Influence of Hall on the Motion of a Newtonian Fluid through a Porous Medium in an Inclined Planar Channel with Peristalsis

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Abstract--- The magneto hydrodynamic flow of a liquid in a strait with flexible, in a pattern constricting walls (peristaltic flow) is of concern in correlation by means of convinced troubles of the progress of conductive anatomical fluid flows, e.g., the blood, apparatus which are used to transfer blood and necessitate for research on the process of a peristaltic MHD compressor. Agrawal et.al (1984) considered the consequence of affecting magnetic ground on blood stream. Agarwal.et.al considered a plain statistical representation for blood throughout a uniformly divided strait by means of elastic surface fortifications executing peristaltic impressions as wave. The outcome discovered shows, swiftness of the fluid rises as change happens in magnetic field.

Keywords--- Magnetic Field, Porous Medium, Peristaltic Motion.

I. Introduction

The magneto hydrodynamic flow of a liquid in a strait with flexible, in a pattern constricting walls (peristaltic flow) is of concern in correlation by means of convinced troubles of the progress of conductive anatomical fluid flows, e.g., the blood, apparatus which are used to transfer blood and necessitate for research on the process of a peristaltic MHD compressor. Agrawal et.al (1984) considered the consequence of affecting magnetic ground on blood stream. Agarwal.et.al considered a plain statistical representation for blood throughout a uniformly divided strait by means of elastic surface fortifications executing peristaltic impressions as wave. The outcome discovered shows, swiftness of the fluid rises as change happens in magnetic field. The peristaltic stream of a MHD fourth rank flow in a planer channel has deliberated by “Hayat et al” (2007). Ali et al. (2008) have investigated the effect of slip condition on the “peristaltic stream” of a Newtonian flowing with variable viscosity with influence of “magnetic field”. peristaltic motion of a Carreau fluid which is non linear, along with effect’s of a magnetic field in a leaning simple strait was studied by Subba Reddy and Gangadhar (2010). Subba Narasimhudu and Subba Reddy (2017) have studied the “Hall effects on the peristaltic flow of a Newtonian fluid in a channel”. Eldabe (2015) considered the Hall Effect and its influence on a third order fluid with peristalsis and in presence of porous with heat and mass transfer.

On basis of the above observations, we deliberate the outcome of hall on the peristaltic stream of a Newtonian fluid all the way through a porous intermediate in an inclined planar strait with the postulation of elongated wavelength. One of the closed outline explanation is found for axial velocity and pressure gradient. The property of diverse budding parameters on time-averaged volume flow rate is discussed along with the plots.

II. Geometric Representation (Mathematical)

We think about the peristaltic pumping of a conducting Newtonian fluid flow during a porous medium in a waterway with inclination α of half-width a. A longitudinal train of progressive sinusoidal impression takes place on the superior and inferior walls of the channel. On confining our conversation to the 0.5 part of the waterway as revealed in the Fig.1.

DOI: 10.5373/JARDCS/V12SP7/20202195
ISSN 1943-023X
Received: 13 May 2020/Accepted: 15 June 2020

Deformation of the wall equation is considered as

$$H(X,t)=a+b\sin\left[\frac{2\pi}{\lambda}(X-ct)\right] \quad (2.1)$$

Here b represents the amplitude, λ represents the wave length and c represents the wave speed

"Under the assumptions that the channel length is an integral multiple of the wavelength λ and the pressure difference across the ends of the channel is a constant, the flow becomes steady in the wave frame (x, y) moving with velocity c away from the fixed (laboratory) frame (X,Y)". The transformation between these two frames is given by

$$x=X-c\,t,\ y=Y,\ \ u=U-c,\ \ v=V \text{ and } p(x)\ =\ P(X,\ t), \quad (2.2)$$

Where $(u,\ v)$ and $(U,\ V)$ are the velocity components, " p and P are pressures in the wave and fixed frames of reference, respectively".

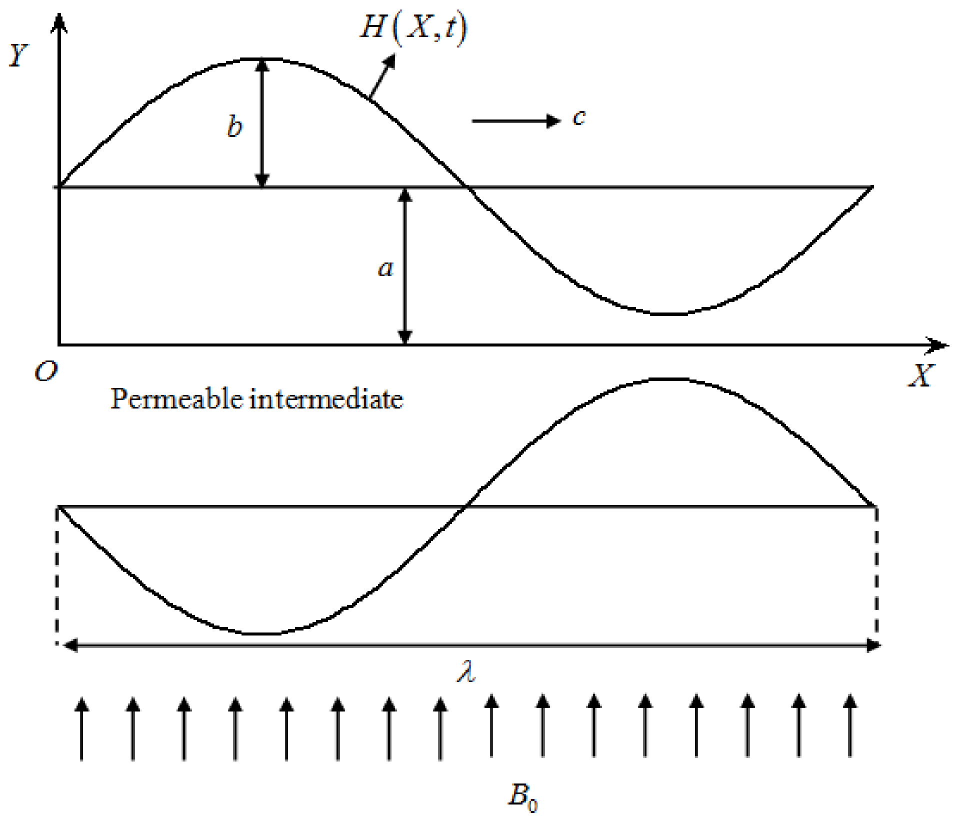

Figure 1: Substantial Representation

The governing flow equations in wave frame are

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0, \quad (2.3)$$

$$\rho\left(u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\frac{\sigma B_0^2}{1+m^2}\left(mv-(u+c)\right)-\frac{\mu}{k}(u+c)+\rho g\sin\alpha \quad (2.4)$$

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$$\rho\left(u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)-\frac{\sigma B_0^2}{1+m^2}\left(m\left(u+c\right)+v\right)-\frac{\mu}{k}v-\rho g\cos\alpha \qquad (2.5)$$

Where ρ here represents density, σ here represents electrical conductivity, B_0 here represents strength of magnetic field, m here represents Hall parameter, k is the permeability of the permeable intermediate.

The dimensional boundary conditions are

$$u=-c \qquad \text{at} \qquad y=H \qquad (2.6)$$

$$\frac{\partial u}{\partial y}=0 \qquad \text{at} \qquad y=0 \qquad (2.7)$$

On considering non dimensional parameteres

$$\bar{x}=\frac{x}{\lambda},\bar{y}=\frac{y}{a},\bar{u}=\frac{u}{c},\bar{v}=\frac{v}{c\delta},\delta=\frac{a}{\lambda},\bar{p}=\frac{pa^2}{\mu c\lambda},\bar{t}=\frac{ct}{\lambda},h=\frac{H}{a},\phi=\frac{b}{a},$$

$$\bar{q}=\frac{q}{ac},M^2=\frac{\sigma a^2 B_0^2}{\mu},\ Da=\frac{k}{a^2},Fr=\frac{c^2}{ag}$$

Into equations (2.3) to (2.5), we obtain

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad (2.8)$$

$$\mathrm{Re}\,\delta\left(u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=-\frac{\partial p}{\partial x}+\left(\delta^2\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\frac{M^2}{1+m^2}\left(m\delta v-\left(u+1\right)\right)-\frac{1}{Da}\left(u+1\right)+\frac{Re}{Fr}\sin\alpha \qquad (2.9)$$

$$\mathrm{Re}\,\delta^3\left(u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right)=-\frac{\partial p}{\partial y}+\delta^2\left(\delta^2\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)-\frac{\delta M^2}{1+m^2}\left(m\left(u+1\right)+\delta v\right)-\frac{\delta^2}{Da}v-\frac{\mathrm{Re}\,\delta}{Fr}\cos\alpha \qquad (2.10)$$

Re here represents Reynolds number, M here represents Hartmann number and Da here represents Darcy number.

Using long wavelength (i.e., $\delta << 1$) approximation, the equations (2.9) and (2.10) become

$$\frac{\partial^2 u}{\partial y^2}-\beta^2 u=\frac{\partial p}{\partial x}-\frac{\mathrm{Re}}{Fr}\sin\alpha+\beta^2 \qquad (2.11)$$

$$\frac{\partial p}{\partial y}=0 \qquad (2.12)$$

where $\beta=\sqrt{\frac{M^2}{1+m^2}+\frac{1}{Da}}$.

as of Eq. (2.12), it is graspable that p is self-governing of y. for that reason Eq. (2.11)can be rewritten as

$$\frac{\partial^2 u}{\partial y^2}-\beta^2 u=\frac{dp}{dx}-\frac{\mathrm{Re}}{Fr}\sin\alpha+\beta^2 \qquad (2.13)$$

The subsequent non dimensional boundary situation are specified as

$$u=-1 \qquad \text{at} \qquad y=h=1+\phi\sin 2\pi x \qquad (2.14)$$

DOI: 10.5373/JARDCS/V12SP7/20202195
ISSN 1943-023X

Received: 13 May 2020/Accepted: 15 June 2020

$$\frac{\partial u}{\partial y}=0 \quad \text{at} \quad y=0 \tag{2.15}$$

Knowing the velocity, the volume stream rate q in a signal surrounding position is considered as

$$q=\int_0^h udy. \tag{2.17}$$

The immediate stream Q(X,t) in the practical approach surrounding is

$$Q(X,t)=\int_0^h UdY=\int_0^h (u+1)dy=q+h \tag{2.18}$$

The time averaged quantity stream rate $\overline{Q}$ in more than one phase $T\left(=\frac{\lambda}{c}\right)$ of the peristaltic signal is specified by

$$\overline{Q}=\frac{1}{T}\int_0^T Qdt=q+1 \tag{2.19}$$

III. Elucidation

When Eq. (2.13) is solved in consideration of the boundary situation (2.14) and (2.15), we get

$$u=\frac{1}{\beta^2}\left(\frac{dp}{dx}-\frac{\text{Re}}{Fr}\sin\alpha\right)\left[\frac{\cosh\beta y}{\cosh\beta h}-1\right]-1 \tag{3.1}$$

"The volume flow rate q in a wave frame of reference" is specified by means of

$$q=\frac{1}{\beta^3}\left(\frac{dp}{dx}-\frac{\text{Re}}{Fr}\sin\alpha\right)\left[\frac{\sinh\beta h-\beta h\cosh\beta h}{\cosh\beta h}\right]-h \tag{3.2}$$

From Eq. (3.3), we write

$$\frac{dp}{dx}=\frac{(q+h)\beta^3\cosh\beta h}{\sinh\beta h-\beta h\cosh\beta h}+\frac{\text{Re}}{Fr}\sin\alpha \tag{3.3}$$

The pressure rise for single wavelength inthe signal surrounding is clear as

$$\Delta p=\int_0^1\frac{dp}{dx}dx \tag{3.4}$$

As the Darcy number tends to infinity "$Da\to\infty$" and "$\alpha\to 0$" our outcomes matches with outcome of Subbanarasimhudu and Suba Reddy (2017).

IV. Outcomes and Conversations

Fig. 2 depicts the disparity of heaviness ascending nature in Δp among time averaged flood pace $\overline{Q}$ for diverse numerals of M keeping $Da=0.1$, $\text{Re}=5$, $Fr=2$, $\alpha=\frac{\pi}{4}$, $\phi=0.5$ and $m=0.2$. It is originate so as to, the time-averaged stream pace $\overline{Q}$ rises in the pumping section $(\Delta p>0)$ as M rises, where as it declines in the free pumping $(\Delta p=0)$ and co-pumping $(\Delta p<0)$ regions when M values rises.

DOI: 10.5373/JARDCS/V12SP7/20202195
ISSN 1943-023X

Received: 13 May 2020/Accepted: 15 June 2020

The dissimilarity of heaviness rise Δp among time averaged stream pace $\overline{Q}$ for diverse values of Hall parameter m with $Da = 0.1$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \frac{\pi}{4}$, $\phi = 0.5$ and $M = 1$. is depicted in F.3. It is bring into being that, the time averaged stream rate $\overline{Q}$ decreases in the pumping area on escalating m, whereas it increases equally both in free pumping and co-pumping regions on rise in m.

Fig. 4 Deliberates the dissimilarity of heaviness rise Δp by way of time averaged stream rate $\overline{Q}$ on behalf of unlike weightages of Darcy parameter Da with $M = 1$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \frac{\pi}{4}$, $\phi = 0.5$ along with $m = 0.2$. It is establish that, the time averaged stream pace $\overline{Q}$ decreases in pumping section when there is a increase in Da, while it increases in free pumping as well as in co-pumping regions with increasing Da.

The dissimilarity of heaviness rise Δp by way of time averaged stream rate $\overline{Q}$ for unlike values of Reynolds number Re with $Da = 0.1$, $M = 1$, $Fr = 2$, $\alpha = \frac{\pi}{4}$, $\phi = 0.5$ and $m = 0.2$ is shown in graph. 5. It's observed that, the "time-averaged flow rate $\overline{Q}$ increases in all the pumping free pumping as well as co-pumping regions by way of increasing Re".

Fig. 6 illustrates the dissimilarity of heaviness increase Δp with time averaged stream rate $\overline{Q}$ for diverse weightages of Froude number Fr with $Da = 0.1$, $\mathrm{Re} = 5$, $M = 1$, $\alpha = \frac{\pi}{4}$, $\phi = 0.5$ and $m = 0.2$. It's seen that, the time averaged flow rate $\overline{Q}$ decreases in all the pumping, free pumping and co-pumping regions with escalating Fr.

The deviation of heaviness rises Δp together with time averaged flow rate $\overline{Q}$ meant for diverse weight ages of inclination angle α through $Da = 0.1$, $\mathrm{Re} = 5$, $Fr = 2$, $M = 1$, $\phi = 0.5$ and $m = 0.2$ is shown in Fig. 7. It's established that, the time averaged stream pace $\overline{Q}$ rises in all the pumping, free pumping and co-pumping portions on escalating α.

Due to the difference values of heaviness rise Δp through time averaged stream pace $\overline{Q}$ for unlike weightages of amplitude ratio ϕ with $Da = 0.1$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \frac{\pi}{4}$, $M = 1$ and $m = 0.2$ is shown in Fig. 8. Which deliberates that the time averaged stream pace $\overline{Q}$ takes ascending shape when there is a ascending values assigned to amplitude ratio ϕ in all regions like pumping and free pumping areas, whereas decreases with escalating amplitude ratio ϕ in the co-pumping area for chosen $\Delta p(< 0)$.

V. Conclusions

Here in the document, the consequence of hall on the peristaltic stream of a conducting flow all the way from side to side a porous medium in a leaning 2-D canal with the assumption of long wavelength approximation is investigated. "The expressions for the velocity field and temperature field and pressure gradient are obtained analytically". It is observed that, the time averaged stream rate in the pumping area rises through rise in Hartmann

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number M, Reynolds number Re, leaning angle α and amplitude ratio ϕ, while they decreases with rise in hall parameter m, Froude number Fr and Darcy number Da.

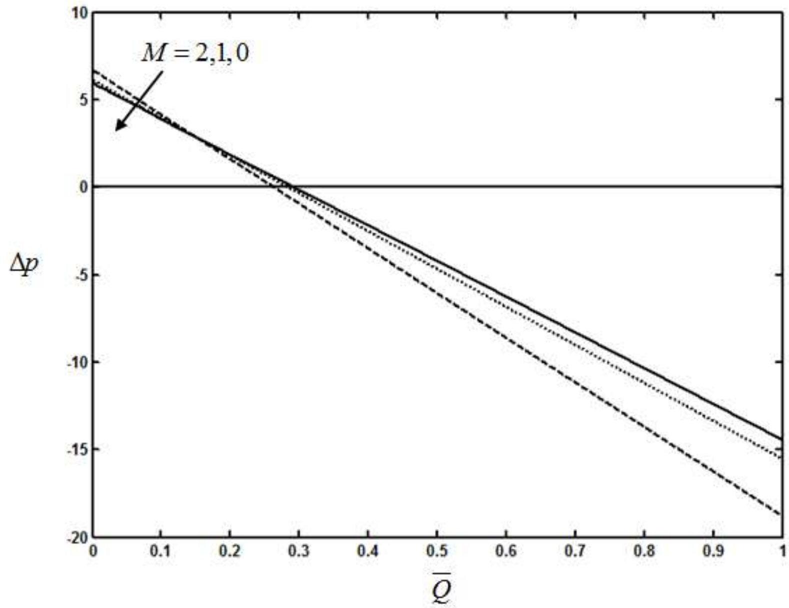

Figure 2: The Deviation in Heaviness in Ascending Direction Δp with Time Averaged Flow Rate $\overline{Q}$ for Different Values of M with $Da = 0.1$, $\phi = 0.5$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \dfrac{\pi}{4}$ and $m = 0.2$.

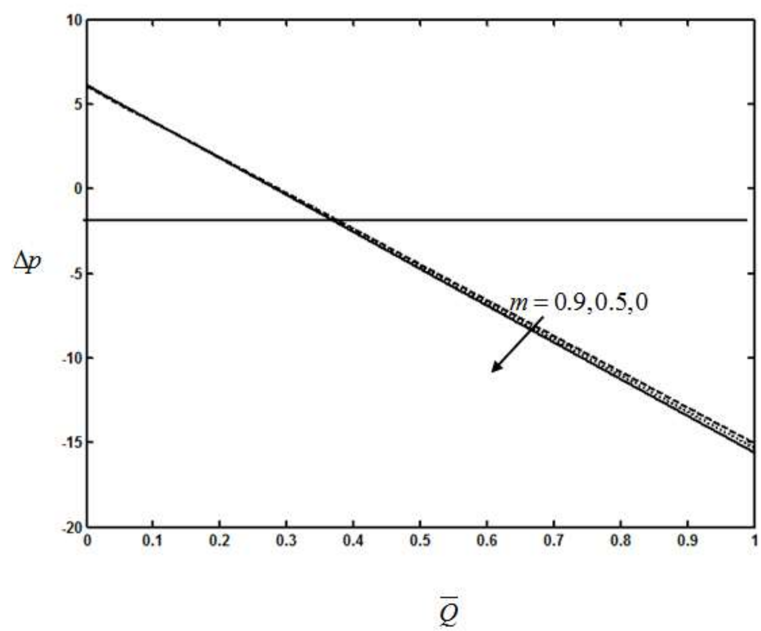

Figure 3: Δp Changes with Time Averaged Flow Rate $\overline{Q}$ is Explained for Diverse Numerals of Hall Parameter m with $Da = 0.1$, $\phi = 0.5$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \dfrac{\pi}{4}$ and $M = 1$.

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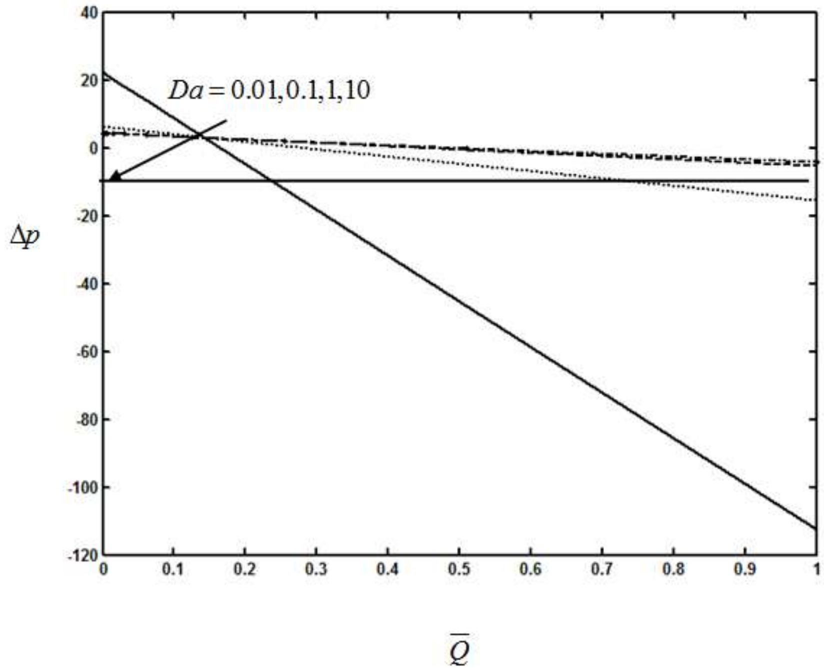

Figure 4: The Changes Δp with $\overline{Q}$ for Unlike Values of Da with $m = 0.2$, $\phi = 0.5$, $\text{Re} = 5$, $Fr = 2$, $\alpha = \frac{\pi}{4}$ and $M = 1$.

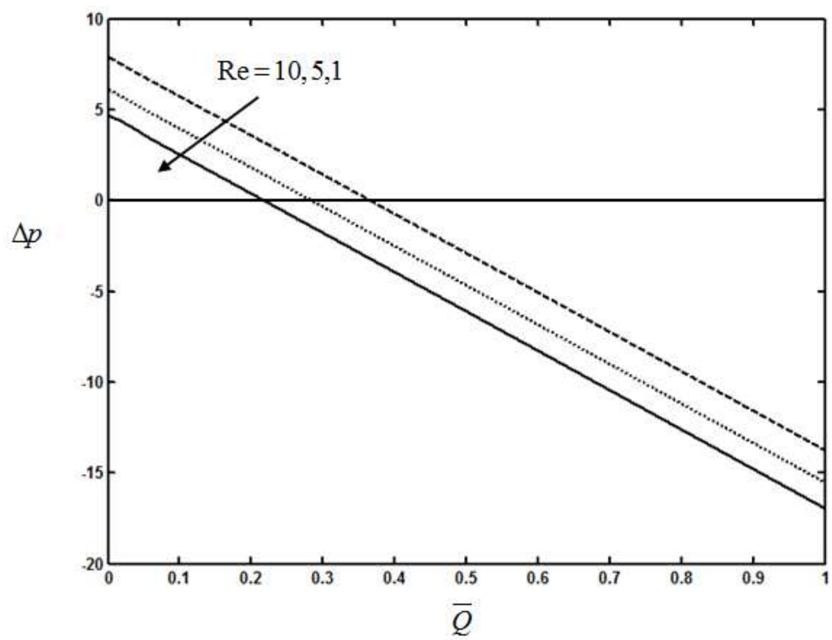

Figure 5: The Changes in Δp in Association with Time Averaged Stream Pace $\overline{Q}$ for Various Numerals of Re with $M = 1$, $\phi = 0.5$, $Fr = 2$, $\alpha = \frac{\pi}{4}$ and $m = 0.2$.

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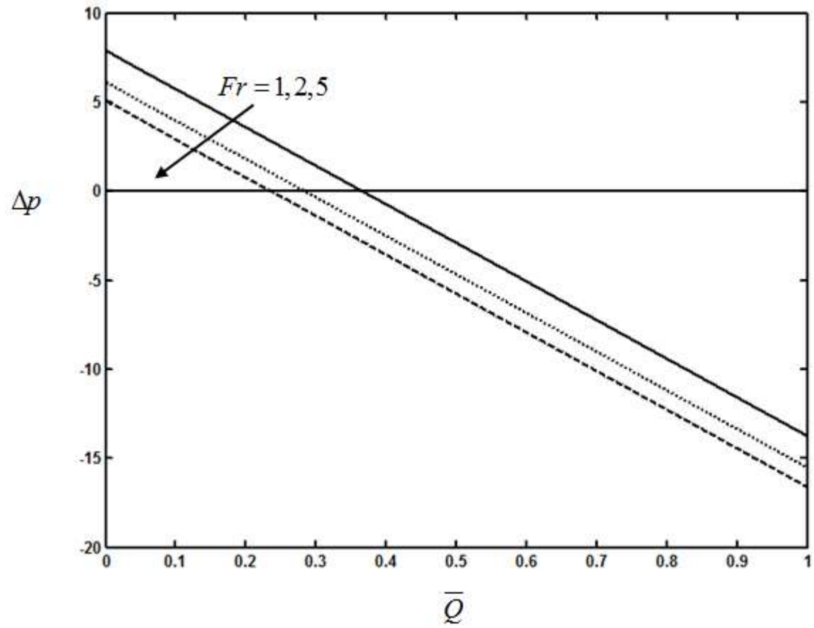

Figure 6: Changes in Δp and Time Averaged Stream Pace $\overline{Q}$ for Unlike Values of Froude Number Fr with $M = 1$, $\phi = 0.5$, $\mathrm{Re} = 5$, $\alpha = \frac{\pi}{4}$ and $m = 0.2$.

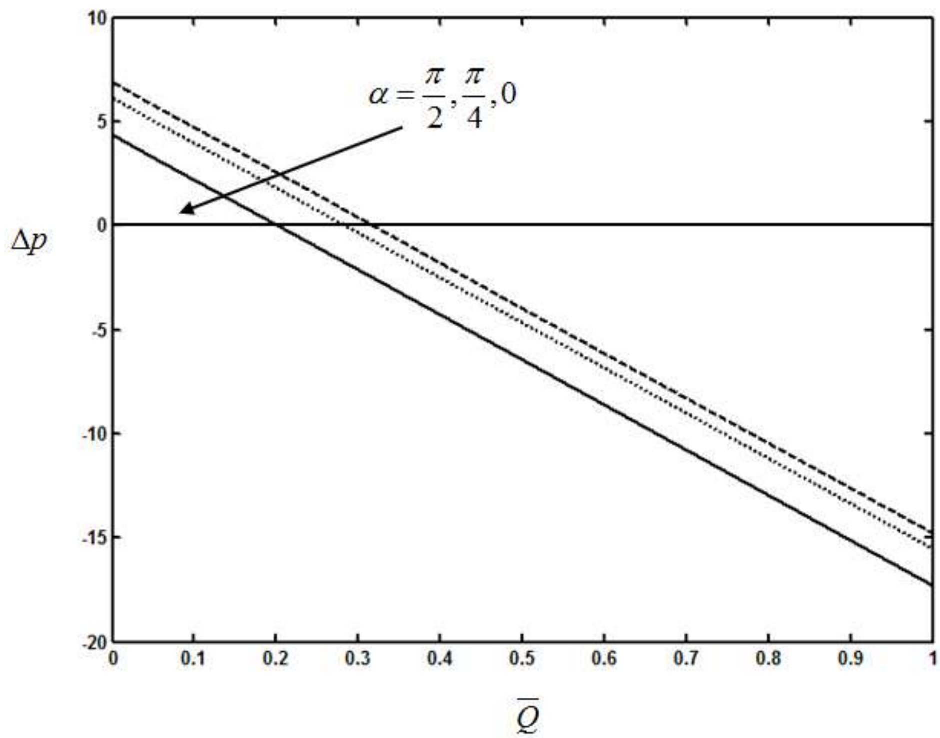

Figure 7: The Changes in Δp and Time Averaged Stream Pace $\overline{Q}$ for Dissimilar Numbers of α with $M = 1$, $\phi = 0.5$, $Fr = 2$, $\mathrm{Re} = 5$ and $m = 0.2$.

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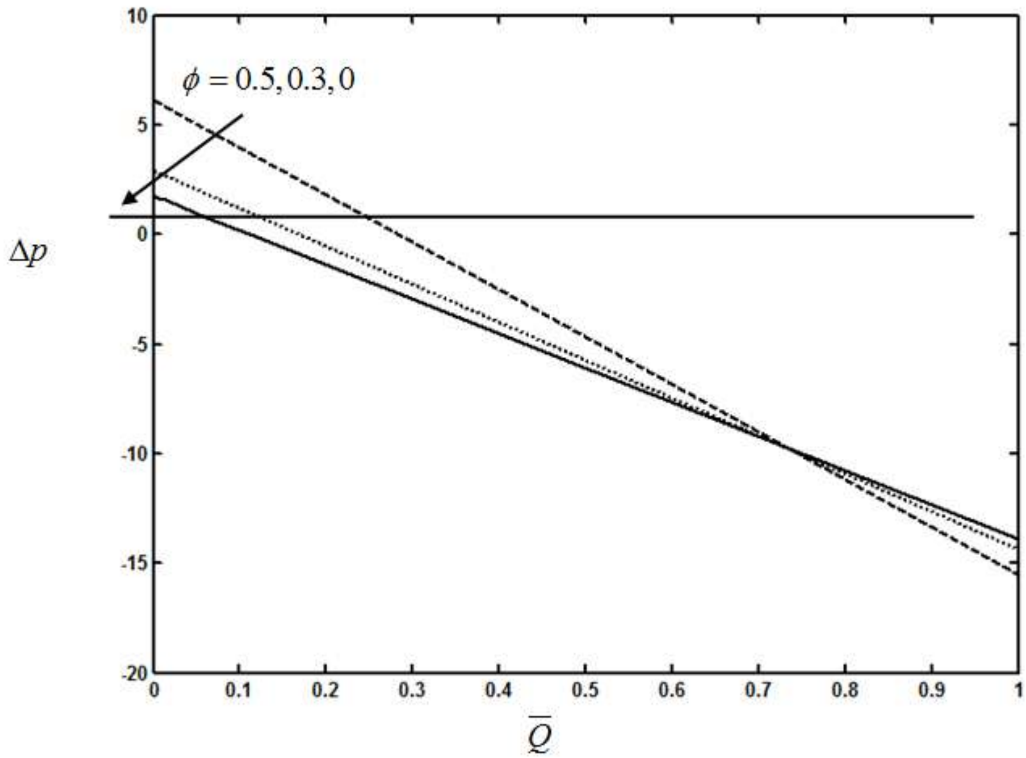

Figure 8: Changes Δp with Time Averaged Stream Pace $\overline{Q}$ for Unlike Values of Amplitude Ratio ϕ with

$M = 1$, $\mathrm{Re} = 5$, $Fr = 2$, $\alpha = \dfrac{\pi}{4}$ and $m = 0.2$.

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ISSN 1943-023X

Received: 13 May 2020/Accepted: 15 June 2020

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DOI: 10.5373/JARDCS/V12SP7/20202195
ISSN 1943-023X
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