



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: A
ELECTRICAL AND ELECTRONICS ENGINEERING

Volume 17 Issue 4 Version 1.0 Year 2017

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Heat and Mass Transfer in Porous Cavity: Opposing Flow

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Abstract- Heat and mass transfer in porous medium is one of the important topics of study due to its varied applications. The current work is undertaken to understand the heat and mass transfer behavior in a porous cavity subjected to opposing flow controlled by two opposing buoyancy i.e. thermal and concentration buoyancy. The left vertical wall of the cavity is maintained at isothermal temperature T_w and concentration C_w , whereas the right vertical wall is exposed to lower temperature T_c and concentration C_c . The top and bottom surfaces of cavity are kept adiabatic such that no heat or mass transfer can cross the boundary. The investigation is particularly focused to study the effect of negative values of buoyancy ratio indicating opposing flow. The heat and mass transfer behavior is studied for various physical parameters such as Lewis number, Rayleigh number etc.

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GJRE-A Classification: FOR Code: 091399p



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Heat and Mass Transfer in Porous Cavity: Opposing Flow

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Abstract- Heat and mass transfer in porous medium is one of the important topics of study due to its varied applications. The current work is undertaken to understand the heat and mass transfer behavior in a porous cavity subjected to opposing flow controlled by two opposing buoyancy i.e. thermal and concentration buoyancy. The left vertical wall of the cavity is maintained at isothermal temperature T_w and concentration C_w , whereas the right vertical wall is exposed to lower temperature T_c and concentration C_c . The top and bottom surfaces of cavity are kept adiabatic such that no heat or mass transfer can cross the boundary. The investigation is particularly focused to study the effect of negative values of buoyancy ratio indicating opposing flow. The heat and mass transfer behavior is studied for various physical parameters such as Lewis number, Rayleigh number etc.

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I. INTRODUCTION

Recent development in the field of heat and mass transfer through porous medium has led to the intensive research, as a result of that, many researchers have shown significant interest to explore the various aspects during the last few decades. The fundamental concept about the flow through porous medium and various applications encompassing it has been well documented by the recently published books by Nield and Bejan [1], Ingham and Pop [2], Vafai [3], Pop and Ingham [4] and, Bejan and Kraus [5]. The various aspects of the convective heat transfer pertaining to the various physical and geometrical parameters, is thoroughly discussed in the available literature [6-29]. Especially the double diffusion phenomenon, which finds various industrial and technological applications such as; drying of vegetables, drying of seeds, migration of pollutants through soil, cooling of nuclear reactor and many more, has made eminent researchers to delve in to this particular area, to understand the micro details of the

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subject. It is evident from the literature that the specific geometries such as cavities find special applications in industries, therefore the research pertaining to the flow through porous cavities is of significant importance which is reflected in the literature [31-35]. The present work is an extension of [24] where only assisting flow was analyzed. The current work tries to understand the double diffusion due to opposing flow.

The mathematical model of square porous cavity and its relevant equations are given in [24]. It should be noted that the current work focuses only on opposing flow caused by negative value of buoyancy ratio where thermal and concentration buoyancy opposes each other.

II. RESULTS AND DISCUSSION

The results are discussed with respect to isotherms and iso-concentration lines in the porous medium. Figure 1 shows the heat and mass transfer behavior in terms of temperature, concentration and streamlines. The left column of figure corresponds to $N=-0.2$ where as right column belongs to $N=-0.5$. The whole figure is obtained by maintaining $Ra=100$, $Rd=0.5$ and $Le=5$. It is found that the isotherms move towards the hot surface due to change in N from -0.2 to -0.5. This indicates that as the magnitude of two buoyancy forces increases the heat transfer rate increases. Similar effect is seen with respect to mass transfer also. The concentration lines moves towards the hot surface when magnitude of opposing buoyancy increases. The penetration of higher concentration deep into porous region increased due to change in N from -0.2 to -0.5.

III. CONCLUSION

Heat and mass transfer in a square porous cavity due to opposing buoyancy is studied. It is found that the heat transfer increases with increase in magnitude of opposing buoyancy forces. It is found that the mass transfer increases with increase in buoyancy forces.

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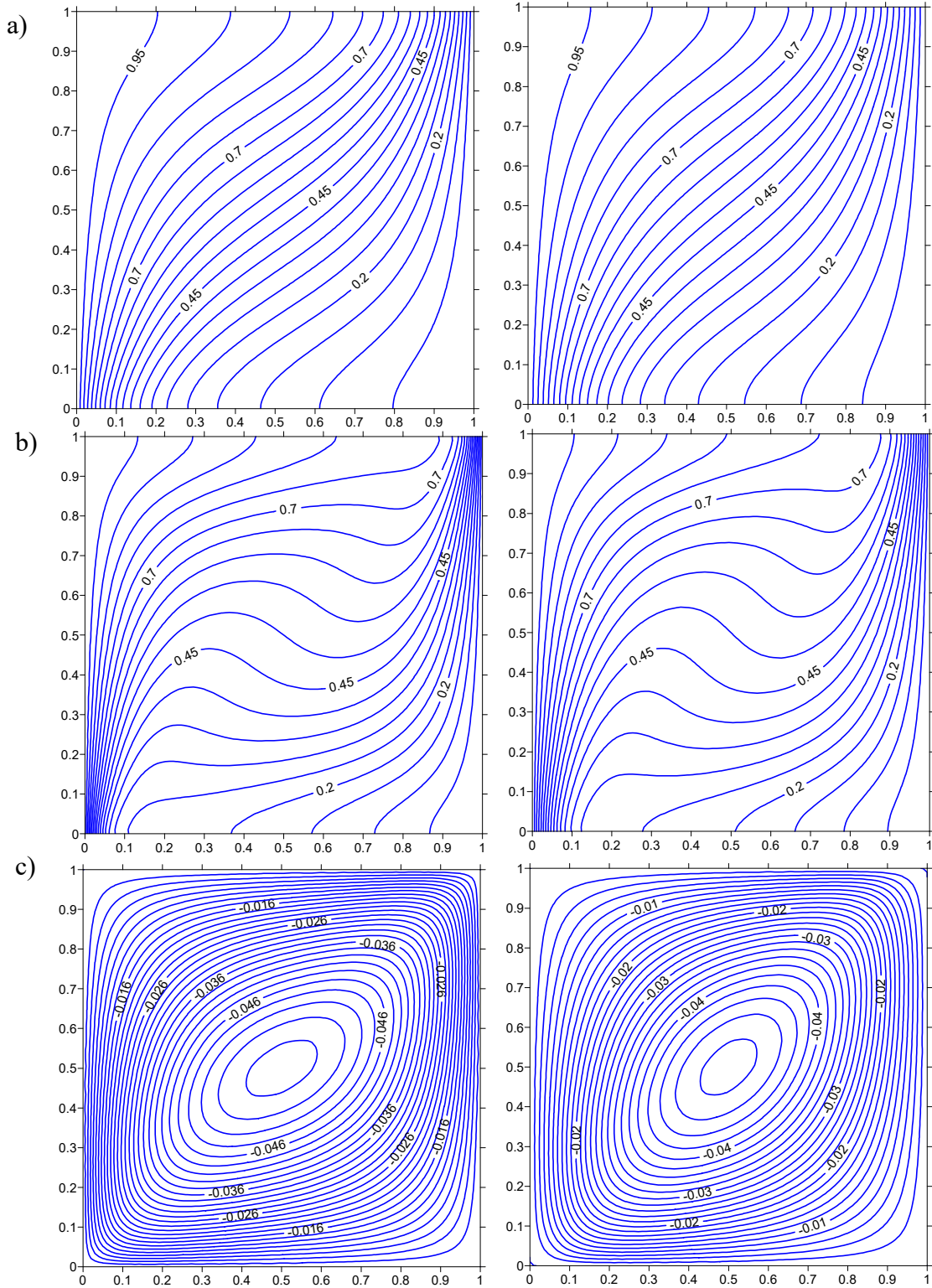


Figure 1: a) Isotherms b) Iso-concentration lines c) Streamlines at
Left $N = -0.2$ Right $N = -1$