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Numerical Analysis of Natural Convection in Square Cavity at Aspect Ratio 1

Manoj Kumar Sahu, Pushparaj singh, Mahendra kumar patley

***Abstract*— In this research work natural convection in two dimensional square cavities is studied numerically for differently heated air filled square cavity. Vertical cavity with two adiabatic and one hot and cold wall at aspect ratio 1 have taken for investigation. Naturally the heat transfer was investigated over the wide range of Rayleigh number from 103 to 106 .the fluid media is air in between the closure wall and a correlation of average Nussalt number are proposed for vertical cases of square enclosure. Solutions are obtained for several Rayleigh numbers with Prandtl number Pr 0.70 and aspect ratio 1.**

***Index Terms*— CFD (computational fluid dynamic), AR (aspect ratio), Ra (Rayleigh Number).**

I. INTRODUCTION

The natural convection flow and heat transfer in rectangular enclosures are extensively Studied due to its diverse applications. In the vertical position enclosures can acts as insulation for doors and windows of buildings, air conditioning compartment of trains, industrial furnaces, chimney and many heat transfer equipments and in an inclined position it is used in skylights, roof windows, solar collector storage and many other solar applications. The present study is concern with

Natural convection heat transfer in vertical enclosures. The vertical enclosures consist of two glass panels set in a frame and separated by a small space. The gap between the glass panels is filled with air since air acts as insulator and air being a transparent medium allows light to pass through it.

II. PROBLEM IDENTIFICATION

The present study deals with two-dimensional natural convection taking place inside enclosed

Space. The enclosed cavity has differentially heated side walls and adiabatic top and bottom wall. In this problem the cavity is filled with air and the effect of conduction and radiation is neglected. The space between the enclosures is filled with air since air being transparent allows light rays to pass through it and also acts as insulator.

Properties of fluid air

PROPERTY	UNIT	METHOD	VALUES
Temperature	K	Constant	302.5
Density	Kg/M3	Boussinesq	1.15575
Specific heat	J/kgK	Constant	1005
Thermal conductivity	W/mk	Constant	0.02634
Viscosity	Kg/ms	Constant	1.87E-05
Thermal expansion	1/K	Constant	0.003273
Gravitational acceleration	m/s2	Constant	9.801
Dynamic viscosity	Kg/ms	Constant	0.00002074
Beta	1/k	Constant	2.87E-03

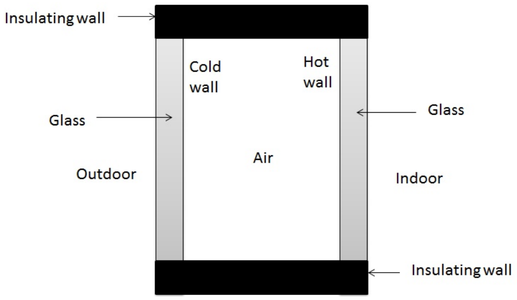

Figure - (1)

Assumptions

The following assumptions are made in the present work:

1. Flow is steady laminar natural convection.
2. Flow is two -dimensional.
3. The fluid properties are constant except that the variation of density with temperature is accounted for in the formulation of buoyancy term (Boussinesq approximation).
4. The effect of conduction and radiation effects are neglected.

III. CAD MODELING

Geometric Creation

The geometry of the enclosed space, meshing and boundary identification is carried out in Ansys software. The dimensions of the cavity are permit to cover wide range of Rayleigh number ($10^3 \leq Ra \leq 10^6$) and aspect ratio 1. The fig. 2 & 3 shows geometry & mesh of square enclosure for Ra=10^3.

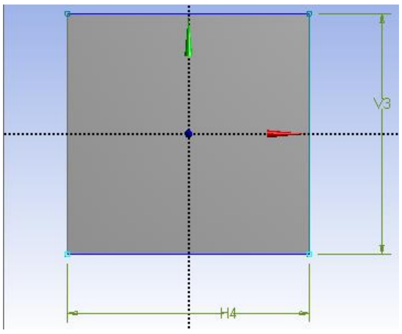

Figure - (2)

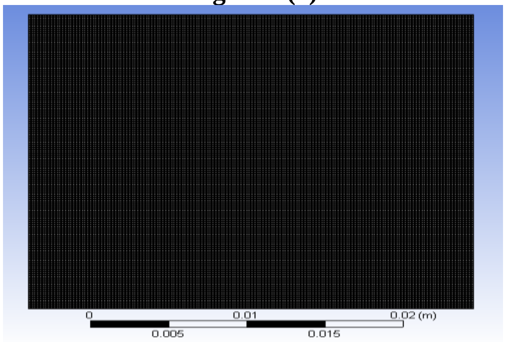

Figure - (3)

IV. RESULT & ANALYSIS

In order to validate the code two-dimensional, laminar, steady natural convection of air with differentially heated side walls and adiabatic top and bottom walls of square cavity was solved. The thermal conditions and dimensions of the enclosures are permit to cover wide range of Rayleigh number varying from 10^3 to 10^6. The temperature difference between side walls was kept at constant for all the cases. The property of air is obtained at mean temperature of hot wall and cold wall. The computed results of heat transfer for average Nusselt number are obtained by using commercial Computational Fluid Dynamics software and compared with results available in the literature shown in the table 6.1.

Validation of results for square enclosure

S No	*Rayleigh Number Ra*	*Present Study (Nu)*	*Byong-Hoon Chang [1] (Nu)*	*De Vahl [8] (Nu)*
1	10^3	1.18	1.118	1.118
2	10^4	2.18	2.241	2.243
3	10^5	4.42	4.532	4.519
4	10^6	8.77	8.848	8.799

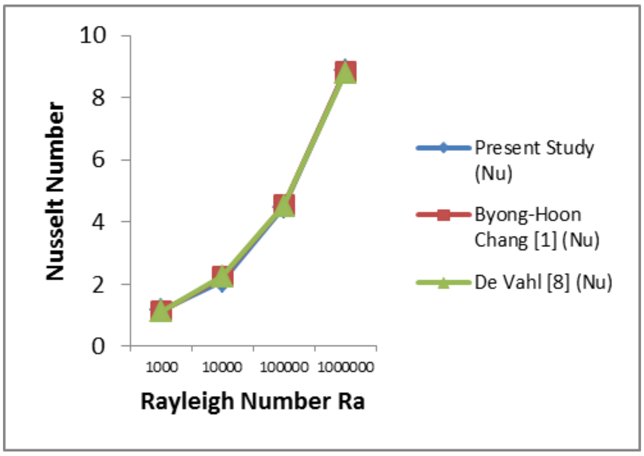

Figure 4 Validation of Nusselt number for square enclosure at different Rayleigh number

V. CONCLUSION

The two different validation has been performed to analyzed the nature of natural convection of heat transfer in square cavity. The phase I we compare the Fluent result with the results of Byong-Hoon Chang and with reference to the graph plot in figure no 4 it shows that both curve are very close and reflect good agreement with each other.

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Manoj Kumar Sahu, Department of Mechanical Engineering, Rewa institute of technology, Rewa (M.P.) 486001

Pushparaj singh, Department of Mechanical Engineering, Rewa institute of technology, Rewa (M.P.) 486001

mahendra kumar patley, Department of Mechanical Engineering, Rewa institute of technology, Rewa (M.P.) 486001