Available Online
International Journal of Advancements in Mathematics
ISSN: 2959-2755 (Print), 2959-2763 (Online)
http://www.scienceimpactpub.com/IJAM

Shape Effects of Gold nano-particles on Squeezing nanofluid Flow and Heat Transfer between parallel Plates

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Abstract The current paper examines how the form of gold (Au) nanostructures affects the compression of nanofluids and heat transmission across parallel surfaces. Water has been used as the porous medium to explore the various morphologies of nanomaterials, including columns, spheres, hexahedron, tetrahedron, and lamina. In order to create (ODEs), proper modifications must be applied to (PDEs). To solve nonlinear boundaries value regular differential equations statistically, the homotopy analysis method (HAM) guarantees converging of the numerical integration. On temperature and velocity profiles the impacts of several variables, including a solid volume fraction, thermal radiation, Reynolds number, magnetic field, Eckert number, sucking component, and slope angle, are represented graphically. The Nusselt is studied graphically for different values of the relevant factors. The obtained data show that, in comparison to other shapes of nanoparticles, lamina-shaped nanoparticles have the highest rate of heat transport and that sphere-shaped nanoparticles have played a significant role in thermal dispersion. **Keywords**: Stagnation point, Magnetohydrodynamics, Cattaneo-Christov heat flux model, Upper convected Maxwell fluid.

1. Introduction

During the previous several decades, nano materials have grown to be a global revolutionary for achieving extraordinary traits. It progressed at such a rapid rate and

https://doi.org/10.52223/ijam.2023.311
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is now in the middle of a turbulent period. In our futuristic society, nanomaterials is useful to play significant and economical function. Among the most important types of stable metal nanoparticles and their intriguing current characteristics the assembling of sorts of components in materials engineering, and particular ferromagnetic, cytotoxic, nanotoxic, and visual characteristics of nanoparticles substantial catalysts, size-related electrical, and uses in biology. Because of their features and numerous possible uses, gold nano particles have drawn study interest. The next step would be to advance a later stage of nanomaterials, which calls for goods made from pure nano particles with precise shape, controlled size, and vast manufacturing facilities. Due to their distinctive optical and mechanical characteristics, including surface plasmon oscillation for labelling, sensors, image, gold nanoparticles frequently employed as important material in variety of industries. Attain the objective in biological domains with greater bioactivity in therapies and the therapy of numerous ailments has recently occurred. Many team helpers agents, including aptamers, ligand, surfactants, RNA, DNA, peptides, polymers, oligonucleotides, medicines, and enzymes, can be used to produce and attach nanoparticles which was explored by (1). Practical applications of heat radiation and (MHD)-induced nanofluid flow compression are significant. Because of its broad range of applications, it really has caught the attention of scientists. Trying to squeeze flow is increasingly used in a variety of fields, including bioengineering and food preservation. Many papers in the available literature have provided explanations of the tasks and characteristics of the compressing stream of nanofluid towards commercial applications in the fields of electronics, mobility, biomechanical, meals, and nuclear reactors. There are many forms of compressing flow, but injections, contraction, and polymers preparation stand out among most prominent ones. Because of numerous beneficial implications inside the biological and physical areas, the compressing movement of nanofluids have attracted considerable attention which was reveealed by (2). By utilising two discs, Hayat et al. (3) examined the magnetohydrodynamic in compressing motion. Dib et al(4) in the analysis of compressing nanofluid flow, derived the exact solution. Heat transmission on viscosity compressed flow among parallel plates was studied by Duwairi et al. (5). Using variational iteration methods, Domairry and Hatami (6) investigated the moment compression of nano fluids flow across two substrates. Depending on the variational iteration method, Sheikholeslami and Ganji (7) examined heat exchange in compressed nanofluid. Khan et al. (8) studied the heat radiating impact inside two dimensional, moment compressing stream using technique of homotopy analysis. Impact of magnetohydrodynamic on compressing convection flow inside a rotational system was explored by Sheikholeslami et al. (9). The interpolation waveform extension was used by Gupta and Saha Ray (10) to study the unstable squeezed nanofluids flow across two parallel surfaces. Mahmood and Kandelousi (11) looked into the impact of magnetohydrodynamic on the heat transmission between two vertical surfaces and the aluminum oxide nano fluids. There are numerous mathematics puzzles to solve in the scientific and technical disciplines, however the precise answer is often times challenging. Homotopy method is an established and important technique for resolving issues for the mathematical problems. The fundamental benefit of using homotopy analysis technique is that it can solve nonlinear evolution equation approximatively without the need for linearization or discretization. The author came to the conclusion that the homotopy method of analysis (HAM) swiftly flow type on a rough answer. The homotopy process gives us a number of answers. Since it included all of physical factors involved in issue, an approximation solution obtained through homotopy analytical technique is nearly perfect. Numerous researchers, including Rashidi et al. (12),(13) and Abbasbandy and Shirzadi (14), (15) used homotopy analytical approach (HAM) to identify the resolutions of nonlinear dynamic and connected equations because of its efficiency and speedy resolution. The convective heat transfer model for squeezed flow was proposed by Hussain et al. (16). Utilizing the homotopy analytical approach with influence of thermo radiation heat absorption. Various methods and strategies can be used to boost heat transmission, such as raising thermal efficiency or heat exchange area, that enables a faster thermal efficiency in a smaller volume concentration. A growing variety of businesses, including those in microelectronic devices, transport, manufacture, and strong light sources, have a significant technological difficulty with cooling, therefore, a higher success in new cooling that would utilized for improved characteristics is really necessary (17). The new and inventive class of heat exchange nano - fluid have just benefited from advances made by nanomaterials. To create nanofluids, such as nanofibers, nanomaterials, nanotubes, nanorods, nanostructured, droplets, or nanosheets, base liquids are implanted with nanometer size elements (18). An important point is that nanoparticles can speed up thermal performance in a various applications, including nuclear reactors, photovoltaic panels, mass transit (trucks, cars, and aircraft), electronic goods and equipment, biomedicine uses, nanoelectromechanical systems, and factory cooling (cancer therapeutics, cryogenics, and nanodrug distribution) (19). There are numerous research that demonstrate the uses of nano fluids heat exchange. TiO2-water nanoparticles was used by Kristiawan et al. (20) to study convective heat transport in a horizontal circular tube. Mass and heat exchange of convective flow of nanofluid including nanoparticles of Ag, Cu, TiO_2, Al_2O_3, and CuO were explored by Turkyilmazoglue and Pop (21). Analytical findings of heat transmission inside nano fluid were reported by Sheikholeslami and Ganji (7). Advective heat transport inside nano fluid was the subject of exploratory studies by Qiang and Yimin (22). Elgazery (23) looked at experiments with such a nanofluids of Ag, Cu, Al_2O_3, TiO_2, and liquid over a vertically flexible stretching surface with a nonuniform convectively heated. In a high temperature linear tube filled with $Al_2O_3 - ZrO_2$-water nanofluid, Rea et al. (24) investigated the viscosity stress and heat exchange by convection. Salman et al(24) discussed the idea of modifying convective heat transfer of a nanofluids in a microfuge tube by utilizing various classifications of nanomaterials, like Al_2O_3, Cuo, SiO_2, and ZnO, utilized a mathematical formula. Variant nanoparticles for heat exchange growth were researched by Sheikholeslami et al. (25) , (26). Ag-Cu nano fluids flow heat exchange by convection was covered by Hassan et al. (27). Bhatti et al. (23) . Mathematical study of impact of heat exchange and hall existing on frequency response motion of fine materials. According to aforementioned literature review, it has discovered that most common materials used to calculate thermal performance are $Cu, Ag, Al_2O_3, SiO_2, CuO$, and ZnO. To determine the rates of heat exchange resulting from variable viscosity, gold (Au) was infrequently employed (28). The improvement of heat transport is greatly aided by nature of nanoparticles. The rate at which transmission in a nanofluids under specific nanostructure particles morphologies must be determined (29). According to the research study, no attempt has taken to study how the form of gold (Au) nanostructures partices affects flow compression. The main goal of the current study is to examine how the form of gold (Au) nanostructure particles affects the compression of nanofluid flow and heat transmission. These include pillar, globe, hexahedron, quaternion, and laminar forms of nanostructures. Plotted graphics are used to study how different physical characteristics affect speed and temperature variations. According to the review of literature, no attempt has been done to determine how gold (Au) nanomaterials may affect compression flow. The main goal of current work is to investigate how gold (Au) nanoscale form affects compression nanofluid circulation and heat transmission. The column, sphere, hexahedron, tetrahedron, and lamina types of nanostructures are among the many under consideration. Through carefully planned graphs, effects of various mathematics problems in architecture physiological variables on speed and temperature variations are examined. Technologies for heat transference in architecture and industry include combustors, gasoline turbines blades, axial and centrifugal blade compressors, microelectronic boards circuits, and hybrid-powered engines, amongst others. Low thermally conductance is the main obstacle to thermal transmission. To get around this obstacle and increase thermal conductance of different basic fluids, several investigators has added many kinds of hard particles, frequently referred to as nanostructurs. To start with, Choi and Estaman (30) enhanced the heat conductance of a firm nanoparticle by suspending it in a base fluid. The volumetric portion of the nanomaterials and Eckert ratio are equivalent to Nusselt number, according to Sheikholeslami and Ganji (7), who used metal nanostructures in liquid to generate a nanofluid across two endless plates. Azimi et al.'s (31) study the time-dependent movement for water-based graphite oxide nanofluid between two movable plates. Kumar investigated how dynamically emitted MHD affected the movement of nanomaterials through a vertically plate. Rasool and his coworkers (32). MHD and the Darcy Forchheimer connection turbulent motion pasta by Jeffrey By (33), an extended layer has been investigated. Shah and his coworkers (34) employed among two limitless planes nanocrystals of gold made of blood. The paper's writers carried out a inquiry of comparison, having good congruence between their conclusions and people who have been written about previously. Thermally an extended and revolving surface with nanoparticles in radial motion (35), cylinders was investigated. The stream mechanism described Joule heating, temperature production, temperature absorption, and thermally radiological impacts Alfaryjat et al.(36). Aluminum, CuO, and Sio_2 nanostructure mixed together in flowing water via a micro - channels Their research showed that creation of entropy have decreased as a consequence of an increase in thermal gradient. Khan et al. (37) used graphite and tin oxide (TiO_2) in their work. Nanoparticles of oxide (GO) to accelerate the irreversibility process between two flexible and rotating discs. Devi and Devi (38) cited a studied on it. drifting copper and aluminium oxide (Al_2O_3) mixed based nanofluid (Cu) Using water as the base fluid and nanostructure particles to achieve the required speed of heat transfer by adjusting the ratios of the nanoparticles in the foundation fluid. Various researchers have indeed conducted several comparisons. Research to determine whether pristine thermal efficiency has been enriched liquids. Heris et al. (39) studied the heat transfer properties of copper oxide (CuO) and aluminium oxide (Al_2O_3) suspended in water. Propagation of nano fluid flow in a spherical tube. It was found out that observed experimental results for CuO pure water and Al_2O_3 water showed that ratio of $Al_2O_3toH_2O$'s temperature transfer coefficient is much higher than Namburu all his friends, $CuOH_2O$. (40) used Al_2O_3, CuO, and SiO_2 nanoparticles were detected in freshwater at such a 6 percent concentration. (41) examined heat transfer and unsustainability. Creation for the movement of nano - fluid among two multiple cores. The heat transmission cost for SWCNTs nanofluids in this research was found to be lower than that for Sequence of numbers and multi - walled carbon nanotubes nano fluids. It was also found that SWCNTs and MWCNTs changed from 3.77 percent to 9.07 percent and 4.04 percent to 9.58 percent respectively when one percent and three percent of both the nanomaterials were taken into account. A conductive fluid motion under the influence of an external magnetism, such as salt water or liquid metals, can be explained physically by the action of MHD. Additionally it has been carefully examined in a variety of research and manufacturing fields, from heat of sun (42) to magnetohydrodynamic biosensors (43). Ahmad and Iqbal(44) studied the streams and heat propagation of power stations law nanofluid via annular duct while taking into account the effects of a semi differential pressure. In this investigation, copper and iron oxide nanomaterials were used, and a rise in heat flow rate, the geometric fraction of microcrystals, and the magnetization were all observed.

2. Mathematical model

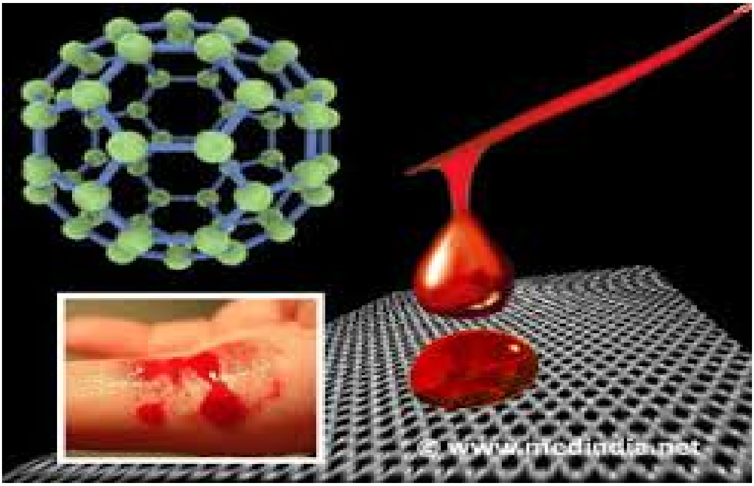


Figure 1: Geometry of the model.

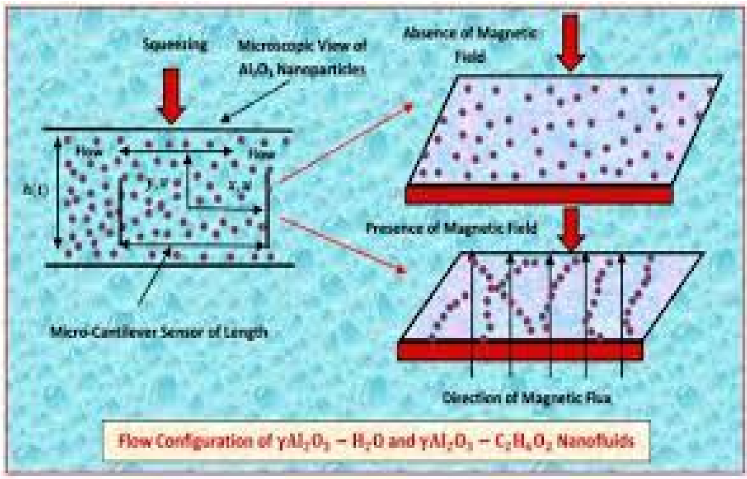


Figure 2: Geometry of the model.

Think about heat transmission in a 2 different, streaming, friction coefficient, stable, and compressing nanofluid across horizontal plane plates at y = 0 and y = h. Two equal and opposing pressures hold the lowest plate in place. The separation between the two plates is h. According to the y-axis, a consistent B magnet field is applied. Additionally, the impact of variable thermal conductivity is taken into account Table 4.1 shows the thermo - physical characteristics of water and nanomaterials. This Table shows model parameters associated to nanoparticle forms. The problem's complete system of equations are represented.

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

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho_{nf}}\frac{\partial p}{\partial x}+\frac{\mu_{nf}}{\rho_{nf}}(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2})-\frac{\sigma_n f B^2 u}{\rho_n f}, \tag{2}$$

$$v\frac{\partial v}{\partial y}=-\frac{1}{\rho_{nf}}\frac{\partial p}{\partial y}+\frac{\mu_{nf}}{\rho_{nf}}(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}), \tag{3}$$

$$\begin{aligned}u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k_n f}{(\rho Cp)_n f}(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2})+\frac{\mu_n f}{(\rho Cp)_n f}.(2[(\frac{\partial u}{\partial x})^2+(\frac{\partial v}{\partial y})^2]+(\frac{\partial v}{\partial x})^2)\\+(\frac{16\sigma*}{3(\rho Cp)_{nf}K*})(\frac{\partial^2 T}{\partial y^2})+\frac{Q_T}{(\rho_{cp})_F}(T_2-T_1)+\frac{Q^*E}{\rho_{cp}}(T_2-T_1)e^{-}\frac{y}{h}n\end{aligned} \tag{4}$$

Boundary value conditions are:

$$\begin{aligned}f=0,\ f'=1,\ \theta=1,\ at\ \eta=0, f=\frac{v_0}{ah},\ \ f'=0,\\ \theta=0, at\ \eta=1 u=0, v=\frac{dh}{dy},\frac{\partial T}{\partial y}=0, at\ \eta=1\end{aligned} \tag{5}$$

In order to non dimensional controlling equations (4.1.1) to (4.1.4), the following similarity variables are announced:

$$u = axf\prime(\eta), v = -ahf(\eta), \eta = \frac{y}{h}, \theta(\eta) = \frac{T - T_1}{T_2 - T_1}, \tag{6}$$

Expression (4.1.1) is also fulfilled in the same way. Following finite difference constraint problems result from removing the pressure and plugging solution (4.1.6) into solutions (4.1.2), (4.1.3), as well as (4.1.4).

$$f'''' - R\frac{A_1}{A_2}(f'f'' - ff''') - \frac{1}{A_2}Mf'' = 0 \tag{7}$$

$$(1 + Rd)\theta'' + f\theta' ah^2 \frac{(\rho c_p)_{nf}}{K_{nf}} + \frac{\mu_{nf} 4a^2h^2}{K_{nf(T_2 - T_1)}} f'^2 + \frac{Q_T h^2 \theta}{K_{nf}} + \frac{QEh^2h^2}{K_{nf}} e^- \eta n = 0 \tag{8}$$

$$f(0) = 0, f'(0) = 1, f(1) = A, f'(1) = 0, \theta(0) = 1, \theta(\infty) = 0 \tag{9}$$

The Parameter amounts are given below:

$$\begin{gathered} A = \frac{v_0}{ah}, R = \frac{ah^2}{v_f}, \\ Pr = \frac{\mu_f (\rho CP)_f}{\rho_f K_f}, Ec = \frac{\rho_f a^2 h^2}{(\rho CP)_f (T_\omega - T\infty)}, \\ M = \frac{\sigma_n f B^2 h^2}{v_f \rho_f}, Rd = \frac{16\sigma * T_\infty^3}{3K_n f K*}, \end{gathered} \tag{10}$$

The sucking parameter, number, magnet parameter, Reynolds number, Eckert number, and radiative heat variable are all represented here by the letters A, Pr, M, R, Ec, and Rd, accordingly. a single

$$A_1 = \frac{\rho_n f}{\rho_f}, A_2 = \frac{\mu_n f}{\mu_f}, A_3 = \frac{(\rho CP)_n f}{(\rho CP)_f}, A_4 = \frac{K_n f}{K_f}, \tag{11}$$

The ratios of density, viscous, heat capacitances, as well as thermal conductivity are shown here as A1, A2, A3, and A4, accordingly. In this The ratios of density, viscous, heat capacitances, as well as thermal conductivity are shown here as A1, A2, A3, and A4, accordingly. In this research, we take into

$$A_1 = \frac{\rho_n f}{\rho_f} = (1-\phi) + \frac{\rho_s}{\rho_f}\phi,$$
$$A_2 = \frac{\mu_n f}{\mu_f} = \frac{1}{(1-\phi)^2.5},$$
$$A_3 = \frac{(\rho CP)_n f}{(\rho CP)_f} = (1-\phi) + \frac{(\rho CP)_s}{(\rho CP)_f}\phi,$$
$$A_4 = \frac{K_n f}{K_f} = \frac{[k_s + (m-1)k_f] - (m-1)\phi(k_f - k_s)}{[k_s + (m-1)k_f] + \phi(k_f - k_s)}, \tag{12}$$

in which the heat transfer, dynamic viscosity, density, heating value of the liquid are represented by the letters kf, f and $(Cp)_f$, including both, while the heat transfer, fluid viscosity, density and specific heating value of the solid are represented by the letters ks, s and $(Cp)_s$, including both. The form factor and volume fraction of nanoparticles are denoted by m and, accordingly. The definition of Nusselt number appears numeric value is given:

$$Nu = |A_4\theta'(0)| \tag{13}$$

3. Numerical Solution

Using shooting method for different values of concerned parameters Eq. (4.1.9) and Eq. (4.1.10) having values of Eq. (4.1.11) is investigated. After putting $\eta = 7$, the result is no importance. Alternatively of [0, ∞) we consider the domain by using [0, 7]. Five first-order ODEq's is studied to converting B.V.P to I.V.P.

$$y_7 = \theta'', \quad y_6 = \theta', \quad y_5 = \theta, \; y_4 = f''', \; y_3 = f'', \; y_2 = f', \; y_1 = f. \tag{14}$$

Following system of five first order DE's is used to transform heat equation and momentum, and the initial conditions are shown below:

$$\begin{aligned}
&y_2 = y_1', && 0 = y_1(0)\\
&y_3 = y_2', && 1 = y_2(0)\\
&y_4 = y3', && 1 = y_3(0)\\
&R_1\frac{A_1}{A_2}(y_2y_3 - y_1y_4) + \frac{1}{A_2}My_3 = y_4', && s = y_4(0)\\
&y_6 = y_5', && 1 = y_5(0)\\
&-\frac{1}{1+Rd}\left(\frac{ah^2(\rho c_p)_{nf}}{K_{nf}}y_1y_6 + \frac{\mu_{nf}4a^2h^2}{K_{nf}(T_2-T_1)}{y_2}^2 + \frac{Q_Th^2y_5}{K_{nf}} + \frac{Q_Eh^2}{K_{nf}}e^{-\eta n}\right) = y_6', && t = y_6(0)
\end{aligned} \tag{15}$$

4. Step by step Graphical detail of the problem

4.1 Problem formulation

4.2 Modeling

Nonlinear ODEs

$$f'''' - R\frac{A1}{A2}(f'f'' - ff''') - \frac{1}{A2}Mf'' = 0$$

$$(1 + \mathrm{Rd})\Theta'' + \mathrm{pr}(\frac{A3}{A4}\mathrm{Rf}\Theta' + 4\frac{A2}{A4}\mathrm{Ecf'}^2) = 0$$

transformed boundary conditions are as follows:

$$f(0) = 0\,,\ f'^{(0)} = 1\,,\ f(1) = A\,,\ f'^{(1)} = 0\,,\ \theta(0) = 1\,,\ \theta(\infty) = 0$$

First order ODEs for Lobatto 111A

$y7 = \theta'', y6 = \theta', y5 = \theta, y4 = f''', y3 = f'', y2 = f', y1 = f.$

Following system of five first order DE's is used to transform heat equation and momentum, and the initial conditions are shown below:

Y2=y1'

Y3=y2'

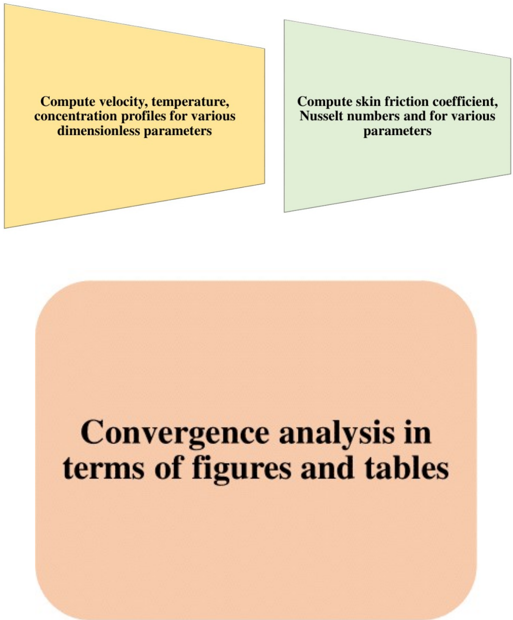
Y4=y3'

$R1\frac{A1}{A2}(y2y3 - y1y4) + \frac{1}{A2}M\ y3 = y4'$

Y6=y5'

$$\frac{-Rr(\frac{A3}{A4}Ry1y6 + 4\frac{A2}{A4}ECy2^2)}{1 + Rd} = y6'$$

0=y1(0), 1=y2(0), 1=y1(∞), 0=y2(∞), 1=y5(0), 0=y5(∞)



4.3 Numerical process

4.4 Numerical results

4.5 Analysis

5. Results and Discussions

This section discusses the problem's physical understanding. ϕ is an essential factor for nano-fluids squeeze flow.The dynamics of heat transfer rate in a squeezing nano-fluids flow are described by changes in the thermal density also volume fraction of dimensionless solid. Electromagnetic field, Eckert number, Reynolds number form factor and the suction parameter. Figures 4.1 and 4.3 demonstrate how M impact grows as a result of Lorentz force it produces on the velocity. Figures 4.2 and 4.4 show the variations in A on velocity field. Figure 4.6 illustrates the relationship between temperature distribution and the Eckert number E_c. The effect of the heat sink and heat source parameters on temperature distribution is seen in figures 4.6 and 4.7. It is clear from the figure that a positive change in the heat sink parameter causes the liquid to absorb more heat, improving the thermal boundary layer thickness and temperature profile.

Table 1
statistical data of skin friction.

MM	Rd	EC	$R1$	$\theta'(\eta)$	$f''(\eta)$
0.3				10.065385	-0.699639
0.4				10.062725	-0.713137
0.5				10.060129	-0.726394
	0.3			10.065385	-0.699639
	0.4			3.543873	-0.699644
	0.5			1.237769	-0.699644
		0.1		10.065385	-0.699639
		0.2		10.391061	-0.699639
		0.3		10.716760	-0.699639
			0.1	10.065385	-0.699639
			0.2	10.046081	-0.799725
			0.3	10.027692	-0.893650

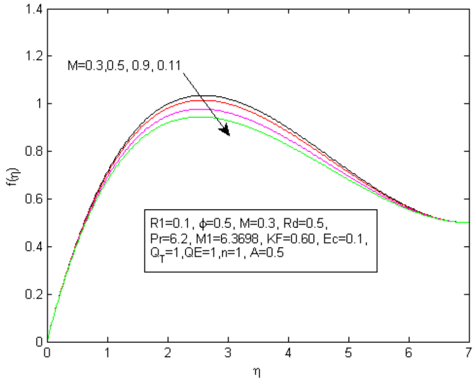


Figure 1

$f(\eta)$ **for scores of** $\phi = 0.5, A = 0.5, R = 0.1, and M = 0.3, M1 = 6.3698, kF = 0.60, Ec = 0.1, Q_T = 1, Q_E = 1, n = 1, A = 0.5$**.**

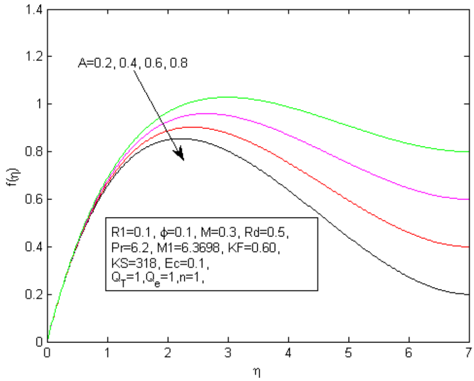


Figure 2

$f(\eta)$ **for scores of**

$\phi = 0.5, A = 0.5 and M = 0.3, R = 0.1, kF = 0.60, Ec = 0.1, Q_T = 1, Q_E = 1, n = 1, A = 0.5$**.**

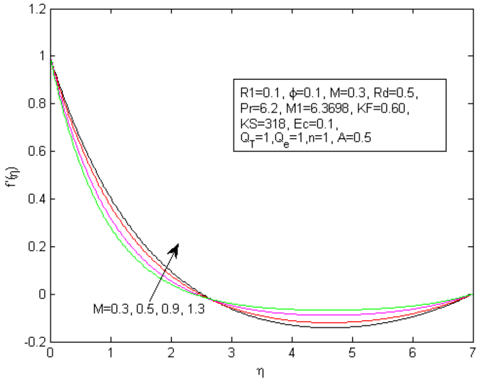


Figure 3

Velocity profile for scores of

$\phi = 0.5, A = 0.5 and M = 0.3, kF = 0.60, Ec = 0.1, R = 0.1, Q_T = 1, Q_E = 1, n = 1, A = 0.5$.

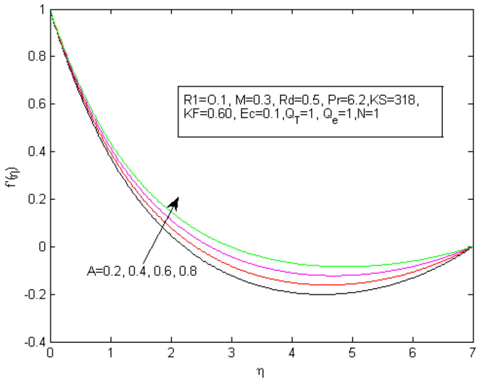


Figure 4

$f'(\eta)$ **for scores of**

$\phi = 0.5, A = 0.5 and M = 0.3, kF = 0.60, Ec = 0.1, Q_T = 1, R = 0.1, Q_E = 1, n = 1, A = 0.5$.

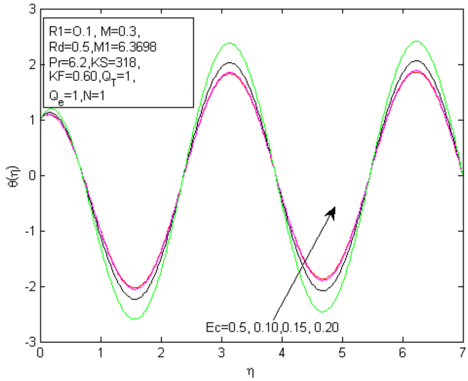


Figure 5

Velocity profile for scores of

$\phi = 0.5, A = 0.5 and M = 0.3, kF = 0.60, Ec = 0.1, Q_T = 1, Q_E = 1, n = 1, R = 0.1, A = 0.5$.

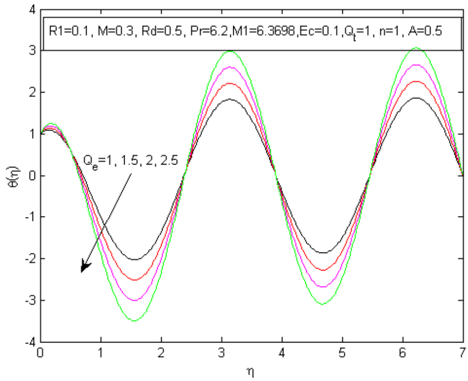


Figure 6

Temperature profile for scores of

$R1 = 0.1, \phi = 0.5, M = 0.3, M1 = 6.3698, kF = 0.60, Ec = 0.1, Q_T = 1, Q_E = 1, n = 1, A = 0.5$

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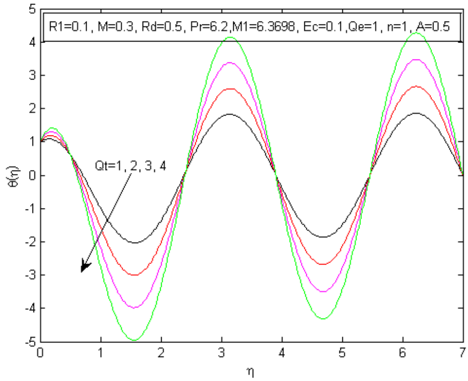

Figure 7
Temperature profile for scores of
$R1 = 0.1, \phi = 0.5, M = 0.3, M1 = 6.3698, kF = 0.60, Ec = 0.1, Q_T = 1, Q_E = 1, n = 1, A = 0.5$.

6. Concluding remarks

The impact of gold (Au) nanoparticles on compressing micropolar fluid has already been carefully explored in the current thesis. Homotopy strategy was applied to arrive at an exact solution. Shooting method for a number of important factors, including heat radiation, particle volume percentage, and form factor Reynolds Suction parameter, number, magnetic field, and Eckert. The impacts of different parameters have already been demonstrated in a variety of situations using graphs. In light of the findings and conversations, the following conclusions have been drawn:

- The sphere-shaped nanoparticles play a notable function in the disruption of thermal performance.
- The disruption of thermal performance is moderately attributed to the tetrahedron-shaped nanoparticles.
- The disruption of thermal performance is less affected by lamina-shaped nanoparticles.

- Lamina-shaped nanoparticles have a significant influence on rate of heat exchange.
- Tetrahedron-shaped nanoparticles play a moderate influence in heat flux.
- Tetrahedron-shaped nanoparticles play a less significant influence in the heat transfer rate.
- Accomplishments of hexahedron and tetrahedron shapes nanoparticles in forms of the disturbance temperature distributions and heating are dissimilar from each other.
- Outer layer and spheroid shapes nanomaterials perform in opposition to one another in terms of disruption on temperature distributions and thermal expansion.

Conflict of interest: Authors have no conflict of interest for this publication.

7. Author's Contributions

All authors contributed equally to the writing of this paper. All authors read and approved the final manuscript.

References

[1] Minakshi Das, Kyu Hwan Shim, Seong Soo A An, and Dong Kee Yi. Review on gold nanoparticles and their applications. *Toxicology and Environmental Health Sciences*, 3(4):193–205, 2011.

[2] Sher Muhammad, Syed Inayat Ali Shah, Gohar Ali, Mohammad Ishaq, Syed Asif Hussain, and Hidayat Ullah. Squeezing nanofluid flow between two parallel plates under the influence of mhd and thermal radiation. *Asian Research Journal of Mathematics*, 10(1):1–20, 2018.

[3] Tasawar Hayat, Tehseen Abbas, Muhammad Ayub, Taseer Muhammad, and Ahmed Alsaedi. On squeezed flow of jeffrey nanofluid between two parallel disks. *Applied Sciences*, 6(11):346, 2016.

[4] A Dib, A Haiahem, and B Bou-Said. Approximate analytical solution of squeezing unsteady nanofluid flow. *Powder technology*, 269:193–199, 2015.

[5] HM Duwairi, Bourhan Tashtoush, and Rebhi A Damseh. On heat transfer effects of a viscous fluid squeezed and extruded between two parallel plates. *Heat and mass transfer*, 41(2):112–117, 2004.

[6] G Domairry and M Hatami. Squeezing cu–water nanofluid flow analysis between parallel plates by dtm-padé method. *Journal of Molecular Liquids*, 193:37–44, 2014.

[7] M Sheikholeslami and DD Ganji. Heat transfer of cu-water nanofluid flow between parallel plates. *Powder Technology*, 235:873–879, 2013.

[8] Sheikh Irfanullah Khan, Umar Khan, Naveed Ahmed, and Syed Tauseef Mohyud-Din. Thermal radiation effects on squeezing flow casson fluid between parallel disks. *Communications in Numerical Analysis*, 2016(2):92–107, 2016.

[9] M Sheikholeslami, M Hatami, and DD Ganji. Nanofluid flow and heat transfer in a rotating system in the presence of a magnetic field. *Journal of Molecular liquids*, 190:112–120, 2014.

[10] AK Gupta and S Saha Ray. Numerical treatment for investigation of squeezing unsteady nanofluid flow between two parallel plates. *Powder Technology*, 279:282–289, 2015.

[11] M Mahmoodi and SH Kandelousi. Kerosene- alumina nanofluid flow and heat transfer for cooling application. *Journal of Central South University*, 23(4):983–990, 2016.

[12] Mohammad Mehdi Rashidi, Abdul Majid Siddiqui, and Mostafa Asadi. Application of homotopy analysis method to the unsteady squeezing flow of a second-grade fluid between circular plates. *Mathematical Problems in Engineering*, 2010, 2010.

[13] MM Rashidi and SA Mohimanian Pour. Analytic approximate solutions for unsteady boundary-layer flow and heat transfer due to a stretching sheet by homotopy analysis method. *Nonlinear Analysis: Modelling and Control*, 15(1):83–95, 2010.

[14] S Abbasbandy. Homotopy analysis method for heat radiation equations. *International communications in heat and mass transfer*, 34(3):380–387, 2007.

[15] Saeid Abbasbandy and A Shirzadi. A new application of the homotopy analysis method: Solving the sturm–liouville problems. *Communications in Nonlinear Science and Numerical Simulation*, 16(1):112–126, 2011.

[16] Syed Asif Hussain, Sher Muhammad, Gohar Ali, Syed Inayat Ali Shah, Mohammad Ishaq, Zahir Shah, Hameed Khan, Mohammad Tahir, and Muhammad Naeem. A bioconvection model for squeezing flow between parallel plates containing gyrotactic microorganisms with impact of thermal radiation and heat generation/absorption. *Journal of Advances in Mathematics and Computer Science*, 27(4):1–22, 2018.

[17] Oronzio Manca, Yogesh Jaluria, Guy Lauriat, Kambiz Vafai, and Liqiu Wang. Heat transfer in nanofluids 2013. *Advances in Mechanical Engineering*, 2014:832415, 2014.

[18] Wei Yu and Huaqing Xie. A review on nanofluids: preparation, stability mechanisms, and applications. *Journal of nanomaterials*, 2012, 2012.

[19] Yimin Xuan and Qiang Li. Heat transfer enhancement of nanofluids. *International Journal of heat and fluid flow*, 21(1):58–64, 2000.

[20] Budi Kristiawan, Budi Santoso, Agung Tri Wijayanta, Muhammad Aziz, and Takahiko Miyazaki. Heat transfer enhancement of tio2/water nanofluid at laminar and turbulent flows: A numerical approach for evaluating the effect of nanoparticle loadings. *Energies*, 11(6):1584, 2018.

[21] M Turkyilmazoglu and I Pop. Heat and mass transfer of unsteady natural convection flow of some nanofluids past a vertical infinite flat plate with radiation effect. *International Journal of Heat and Mass Transfer*, 59:167–171, 2013.

[22] Qiang Li and Yimin Xuan. Convective heat transfer and flow characteristics of cu-water nanofluid. *Science in China Series E: Technological Science*, 45(4):408–416, 2002.

[23] MM Bhatti, Rahmat Ellahi, A Zeeshan, M Marin, and N Ijaz. Numerical study of heat transfer and hall current impact on peristaltic propulsion of particle-fluid suspension with compliant wall properties. *Modern Physics Letters B*, 33(35):1950439, 2019.

[24] Ulzie Rea, Tom McKrell, Lin-wen Hu, and Jacopo Buongiorno. Laminar convective heat transfer and viscous pressure loss of alumina–water and zirconia–water nanofluids. *International Journal of Heat and Mass Transfer*, 52(7-8):2042–2048, 2009.

[25] M Sheikholeslami, R Ellahi, and C Fetecau. Cuo–water nanofluid magnetohydrodynamic natural convection inside a sinusoidal annulus in presence of melting heat transfer. *Mathematical Problems in Engineering*, 2017, 2017.

[26] S Manikandan and KS Rajan. New hybrid nanofluid containing encapsulated paraffin wax and sand nanoparticles in propylene glycol-water mixture: Potential heat transfer fluid for energy management. *Energy Conversion and Management*, 137:74–85, 2017.

[27] Mohsan Hassan, Marin Marin, Rahmat Ellahi, and Sultan Z Alamri. Exploration of convective heat transfer and flow characteristics synthesis by cu–ag/water hybrid-nanofluids. *Heat Transfer Research*, 49(18), 2018.

[28] Sidra Aman, Ilyas Khan, Zulkhibri Ismail, and Mohd Zuki Salleh. Impacts of gold nanoparticles on mhd mixed convection poiseuille flow of nanofluid passing through a porous medium in the presence of thermal radiation, thermal diffusion and chemical reaction. *Neural Computing and Applications*, 30(3):789–797, 2018.

[29] R Kandasamy, Nur Atikah bt Adnan, and Radiah Mohammad. Nanoparticle shape effects on squeezed mhd flow of water based cu, al2o3 and swcnts over a porous sensor surface. *Alexandria engineering journal*, 57(3):1433–1445, 2018.

[30] S US Choi and Jeffrey A Eastman. Enhancing thermal conductivity of fluids with nanoparticles. Technical report, Argonne National Lab.(ANL), Argonne, IL (United States), 1995.

[31] Mohammadreza Azimi, Alireza Azimi, and Masoomeh Mirzaei. Investigation of the unsteady graphene oxide nanofluid flow between two moving plates. *Journal of Computational and Theoretical Nanoscience*, 11(10):2104–2108, 2014.

[32] M Anil Kumar, Y Dharmendar Reddy, V Srinivasa Rao, and B Shankar Goud. Thermal radiation impact on mhd heat transfer natural convective nano fluid flow over an impulsively started vertical plate. *Case studies in thermal engineering*, 24:100826, 2021.

[33] Ghulam Rasool, Anum Shafiq, and Hülya Durur. Darcy-forchheimer relation in magnetohydrodynamic jeffrey nanofluid flow over stretching surface. *Discrete & Continuous Dynamical Systems-S*, 14(7):2497, 2021.

[34] Zahir Shah, Arshad Khan, Waris Khan, M Kamran Alam, Saeed Islam, Poom Kumam, and Phatiphat Thounthong. Micropolar gold blood nanofluid flow and radiative heat transfer between permeable channels. *Computer Methods and Programs in Biomedicine*, 186:105197, 2020.

[35] Arshad Khan, Anwar Saeed, Taza Gul, Safyan Mukhtar, Ishtiaq Ali, and Muhammad Jawad. Radiative swirl motion of hydromagnetic casson nanofluid flow over rotary cylinder using joule dissipation impact. *Physica Scripta*, 96(4):045206, 2021.

[36] AA Alfaryjat, A Dobrovicescu, and D Stanciu. Influence of heat flux and reynolds number on the entropy generation for different types of nanofluids in a hexagon microchannel heat sink. *Chinese Journal of Chemical Engineering*, 27(3):501–513, 2019.

[37] M Ijaz Khan, Sohail A Khan, Tasawar Hayat, M Imran Khan, and Ahmed Alsaedi. Entropy optimization analysis in mhd nanomaterials (tio2-go) flow with homogeneous and heterogeneous reactions. *Computer Methods and Programs in Biomedicine*, 184:105111, 2020.

[38] S Suriya Uma Devi and SP Anjali Devi. Numerical investigation of three-dimensional hybrid cu–al2o3/water nanofluid flow over a stretching sheet with effecting lorentz force subject to newtonian heating. *Canadian Journal of Physics*, 94(5):490–496, 2016.

[39] S Zeinali Heris, S Gh Etemad, and M Nasr Esfahany. Experimental investigation of oxide nanofluids laminar flow convective heat transfer. *International communications in heat and mass transfer*, 33(4):529–535, 2006.

[40] Praveen K Namburu, Debendra K Das, Krishna M Tanguturi, and Ravikanth S Vajjha. Numerical study of turbulent flow and heat transfer characteristics of nanofluids considering variable properties. *International journal of thermal sciences*, 48(2):290–302, 2009.

[41] Muhammad Usman, Taza Gul, Arshad Khan, Abdelaziz Alsubie, and Malik Zaka Ullah. Electromagnetic couple stress film flow of hybrid nanofluid over an unsteady rotating disc. *International Communications in Heat and Mass Transfer*, 127:105562, 2021.

[42] Eric Ronald Priest. *Solar magnetohydrodynamics*, volume 21. Springer Science & Business Media, 2012.

[43] Darren R Laughlin. A magnetohydrodynamic angular motion sensor for anthropomorphic test device instrumentation. *SAE transactions*, pages 1648–1682, 1989.

[44] Farhan Ahmed and Mazhar Iqbal. Heat transfer analysis of mhd power law nano fluid flow through annular sector duct. *Journal of Thermal Science*, 29(1):169–181, 2020.