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Natural Convection Flow in Sinusoidally Heated Porous Enclosure

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ABSTRACT

Natural convection flow in a cavity filled with a porous media is investigated numerically using Brinkman–extended Darcy model. The flow is caused by heating at lower half of the left vertical wall and cooling at upper half of the right vertical wall with the horizontal and rest of walls are insulated. The temperature of heating is varying by sinusoidal profile. The problem is analyzed for different values of Rayleigh number 103 ≤ Ra ≤ 106 and different values of aspect ratio 1≤ Ar ≤ 4. The numerical results show that the heat transfer is mainly due to the conduction at low Rayleigh numbers Ra ≤ 106. The convection becomes gradually dominant as the Rayleigh number increases and as the aspect ratio decreases. Heat transfer increases with increasing Rayleigh number Ra and enhanced at aspect ratio Ar = 2, when the convection regime is dominated.

Keywords: Natural Convection, Porous Medium, Sinusoidal Temperature Profile,

1. Introduction

The effects of partially heating on natural convection in rectangular enclosure filled with porous media are investigated by many researchers. Mainly Alam et al. [1] studied natural convection in a square cavity partially heated and cooled on vertical walls, and Abdelkareem et al. [2] investigated experimentally the oscillatory motion of natural convection using a Hele-Shaw cell technique. The main purpose of the present study is to consider the natural convection flow in a rectangular cavity filled with a fluid-saturated porous medium with partially and non-uniformly heated wall, for different Rayleigh numbers and different amplitudes of sinusoidal temperature profile. The implication of this study is the control of convective fluxes and temperatures in porous cavities.

2. Experimental

A schematic of physical model and boundary conditions are shown in Figure 1. Temperature distributions applied on the partial left and right vertical sides is given respectively by:

$$\left.\begin{array}{l} T\left(y\right) = T_{ref} + A\,\Delta T\,\sin(2\pi y/H) \\ T\left(y\right) = 0 \end{array}\right\}$$

The finite control volume method has been used to solve numerically the governing conservative equations of mass, momentum and energy. The SIMPLE algorithm based pressure-correction method is used to couple the momentum and continuity equations.

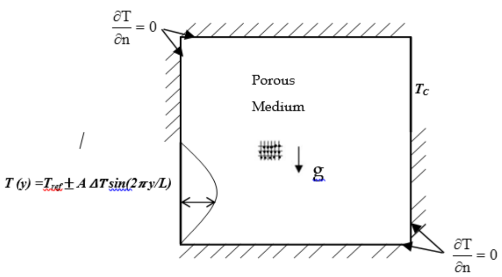

Figure 1: Schematic illustration of physical model under consideration

The SIMPLE algorithm based pressure-correction method is used to couple the momentum and continuity equations.

3. Results and Discussion

The figures 2 and 3 summarize the variations of the local and average Nusselt numbers with the Rayleigh number for different values of amplitude for heating A. It is observed that Nusselt numbers increases with

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increasing, Ra and A. The figures 4 and 5 show that the convection becomes gradually dominant as the Rayleigh number increases and as the aspect ratio decreases

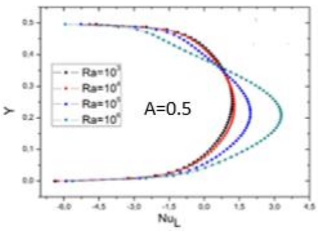

Figure 2: Variation of the local Nusselt number with Rayleigh number for A=0.5

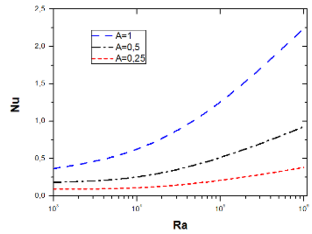

Figure 3: Variation of the mean Nusselt number with Ra and different values of A

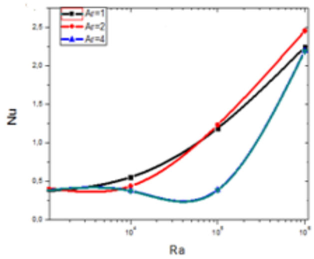

Figure 4: Variation of mean Nusselt number with the Rayleigh number for different values of aspect ratio

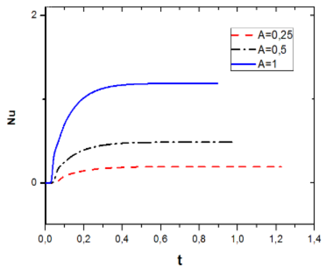

Figure 5 :Variation of mean Nusselt number with time for different values of amplitude A

4. Conclusions

The numerical results show that the heat transfer is mainly due to the conduction at low Rayleigh numbers Ra ≤ 106. The conduction heat transfer regime has also indicated for low amplitudes of sinusoidal functions of temperatures. The convection becomes gradually dominant as the Rayleigh number increases and as the aspect ratio decreases. Heat transfer increases with increasing Rayleigh number Ra and enhanced at aspect ratio Ar = 2, when the convection regime is dominated.

References

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