IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 4 Ver. VI (Jul. - Aug. 2016), PP 26-30
www.iosrjournals.org

Study on Natural Convection Heat TransferIn an Enclosure–Areview

Akhil Soman[1],Anu Nair P[2] ,RemilBabu[3], SambathKiran P. K[4],Sumesh V. S[5]
[1,3,4,5]*B.Tech Scholar, Department of Mechanical Engineering, Gurudeva Institute Of Science And Technology, Puthupally, Kottayam686011*
[2]*Assistant Professor, Department of Mechanical Engineering, Gurudeva Institute Of Science And Technology, Puthupally, Kottayam686011*
Corresponding Author-anunair67@gmail.com

Abstract: *Natural convection heat transfer in an enclosure is used in several technological applications for the dissipation of generated heat from the equipment. There are so many researches are conducting on the above same topic in different aspects by changing the position of the heated plate and the boundary conditions of the enclosure. This paper deals with the study of natural convection heat transfer in an enclosure with a heated plate at different position and different boundary conditions. The correlations generated by the researches are presented.*

Keywords: *Natural Convection, Heat Transfer, Heat Transfer Correlations*

I. Introduction

Natural convection is considered asa preferable heat transfer method wherever possible due to itseasiness, loyalty, and cost effectiveness. Thermal management of electronics equipment is an active area of research in consideration of the fact that heat dissipation in electronic components has gone up many overlap with every new design. The heat induced by electronic components must be blown to prevent urgent failure and improve long term authenticity. The increasing heat generation rate also add to potential reliability concerns, as failure of these systems consistently results in device failures. The cooling by natural convection is considered as the most effective and efficient cooling mechanism. Application of active cooling techniques is limited because of the additional design resulting in higher operating costs.

II. Literature Survey

M.R.Rajkumar, G.Venugopal and S. Anil Lal[1] experimentally and numerically studied about the natural convection from free standing tandem planar heat sources
in a vertical channel. Result showed that Effect of side confining walls is found inconsequential on heat transfer for aspect ratio <0.21.Rajesh Baby and C. Balaji[2] experimentally studied about the investigations on phase change material based finned heat sinks for electronic equipment cooling. They found that the effectiveness of a PCM based heat sink depends on the volumetric percentage of the TCE, fin configuration, TCE material, the amount of PCM, heat source power level and so on.

Claudio Cianfrini et al[3] studied Natural convection in tilted square cavities with differentially heated opposite walls and concluded that ,for a sufficiently wide range of γ around 135◦ the overall amount of heat transferred in the *x*-direction across the cavity is larger than that corresponding to the untilted case.MostafaMahmoodi[4]did Numerical simulation of free convection of nanofluid in a square cavity with an inside heater and found that , for the vertical heaters, the rate of heat transfer is directly proportional to the length of heater for all range of Rayleigh numbers considered.

S.A. Nada[5]conducted an experiment on Natural convection heat transfer in horizontal and vertical closed narrow enclosures with heated rectangular finned base plate and results showed that introduction of fins with any fin array geometries increases the rate of transfer of heat.M.J. Sable et al[6]investigated an enhancement of natural convection heat transfer on vertical heated plate by multiple v-fin array and new heat transfer technique is found out to increase the effect of natural convection heat transfer on a heated plate which is vertical.Lahcen Boukhattem [7] conducts a numerical study on heat transfer in a room with internal heated plate. He conducts this experiment by keeping two vertical walls insulated and two horizontal plate at a constant temperature. And he found that heat transfer from the heated plate is mainly directed to the top wall.

Manmatha K Roul [8] conducted an experiment on natural convection heat transfer through a vertical tube. In his work he conducts his experiment on an aluminum tube. And cover the tube with insulating materials and after observe the heat transfer rate he found that the length of the channel ring cheekiness and ring spacing has a significant effect on heat transfer.Hisanobukawashima [9] he conducts an experimental and numerical study on heat transfer on a cooling plate with and without grooves on the plate. He conclude that the grooved plate reduces the heat transfer due to the formation of vortex inside the grooves.S. Anil Lal [10] conducts a numerical study on natural flow of air in a room. He construct a 2-D room with a two sets of sloped roof at two levels and four opening on both sides and assume east side roof receives solar radiation heat and a part of it is transmitted into the roof and he found that the speed of air entering the room increases with Rayleigh number and leaves through the top opening at same rate and the heating of air occur only in a small region near the heated wall.

M. Al-Arabi [11] he conducted an experimental and numerical study on natural convection heat transfer from an isothermal horizontal plate for different shapes and he and he arrive in an expressions for Nusselt number in terms of Rayleigh number, and also he found that the average heat transfer coefficient from a circular plate is almost equal to the heat transfer coefficient for the square plate, only when the heat transfer at the corner is negligible.

Stuart W. Churchill [12] he makes a correlation for laminar and turbulent type convective heat transfer from a vertical plate. He derived the expressions for Nusselt number in terms of Rayleigh number and Prandlt number for inclined vertical plates up to 60^0.R. Ruiz [13] he conducted an experimental study on natural convection heat transfer in V-shaped and L-shaped corners by using water as heat transfer medium. He found that the value of Nusselt number is greater for V corner than single inclined plate and also Nusselt number is greater for horizontal wall of L corner than single horizontal plate. And when comparing L and V shapes L corner has higher value for Nusselt number.P. Kandaswamy [14] he conducted an experimental and numerical study on natural convection heat transfer in a square cavity in the presence of a heated plate placed in vertical and horizontal direction and also for different aspect ratio. He conclude that as the aspest ratio increases the heat transfer also increases and the heat transfer rate for vertical plate is higher than horizontally placed heated plate.

MostafaMahmoodi [15] he conducted a numerical study on natural convection heat transfer of various water based Nano fluids in a square cavity with a thin heated plate. He found that for high value of Rayleigh number the water based Nano fluid is more effective in heat transfer and for low values of Rayleigh number the water based Nano fluid is ineffective.ZakeriyaAltac [16] he conducted an experimental and numerical study on natural convection heat transfer from a thin horizontal isothermal plate in an air filled cavity. He found that maximum heat transfer is possible when the plate is placed near the bottom of the enclosure and also he made a correlation for Nusselt number in terms of Rayleigh number.

Sir w.wu,D. Ewing &C.Y Ching[17]Conduct a study on the topic "The effect of top and bottom wall temperature on the laminar natural convection in an air filled square cavity.In this study the experiment is done by using a square cavity of 305 mm height and width of 305 mm and the depth of the cavity is 914 mm . one vertical and one top wall are heated and other vertical and bottom wall are cooled. The heated wall are constructed by using an aluminium plate.The temperature of the heated and cooled wall are noted hy using a t-type thermocouple.From this study he conclude that the changes in the top and bottom wall temperature also affect the temperature of the air out side the thermal boundary layer in the square cavity

TanmyBasak,S.Roy,A.RBalakrishnan[18]conduct a study on the topic "The effect of thermal boundary condition on natural convection flow with in a square cavity "This experiment is conducted to study the laminar natural convective flow in a square cavity.The bottom wall are uniformly and non uniformly heated and the top wall maintaining at constant temperature.The experiment is a prototype of different industrial application such as operation and safety of nuclear reactor and convective heat transfer associated with boiler.From this study he conclude that the thermal boundary layer developed over 80% of the cavity in uniform heating and in non uniform heating the thermal boundary layer developed is only 60%.ZeevRotem and Lutz Claassen[19]conduct a study on the topic Natural connection above unconfined horizontal surface .This paper deals with the free convective flow above a horizontal plate .Experiment is conducted to demonstrate the existence of laminar boundary layer above a horizontal plate at intermediate grashof number.

A Daloglu and T.Ayhan[20]conducted a study on the topic Natural convection in a periodically finned vertical channel. This paper present the experimental result of natural convection in a rectangular cross-sectional vertical channel . The fins are connected to the channel and both plate are placed periodically.Theunifom heat flux is maintained on the channel.And he conclude that natural convection in a finned rectangular cross section vertical channel is investigated and result compared with smooth channel experimentally.I.Dagtekin and H.F Ozotop[21] conduct a study on the topic natural convection heat transfer by heated partitions with in enclosure .In this study natural convection heat transfer and fluid flow of heated partition with in an enclosure have been studied numerically.the right side wall and bottom wall are insulated and left side wall and top side wall are maintained at same temperature

Witold M .Lewandowski,EWa Rad ziemskg,Buzuk[22] conduct a study on the topic free convection heat transfer and fluid flow above horizontal rectangular plate . This topic is based on the study of natural convective heat transfer from horizontal rectangular isothermal plate having different aspect ratio . three dimensional physical model where proposed for convective fluid flow above heated rectangular plate and analytical expression for the dependence of the nusselt number and the Rayleigh number were obtained as solution from the modelM.R Rajkumar ,G.Venugopal,S.AnilLal [23]conduct a study on the topic natural convection with surface radiation from a planar heat generating element mounted freely in a vertical channel . in this study experimental and numerical stimulation is done and heat transfer by natural convection and radiation from a planar heat generating element placed centrally between two adiabatic vertical plate are studiedC.E kwak and T.H Song[24]conduct a study on the topic experimental and numerical study on natural convection from vertical plate with horizontal rectangular grooves. In this study natural convection from two dimensional vertical plate with horizontal rectangular groove was studied experimentally and numerically

Giovanni Tanda[25] conducts experiment on natural convection from two staggered vertical plates and found that ,the input power provided to each plates is changed to natural convection and radiationKenzoKitamura,Fumiyoshi Kimura[26] studied the Heat transfer and fluid flow of natural convection adjacent to upward facing horizontal plates and found that On the leading edges of the plate heat transfer coeffients are largest and reduces with distance.The turbulent fluid motion was created irregular and unsteady temperature.On the central region of the plate.C.Balaji and S.P Venkateshan[27] studied Interaction of radiation with free convection in an open cavity and a Correlation created for convective and radiative transfer based on numerical results.M.Fuji et al[28] studied on Natural convection to air from an array of vertical parallel plates with discrete and protruding heat sources and finally found that Numerical results satisfy with experimental results except where three dimensional effects occur.L.Boukhattemet al[29] carried out a numerical simulation of thermal convection in a closed cavity in the presence of thin horizontal heated plate and results obtained is that the heat transfer from heated plate to isothermal horizontal wall is flows to top wall
M.R Rajkumar[30] studied on experimental correlation for multimode heat transfer developed using asymptotic expansion method and found that, when emissivity increases temperature of heat source decreases.

Anu Nair et al [31] conducted an review of Natural Convective Heat Transfer From Horizontal Heated Plate Facing Upward In Vertical Channel. He compared correlation for Nussult number in terms of Rayleigh number with different working fluid in different shapes of plates in detailed manner. Anu Nair et al. [32,33] Conducted new Optimization method (i. e, Least square method and Bayesian Approach) to find out the Value of C in the Nusslet Number.. Anu Nair et al [34,35] conducted a numerical investigation of natural convection flow and heat transfer in a square enclosure due to heat source or sources on its left wall has been investigated. M.Ebenezer et al[36]studied Determination of hot spot temperature of a single phase transformer subjected to harmonic pollution and conclude that, When number of cells increases average surface temperature increases.From numerical analysis temperature distribution and location of hot spot temperature is determined.

III. Comparision of Correlations

From the literature survey of natural convection heat transfer from a heated plate of different geometry we got some correlation. They are listed below.

SI no	Researchers	Investigation	Fluid	Plate geometry	correlations	Buoyancy strength
1	M. Al-Arabi and M. K. El-Riedy [11]	Experiment	Air	Rectangular (L/W =1 to 4)	$Nu= 0.700Ra^{1/4}$ $Nu= 0.155Ra^{1/3}$	$2\times10^5 \le Ra \le 4\times1$ $4\times10^7 \le Ra \le 10^9$
2	Stuart W. Churchill and HumbertH.S .Chu[12]	Experiment	Air	Inclined rectangular	$\overline{Nu}^{\frac{1}{2}} = \left\{0.825 + \frac{0.38Ra^{\frac{1}{6}}}{\left[1+(0.49/Pr)^{\frac{9}{16}}\right]^{\frac{8}{27}}}\right\}^2$	$0 \le \theta \le 60^{\circ}$
3	ZekeriyaAtlac and SedaKonrat[16]	Analytic	Air	Rectangular(L/W=0.5-.075	$Nu = 0.2354Ra^{0.2085}A^{0.752}Y_0^{-0.223}\left(\frac{L}{l}\right)^{0.543}$	$10^5 \le Ra \le 10$ $0.25 \le Y_0 \le 0.$ $0.5 \le l/L \le 0.$
4	C.Balaji and S.P Venkateshan[27]	Experiment	Air	Vertical rectangular	$Nu=0.425(Gr_H^{0254}\left(\frac{N_{RC}}{N_{RG1}}\right)^{181} + (1+\varepsilon^{-0039})$	$X=0,0\angle Y\angle 2$ $Y=0,0\angle X\angle 2.A$

Nomenclature

Nu Nusselt number
Pr Prandtl number
Ra Rayleigh number
Gr Grashoff number
W width
h Coefficient of heat transfer
k Thermal conductivity
L Length of the plate
x Distance from the which plate is placed
θ Angle of inclination

References

[1] M.R. Rajkumar, G. Venugopal, S. Anil Lal,2013,"Natural convection from free standing tandem planar heat sources in a vertical channel,"Applied Thermal Engineering,vol-50,pp no.1386-1395.
[2] Rajesh Baby, C. Balaji,2012," Experimental investigations on phase change material based finned heat sinksfor electronic equipment cooling," International Journal of Heat and Mass Transfer,vol.55,pp no. 1642–1649.
[3] Claudio Cianfrini, Massimo Corcione , Pier Paolo Dell'Omo,2005," Natural convection in tilted square cavities with differentiallyheated opposite walls," International Journal of Thermal Sciences,vol.44,pp no. 441–451
[4] Mostafa Mahmoodi,2011,"Numerical Simulation Of Free Convection Of Nanofluid In A Square Cavity With An Inside Heater,"International Journal Of Thermal Science,vol.50,pp.2161-2175.
[5] S.A. Nada,2007," Natural convection heat transfer in horizontal and vertical closed narrow enclosures with heatedrectangular finned base plate," International Journal of Heat and Mass Transfer,vol.50,pp no. 667–679.
[6] M.J. Sable, S.J. Jagtap , P.S. Patil , P.R. Baviskar , S.B. Barve,2010,"Enhancement of natural convection heat transfer on vertical heated plate by multiple v-fin array," IJRRAS,vol.5(2)
[7] Lahcen Boukhattem, Hassan H5amdi, & D. R. Rousse, 2013, "Numerical simulation of heat transfer in a room in the presence of a thin horizontal heated plate, "Energy Procedia, vol.42,pp.549-556.
[8] Manmatha K. Roul, Ramesh Chandra Nayak,2012,"Experimental Investigation of natural convection heat transfer through heated vertical tubes,"IJERA,vol.2,pp.1088-1096.
[9] HisanobuKawashima,YusukeSakai,Shigeaki Inada,2010,"Suppression Of Natural Convection Heat Transfer Along A Vertical Flat Plate With Periodic Circular Grooves,"International Symposium On Next Generation Air Conditioning And Refrigeration Technology,vol.1,pp.17-19.
[10] S. Anil Lal&R. V. Reji,2012,"Numerical simulation of natural flow of air through a room, "International Journal of Green Energy,vol.9,pp.540-552.
[11] Al-Arabi, M., El-Riedy,M.K.,1976,"Natural convection heat transfer from isothermal horizontal plates of different shapes,"International Journal of heat and mass transfer,vol.19,pp.1399-1404.
[12] Stuart W. Churchill &Humbert H. S. Chu,1975,"Correlating equation for laminar and turbulent free convection from a vertical plate,"International Journal of heat and mass transfer,vol.18,pp.1323-1329.
[13] R. Ruiz & E. M. Sparrow,1987," Natural convection in V-shaped and L-shaped Corners,"International Journal Of Heat And Mass Transfer,vol.12,pp.2548-1987.
[14] P.Kandawsamy, J. Lee, A. K. Abdul Hakeem,2007,"Natural Convection In A Square Cavity In The Presence Of Heated Plate,"NonlinearAnalysis:Modelling and Control,vol.12,pp.203-212.
[15] Mostafa Mahmoodi,2011," Numerical simulation of free convection of nanofluid in a squarecavity with an inside heater."International Journal of Thermal Sciences,vol.50,pp no. 2161-2175.
[16] ZekeriyaAltac,Seda Konrat,2009,"Natural Convection Heat Transfer From A Thin Horizontal Isothermal Plate In Air-Filled Rectangular Enclosures,"IsiBilimiveTeknigi Dergisi,vol.29,pp.55-65.
[17] W. Wu, D. Ewing, C.Y. Ching,2006," The effect of the top and bottom wall temperatures on the laminarnatural convection in an air-filled square cavity," International Journal of Heat and Mass Transfer,vol.49,pp no. 1999–2008.
[18] TanmayBasak, S.Roy , A.R. Balakrishnan,2006," Effects of thermal boundary conditions on naturalconvection flows within a square cavity, International Journal of Heat and Mass Transfer,vol.49,pp no. 4525–4535.
[19] Zeevrotem, Lutz claassen, 1969," Natural convection above unconfined horizontal surfaces,"J .Fluid Mech, vol.38,pp no. 173-192.
[20] A. Daloglu , T. Ayhan,1999," Natural convection in a periodically finned vertical channel, Int. Comnt Heat Mass Transfer, Vol. 26,pp no. 1175-1182.
[21] I. Dagtekin , H.F. Oztop,2001," Natural convection heat transfer by heatedPartitions within enclosure,"Inr. Comm. Hear Mass Transfer; Vol 28,pp no. 823-834.
[22] Witold M. Lewandowski, EwaRadziemska, MaciejBuzuk,Henryk Bieszk,2000," Free convection heat transfer and fluid fowabove horizontal rectangular plates,"vol.66,pp no. 177-197.
[23] M. R. Rajkumar , G. Venugopal , S. Anil Lal,2011," Natural convection with surface radiation from a planar heatgenerating element mounted freely in a vertical channel," Heat Mass Transfer,vol.47,pp no. 789–805.
[24] C. E. Kwak ,T. H. Song,1998," Experimental and numerical study on natural convection from vertical plates withhorizontal rectangular grooves," Int. J. Hear Mass Transfer. Vol. 41,pp no. 2517-2528.
[25] Giovanni Tanda,1997," Natural convection heat transfer in vertical channels with and without transverse squareribs," Inf. J. Heat Mass TransJk. Vol. 40,pp no. 2173-2185.
[26] KenzoKitamura ,Fumiyoshi Kimura,1995," Heat transfer and fluid flow of natural convection adjacent to upward-facing horizontalplates,"Int. J Heat Mass Transfer. Vol. 38,pp no. 3149-3159.
[27] C. Balaji ,S. P. Venkateshan,1994," Interaction of radiation with free convection in an open cavity,"Int. J. Heat and Fluid Flow, Vol. 15,pp no.4.
[28] M. Fujii, S. Gima, T. Tomimura and X. Zhang,1996," Natural convection to air from an arrayof vertical parallel plates with discrete and protruding heat sources," Int. J. Heat and Fluid Flow,vol.17,pp no. 483-490.

[29] L. Boukhattem, H. Hamdi, A. Bendou, D. R. Rousse,2012," Numerical simulation of thermal convection in a closed cavity in the presence of a thin horizontal heated plate," ICHMT International Symposium on Advances in Computational Heat Transfer, CHT-12-NC17.

[30] M.R. Rajkumar, C.D. John Paul, G. Venugopal,2013," Experimental correlation for multimode heat transfer developed using asymptoticexpansion method," International Communications in Heat and Mass Transfer,vol.46,pp no. 22–26.

[31]P. AnuNair, K, Karuppasamy, B. Benziger, and P. Balkrishnan ,Natural convective heat transfer from horizontal heated plate facing upward in vertical channel-A review , International Journal of Mechanical Engineering Research, 5(1), 2015,27-38.

[32] P. Anu Nair and K. Karuppasamy ,Comparitive study of Bayesian approach and least square residual optimization method in horizontal heated plate facing upward-an experimental approach , International Journal of Research in Aeronautical and Mechanical Engineering, 3(4), 2015,7-18.

[33] P.Anu Nair P, Saju Elias, Vincy John and Rajan K Amboori,An Inexpensive Technique to Determine the Parameter in Free ConvectionHeat Transfer from Two Parallel Heated Vertical Plates ,European Journal of Advances in Engineering and Technology,2(10),2015,49-55

[34] P. AnuNair,Aby.K.Abraham and PremjithS,Optimal Location Of Discrete Heat Sources On And Inside A Wall With Natural Convection, International Journal of Applied Engineering Research , 10(20),2015, 41205-41211.

[35] P. Anu Nair and K. Karuppasamy,Experimental Approach Of Natural Convection Heat Transfer In Vertical Channel With Horizontal Heated Plate At Small Height Ratio,Asian journal of Engineering and Technology,.3(4),2015,316-325.

[36] M. Ebenezer , M. R. Rajkumar , P. S. Chandramohanan Nair,2012," Determination of Hot Spot Temperature of a Single PhaseTransformer Subjected to Harmonic Pollution," J. Inst. Eng. India Ser. B,vol. 93(3),pp no. 143–149.