Journal of Molecular Liquids 237 (2017) 242–246

Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

CNT-water nanofluid thermal radiation heat transfer over a stretching sheet considering heat generation

P. Valipour [a], R. Moradi [b], F. Shakeri Aski [c,*]

[a] Nazm Avaran Sanat V Madan e Gol e Gohar Company, Sirjan, Iran
[b] Department of Chemical Engineering, School of Engineering and Applied Science, Khazar University, Baku, Azerbaijan
[c] Department of Mechanical Engineering, Shahid Bahonar University of Kerman, Kerman, Iran

ARTICLE INFO

Article history:
Received 2 February 2017
Received in revised form 16 March 2017
Accepted 15 April 2017
Available online 19 April 2017

Keywords:
CNT-water nanofluid
Radiation
Heat generation
Stretching sheet

ABSTRACT

CNT-water nanofluid flow over a stretching plate is examined considering heat generation and thermal radiation effects. Runge–Kutta scheme is utilized to solve the ODEs. Numerical investigation is completed by examining the various values of temperature index parameter, radiation parameter, heat generation parameter and velocity ratio parameter. Results indicated that temperature gradient augments with increase of temperature index parameter and velocity ratio parameter while it reduces with increase of heat generation parameter and radiation parameter.

1. Introduction

Flow over an extending cylinder was analyzed by Wang [1]. Magnetohydrodynamic free convection has several applications such as combustion modeling, geophysics, fire engineering and etc. In recent decade, nanotechnology has been offered as innovative passive method for heat transfer improvement. Unsteady flow in existence of titled magnetic field over a cone was studied by Vanita and Kumar [2]. Impact of magnetic field on boundary layer flow was examined by Beg et al. [3]. Peristaltic magnetic nanofluid flow a duct was studied by Akbar et al. [4]. The influence of atherosclerosis on hemodynamics of stenosis has been forecasted by Nadeem and Ijaz [5]. They showed that the velocity gradient on the wall of titled arteries reduces with augment of Strommers number. Sheikholeslami and Rokni [6] examined the effect of EFD viscosity on nanofluid forced convection in a cavity with sinusoidal wall. Hayat et al. [7] presented the influence of radiation on mass transfer of nanofluid. They showed that temperature gradient reduces with augment of thermal radiation. Sheikholeslami and Bhatti [8] utilized electric field as a new active method for nanofluid heat transfer enhancement. Sheikholeslami [9] utilized LBM for magnetohydrodynamic nanofluid forced convection in a porous lid driven cubic cavity. Selimefendigil and Oztop [10] examined nanofluid conjugate conduction-convection mechanism in a titled cavity. They proved that temperature gradient augments with enhance of Grashof number. Rokni et al. [11] studied nanofluid rotating flow in existence of electric field. Sheikholeslami and Shehzad [12] investigated thermal radiation influence on ferrofluid flow in existence of Lorentz forces. Sheikholeslami [13] presented the numerical simulation for magnetic nanofluid natural convection in porous media.

Influence of non-uniform Lorentz forces on nanofluid flow style has been studied by Sheikholeslami Kandelousi [14]. He concluded that improvement in heat transfer reduces with rise of Kelvin forces. Cheng [15] studied nanofluid free convection over a porous cone. Sheikholeslami and Vajravelu [16] examined the effect of variable magnetic field on nanofluid flow and heat transfer in a cavity. Sheikholeslami and Chamkha [17] studied MHD Fe_3O_4-water flow in a wavy cavity with moving wall. Forced convection heat transfer on nanofluid in presence of magnetic field was studied by Sheikholeslami et al. [18]. Recently, several researchers investigated about nanofluid flow [19–42].

The chief goal of this article is to examine the nanofluid flow over a stretching sheet. Runge–Kutta method utilized to solve the ODEs which are obtained by means of similarity transformation. Influences of effective parameter on velocity and temperature are examined.

2. Problem formulation

CNT-water nanofluid forced convection over a stretching plate is considered (Fig. 1). The properties of nanofluid exist in Table 1. The basic PDEs can be presented as [19]:

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

* Corresponding author.
E-mail address: f.shakeriaski@gmail.com (F. Shakeri Aski).

http://dx.doi.org/10.1016/j.molliq.2017.04.058
0167-7322/

Nomenclature

b	free stream parameter
	A_1, A_2, A_3, A_4 constants parameters
f	Dimensionless stream function
C_f	Skin friction coefficient
a	stretching parameter
Rd	Radiation parameter
k	Thermal conductivity
Pr	Prandtl number
Nu	Nusselt number
Q_0	heat generation
(x,y)	Cartesian coordinates along x, y axes, respectively
T	Fluid temperature
v, u	(y,x) directions velocity components

Greek symbols

τ_w	Wall shear stress
α	Thermal diffusivity
ϕ	nanoparticle volume fraction
ρ	Density
θ	Dimensionless temperature
η	Similarity parameter
μ	Dynamic viscosity
λ	Velocity ratio parameter

Subscripts

s	Nano-solid-particles
∞	Condition at infinity
f	Base fluid
w	Condition at the surface
nf	Nanofluid

$$\rho_{nf}\left(v\frac{\partial u}{\partial y}+u\frac{\partial u}{\partial x}-\frac{dU_\infty}{dx}U_\infty\right)=\mu_{nf}\frac{\partial^2 u}{\partial y^2}, \tag{2}$$

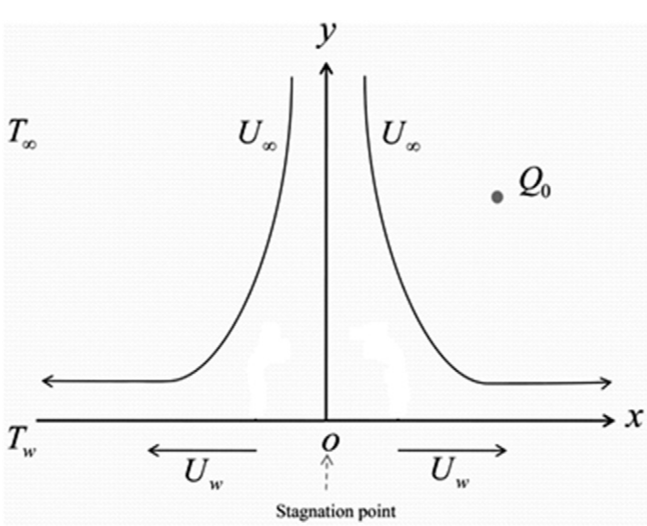

Fig. 1. Figure of geometry.

Table 1
Thermo physical properties of water and nanoparticles.

	$\rho(kg/m^3)$	$C_p(j/kgk)$	$k(W/m.k)$	$\beta\times10^5(K^{-1})$
H_2O	997.1	4179	0.613	21
CNT	1350	650	3500	4

Table 2
Values of $-\theta'(0)$ for different values of λ are compared with the results obtained Sharma and Singh [19] when $\Pr=0.05, \phi=0$.

	$-\theta'(0)$	
λ	[19]	Present work
0.1	0.081245	0.0812
0.5	0.135571	0.1356
2	0.241025	0.2413

$$(\rho C_p)_{nf}\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)=k_{nf}\frac{\partial^2 T}{\partial y^2}+Q_0(T-T_\infty)-\frac{\partial q_r}{\partial y},\quad q_r =-\frac{4\sigma_e}{3\beta_R}\frac{\partial T^4}{\partial y},\; T^4\cong 4T_\infty{}^3T-3T_\infty{}^4 \tag{3}$$

$$@y=0:\quad T=T_w,\quad v=0,\quad u=U_w$$
$$@y\to\infty:\quad T\to T_\infty,\quad u\to U_\infty \tag{4}$$

μ_{nf}, $(\rho C_p)_{nf}$ and ρ_{nf} are:

$$\mu_{nf}=\frac{\mu_f}{(1-\phi)^{2.5}} \tag{5}$$

$$(\rho C_p)_{nf}=(\rho C_p)_f(1-\phi)+(\rho C_p)_s\phi \tag{6}$$

$$\rho_{nf}=\rho_f(1-\phi)+\rho_s\phi \tag{7}$$

k_{nf} can be calculated as:

$$\frac{k_{nf}}{k_f}=\frac{k_s+2k_f-2\phi(k_f-k_s)}{k_s+2k_f+\phi(k_f-k_s)} \tag{8}$$

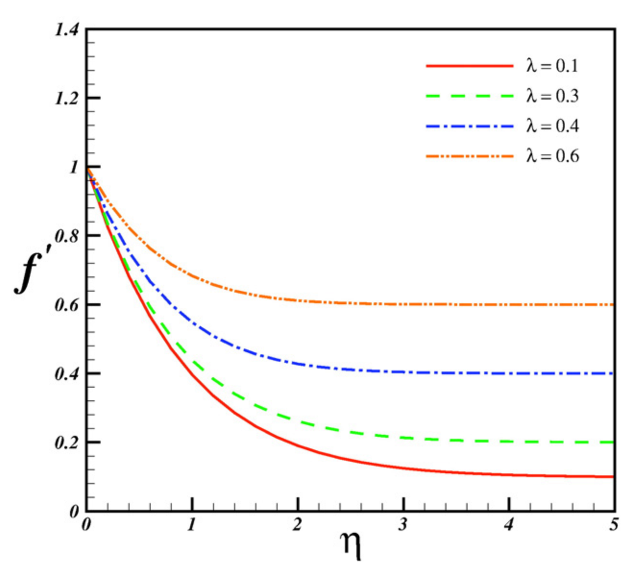

Fig. 2. Effect of velocity ratio parameter on velocity distribution.