Penetrative electroconvective instability in a saturated porous layer heated from above and within

Savitha B[1]
[1]Department of Mathematics, RajaRajeswari College of Engineering , Bengaluru 560074, Karnataka, India
Email: savibraj@gmail.com

1. INTRODUCTION & OBJECTIVE

Convective instability problems are studied by buoyancy force in the existence of vertical electric is called electrothermal convection (ETC). A electroconvective instability system in which the penetration of boundary conditions between stabilized and destabilized occurs in that of dielectric fluid (DEF) contained between saturated porous layers. Theoretical investigations of this situation were carried out by several authors [1-3]. Joule heating caused by passing AC electric field through electrolyte was used as the non-uniform temperature distribution and heat transport during rotating saturated porous layer were made. The current paper deals with theoretical aspects of the problem of penetrative ETC in a layer of DEF- -saturated porous heated from above and within. The critical stability parameters are the eigenvalue problem is solved numerically over a large of relevant physical parameters. Implications for ETC in a saturated porous layer are discussed.

2. THE GOVERNING EQUATIONS

Consider a horizontal infinite layer of DEF in the existence of AC electric field $\vec{E}$ contained between $z=0$ and $z=d$ which are maintained at fixed temperature: $T=T_0$ at $z=0$; $T=T_0+\Delta T$ at $z=d$, where ΔT can be positive, negative or zero and the gravity $\vec{g}=(0,0,-g)$ taken to be pointing downwards. The layer is filled with a porous medium within uniform incompressible fluid. The governing equations of Brinkmann type of dielectric fluid are[ref]:

$$\nabla\cdot\vec{q}=0$$

$$\rho_0\left[\frac{1}{\varepsilon}\frac{\partial\vec{q}}{\partial t}+\frac{1}{\varepsilon^2}\left(\vec{q}\cdot\nabla\right)\vec{q}\right]=-\nabla p+\rho_0\left\{1-\alpha\left(T-T_0\right)\right\}\vec{g}-\frac{\mu_f}{k}\vec{q}+\tilde{\mu}_f\nabla^2\vec{q}-\frac{1}{2}\left(\vec{E}\,.\,\vec{E}\right).\nabla\varepsilon$$

$$\rho_0 C_p\frac{\partial T}{\partial t}+(\vec{q}\cdot\nabla)T=\kappa\nabla^2 T+Q$$

$$\nabla\times\vec{E}=0,\quad \vec{E}=-\nabla\phi$$

$$\nabla\cdot\varepsilon_0[1-\gamma(T-T_0)]\vec{E}=0$$

where, the physical quantities have their usual meanings in the ETC. These equations are non-dimensionalized according to the scaling's. and then exchange of stability holds, the following equations for the amplitudes at marginal stability:

$$\left[\Lambda\left(D^2-a^2\right)-Da^{-1}\right]\left(D^2-a^2\right)W=a^2R_t\Theta+a^2R_e\left(G-z+1/2\right)(DV+\Theta)$$

$$\left(D^2-a^2\right)\Theta-\left(G-z+1/2\right)W=0$$

$$\left(D^2-a^2\right)V+D\Theta=0$$

where, thermal Rayleigh number, $R_t=\alpha\,g\,Q\,d^5/\nu\kappa k$ and AC electric Rayleigh number $R_e=R_t\times El=\varepsilon_0E_0^2\eta^2Q^2d^6/k^2\kappa\mu$, $G=\dfrac{1}{2Ns}=\dfrac{\Delta TK}{Qd^2}$ is a dimensionless quantity describing the ratio of the imposed temperature difference to that due to internal heating.The boundary conditions are at (i) no-slip (rigid-rigid) $W=DW=\Theta=V=0$ at $z=0,\ 1$, and (ii) free-slip (free-free) $W=D^2W=\Theta=DV=0,$ at $z=0,\ 1$.

3. RESULTS & HIGHLIGHTS

Penetrative ETC in a dielectric fluid-saturated porous layer heated from within and above is investigated through internal heat source strength. The problem of eigenvalue is solved for several physical parameter values using the "higher order Galerkin" method with different physical parameters. For the range of $G < -0.3$ (see Fig.1) is to hasten the onset of penetrative ETC while an opposite trend is observed for $G > -0.3$(Fig.2) when strength of the electric field $El \geq 2$. The more stable system with increasing in Da^{-1}(Fig.3), El (Fig.4) and Λ(Fig.5).

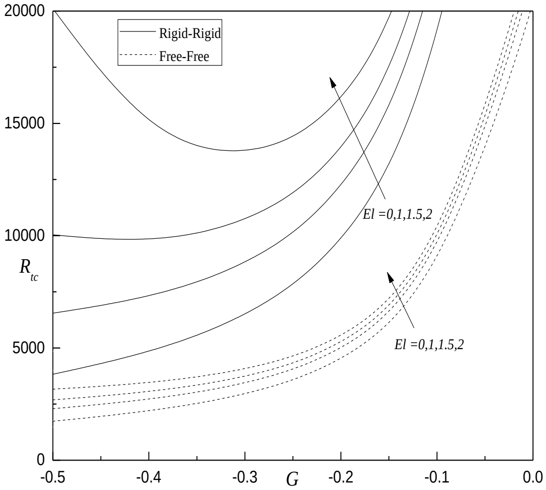

Fig. 1 Variation of R_{tc} verses *G* (< 0) for different *El* when $Da^{-1} = 5$ and $\Lambda = 1$

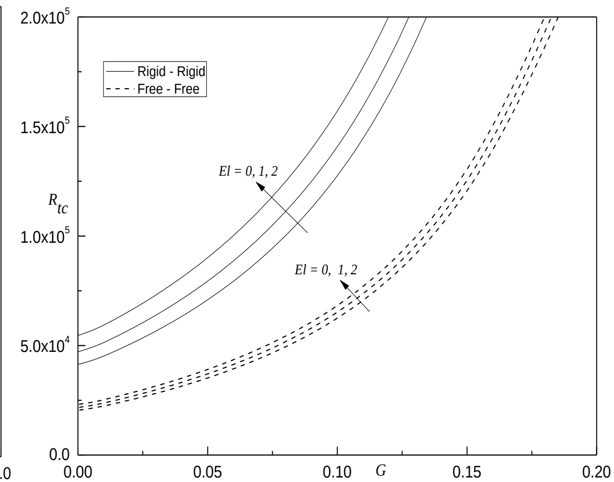

Fig.2 Variation of R_{tc} verses *G* (> 0) for different *El* when $Da^{-1} = 5$ and $\Lambda = 1$

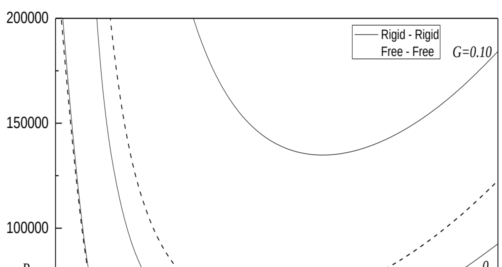

Fig .3 Neutral curves for different *G* when $Da^{-1} = 5$, $El = 1$ and $\Lambda = 1$

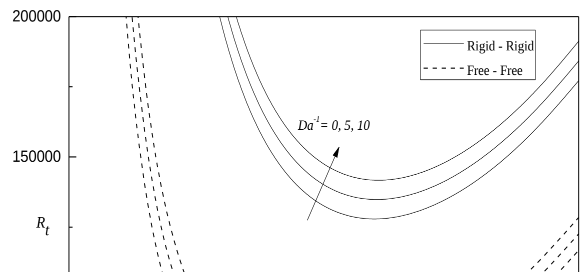

Fig.4 Neutral curves for different Da^{-1} when $G = 0.10$, $El = 1$ and $\Lambda = 1.5$

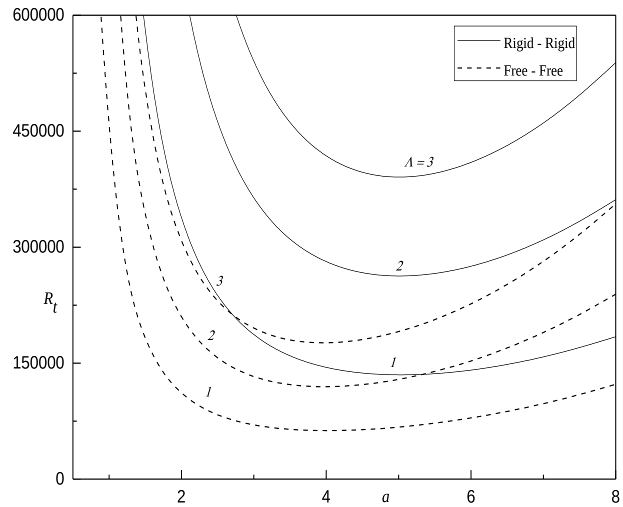

Fig.5 Neutral curves for different Λ when $G=0.10$, $El=1$ and $Da^{-1}=5$

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