Experimental Investigation of Heat Transfer in Compact Heat Exchanger using Water-Ethylene Glycol

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***Abstract*—Now days a days, the demand of automobile is on peak. With the advance in technology the compact heat exchanger has been widely used in various applications in the thermal fluid system including automotive thermal management system. The compact heat exchanger that can be found in automobile vehicle radiators for engine cooling system, evaporators and condenser for HVAC system, oil coolers, and intercoolers. Radiator is the key apparatus for such system. Generally, tube finned type cross flow compact heat exchanger is widely used as radiator.**

Car radiator is heat exchanger used to transfer thermal energy from one medium to another medium for the purpose of cooling and heating. In this study the heat transfer performance of the car overall heat co-efficient according to the conventional LMTD technique. By using ETHYLENE GLYCOL - WATER at different proportion of the 1) 100% water and 2) 70% of water and 30% of ethylene glycol 3) 50% of water and 50% of ethylene glycol 4) 60% of water and 40% of ethylene glycol. The ambient air for cooling and hot liquid is used at constant temperature by adding ethylene glycol and water mixture to find heat transfer rate.

Keywords—Compact heat exchangers , Ethylene glycol , distilled water, Heat transfer .

I. INTRODUCTION

Today, the demand of automobile vehicle is on peak. So, it is a great challenge for automotive industries to provide an efficient and economical engine. The performance of an engine affects by various system like fuel supply system, lubrication system, transmission system, cooling system etc., so, it becomes to account them while designing an engine for improves the engine performance. From all the system cooling system is most important one. It is responsible to carry the large amount of heat waste to surroundings for efficient work of an engine. It also enhances heat transfer and fuel economy due to which the efficiency of engine can be improved. Most I.C engines are fluid cooled either with air or liquid coolant run through a heat exchanger. The heat transfer through radiator can be improved by maximizing the heat transfer area and increasing the heat transfer co-efficient. The heat transfer co-efficient can be increased either by using more efficient heat transfer methods or by improving the thermo physical properties of the heat transfer material i.e. coolant.

1.1 METHOLOGY

Conventional Method

The conventional method for solving this type of problem is the -NTU or LMTD method, since these methods used most commonly in industries. In this section, step by step method for rating of tube finned cross flow heat exchanger is described. The basic steps involved in analysis of a rating problem are determination of the surface geometrical properties, fluid physical properties, Reynolds number, mass velocities, heat transfer coefficients, fin or log mean temperature difference, heat transfer rate, and outlet temperatures for air side and water coolant side.

The steps for calculation of thermal performance of heat exchanger are outlined in detail as follows:

1. Log Mean Temperature Difference (LMTD) method is used to the rate of heat transfer. Calculate the heat transfer rate as follows.

The steps for calculation of thermal performance of heat exchanger are outlined in detail as follows:

$$Q_w = m_w \times c_{p,w} \times (T_{i,w} - T_{o,w})$$

$$Q_a = m_a \times c_{p,a} \times (T_{o,a} - T_{i,a})$$

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Compute the fluid mean temperatures of water and air from the given inlet temperatures and outlet temperatures obtained from above equations 1 and 2, respectively.

2 .The hydraulic diameter, $D_{h,w}$ is defined as;

$$D_{h,w} = \frac{4L_t \times w_t}{2(L_t + w_t)} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

3. Calculate mass flow rate of air ma, Reynolds numbers Re and/or any other relevant dimensionless groups needed to determine the heat transfer coefficients for fluid side of the heat exchanger. Subsequently, compute Nusselt number, Nu_w for water.
Nusselt number for water is taken from the book. [10]
From the given Dittus- Boelter relationship,

$$Nu_w = 0.023(Re)^{0.8}(Pr)^{0.4} \ldots\ldots\ldots\ldots (4)$$

$$Re = \frac{\rho v D_{h,w}}{\mu} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$Re = \frac{\rho v D_{h,w}}{\mu} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Mass of air,

$$m_a = \rho \times A_{fr} \times V_a$$

Where, $A_{fr} = L_1 \times L_3$

Mass flow rate of coolant,

$$m_c = \rho \times A_t \times V \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where,

$$A_t = \frac{\pi}{4} \times {D_{h,w}}^2$$

From Nusselt number of water, Nu the convective heat transfer coefficient for the water side, h_w is calculated as;

$$h_w = \frac{Nu_w K_w}{D_{h,w}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Heat transfer coefficient of air,

$$Q_a = h_a A \Delta T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where,
A = heating surface area, (π×d×l×No.of Tubes)

Fin efficiency,

$$\eta_{fin} = \frac{\tanh(ml)}{(ml)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Where, $m = \sqrt{\frac{2h_a}{k_f t_f}}$ and $L = \frac{b}{2}$

Overall heat transfer coefficient (U),

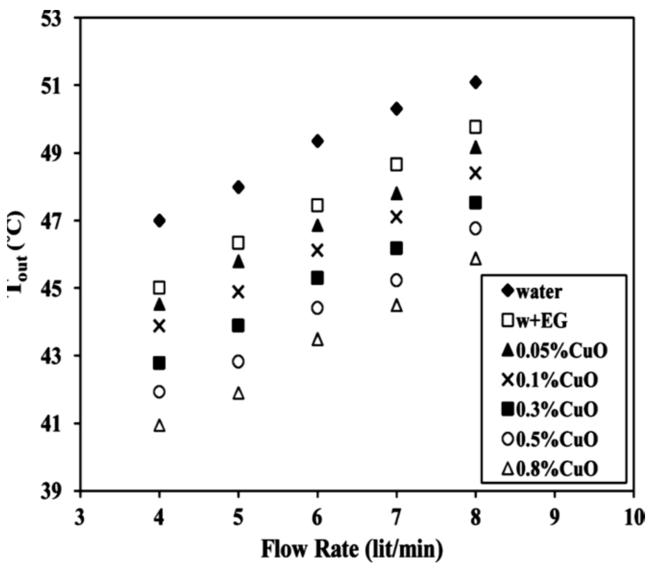
$$\frac{1}{U} = \frac{1}{h_w} + \frac{1}{h_a}$$

$$U = \frac{h_w \times h_a}{h_w + h_a}$$

II.REVIEW

S. Zeinali Heris, M. Shokrgozar, S. Poorpharhang, M. Shanbedi, and S. H. Noie [1]

Conventional heat transfer fluid such as water and ethylene glycol (EG) can be used for cooling fluids in car radiators, and have relatively poor heat transfer performance. One method for increasing heat transfer in car radiators uses nanofluids. Nanofluids as a new technology are obtained by dispersing nanoparticles on the base fluid. In the present study, CuO (60 nm) nano-particles were used in a mixture of water/EG as a base fluid. Then, the thermal performance of a car radiatorwas studied. The experiment was performed for different volumetric concentrations (0.05–0.8 vol %) of nanofluids of different flow rates (4–8 lit/min) and inlet temperatures (35, 44, 54○C).The results showed that nanofluids clearly enhanced heat transfer compared to the base fluid. In thebest condition, the heattransfer coefficient enhancement of about 55% compared to the base fluid was recorded.



K.Ramesh1, R.Haridass2, E.Vignesh 3, T.Rajeshkumar4 [2]
The performance of an engine affects by various systems like fuel supply system, lubrication system, transmission system, cooling system etc. So, it becomes essential to account them while designing an engine for improves the engines performance. Cooling system is one of the important systems amongst all. It is responsible to carry large amount of heat waste to surroundings for efficient working of an engine. It also enhances heat transfer and fuel economy which leads to maximize the performance of an engine. Most internal combustion engines are fluid cooled using either air or a

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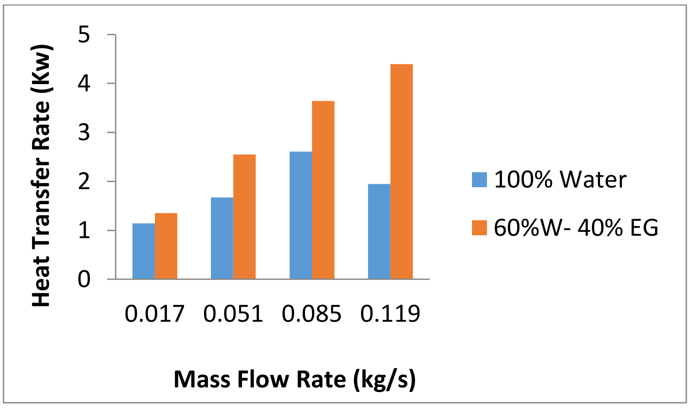
liquid coolant run through a heat exchanger (radiator) cooled by air. The heat transfer through radiator can be improved by maximizing the heat transfer area and increasing the heat transfer coefficient. The heat transfer coefficient can be increased either by using more efficient heat transfer methods or by improving the thermo physical properties of the heat transfer material i.e. coolant. Earlier, Water was widely used in radiator as a coolant for its good ability to holding heat, transfer heat and can be readily obtained. Also the mixture of water & ethylene glycol later introduced as a coolant.From the experimental result, the antifreeze coolant solutions can vary with their boiling point and freezing point depression. By increasing the mixing ratio of glycol with deionised water the boiling point are also get increased. Similarly the freezing point of the mixture is also get decreases. The boiling pointvariation and viscosity variation of Ethylene glycol mixture is get calculated and proved successfully.

Datta N. Mehtre, Sandeep S. Kore [3]

The objective of this experimental study is to discuss the thermal performance of car radiator using Al2O3–nanofluid in temperature ranges from (40-75°C) under different fractions of nano particles from 0.5, 1, 1.5% by volume. In this study, the heat transfer with water based nanofluids was experimentally compared to that of pure water as coolant in an automobile radiator. By varying the amount of Al2O3 nano particles blended with base fluid water, three different concentrations of nanofluid 0.5%, 1%, 1.5% (by vol.) were obtained. The size of nano particle used was 100 nm. Liquid flow rate has been changed in the range of 50 lph to 200 lph and air velocity in the range of 3.8 m/s to 6.2 m/s. The fluid inlet temperature was varying from 40°C to 75°C to find the optimum inlet condition. Results demonstrate that increasing coolant flow rate can improve the heat transfer performance. Also increasing the air flow rate improves the heat transfer rate.

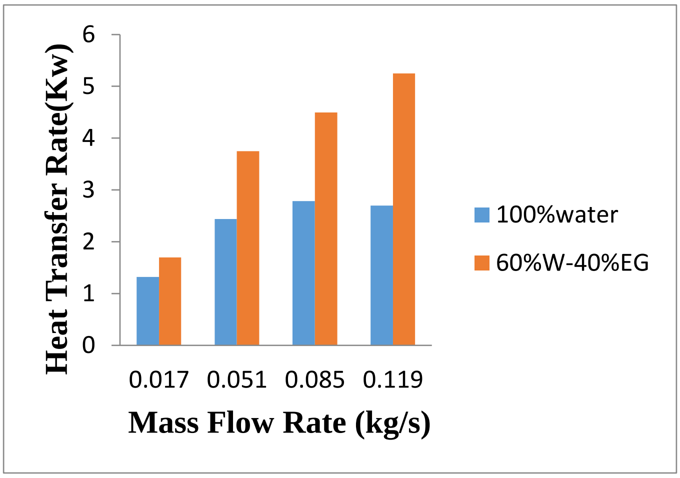
III RESULT AND DISCUSSION

This chapter consists of graphical representation of our project comparing all our proportion with 100% water which is pure distilled water without any involvement of ethylene glycol. The following are charts of our experiment:-



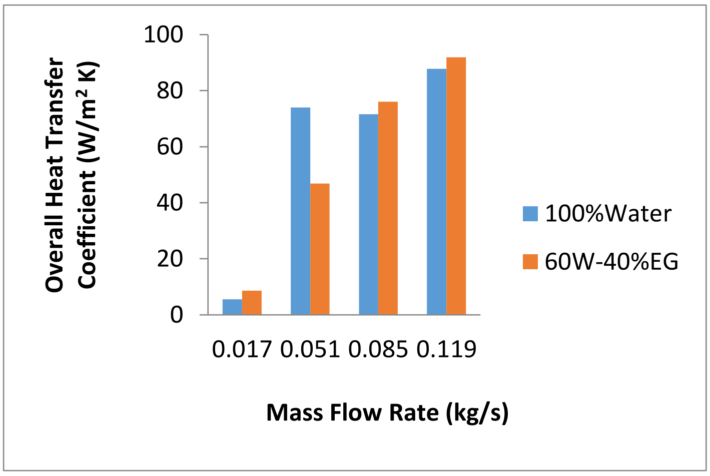
Comparison of 100% Water & 60%Water-40%EG at 60 °C

As shown as above fig. Here 60% water and 40% ethylene glycol at 60°C is used where heat transfer rate is gradually increasing as the mass flow rate is increased and better result than 70% water and 30% ethylene glycol.



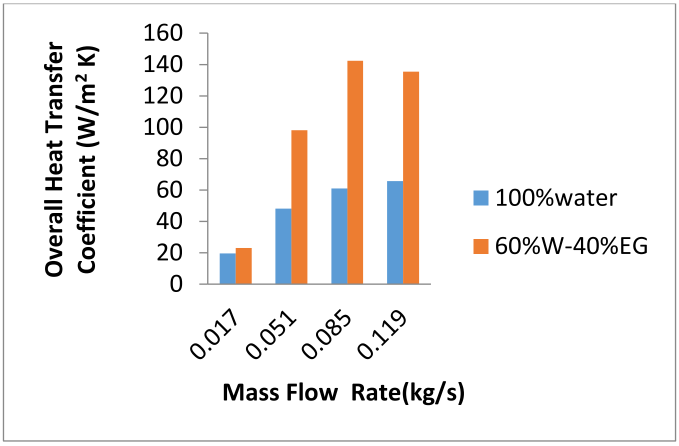
Comparison of 100% Water & 60%Water-40%EG at 70 °C

As shown as above fig, Here 60% water and 40% ethylene glycol at 70°C is used where heat transfer rate is gradually increasing as the mass flow rate is increased.



Comparison of 100% Water & 60%Water-40%EG at 60 °C

As shown as above fig. Here 60% water and 40% ethylene glycol at 60°C is used where overall heat transfer co-efficient is gradually increasing and is more than 100% water.



Comparison of 100% Water & 60%Water-40%EG at 70 °C

As shown as above fig. Here 60% water and 40% ethylene glycol at 70°C is used where overall heat transfer co-efficient is gradually increasing at a certain limit when mass flow rate is (0.085) and then after decreasing on next mass flow rate.

IV. CONCLUSION

In present study, an experimental analysis is carried out for a tube finned type mobile radiator. From this experiment, some conclusions are observed which mentioned in this chapter.

By increasing proportion of ethylene glycol in water on different temperature, mass flow rate increases and due to that heat transfer rate and overall heat transfer co-efficient increases. We conclude that heat transfer rate increases when proportion of coolant is 60% water - 40% ethylene glycol at 60°C which is 4.39819 Kw and increases at 60% water- 40% ethylene glycol at 70°C which is 5.2479 Kw. Overall heat transfer co-efficient at 60% water-40% ethylene glycol at 60°C which is 91.92628W/m^{2}K which increases to 60% water-40% ethylene glycol at 70°Cwhich is 142.2622 W/m^{2}K.

V. REFERENCES

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