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Experimental Analysis on Convective Heat Transfer through Helical Coil

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Abstract--*This research work consists of Experimental analysis of Convective heat transfer process through copper helical coil of. The helical coil is designed and selected of diameter 8.04mm and 380mm length. Nusselt number and Reynolds number were considered as performance parameters. Correlation equations were developed for the heat transfer. A cylindrical shell of internal diameter of 350mm and height 510mm is used to accommodate helical coil arrangement and is also used for bath solution. The cylindrical shell is well insulated in order to avoid heat loss. Experimental Analysis is carried out and values of heat transfer coefficient and overall heat transfer coefficient is calculated. It is seen that value of different parameters related to heat transfer have much more effect on the mass flow rate flowing through helical coil.The objective of this dissertation work is to obtain a better and more quantitative insight into the heat transfer process that occurs when a fluid flows in a helical coils tube*

Keywords--*Heat Transfer1, Helical coil2, copper Coil 3*

I. INTRODUCTION

Helical coils are compact in size and provides distinct benefit like higher film coefficient, more effective utilization of available pressure drop, which results in efficient and less expensive design. Helical coil permits handling of high temperature and extreme temperature differentials without high induced stresses or costly expansion joints. Helical coil offer advantages over straight tubes due to their compactness and increased heat transfer coefficient. The increased heat transfer coefficients are a consequence of the curvature of the coil, which induces centrifugal forces to act on the moving fluid, resulting in secondary flow.

A. Flow through Helical Coil

When a fluid flows through a straight tube the velocity is maximum at the tube centre, zero at the tube wall and symmetrically distributed about the axis. However when a fluid flows through a curved tube, the primary velocity profile shown in Figure 1.1 is distorted by the addition of secondary flow pattern. The secondary flow is generated by the centrifugal action and acts in the plane perpendicular to the primary flow. Since the velocity is maximum at the tube centre the fluid at the centre is subjected to maximum centrifugal action, which pushes the fluid towards outer wall. The fluid at the outer wall moves inward along the tube wall to replace the fluid ejected outwards. This results in the formation of two vortices symmetrically about a horizontal plane through the tube centre.

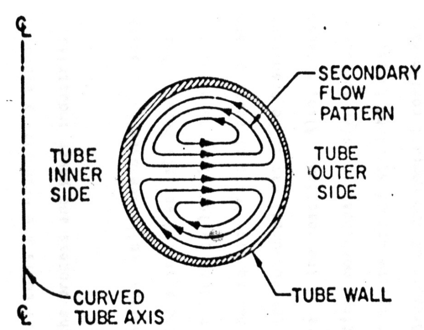

Fig-1: Basic Geometry of Helical Coil

II. LITERATURE SURVEY

Many researchers worked on the heat transfer through helical coil in order to find out overall heat transfer coefficient and pressure drop through helical coil. They developed different relation to find out heat transfer parameters

Vegugopala Kubair and N. R. Kuloor [2] has objective to give correlation on heat transfer to aqueous solution of glycerol flowing in

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different types of coiled pipes for laminar flow in the range of Reynolds number 80 to 6000. They reported that the intensity of free vortex flow in a curved pipes is changes with the length and the curvature ratio of the coiled pipe.

G. S. Arvind, Y. Arun, R. Sunder and S. Subrahmaniyam [8] has an objective to obtain overall heat transfer coefficient for different solutions Rectangular channel. They experimentally studies overall heat transfer coefficient is high for water and for soap solution and CMC solution it has low heat transfer coefficient, which increases if mass flow rate is increased.

V. V. Sitram Murthy and R. Sastry [9] has an objective to propose heat transfer coefficient in a coil applicable both for viscous and non-Newtonian liquids. They experimentally reported that for laminar region film heat transfer coefficient is given by

$$h = Q / A (\Delta T) \ln \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

R. Ramasubramanian and S. K. Pandey [10] has a objective to study the effect of agitator speed on heat transfer coefficient. They experimentally stated that heat transfer coefficient increases with an increase in speed of agitation for all suspension. They presented the Nusselt number correlation in following manner

$$Nu = B (Re)n \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, n =0.7 for water suspension

B = constant

III. EXPERIMENTAL SET-UP

The experimental set-up consisting of the following parts

Cylindrical Tank

Helical Coil

Digital Temperature Indicator

Set of Thermocouple

Dimmerstat

Heater Unit

Stirrer and Motor

flow measuring Device

A. Cylindrical Tank

The criteria for selection of cylindrical tank should be such that, the helical coil arrangement, the heater and stirrer for agitation must accommodate in it. Considering the proper sizes, height of coil & the distance of helical coil from the heater, a cylindrical tank of dimensions 35 cm inner diameter, height 51.0 cm with a thickness of 25 mm is selected. The tank selected is of material Stainless Steel.

B. Helical Coil

The material selection for the helical coil is such that, it must have maximum thermal conductivity At the same time material should be easy to bend in the form of helical structure, so the material selected for the helical coil which has both these properties and it is easily available. Thus for this purpose maximum thermal conductivity material Copper coil is used for the experimental analysis of convective heat transfer through helical coil.

C. Experimental Procedure

The convective heat transfer analysis of helical coil is basically heat transfer between the bath liquid & fluid flowing through helical coil i.e. water. The bath liquid used for the analysis purpose are namely water. To find out the various parameters required for the analysis certain procedure must be adopted. So a testing procedure is designed and the same as followed during this experimentation

Fill the cylindrical tank with proper liquid water such that the entire setup of helical coil immersed in liquid.

Adjust the heat supplied to setup by properly adjusting dimmer. Heat input should be recorded from the values of voltage and current.

Adjust the flow rate of water entering in helical coil in a way to maintain constant flow rate after enough heating of liquid.

Note down the various thermocouple reading with the help of temperature indicator at steady state.

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Carry out the experimentation for the various values of heat input and by changing the mass flow rate.

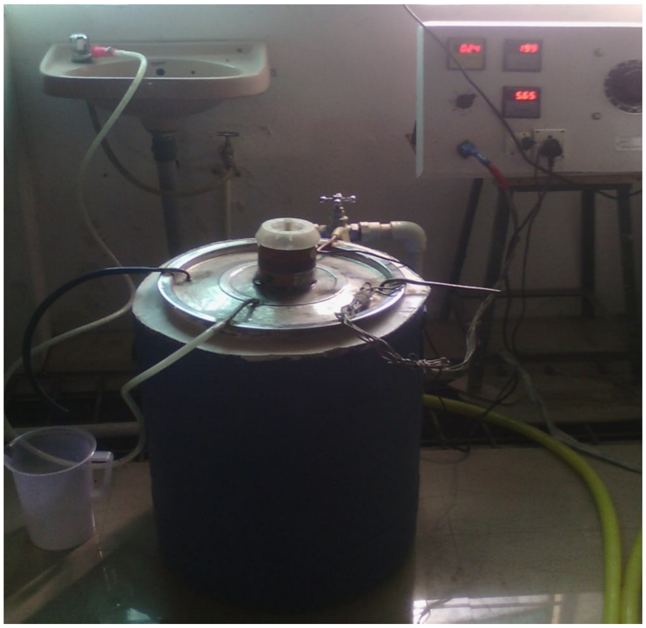

Fig.-1 Actual Experimental Set

D. Experimental Methodology

1) Governing Equations: The convective heat transfer rate Q convection from electrically heated coil surface is calculated by using

Q(conv.)= Qelect.

The electrical heat input is calculated from the electrical potential and current supplied to the surface.

Qelect. =V×I

The heat transfer through by convection can be expressed as

Q(conv.)=h A(To-Ti)

A=πdL (For Helical Coil)

Where d is the diameter of coil

In all calculations, the values of thermo physical properties of air were obtained at the bulk mean temperature, which is Tm= (Tin +Tout)⁄2

2) Deciding Type Of Flow:

For Laminar Flow:

$$Nu = \frac{0.364}{A}(De)^{\frac{1}{2}}\left\{1+\frac{2.35}{(De)^{\frac{1}{2}}}\right\}$$

$$A = \left[\frac{2}{11}\right]\left[1+\{1+\frac{77}{4.\mathrm{Pr}^2}\}^{0.5}\right]$$

For De > 30 ∞ 60 & (Pr=1)

For Turbulent Flow:

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$$Nu = \frac{1}{41} x \Pr^{0.4} x \operatorname{Re}^{\frac{5}{6}} \left(\frac{d_i}{D_c}\right)^{\frac{1}{12}} \left\{1 + \frac{0.061}{\left[\operatorname{Re}\left(\frac{d_i}{D_c}\right)^{2.5}\right]^{\frac{1}{6}}}\right\}$$

For Pr>1 and Re $= \left(\frac{d_i}{D_c}\right)^{2.5} > 0.4$

IV. RESULT AND DISSCUSSION

Sr No.	V (volt)	I (amp)	Qi (watt)	M (gm/sec)	T1 °c	T2 °c	T3 °c	Tm °c	Tb °c	Ti °c	To °c	Re	Nu	h	U
1	40	1.18	47.2	4	24	25	25.5	25	26	20	23	1140	10.86	0.5657	0.565
2	80	2.26	180.8	5.75	28	29	28.5	29	31	20	30	1170	13.86	1.36	1.178

Table-1: Copper Helical Coil

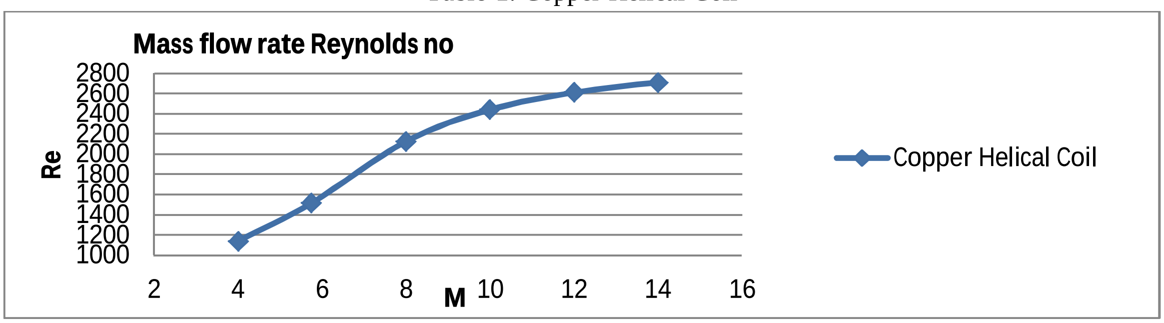

Fig-1: Variation of M with Reynolds No. (Re) -copper helical coil

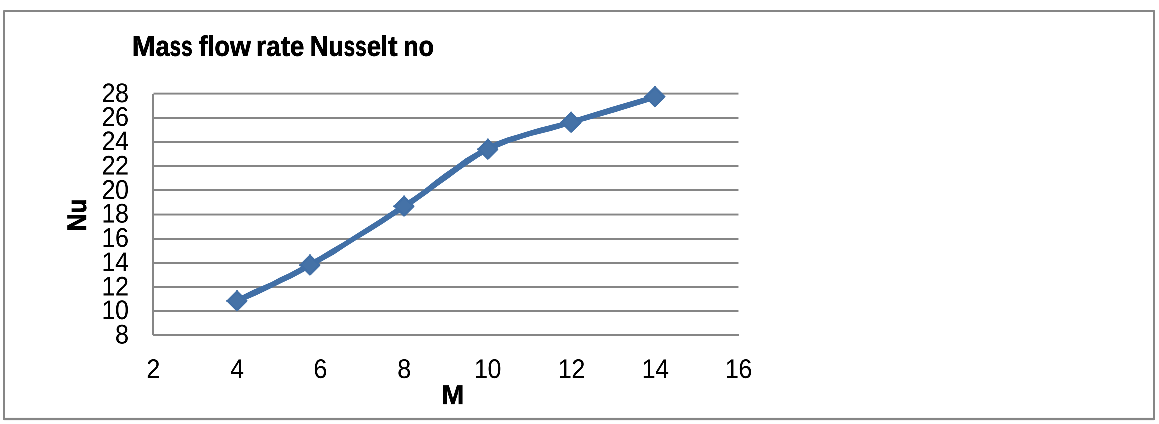

Fig-2: Variation of M with Nusselt No (Nu) -copper helical coil

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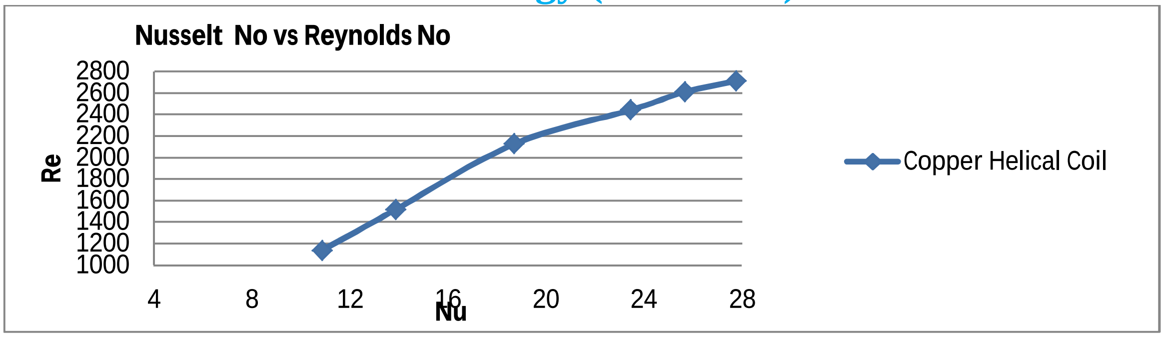

Fig-3: Variation of Nusselt No(Nu) with Reynolds No. (Re) - copper helical coil

V. CONCLUSION

Reynolds number increases with increase in mass flow rate for water and at all heat inputs

Nusselt No. number increases with increase in mass flow rate for water and at all heat inputs

Overall Heat transfer coefficient is high for copper coil. Hence heat transfer rate will be more for copper coil leads to its industrial application.

Average value of Heat transfer coefficient is more for copper helical coil and increases with mass flow rate.

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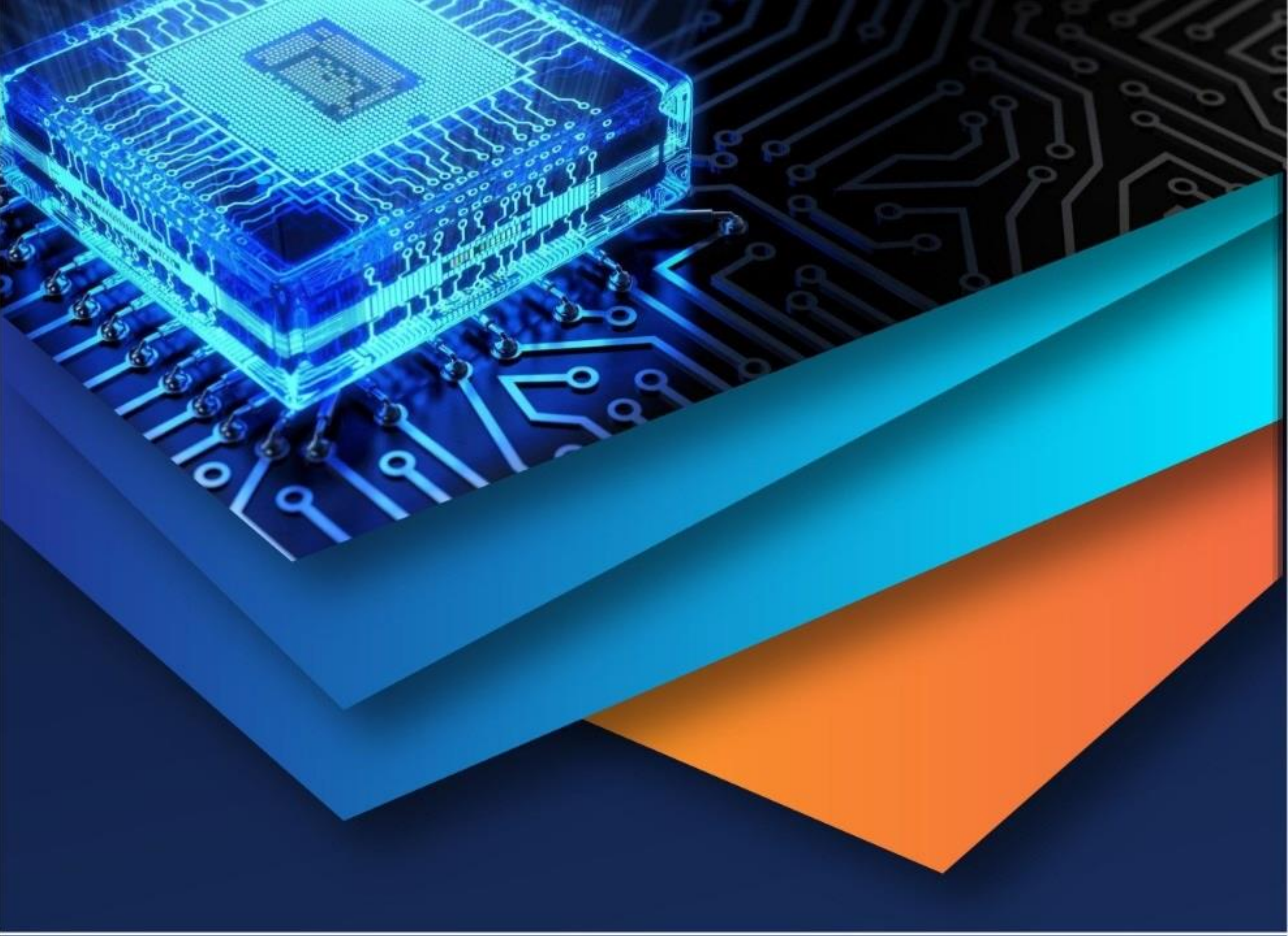

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