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ScienceDirect
Journal of the Nigerian Mathematical Society 35 (2016) 48–65
Journal of the Nigerian Mathematical Society
www.elsevier.com/locate/jnnms

Influence of chemical reaction, radiation and rotation on MHD nanofluid flow past a permeable flat plate in porous medium

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Received 13 March 2015; received in revised form 16 August 2015; accepted 22 August 2015
Available online 15 September 2015

Abstract

In this paper we investigated an unsteady free convection flow of a nanofluid bounded by a moving vertical flat plate through porous medium in a rotating system with convective and diffusive boundary conditions. We considered two types of nanofluids namely Ag-water and TiO_2-water. The governing equations are solved analytically by using perturbation technique. Finally the effects of various dimensionless parameters like magneticfield parameter, chemical reaction parameter, thermal radiation parameter, volume fraction of the nano particles and shape of the nano particles on velocity, temperature and concentration profiles along with the friction factor, local Nusselt and Sherwood numbers are discussed with the help of graphs. Comparisons of the present results made with the existed studies and found an excellent agreement under some special limited cases. Moreover, we observed that the rate of heat transfer in Ag-water nanofluid is higher than that of TiO_2-water nanofluid and spherical shaped nano particles effectively enhances the heat transfer rate while compared with the cylindrical shaped nano particles.

Keywords: Nanofluid; Rotation; Radiation; MHD; Chemical reaction

1. Introduction

Presently, convective heat transfer in nanofluids has wide range of applications, and plays a pivotal role in both sciences and engineering. They have many applications in almost every technology requiring heat transfer fluids (cooling or heating), solar energy, nuclear reactors etc. So, from the last few years the researchers of fluid dynamics are showing a keen interest in the study of nanofluids due to their applications in various fields. It is the fact that the commonly using fluids exhibits low thermal conductivity compared with the metals. So, it is required to mix both the fluid and metals (nano-sized) for increasing the heat transfer capability of the fluids. The suspension of nano-sized particles in the base fluid is called the nanofluid. The concept of nanofluids was developed by Choi [1] during an investigation of cooling technologies in Argonne National Lab. There are different types of nanofluids like process

Peer review under responsibility of Nigerian Mathematical Society.
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http://dx.doi.org/10.1016/j.jnnms.2015.08.004

Nomenclature

u, v, w	Velocity components of the fluid in x, y and z directions respectively
U_r	Velocity characteristic
x, y, z	Cartesian coordinates
t	Time
Ω	Rotating velocity of the system
ρ_{nf}	Density of the nanofluid
ρ_f	Density of the base fluid
ρ_s	Density of the solid nano particles
μ_{nf}	Dynamic viscosity of the nanofluid
μ_f	Dynamic viscosity of the nanofluid
υ_f	Kinematic viscosity of the base fluid
ϕ	Volume fraction of nano particles
β_{nf}	Coefficient of thermal expansion of the nanofluid due to temperature difference
g	Acceleration due to gravity
T	Temperature of the fluid
T_∞	Ambient temperature of the fluid
T_w	Temperature of the fluid near the plate
β^*_{nf}	Coefficient of thermal expansion of the nanofluid due to concentration difference
C	Concentration of the fluid
C_∞	Ambient concentration of the fluid
C_w	Concentration of the fluid near the plate
k	Dimensioned permeability of the porous medium.
B_0	Uniform magnetic field
σ_{nf}	Electrical conductivity of the nanofluid
σ_f	Electrical conductivity of the base fluid
σ_s	Electrical conductivity of the solid nano particles
α_{nf}	Thermal diffusivity of the nanofluid
α_f	Thermal diffusivity of the base fluid
$(c_p)_{nf}$	Specific heat capacity of the nanofluid at constant pressure
q_r	The radiative heat term
Q	The temperature dependent volumetric rate of heat source
k_{nf}	Thermal conductivity of nanofluid
k_f	Thermal conductivity of the base fluid
k_s	Thermal conductivity of the solid nano particles
D_B	Chemical molecular diffusivity
k_l	Dimensioned chemical reaction parameter
N_c	Convective parameter
N_d	Diffusive parameter
V	Velocity of the fluid
θ	Dimensionless temperature
ψ	Dimensionless concentration
S	Suction/injection parameter
M	Magnetic field parameter
R	Rotational parameter
K	Dimensionless permeability parameter of the porous medium
Q_H	Dimensionless heat source parameter
F	Thermal radiation parameter
Kr	Dimensionless chemical reaction parameter
Pr	Prandtl number