Effect of Investigation On Heat Transfer Characteristics And Pumping Power Of A Water And Ethylene Glycol Mixture In Jet Impingement

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Abstract:- In this paper, experimental investigation of convective heat transport characteristic in the jet impingement with constant heat flux. This work is on purified water, ethylene glycol and a mixture of distilled water and ethylene glycol (10%, 30% and 50% by volume) Results of Thermal conductivity, over all heat transfer coefficient, Reynolds number, pumping power have been represented in the present work. The present experimental results show that mixing of ethylene glycol in distilled water enhances the thermal performance of the impingement of jet.

Keywords: **Heat Transfer Enhancement, Convective heat transport coefficient, Ethylene glycol, jet impingement.**

I. INTRODUCTION

Heating or cooling in the industries like Electronics, Auto-sector and various manufacturing sector have the important challenging task related to heat transport.. To achieve high heat transport, the smaller units become an increasing demand from commercial applications.

Traditional heat transporter fluids such as pure water, oil, and ethylene glycol mixtures are inherently less heat transport fluids. With increasing global demand, competition, industries have a strong need to develop advanced heat transport fluids with significantly more thermal conductivity than pure water. The thermal conductivity of heating or cooling fluid is a very important property in the development of energy efficient heat transport systems. At the same time, in all processes involving heat transport, the thermal conductivity of the fluid is one of the basic properties taken account in designing and controlling the process.

II. LITERATURE REVIEW

M Kumar (2015) Conducted experiments on the enhancement of heat transport in laminar and turbulent flow of varying composition of ethylene glycol mix with water using miniature double tube hair-pin heat exchanger. Find results indicate that heat transport coefficient of a mixture of ethylene glycol and water increases with Re number and ethylene glycol concentration. This is because of enhanced fluid properties.

B. P. Singh Tomar(2015) tried the heat transport analysis on car radiator using with nano fluid-Al_2O_3 and Water mixture as coolant and conclude that Extra 3% pumping power is requirement for the radiator using 1% Al_2O_3 nano particles with Ethylene Glycol +Water combination (50:50) at 5 LPM coolant flow rate compared to that of using Base fluid same radiator.

Paresh Machhar(2013) Conducted Heat Transport Enhancement in car Radiator with TiO_2 and Water Nanofluid Meanwhile it was observed from investigators, application of nanofluid with low mixture of pure water and ethylene glycol can enhance heat transport efficiency get up to 45% in comparison with pure water.

Satish G. Kandlikar(1999) investigate boiling of flow at ethylene glycol and pure water mixture uses in horizontal channel ,conclude the An experimental study is conducted to study the subcooled flow boiling heat transport of aqueous ethylene glycol solutions. Experimental results are obtained for surface heat flux as a function of wall superheat by systematically varying the mass concentration of ethylene glycol in the range of 0 to 40%. The flow configuration is a rectangular flow channel 3 mm * 4 mm c/s with a circular heater 9.5-mm diameter. And suggest next work is warranted to determine accurate values of the fluid-dependent parameter Fn for ethylene glycol.

Selvaraj P., Sarangan J. and S. Suresh shows ethylene glycol prevents corrosion and also play role of antefreezing agent. The increase of Re number & Nu number indicates that the heat transport rate also increases. maximum heat transport enhancement is obtained up to 36% for circular grooved tube, 55% for square grooved tube and 10 % trapezoidal grooved tube in comparison with smooth tube. water and ethylene glycol mixture has a good potential to be used for heat exchangers with a different proportions of pure water and ethylene glycol and different geometries of tube.

S.N. Manjunath studied on the heat transport and friction loss of louver fins heat exchanger at Reynolds number ranging from 100-1000. Good agreement is observed as far as Stanton number with the deviation in heat transport of 1% up to 12%.

G.P. celata the stainless steel tubes evidenced fairly classical behaviour in that the local Nusselt numbers approached the fully developed constant for uniformly heated tubes as Reynolds number decreased and For the smooth glass tubes, the anomalous overall decrease in Nusselt number well below the fully developed constant, for diminishing Reynolds number, is most probably because of the dispersion of the heat generated in the outer surface thin film through peripheral attachments rather than through conduction across the thick, poorly conducting wall to the fluid interface.

III. EXPERIMENTAL SETUP

For this experimental work test rig was such designed in order to find effect of flow rate, nozzle spacing from plate surface and for different water and ethylene glycol conc. to measure effects of mention parameters on heat transport. Figure 1 shows the experimental set up for heater, cu plate, Mica sheet and wire thermocouples. Mica sheet plays role of electrical insulator. Plate of heater sandwiched in between mica sheets to avoid hazards. Assembly is enclosed in thin metal sheet and Cu plate is placed above this. Eight wire j type thermocouples are brazed shown in the fig. 1 to the plate from center to in radial direction with 20 mm distance apart. One end of thermocouple is brazed to Cu plate. Other end of wire is attached to the temperature indicator.

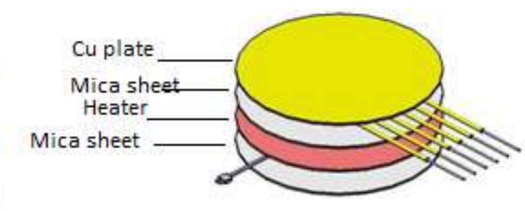

Fig. 1 Experimental Set-Up

Experiments were performed for characterization of heat transport and effect of various parameters on local convective heat transport coefficient. A schematic of experimental set-up is shown in figure 2, the setup was implemented with a suitable instrument to control and measure the different variable affecting phenomena.

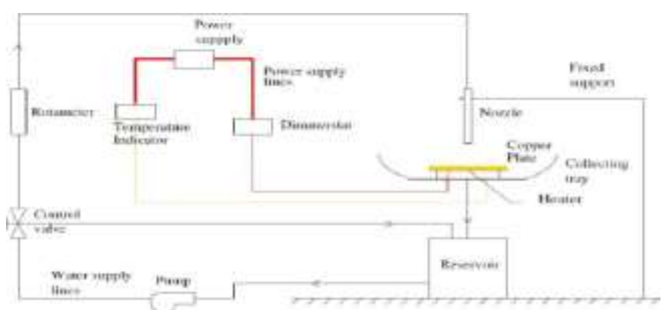

Fig.2 Schemt.Experimental set up

A centrifugal pump is used for sending mixture in the form of jet at the required flow rate. The flow rate was measured by rotameter which connected to 6 mm nozzle arrangement through the PVC piping. The round pipe of internal diameter 6 mm are used as nozzles. The tubes have length to dia. ratio above 50, so as to ensure flow

condition at exit is fully developed. Provisions are also made to get the vertical positions of nozzle. A Jet from nozzle fall on heated circular Cu plate of 2 mm thickness and 300 mm diameter, mounted on fixed leveled surface. The jet impinging centered over flat horizontal Cu plate assembly spreads radially and falls freely into collecting tray of dimension 480 mm x 480 mm. The entire things are mounted on heavy frame structure so that no more effect of external vibrations. The setup fabricated such that local temperature of the plate is measured at 8 various locations. These temperatures can be recorded by operating temperature indicator. Dimmer stat is used for controlling current supplied to the heater. During the experimentation, Perfect horizontal arrangement of target plate was ensured all along with the aid of spirit level, in addition, free fall of the liquid was also observed to be uniform from all the edges of plate to ensure that no perceptible error because lacks flatness of target plate.

IV. EXPERIMENTAL PROCEDURE

An experiment is carried for examine effect of water and ethylene glycol concentrations and flow rate on circular horizontal disk with steady state cooling. Pure water, ethylene glycol and a mixture of pure water and ethylene glycol 10%, 30% and 50% by volume. At the beginning of the experimentation, the rotameter use to establish the required flow rate through the nozzle. Then, the heater is turned on where the electric power is adjusted using the dimmer stat and recorded with voltmeter and ammeter. Then temp. Indicator collects thermocouple readings and noted manually. it should note that system reaches steady state in 45 min where temp is recorded .the experiments are done first for water, ethylene glycol sol. and then mixtures with different concentration.

V. RESULT AND DISCUSSION

This part deals with the investigation of average heat transport coefficient for copper disc. Flow rate for fluid is varied form 1 LPM to 5 LPM.. Initially, plain water and plain ethylene glycol has been impinged upon disc and temperature variation is recorded for flow rates mentioned earlier. Same operating parameters are maintained for Ethylene glycol conc. with volume proportion of ethylene glycol of 10 %, 30 % and 50 % and temperature variation has been recorded. The power required for pumping to water, ethylene glycol sol. and three ethylene glycol conc. is also determined while carrying out experimentation.
Comparison of Experimental convective heat transport coefficient obtained from Nu Number correlations with Reynolds number. There are limited models available to find the average Nu number in jet impingement along circular disk such models are those given by Zhao They used whole analysis method to solve the flow in radial direction of circular disk. The film was divided into stagnation, near impingement point, boundary layer and similarity regions.

Equation proposed by Zao

$$Nu_j = 0.77212\,[2D_j/D]^{2*} Pr^{0.4} Re^{0.5}{}_j + 0.89[2D_j/D]^2 * \{[D/2D_j]^{3/2} - 1\} * Pr^{1/3} Re^{0.5} \qquad (1)$$

Empirical correlation for forced convection over flat plate

$$Nu = 0.663 Re_j^{0.25} * Pr^{0.3} \qquad (2)$$

$$Pr = \mu f\ Cpf/Kf \qquad (3)$$

The above correlations Re Number is calculated at jet exit from nozzle and subscript j represent jet exit conditions.

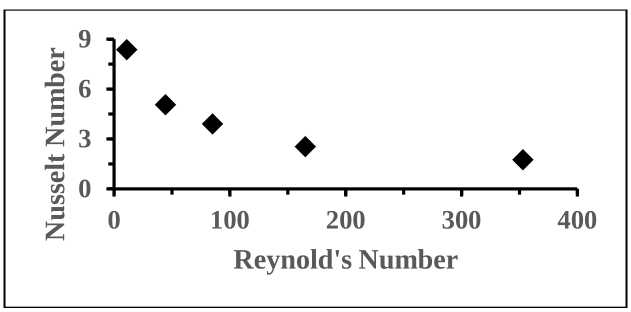

Fig.3 Comparison between Nusselt with Reynolds number for 1 LPM

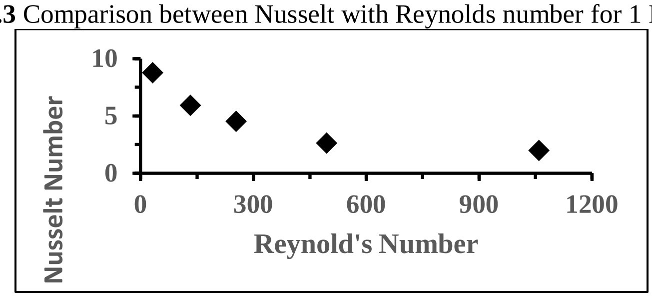

Fig.4 Comparison between Nusselt with Reynolds number for 3 LPM

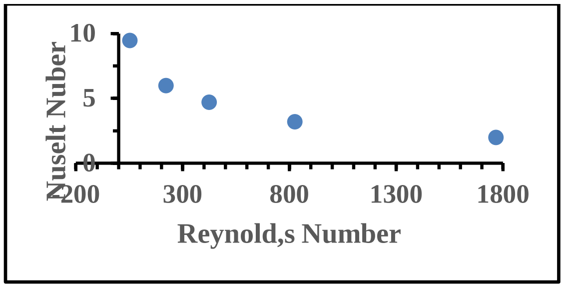

Fig.5 Comparison between Nusselt with Reynolds number for 5 LPM

Pumping Power Requirement

Variation in pump power is also an effective way to observe effect of Ethylene Glycol conc. Percentage of ethylene glycol increases density as well as viscosity of mixture with increase in proportion. As these two properties are dominant in varying the pumping power the same effect observed in following graph.

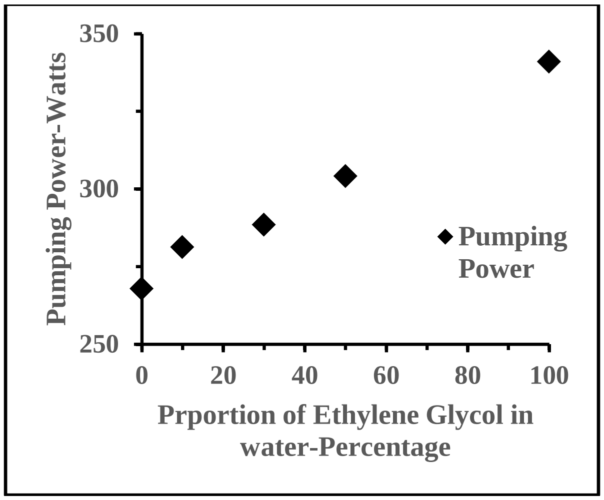

Fig.6 Pumping power required for water, ethylene glycol and three concentrations of ethylene glycol.

VI. CONCLUSION

The experimental results indicate that heat transport coefficient of a mixture of ethylene glycol and water increases with Reynolds number as well as ethylene glycol concentration. This is because of enhanced fluid properties. Factors such as thermal conductivity, density and viscosity, especially in high Prandtl number may cause the augmentation of heat transport coefficient.

Considering the economy and mechanical stability of the jet impingement, the concentration of ethylene glycol cannot be increased above the optimal limit, because more concentration provides higher Pumping cost.

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