Global Journals LaTeX JournalKaleidoscope™
Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

Heat and Mass Transfer in Porous Cavity: Opposing Flow

Abdulwahab A. Alnaqi[1]

[1] The Public Authority for Applied Education and Training

Received: 16 December 2016 Accepted: 5 January 2017 Published: 15 January 2017

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 Tw and concentration Cw, whereas the right vertical wall is exposed to lower temperature Tc and concertation Cc. 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 studies for various physical parameters such as Lewis number, Rayleigh number etc.

Index terms— porous media, opposing flow, finite element method.

1 I. Introduction

ecent 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 . 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 delved in to this particular area, to understand the micro details of the 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] **??**32] **??**33] **??**34] **??**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 focusses only on opposing flow caused by negative value of buoyancy ratio where thermal and concentration buoyancy opposes each other.

2 II.

3 Results and Discussion

The results are discussed with respect to isotherms and iso-concentration lines in the porous medium. Figure **??** 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.

4 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. [1] [2]

[1] R© 2017 Global Journals Inc. (US)
[2] © 2017 Global Journals Inc. (US)

radiation on double conjugate diffusion in a porous cavity, AIP Conference Proceedings 1728, 020283 (2016); doi: 10.1063/1.4946334.
28. Irfan Anjum Badruddin, N. J. Salman Ahmed, Abdullah A. A. A. Al-Rashed, Jeevan Kanesan, Sarfaraz Kamangar, H. M. T. Khaleed, Analysis of Heat and Mass Transfer in a Vertical Annular Porous Cylinder Using FEM, Transp. Porous Media, 91(2), 697-715(2012).
29. Trevisan, Osvair and Adrian Bejan, Combined heat and mass transfer by natural convection in a porous medium, Advances in Heat Transfer 20 315-352 (1990). 30. G.H.R. Kefayati, Simulation of double diffusive natural convection and entropy generation of power-law fluids in an inclined porous cavity with Soret and Dufour effects (Part I: Study of fluid flow, heat and mass transfer). Int. J. Heat Mass Transfer, Volume 94, March, Pages 539-581 (2016). 31. Soto-Meca, J. Serna, F.J.Velasco. Heat and mass transfer enhancement in a double diffusive mixed convection lid cavity under pulsating flow. Comp. & Chem. Engg. Jul 30 (2016). 32. R. Rebhi, M. Mamou, P. Vasseur, M.Alliche, Form drag effect on the onset of non-linear convection and Hopf bifurcation in binary fluid saturating a tall porous cavity. Int. J. Heat Mass Transfer. Sep 30; 100: 178-90 (2016). 33. C.S. Balla, K. Naikoti, Soret and Dufour effects on free convective heat and solute transfer in fluid saturated inclined porous cavity. Engg. Sci. Tech., Int. J. Dec 31; 18(4): 543-54 (2015). 34. K. Al-Farhany, A. Turan, Numerical study of double diffusive natural convective heat and mass transfer in an inclined rectangular cavity filled with porous medium. Int. commun. Heat Mass Transfer, Feb 29; 39(2): 174-81 (2012). 35. Serrano-Arellano J, Gijon-Rivera M. Conjugate heat and mass transfer by natural convection in a square cavity filled with a mixture of Air-CO 2. Int. J. Heat Mass Transfer, Mar 31; 70: 103-13 (2014).

Figure 1:

[] , 10.1063/1.4952363. http://dx.doi.org/10.1063/1.4952363

[] , 10.1063/1.4952361. http://dx.doi.org/10.1063/1.4952361

[] , 10.1063/1.4952360. http://dx.doi.org/10.1063/1.4952360

[Azeem et al.] T M Azeem , I A Khan , N Badruddin , Nik-Ghazali . *Mohd Yamani Idna Idris*, (Influence of)

[Badruddin et al. ()] I A Badruddin , T M Yunus Khan , Salman Ahmed , N J Sarfaraz Kamangar . 10.1063/1.4946740. *Effect of variable heating on double diffusive flow in a square porous cavity*, 2016. 1728 p. 20689.

[Badruddin et al. ()] 'Conjugate Heat Transfer in an Annulus with Porous Medium Fixed Between Solids'. I A Badruddin , N J Ahmed , N Al-Rashed , Nik-Ghazali , S Jameel , H M T Kamangar , T M Khaleed , Khan . *Transp. Porous media* 2015. 109 (3) p. .

[Khan ()] 'Conjugate heat transfer in porous annulus'. Khan . *J. Porous Media* 2014. 19 (12) p. .

[Pop and Ingham ()] *Convective heat transfer: Mathematical and computational modeling of viscous fluids and porous media*, D B Pop , Ingham . 2001. Pergamon, Oxford.

[Nik-Ghazali et al. (2014)] 'Dufour and Soret Effects on Square Porous Annulus'. N Nik-Ghazali , Irfan Anjum Badruddin , A Badarudin , S Tabatabaeikia . *Adv. Mech. Engg* January-December, 6. 2014. p. 209753.

[Badruddin et al. ()] 'Effect of viscous dissipation and radiation on natural convection in a porous medium embedded within vertical annulus'. I A Badruddin , Z A Zainal , Z Khan , Z Mallick . *Int. J. Therm. Sci* 2007. 46 (3) p. .

[Ting et al. ()] 'Entropy generation of viscous dissipative nanofluid flow in thermal nonequilibrium porous media embedded in microchannels'. T W Ting , Y M Hung , N Guo . *Int. J. Heat Mass Transfer* 2015. 81 p. .

[Irfan Anjum Badruddin1 et al. ()] 'Free convection and radiation characteristics for a vertical plate embedded in a porous medium'. Z A Irfan Anjum Badruddin1 , P A Zainal , K N Narayana , Seetharamu , Lam Weng , Siew . *Int. J for Num. Methd. in Engg* 2006. 65 (13) p. .

[Irfan Anjum Badruddin1 et al. ()] 'Free convection and radiation characteristics for a vertical plate embedded in a porous medium'. Z A Irfan Anjum Badruddin1 , P A Zainal , K N Narayana , Seetharamu , Lam Weng , Siew . *Int. J for Numerical Methods in Engineering* 2006. 65 (13) p. .

[Badruddin et al. ()] 'Free convection and radiation for a vertical wall with varying temperature embedded in a porous medium'. I A Badruddin , Z A Zainal , P A Narayana , K N Seetharamu , L W Siew . *Int. J. Therm. Sci* 2006. 45 (5) p. .

[Vafai ()] *Hand book of porous media*, K Vafai . 2000. New York: Marcel Dekker.

[Badruddin et al. ()] 'Heat transfer by radiation and natural convection through a vertical annulus embedded in porous medium'. I A Badruddin , Z A Zainal , P A Narayana , K N Seetharamu . *Int. Commun. Heat Mass Transfer* 2006. 33 (4) p. .

[A.D. Bejan, Kraus (ed.) ()] *Heat transfer handbook*, A.D. Bejan, Kraus (ed.) 2003. New York: Wiley.

[Ahmed et al. ()] 'Heat transfer in a conical cylinder with porous medium'. N J S Ahmed , I A Badruddin , Z A Zainal , H M T Khaleed , J Kanesan . *Int. J. Heat Mass Transfer* 2009. 52 p. .

[Badruddin et al. ()] 'Heat transfer in porous cavity under the influence of radiation and viscous dissipation'. I A Badruddin , Z A Zainal , P A Narayana , K N Seetharamu . *Int. commun. Heat Mass Transfer* 2006. 33 (4) p. .

[Irfan Anjum Badruddin and Quadir ()] 'Heat transfer in porous medium embedded with vertical plate: Non-equilibrium approach -Part A'. G A Irfan Anjum Badruddin , Quadir . *AIP Conf. Proc* 2016. 1738 p. 480124.

[Quadir and Irfan Anjum Badruddin ()] 'Heat transfer in porous medium embedded with vertical plate: Non-equilibrium approach -Part B'. G A Quadir , Irfan Anjum Badruddin . *AIP Conf. Proc* 2016. 1738 p. 480125.

[Badruddin et al. ()] 'Investigation of heat transfer in square porous-annulus'. I A Badruddin , A A A A Abdullah , N J S Ahmed , S Kamangar . *Int. J Heat Mass Transfer* 2012. 55 (7-8) p. .

[Irfan Anjum Badruddin and Quadir ()] G A Irfan Anjum Badruddin , Quadir . 10.1063/1.4952362. http://dx.doi.org/10.1063/1.4952362 *Heat and mass transfer in porous cavity: Assisting flow, AIP Conf. Proc*, 2016. 1738 p. 480126.

[Badruddin et al. ()] 'Natural convection in a square porous annulus'. I A Badruddin , A A A A Al-Rashed , N J S Ahmed , S Kamangar , K Jeevan . *Int. J. Heat Mass Transfer* 2012. 55 (23-24) p. .

[Nield and Bejan ()] D Nield , A Bejan . *Convection in Porous Media*, (New York) 2006. Springer Verlag. (3rd)

[Badruddin et al. ()] 'Numerical analysis of convection conduction and radiation using a non-equilibrium model in a square porous cavity'. I A Badruddin , Z A Zainal , P A Narayana , K N Seetharamu . *Int. J. Therm. Sci* 2007. 46 (1) p. .

[Irfan Anjum Badruddin and Quadir ()] 'Radiation and viscous dissipation effect on square porous annulus'. G A Irfan Anjum Badruddin , Quadir . *AIP Conf. Proc* 2016. 1738 p. 480127.

[Ahmed et al. ()] 'Study of mixed convection in an annular vertical cylinder filled with saturated porous medium, using thermal non-equilibrium model'. N J S Ahmed , I A Badruddin , J Kanesan , Z A Zainal , K S N Ahamed . *Int. J. Heat Mass Transfer* 2011. 54 p. .

[Badruddin et al. ()] 'Thermal non-equilibrium modeling of heat transfer through vertical annulus embedded with porous medium'. I A Badruddin , Z Zainal , P A Narayana , K N Seetharamu . *Int. J. Heat Mass Transfer* 2006. 49 p. .

[Ingham Pop (ed.) ()] *Transport phenomena in porous media*, D B Ingham, I Pop (ed.) (Pergamon, Oxford) 1998.