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Heat Transfer Analysis of Micro Polar Fluid with AL_2O3 and CuO Hybrid Nanofluid Over a Plate with and Without Out Viscous Dissipation

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Abstract: This work analysis investigated with the boundary layer stream and heat transfer aspects of a micropolar nanofluid over a porous shrinking sheet with thermal radiation. The boundary layer equations governed by the partial differential equations are transformed in to a set of ordinary differential equations with the help of suitable local similarity transformations. The coupled nonlinear ordinary differential equations are solved by the commercial MATLAB code bvp4c.The solutions of dimensionless velocity ,velocity gradient and temperature profiles are analyzed by the effect of various controlling flow parameters nonlinear parameter ,material property and Eckert number. and temperature and Prandtl number. Physical quantities such as skin frication coefficient, local heat, computed.
Keywords: Viscous effects .flat plate, Nanofluid, hybrid nanofluid, micro polar fluid , local Nusselt number, skin friction, micro rotation

I. INTRODUCTION

The technical and scientific advances have bring a great development of attention in constructing dissimilar types of fluids and investigate their flow performance in a variety of practical geometries. Fluids with microstructures act in a different way as of the conventional fluids. The flow and heat transfer performance of these fluids cannot be described adequately with the classical theory of Newtonian fluid flows. Several theories have been existing to describe the very nature of these fluids. However, theory of micropolar fluids accessible by Eringen [1] provides ample details necessary for justification of dynamics of such fluids. Micropolar fluids consist of rigid, arbitrarily leaning, sphere-shaped particles with their possess spins and micro rotation, hovering in a viscous medium. At this point the microelements are permissible to experience unbending rotation only devoid of extend. The micropolar fluid representation, at a distance as of us speed vector involve a micro rotation vector and a twist limit to replicate the kinematics of micro rotation. These fluids have mono symmetric stress tensor. Eringen [2] extensive his assumption for thermo-micropolar fluids and resulting the constitutive laws. Ariman et al. [3,4] presented an outstanding appraisal of micropolar fluids and their applications. Ahmadi [5] investigated the boundary layer flow of micropolar fluids past a semi-infinite plate. The fundamental hypothesis of micropolar fluids can be viewed in the book printed by Eringen [6] as well as by Be'g et al. [7]. Rehman et al. [8] considered heat transfer in two-dimensional steady hydro magnetic natural convection flow of a micropolar fluid past a non-linear stretching sheet with temperature dependent viscosity presence of transverse magnetic field near a stagnation point. Berre et al. [9] described detailed reviews on modeling approaches for flow in fractured porous media, from physical, conceptual and mathematical Upendar and Srinivasacharya [9] analyzed a mathematical model for the steady, mixed convection heat and mass transfer along a semi-infinite vertical plate embedded in a micropolar fluid in the presence of a first-order chemical reaction and radiation. Sharma et al. [11] studied the fully developed electrically conducting micropolar fluid flow and heat transfer along a semi-infinite vertical porous moving plate including the effect of viscous heating and in the presence of a magnetic field applied transversely to the direction of the flow. Mohammedein and Gorla [12] analyzed the flow of micropolar fluids bounded by a stretching sheet with a prescribed wall heat flux, viscous dissipation and internal heat generation. Abo-Eldahab and El-Aziz [13] considered heat transfer effect in a micropolar fluid flow induced by a stretching surface immersed in a porous medium with uniform free stream. Ahmad et al. [14] obtained closed form solution for a viscous, incompressible, MHD flow over a porous stretching sheet. Dayyan et al. [15] studied the Newtonian fluid flow with heat transfer through porous medium and presented analytical solution by employing the Homotopy Analysis Method (HAM). Aluminum Oxides that are known as chemical combination (Al2O3) or Alumina can be counted for a part of Nanoscale elements that is applied in order to make rigorous thermal quality performance of Molecular liquids. They have been classified into two types that are known as αAl2O3 or γAl2O3 based on their magnitudes.

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Phenomenon of bunch scattering on the stretching cylinder through Al2O3 and Cu–water-Nanofluids has been studied by Alshomri and Gui [16]. The entropy generation and 2D stream property in γAl2O3−H2O and γAl2O3−C2H6O2 Nanoliquids by Prandtl number model has been investigated in [17].3D flow state in γAl2O3−H2O and γAl2O3−C2H6O2 Nanoliquids amid parallel rotating surfaces has been interrogated by Khan et al [18]. Also, this type of Nanoliquids from aspect of entropy analysis of model has been worked by Hayat et al [19].Chemical reaction and Thermal radiation of MHD streaming of Nano liquids and heat transport investigation on Water based Nanofluids coated with Ag, TiO2, Cu and Al2O3 on a stretchable sheet has been surveyed by Jain et al [20]. The effect of viscous dissipation effects with different parameters are analyses by Kartini Ahmad, ea. al [16] . The present aim of the paper is to analyses the numerical simulation of water, water based nano fluid and water base hybrid nanofluid. The present problem considered with micro polar fluid passing over a sheet eith effect of viscous dissipation effect. The fluid is passing over a the sketching plate at different temperatures 40^0C ,60^0C. to get the variation beteen the Pd .the other parameters n , Ec [viscous dissipations parameters. The effect various parameters with nondimensional temperature and velocity profiles are Nusselt numbers, Skin friction are graphically.

II. MATHEMATICAL MODELING

The steady two-dimensional laminar boundary layer flow over a nonlinearly stretching plate wrapped up in an incompressible micropolar fluid of ambient temperature $T\infty$ the stretched velocity of the plate is implicit as $Un = ax^n$, and the plate temperature varies like $Tw = T\infty + bx^{2n}$, where x is the distance beginning the slot where the plate is supplied and a, b, and n are constants. The boundary layer equations are. The boundary layer equations are [17, 18]

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{1}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y} = \frac{\mu+\varphi}{\rho}\frac{\partial u^2}{\partial y^2} + \frac{\varphi}{\rho}\frac{\partial N}{\partial y} \tag{2}$$

$$\rho j\left(u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}\right) = \gamma\frac{\partial^2 N}{\partial y^2} - \varphi\left(2N + \frac{\partial u}{\partial y}\right) \tag{3}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k}{\rho Cp}\frac{\partial T^2}{\partial y^2} + \frac{\varphi+\mu}{\rho Cp}\left(\frac{\partial u}{\partial y}\right)^2 \tag{4}$$

where u and v are the velocity components in the x and y directions, respectively. Further more, μ is the dynamic viscosity, φ is the vortex viscosity (or the microrotation viscosity), ρ is the fluid density, k is the thermal conductivity, Cp is the specific heat at constant pressure, T is the fluid temperature, j is the microinertia density, N is the micro rotation (or angular velocity), and γ is the spin gradient viscosity. The boundary conditions are

$$u = U_{w,}\ v = 0, N = -m\frac{\partial u}{\partial y}\ ,T = T_w\ \ at\ y = 0, u \to 0, T \to 0, as\ y \to \infty \tag{5}$$

where m is a constant with $0 \le m \le 1$. The case m = 1/2 indicates the vanishing of anti symmetric part of the stress tensor and denotes weak concentrations which is considered in the present paper. Furthermore, we follow the work of many recent authors by assuming that $\gamma = (\mu + \varphi/2)j = \mu(1 + K/2)j$, where $K = \varphi/\mu$ is the micropolar or material parameter. This assumption is invoked to allow the field of equations to predict the correct behavior in the limiting case when the microstructure effects become negligible and the total spin N reduces to the angular velocity (see Ahmadi [27] or Yucel [¨ 28]).

In order to solve (1)–(4) subject to the boundary conditions (5), we introduce the following similarity transformation

$$\eta = \left(\frac{Uw}{vx}\right)^{\frac{1}{2}} y,\quad \psi = (vxU_w)^{\frac{1}{2}} f(\eta),\ N = U_w\left(\frac{Uw}{vx}\right)^{\frac{1}{2}} h(\eta) \tag{6}$$

$$h(\eta) = -\frac{1}{2}f''(\eta), \theta(\eta) = \frac{T-T_\infty}{T_w-T_\infty} \tag{7}$$

where η is the similarity variable, primes denote differentiation with respect to η, $v = \mu/\rho$ is the kinematic viscosity, f is the dimensionless stream function, h is the dimensionless microrotation, and ψ is the stream function defined as $u = \partial\psi/\partial y$ and $v = -\partial\psi/\partial x$ which identically satisfies (1). Using transformation (6) and utilising the boundary condition $N = -(1/2)(\partial u/\partial y)$ from (5), (2) and (3) reduce to the single equation

$$\left(1 + \frac{k}{2}\right)f''' + \left(\frac{n+1}{2}\right)ff'' - nf'^2 = 0 \tag{8}$$

and the energy equation (4) becomes

$$\frac{\theta''}{Pr} + \left(\frac{n+1}{2}\right)f\theta' - 2nf\theta' + Ec(1 + K)f''^2 = 0 \tag{9}$$

where Pr is the Prandtl number and Ec is the Eckert number defined as

$$Pr = \frac{\mu Cp}{k}, Ec = \frac{U_w^2}{Cp(Tw - T\infty)}$$

The boundary conditions after the transformation conditions are

$$f(0) = 0, f'(0) = 1, \theta(0) = 1 \tag{10}$$

$$f'(\eta) = 0, \theta(\eta) = 0 \tag{11}$$

The other evaluated parameters are the skin friction coefficient Cf and the local Nusselt number Nu_x which are defined as

$$Cf = \frac{\tau w}{\rho U_w^2}, = \frac{xqw}{k\,(Tw - T\infty)}, \qquad (12$$

$$\tau_w = \left[(\mu + \varphi)\frac{\partial u}{\partial y} + \varphi N\right]_{y=0}, q_w = -k\left(\frac{\partial T}{\partial y}\right)_{y=0} \tag{13}$$

Using the dimensionless variables in (6), the obtain

$$C_f Re_x^{1/2} = (\left(1 + \frac{k}{2}\right) f''(0)$$

$$\frac{Nu_x}{Re_x^{1/2}} = \theta'(0) \tag{14}$$

where $Re_x = \frac{U_w x}{\nu}$ is the local Reynolds number.

III. PROPERTIES OF NANOFLUID AND HYBRID NANOFLUID

The properties of nanofluid and hybrid nanofluid are evaluated from the literature with the following equations in table 1. and 2.0

Thermophysical properties of Al2O3 ,Cu (nanoparticles) and H2O (base fluid) represents in the Table 1.0

Property	Al2O3	Cu	H2O
Density (kg-m^{-3})	3970	8933	997.1
Thermal conductivity (WK^{-1}m^{-1})	40	400	0.6071
Thermal expansion coefficient(K^{-1})	0.000051	0.000076	0.000256
Heat capacitance (JK^{-1})	765	385	4159

Table 2.0 Thermophysical model of nanofluid and Hybrid nanofluid

Properties	Nanofluid Model	Hybrid Nanofluid Model
Density (kg m^{-3})	$\rho_{nf} = (1-\emptyset)\rho_f + \emptyset\rho_s$	$\rho_{hnf} = \left[(1-\emptyset_2)\left\{(1-\emptyset_1)\rho_f + \emptyset_1\rho_{s1}\right\} + \emptyset_2\rho_{s2}\right]$
Heat capacity (JK^{-1})	$(\rho Cp)_{nf} = (1-\emptyset)(\rho Cp)_f + \emptyset(\rho Cp)_s$	$(\rho Cp)_{hnf} = \left[(1-\emptyset_2)\left\{(1-\emptyset_1)(\rho Cp)_f + \emptyset_1(\rho Cp)_{s1}\right\} + \emptyset_2(\rho Cp)_{s2}\right]$
Viscosity	$\mu_{nf} = \frac{\mu_f}{(1-\emptyset)^{2.5}}$	$\mu_{hnf} = \frac{\mu_f}{(1-\emptyset_1)^{2.5}(1-\emptyset_2)^{2.5}}$
Thermal conductivity (W.K^{-1} m^{-1})	$\frac{K_{nf}}{K_{bf}} = \frac{K_s + (n-1)K_f - (n-1)\emptyset(K_f - K_s)}{K_s + (n-1)K_f + \emptyset(K_f - K_s)}$	$\frac{K_{hnf}}{K_{bf}} = \frac{K_{s2} + (n-1)K_{bf} - (n-1)\emptyset_2(K_{bf} - K_{s2})}{K_{s2} + (n-1)K_{bf} + \emptyset_2(K_{bf} - K_{s2})}$ Where $\frac{K_{bf}}{K_f} = \frac{K_{s1} + (n-1)K_f - (n-1)\emptyset 1(K_f - K_{s1})}{K_{s1} + (n-1)K_f + \emptyset 1(K_f - K_{s1})}$
Thermal expansion Coefficient (K^{-1})	$\beta_{nf} = (1-\emptyset)\beta_f + \emptyset\beta_s$	$\beta_{hnf} = \left[(1-\emptyset_2)\left\{(1-\emptyset_1)\beta_f + \emptyset_1\rho\beta_{s1}\right\} + \emptyset_2\beta_{s2}\right]$

IV. NUMERICAL METHOD

The similarity solutions are adopted for the present problem .The equations[8] ,[9] with boundary conditions [10],[11],12], [13] and [14] solved obtained from the transformation are solved with a finite difference method and compared with MATLAB bvp4c code. The skin friction and Nusselt number are calculated with the equations [13] &[14] . The transformed boundary layer equations are converted into first order differential equations and solved with the given boundary conditions.

V. RESULTS AND DISCUSSIONS

The fig1.0 represents the variation of velocity profiles for without micro rotation and viscous dissipation and nonlinear parameter. [K=0,Ec=0,n=0] the fluid itself acts as ordinary nanofluid. The effect of prandtl number on velocity profile are notified. The different Prandtl numbers at different Temperatures are considered. The present problem analysis the water, and

Water base nanofluid and combined Al2O3 and CuO hybrid nanofluids are considered. Prandtl numbers for 40^0C and 60^0C water and water based nano and hybrid nanofluids are used and analyzed for the current problem From the figure 1.0 & 2.0 the effect of Prandtl number has less significance on velocity profiles

The figure 3.0 represents the effect of Pr on non dimensional temperature . the temperature profiles are increases with increasing the temperature and the Pr values. The temperature profiles for the hybrid nanofluid as higher than water and nanofluid Al2O3, Cuo due to its moderate properties .

The figure 4.0 and figure 5.0 represents the variation of local Nusselt number and skin friction factor. The local Nusselt numbers are increases with increasing the temperature and Pr from the figure 6.0 there no

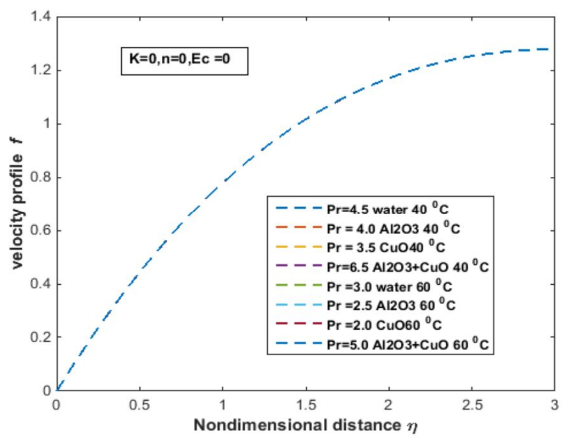

Fig1.0 Effecrt of Pr at different Temperatures on velocity profiles for water, nano fluid and Hybrid nanofluid K=0,Ec =0,n=0

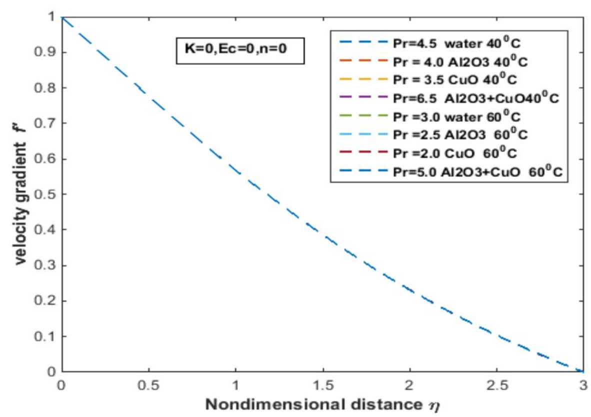

Fig 2.0 Effecrt of Pr at different Temperatures on velocity gradient for water, nano fluid and Hybrid nanofluid K=0,Ec =0,n=0

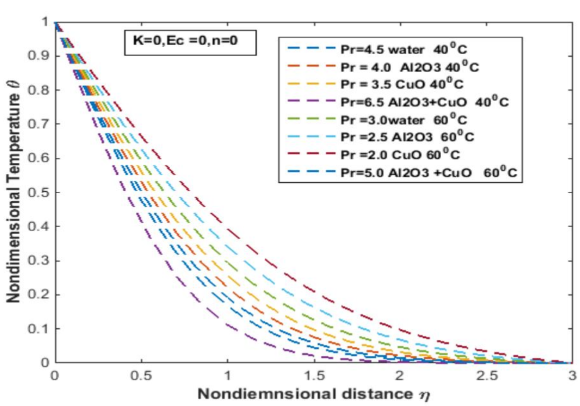

Fig 3.0 Effecrt of Pr at different Temperatures on non diemnsional temerature for water, nano fluid and Hybrid nanofluid K=0,Ec =0,n=0

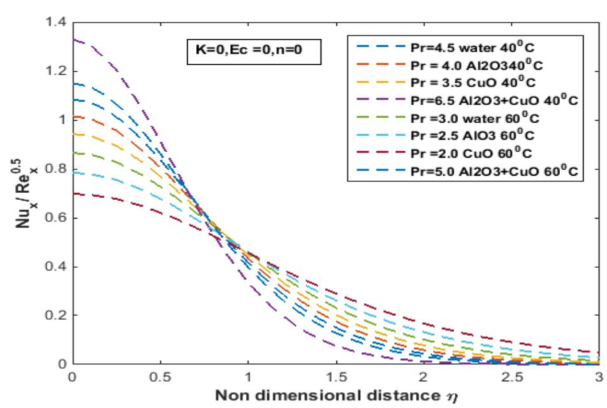

Fig4.0 Variation of local Nusselt numbers with effect of temperature on at K=0,Ec =0,n =0

Much significance on skin friction of Pr at different Temperature. Figure 6.0 and Figure 7.0 represents effect of nonlinear parameter n .the computations are innovated for different values of nonlinear parameter [n=0,1,2] on velocity profile and velocity gradient at the constant with constant Pr and Ec =0,K=1. The slope of the velocity profiles increases with increasing the values of nonlinear parameter.

The figure 8.0 the represents the variation of velocity gradient with nonlinear parameter [n=0,1,2]. The velocity profiles Are decreases with increasing the nonlinear parameter.Thefig.8.0represents the effect of nonlinear parameter on nondimensional temperature distribution

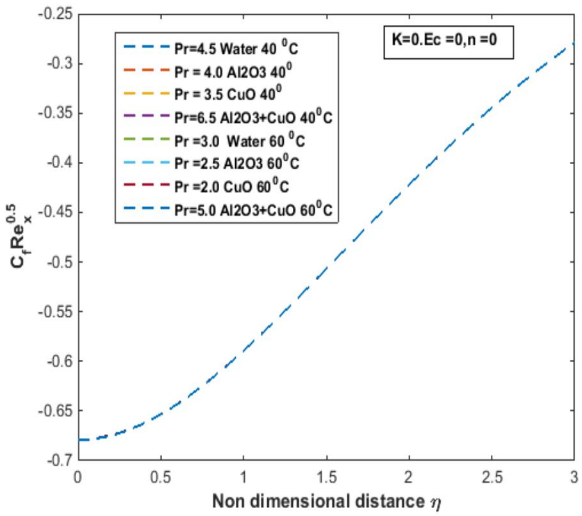

Fig5.0 representation of skin friction with variation Pr for Water ,Nano fluid,hybrid nanofluid at K =0,Ec =0n =0

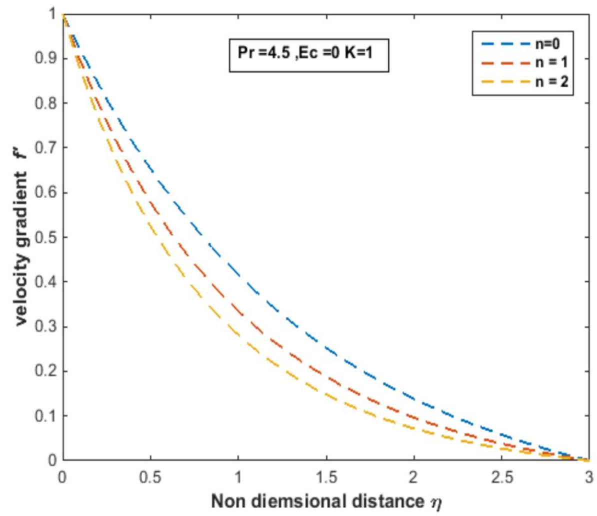

Fig6.0 Effect of n on velocity profiles for water at Pr 4.5 Ec =0,K =1

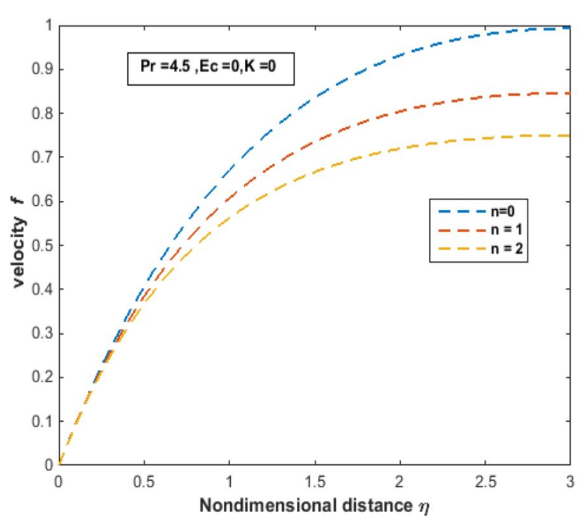

Fig7 Effect of n on velocity profiles for water at Pr 4.5 Ec =0,K =1

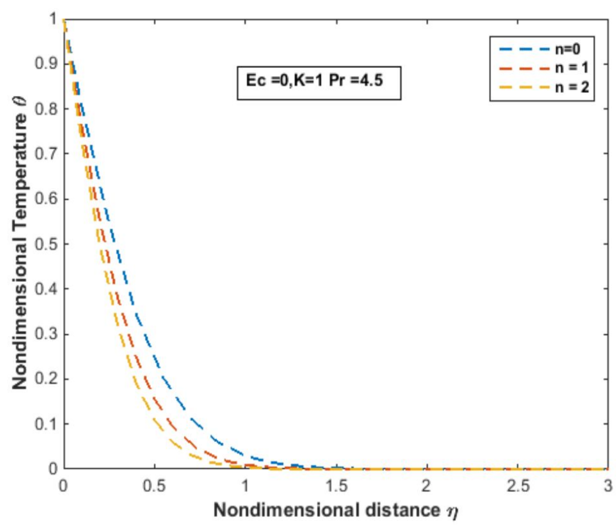

Fig8.0 Effect of n on velocity profiles for water at Pr 4.5Ec =0,K =1

The slope of temperature distribution is increases with increasing the values of n . Fig 9.0 Fig 10.0 represents the variation of local Nusselt numbers and skin friction values with the variation in nonlinear parameter. The Nusselt numbers are increases with increasing the nonlinear parameter. From the figure10. The skin friction is increases with increasing the values of n.

Fig 11.0 &12.0 exhibits the variation of velocity and velocity gradient with variation of Eckert number at [0,1,2] for water [Pr =4.5 K=0,n=0].

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The velocity profiles have no much significance on velocity and its gradients .Fig13.0 reports the variation of nondimensional temperature with distance with the effect of Ec number at different[Ec =0,1,2]. The temperature distribution is more with high Ec value. Due to the higher heat flux. Fig14& 15 represents the variation of Nusselt and skin friction variation with nondimensional distance.The Nusselt numbers increases with increasing the Ec number and all the slope of the local Nusselt numbers are merging at the 0.9 from the initial position of the nondimensional distance.

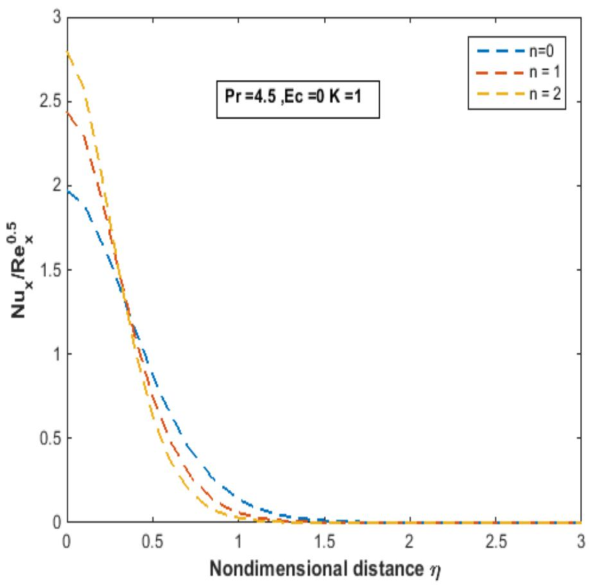

Fig9.0 Effect of n on velocity profiles for water at =0,K -1

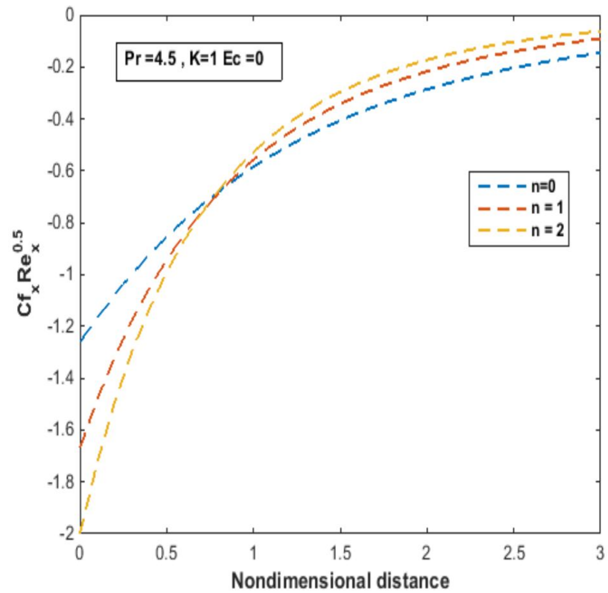

Fig10 Effect of n on velocity profiles for water at Pr 4.5Ec Pr 4.5Ec =0,K =1

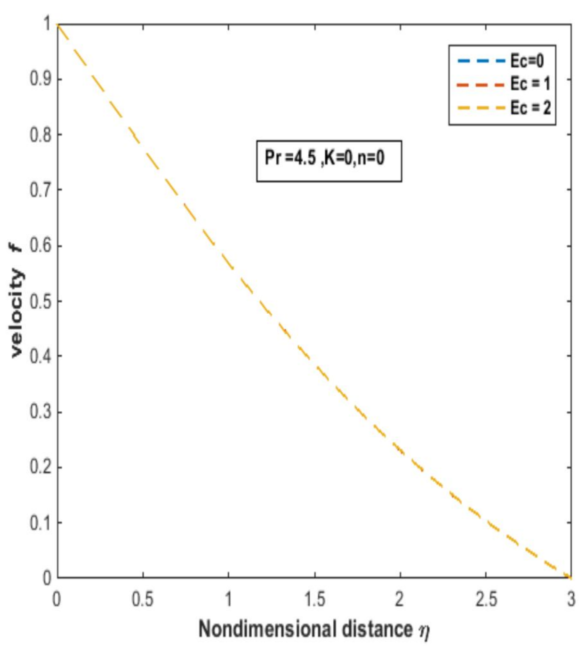

Fig 11.0 effect of Ecklet number on velocity with nondiemnsional distamce at Pr =4.5,K=0,n =0

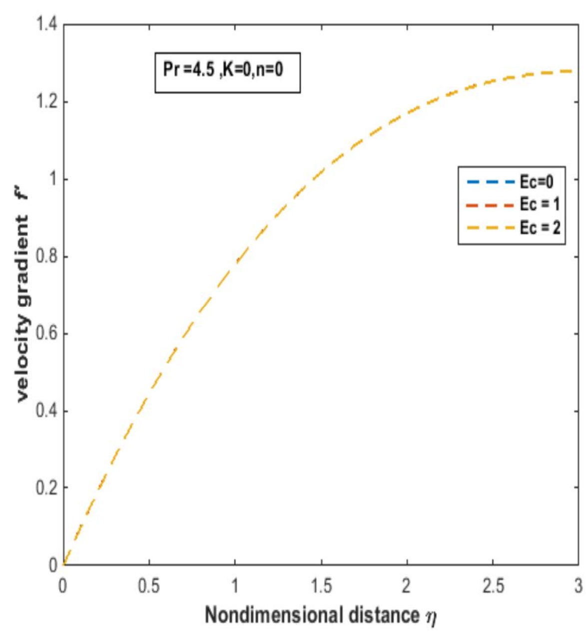

Fig12.0 varition of velocity graident with Eclet nymber With nondimensional distance for water at Pr =4.5,K =0,n=0

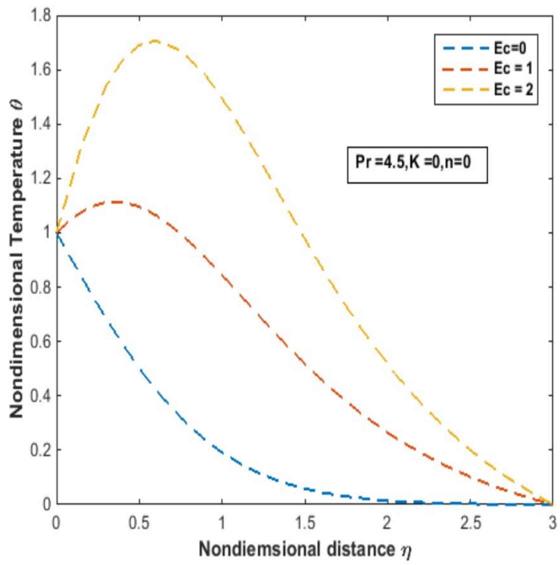

Fig 13.0 Effect of Ecket number on velocity profiles for water at Pr 4.5 n=0,K =0

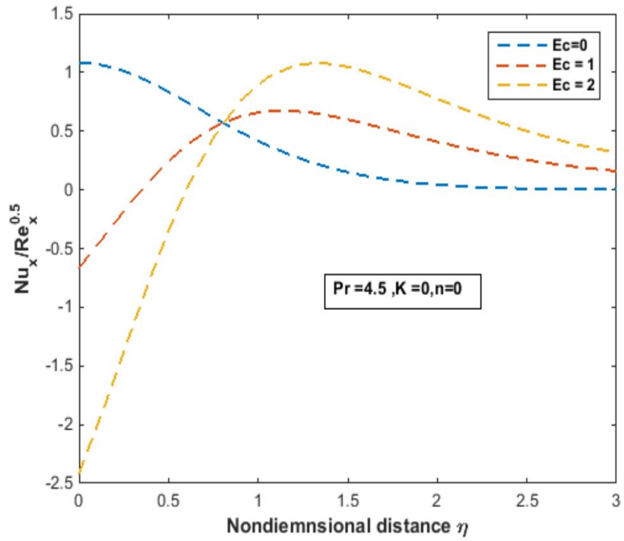

Fig 14.0 Effect of Ecket number at[Ec =0,1,2] on velocity profiles for water at Pr 4.5 n=0,K =0

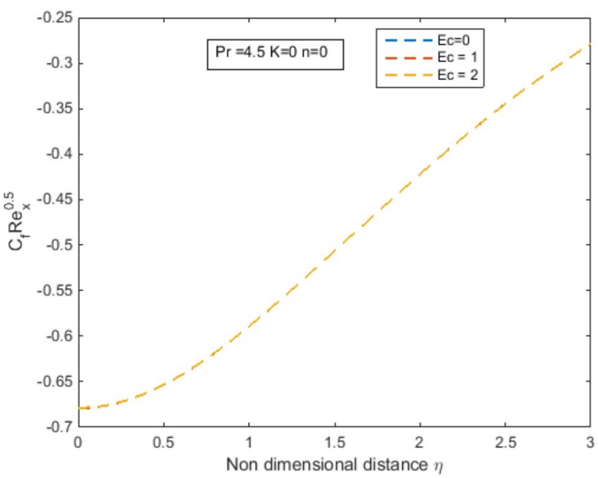

Fig 15.0 Effect of Ecket number [0,1,2] on velocity profiles for water at Pr 4.5 n=0,K =0

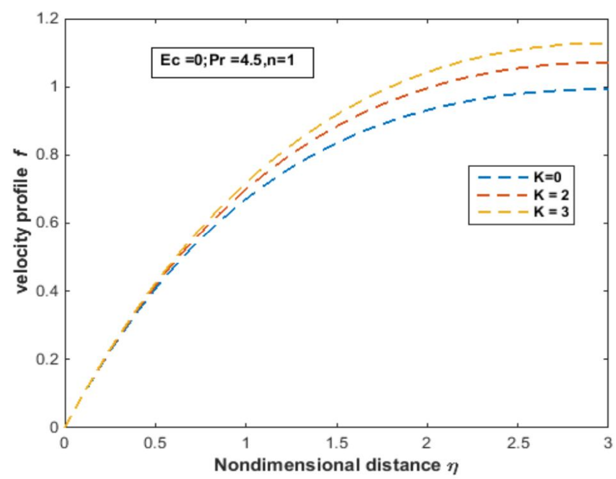

Fig16 Effect of K(material property) on velocity profiles at Pr =45 Ec =0,n =1

Fig16.0 & Fig17.0 represents the variation of velocity and its gradient variation with [K=0,1,2] for Pr number for water [Pr =4.5,Ec =0,n=1] The velocity profiles are increases with increasing the values of K.

Fig18. Represents the variation of nondimensional temperature with non dimensional distance for [Pr =4.5 Ec =0,n=1] the effect of K have no much significance on nondimensional temperature .Fig19& 20 represents the variation Nusselt number and skin friction with effect of K for constant Prandtl number Pr =4.5 n=1 Ec =0 . The local Nusselt numbers have no much significance and friction increases with increasing the value of K.

Fig 21& 22 represents the variation of all parameters K, n, Ec the variation of velocity and velocity gradient at different values of [K =1,2,3],[n=1,2,3] Ec=[1,2,3] at constant Pr =4.4 for water.The velocity and velocity gradient are increases with increasing the K ,n, EC, Fig 23 represents the variation of non dimensional numbers with the parametric change of [K ,n, Ec] at the constant Pr 4.5 for water, the temperature profiles are increases with increasing the values of [K, n, Ec]. Fig24 &25 represents the variation of Nusselt number and skin friction for the variation of parametric study of [K. n, Ec].The skin friction and Nusselt numbers are increases with increasing the values of [K, n, Ec]

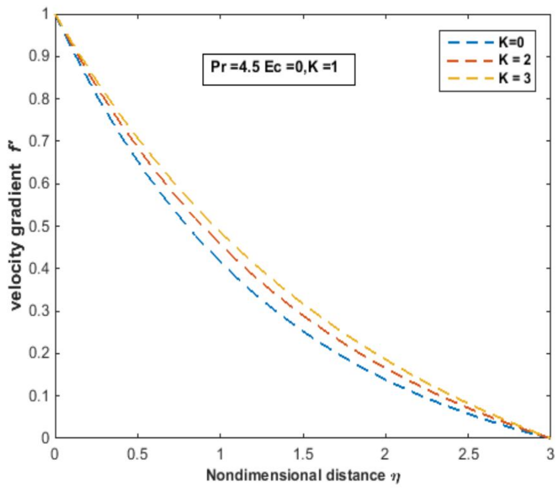

Fig17 Effect of K on velocity profiles at Pr =45 Ec =0,n =1

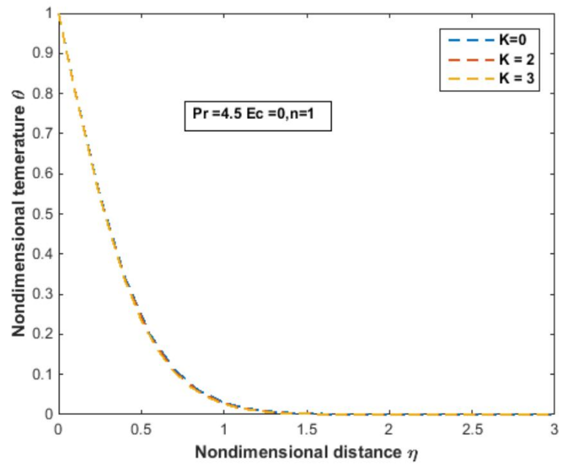

Fig18 Effect of K on nondimensional temperature profiles at Pr =45 Ec =0,n =1

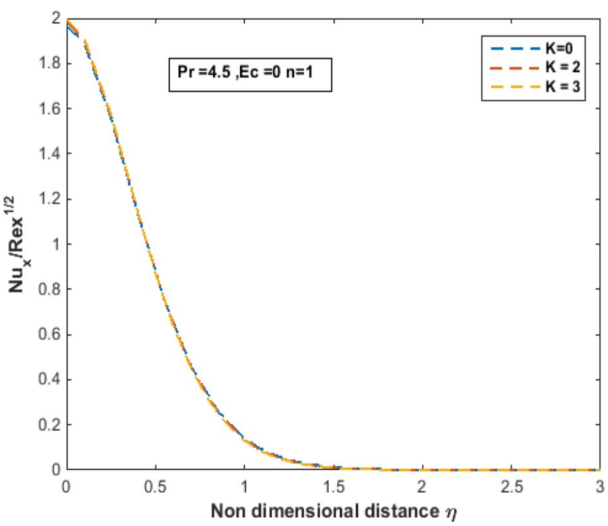

Fig19 effect of K [K=0,1,l,2] on Nusselt number at Pr =45, Ec =0,n =1

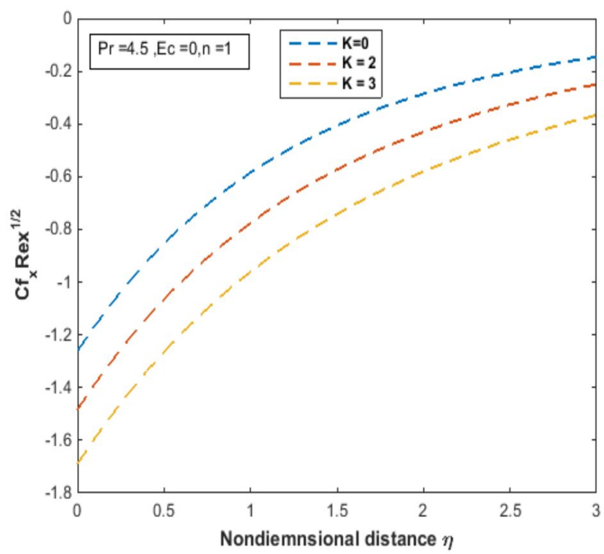

Fig20 Effect of K on skin friction at Pr =45 Ec =0,n =1

VI. CONCLUSIONS

The numerical investigation are carried out the effects of the substance factor K, the viscous dissipation Ec, the nonlinear stretching parameter n, and the Prandtl number Pr on the fluid flow and heat transfer characteristics toward a nonlinear stretching sheet immersed in a micropolar fluid. The prandtl number at different temperatures 40^0C .60^0C are considered for the water and water based nanofluids (Al2o3,CuO,and hybrid nanofluid. It is found that both the magnitude of the skin friction coefficient and the local Nusselt number increase with the nonlinear stretching parameter n and decrease when K increases for fixed values of n and also increases with increasing the n. The nondimensional temperatures increases with increasing the temperature and Pr and velocity profiles and velocity gradient are increases with increasing the Pr. Number. The hybrid nanofluid are better and super nanofluids for increasing the het transfer rate comparatively other convectional fluids

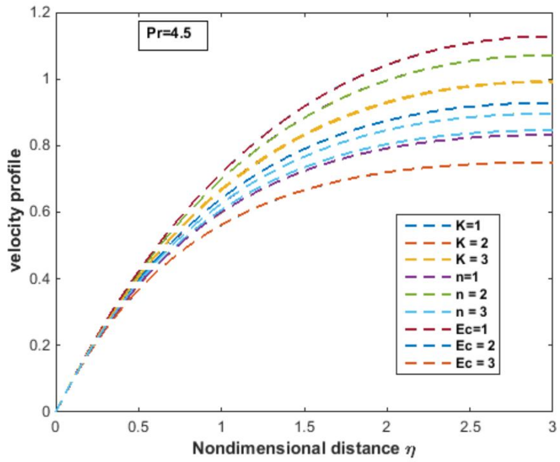

Fig21 Effect of velocity profiles with nondimensional distance [K=1,2,3],[n=1,2,3] [Ec=1,2,3] at Pr =45

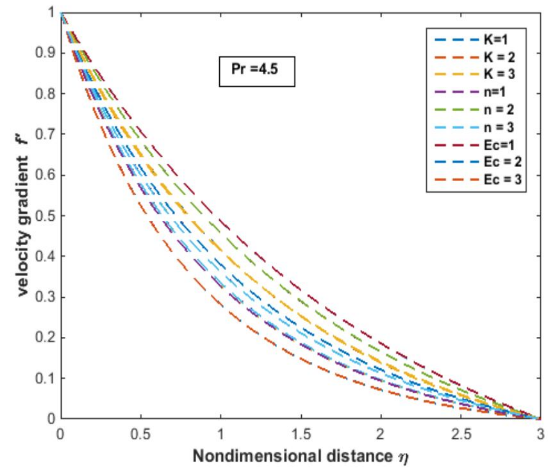

Fig22 Effect of K,n Ec and n [at equal values on velocity profiles with nondimensional distance at Pr =4.5

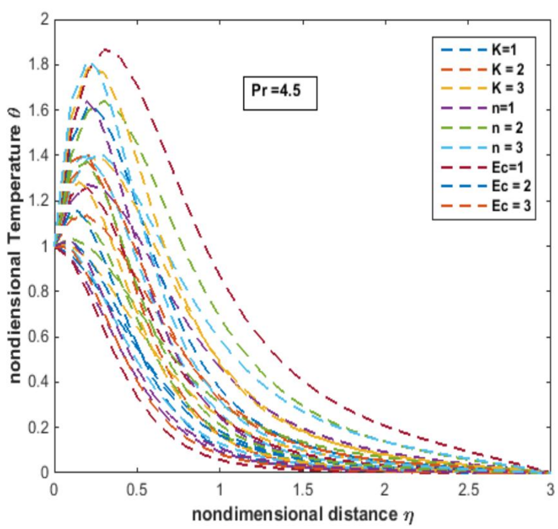

Fig23.0 effect of K,n,Ec [1,2,3] on o velocity profiles at Pr =45

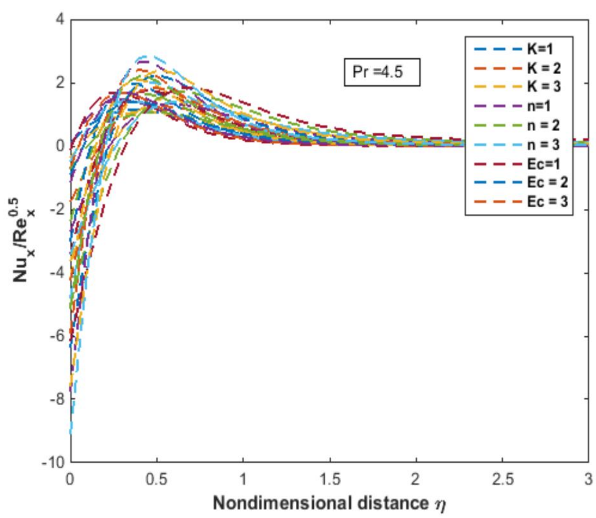

Fig24.0effect of K, n, Ec on Nusselt numbers at Pr =45

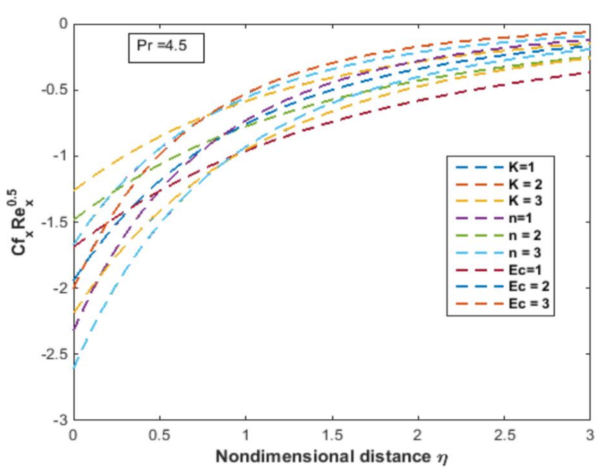

Fig25 Effect of K, n, Ec on skin friction at Pr =45 for water

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