Newtonian Oldroyd-B fluid-induced due to non-linear deforming sheets in the existence of a strong magnetic field.

The study of flows through porous medium also has real-world applications especially, in the geophysical fluid dynamics. Natural porous medium includes bile duct, beach sand, limestone, sandstone, rye bread, wood,
the human lung, small blood vessels, and gall bladder with stones. Because of this, many researchers examined the porous impact of the peristaltic flow of fluid models in different geometry/channels. Sanked et al [22] studied the impact of the flexible wall in the MHD peristaltic movement of different couple stress fluid models in the porous medium using thermal and momentum slip conditions. Veera et al [23] discussed the peristaltic movement of electrically conducting and incompressible fluid with viscous dissipation and Joule heating impact for the Williamson fluid model in the uniform symmetric flexible channel with the inclined magnetic field. Elangovan et al [24] investigated the Non-Newtonian blood movement for velocity slip with periodic body acceleration. Sankad and Nagathan [25] explained the peristaltic transport phenomena for MHD, heat transfer, thermal slip, wall properties, and porous medium for couple stress fluid mode. Ramesh and Devakar [26] studied the mass and heat transfer for peristaltic transport phenomena due to myometrial contractions occur in both symmetric and asymmetric channels.

The concept of wall properties, wall rigidity, and wall tension has great importance in peristalsis. Radhakris et al [27] explored peristaltic flow with plaint walls under the influence of heat transfer. The influence of micropolar fluid in cylindrical tubes having compliant walls in peristalsis was discussed by Muthu et al [28]. Hayat et al [29] described the influence of Johnson-Segalman fluid on peristaltic momentum having compliant walls. Hina et al [30] described the peristaltic flow with flexible walls channel under the chemical effect reaction. Under the impact of slip for peristaltic flow of wall properties and Nanofluid were analyzed by Mustafa et al [31]. Bhatti et al [2] investigated the teradiation effect for electro-hydrodynamic through the Riga plate. They solved the fluid flow expressions with numerical shooting techniques. They also incorporated the in this study, the effect of Nusselt and Sherwood numbers. The main outcomes of this analysis are that, temperature profile boosts up for larger values of thermal radiation effect and observed opposite nature for Prandtl number.

The concept of fluid flow subject to heat and mass transfer has significant importance in vaporization, biomedical production, desert chiller, and microfabrication technologies. Especially the heat transfer in peristaltic transport has an important character in homo dialysis processes and oxygenation. Hayat et al [32] addressed the transport of Jeffery nanofluid in compliant channels. In the study, they also incorporated the impact of thermal radiation, chemical reaction, and Brownian motion. They observed that momentum profile raises for Darcy and Hall effect. Hayat et al [33] investigated the mixed convective transport of MHD Jeffery fluid in an asymmetric porous channel. They handle the expression of fluid flow using the ND solver program. The velocity profile of the fluid motion is directly proportional to the Soret and Dufour effects. Some references from recent exploration are explained in [34–37].

It is evident from the literature survey, the influence of the Sisko fluid model with a compliant channel under the effects of thermal slips with chemical reaction and thermal radiation for power index, upper Newtonian regions model and power-law model for heat and mass transfer in peristalsis is still unexplored. Therefore, our current study targeted to explore heat and mass transfer effect for chemical reaction and thermal radiation effects on MHD peristaltic transport in a compliant channel. The solution of non-linear fluid flow equations has been computed using the perturbation technique and effects of controlling factors are analyzed through graphs for the thermal profile, concentration distribution profile, momentum distribution, and coefficient of the rate of heat transfer.

2. Problem formulation

Consider a viscous incompressible Sisko fluid model moving in a two-dimensional flexible channel of width. Homogeneous liquefied saturates with a strong magnetic field in a porous medium. The compliant walls temperature and concentration are \( T_0, C_0 \) and \( T_1, C_1 \) respectively. The geometry and coordinate system are illustrated in figure 1. The sinusoidal wave propagating for the small amplitudes along flexible walls of the channel is

\[
y = \pm \eta^* = \pm \left[a \sin \left(\frac{2\pi}{\lambda}(-\alpha t^* + x^*)\right) + d\right],
\]

(1)

where \( \alpha, \lambda \) and \( \epsilon \) are the wave amplitude, wavelength and wave speed.

The basic flow governing equations for viscous fluid model are:

\[
\frac{\partial}{\partial x^*} (\nu^*) + \frac{\partial}{\partial x^*} (u^*) = 0,
\]

(2)

\[
\rho \left( \frac{\partial}{\partial t^*} + (v^*) \left( \frac{\partial}{\partial y^*} \right) + (u^*) \left( \frac{\partial}{\partial x^*} \right) \right) u^* =
\]

\[
- \frac{\partial p^*}{\partial x^*} + \frac{\partial}{\partial x^*} (S_{xx^*} x^*) + \frac{\partial}{\partial y^*} (S_{xy^*} y^*) - \alpha B_0^2 u^* + R_{xx^*},
\]

(3)
\[
\rho \left( \frac{\partial}{\partial t^{*}} + (v^{*}) \frac{\partial}{\partial y^{*}} + (u^{*}) \frac{\partial}{\partial x^{*}} \right) v^{*} = -\frac{\partial}{\partial y^{*}} p^{*} + \frac{\partial}{\partial x^{*}} (S_{xyy^{*}}) + \frac{\partial}{\partial y^{*}} (S_{y^{*}yy^{*}}) + R_{y^{*}},
\]

(4)

\[
\rho C_{p} \left( \frac{\partial}{\partial t^{*}} + (v^{*}) \frac{\partial}{\partial y^{*}} + (u^{*}) \frac{\partial}{\partial x^{*}} \right) T = k \nabla^{2} T + \frac{1}{\sigma} (j_{j}) + \left( \frac{\partial u^{*}}{\partial x^{*}} \right) S_{xxy^{*}} + \frac{\partial}{\partial y^{*}} q_{s} + \frac{\partial}{\partial y^{*}} q_{r},
\]

(5)

\[
\left( \frac{\partial}{\partial t^{*}} + (v^{*}) \frac{\partial}{\partial y^{*}} + (u^{*}) \frac{\partial}{\partial x^{*}} \right) C = D \left( \frac{\partial}{\partial x^{*2}} + \frac{\partial}{\partial y^{*2}} \right) C
\]

\[
\left( \frac{\partial}{\partial t^{*}} + (v^{*}) \frac{\partial}{\partial y^{*}} + (u^{*}) \frac{\partial}{\partial x^{*}} \right) C = D \left( \frac{\partial}{\partial x^{*2}} + \frac{\partial}{\partial y^{*2}} \right) C
\]

(6)

the corresponding boundary conditions for equations (2)–(6) are:

\[
u^{*} \pm \beta_{1} S_{xxy^{*}} = 0 \text{ at } y = \pm \eta^{*} = \pm \left[ d + a \sin \left( \frac{2\pi}{\lambda} (x^{*} - c^{*}) \right) \right],
\]

(7)

\[
\left( \frac{\partial}{\partial x^{*}} \right) L(\eta^{*}) = \frac{\partial}{\partial x^{*}} (S_{xxy^{*}}) + \frac{\partial}{\partial y^{*}} (S_{xyy^{*}}) - \rho \left( \frac{\partial}{\partial t^{*}} + (u^{*}) \frac{\partial}{\partial x^{*}} + (v^{*}) \frac{\partial}{\partial y^{*}} \right) u^{*}
\]

\[
- \sigma B_{0}^{2} u^{*} + R_{x^{*}},
\]

(8)

\[
\pm \beta_{2} \frac{\partial T}{\partial y} + T = \begin{cases} T_{0} & \text{on } y^{*} = \pm \eta^{*}, \\ C_{0} & \text{on } y = \pm \eta^{*}. \end{cases}
\]

(9)

Radiative heat flux \((qr)\) is given as,

\[
qr = \left( \frac{-4\sigma}{3k} \right) \frac{\partial}{\partial y} T^{4},
\]

(11)

here \((\sigma)\) expressed the Stefan-Boltzmann constant. By expanding \(T^{4}\) about \(T_{0}\) and ignoring higher-order terms one obtained

\[
T^{4} = \approx 4T_{0}^{4} T - 3T_{0}^{4},
\]

(12)

the above appearance and equation (12) now yield

\[
qr = \frac{-16\sigma T_{0}^{4} \frac{\partial T}{\partial y}}{3k},
\]

(13)
where $v^*$ and $u^*$ are the velocity components. The displacement compliant wall is given as

$$ (P) = -P_0 + P $$

(14)

where $L$ represents the movement of a flexible walls of the channel,

$$ L = -\tau \frac{\partial^2 v}{\partial x^2} + C \frac{\partial v}{\partial t} + m_1 \frac{\partial^2 v}{\partial t^2}, $$

(15)

where $\tau$, $C$ and $m_1$ indicated the elastic membrane tension, viscous damping effect and plate mass/unit area.

$$ \frac{\partial}{\partial x}(P) = E_1 \left( \frac{\partial^3 (P_2)}{\partial y^3} \right) + E_2 \left( \frac{\partial^3 (P_2 \partial^2 x)}{\partial x} \right) + E_3 \left( \frac{\partial^3 (P_2 \partial t \partial x^2)}{\partial t} \right), $$

(16)

where $S_{xx}*\**, S_{xy}*\*\*\text{ and } S_{yy}*\*\*\text{ are the component of extra stress tensor of sisko model, defined as}

$$ S^* = [a_s + b_s(\sqrt{\Pi})^{n-1}] (A^*) $$

(17)

$$ A^*_t = (L^* + L'_t), \quad L^* = \text{grad} v, \quad \Pi = \frac{1}{2} \text{tr}(A^*_t^2), $$

(18)

$$ R = [a_s + b_s(\sqrt{\Pi})^{n-1}] V, $$

(19)

where $n$, $a$, and $b_s$ represented the material parameters of non-Newtonian Sisko fluid model. Sisko fluid model reduced for shear thinning nature when $(n < 1)$, fluid behavior is shear thinning, fluid describes shear thickening for $(n > 1)$, and for $(n = 1)$, it reduced to Newtonian fluid model. For $(n = 0)$, model reduced to the generalized power law model.

Introducing the following non-dimension transformations

$$ x = \frac{1}{\lambda}(x^*), \quad y = \frac{1}{d}(y^*), \quad u = \frac{1}{c}(u^*), \quad t = \frac{1}{\lambda}(\tau^*), \quad p = \frac{d^2}{\lambda c}(p^*), $$

$$ A = \frac{b_s}{a_s}(\frac{d}{\lambda})^{n-1}, $$

$$ \delta = \frac{d}{\lambda}, \quad M^2 = \frac{1}{\mu} \beta_0 d, \quad \theta = \frac{-T_0 + T}{-T_0 + T}, \quad \varphi = \frac{C_0 + C}{-C_0 + C}, $$

$$ K = \frac{K^*}{d}, $$

$$ Pr = \frac{a_s c_p \mu}{k}, \quad Ec = \frac{c_p}{c_p(-T_0 + T)}, \quad Sr = \frac{Dk_t(-T_0 + T)}{T_m \nu(-C_0 + C)}, $$

$$ Sc = \frac{v}{D}, $$

$$ Re = \frac{A(C_1 - C_2)}{v}, \quad \Psi = \frac{\psi}{c d}, \quad D_a = \frac{k}{d^2}, \quad Re = \frac{\rho c d}{\mu}, $$

(20)

Denoting acquainting stream function by $\Psi$ as

$$ u = \frac{\partial \Psi}{\partial y}, \quad v = -\delta \frac{\partial \Psi}{\partial x}, $$

(21)

using approximations of low Reynolds number $Re$ and long wavelength $(\delta \ll 1)$ and equations (14) and (15), equation (2) is satisfied identically and equations (3)–(12), one has

$$ \frac{\partial p}{\partial x} = \left( M^2 + \frac{1}{Da} \frac{\partial \Psi}{\partial y} \right) \frac{\partial ^2 \Psi}{\partial y^2} + \frac{1}{Da} \left( 1 + A \left( \frac{\partial ^2 \Psi}{\partial y^2} \right) ^2 \right) \frac{\partial \Psi}{\partial y}, $$

(22)

$$ \frac{\partial p}{\partial y} = 0 $$

(23)

$$ \frac{1}{Pr} \frac{\partial^2 \Psi}{\partial y^2} \left( \frac{\partial \Psi}{\partial y} \right) + Ec \left( S_{xx} \frac{\partial^2 \Psi}{\partial y^2} \right) + Re_n \frac{\partial^2 \varphi}{\partial y^2} = 0, $$

(24)

$$ \frac{1}{Sr} \frac{\partial^2 \varphi}{\partial y^2} + Sc \frac{\partial \varphi}{\partial y} = Re_c \varphi = 0. $$

(25)

The suitable boundary conditions as follows:

$$ \frac{\partial \Psi}{\partial y} \pm \beta_1 S_{xy} = 0 \quad \text{at} \quad y = \pm \eta, $$

(26)
\[
\frac{\partial}{\partial x} \left(-\tau \frac{\partial^2}{\partial x^2} + m \frac{\partial^2}{\partial t^2} + C \frac{\partial}{\partial t} \right) \eta = \frac{\partial}{\partial y} \left( S_{xy} - L^2 \frac{\partial^2 \psi}{\partial y^2} - \frac{A}{D_a} \left( \frac{\partial^2 \psi}{\partial y^2} \right)^2 \right) \frac{\partial}{\partial y} \Psi, \quad \text{at } y = \pm \eta, \quad (27)
\]

\[
\theta \pm \beta_2 \frac{\partial \theta}{\partial y} = \begin{cases} 1 \\ 0 \end{cases} \quad \text{at } y = \pm \eta, \quad x
\]

\[
\varphi \pm \beta_2 \frac{\partial \varphi}{\partial y} = \begin{cases} 1 \\ 0 \end{cases} \quad \text{at } y = \pm \eta,
\]

where

\[
S_{xx} = 0, \quad S_{yy} = 0,
\]

\[
S_{xy} = \left[ 1 + A \left( \frac{\partial^2 \psi}{\partial y^2} \right)^2 \right]^{-\frac{n-1}{2}} \frac{\partial \psi}{\partial y}.
\]

3. Solution methodology

Using perturbation technique on equations (16)-(19) for small Sisko fluid parameters \(A\), for along with corresponding boundary condition equations (20)-(23). We obtained the following expressions

\[
\psi = \psi_0 + A \psi_1 + \ldots,
\]

\[
\theta = \theta_0 + A \theta_1 + \ldots,
\]

\[
\phi = \phi_0 + A \phi_1 + \ldots
\]

(31)

After applying equation (25), to equations (15)-(18), one has,

\[
\frac{\partial^2}{\partial y^2} \left( \frac{\partial^2 \psi}{\partial y^2} \right)^n - L^2 \frac{\partial^2 \psi}{\partial y^2} - \frac{A}{D_a} \left( \frac{\partial^2 \psi}{\partial y^2} \right)^n = 0,
\]

(32)

\[
\frac{\partial^2 \theta}{\partial y^2} (1 + RnPr) + Br \left( \frac{\partial^2 \psi}{\partial y^2} + A \left( \frac{\partial^2 \psi}{\partial y^2} \right)^n \right) = 0,
\]

(33)

\[
\frac{1}{Sc} \frac{\partial^2 (\varphi)}{\partial y^2} + Sr \frac{\partial^2 (\theta)}{\partial y^2} - Re(\varphi) = 0,
\]

(34)

where \(Br = (Pr)(Ec)\) represent the Brinkman number and \(L^2 = \left(M^2 + \frac{1}{Da}\right)\).

3.1. Zero order syste

\[
\frac{\partial^4 \psi_0}{\partial y^4} - L^2 \frac{\partial^2 \psi_0}{\partial y^2} = 0,
\]

(35)

\[
\frac{\partial^2 \theta_0}{\partial y^2} (1 + RnPr) + Br \left( \frac{\partial^2 \psi_0}{\partial y^2} \right)^2 = 0,
\]

(36)

\[
\frac{1}{Sc} \frac{\partial^2 \varphi_0}{\partial y^2} + Sr \frac{\partial^2 \theta_0}{\partial y^2} = 0,
\]

(37)

with subject boundary conditions as

\[
\left[ \frac{\partial \psi_0}{\partial y} \right] \pm \beta_1 S_{xy} = 0 \quad \text{at } y = \pm \eta,
\]

(38)

\[
\left[ \frac{\partial \theta_0}{\partial y} \right] - \tau \left( \frac{\partial^2}{\partial x^2} \right) m_1 \left( \frac{\partial^2}{\partial t^2} \right) C \left( \frac{\partial}{\partial t} \right) \eta = \frac{\partial}{\partial y} \left( \frac{\partial^2 \psi_0}{\partial y^2} \right) - L^2 \left( \frac{\partial}{\partial y} (\Psi) \right), \quad \text{at } y = \pm \eta,
\]

(39)

\[
\pm \beta_2 \left[ \frac{\partial \theta_0}{\partial y} \right] + \theta_0 = \begin{cases} 1 \\ 0 \end{cases} \quad \text{at } y = \pm \eta,
\]

(40)
\[ \pm \beta_j \left( \frac{\partial^2 \varphi}{\partial y^2} \right) + \varphi_0 = \begin{cases} 1 \\ 0 \end{cases} \text{ at } y = \pm \eta. \] (41)

### 3.2. First order system

\[ \frac{\partial^4 \Psi_1}{\partial y^4} - L_x \frac{\partial^2 \Psi_1}{\partial y^2} = - \frac{\partial^2}{\partial y^2} \left( \frac{\partial^2 \Psi_0}{\partial y^2} \right)^3 - \frac{1}{Da} \left( \frac{\partial^3 \Psi_0}{\partial y^3} \right)^3, \] (42)

\[ \frac{\partial^4 \theta_1}{\partial y^4} (1 + Pr_Ru) + Br \left[ 2 \frac{\partial^3 \theta_0}{\partial y^2} \frac{\partial^2 \Psi_1}{\partial y^2} + \left( \frac{\partial^3 \Psi_0}{\partial y^2} \right)^3 \right] = 0, \] (43)

\[ \frac{1}{Sc} \frac{\partial^2 \varphi_1}{\partial y^2} + Sr \frac{\partial \theta_1}{\partial y} - R\varphi_1 = 0, \] (44)

with respective Boundary conditions

\[ \frac{\partial \Psi_1}{\partial y} \pm \beta_i \left( \frac{\partial^2 \Psi_1}{\partial y^2} + \left( \frac{\partial^2 \Psi_0}{\partial y^2} \right)^3 \right) = 0 \text{ at } y = \pm \eta, \] (45)

\[ \frac{\partial}{\partial y} \left( \frac{\partial \Psi_0}{\partial y^2} \right)^3 + \frac{\partial^2 \Psi_1}{\partial y^2} - L_x \frac{\partial \Psi_1}{\partial y} = \frac{1}{Da} \left( \frac{\partial^3 \Psi_0}{\partial y^3} \right)^2 \frac{\partial \Psi_0}{\partial y} = 0, \text{ at } y = \pm \eta, \] (46)

\[ \theta_1 \pm \beta_i \frac{\partial \theta_1}{\partial y} = 0 \text{ at } y = \pm \eta, \] (47)

\[ \varphi_1 \pm \beta_i \frac{\partial \varphi_1}{\partial y} = 0 \text{ at } y = \pm \eta. \] (48)

Solution for system of equations

\[ u = [D3y + \sinh(Ly)]D2 + AD23[D10(\cosh[3L(y + \eta)] - D9 \sinh[3L(y + \eta)])], \]

\[ \theta = [D24 + D26y + D27(y + \eta)(y - \eta) + D25(- \cosh(2Ly) + \cosh(2Ly))] + A[D29 + y(D37 + D38y) + D34 \cosh[2Ly] + D34 \cosh[4Ly] + D43 \sinh[2Ly] + D44 \sinh[4Ly]), \]

\[ \varphi = D47[D49(D48 + 245L^2(-y^2 + \eta^2) + D46 \cosh(2Ly) + D46 \cosh(2Ly))] + 2L^2(y + \eta) + AD50(\cosh(2Ly))(D34\eta + 2D47Ly) + \cosh(4Ly)(D33\eta + (D33 + D44Ly) + D38(y + \eta)(y - \eta) + D34 \cosh(2Ly) + D44 \sinh[2Ly] + D33 \sinh[4Ly]D60y^2]. \]

\[ D1 = \cosh L\eta + L \sinh L\eta \beta_1, \quad D2 = \frac{\Omega}{(\cosh L\eta + L \sinh L\eta \beta_1)}L^{1}, \quad D3 = DL^{3}, \]

\[ D4 = 2D3^2L^2, \quad D5 = 2D3^3L, \quad D6 = \frac{\Omega[x,t]}{(48L^2(\sinh L\eta + L \cosh L\eta \beta_1))(\cosh L\eta + L \sinh L\eta \beta_1)} \]

\[ D7 = 6L(D4 - D5L) \cosh 4\eta, \quad D8 = 6L(D4 - D5L), \quad D9 = (4D4 - 6D5L), \]

\[ D10 = -4D4 \sinh L\eta + 2D4 \cosh 2L\eta, \quad D11 = 2 \cosh L\eta - 2 \cosh 2L\eta + 6 \cosh 3L\eta, \]

\[ D12 = 2D4 \sinh 4L\eta, \quad D13 = 2D5L \sinh 4L\eta, \quad D14 = 6L(D4 - 5L), \]

\[ D15 = 6L(D4 - 5L) \cosh 4L\eta, \quad D16 = -4D4 + 6D3^2L^2, \quad D17 = 8D4 \sinh L\eta - 36D3^2L^2 \sinh 2L\eta, \]

\[ D18 = 2(2D4 - 3D3^2L^2), \quad D19 = 4(-2D4 + 9D3^2L^2) \sinh L\eta, \quad D20 = D14 - D15, \quad D21 = D5 \cosh L\eta^2, \]

\[ D22 = D3^2L \sinh 2L\eta, \quad D23 = 2D4 \sinh 2L\eta, \quad D24 = 2D4 \cosh 2L\eta, \quad D25 = 3(D12 - D13)L, \]

\[ D26 = 2(2D4 - 3D5L), \quad D27 = 2D4 - 3D5L, \quad D28 = -8D4 + 6D5L, \quad D29 = D8 - D7, \]

\[ D30 = \frac{3D3^2 Br}{4}, \quad D31 = \frac{3D3^2 Br(\sinh 2L\eta)(\cosh 2L\eta)\beta_2}{4L} + \frac{1}{2}, \quad D32 = \frac{1}{2(\eta + \beta_2)} \]

\[ D33 = \frac{D3^2 Br}{8L^2}, \quad D34 = D33 \cosh L\eta - D30\eta^2, \quad D35 = \frac{1}{72L^2(\eta + \beta_2)}(-432BrD3D4D6L^4\eta), \]

\[ D36 = \frac{1}{72L^2(\eta + \beta_2)}(72BrD3D4D6L^2\eta \cosh 3L\eta), \quad D37 = \frac{1}{72L^2(\eta + \beta_2)}(72BrD3^2L^2 \eta \sinh 3L\eta), \]

\[ D38 = 72BrD3^3D37L^3 \eta - 108BrD3D37D4D6L^2 \eta \sinh 2L\eta, \quad D39 = -2BrD3^3D37L^3 \eta. \]
The rate of heat transfer coefficient at flexible channel is expressed as

\[ C_f = \eta \phi' (\eta), \]

\[ = \frac{1}{2(\eta + \beta)} D_{49} = -24D_{33}D_{30} \cos 2\eta \beta_3 - 4D_{33}L_Sc \beta_3, \]

4. Graphical Investigation and discussion

In this section, we explored the behaviors of numerous effective parameters on thermal profile, momentum profile, concentration profile, rate of heat transfer coefficient, skin friction coefficient, and Sherwood number. The impact three different power index values, \( n = 0 \) and \( A = 0 \) indicated the viscous fluid model, the sisko fluid model deduced to power-law fluid model for \( n = 1 \) and \( A = 0 \), and it became sisko fluid model when \( n = 1 \) and \( A = 0 \). Figures 2–7 are plotted for such interest.

The effects of numerous parameters on longitudinal velocity \( u(y) \) are present in figures 2(a)–(h). In figure 2(a) the velocity profile \( u \) is reduced rapidly for larger values of magnetic parameter \( M \) in Newtonian fluid model as compare to Non-Newtonian model in figure 2(b). It is due to the fact that the magnetic parameter (Lorentz force) enhanced, in response it resist the fluid flow, so velocity profile decreases. Opposite trend is noticed for larger values of Sisko fluid parameter \( A \) in figures 2(c) and (d). In fact, that for larger values of Sisko model parameter \( A \), it decreases the effective conductivity of fluid, and consequently it reduced the magnetic damping effect. Therefore, velocity is increases. Figures 2(e) and (f) indicated reduction in momentum profile for both Newtonian and Non-Newtonian Sisko fluid model. The impact of elastic parameter \( E_1, E_2 \) and \( E_3 \) are plotted in figures 2(g) and (h) it is exciting to note that the momentum distribution profile is enhancing for larger values of elastic parameters. It is also observed that for non-Newtonian case fluid flow is rapidly increases. Furthermore momentum profile contour a parabolic shape for the different amount of parameter and having extreme magnitude in bordering to center of the flexible channel.

Figures 3(a) and (l), shows impact of the different parameters on thermal distribution for Newtonian and non-Newtonian fluid model. Figures 3(a) and (b), indicated that, temperature profile \( \theta(y) \) is decline by enhancing the magnetic effect \( M \) for Sisko and power law model. Since the liquid diffusivity rises for larger values of magnetic parameter \( M \) which become reduce the thermal profile. It is noted from figures 3(c) and (d), that porous median parameter \( D_a \) prompts the thermal profile of the fluid for both cases. It is due to the fact that larger values of Darcy parameter raises the fluid flow and it response it increases the thermal profile. Figures 3(e) and (f), indicated the increase in the temperature profile by enhancing the values of elastic parameters. It noted that thermal profile is increase rapidly in case of non-Newtonian model. The same tends of thermal distribution is noted for Sisko fluid parameter \( A \) in figures 3(g) and (h). Materially Sisko fluid parameter \( A \) extracted toward the cold liquid area from hot boundary layer. Figures 3(i) and (j) indicated the increase in concentration profile for larger values of thermal radiation parameter for both models. Temperature distribution profile shows totally opposite tends for Brinkman number \( Br \) for Newtonian and Non-Newtonian models in figures 3(k) and (l).
Results shown in figures 4(a)–(j) explored the behaviors of numerous effective parameters on the concentration profile $c(y)$. In figures 4(a) and (b) indicated the impact of the Brinkman number $Br$ with different rheology of fluid model. It is noted that concentration profile is decreasing function of $Br$. It due to the fact higher values of Brinkman number parameter, reducing the thermal conductivity effect of the fluid, which prompts the decrease of concentration. Figure 4(c) elucidate that, concentration distribution profile is decreasing for larger value of Darcy number $Da$ in case of non-Newtonian model, while totally reverse nature is noted in case of Newtonian model for Darcy number $Da$, indicated in figure 4(d). Figures 4(e) and (f) shows the opposite result for Schmidt number $Sc$ and Soret number $Sr$ for non-Newtonian model. The concentration profile raises for larger amount of Hartman number indicated in figure 4(g). In fact, that for larger values of $M$, it decreases the effective conductivity of fluid, and consequently it reduced the magnetic damping effect. Therefore, concentration profile is increases. Concentration profile is decreasing function of slip parameter $\beta_3$ are plotted in figure 4(h). It’s observed from figures 3(i) and (j), that concentration is the decreasing function for larger values of chemical reaction and elastic parameters $E1, E2$ and $E3$.

Results obtainable in figures 5(a)–(f), shows the performances of velocity slip parameter $\beta_1$, Darcy number $Da$, thermal slip parameter $\beta_2$, Magnetic parameter $M$, Brinkman number $Br$ and Sisko model parameter $A$ on the rate of heat transfer coefficient $Z$. Oscillatory comportment of the heat transfer coefficient is observed. In fact this behavior is because of the peristaltic movement. Figures 5(a)–(d) elucidate that enhancing in heat transfer coefficient for Darcy number $Da$ and thermal slip parameter $\beta_2$. It is also observed from figure 5(e) that the magnitude of rate of heat transfer raises rapidly increase for Hartman number $M$ as compare to momentum slip parameter $\beta_1$ in figure 5(f).

Impact of velocity slip parameter $\beta_1$, Hartman number $M$ and Prandtl number $Pr$ on the $Sh$ are presented in figure 6(a). It is noted that $Sh$ describes increasing tends for velocity slip parameter and reverse relation is observed for Darcy number $Da$. 

Figure 2. (a) Plot of velocity profile $u(y)$ against multiple values of magnetic parameter $M$, (b) Plot of velocity profile $u(y)$ against multiple values of magnetic parameter $M$, (c) Plot of velocity profile $u(y)$ against multiple values of Sisko fluid parameter $A$, (d) Plot of velocity profile $u(y)$ against multiple values of Sisko fluid parameter $A$, (e) Plot of velocity profile $u(y)$ against multiple values of Darcy number $Da$, (f) Plot of velocity profile $u(y)$ against multiple values of Darcy number $Da$, (g) Plot of velocity profile $u(y)$ against multiple values of elastic parameter $E1, E2$ and $E3$, (h) Plot of velocity profile $u(y)$ against multiple values of elastic parameter $E1, E2$ and $E3$. 

Figure 6. (a) Plot of velocity profile $u(y)$ against multiple values of magnetic parameter $M$, (b) Plot of velocity profile $u(y)$ against multiple values of magnetic parameter $M$. (c) Plot of velocity profile $u(y)$ against multiple values of Sisko fluid parameter $A$, (d) Plot of velocity profile $u(y)$ against multiple values of Sisko fluid parameter $A$. (e) Plot of velocity profile $u(y)$ against multiple values of Darcy number $Da$, (f) Plot of velocity profile $u(y)$ against multiple values of Darcy number $Da$. (g) Plot of velocity profile $u(y)$ against multiple values of elastic parameter $E1, E2$ and $E3$, (h) Plot of velocity profile $u(y)$ against multiple values of elastic parameter $E1, E2$ and $E3$. 

Impact of velocity slip parameter $\beta_1$, Hartman number $M$ and Prandtl number $Pr$ on the $Sh$ are presented in figure 6(a). It is noted that $Sh$ describes increasing tends for velocity slip parameter and reverse relation is observed for Darcy number $Da$. 


Figure 7(a) shows the effect of several pertinent parameters on $C_f$. It is noted that magnitude of $C_f$ enhanced for max values of the elastic effect and Hartman number $M$, while an opposite nature is noted in case of Hall parameter wall effect and slip parameter. It is observed that skin friction coefficient is increasing function of all parameters. Table 1 include the comparison of the present analysis of local Nusselt number for various values of Prandtl number $Pr$ with the results of Wang et al [36] and Asghar et al [34].

Figure 8 indicated that for larger amount of rigidity effect ($E_1$), the stream lines get closer and the shaped of the trapped bolus enhanced in some region. Figure 9 show that for higher values of Hartman number ($M$), the trapped bolus and size of stream lines enhanced.

Figure 2: We elaborate the variations in longitudinal velocity $u$ for various values of Magnetic parameter $M$, Darcy number $Da$, Sisko fluid parameter $A$, Wall parameters, Slip parameter $b_1$ and Elastic parameters $E_3$, $E_2$, $E_1$. The other parameters consider are $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $\beta_1 = 0.5$, $\beta_2 = 0$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $Da = 2$, $A = 2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2a); $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $M = 0.8$, $A = 2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2b); $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $Da = 2$, $A = 2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2c); $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $M = 1.2$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $Da = 2$, $A = 2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2d) and $A = 2$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $Da = 2$, $M = 1.2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2e), $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $M = 1.2$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $\beta_3 = 0.5$, $\varepsilon = 0.005$, $Da = 2$, $A = 2$, $x = 0.05$, $Br = 2$ and $t = 0.3$ (panel 2f); $A = 2$, $\beta_1 = 0.5$, $\beta_2 = 0.5$.

| $Pr$ | Presents results | Wang et al [36] | Asghar et al [34] |
|------|------------------|------------------|------------------|
| 0.1  | 0.45382          | 0.4538           | 0.4538           |
| 0.2  | 0.51135          | 0.5113           | 0.5114           |
| 0.3  | 0.79543          | 0.7954           | 0.7955           |
| 0.4  | 0.85395          | 0.8534           | 0.8538           |
| 0.5  | 0.91465          | 0.9146           | 0.9143           |
\[ \beta_3 = 0.5, \varepsilon = 0.005, Da = 2, M = 1.2, x = 0.05, Br = 2 \text{ and } t = 0.3 \text{ (panel 2g)} \] and \( A = 2, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.005, Da = 2, M = 1.2, x = 0.05, Br = 2 \text{ and } t = 0.3 \text{ (panel 2h)}. \]

Figure 3: Variations in the temperature profile \( \theta \) for various values of Slip parameter \( \beta_s \), Magnetic parameter \( M \), Darcy number \( Da \), Brinkman number \( Br \), Sisko fluid parameter \( A \), wall parameters and Slip parameter \( \beta_1 \) and elastic parameters \( E_3, E_2, E_1 \). The additional parameters chosen are \( E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 2, M = 1.2, x = 0.05, Br = 2 \text{ and } t = 0.3 \text{ (panel 3a)}; E_3 = 0.3, E_2 = 1.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 1.7, A = 2, x = 0.2, Br = 3 \text{ and } t = 0.01 \text{ (panel 3b)}; E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, M = 1.2, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 1.7, A = 0.5, x = 0.05 \text{ and } t = 0.3 \text{ (panel 3c)}; E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 1.7, A = 1.2, x = 0.05, t = 0.34 \text{ and } Da = 2 \text{ (panel 3d)}; E_3 = 0.3,
Figure 4: Variations in concentration profile $\phi$ for the various values of Slip parameter $b$, Magnetic parameter $M$, Darcy number $Da$, Brinkman number $Br$, Sisko fluid parameter $A$, elastic parameters $E_3$, $E_2$, $E_1$, Schmidt Number $Sc$ and Soret Number $Sr$. The other parameters are selected as $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $b_1 = 0.5$, $b_2 = 0.5$, $b_3 = 0.5$, $\epsilon = 0.015$, $Da = 2$, $A = 1.5$, $x = 0.2$, $Br = 2$, $t = 0.2$, $Sr = 1.5$ and $Sc = 15$ (panel 4a); $E_3 = 0.3$, $E_2 = 0.2$, $E_1 = 1.5$, $b_1 = 0.5$, $b_2 = 0.5$, $b_3 = 0.5$, $\epsilon = 0.015$,
Figure 4. (a) Plot of concentration profile \( \Phi(y) \) against multiple values of Brinkman number \( Br \). (b) Plot of concentration profile \( \Phi(y) \) against multiple values of Soret number \( Sr \). (c) Plot of concentration profile \( \Phi(y) \) against multiple values of Darcy number \( Da \). (d) Plot of concentration profile \( \Phi(y) \) against multiple values of magnetic parameter \( M \). (e) Plot of concentration profile \( \Phi(y) \) against multiple values of Darcy number \( Da \). (f) Plot of concentration profile \( \Phi(y) \) against multiple values of chemical reaction \( R_c \).

\[
M = 0.3, A = 1.5, Sc = 15, x = 0.09, Br = 5 \text{ and } t = 0.2 \text{ (panel 4b)}; E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, \\
M = 0.3, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 2, A = 1.5, x = 0.09, Sr = 1.5, Br = 2 \text{ and } \\
t = 0.2 \text{ (panel 4c)}; E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, M = 0.3, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, \\
t = 0.2, A = 1.5, x = 0.09, Da = 2, Sc = 1.5 \text{ and } Sc = 1.5 \text{ (panel 4d)}; E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, \\
M = 0.3, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \varepsilon = 0.015, Da = 2, Sr = 1.5, Sc = 1.5, x = 0.05, Br = 2 \text{ and } \\
t = 0.2 \text{ (panel 4e)}; M = 0.3, E_3 = 0.3, E_2 = 0.2, E_1 = 1.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, Sc = 0.1, Sc = 0.5, \\
A = 2, \varepsilon = 0.015, Br = 2, x = 0.05 \text{ and } t = 0.2 \text{ (panel 4f)}; Br = 2.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, \\
Sc = 1.5, Sr = 1.5, M = 0.3, \varepsilon = 0.1, Da = 2, x = 0.01 \text{ and } t = 0.2 \text{ (panel 4g)}; E_3 = 0.3, E_2 = 0.2, \\
E_1 = 1.5, M = 0.3, Sr = 1.5, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, A = 0, \varepsilon = 0.015, M = 0.3, x = 0.01 \text{ and } \\
t = 0.2 \text{ (panel 4h)}; E_2 = 0.2, E_1 = 1.5, Sr = 1.5, M = 0.3, t = 0.25, \beta_1 = 0.5, \beta_2 = 0.5, \beta_3 = 0.5, Da = 2, \\
E_3 = 0.3 Br = 1, A = 0, \varepsilon = 0.015, M = 0.3, t = 0.2 \text{ and } x = 0.01 \text{ (panel 4i)} \text{ and } E_2 = 0.2, E_1 = 1.5.
Figure 5: Variations in heat transfer coefficient $Z$ for diverse values of Sisko fluid parameter $A$, slip parameter $\beta_2$, Brinkman number $Br$, Magnetic parameter $M$ and Darcy number $Da$. The additional parameters chosen are $E = 0.3$, $E = 0.4$, $E = 1.5$, $Br = 2$, $\beta_2 = 0.5$, $\beta_1 = 0.5$, $\varepsilon = 0.2$, $Da = 5$, $Da = 0.5$, $x = 0.02$ and $t = 0.27$ (panel 5a); $E = 0.3$, $E = 0.4$, $E = 1.5$, $Br = 2$, $Da = 0.5$, $\beta_1 = 0.5$, $\beta_2 = 0.5$, $x = 0.02$, $\varepsilon = 0.2$, $M = 0.5$, $A = 0.5$ and $t = 0.27$ (panel 5b); $E = 0.3$, $E = 0.4$, $E = 1.5$, $Br = 2$, $\beta_2 = 0.5$, $\beta_1 = 0.5$, $\beta_3 = 0.5$, $M = 0.5$, $x = 0.02$, $t = 0.27$, $\varepsilon = 0.2$, $Da = 0.5$, $M = 0.5$, $A = 0.5$ and $t = 0.17$ (panel 5c); $E = 0.3$, $E = 0.4$, $E = 1.5$, $Br = 2$, $\beta_2 = 0.5$, $\beta_1 = 0.5$, $\beta_3 = 0.5$, $M = 0.5$, $x = 0.02$, $t = 0.27$, $\varepsilon = 0.2$, $Da = 0.5$, $A = 0.5$ and $t = 0.17$ (panel 5d); $E = 0.3$, $E = 0.4$, $E = 1.4$, $Br = 2$, $\beta_2 = 0.5$, $\beta_1 = 0.5$, $\beta_3 = 0.5$, $A = 0.5$, $t = 0.27$, $\varepsilon = 0.2$, $M = 0.5$, $x = 0.02$ and $t = 0.27$ (panel 5e).

5. Key findings of accomplished investigation

In the present analysis, we have explored the role of slip effects, compliant wall, and thermal radiation effects on the peristaltic mechanism for the non-Newtonian Sisko fluid model in a porous symmetric channel. More explicitly, the authors examined the impact on concentration distribution, momentum profiles, thermal analysis, Nusselt number, chemical reaction, Sherwood number, and skin friction coefficient profiles. The variations of streamline are also presented for the Hartman number and elastic parameters. The scope of the present article is valuable in explaining the chyme motion in the gastrointestinal tract and blood transport dynamics in small vessels while considering the important wall features and chemical reaction. Graphical sketches are plotted for physical parameters. Noticeable features discoveries can be summarized below.
In the center of the channel and near the walls, the longitudinal velocity is reduced for larger values of magnetic effect, while a conflicting performance noted for Sisko fluid parameter.

Fluid temperature is increased by mounting the value of fluid parameter and radiation parameter.

Fluid velocity raises for Darcy parameter in case of the Newtonian model, while opposite tends for non-Newtonian model.

Growing values of elastic parameters upsurge the thermal distribution and velocity field.

Thermal profile reduces for a larger amount of magnetic parameter, while an inverse tends for Darcy number.

Figure 5. (a) Plot of coefficient of heat transfer $Z$ against multiple values of Sisko fluid parameter $A$. (b) Plot of coefficient of heat transfer $Z$ against multiple values of Brinkman number $Br$. (c) Plot of coefficient of heat transfer $Z$ against multiple values of magnetic parameter $M$. (d) Plot of coefficient of heat transfer $Z$ against multiple values of Darcy number $Da$. (e) Plot of coefficient of heat transfer $Z$ against multiple values of velocity slip $S$. (f) Plot of coefficient of heat transfer $Z$ against multiple values of magnetic parameter $M$. 

- In the center of the channel and near the walls, the longitudinal velocity is reduced for larger values of magnetic effect, while a conflicting performance noted for Sisko fluid parameter.
- Fluid temperature is increased by mounting the value of fluid parameter and radiation parameter.
- Fluid velocity raises for Darcy parameter in case of the Newtonian model, while opposite tends for non-Newtonian model.
- Growing values of elastic parameters upsurge the thermal distribution and velocity field.
- Thermal profile reduces for a larger amount of magnetic parameter, while an inverse tends for Darcy number.
Similar important of Darcy number on velocity and temperature fields have been reported.

Concentration profile reduced for the larger amount of Brinkman number for both cases.

Concentration profile show opposite behavior for Newtonian and non-Newtonian models for the Darcy number.

Figure 6. (a) Plot of Sherwood number $Sh$ against multiple values of chemical reaction $M, \beta_1$ and $Pr$.

Figure 7. (a) Plot of Skin friction coefficient $Cf$ against multiple values of chemical reaction $M, E_1$ and $Da$.

Figure 8. Influence of $E_1$ on $\Psi$ with (a) $E_1 = 0.5$ (b) $E_1 = 1.5$. 

- Similar important of Darcy number on velocity and temperature fields have been reported.
- Concentration profile reduced for the larger amount of Brinkman number for both cases.
- Concentration profile show opposite behavior for Newtonian and non-Newtonian models for the Darcy number.
Influence of larger value elastic parameters show a decrease in concentration profile.

Concentration decreased with an increase in chemical reaction and concentration slip parameters.

Skin friction coefficient is increasing function of magnetic parameter and elastic parameters.

Magnitude of coefficient of heat transfer rises at the upper part of flexible channel for Sisko fluid parameter, while it reduced for larger amount of momentum slip parameter.

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