HEAT TRANSFER AND FLOW ANALYSIS OF HYBRID NANOFLUID WITH VICSOUS DISSIPATION IMPACT

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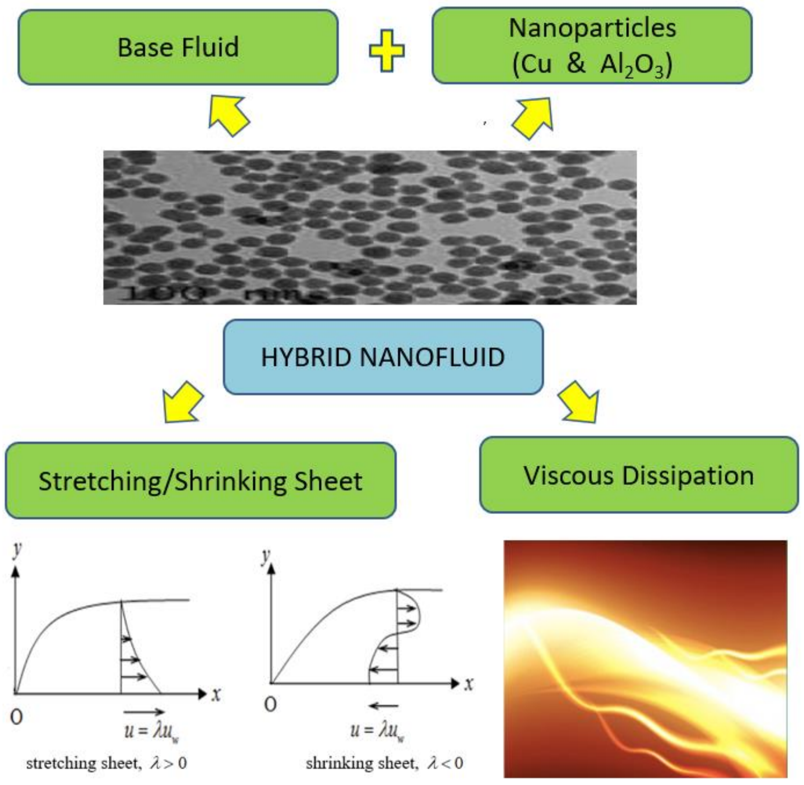
Background/Introduction



State of the Art/Methods

1. Formulate and construct the mathematical model of nanofluid
2. Reduce the partial differential equations into a system of nonlinear ordinary differential equations (ODEs) by using the similarity transformations.
3. Use the bvp4c programme to solve the ODEs and produce the numerical solutions.
4. Obtain dual solutions
5. Conduct stability analysis

Mathematical Formulations

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \quad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{\mu_{hnf}}{\rho_{hnf}}\frac{\partial^2 u}{\partial y^2} \quad (2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha_{hnf}\frac{\partial^2 T}{\partial y^2}+\frac{\mu_{hnf}}{(\rho C_p)_{hnf}}\left(\frac{\partial u}{\partial y}\right)^2 \quad (3)$$

boundary conditions

$$u=\lambda u_w(x)=\lambda ax \quad v=-v_w \quad T=T_w \quad \text{at} \quad y=0$$
$$u\to 0, \quad T\to T_\infty \quad \text{as} \quad y\to\infty. \quad (4)$$

The stream function and similarity transformations are introduced to solve eqs (1)-(3) t equation (4):

$$u=axf'(\eta), \quad v=-\sqrt{av_f}\cdot f(\eta), \quad \eta=y\sqrt{\frac{a}{v_f}}, \quad \theta(\eta)=\frac{T-T_\infty}{T_w-T_\infty} \quad (5)$$

where primes denotes differentiation with respect to η .It means that, we can take

$$v_w=\sqrt{av_f}\,s \ . \quad (6)$$

After the implication, the eqs (2) and (3) could be reduced as the following ordinary diffe equations

$$\frac{\mu_{hnf}/\mu_f}{\rho_{hnf}/\rho_f}f'''+ff''-f'^2=0 \quad (7)$$

$$\frac{k_{hnf}/k_f}{\Pr(\rho C_p)_{hnf}/(\rho C_p)_f}\theta''+f\theta'+\frac{Ec}{[(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}(\rho C_p)_{hnf}]/(\rho C_p)_f}f''^2=0 \quad (8)$$

and the boundary conditions become

$$f(0)=s, \quad f'(0)=\lambda, \quad \theta(0)=1,$$
$$f'(\eta)\to 0, \quad \theta(\eta)\to 0 \quad \text{as} \quad \eta\to\infty \quad (9)$$

Stability Analysis

$$\frac{\mu_{hnf}/\mu_f}{\rho_{hnf}/\rho_f}F'''+f_0F''+Ff_0''-2f_0'F'+\gamma F'=0$$

$$\frac{k_{hnf}/k_f}{\Pr(\rho C_p)_{hnf}/(\rho C_p)_f}G''+f_0G'+F\theta_0'$$
$$+\frac{Ec}{(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}(\rho C_p)_{hnf}/(\rho C_p)_f}\left(2f_0''F''\right)+\gamma G=0$$

boundary conditions

$$F(0)=0, \quad F'(0)=0, \quad G(0)=0,$$
$$F'(\infty)\to 0, \quad G(\infty)\to 0$$

Graphical Results

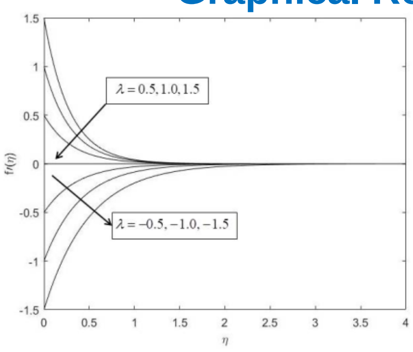


Figure 1: Velocity profiles for various λ

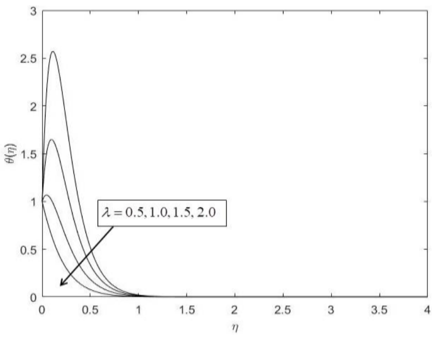


Figure 2: Temperature profiles for various λ

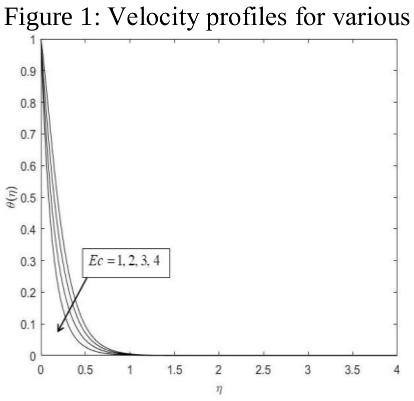


Figure 3: Impact of viscous dissipation

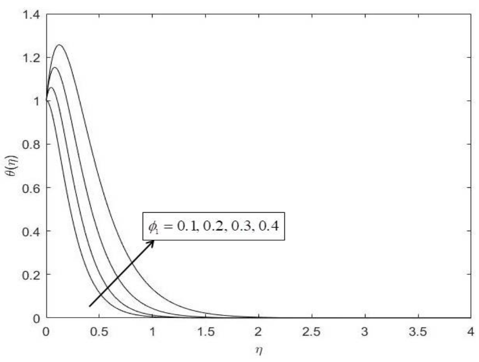


Figure 4: Impact of Cu nanoparticles

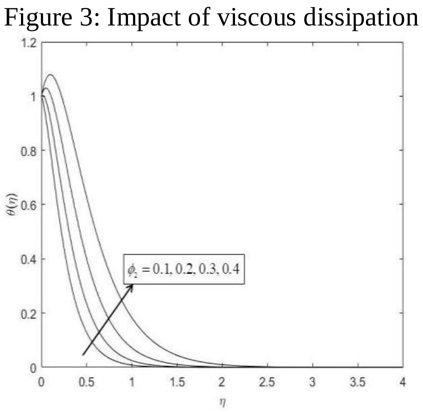


Figure 5: Impact of Al_2O_3 nanoparticles

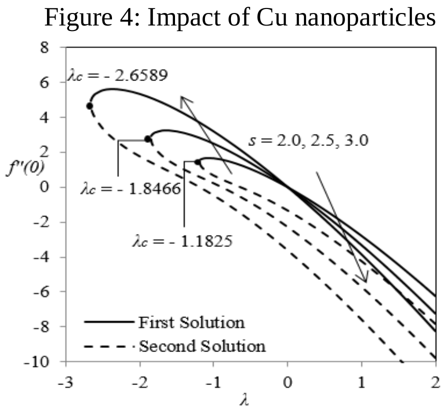
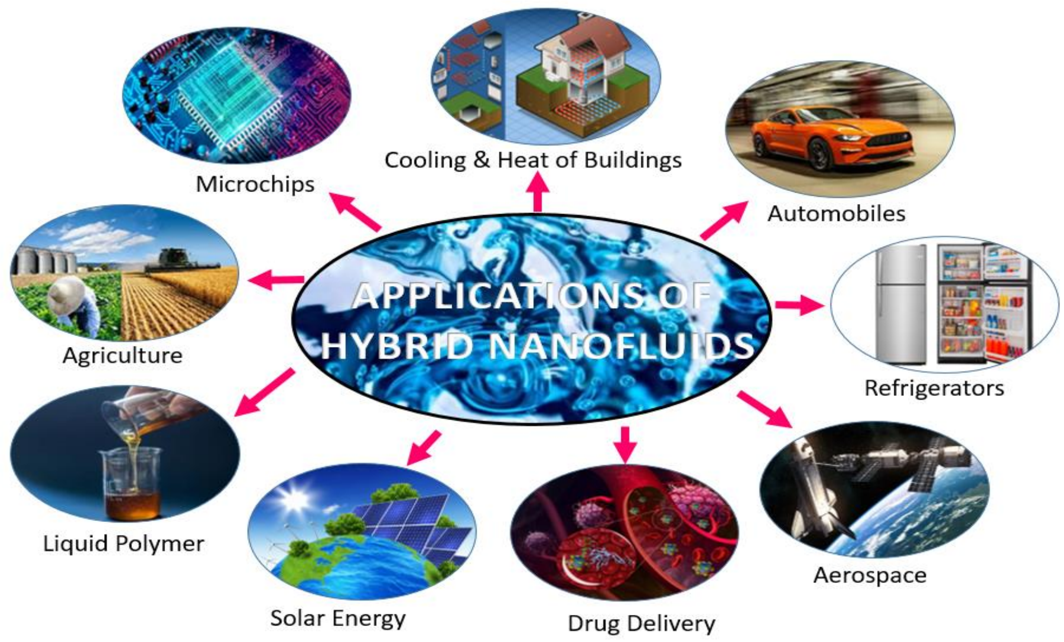


Figure 6: Impact of suction to $f''(0)$

Table 1: Results of Stability Analysis

λ	γ (1st Solution)	γ (2nd Solution)
-1	1.4280	-0.7832
-1.2	1.2179	-0.7411
-1.4	0.9527	-0.6505
-1.6	0.5610	-0.4257
-1.69	0.2220	-0.1181
-1.696	0.1792	-0.0244
-1.6962	0.1776	-0.0117

Applicability



Conclusions

- The velocity and temperature profiles drop as increasing the value of stretching/shrinking parameter since the fluid flows motion over the surface of sheet produce friction force and consequently resulting against the flow motion.
- As the viscous dissipation increases, the internal heat energy also increases which leading to the deterioration of the process of heat transfer
- The appearance of Cu and Al_2O_3 nanoparticles strongly affect the thermophysical properties and stability of hybrid nanofluids flow, especially increase dramatically in thermal conductivity of the fluids.
- Higher values of suction increases the magnitude of the skin friction since it acts as a deceleration factor for the fluid flow and deploys a drag force.
- From the stability analysis, the first solution is stable since the generated smallest eigenvalue is positive.

Achievement/Award

SILVER MEDAL (CITREX, 2020)
Dual Solutions of Magnetohydrodynamic Rotating Flow and Heat Transfer of Nanofluids

Publication

Data Analytics and Applied Mathematics (DAAM), vol. 1 (01), pp:11-22 (2020) *Mathematical analysis of the flow and heat transfer of Ag-Cu hybrid nanofluid over a stretching/ shrinking surface with convective boundary condition and viscous dissipation*.

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Collaboration/Industrial Partner

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