Effect of Nanoparticle Shape on Thin Film flow of Fe_3O_4 Nanofluid and Heat Transfer over an Inclined Stretching Surface in Porous Media

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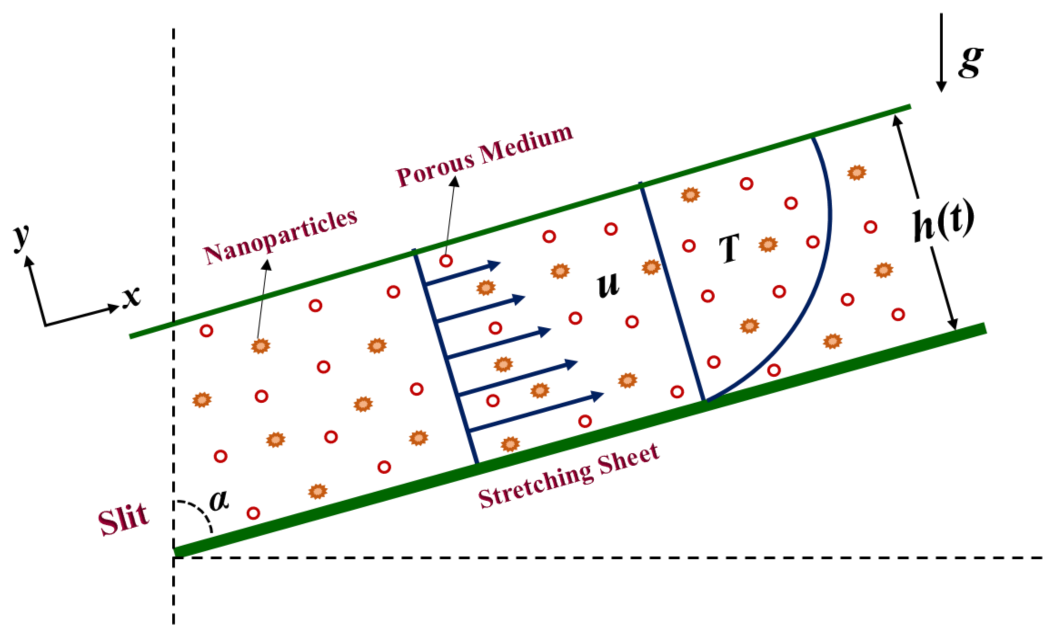
1. INTRODUCTION & OBJECTIVE

The study aims to address research gaps in the literature regarding Fe_3O_4 - H_2O nanofluid flow and heat transfer in a thin film over an unsteady stretching sheet in a porous medium. Specifically, previous studies have not sufficiently investigated Fe_3O_4 - H_2O nanofluid dynamics in combination with nanoparticle shapes like lamina, tetrahedron, and hexahedron. The effects of parameters like stretching rate, and porous medium properties on nanofluid flow and heat transfer are still unclear. This study therefore aims to analyze Fe_3O_4 - H_2O nanofluid flow and heat transfer in a thin film over an unsteady stretching sheet by considering the effects of thermal radiation, slip boundary condition, and nanoparticle shape factors. The time-dependent equations governing the system are transformed using similarity transformations and solved numerically using the 4th order Runge-Kutta method and shooting technique. This study aims to provide insights into the influence of physical parameters on fluid flow and also to investigate the effect of nanoparticle shape factors. The study aims to address key research gaps regarding Fe_3O_4 - H_2O nanofluid thin film flow over an unsteady stretching sheet in a porous medium. The numerical simulations and results will provide useful insights to advance the field.



Employing the nanofluid framework proposed by Tiwari and Das[1], governing equations pertaining to the current problem is expressed as follows,

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

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{\mu_{nf}}{\rho_{nf}}\left(\frac{\partial^2 u}{\partial y^2}\right)-\frac{\nu_{nf}}{K}u-\sigma_{nf}\mathrm{B}^2u+\frac{(\rho\beta^*)_{nf}}{\rho_{nf}}g(T-T_\infty)cos\,\alpha, \tag{2}$$

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k_{nf}}{(\rho c_p)_{nf}}\frac{\partial^2 T}{\partial y^2}-\frac{1}{(\rho c_p)_{nf}}\frac{\partial q_r}{\partial y}, \tag{3}$$

with boundary constraints,

$$u=\mathrm{U}+A\nu_f\frac{\partial u}{\partial y}, v=0, -k_{nf}\frac{\partial T}{\partial t}=h_f(T_w-\mathrm{T}),\ at\ y=0, \tag{4}$$

$$\frac{\partial u}{\partial y}=0,\ \frac{\partial T}{\partial y}=0, v=\frac{dh}{dt}\ at\ y=h(t)\,. \tag{5}$$

2. RESULTS & HIGHLIGHTS

Flow profiles for various physical parameters with different shape factors are investigated. The major conclusion of this research are as follows:

- In comparison to other nanoparticle shapes, lamina-shaped nanoparticle have the highest heat transmission properties.
- Increasing magnetic parameter and porosity cause a decline in the velocity contour, but increasing volume fraction, inclined angle parameter hold a reverse effect.
- Temperature contour enhances for rising values of radiation parameter, volume fraction.

REFERENCES

1. Tiwari RK, Das MK. Heat transfer augmentation in a two-sided lid-driven differentially heated square cavity utilizing nanofluids. International Journal of Heat and Mass Transfer. 2007; 50(9-10):2002–2018A. Gelman, J. B. Carlin, H. S. Stern, and D. B. Rubin, *Bayesian Data Analysi*s, Chapman and Hall,London, 1995.
2. Alabdulhadi S, Abu Bakar S, Ishak A, Waini I, Ahmed SE. Effect of Buoyancy Force on an Unsteady Thin Film Flow of Al2O3/Water Nanofluid over an Inclined Stretching Sheet. Mathematics. 2023; 11(3):739.
3. Timofeeva EV, Routbort JL, Singh D. Particle shape effects on thermophysical properties of alumina nanofluids. Journal of applied physics. 2009;106 (1).
4. Vajjha RS, Das DK. Experimental determination of thermal conductivity of three nanofluids and development of new correlations. International Journal of Heat and Mass Transfer. 2009;52(21-22):4675–4682.
5. Shah Z, Bonyah E, Islam S, Khan W, Ishaq M. Radiative MHD thin film flow of Williamson fluid over an unsteady permeable stretching sheet. Heliyon. 2018;4(10).