Journal of Advances in Applied Mathematics, Vol. 4, No. 4, October 2019
https://dx.doi.org/10.22606/jaam.2019.44003

The Effective of Nano Particles from Many Materials with the Free Convection Nanofluid Flow and Heat Transfer over Stretching Sheet with Heat Source

H. A. El-dawy

The High Institute of Engineering & Technology- Tod- Luxor -Egypt
Email: Ha_sa3000@yahoo.com, Dr_hassan@luxorhiet.edu.eg

Abstract. In this work, we are studying the effect of nanoparticle from cu, AL_2O_3 and TIO_2 on micropolar fluid flow and heat transfer. The governing fundamental equations are approximated by a system of nonlinear ordinary differential equations and are solved numerically by using the Runge Kutta Gill and shooting methods. The coupled non-linear (PDE) representing momentum, angular momentum and non-homogeneous heat equation are solved and reduced into a set of non-linear (ODE). In these equations, there are two parameters. We can change its values, nano particle and parameter radiation and their effect on heat profile.

Keyword: Nanoparticle- micropolar-radiation free convection

1 Introduction

Before this work, there are many papers and many investigations about micro polar fluids and heat transfer. Lately many works declared the importance of the effect of nano particle in many fields; in industry, as glass, in the army, in solar energy and in nuclear reactors. Also, there are effects of nano particle on human body as in the flow of urine in kidneys and the bladder. The works which can describe the properties of non-Newtonian fluids, the fluid dynamics over a stretching surface, are important in many practical applications such as: extrusion of plastic sheets, paper production, glass blowing, metal spinning and drawing Plastic films, these are just examples. Because of the great diversity in the physical structure of non-Newtonian fluids, there is no single constitutive for some recent investigations in this direction are made in the studies. Amongst the several models of non-Newtonian fluids, the micropolar fluids have attracted much attention from researchers. This is due to the fact that the equation governing the flow of a micropolar fluid, involves a micro rotation vector and a gyration parameter in addition to the classical velocity vector field, the quality of the final product depends on the rate of heat transfer at the stretching surface and many cases for convection-free S.R. Mishra, et al [1]. Forced and mixed H.A. El-dawy [2]. Thermophoresis is a phenomenon, which causes small particles to go from direction of a hot surface to a cold one. Small particles such as: dust Copper, Aluminum, and Titanium etc..,. When suspended in a gas with a temperature gradient, experience a force in the direction opposite to the temperature gradient so for this reason have many practical applications in removing small particles from gas streams and in studying the particulate material deposition on turbine blades. It has also been shown that thermophoresis is the dominant mass transfer mechanism in the modified chemical vapor deposition process used in the fabrication of optical fiber perform and is also important in view of its relevance to postulated accidents by radioactive particle deposition in nuclear reactors. In many industries, the composition of processing gases may contain any of an unlimited range of particle, liquid or gaseous contaminants and may be influenced by uncontrolled factors of temperature and humidity. When such an impure gas is bounded by a solid surface, a boundary layer will develop energy and momentum transfer gives rise to temperature gradients. Mass transfer caused by gravitation, molecular diffusion, eddy diffusion and inertial impact results in deposition of the suspended components onto the surface. Micro polar boundary layer flow at stagnation on a moving wall was investigated by Gorla [3]. The problem of fluid past a stretching sheet has received a wide range of attention because of its technological applications in the field of metallurgy and chemical engineering. Crane [4] was the first to give an analytical solution for laminar boundary layer flow past a stretching sheet. The magneto hydrodynamic flow of a power-law fluid over a stretching

Copyright © 2019 Isaac Scientific Publishing

sheet was discussed by Cortell [5]. Wang [6] and Hayat et al [7] studied the two-dimensional MHD stagnation-point flow of an incompressible micropolar fluid over a nonlinear stretching surface. V. Kumaran, A [8] Transition of MHD boundary layer flow past a stretching heat, Mohammadein and Gorla [9] studied Heat transfer in a micropolar fluid over a stretching sheet with viscous dissipation and internal heat generation. Walid Aniss and Mohammadein [10] investigated joule heating effects on a micropolar fluid past a stretching sheet with variable electric conductivity. The theory of micropolar fluids proposed by Eringen [11, 12] is capable of explaining the behavior of exotic lubricants, polymeric fluids, liquid crystals, animal bloods, colloidal and suspension solutions, etc., for which the classical Navier – Stokes theory is inadequate. Ho et al. [13] analysed the effects of effective dynamic viscosity and thermal conductivity of a nanofluid on laminar natural convection heat transfer in a square enclosure computationally, using a homogeneous solid–liquid mixture formulation for the two-dimensional buoyancy-driven convection in an enclosure filled with alumina–water nanofluid. Further studies of nanofluid thermal convection flows have been communicated by Putra et al. [14], Jang and Choi [15], and Nanna et al. [16]. In this work we are studying the effects of nanoparticle in fluid flow and heat transfer over stretching sheet by free convection. And using many different material and observation what happens in the behavior of velocity, angular velocity and temperature under heat source. The solution of the present problem is obtained by Runge-Kutta method followed by shooting technique. This method can try many ordinary differential equations in many variables in higher order easily than any methods and gives good result and exactly science is using matrices from in this work we try comparing between effective of nanoparticle on temperature and velocity and the range of effective by change material.

2 Formulation of the Problem

A two-dimensional steady flow of micropolar fluid with heat transfer and thermal radiation over a stretching sheet is considered. The shrinking velocity of the sheet is $Uw = -cx$ where c is the stretching constant such that $c > 0$. The equations of motion for the micropolar fluid and heat transfer under the boundary layer approximation are

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

$$\rho_{\eta f}\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = \mu_{\eta f}\frac{\partial^2 u}{\partial y^2} + \frac{\partial N}{\partial y} + \beta_{\eta f}(T - T_\infty) \tag{2}$$

$$\rho_{\eta f}\left(u\frac{\partial N}{\partial x} + v\frac{\partial N}{\partial y}\right) = \mu_{\eta f}\frac{\partial^2 N}{\partial y^2} - (2N + \frac{\partial u}{\partial y}) \tag{3}$$

$$\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = \alpha_{\eta f}\frac{\partial^2 T}{\partial y^2} - \frac{\partial q_r}{\partial y} + Q(T - T_\infty) \tag{4}$$

ρ_f and ρ_s are the densities of the fluid and of the solid fractions, $\mu_{\eta f}$ is the viscosity of the nanofluid. $\rho_{\eta f}$ is denesity of nanofluids, $\beta_{\eta f}$ thermal expansion coefficient nanofluids and $\alpha_{\eta f}$ is the thermal diffusivity of the nanofluids, which are given by,

$$\frac{K_{nf}}{K_f} = \frac{(K_s + 2K_f) - 2\varphi(K_s - K_f)}{(K_s + 2K_f) + \varphi(K_s - K_f)} \quad \mu_{nf} = \frac{\mu_f}{(1-\varphi)^{2.5}}$$

$$\alpha_{nf} = \frac{K_{nf}}{(\rho C_p)_{nf}} \qquad (\rho C_p)_{nf} = (1-\varphi)(\rho C_p)_f + \varphi(\rho C_p)_s \qquad \beta_{nf} = (1-\varphi)\beta_f + \varphi\beta_s$$

Table 1. ThermoPhysical properties of fluid and nanoparticles (Oztop and Abu-Nada [17]

Physical properties	Fluid phase	Cu	AL_2O_3	TiO_2
CP (j/kg k)	4179	385	765	686.2
ρ (kg/m3)	997.1	8933	3970	4250
k (w/m k)	0.613	400	40	8.9538
$\beta \times 10^5 (K^{-1})$	21	1.67	0.85	0.9

 Copyright © 2019 Isaac Scientific Publishing

The boundary conditions

$$u = U_w = -cx,\ v = V_w,\ N = -m\frac{\partial u}{\partial y},\ T = T_w. \quad \text{at } y = 0 \quad (5)$$
$$u \to 0, \quad N \to 0, \quad T \to T_\infty \quad \text{as } y \to \infty$$

Have a direction normal to the xy-plane, T_w and T_∞ both are assumed to be constants. Here, we note that m is a constant such that $0 \leqslant m \leqslant 1$. The case $m = 0$ indicates $N = 0$ at the surface. It represents flow of concentrated particle in which the microelements closed to the wall surface are unable to rotate. This case is also known as strong concentration of microelements. The case $m = 0.5$ indicates the vanishing of the anti-symmetric Part of the stress tensor and denotes weak concentration of microelements. Whereas, the case $m = 1$ is used for the modeling of turbulent boundary layer flows. We obtain ($q_r = -\left(\frac{4\sigma}{3k_1}\right)\frac{\partial T^4}{\partial y}$), where σ is the Stefan-Boltzmann constant, k_1 is the absorption coefficient. We presume that the T^4 may be expanded in a Taylor's series. Expanding T^4 about T_∞ and neglecting higher order terms we get,

$$T^4 = 4T_\infty^3 T - 3T_\infty^4.$$

Now Eq. (4) reduces to:

$$\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = \alpha_{\eta f}\frac{\partial^2 T}{\partial y^2} - \frac{16T_\infty^4}{3k_1(\rho C_p)_{nf}}\frac{\partial^2 T}{\partial y^2} + \beta_{nf}T \quad (6)$$

where

$$\psi = (cv)^{1/2}xf(\eta), \quad N = cx(^C/_v)^{1/2}h(\eta) \quad (7)$$
$$T = T_\infty + (T_w - T_\infty)\theta(\eta) \quad and \quad \eta = (^C/_v)^{1/2}y \quad (8)$$

where ψ is the stream function defined as:

$$u = \frac{\partial \psi}{\partial y} \text{ and } v = -\frac{\partial \psi}{\partial x}\text{, } \eta \text{ is similarity varaible}$$

Now, E.q(1) is identically satisfied and the E.qs (2), (3), and (6) reduce to the following nonlinear self-similar ordinary differential equations:

$$\frac{\mu_{nf}}{\rho_{nf}}f''' + ff'' - f'^2 + \mu_{nf}h' + \beta_{nf}\theta = 0 \quad (9)$$
$$\frac{\mu_{nf}}{\rho_{nf}}h'' + fh' - f'h - \mu_{nf}(2h + f'') = 0 \quad (10)$$
$$(1+3R)\,\alpha_{nf}\theta'' + f\theta' + \beta_{nf}\theta = 0 \quad (11)$$

The boundary conditions are:

$$f(\eta) = 0,\ f'(\eta) = 1,\ h(\eta) = -mf'',\ \theta(\eta) = 0 \quad (12)$$
$$f'(\eta) \to 0,\ h(\eta) \to 0,\quad \theta(\eta) \to 0, \quad \eta \to \infty \quad (13)$$

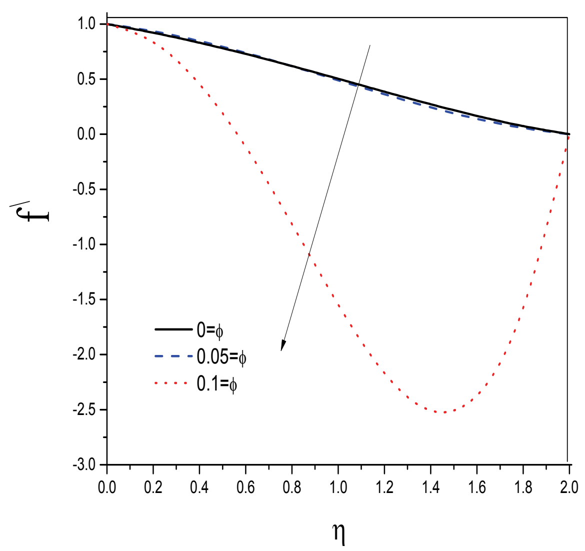


Figure 1. Effect of nanoparticle φ from cu in velocity profile

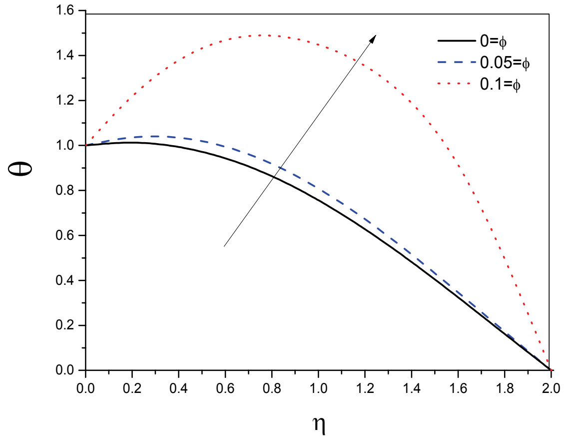


Figure 2. Effect of nanoparticle φ from cu in temperature profile

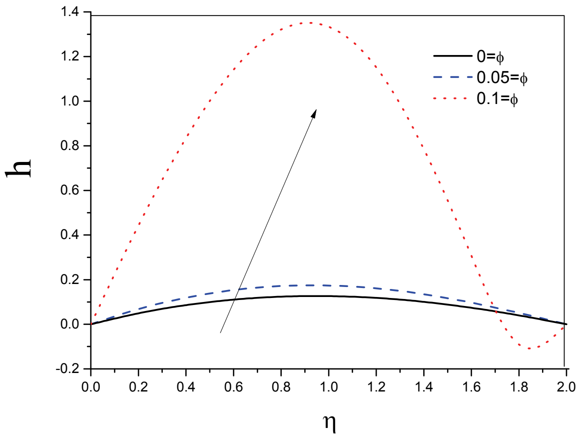
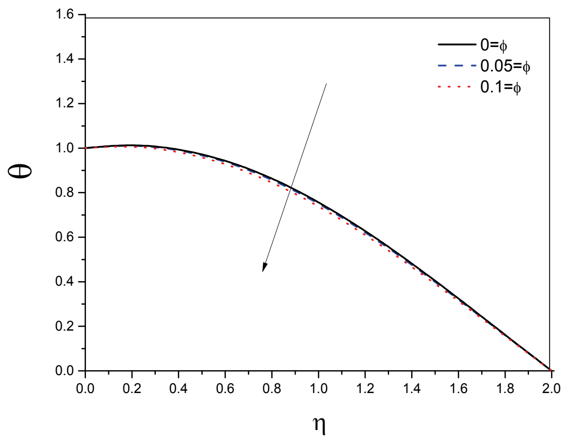


Figure 3. Effect of nanoparticle φ from cu in angular velocity profile



Copyright © 2019 Isaac Scientific Publishing

Figure 4. Effect of nanoparticle φfrom TiO2 in temperature profile

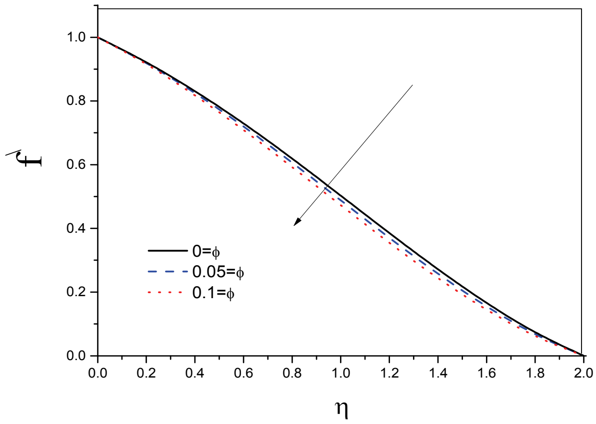


Figure 5. Effect of nanoparticle φ from TiO2 in velocity profile

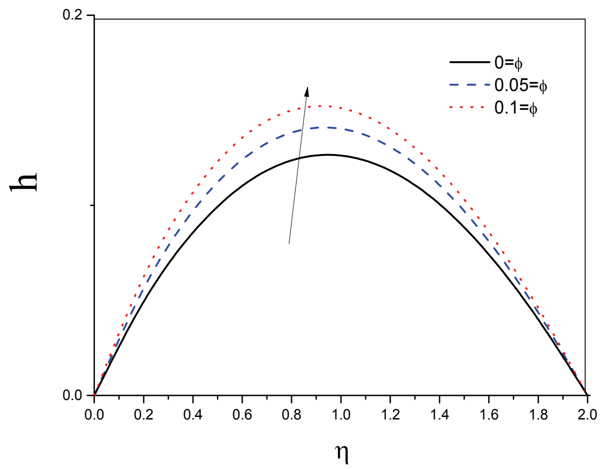
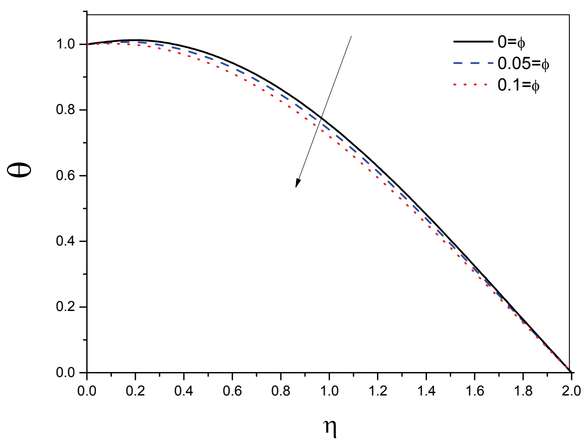


Figure 6. Effect of nanoparticle φ from TiO_2 in angular velocity profile



Copyright © 2019 Isaac Scientific Publishing

Figure 7. Effect of nanoparticle φ from AL_2O_3 in temperature profile

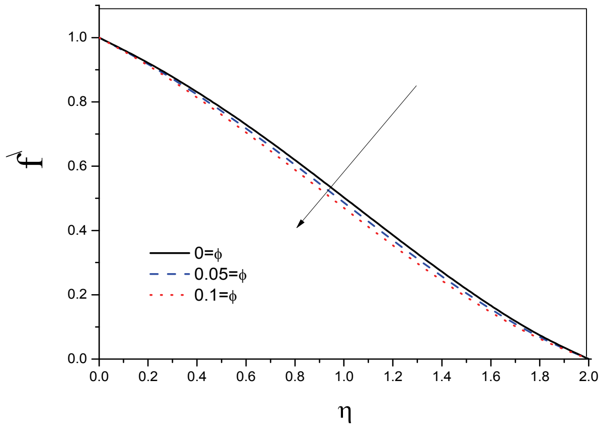


Figure 8. Effect of nanoparticle φ from AL_2O_3 in velocity profile

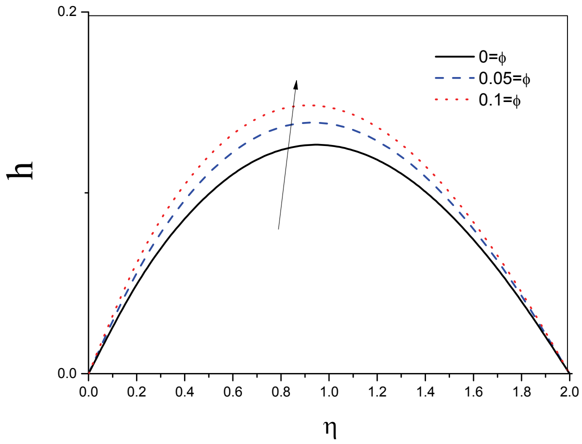


Figure 9. Effect of nanoparticle φ from AL_2O_3 in angular velocity profile

3 Result and Discussion

In this investigation we try to know about the effectiveness of nano particle from many different materials like cu, TiO_2 and AL_2O_3 in the behavior temperature and velocity in stretching sheet with heat source Q and radiation q_r in exist micro rotation velocity, we see different effect according to properties of the nanoparticle by solving Eq.s by technique methods numerically shooting methods (Runge Kutta.

We see the first group figures for cu, in fig. (1), fig. (2) and fig. (3) show the effectiveness of nanoparticle when increase nanoparticle both temperature and angular velocity increases but velocity decrease.

We see second group figures for TiO_2, in fig. (4), fig. (5) and fig. (6) show effective of nanoparticle when nanoparticle increases both temperature and velocity decrease but angular velocity increases.

We see third group figures for AL_2O_3, in fig. (7), fig. (8) and fig. (9) show effective of nanoparticle when nanoparticle increases both temperature and velocity decreases but angular velocity increases. But an effect of AL_2O_3 more than effective of TiO_2 this appears from figures.

 Copyright © 2019 Isaac Scientific Publishing

And the following table shows the effectiveness of nanoparticle in skin fraction and Nusselt number when increasing the nanoparticle from cu the skin fraction decreases but, Nusselt number increases but, in nanoparticle from Tio2 the skin fraction decreases and Nusselt number decreases. Also in nanoparticle from AL_2O_3 the skin fraction decreases and Nusselt number decreases also. But, decreases in Nusselt number are more than in TiO_2.

Table 2. Nanoparticle from cu

φ	$-f''$	$-\theta'$
0.0	0.3646	-0.1392
0.05	0.2704	-0.2701
0.1	0.2688	-1.2053

Table 3. Nanoparticle from TiO2

φ	$-f''$	$-\theta'$
0.0	0.3646	-0.1392
0.05	0.3723	-0.1285
0.1	0.3844	-0.1039

Table 4. Nanoparticle from AL2O3

φ	$-f''$	$-\theta'$
0.0	0.3646	-0.1392
0.05	0.3805	-0.1041
0.1	0.3989	-0.0616

4 Conclusion

Finally, we can be using this property in many fields in heater and paint house, because increasing heat by increasing nanoparticle from cu and decreasing by increasing nanoparticle from TiO_2 and AL_2O_3 is more useful for us in our life.

Reference

1. S.R. Mishra et al. Case Studies in Thermal Engineering 11 (2018) 113–119.
2. H.A. El-dawy et al. “Mixed convection over Vertical Plate Embedded in a porous medium saturated with a nanofluid,” Nanofluids Journal, volume 3, pp1-11 (2014).
3. R.S.R. Gorla, Micropolar boundary layer flow at a stagnation on a moving wall, Int. J. Eng. Sci. 21 (1983) 25–33.
4. L.J. Crane, Flow past a stretching plate, ZAMP 21 (1970) 645–647.
5. R. Cortell, Analyzing flow and heat transfer of a viscoelastic fluid over a semi-infinite horizontal moving flat plate, Int. J. Non-Linear Mech. 43, (2008) 772–778.
6. C.Y. Wang, Liquid film on an unsteady stretching sheet, Q. Appl. Math. 48 (1990) 601–610.
7. T. Hayat, T. Javed, Z. Abbas, MHD flow of a micropolar fluid near a stagnationpoint towards a non-linear stretching surface, Nonlinear Anal. Real 10 (2009)1514–1526.
8. V. Kumaran, A.V. Kumar, I. Pop, Transition of MHD boundary layer flow past a stretching heet, Common. Nonlinear Sci. Numer. Simul. 15 (2010) 300–311.
9. A. A. Mohammadein and Gorla, “Heat transfer in micropolar,” International Journal of Numerical Methods for Heat and Fluid Flow VOL .11 No. 1, 2001, pp 50-58.

Copyright © 2019 Isaac Scientific Publishing

10. W. Aniss and A. A. Mohammadein “joule heating effects on a micropolar fluid past a stretching sheet with variable electric conductivity,” Journal of Computational and Applied Mechanics, Vol.6.,No1., 2005, pp 3-13.
11. 11. A. C. Eringen, Theory of micropolar fluids, J. Math. Mech., 16, 1–18, 1966.
12. 12. A. C. Eringen, Theory of thermomicrofluids, J. Math. Analy. Appl., 38, 480–496, 1972.
13. C.J. Ho, M.W. Chen, Z.W. Li, Numerical simulation of natural convection of nanofluid in a square enclosure: effects due to uncertainties of viscosity and thermal conductivity, Int. J. Heat Mass Transfer 51 (2008) 4506–4516.
14. N. Putra, W. Roetzel, S.K. Das, Natural convection of nano-fluids, Int. J. Heat Mass Transfer 39 (2003) 775–784.
15. S.P. Jang, S.U.S. Choi, Cooling performance of a microchannel heat sink with nanofluids, Appl. Therm. Eng. 26 (2006) 2457–2463.
16. A.G.A. Nanna, T. Fistrovich, K. Malinski, S. Choi, Thermal transport phenomena in buoyancy-driven nanofluids, in: Proc. 2005 ASME Int. Mechanical Engineering Congress and RD&D Exposition, 15–17 November, Anaheim, California, USA, 2004.

 Copyright © 2019 Isaac Scientific Publishing