Spatially intricacies non-uniform internal heating on thermomagnetic porous convection

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1. INTRODUCTION & OBJECTIVE

During the recent decades, the magnetic and electric fields applications in fluid flow control expanded a significant noticed with projections in areas such as medicine, chemical engineering, nuclear fusion, high speed noiseless printing etc. Thermomagnetic porous convection, often known as magnetic fluids, is the subject of this study. It occurs in ferrofluid (FF) layers. The effects of uniform heat source with uniform vertical magnetic field are considered and many studies related to porous convection are discussed in [1]-[4]. In this problem, some individual cases are investigated on spatially intricacies non-uniform internal heating on thermomagnetic porous convection in a FF layer. Here, we considered two cases, where the heat source varies constantly with height. For the first example, (i) the heat source strength distribution varies about the mean in a linear manner and so is anti-symmetric on the mid-layer plane. In the second example, (ii) the heat source strength varies on the mean in a quadratic symmetric manner. For each example, we treated as two cases of temperature bounding surfaces: Case (A) both the surfaces at isothermal; Case (B) lower at isoflux and upper at isothermal set. It is found that the ratio of gravitational force to the viscous force decreases as the magnetic field increases.

2. GOVERNING STABILITY EQUATIONS

A horizontal layer of FF-saturated porous of thickness d and spatially heated internally is considered. The lower and upper surfaces are rigid, which are either held at the same temperature T_0 (isothermal) or at constant heat flux $\partial T/\partial z = C$ (isoflux) at the lower surface. The governing linear stability equations in dimensionless form can be stated as the following [1] and [4]:

$$\left[\frac{1}{\Pr}\omega-\left(D^2-a^2\right)+\frac{1}{Da}\right]\left(D^2-a^2\right)W=-\left[1+M_1R_g\,G(z)\right]a^2\Theta+M_2R_g\,G(z)a^2D\Phi \quad (1)$$

$$A\omega\,\Theta=R_gG(z)W+\left(D^2-a^2\right)\Theta \quad (2)$$

$$\left(D^2-M_3a^2\right)\Phi=\frac{M_1}{M_2}D\Theta \quad (3)$$

where, $\Pr=\mu(\rho c)_f/\rho_0\kappa$ is the Prandtl number, ω is the growth rate, $Da=k_1/d^2$ is the Darcy number, $R_g=\rho_0\alpha_t g\beta d^4/\mu_f\kappa_t$ is the gravitational Rayleigh number, $M_1=\mu_0\mu\kappa\chi^2H_0^2/\left(\rho_f g\alpha T_0\right)^2 k_m d^2\left(1+\chi\right)$ and $M_2=\mu_0\chi H_0^2/\rho_f g\alpha d T_0$ are the magnetic parameters, $M_3=\left(1+M_0/H_0\right)/(1+\chi)$ is the non-linearity of fluid magnetization.

$G(z)=-\left(1/R_g\right)\left(dT_b/dz\right)$. $T_b=32\,R_g\left[z-z^2-\frac{\varepsilon_1}{6}\left(z-3z^2+2z^3\right)\right]$ and $T_b=32\,R_g\left[1-z^2-\frac{\varepsilon_1}{6}\left(1-3z^2+2z^3\right)\right]$.

The boundaries are
Case A: $W=DW=\Theta=0$ at $z=0,\ 1$ (isothermal/isothermal)
Case B: $W=DW=D\Theta=0$ at $z=0$, (isoflux)

$W=DW=\Theta=0$ at $z=1$ (isothermal)

with $D\Phi=a\Phi/(1+\chi)$ at $z=0$ and $D\Phi=-a\Phi/(1+\chi)$ at $z=1$.

3. RESULTS & HIGHLIGHTS

Theoretically, the effects of two different thermal boundary condition techniques on thermomagnetic porous convection in an FF layer of linear and quadratic variations of internal heating are examined. The critical eigenvalues are extracted using the Galerkin approach, which is based on the weighted residual method. The thermal boundary surfaces of the (i) lower and upper in the isothermal case and (ii) lower in the isoflux and upper in the isothermal case are the subjects of this discussion. We found that linear variation of source strength in isoflux/isothermal case (Case-B), R_{gc} increases as the non-uniformity parameter (ε) increases. For isothermal/isothermal case (Case-A), R_{gc} varies insignificantly stabilizing and destabilizing tendencies results from the source strength in linear variation approximately balance each other. An increase of Da^{-1}(Fig. 1) and Λ(Fig. 2) helps to the stabilizing process and the opposite outcome can be seen in when increasing in M_1(Fig. 3) and M_3(Fig. 4). It is worth mentioning that the critical gravitational number R_{gc} recorded for isothermal/isothermal bounding surfaces is the highest, this indicates that the more stable compared to the isoflux/isothermal case.

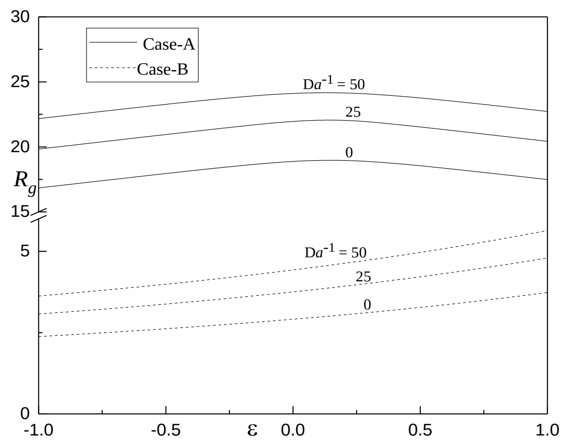

Fig. 1

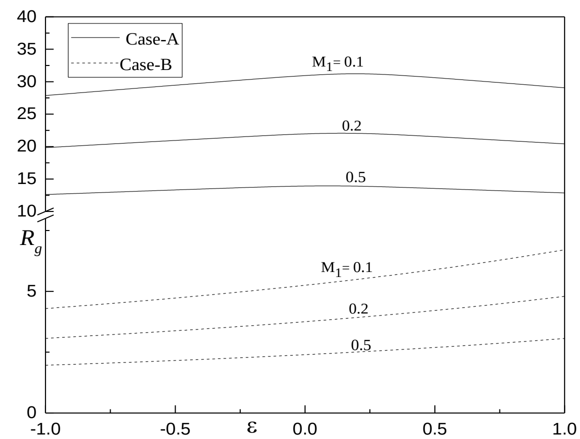

Fig. 3

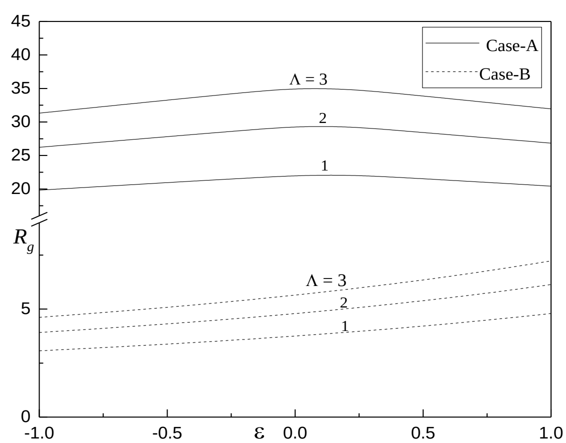

Fig. 2

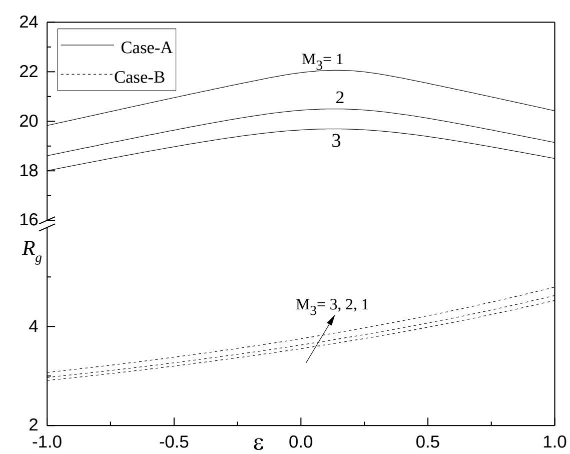

Fig. 4

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