Uranium,Thorium-Water based Nanofluid Hydromagnetic Stagnation-Point Flow and Heat Transfer over a Flat Plate

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Abstract

The present work dealt with numerical study of a uranium, thorium-water nanofluid MHD stagnation-point flow and temperature distribution over a flat plate in the presence of magnetic field which is non uniform. The fluid is assumed to be an electrically conducting with viscous incompressible. By using similarity transformation, we reduce the steady boundary layer equations to a nonlinear ordinary differential system. Numerical solutions of out coming nonlinear differential equations are formed by using Runge-Kutta Gill method with the aid of shooting technique. Numerical results are revealed graphically by means of graphs.

Keywords: *Nanofluid, Hydromagnetic, Flow and Heat transfer, Flatplate, MagneticHydroDynamics,*

1. Introduction

Over the years boundary layer flows have been of much an importance to researchers because of their real world purposes such as glass fiber production, mechanized of rubber sheets, engineering melt spinning, and so on. The stagnation-point flow is also one of these boundary layer flows. These type of flow applied incooling of nuclear reactors during disaster shut downs,electronic machines by fans, etc.This type of problem initially introduced by Crane [1].

Nowadays nanotechnology concept is considered as a noteworthy factor which have an effect on the industrial rebellion of the current century.Recent studies on nanofluids proved that nanosolids distorted the fluid characteristics because heat transfer of these solids was upper than convetional fluids. These nanosolids are typically made of carbon nanotubes, oxides,metals, or Carbides.They presented both thermophoresis effects and Brownian motion on move toequs. by plummeting them to a nonlinear surface value problem. The 2-D stationary semi-infinite wall was first analyzed by Hiemenz [2].Tiwari et al. [3] andOztop et al. [4] and Kazem et al. [5] discussed improved analytical solutions in heat generation with aporous stretching sheet. Nadeem et al. [6] calculated the thermo-diffusion consequences on convective surface with MHD flow of a viscoelastic fluid.

MHD surface layer flow is of significant notice due to its wide usasge in geothermal submission, industrial knowledge, MHD power generation systems and high heat plasmas related to nuclear combination energy translation, and fluid metal. Anjali Devi and Thiyagarajan [7] analyzed steadyMHD flow over a stretching exterior of variable warmth. Kandasamy et al. [8] discussed analytically thermophoresis effects and substance reaction on heat transfer for MHDradiative flow. Ellahi [9] studied the analytical solutions of MHD fluid in a pipe and heat reliant viscosity on the flow. The numerical and analytical solutions for Flow of nanofluidsanalysed in stretching sheet with different phenomena [10,11]. The HPM applied and entrophy analysis in MHDNanofluid flow discussed for horizontal and nonlinear stretching sheet [12,13].

Uranium-water based nanofluid applications finds significant role in nuclear reactors. Some examples filtration and purification processes, cooling with pipe containing therma fluid are confined from over heating over the petroleum technology, exterior surface of the pipe, leakage of water in river beds, ground water hydrology, lubrication of permeablebehaviors, methods of tumblingcharge of heat move in ignition chambers wear outhypodermics and porous partitioned flow reactors.

Owing to these and many more applications, In this chapter is devoted to the study of nonlinear steady MHD thermal transmit over a flat plate in uranium, thorium-water nanofluid.

2. Mathematical Formulation

Consider the uniform magnetic field in a steady incompressible nanofluid over a flat plate with stagnation-point. The ambient uniform heat and wall temperature are T_∞ and T_w respectively. The boundary layer linear velocity of the flow is $U(x) = ax$. Under these considerations, the major equations surface flows are proposed by [1] can be written as:

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

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = U\ \frac{\partial U}{\partial x} + V_{nf}\frac{\partial^2 u}{\partial y^2} + \frac{\sigma_{nf}{B_0}^2}{\rho_{nf}}(U-u) \tag{2}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{K_{nf}}{(\rho C_p)_{nf}}\frac{\partial^2 T}{\partial y^2} \tag{3}$$

The associated surface conditions are

$$u=0,\ T = T_w\ v = 0, \text{ at } y=0 \tag{4}$$

$$T = T_\infty\ u = U(x) = ax, \text{ as } y \to \infty \tag{5}$$

where μ_{nf} is the viscosity of the nanofluid, ρ_{nf} and v_{nf} are the density and kinematic viscosity of the nanofluid respectively, σ_{nf} is the electrical conductivity of the nanofluid, α_{nf} and K_{nf} are the thermal diffusivity and thermal conductivity of the nanofluid respectively, T is the temperature, and $(\rho Cp)_{nf}$ is the heat capacity, which are given by Oztop and Abu-Nadu [4]

$$\left(\rho C_p\right)_{nf} = (1-\emptyset)\left(\rho C_p\right)_f + \emptyset\left(\rho C_p\right)_s,\ \mu_{nf} = \frac{\mu_f}{(1-\emptyset)^{2.5}},\ \frac{K_{nf}}{K_f} = \frac{(K_s+2K_f)-2\emptyset(K_f-K_s)}{(K_s+2K_f)+2\emptyset(K_f-K_s)},$$

$$\rho_{nf} = (1-\emptyset)\rho_f + \emptyset\rho_s\ ,\ V_{nf} = \frac{\mu_{nf}}{\rho_{nf}} \tag{6}$$

here μ_f is the viscosity of the fluid, ρ_f and ρ_s are the situation density of the fluid fraction and solid fraction respectively, K_f and K_s are the thermal conductivity of the fluid and solid respectively, and Ø is the nano particle volume fraction.

Introducing a variable η and the dimensionless form of f and θ as

$$\theta(\eta) = \frac{T-T_\infty}{T_w-T_\infty},\quad \psi = \sqrt{av_f}\,xf(\eta),\qquad \eta = y\sqrt{\frac{a}{v_f}}, \tag{7}$$

The flow mechanisms are comparatively obtained as $u = \frac{\partial\psi}{\partial y}$ and $v = -\frac{\partial\psi}{\partial x}$

Here f(η) and $\theta(\eta)$ are the dimensionless flow and heat functions respectively.

The mathematically problem defined as Eqns. (2) to (6) are transformed into a set of ODE and their associated surface conditions become

$$f''' + (1-\phi)^{2.5}\left[1-\phi+\phi\left(\frac{\rho_s}{\rho_f}\right)\right]\left[ff''-f'^2+M^2(1-f')+1\right]=0$$
(8)

$$\theta'' + \frac{\left[1-\phi+\phi\frac{(\rho C_p)_s}{(\rho C_p)_f}\right]}{\left(\frac{K_{nf}}{K_f}\right)} Prf\theta' = 0 \quad (9)$$

With f(0) = 0, $\theta(0)$ = 1, f'(0) = 0 (10)

$\theta(\infty)$ = 0, f'(∞) = 1, (11)

where

$M = \frac{\sigma_{nf}{B_0}^2}{\rho_{nf}a}$ is the Hartman number, $Pr = \frac{\mu C_p}{\alpha}$ is the Prandtlnumber

The physical quantities like C_{nf} and Nu_x are

$$C_{nf} = \frac{\tau_w}{\rho_f {u_w}^2}, \quad Nu_x = \frac{x}{K_f(T_w - T_\infty)}, \quad (12)$$

where $\tau_w = \mu_{nf}\left(\frac{\partial u}{\partial y}\right)_{y=0}$ and u_w is the surface velocity.

Using the Eqns. (7), we get

$$Re_x^{1/2}C_f = \frac{1}{(1-\phi)^{2.5}} f''(0) \quad (13)$$

$$Nu_x Re_x^{-1/2} = -\frac{K_{nf}}{K_f}\theta'(0) \quad (14)$$

3. Solutions of the Problem

Results of system of nonlinear ODEs (8) and (9) subject to boundary conditions (11) are obtained by the Runge-Kutta Gill method along with shooting technique. Numerical solutions are found for different values of the physical parameters M, ∅ and Pr.

4. Results and Discussion

Runge-Kutta Gill method with help of shooting process in used to obtain the results of nonlinear MHD flow over a flat plate with uranium, thorium-water based nanofluid by fixing some values for the corporal parameters.

The impact uranium nanosolid fraction parameter ∅ on thestagnation-point flow velocity is shown in the Figure 1. It is well-known that the enhancingrates of the nanosolid ∅ enhances the stagnation-point flow velocity of the nanofluid. This is clear that the presence of nanosolidsescorts to further reduction of the surface layer. It is understandable that the growing principles of nanosolid fraction enhance the velocity.

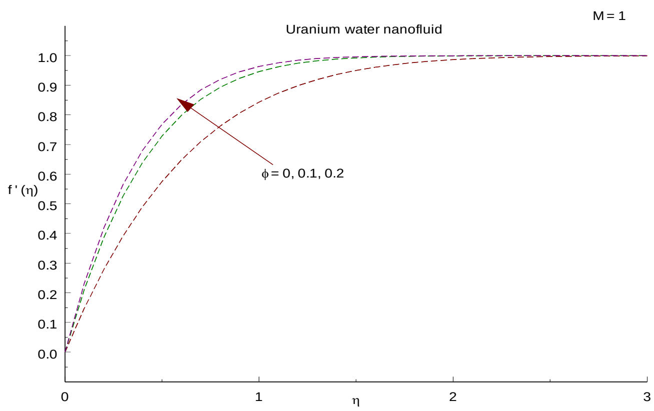

Figure 1. Velocity profiles f ’(η) for different nanosolid fraction for uranium water nanofluid

The value of∅ on the heat profile of uranium water nanofluidis displayed through Figure 2. The existence of uranium nanosolid capacity fraction leads to rise in the depth of the thermal surface stratum profile. This is for the reason that nanosolid has high heat conductivity, so the depth of the heat surface layer enhances.

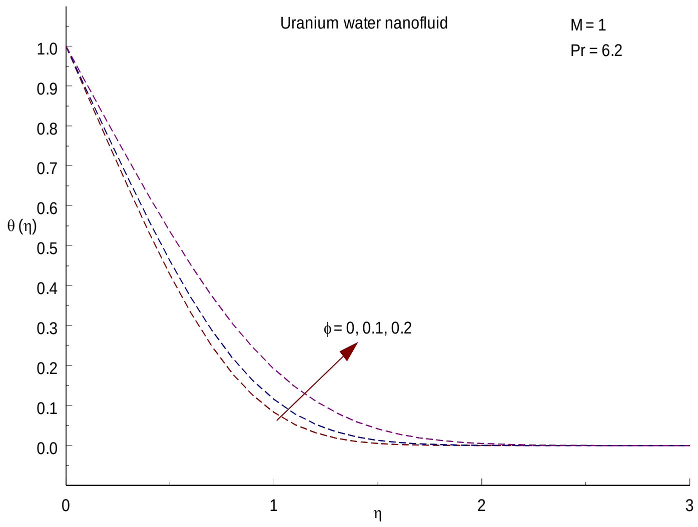

Figure 2.Temperature profiles θ(η) for different nanosolid fraction for uranium water nanofluid

The impact of stagnation-point flow for various values of Hartmann number for uranium water nanofluidis plotted through Figure 3. From this figure the velocity enhances with an increasing M and therefore the depth of the surface layer decreases.

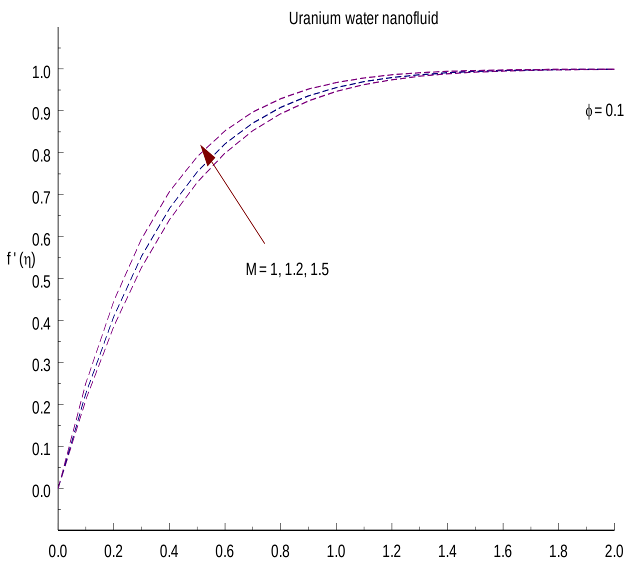

Figure 3.Impact of M on f ’(η) for uranium water nanofluid

Figure 4 exhibit the effect of heat profile for various values of uranium water nanofluid magnetic parameter. It is understandable that increase in the uranium water nanofluid electrically conducting parameter decreases the thermal profile. This demonstrates that the increasing value of magnetic field with increases the thermal surface layer becomes thicker.

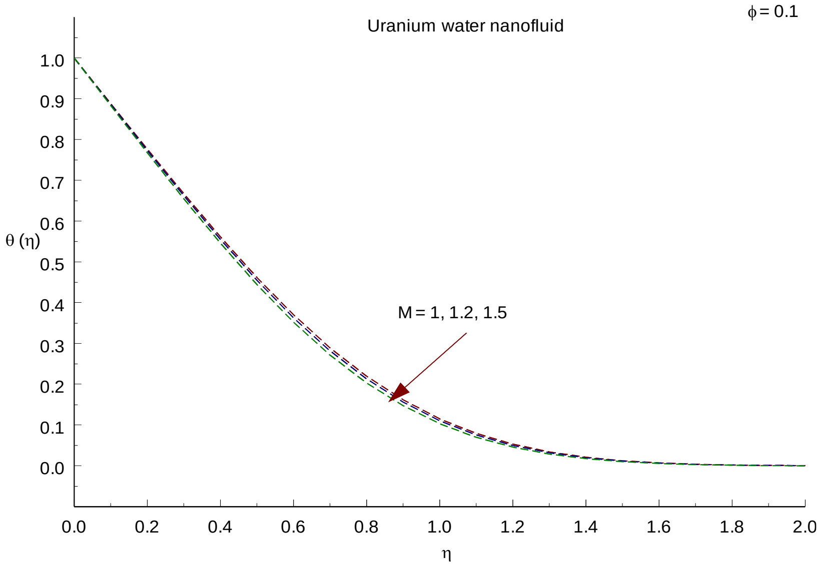

Figure 4.Effect of the M on $\theta(\eta)$ for uranium water nanofluid

Figure 5. Demonstrates the outcome of thorium nanosolid fraction $\emptyset$ on the stagnation-point flowvelocity profile. It is distinguished that the enhancing values of $\emptyset$ is enlarge the stagnation-point flowvelocity. This is due to the actuality that the attendance of nanosolidsescorts to in addedreduction of the surface layer. It is to fact that the enhancing values of nanosolid increase the stagnation-point flowvelocity.

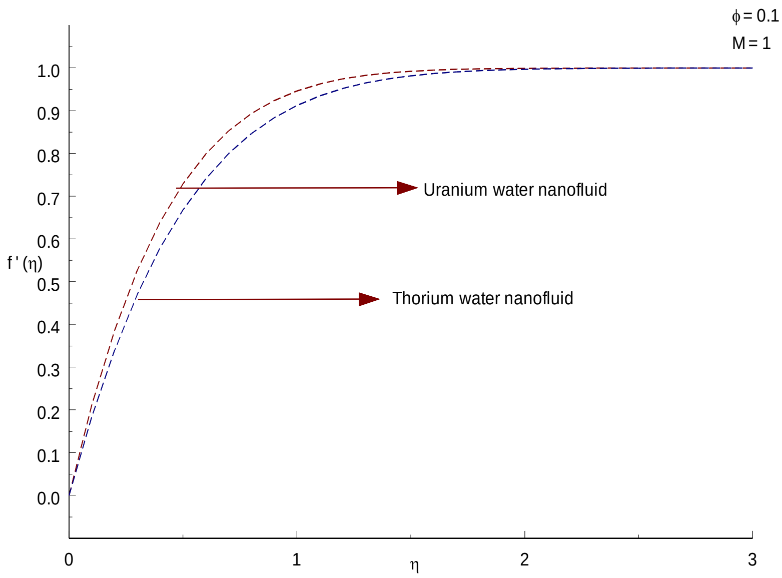

Figure 5. Impact of f '(η) for different nanosolids when $\emptyset = 0.1$

The impact of nanosolid fraction ∅ on the thermal profile of thorium water nanofluidis plotted through Figure 6. The attendance of nanosolid volume fraction directs to enhance in the depth of the temperature surface layer. This is for the reason that nanosolids have elevated heat manner, so the depth of the temperature surface layer boosts.

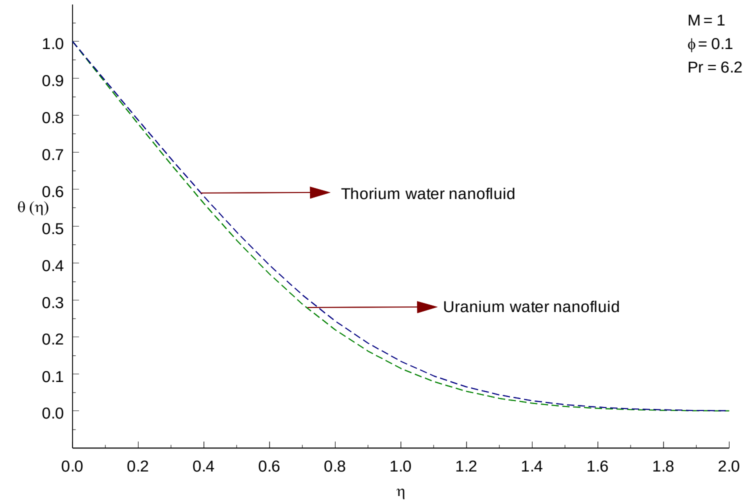

Figure 6. Effect of temperature profiles $\theta(\eta)$ for different nanoparticles

The different nanofluid velocities are analyzed in Figure 7. It is experimental that the dissimilar nanofluids have dissimilar stagnation-point flow velocities and also noted that uranium nanofluid has upper stagnation-point flow velocity evaluated to thorium nanosolid. From Figure 8 it is experimental that the nanosolids of thorium have the uppermost value of heat profile evaluated to uranium nanosolids.

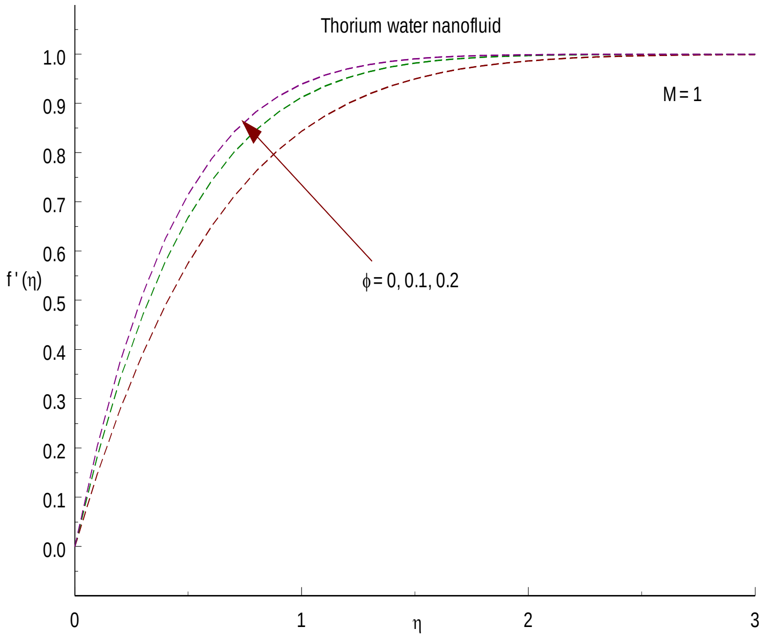

Figure 7. Impact of f ’(η) for different nanosolid fraction for thorium water nanofluid

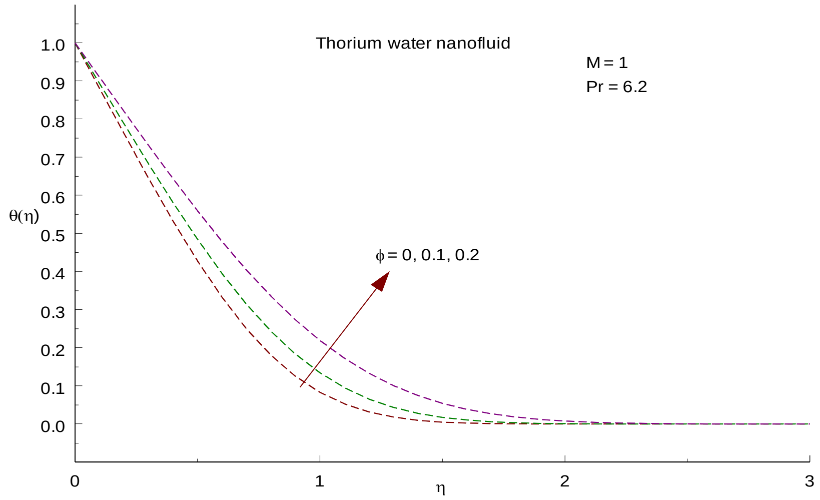

Figure 8. Temperature profiles θ(η) for different nanosolid fraction for thorium water nanofluid

The rate of temperate transfer and skin friction due to electrically conducting for uranium and thorium nanofluids is described in Figures 9 and 10 respectively. It is understandable that the impact of M is to improve the coefficient of friction whereas its consequence radiuses the charge of thermal transmits. In Addition, evaluated with uranium and thorium H_2O nanofluid, coefficient of friction is boost for uranium H_2O nanofluid but rate of heat transfer is decreased for uranium water nanofluid.

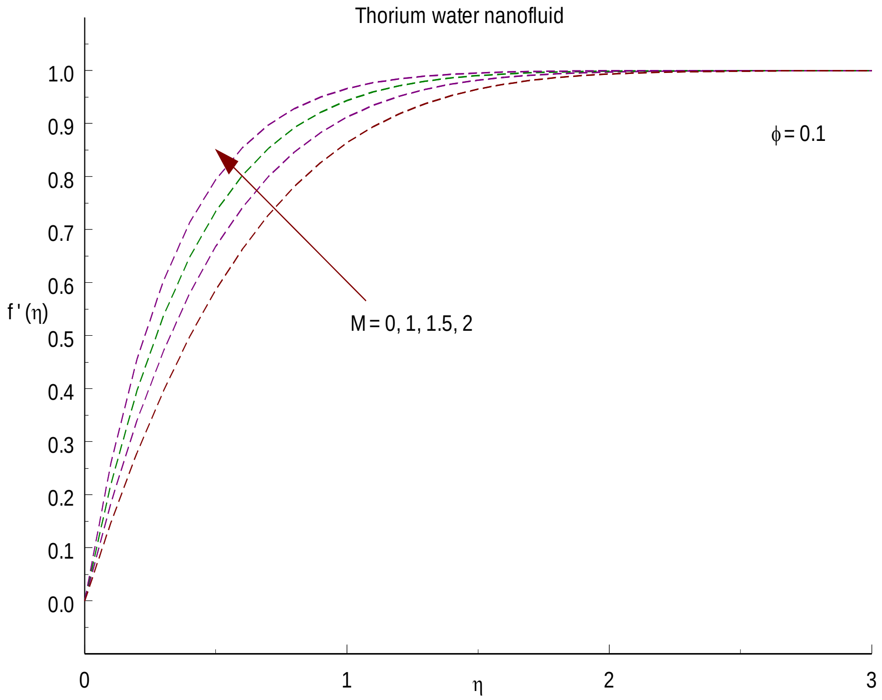

Figure 9.Impact of M on f '(η) for thorium water nanofluid

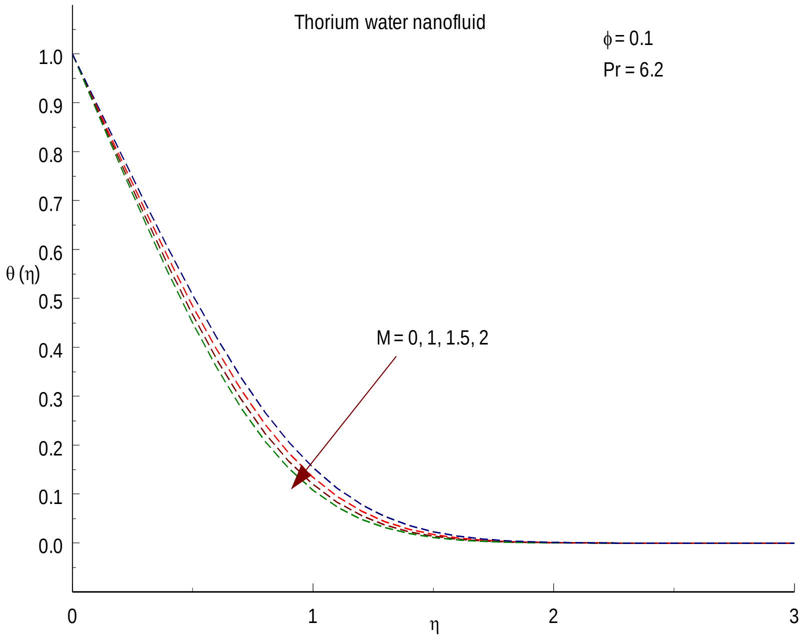

Figure 10.Impact of M on $\theta(\eta)$ for thorium water nanofluid

The value of ∅ on the skin friction coefficient for uranium and thorium water nanofluid is shown in Figure 11. It is analyzed that the electrically conducting effect of coefficient of skin friction enhances with enhancing values of uranium and thorium H_2O nanofluid for ∅.

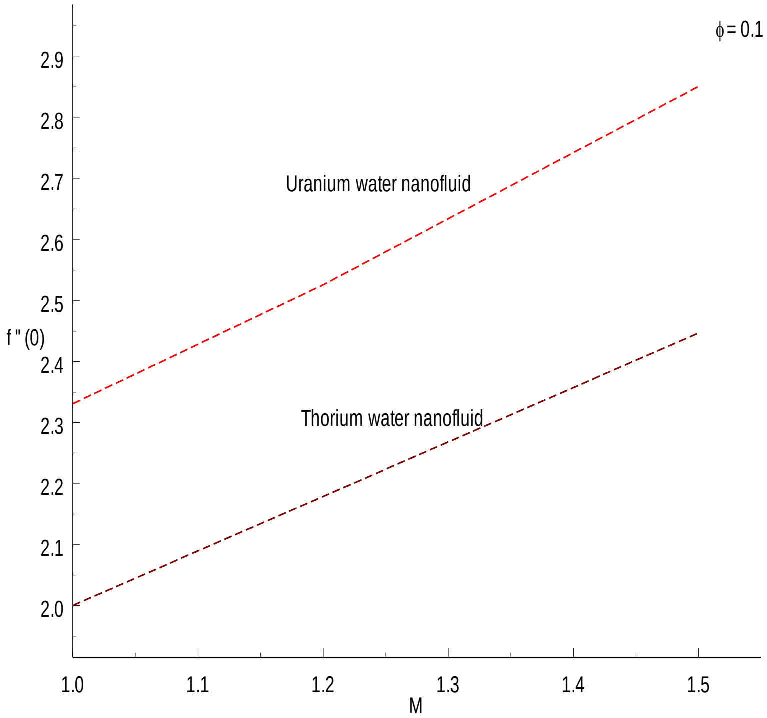

Figure 11.Skin friction against M for different nanofluids

The influence of ∅ on the rate of thermal transmit for dissimilar nanofluids are shown in Figure 12. It is distinguish that the rate of high temperature transfer increases with enlarges of∅. Moreover, it is make a note that the buck thermal transmit rate is attained for nanosolid due to dominance of transmission form of thermal movement.

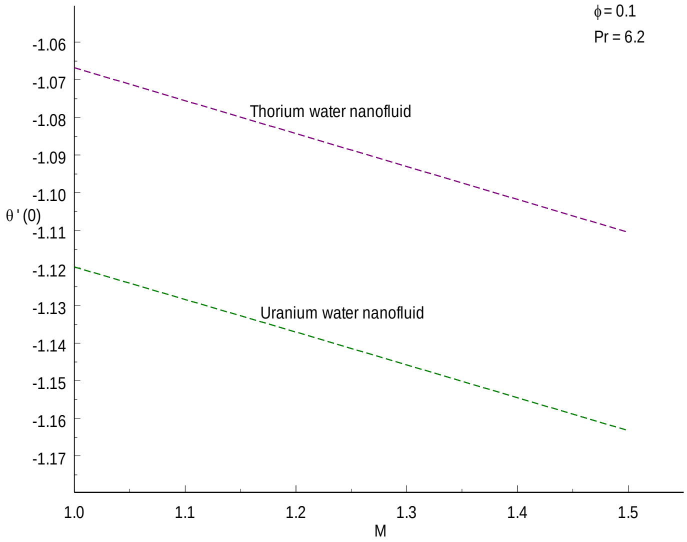

Figure 12. Rate of heat transfer against M for different nanofluids

Table 1. Thermophysical properties of base fluid and the nanoparticles at 300K

	$\rho(kg/m^3)$	$C_p(J/kgk)$	$k(W/mk)$	$\alpha \times 10^{-7}(m^2/s)$
Water	996.5	4180	0.609	1.4268
Thorium	11724	118	54	390.33
Uranium	19070	116	27.6	124

This is for the reason that thorium nanosolid has the decreasing value of heat conductivity evaluated to uranium nanosolid as seen in Table 1. The uranium nanosolids have far above the ground values of heat diffusivity and, consequently, these reduce the rate of temperature, which will change the recital of uranium nano particles.

5. Conclusion

- The magnitude of the rate of heat transfer and the coefficient of skin friction increases with∅.
- Fixed value of∅, the H_2O velocity of nanofluid boost up by increasing M.
- Thorium nanosolid have the far above the ground value of temperature profile compared to uranium nanosolids.
- The increasing values of ∅ increase the stagnation-point flowvelocity.

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