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Free Convection In A Square Cavity Partially Filled With Porous Media With Spatial Wall Temperature

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Abstract

Free convective fluid flow and heat transfer in cavity domains has received considerable attention over the past few years and the importance of this problem is due to the broad spectrum of industrial applications and environmental situations. It has clearly been used in geothermal systems, thermal insulation, etc. Joseph (1967) investigated the simple situation of the boundary conditions between a porous media and a homogeneous fluid. Singh and Thorpe (1995) conducted a comparative study of different models for the investigation of natural convection in a confined fluid and overlying porous layer. The problem of free convective in close cavities with boundary walls having non-uniform temperatures have been considered in several studies. Saeid and Mohamad (2005) studied numerically the natural convection in a porous cavity with spatial side-wall temperature variation using finite element method. The aim of this study is to investigate the effect of Darcian free convective heat transfer in a square cavity partially filled with porous media with spatial side-wall temperature. The left vertical wall is implicit to consume side-wall temperature, which is greater than the the right vertical wall. While the horizontal walls are adiabatic, as presented in Figure 1. The governing parameters of present Rayleigh number, Darcy number, wave number, and porous layer thickness. It is found that when the wave number increases, the expansion of the streamline circulation cell tend to increases horizontally. The isotherm patterns are raised with high intensity and with irregular-shaped next to the left wall by the increase of the wave number, while near to the cold wall, the isotherm patterns occur with vertical lines, as shown in Figure 2. Figure 3 illustrates the effect of various porous layer thickness on the average Nusselt number with Rayleigh number. The convection heat transfer enhancement occurs significantly at higher Rayleigh number, while low Rayleigh number values have less effect on the heat transfer rate. The heat transfer rate decreases for higher Rayleigh number. Increasing Rayleigh number leads to increase the average Nusselt number, due the fact that the fluid has higher thermal conductively than porous, the smaller porous thickness layer has stronger effect on the heat transfer rate which has higher average Nusselt number. Figure 4 displays the effect of various Darcy number on the average Nusselt number with wave number. We find that the convection heat transfer significantly increasing for lower wave number values, increasing the wave number tends to decrease and then increase the average Nusselt number, the heat transfer rate in the form of wavy lines, due to the effect of the non-uniform heating. The stronger heat transfer appears with lower Darcy number values, which has the maximum average Nusselt number.

Reference

Beavers, G. S. and Joseph, D. D., Boundary conditions at a naturally permeable wall, Journal of Fluid Mechanics, vol. 30, no. 01, pp. 197–207, 1967.

Singh, A. and Thorpe, G., Natural convection in a confined fluid overlying a porous layer-a comparison study of different models, Indian Journal of Pure and Applied Mathematics, vol. 26, pp. 81–95, 1995.

Saeid, N. H. and Mohamad, A., Natural convection in a porous cavity with spatial sidewall temperature variation, International Journal of Numerical Methods for Heat & Fluid Flow, vol. 15, no. 6, pp. 555–566, 2005.

Figures used in the abstract

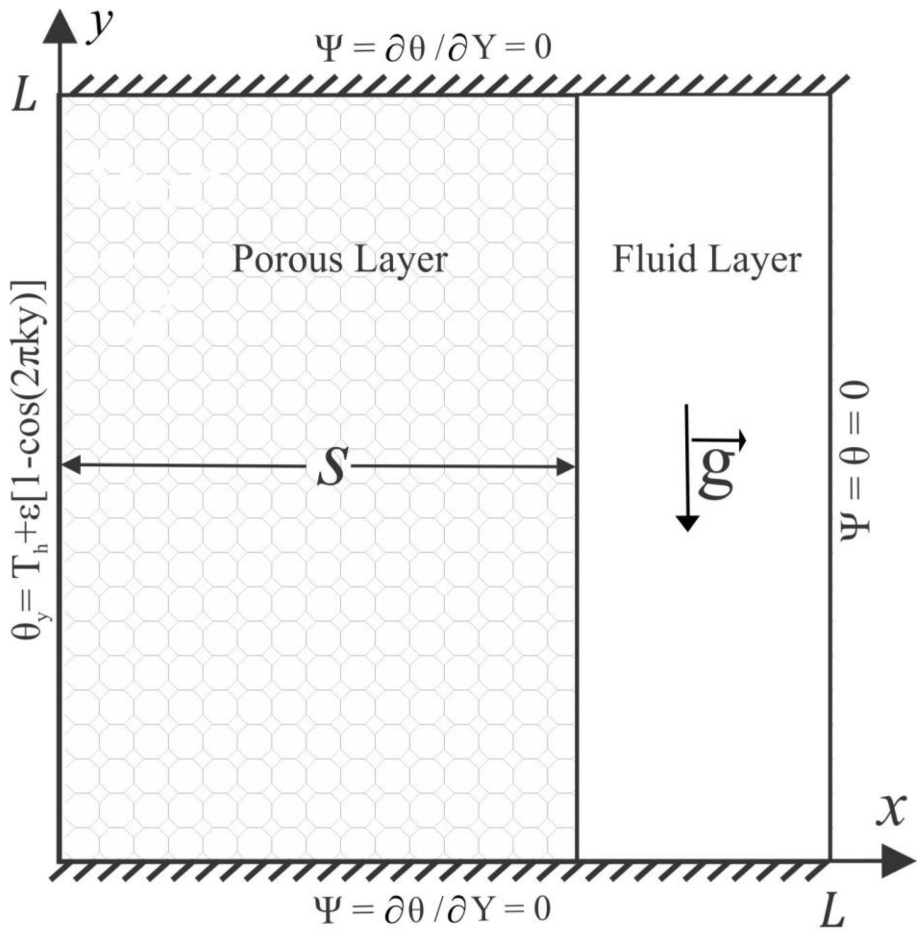
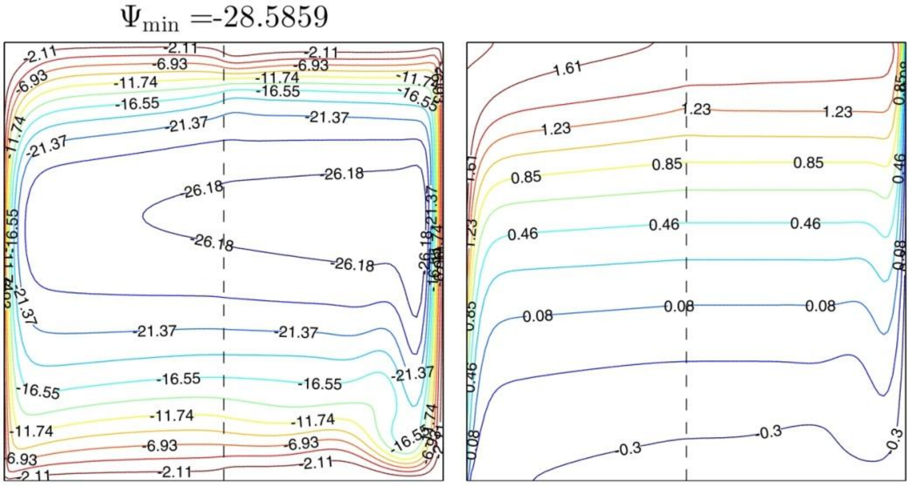
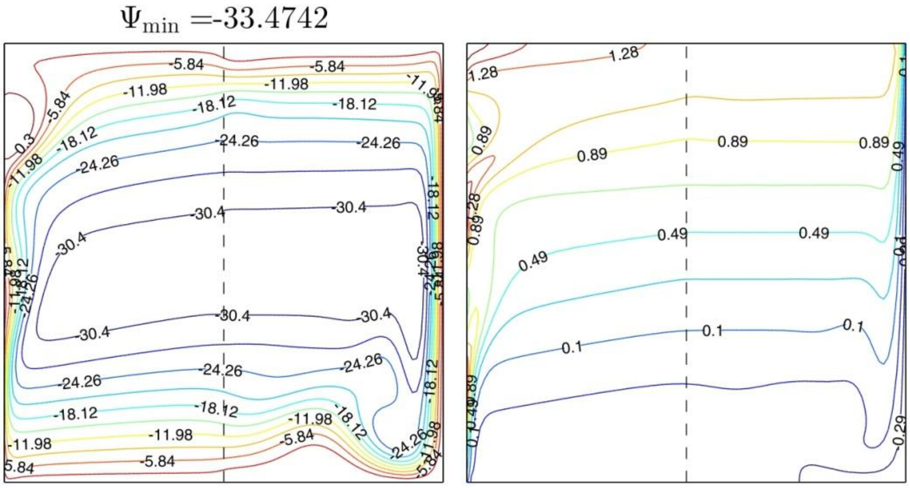


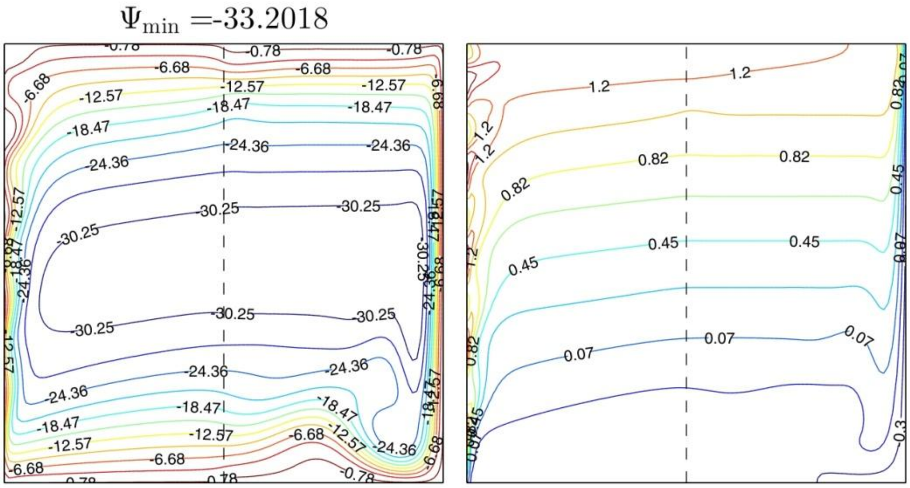
Figure 1: Physical model of convection in a square cavity together with the coordinate system.



(a) $k = 0.7$



(b) $k = 2.5$



(c) $k = 5$

Figure 2: Streamlines (left) and isotherms (right) evolution by wave number for Rayleigh number=10^7, Darcy number=10^-4, non-dimensional amplitude=0.5 and porous layer thickness=0.5.

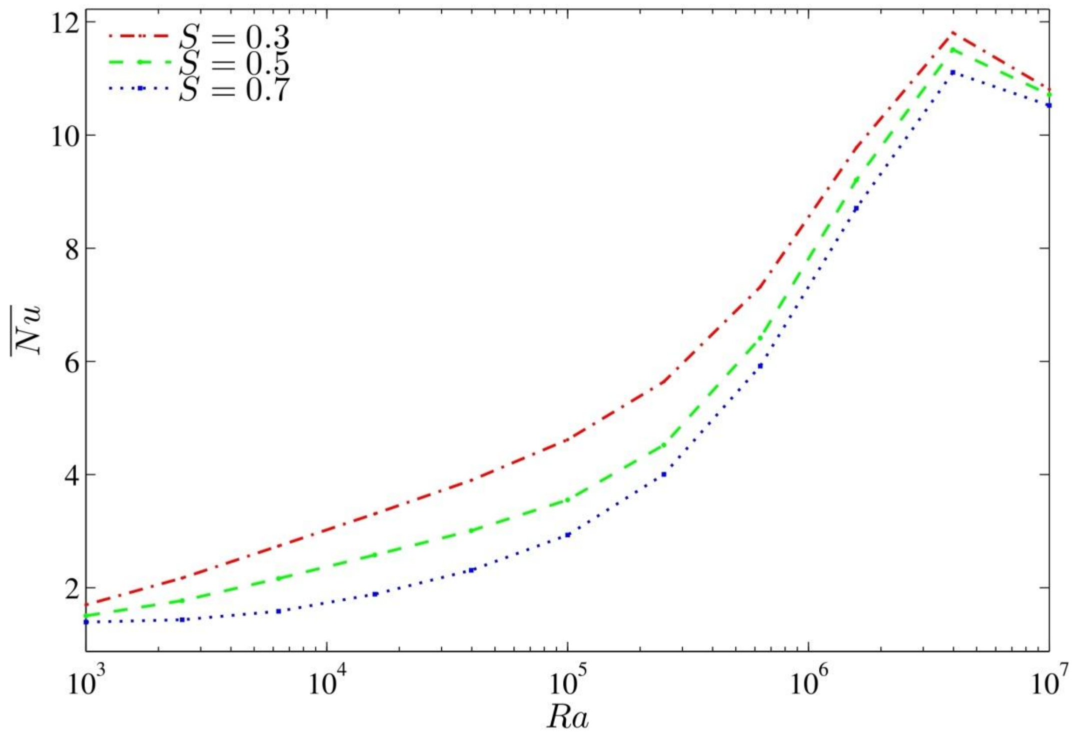


Figure 3: Variation of the average Nusselt number interfaces with Rayleigh number for different porous layer thickness at Darcy number=10^-4, wave number=2.5 and non-dimensional amplitude=0.5.

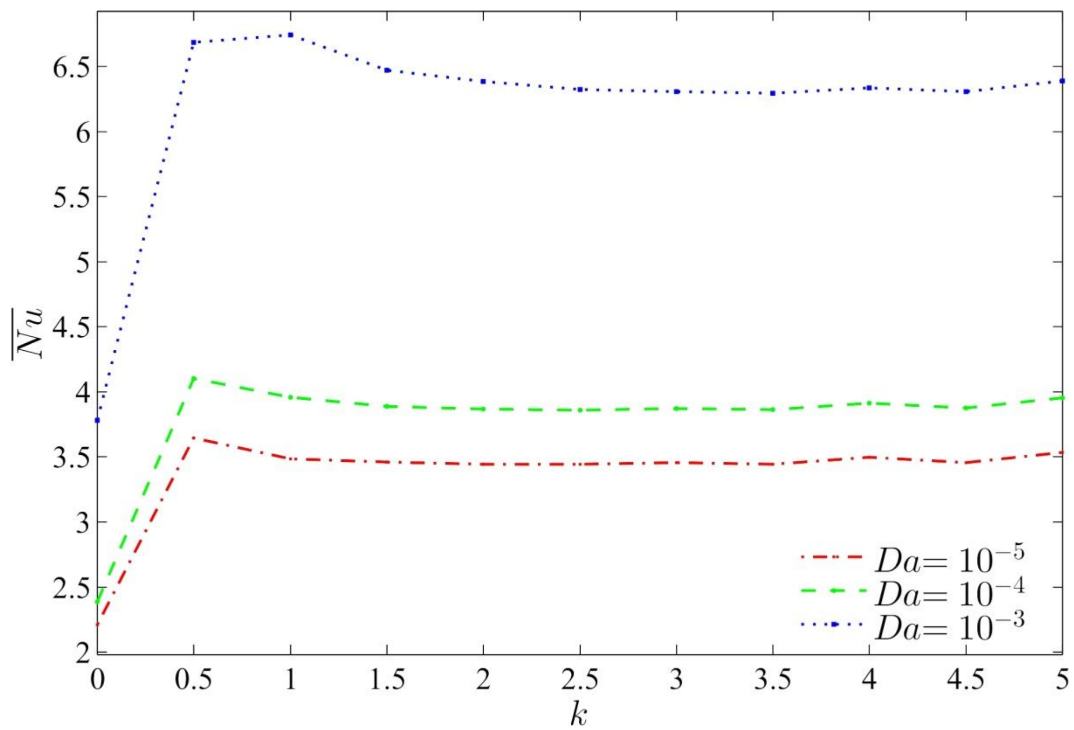


Figure 4: Variation of the average Nusselt number interfaces with wave number for different Darcy number at Rayleigh number=10^5, non-dimensional amplitude=0.5 and porous layer thickness=0.5.