Def Sci J, Vol 33, No 2, April 1983, pp. 137-146

Heat Transfer for Elastico-Viscous Flow Between Two Rotating Porous Discs

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Received 25 May 1982

Abstract. The problem of temperature distribution and heat transfer for elastico-viscous fluid flow between two rotating porous discs is studied. The equations of motion and energy are solved by a regular Perturbation method for small Reynolds number. The effects of the elasticity of the fluid, suction/injection parameter, rotation parameter, Prandtl number and Eckert number on Nusselt numbers at the two discs have been discussed numerically and compared with Newtonian fluid case.

1. Introduction

Flow problems through porous parallel discs with uniform suction or injection velocities, have been examined by various authors. Recently, Wang[1] studied symmetric viscous flow between two rotating porous discs at moderate rotation. Sharma & Verma[2] investigated the elastico-viscous fluid flow between two rotating porous discs.

However, little efforts have so far been made in determining the effect of injection/suction at the boundaries on the temperature distribution and heat transfer through pipes, channels or parallel discs, more especially, when the fluid considered is of non-Newtonian character. Inman[3] has determined the effect of the variation of cross-flow velocity on the temperature distribution and heat transfer for flow in an annulus with porous walls under the assumption that the fluid injection rate at one wall is equal to the fliud withdrawn rate is at the other wall. Verma & Bansal[4] have studied the effect of suction on the temperature distribution and heat transfer in a plane Couette flow and laminar flow in a circular pipe, while the unsteady temperature distribution for laminar flow in a porous straight channel, has been studied by Gaur[5]. Chaudhary & Gaur[6] have discussed the heat transfer for laminar flow through parallel porous discs.

In this paper our aim is to investigate the problem of temperature distribution and heat transfer for elastico-viscous liquid flow between two rotating porous discs. The elastico-viscous liquid Walters[7] model B′ has been used in the present analysis and the velocity profiles as obtained by Sharma & Verma have been used.

The present investigation can be made use of in porous bearings and self-impregnated bearings used in defence equipments. The practical application that can be envisaged for this problem is in the design of thrust bearings, radial diffusers etc.

2. Formulation of the Problem

Consider two coaxial porous discs situated at $Z = \pm L$ and rotating with the same angular velocity Ω (Fig. 1). Fluid is withdrawn from both discs with velocity W (W is negative in the case of injection). Assuming that, the gap with $2L$ is small compared to the diameter of the discs, so that the end effects are neglected. The flow field is symmetric about $Z = 0$ plane and the Z-axis.

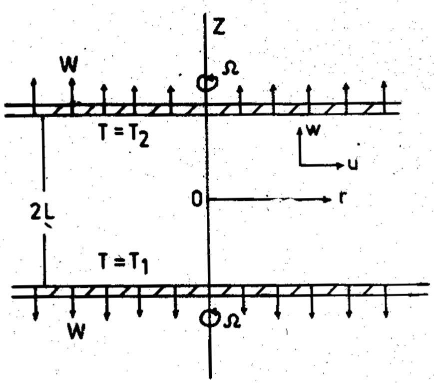

Figure 1. Physical model.

The axisymmetric form of the energy equation for an incompressible elastico-viscous fluid in cylindrical polar co-ordinates (r, θ, z) is

$$\rho C_p \left(u \frac{\partial T}{\partial r} + w \frac{\partial T}{\partial z} \right) = k \left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} + \frac{\partial^2 T}{\partial z^2} \right) + \eta_0 \left[2 \left(\frac{\partial u}{\partial r} \right)^2 \right.$$

$$\left. + 2 \frac{u^2}{r^2} + 2 \left(\frac{\partial w}{\partial z} \right)^2 + \left(\frac{\partial v}{\partial r} - \frac{v}{r} \right)^2 + \left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial r} \right)^2 + \left(\frac{\partial v}{\partial z} \right)^2 \right]$$

$$+ k_0 \left[- 2u \frac{\partial u}{\partial r} \frac{\partial^2 u}{\partial r^2} - 2w \frac{\partial u}{\partial r} \frac{\partial^2 u}{\partial r \, \partial z} + 4 \left(\frac{\partial u}{\partial r} \right)^3 + 2 \frac{\partial u}{\partial r} \frac{\partial u}{\partial z} \frac{\partial w}{\partial r} \right.$$

$$+ 2 \frac{\partial u}{\partial r} \left(\frac{\partial u}{\partial z} \right)^2 - 2 \frac{u^2}{r^2} \frac{\partial u}{\partial r} - 2 \frac{u}{r} \frac{w}{r} \frac{\partial u}{\partial z} + 2 \frac{u}{r} \left(\frac{\partial v}{\partial r} - \frac{v}{r} \right)^2$$

$$+ 6\ \frac{u^3}{r^3} + 2\ \frac{u}{r}\left(\frac{\partial v}{\partial z}\right)^2 - 2\,u\ \frac{\partial w}{\partial z}\ \frac{\partial^2 w}{\partial r \partial z} - 2\ w\frac{\partial w}{\partial z}\ \frac{\partial^2 w}{\partial z^2} + 4\left(\frac{\partial w}{\partial z}\right)^3$$

$$+ 2\,\frac{\partial u}{\partial z}\,\frac{\partial w}{\partial r}\,\frac{\partial w}{\partial z} + 2\ \frac{\partial w}{\partial z}\left(\frac{\partial w}{\partial r}\right)^2 - \left(\frac{\partial v}{\partial r} - \frac{v}{r}\right)\left\{u\,\frac{\partial^2 v}{\partial r^2} - 2\,\frac{u\partial v}{r\partial r}\right.$$

$$+ 2\,\frac{uv}{r^2} + w\ \frac{\partial^2 v}{\partial r \partial z} - \frac{w}{r}\ \frac{\partial v}{\partial z} - 3\ \frac{\partial u}{\partial r}\left(\frac{\partial v}{\partial r} - \frac{v}{r}\right) - 2\,\frac{\partial u}{\partial z}\,\frac{\partial v}{\partial z}$$

$$\left. - \frac{\partial v}{\partial z}\,\frac{\partial w}{\partial r}\right\} - u\ \frac{\partial w}{\partial r}\ \frac{\partial^2 u}{\partial r \partial z} - u\ \frac{\partial u}{\partial z}\ \frac{\partial^2 u}{\partial r \partial z} - \frac{\partial w}{\partial r}\ \frac{\partial^2 w}{\partial r^2} - \frac{\partial u}{\partial z}\ \frac{\partial^2 w}{\partial r^2}$$

$$- w\ \frac{\partial w}{\partial r}\ \frac{\partial^2 u}{\partial z^2} - w\ \frac{\partial u}{\partial z}\ \frac{\partial^2 u}{\partial z^2} - w\ \frac{\partial w}{\partial r}\ \frac{\partial^2 w}{\partial z \partial r} - w\ \frac{\partial u}{\partial z}\ \frac{\partial^2 w}{\partial z \partial r} + 3\ \frac{\partial u}{\partial r}\left(\frac{\partial w}{\partial r}\right)^2$$

$$+ 3\ \frac{\partial u}{\partial r}\ \frac{\partial u}{\partial z}\ \frac{\partial u}{\partial r} + 3\ \frac{\partial u}{\partial z}\ \frac{\partial w}{\partial r}\,\frac{\partial w}{\partial z} + 3\left(\frac{\partial u}{\partial z}\right)^2\frac{\partial w}{\partial z} + \left(\frac{\partial w}{\partial r}\right)^2\ \frac{\partial w}{\partial z}$$

$$+ \frac{\partial u}{\partial z}\,\frac{\partial w}{\partial r}\,\frac{\partial w}{\partial z} + \frac{\partial u}{\partial r}\,\frac{\partial u}{\partial z}\ \frac{\partial w}{\partial r} + \frac{\partial u}{\partial r}\left(\frac{\partial u}{\partial z}\right)^2 - u\,\frac{\partial v}{\partial z}\ \frac{\partial^2 v}{\partial r \partial z} - w\ \frac{\partial v}{\partial z}\,\frac{\partial^2 v}{\partial z^2}$$

$$+ 2\ \frac{\partial v}{\partial r}\ \frac{\partial v}{\partial z}\,\frac{\partial w}{\partial r} + 2\ \frac{v}{r}\ \frac{\partial v}{\partial z}\ \frac{\partial w}{\partial r} - \frac{v}{r}\,\frac{\partial v}{\partial z}\,\frac{\partial u}{\partial z} + \frac{u}{r}\left(\frac{\partial v}{\partial z}\right)^2$$

$$+ \frac{\partial u}{\partial z}\ \frac{\partial v}{\partial r}\ \frac{\partial v}{\partial z} + \left(\frac{\partial v}{\partial z}\right)^2\ \frac{\partial w}{\partial z}\ \Big], \tag{1}$$

where ρ is the density, Cp the specific heat at constant pressure, T the temperature, k represents coefficient of thermal conductivity assumed to be constant, $(u, v, w,)$ are the velocity components in the r, θ and z directions respectively and η_0 the limiting viscosity at small rates of shear is given by

$$\eta_\theta = \int_0^\infty N(\tau)\, d\,\tau \tag{2}$$

and

$$k_0 = \int_0^\infty \tau\ N(\tau)\ d\,\tau \tag{3}$$

$N(\tau)$ being the relaxation spectrum as introduced by walters[8]. This idealized model is a valid approximation of a Walters liquid B' taking very short memory into account so that involving

$$\int_0^\infty \tau^n\, N(\tau)\, d\tau \qquad n \geqslant 2. \tag{4}$$

have been neglected.

The boundary conditions are

$$Z = -L:\ T = T_1$$

and

$$Z = + L : T = T_2 \tag{5}$$

where T_1 and T_2 are some constant temperatures.

3. Solution of the Problem

Using the velocity components u, v, w in the following form

$$\left.\begin{aligned} u &= r f'(\eta)\, W/L \\ v &= r g(\eta)\, W/L \\ w &= -2 f(\eta)\, W \end{aligned}\right\} \tag{6}$$

and non-dimensional temperature

$$\theta = \frac{T - T_1}{T_2 - T_1} \; (T_2 > T_1) \tag{7}$$

in Eqn. (1), we obtain

$$\left.\begin{aligned} &\frac{\partial^2\theta}{\partial\eta^2} + \frac{1}{\xi}\frac{\partial\theta}{\partial\xi} + \frac{\partial^2\theta}{\partial\xi^2} + PR\left(2f\frac{\partial\theta}{\partial\eta} + \xi f' \frac{\partial\theta}{\partial\xi}\right) \\ &\quad + PE\{12 f'^2 + \xi^2 (g'^2 + f''^2)\} + \wedge\, PRE\{24 ff' f'' \\ &\quad - 24 f'^3 + \xi^2 (2 f f'' f''' - 4 f' f''^2 + 2 f g' g'')\} = 0 \end{aligned}\right\} \tag{8}$$

where

$$\eta = z/L, \; \xi = r/L;$$

$R = \dfrac{\rho W L}{\eta_0}$ (Reynolds' number),

$P = \eta_0\, Cp/k$ (Prandtl number),

$E = W^2/Cp\,(T_2 - T_1)$ (Eckert number),

$\wedge = k_0/\rho\, L^2$ (Elastico-viscous parameter),

and the corresponding boundary conditions are reduced to

$$\left.\begin{aligned} \eta &= -1, \; \theta = 0. \\ \eta &= +1, \; \theta = 1. \end{aligned}\right\} \tag{9}$$

Following Verma & Bansal,[4] we seek the solution of (8) in the following form

$$\theta = F(\eta) + \xi\, G(\eta) + \xi^2\, H(\eta) \tag{10}$$

Where $F(\eta)$, $G(\eta)$ and $H(\eta)$ are unknown functions to be determined. Substituting (10) in (8) and equating coefficients of like powers of ξ, we have

$$F'' + 4H + 2\, PRfF' + 12\, PEf'^2 + 24 \wedge PRE\,(ff' f'' - f'^3) = 0, \tag{11}$$

$$G'' + PR\,(2 fG' - f' G) = 0, \tag{12}$$

and

$$H'' + 2\,PR\,(fH' - f'H) + PE\,(g'^2 + f''^2) + 2\wedge PRE\,(ff''f''' + fg'g'' - 2f'f''^2) = 0. \qquad (13)$$

The boundary conditions are

$$\left.\begin{array}{l} F(-1) = 0 = G(-1) = H(-1), \\ F(1) = 1 \text{ and } G(1) = 0 = H(1). \end{array}\right\} \qquad (14)$$

We assume that the suction/injection parameter R is small.

Then all the physical quantities can be expanded in terms of the small parameter R

$$X(\eta) = X_0 + R\,X_1 + R^2X_2 + \ldots \qquad (15)$$

Where X stands for any f, g, F, G and H.

After substituting (15) in Eqns. (11) to (13) and equating coefficients of like powers of R, we obtain the following set of equations.

$$F_0'' + 4\,H_0 + 12\,PEf_0'^2 = 0, \qquad (16)$$

$$G_0'' = 0, \qquad (17)$$

$$H_0'' + PE\,(g_0'^2 + f_0''^2) = 0, \qquad (18)$$

$$F_1'' + 4\,H_1 + 2\,P\,f_0\,F_0' + 24\,PE\,f_0'\,f_1' + 24\wedge PE\,(f_0\,f_0'\,f_0'' - f_0'^3) = 0, \qquad (19)$$

$$G_1'' + P\,(2\,f_0\,G_0' - f_0'\,G_0) = 0, \qquad (20)$$

$$H_1'' + 2\,P\,(f_0\,H_0' - f_0'\,H_0) + 2\,PE\,(g_0'\,g_1' + f_0''f_1'') + 2\wedge PE\,(f_0\,f_0''\,f_0''' + f_0\,g_0'\,g_0'' - 2\,f_0'\,f_0''^2) = 0, \qquad (21)$$

$$F_2'' + 4\,H_2 + 2\,P\,(f_0\,F_1' + F_0'\,f_1) + 12\,PE\,(f_1'^2 + 2\,f_0'\,f_2') + 24\wedge PE\,(f_0\,f_0''\,f_1' + f_1\,f_0'\,f_0'' + f_0\,f_0'\,f_1'' - 3f_0'^2 f_1') = 0, \qquad (22)$$

$$G_2'' + P\,(2\,f_0\,G_1' + 2\,G_0'\,f_1 - f_0'\,G_1 - G_0\,f_1') = 0, \qquad (23)$$

$$H_2'' + 2\,P\,(f_0\,H_1' + H_0'\,f_1 - f_0'\,H_1 - H_0\,f_1') + PE\,(g_1'^2 + 2\,g_0'\,g_2' + f_1''^2 + 2\,f_0''f_2'') + 2\wedge PE\,(f_0''\,f_0'''\,f_1 + f_0\,f_0'''\,f_1'' + f_0\,f_0''\,f_1''' + f_0\,g_1'\,g_0'' + f_0\,g_0'\,g_1'' + f_1\,g_0'\,g_0'' - 4\,f_0'\,f_0''\,f_1'' - 2\,f_1'\,f_0''^2) = 0, \qquad (24)$$

The corresponding boundary conditions are reduced to

$$F_0(-1)=0=G_0(-1)=H_0(-1),$$
$$F_1(-1)=0=G_1(-1)=H_1(-1),$$
$$F_2(-1)=0=G_2(-1)=H_2(-1),$$

$$\left.\begin{array}{l} F_0(1)=1,\quad G_0(1)=0=H_0(1),\\ F_1(1)=0=G_1(1)=H_1(1),\\ F_2(1)=0=G_2(1)=H_2(1). \end{array}\right\} \tag{25}$$

From (16) to (24) with (25), the solutions of F_0, F_1, G_0, G_1, G_2, H_0 and H_1 are

$$F_0=(-8\eta^6+45\eta^4-150\eta^2+113)\,PE/40+(\eta+1)/2, \tag{26}$$

$$\left.\begin{array}{l} F_1=(443\eta^{10}-4725\eta^8+23310\eta^6-59850\eta^4-19305\eta^2\\ \quad+60127)\,P^2E/67200+(26\eta^{10}-660\eta^8+2508\eta^6\\ \quad-4080\eta^4+4170\eta^2-1964)\,PE/22400+(-\eta^5\\ \quad+10\eta^3-9\eta)\,P/80+(-1410\eta^8+8736\eta^6+1260\eta^4\\ \quad-99120\eta^2+90534)\wedge PE/22400, \end{array}\right\} \tag{27}$$

$$G_0=0=G_1=G_2, \tag{28}$$

$$H_0=3(-\eta^4+1)\,PE/16, \tag{29}$$

$$H_1=(15\eta^8-252\eta^6+210\eta^4-1260\eta^2+1287)\,P^2E/8960+(9\eta^8-168\eta^6+2347\eta^4-75)\,PE/4480+(6\eta^6-9\eta^4+3)\wedge PE/160. \tag{30}$$

The expressions of F_2 and H_2 are not presented here for the sake of brevity.

Here, f_0, f_1, f_2, g_0, g_1 and g_2 have been taken from reference [2] and are given by

$$f_0=(\eta^3-3\eta)/4, \tag{31}$$

$$f_1=(-\eta^7+21\eta^5-39\eta^3+19\eta)/1120+\wedge(18\eta^5-36\eta^3+18\eta)/240, \tag{32}$$

$$f_2=(63\eta^{11}-1540\eta^9+11682\eta^7+15708\eta^5+2215\eta^3+3288\eta)/5174400+\beta^2(-\eta^7+21\eta^5-39\eta^3+19\eta)/840+\wedge(-210\eta^9+5040\eta^7-9828\eta^5+5376\eta^3-378\eta)/470400+\wedge^2(450\eta^7-756\eta^5+162\eta^3+143\eta)/8400, \tag{33}$$

$$g_0=\beta, \tag{34}$$

$$g_1=\beta(\eta^4-6\eta^2+5)/8, \tag{35}$$

and

$$g_2=\beta[(-9\eta^8+84\eta^6-222\eta^4-3036\eta^2+3138)/6720+\wedge(-2\eta^6+15\eta^4-13)/10], \tag{36}$$

where

$$\beta = \Omega\, L/W \text{ (Rotation parameter).}$$

The rate of heat transfer in terms of Nusselt number is given by

$$N_u = \frac{2\, L\, Q^*}{k\,(T_2 - T_1)}, \tag{37}$$

where

$$Q^* = \frac{1}{\pi\,(r^2 - r_0^2)} \int_{r0}^{r} (2\,\pi\, r\, q)\, dr$$

$$q = -k\, \frac{\partial T}{\partial z}.$$

and r_0 is the distance of a given point from the centre of either disc. Now calculating Q^* for $Z = -L$ and $Z = +L$, Nusselt numbers for the lower and the upper discs can separately be obtained.

The Nusselt number at the lower disc $[(N_u)_{-1}]$ and at the upper disc $[(N_u)_{+1}]$ are given by

$$\begin{aligned}[(N_u)_{-1}] = &-8.4\, PE - 1 + R\,(-5.1048\, P^2E + 0.1829\, PE - 0.4\, P \\ &- 13.5771 \wedge PE) + R^2\,(-2.1387\, P^3E + 0.5379\, P^2E \\ &+ 0.0295\, PE - 0.6451\, \beta^2\, PE - 0.0616\, P^2 + 0.0025\, P \\ &+ 0.01143 \wedge P + 4.0875 \wedge P^2E + 0.0236 \wedge PE \\ &+ 3.6991 \wedge^2 PE) + (\xi^2 + \xi_0^2)\,[-0.75\, PE - 0.3429\, P^2RE \\ &+ R^2\,(-0.2325\, P^3E + 0.0292\, P^2E + 0.0129\, PE \\ &- 0.4857\, \beta^2\, PE - 0.0862 \wedge P^2E + 0.3513 \wedge PE \\ &+ 1.1057 \wedge^2 PE)]\end{aligned} \tag{38}$$

and

$$\begin{aligned}[(N_u)_{+1}] = &\, 8.4\, PE - 1 + R\,(5.1048\, P^2E - 0.1829\, PE - 0.4\, P \\ &+ 13.5771 \wedge PE) + R^2\,(2.1387\, P^3E - 0.5379\, P^2E \\ &- 0.0295\, P + 0.6451\, \beta^2\, PE - 0.06159\, P^2 + 0.0025\, P \\ &+ 0.01143 \wedge P + 4.0875 \wedge P^2E + 0.0236 \wedge PE + 3.66991 \\ &\times \wedge^2 PE) + (\xi^2 + \xi_0^2)\,[0.75\, PE + 0.3429\, P^2RE \\ &+ R^2\,(0.2325\, P^3E - 0.0292\, P^2E - 0.0129\, PE + 0.4857\, \beta^2\, PE \\ &+ 0.0862 \wedge P^2E - 0.3513 \wedge PE - 1.1057 \wedge^2 PE)],\end{aligned} \tag{39}$$

where $\xi_0 = r_0/L$.

4. Numerical Discussion

In this paper the problem of temperature distribution and heat transfer of steady laminar flow of an incompressible elastico-vicous liquid between two rotating porous discs have been studied The basic equations have been solved by the Perturbation method in which the suction/injection parameter 'R' is taken as the small Perturbation parameter. Also, in the present analysis two discs rotating with the same angular velocity in the same sense have been considered.

Figs. 2 & 3 show the variation of Nusselt number i. e. $(N_u)_{-1}$ (Nusselt number at the lower disc) and $(N_u)_{+1}$ (Nusselt number at the upper disc) against ξ/ξ_0 for Prandtl number P ($=$ 5), elastico-viscous parameter $\wedge$ (= 0, 0. 5, 0. 75), Eckert number E (= 0.01), rotation paramter β (= 0.5) and suction/injection parameter R (= − 0.25,0.25).

Fig. 2 shows the variation of the Nusselt number at the lower disc aganist ξ/ξ_0, for the fixed values of $P = 5$, $E = 0.01$, $\beta = 0.5$ and $\xi_0 = 5$. It is observed that $(N_u)_{-1}$ is negative and it goes on decreasing as we move away from the centre, for suction/injection.

The variation of the Nusselt number at the upper disc against ξ/ξ_0, for the same fixed values of P, E, β and ξ_0; has been depicted in Fig. 3. It is observed $(N_u)_{+1}$ is positive throughout and it goes on increasing as we move away from the centre in suction as well as in injection case.

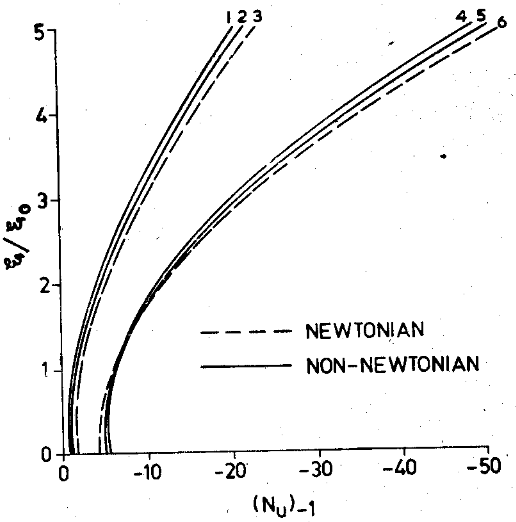

Figure 2. Variation of Nusselt number at the lower disc against ξ/ξ_0 for fixed values of $E = 0.01$, $P = 5$ and $\xi_0 = 5$, (curve 1, 2, 3——$R = -0.25$; $\wedge = 0.75$, 0.5 & 0 and curve 4, 5, 6——$R = 0.25$, $\wedge = 0,75$, 0.5 & 0).

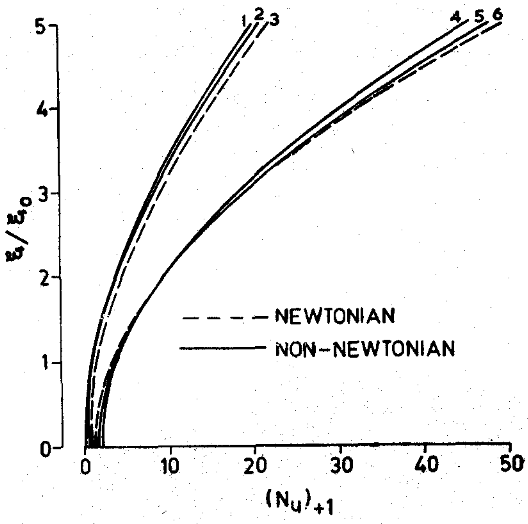

Fig. 3—Variation of the Nusselt nnmber at the upper disc against ξ/ξ_0 for the same fixed values of $E = 0.01$, $P = 5$ and $\xi_0 = 5$, (curve 1,2,3——$R = -0.25$, $\wedge = 0.75$, 0.5 & 0, curve 4,5,6——$R = 0.25$; $\wedge = 0.75$, 0.5 & 0).

The values of the Nusselt number at the lower and upper discs for various values of P (= 5, 10), E (= 0.01, 0.02), β (= 0.5, 1.0), R (= − 0.5, − 0.25, 0.25, 0.5), $\wedge$ (= 0.0.5, 0.75), ξ_0 = 5.0 and ξ/ξ_0 = 3.0 are presented in Tables 1 & 2. We conclude from the tables that the value of the Nusselt number at the lower disc decreases with the increase of either P, or E, or β; when R (suction parameter) is fixed, but it increases with the increase of $\wedge$, when P, R, E and β are constants. The value of the Nusselt number at the upper disc increases with the increase of either R (suction parameter), or P, or E, or β; for both the Newtonian and non-Newtonian fluids.

Table 1. Nusselt number (N_u) of the power and upper disc for $\xi_0 = 5$ and $\xi/\xi_0 = 3$ in suction case

R	P	E	β	$\wedge$	$(N_u)_{+1}$	$(N_u)_{-1}$
0.25	5	0.01	0.5	0	18.5449	−21.7359
0.25	5	0.01	0.5	0.5	18.4816	−21.5992
0,25	5	0.01	0.5	0.75	18.2902	−21.3657
0.5	5	0.01	0.5	0.	37.4455	−42.2093
0.5	5	0.01	0.5	0.5	37.0226	−41.4931
0.25	10	0.01	0.5	0	77.2548	−82.0216
0.25	10	0.01	0.5	0.5	77.5287	−82.0213
0.25	5	0.02	0.5	0	38.6853	−41.8763
0.25	5	0.02	0.5	0.5	38.5538	−41.6048
0.25	5	0.01	1.0	0	18.8310	−21.0219
0.25	5	0.01	1,0	0.5	18.7677	−22.3076

Table 2. Nusselt number (N_u) of the lower and upper disc for $\xi_0 = 5$ and $\xi/\xi_0 = 3$ in injection case

R	P	E	β	Λ	$(N_u)^+{}_1$	$(N_u)_{-1}$
−0.25	5	0.01	0.5	0	8.1958	− 9.3867
−0.25	5	0.01	0.5	0.5	7.9627	− 9.0804
−0.25	5	0.01	0.5	0.75	7.6864	− 8.7631
−0.5	5	0.01	0.5	0	16.7472	−17.5109
−0.5	5	0.01	0.5	0.5	15.9849	−16.4554
−0.25	10	0.01	0.5	0	33.8490	−34.6159
−0.25	10	0.01	0.5	0.5	33.7779	−34.2761
−0.25	5	0.02	0.5	0	16.9870	−18.1779
−0.25	5	0.02	0.5	0.5	16.5223	−17.5671
−0.25	5	0.01	1.0	0	8.4819	− 9.6728
−0.25	5	0.01	1.0	0.5	8.2489	− 9.9585

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