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Study of Heat Transfer Coefficient in Natural and Forced Convection by Different Finishing

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Abstract – *This paper reports the experimental study of natural and forced convection by different finishing on Brass material rod such as plane rod, semi rough rod and fully rough rod. The experimental setup is designed and used to study the natural and forced convection in terms of heat transfer coefficient. The setup consists of brass rod of length 450mm and outside diameter of 38 mm and seven thermocouples are used to measure temperature. The experimental and graphical results were presented.*

Key Words: **Natural Convection, Forced Convection, Heat transfer coefficient, Different finishing**

1. INTRODUCTION

The science of heat transfer is concerned with the generation, use, exchange, and conversion of heat and thermal energy between physical systems. Heat transfer is the discipline of thermal engineering that concerns the calculation of rate at which heat flows within the medium, across the interface or from one surface to another. There are different modes of heat transfer which includes: A. heat transfer through conduction B. heat transfer through convection C. heat transfer through radiation

1.1 Natural Convection

If the motion of fluid is cause only due to difference in density resulting from temperature gradients without the use of pump or fan, then the mechanism is called as natural convection. Consider a hot object exposed to cold air. The temperature of the outside of the object will drop (as a result of heat transfer with cold air), and the temperature of adjacent air to the object will rise. Consequently, the object is surrounded with a thin layer of warmer air and heat will be transfer red from this layer to the outer layers of air. The temperature of the air adjacent to the hot object is higher, thus its density is lower. As a result, the heated air rises. This movement is called as the Natural convection current.

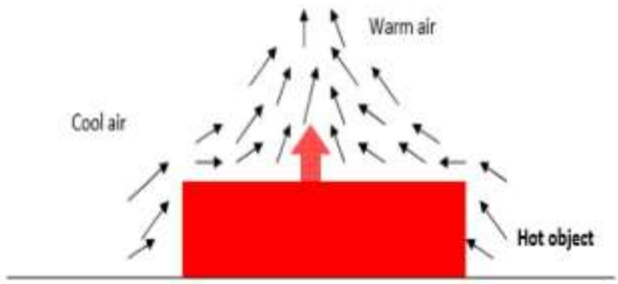

Fig -1: Natural convection heat transfer from a hot body

1.2 Forced Convection

If the motion of fluid is induced by some external means such as pumps or blower, then the heat transfer process is called forced convection. Convection heat transfer is complicated since it involves fluid motion as well as heat conduction. The fluid motion enhances heat transfer. The rate of convection heat transfer is expressed by Newton's law of cooling: $Q_{conv}=h.A.\ (T_s-T_\infty)$ (W) The convective heat transfer coefficient h strongly depends on the fluid properties and roughness of the solid surface, and the type of fluid flow (laminar or turbulent).

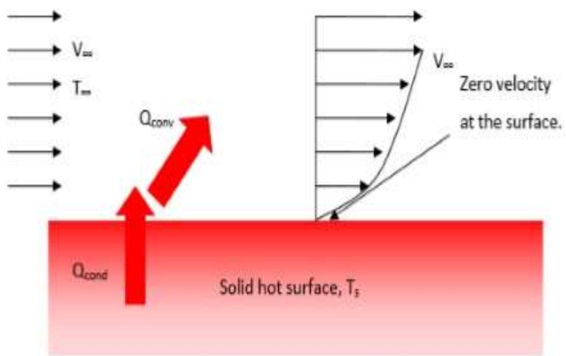

Fig -2: Forced convection

1.3 Heat Transfer Coefficient

The heat transfer coefficient 'h' may be defined as "the amount of heat transmitted for a unit temperature difference between the fluid and unit area of surface in unit time". The value of 'h' depends on the factors such as thermodynamic and transport properties (e.g. viscosity, Density, specific heat etc.) nature of fluid flow, geometry of the surface and prevailing thermal conditions.

The lot of literature has been reported related to the convection, the process parameter such as length, diameter and area have been investigated in order to judge the response variables like heat transfer rate. Nilesh B. Totala [1] had explained about the experimental set up design and used to study the natural convection phenomenon from vertical cylinder in terms of average heat transfer coefficient. Also, practical local heat transfer coefficient along the length of cylinder is determined experimentally and is compared with theoretical value obtained by using appropriate governing equations. Y.A. Cengel [2] derived the governing equations to determine heat transfer coefficient in natural convection in vertical cylinder. L.J.Crane [3] studied the natural convection over the vertical cylinder at very large Prandtl number and discussed how, high Prandtl number affect free convection through vertical cylinder.

2. EXPERIMENTATION AND METHODOLOGY

The apparatus available in our Heat transfer lab is of natural convection. The apparatus is not working properly like thermocouple do not give proper reading, ammeter and voltmeter not working properly. So, we first change the components and modified it with the forced convection. The apparatus consists of brass tube of diameter 38mm diameter and 450 mm length. An electrical heating element is kept in vertical tube which in turns heats the tube surface. The heat loss by tube to surrounding air is by natural convection. Air was used as working fluid which was supplied by the blower during forced convection. Flow control valve is used to regulate the flow correctly. Orifice meter was used to measure the flow rate of the air. Temperature is measured by using thermocouples fitted across the test specimen. The heat input to the heater is measured by an ammeter and voltmeter and is varied by a dimmer stat. Total seven K-type thermocouples were used in the test setup, six for measuring the surface temperature of the test specimen and one is used to measure the mean film temperature as all the properties are to be evaluated at the mean film temperature. Three types of brass tubes are used one is of plane surface, second is of semi rough surface and third one is of fully rough surface. Following are the specifications of setup: 1. Outer Diameter of the tube (d) = 38 mm 2. Length of the tube (L) = 450 mm 3. Number of the thermocouples = 7 4. Thermocouple number 7 reads the ambient temperature and is kept in the duct. 5. Diameter of Orifice (do) = 14mm.

Fig -3: Plane surface of Brass rod

Fig -4: Semi rough surface of Brass rod

Fig -5: Fully rough surface of Brass rod

2.1 Procedure

Natural Convection:

1. Put ON the supply and adjust the dimmer stat to obtain the required heat input – (Say 40W, 60W, 70W etc.)
2. Wait till the steady state is reached, which is confirmed from temperature reading- (T1 to T7)
3. Measure surface temperature at the various point i.e. T1 to T6.
4. Note the ambient temperature i.e. T7.
5. Repeat the experiment at different heat inputs (Do not exceed 80 w).

Forced Convection:

1. Switch ON the mains system
2. Switch ON blower.
3. Adjust the flow by means of gate valve to some desired difference in the manometer level.
4. Switch ON heater
5. Start the heating of the test section with the help of dimmer stat and adjust desired heat input with the help of Voltmeter and Ammeter.
6. Take readings of all the six thermocouples at an interval of 10 min until the steady state is reached.
7. Note down the heater input

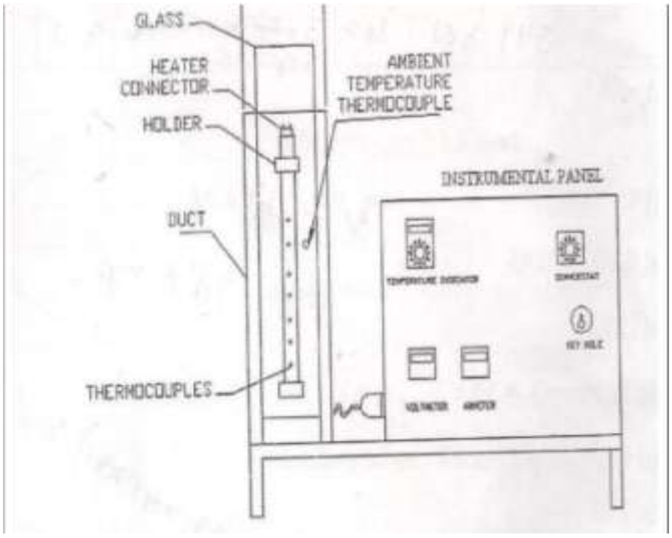

Fig -6: Schematic diagram of Experimental setup

3. RESULT AND DISCUSSION

As per the procedure, the experiment was carried on the setup and the observations noted as given in following tables.

Table -1: For plane surface at V=50V and I=0.05A

Thermocouple Reading	Natural Convection	Forced Convection
T1	38	46
T2	37	47
T3	37	47
T4	38	48
T5	38	48
T6	38	48
T7	37	47

Table -2: For plane surface at V=70V and I=0.08A

Thermocouple Reading	Natural Convection	Forced Convection
T1	50	44
T2	52	44
T3	50	43
T4	52	44
T5	52	43
T6	52	44
T7	50	44

Table -3: For plane surface at V=100V and I=0.3A

Thermocouple Reading	Natural Convection	Forced Convection
T1	58	55
T2	57	56
T3	58	55
T4	58	55
T5	58	55
T6	58	55
T7	57	55

Table -4: For semi rough surface at V=50V and I=0.05A

Thermocouple Reading	Natural Convection	Forced Convection
T1	40	46
T2	41	45
T3	41	45
T4	41	45
T5	41	45
T6	41	45
T7	41	46

Table -5: For semi rough surface at V=70V and I=0.08A

Thermocouple Reading	Natural Convection	Forced Convection
T1	53	46
T2	53	46
T3	53	46
T4	53	46
T5	53	46
T6	53	47
T7	51	46

Table -6: For semi rough surface at V=100V and I=0.3A

Thermocouple Reading	Natural Convection	Forced Convection
T1	60	58
T2	60	57
T3	61	58
T4	61	58
T5	61	58
T6	61	58
T7	60	59

Table -7: For fully rough surface at V=50V and I=0.05A

Thermocouple Reading	Natural Convection	Forced Convection
T1	45	42
T2	45	42
T3	45	41
T4	45	42
T5	45	42
T6	45	43
T7	44	43

Table -8: For fully rough surface at V=70V and I=0.08A

Thermocouple Reading	Natural Convection	Forced Convection
T1	56	52
T2	57	52
T3	56	52
T4	56	52
T5	56	52
T6	56	52
T7	55	51

Table -8: For fully rough surface at V=100V and I=0.3A

Thermocouple Reading	Natural Convection	Forced Convection
T1	66	62
T2	66	61
T3	66	62
T4	66	62
T5	66	62
T6	66	62
T7	65	62

3.1 Calculation

Natural Convection

1. Heat input to the Heater:

$Q = V \times I$

$=50\times0.05$

$= 2.5$ W

2. Average Temperature

$$T_{avg} = \frac{T1+T2+T3+T4+T5+T6}{6}$$

$$= \frac{38+37+37+38+38+38}{6}$$

$= 37.66$ °C

3. Heat transfer Coefficient

$Q = h \times A \times \Delta T \; (T_{avg} - T_7)$

$2.5 = h\times\pi \times 0.03 \times 0.45\times (37.66-37)$

$h = 5.129 \frac{W}{m^2 °C}$

Forced Convection

1. Average Temperature:

$$T_{avg} = \frac{T1+T2+T3+T4+T5+T6}{6}$$

$$= \frac{46+47+47+48+48+48}{6}$$

$= 47.5$°C

2. Mean Temperature:

$$T_{mean} = \frac{Tavg+T7}{2}$$

$$= \frac{47.5+47}{2}$$

$= 47.25$°C

3. Head of air:

$\Delta h_{air} = \Delta h_w \left(\frac{\rho water}{\rho air} - 1\right)$

$= 0.06 \left(\frac{1000}{1.16} - 1\right)$

$= 51.66$

4. Mass flow rate:

$m = C_d\times\rho_{air}\times A_{orifice}\times\sqrt{2g\Delta hair}$

$=0.65\times1.16\times\frac{\pi}{4}\times0.014^2\times\sqrt{2 \times 9.81 \times 51.66}$

$= 3.69\times 10^{-3} \frac{Kg}{s}$

5. Heat transfer rate:

$Q = m\times C_p\times (T_7-T_1)$

$=3.69\times 10^{-3} \times1\times (47-46)$

$=3.69\times 10^{-3}$W

6. Heat transfer coefficient:

$Q = h.A. (T_{avg} - T_{mean})$

$3.69\times 10^{-3} = h\times\frac{\pi}{4} \times 0.03^2\times (47.5-47.25)$

$h= 20.88 \frac{W}{m^2 °C}$

As per the experimentation following experimental results are obtained are as follows

Table -9: Heat Transfer Coefficient, h ($\frac{W}{m^2 °C}$)

Voltage (V)	Current (A)	Heat Transfer Coefficient, h ($\frac{W}{m^2 °C}$)					
		Plane surface		Semi rough surface		Fully rough surface	
		Natural Convection	Forced Convection	Natural Convection	Forced Convection	Natural Convection	Forced Convection
50	0.05	5.129	20.88	6.768	22.8	7.72	27.8
70	0.08	6.758	22.4	7.019	24.7	8.80	36.9
100	0.3	7.975	26.8	8.123	29.5	9.87	37.9

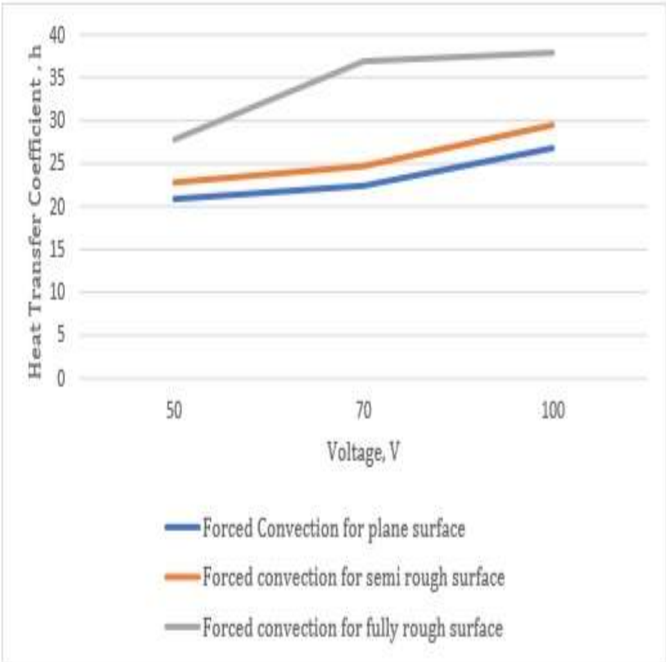

Chart -1: Comparison of Heat Transfer Coefficient in Forced convection using different finishing

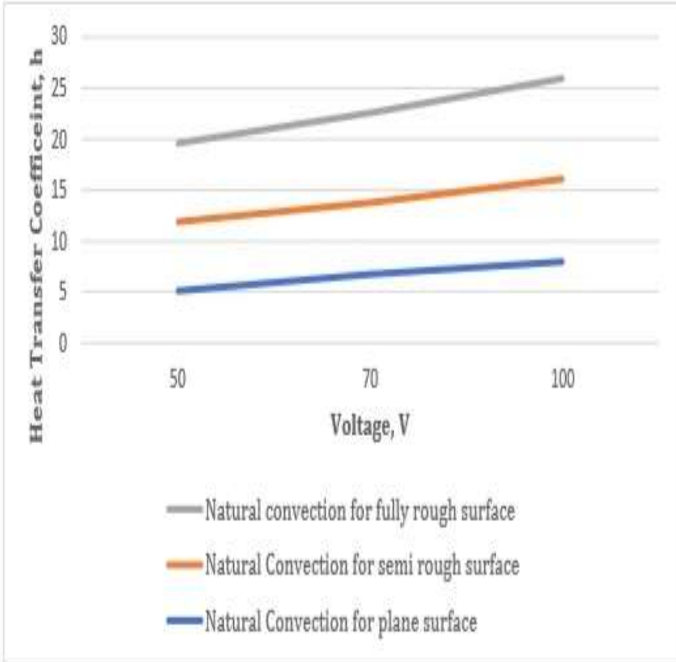

Chart -2: Comparison of Heat Transfer Coefficient in Natural convection using different finishing

3. CONCLUSION

The heat transfer coefficient is increases with increase in roughness as it is depending on the geometry of surface. From chart 1 and chart 2 it is concluded that heat transfer coefficient is increases as we increase the voltage.

REFERENCES

[1] Nilesh B. Totala, "Natural Convection Characteristics in Vertical Cylinder", International Journal of Engineering and Science, Vol.3, Issue 8, September 2013, pp. 27-31.

[2] Y.A. Cengel, Heat and Mass Transfer, A Practical Approach, Tata McGraw-Hill Publication, New Delhi.

[3] L.J. Crane, "Natural Convection on Vertical Cylinder at Very High Prandtl Numbers", Journal of Engineering Mathematics. 10(2), 1976, 115-124.

[4] R.K. Rajput, Heat and Mass Transfer, Laxmi Publication, Eight Edition, 2010.