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Short Communication

Nanoparticle shapes on electric and magnetic force in water, ethylene glycol and engine oil based Cu, Al_2O_3 and SWCNTs

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ABSTRACT

Contribute of nanoparticle shapes on MHD nanofluid flow of water, ethylene glycol and engine oil based Cu, Al_2O_3 and SWCNTs over a stretched surface in the presence of thermal radiation has been investigated. The three classic models of nanoparticle shapes are registered into report, i.e. sphere (m = 3.0), cylinder (m = 6.3698) and lamina (m = 16.1576). The controlling partial differential equations (PDEs) are regenerated into ordinary differential equations (ODEs) by manipulating irrefutable accordance conversion and it is proposed numerically by executing Runge Kutta Fehlberg method with shooting technique. It is recognized that the lamina shape ($m = 16.1576$) SWCNTs in the SWCNTs-engine oil shows a powerful impact on temperature distribution with increase of nanoparticle volume fraction. Nanoparticle shapes have an enlightened outcome on particle transport and heat transfer. The shape of the nanoparticles, particularly the lamina SWCNTs – engine oil with combined effect of thermal radiation in the presence of magnetic field is encountered an important role on cosmical, geophysical fluid dynamics; also in solar physics, involved in the sunspot development, solar cycle and medicine research.

1. Introduction

Lorentz force, the effort executed on an assessed nanoparticle stimulating with velocity through an electric and magnetic field. The perfect electromagnetic strength on the charged nanoparticle is called the Lorentz force. Nanofluids are the organizing cordial interruption of nano-sized particles in perfect heat transfer fluids such as water and oils. Traditional heat transfer fluids typically have depressed thermal conductivity. Nanofluids have pivotal improvement about enhancement in thermal conductivity as correlated with the base fluids. The term nanofluid was first imported by Choi [1]. The nanoparticles in nanofluids are typically formed of metals (Al, Cu), oxides (Al_2O_3), carbides (SiC), nitrides (AlN, SiN) or nonmetals (graphite, carbon nanotubes). Nanofluids have certain engineering and biomedical employment in cooling, cancer therapy and process industries, [2–5]. One of the principal assets of nanomaterials is that their components differ from whole material of the same composition, for example copper, alumina and single walled carbon nanotubes are noticed to be too flexible for some operations such as an immense stability metals, alloys, heat sinks and really thermal conductive materials. In addition, owing to their remarkable thermal conductivity, mechanical, and electrical properties, copper, alumina and carbon nanotubes asset plays as supplements to different structural materials. Noticeable improvement has been built on the shape, synthesis, assets and advantages of carbon nanotubes (CNTs) in the former two decades. In spite of the composed prosperity of single-wall CNTs (SWCNTs) with uniform and predefined designs remains a great challenge, and constructing full utilize of CNTs in operations still have need strong achievement.

Magnetic nanoparticles are a distribution of nanoparticle that can be occupied approving magnetic fields. Magnetic nanoparticle collections that are consumed of a number of exclusive magnetic nanoparticles are noticed as magnetic nanobeads with a diameter of 10–100 nm. Magnetic nanoparticle quantity is a base for their stimulating magnetic accession into magnetic nanotube chains. The magnetic nanoparticles have been the highlight of much research repeatedly because they achieve distinguish prospects which could see credible benefit in catalysis as well as nanomaterial-based catalysts, biomedicine, magnetic resonance imaging, optical filters, defect sensor and cation sensors, [6–10]. There are many elements that can be employed to design nanoparticles, carbon is very satisfying due to its tremendous thermal and mechanical characteristics [11]. A carbon nanotube is crazed of a single wall (SWCNT) or multiwall carbon nano tubes (MWCNT). The thermophysical mechanisms of carbon nanotubes (CNT) deferment are investigated to be more energetic than those of other nanoparticles with the same volume fraction [12]. The transport assets of nanofluid: energetic thermal conductivity and viscosity are not only subordinate on volume fraction of nanoparticle, also strongly reliant on the particle shape. Analyzes predicted that the thermal conductivity as strong as viscosity both enhances by utilize the shape of water or oil based nanoparticles associated to base fluid. So far, different theoretical and experimental analyzes have been controlled and distinct interactions have been suggested for

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Nomenclature

a	stretching plate index, s^{-1}
b	velocity index, s^{-1}
B_0	magnetic flux density, $kg\ s^{-2}A^{-1}$
c_p	specific heat at constant pressure, $J\ kg^{-1}\ K^{-1}$
k_f	thermal conductivity of the base fluid, $kg\ ms^{-3}K^{-1}$
k_s	thermal conductivity of the nanoparticle, $kg\ ms^{-3}K^{-1}$
k_f	thermal conductivity of the base fluid, $kg\ ms^{-3}K^{-1}$
k_{nf}	effective thermal conductivity of the nanofluid, $kg\ ms^{-3}K^{-1}$
M	magnetic parameter, $\frac{\sigma\ B_0^2}{a\ \rho_f}$, $\left(\frac{(\Omega^{-1}m^{-1})(kgs^{-2}A^{-1})^2}{(kg\ m^{-3})s^{-1}}\right)(-)$
Pr	Prandtl number, $\frac{\nu_f}{\alpha_f}$, $\left(\frac{m^2\ s^{-1}}{m^2s^{-1}}\right)(-)$
q''_{rad}	incident radiation flux of intensity, $kg\ m^{-1}s^{-3}K^{-1}$
R	thermal radiation parameter, $\frac{4\sigma_e T_c^3}{\beta_R k_f}\left(\frac{kg\ \ s^{-3}K^{-4}K^3}{kg\ \ ms^{-3}K^{-1}m^{-1}}\right)(-)$
T	temperature of the nanofluid, K
T_w	temperature of the wall, K
T_∞	ambient temperature, K
x, y	streamwise coordinate and cross-stream coordinate, m
u, v	velocity components in x and y direction, $m\ s^{-1}$
U_w	flow velocity of the fluid away from the plate, $m\ s^{-1}$

Greek symbols

β_R	mass absorption coefficient, m^{-1}
λ	velocity ratio parameter, $=\frac{b}{a}\left(\frac{s^{-1}}{s^{-1}}\right)(-)$
ρ_f	density of the base fluid, $kg\ m^{-3}$
ρ_s	density of the nanoparticle, $kg\ m^{-3}$
ρ_{nf}	effective density of the nanofluid, $kg\ m^{-3}$
σ_f	electric conductivity of the base fluid, $\Omega^{-1}m^{-1}$
σ_s	electric conductivity of the nanoparticle, $\Omega^{-1}m^{-1}$
σ_e	Stefan – Boltzmann constant, $kg\ s^{-3}K^{-4}$
σ_{nf}	effective electric conductivity of the nanofluid, $\Omega^{-1}m^{-1}$
μ_f	dynamic viscosity of the base fluid, $kg\ m^{-1}\ s^{-1}$
μ_{nf}	effective dynamic viscosity of the nanofluid, $kg\ m^{-1}\ s^{-1}$
ν_{nf}	kinematic viscosity of the nanofluid, $m^2\ s^{-1}$
ν_f	kinematic viscosity of the base fluid, $m^2\ s^{-1}$
Ω	resistance, $kg\ m^2s^{-3}A^{-2}$
ζ	nanoparticle volume fraction, $(-)$

thermal conductivity and energetic viscosity of the nanoparticle shape. Again, many authors examined the heat transfer attitude of fluent interruption of single walled or multiwalled carbon nanotubes (CNT nanofluids) in different base fluids running through distinct surfaces, [13–16].

The reinforcement of high achievement thermal schemes for heat transfer development has become familiar nowadays. Heat transfer proficiency can also be developed by growing the thermal conductivity of the running fluid. High thermal conductivity of solids can be utilized to enhance the thermal conductivity of a fluid by including tiny solid particles to that fluid. Nanoparticles have strong potential to develop the thermal transit assets correlated to traditional particles fluids interruption, millimeter and micrometer sized particles. In the last decade, nanofluids have boost powerful application due to its enlarged thermal properties. All the experimental outputs have established the enhancement of the thermal conductivity by composition of copper and alumina nanoparticles, [17–19]. Heris et al. [20,21] analyzed the experimental outputs of the convective heat transfer of water based CuO and Al_2O_3 nanofluids inside a circular tube with dependable surface temperature. It was predicted that the boost in heat transfer coefficient as the existence of nanoparticles was more significant than the implication of single phase energy transfer cooperation utilizing nanofluid impressive mechanisms. Anyhow, the Al_2O_3- water nanofluid exhibited more powerful improvement when correlated to CuO - water.

An extensive diversity of industrial mechanisms associates the transfer of heat energy. Universally, any industrial efficiency, heat must be appended, detached, or displaced from one mechanism stream to another and it has become a extensive effort for industrial necessity. These developments contribute an authority for energy restoration and development fluid heating/cooling. Thermal radiation energy is the intercommunication of electromagnetic waves from all elements that has a temperature stronger than complete zero, [22]. It executes a modification of thermal energy into electromagnetic energy. Thermal energy faces of the kinetic energy of random improvement of atoms and molecules in element. All elements with a temperature by perception are composed of nanoparticles which have kinetic energy and which cooperate with each other. These atoms and molecules are consumed of assessed nanoparticles, i.e., protons, electrons and kinetic communications among element nanoparticles result in rate exploration and dipole oscillation. This issues in the electrodynamic recreation of combined electric and magnetic fields, occurring in the emission of photons, radiating energy away from the body over its surface boundary. The aims of thermal radiation design on different assets of the surface are happening from estimating its temperature, it's spectral retentively and spectral progressive power, as proposed by several authors [23–25].

In this work, we addressed the impact of shape and volume fraction of the nanoparticles in the presence of water, ethylene glycol and engine oil based Cu, Al_2O_3 and SWCNTs MHD flow over a stretching surface (Fig. 1). Thermal radiation energy consequence is also examined. Experimental investigations have anticipated that the nanoparticle shape has a meaningful outcome on the heat and mass transfer of nanofluids [27, 28]. Distinctive forms of nanoparticle shapes i.e. sphere, cylinder and lamina, are authorized into report in this work. The parameter affirmation for the issue was arranged and is inspected.

2. Mathematical analysis

Investigate two-dimensional steady MHD boundary layer flow of the water, ethylene glycol and engine oil based Cu, Al_2O_3 and SWCNTs nanofluid over a stretched surface incorporate in the thermal energy

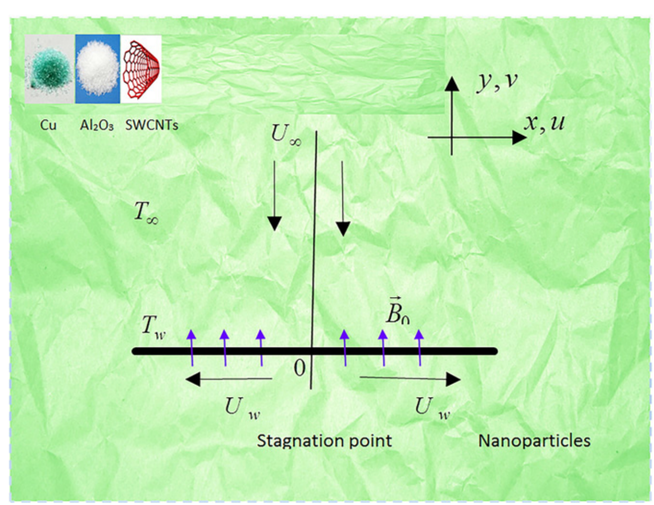

Fig. 1. Physical substance of nanofluid flow over a stretching surface.