Experimental Analysis of Natural Convection over Simple, Dimpled and Corrugated Copper Tube

Kunal Pradip Patil[1], M. H. Patil[2]

[1]M. Tech Mechanical Engineer student at D.N.P.C.O.E. Shahada
[2]Prof. M.H. Patil Ast. Professors at D.N.P.C.O.E. Shahada

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Abstract - *Heat Transfer enhancement by modifying the surfaces of tubes is commonly practices throughout the world grooves, dimpled, flutes or corrugations are placed inside and outside the surface of tubes and channels for enhancement in this article a novel method of heat transfer enhancing by varying the spacing between tubes reported. A comparison Now days Heat Transfer improvement is important concept in these analysis we prove that heat convection improves by making dimpled, corrugated on copper tubes it can be clearly observe by experiment that heat convection is of corrugated tube has more than dimpled one and then plain tube*

There is lot of literature available on different topics of different modes of heat transfer. However, I have restricted the literature survey only to Natural Convection from surfaces. Some correlations for natural convection a physical discussion of natural convection along inclined and horizontal plates

Key Words*: *Dimpled and Corrugated Tubes

1. INTRODUCTION

Heat transfer by convection has wide range of engineering applications of practical and functional significance. The mechanism is found very commonly in everyday life and includes central heating, air conditioning, electronic cooling, cooling towers in power plants and in industries, steam turbines, heat exchangers, pipe flow etc. It is mostly required to predict the significant energy change that takes place as a result of temperature difference. Convective heat transfer is largely categorized as: Free/Natural and forced. Free convection refers to fluid motion by buoyant forces arising due to density gradients which are a result of temperature gradients. Whereas in, forced convection, the flow of the fluid is enhanced by external sources. The present work focuses on a free convection configuration investigating an aspect yet to be discovered. By proper experimentations, the postulations of dependable variables viz ., tube surface orientation, heat source power input and enclosure effects with the aid of heat transfer coefficient. The interest in this class of problems is specifically driven by the need to have better understanding of convective heat transfer occurring over materials. The contributions have been reported in several reviews like Cess(1961), Szewczyk(1964), Whitaker(1972), Cooper et al.,(1986), Copeland(1998), Kim et al.,(1999).The works provide an excellent review on the developments up to the end of the century. Cheng et al., (2002) investigated natural convection on a flat plate with inertia effect and thermal dispersion. They noted that the rate of unsteady heat transfer can be accelerated by the thermal 6 dispersion. Sartori (2006) studied equations of the natural convection heat transfer coefficient over flat surfaces. He reasoned that there must be a decay of heat transfer coefficient along the plate dimension in the wind direction. Abreu et al., (2006) worked on similarity solutions of boundary layer flows in free and forced convection for evaluation of the coupled effects of heat and mass transport. They showed that all convection cases depend on different similarity variables. Yao et al., (2008) studied natural convection due to a non-Newtonian fluid past a flat plate using a modified power-law viscosity model. They showed that the most significant effects occur near the leading edge gradually tailing off far downstream. Seyyedi et al., (2012) probed effects of a splitter plate and an inclined square cylinder with 45° inclination on 2-D unsteady laminar flow and heat transfer in a plan channel using the lattice Boltzmann method.

Although much has been done but complexity of the problem has prevented a complete understanding due to interaction between flow, heat and mass transfer. Therefore, a systematic study is needed to comprehend the mechanisms controlling the free convective heat transfer. In the light of above mentioned works, the present work emphasizes on effects of parameters, tube surface orientation, heat power input (V) and effect of enclosures on free convective heat transfer coefficient so that this knowledge can help us in many known useful heat transfer engineering applications and to prevent related hazards.

2. LITERATURE REVIEW

- **I.H.Toruka** performed experimental study free convection from a cylinder array arranged in a vertical line between parallel walls. Empirical formulas were proposed to predict the average heat transfer coefficient. An enhancement of average Nusselt Number for an entire array of cylinders between parallel walls by 10% to 15% in comparison with the case of free space.

- **Y.Shen, P.Tong[1998]** explained light scattering experiment of turbulent convection in water is carried out in a convection cell with rough upper and lower surfaces. The vertical heat flux is found to be increased by ,20% when the Rayleigh number becomes larger than a transition value. The experiment reveals that the main effect of the surface roughness is to increase the emission of large thermal plumes, which travel vertically through the central region. These extra thermal plumes enhance the heat transport, and they are responsible for the anisotropic behavior of velocity fluctuations at the cell center.

- **Y.B. Du**(1998), performed novel convection experiment is in a cell with rough upper and lower surfaces. The heat transport across the rough cell is found to be increased by more than 76%. Flow visualization and near wall temperature measurements reveal new dynamics for the emission of thermal plumes. The discovery of the enhanced heat transport has important applications in engineering and atmospheric convection

- **N.Onur and M.K.Akta** performed study on natural convection between inclined plates. The plate inclinations were chosen to be 00,300,450 and measured with respect to vertical position. Hot plate is facing downwards and heated isothermally. The lower plate is insulated and unheated. Experiments were performed for various temperature differences in air to determine the effect of plate spacing ranging from 2mm to 33 mm and inclination on natural convection heat transfer. It was observed that heat transfer results do not depend on plate inclination strongly.

- **J.W. Zhou, Y.G. Wang (2008)** studies that determine the influence of unsteadiness on flat plate impinging jet heat transfer implicitly assume that the effect of unsteadiness found on smooth impingement surfaces also holds on surfaces with certain obstacles on them. In order to test this assumption a single roughness element was added to an otherwise smooth surface, and it was found that the steady heat transfer was almost the same as that for a totally smooth surface. The effect of unsteadiness, however, can be fundamentally different when roughness elements are added to a smooth surface. Slight changes in the surface geometry thus can have strong impact with respect to the effect of unsteadiness on heat transfer under impinging jets and cannot be neglected a priori.

- **Rossano Comunelo(2005)**,his work deals with heat transfer coefficient ―h‖ of a isothermal vertical plate with H = 0.15 m. The neighborhood surfaces influence in that coefficient is aimed with simulation and standard experimentation. A novel technology to measure the heat flux, caling ―Tangential Heat Flux meter‖ is applied and simulation with a CFD commercial code was performing. Five heat fluxmeters was glued on the vertical plate, heated 20 0C over the air temperature. The neighborhood and air temperature was maintained constants. The distance between the plate and base wall (floor) was changed as well as the distance between the plate and backside wall. Through simulation results will be compare with experimental. The result expected is a increasing of heat transfer coefficient, very usefully in heat exchange devices.

- **P.Kandaswamy, J. Lee, A.K.Abdul Hakeem (2007)** studies Natural convection heat transfer in a square cavity induced by heated plate numerically. Top and bottom of the cavity are adiabatic, the two vertical walls of the cavity have constant temperature lower than the plate's temperature. The flow is assumed to be two-dimensional. The discretized equations were solved by finite difference method using Alternating Direction Implicit technique and Successive Over-Relaxation method. The study was performed for different values of Grashof number ranging from 103 to 105 for different aspect ratios and position of heated plate. The effect of the position and aspect ratio of heated plate on heat transfer and flow were addressed. With increase of Gr heat transfer rate increased in both vertical and horizontal position of the plate.

- **S.M.Guo,C.C.Lai(2000)** studied influence of surface roughness on heat transfer coefficient and cooling effectiveness for a fully film cooled three dimensional nozzle guide vane(NGV) has been measured in a transonic annular cascade using wide band liquid crystal and direct heat flux gases(DHFG).These techniques have been used to measure the heat transfer coefficient and film cooling effectiveness in a transient blow down tunnel under extreme conditions of transonic flow and high heat transfer coefficient(400-1600 W/m2K). The roughness is shown to increase the heat transfer coefficient significantly, particularly in regions near the rear of pressure and suction surfaces where the non dimensional roughness Re reaches to a value of high as 40. The differences in heat transfer to the rough and smooth point to a requirement to conduct further research including the effect of roughness shape, height, and pattern.

- **Abdel-Aziz** studied the heat transfer by natural convection from the inside surface of a uniformly heated tube at different angles of inclination. The experiments were carried out in the range of *Ra* from 1.44 × 107 to 8.85 × 108, L/D from 10 to 31.4 and angle of inclination from 0º to 75º degree. The results showed that the average Num had a maximum value when the tube was vertical.

- **Hussein and Yasin** experimentally investigated Heat transfer by natural convection from a uniformly heated vertical circular pipe with different entry restriction configurations by using the boundary condition of constant wall heat flux in the ranges of *Ra* from 1.1 × 109 to 4.7 × 109. The apparatus was made from heated cylinder of a length 900 mm and inside diameter 30 mm. The results show that the Nusselt number values increase as the heat flux increases. Empirical correlations were proposed in the form of *LogNum* versus *LogRam* for each case investigated and a general correlation was obtained for all cases.

3. METHODOLOGY

- Enclosure- .Square pyramid
- Tubes- a. Plain Cylindrical Copper tube b. Corrugated copper tube c. Copper tube with Dimples
- Band type heater
- Thermocouples
- Ammeter
- Voltmeter
- Dimmer stat
- Temperature indicator
- Toggle switches
- Stand

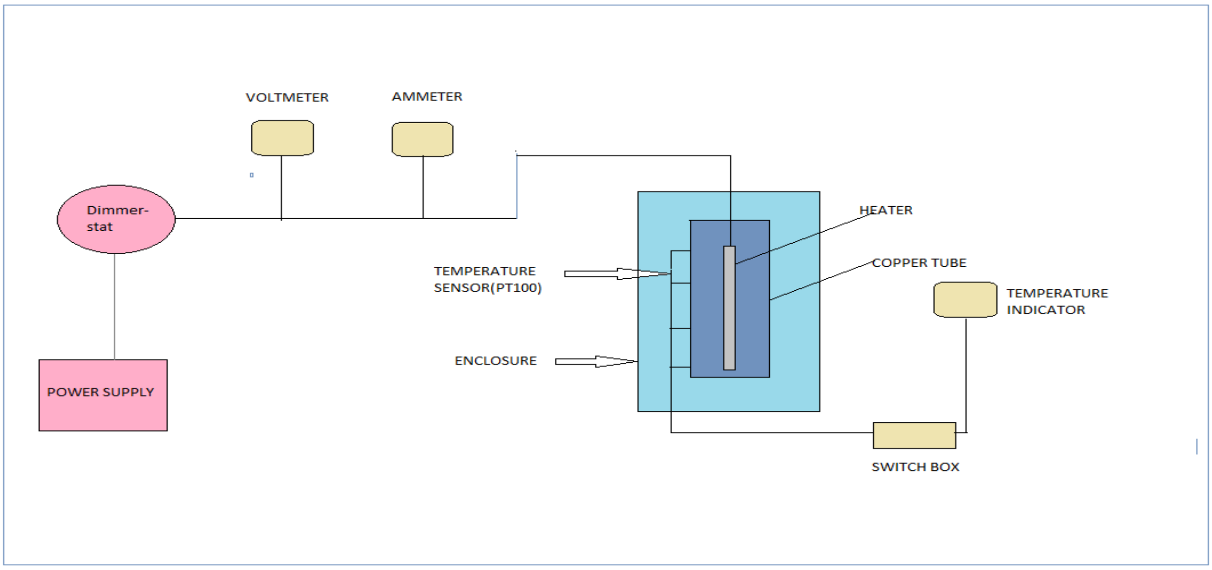

Fig -1: Line diagram of experimental setup

Experimentation and Analysis :

1) O.D. Cylinder = 25.4 mm.

2) Length of Cylinder = 300 mm.

3) Input to heater = V x I Watts.

Observation Table:

SR.NO	Volt	Amp	Temperature °C				
			T1	T2	T3	T4	Ta
1	0	0	23.5	25	22.9	24.9	23
2	60	0.637	85.8	85	79.7	73.9	23.5
3	80	0.844	114.9	117.5	103	90.6	25
4	100	1.05	149.4	144.9	125	105.1	25.5

Table -1: For Simple Tube

SR.NO	Volt	Amp	Temperature °C				
			T1	T2	T3	T4	Ta
1	0	0	24	24.6	24.5	24.8	23
2	60	0.675	82.1	78.3	75.4	72.1	23
3	80	0.894	88.2	85.1	84.2	82.4	25
4	100	1.098	114.3	106.3	94.7	71.8	26

Table -2: For Corrugated tube

SR.NO	Volt	Amp	Temperature °C				
			T1	T2	T3	T4	Ta
1	0	0	23.9	23.6	24.1	22.4	23
2	60	0.635	78	75	73	65	23
3	80	0.84	105.6	95.4	91.8	98.5	25
4	100	1.05	125.1	120.3	118	115.6	26

Table -3: For Tubes with dimples

4. RESULT

Voltage	Plane Tube Heat Transfer Coefficient (W/m2 °C)	Dimple Tube Heat Transfer Coefficient (W/m2 °C)	Corrugated Tube Heat Transfer Coefficient (W/m2 °C)
60	13.7759	15.347	15.39
80	17.34	18.32	24.46
100	20.82254	22.438	31.8234

5. CONCLUSION

It is evident from above result that heat transfer coefficient for corrugated tube is highest. As we go on increasing the voltage the heat transfer rate goes on increasing but there is wide increase in heat transfer in corrugated tube after 80 volts so hence we can have high heat transfer if we use corrugated tube and at higher voltages

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BIOGRAPHIES

Mr. Kunal Pradip Patil.
M.Tech (Mechanical Engineer)
D.N.P.C.O.E, Shahada