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VISCOUS DISSIPATION EFFECT FOR DOUBLE DIFFUSIVE FREE CONVECTION FLOW ALONG A VERTICAL PLATE EMBEDDED IN A POROUS MEDIUM SATURATED WITH A NANOFLUID

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ABSTRACT

Studies of the double diffusive natural convection in the presence of a porous medium are currently subject to an interest ever accru. This interest is due to the many engineering applications (microelectronics, oceanography, underground burial of radioactive waste, Chemistry processes...), Nield and Bejan [2006] and Buongiorno and Hu [2005]. However, the need to improve the heat transfer led to the development of nanofluids (the term was introduced by Choi [1995]) and significant interest to understand certain effects on the heat and mass transport in porous medium.

A numerical analysis was performed to study the effects of combined double diffisive and viscous dissipation under non-uniform wall boundary conditions over a semi-infinite vertical plate embedded in a non-Darcy porous medium. Coupled heat and mass transfer of free convective boundary layer with viscous nanofluid are considered. The model used for the nanofluid includes the effects of Brownian motion and thermophoresis mechanisms, while the Darcy-Forchheimer model is used for the porous medium. Double-diffusion is governed by the conservation of mass, momentum, energy and concentration of species and nanoparticles equations, by employing Oberbeck-Boussinesq approximation and boundary layer for the nanofluid. Based on the model developed by Nield and Kuznetsov [2011], the local thermal equilibrium in the homogeneous porous medium is also supposed. The governing partial differential equations are transformed into the ordinary differential equations using an appropriate similarity transformations and the resulting system of equations is then solved numerically by an the finite-difference method via bvp4c solver. To validate the numerical results, comparison is made with those available and a good agreement is obtained, Nield and Kuznetsov [2011], Murthy and al. [2013]. In order to get a clear insight on the physics of the problem, a parametric study is performed and the obtained numerical results are displayed with the help of graphical illustrations, for some parameters are shown in Figures. And how the governing parameters of the problem affect the local Nusselt number Nu_x, the local regular Sherwood number Sh_x and the local nanoparticle Sherwood number Sh'_x are discussed.

Keywords: Heat and mass transfer; porous media; nanofluid; viscous dissipation.

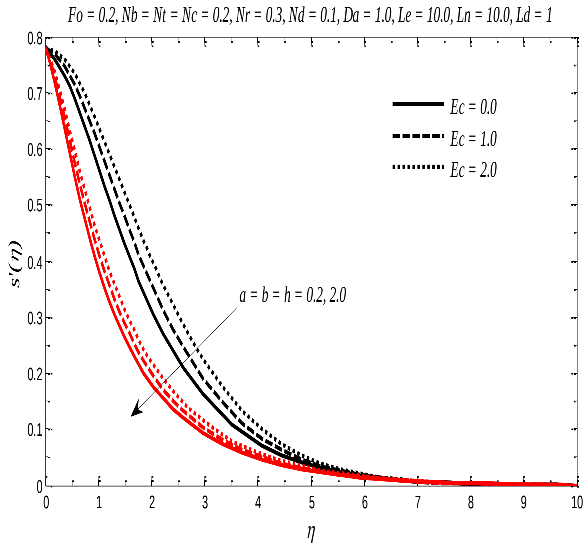

Fig. 1 Effect of *Ec* and *a b h* on velocity profile

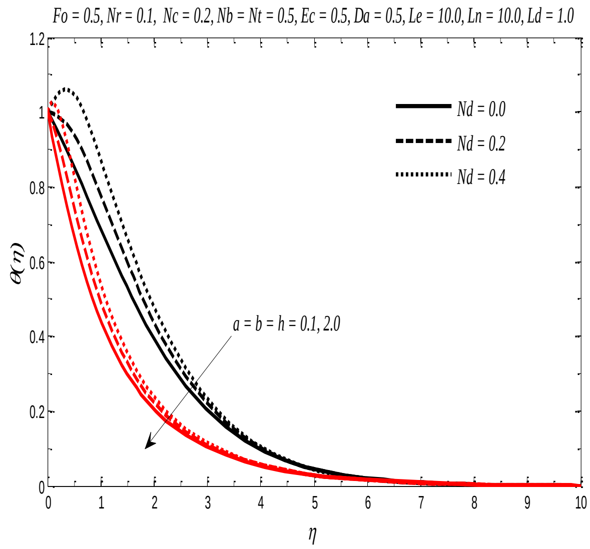

Fig. 2 Effect of *Nd* and *a b h* on temperature

Table 2

Values of $Nu_x/Ra_x^{1/2}$, $Sh_x/Ra_x^{1/2}$ and $Sh'_x/Ra_x^{1/2}$ for selected values of *a*, *b*, *h*, *Ec* and *Nt* with (*Fo=0.3, Nc=Nr=0.5, Nb=0.2, Nd=0.1, Le=Ln=5.0, Ld=1.0, Da=1.0).*

a=b=h	*Ec*	$Nu_x/Ra_x^{1/2}$			$Sh_x/Ra_x^{1/2}$ (regular)			$Sh'_x/Ra_x^{1/2}$ (nanofluid)		
		Nt=0.1	*Nt*=0.3	*Nt*=0.5	*Nt*=0.1	*Nt*=0.3	*Nt*=0.5	*Nt*=0.1	*Nt*=0.3	*Nt*=0.5
0.0		0.2472	0.2190	0.1941	1.0380	1.0515	1.0640	1.0583	1.0382	1.0141
0.5	1	0.4366	0.4034	0.3747	1.5898	1.6009	1.6105	1.6369	1.5612	1.5087
1		0.5730	0.5338	0.4999	2.0123	2.0240	2.0338	2.0763	1.9685	1.8878
	0	0.4749	0.4407	0.4110	1.5604	1.5700	1.5782	1.6186	1.5193	1.4441
0.5	1	0.4366	0.4034	0.3747	1.5898	1.6009	1.6105	1.6369	1.5612	1.5087
	2	0.4041	0.3726	0.3455	1.6138	1.6254	1.6351	1.6520	1.5940	1.5569

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