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Investigating the Convective Heat Transfer Coefficient for Automotive Car Radiator by using Nanofluids

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***Abstract* - Nanofluids are new heat transfer coolant. This study is mainly on the application of water based Al_2O_3 nanofluid at lower concentration in a radiator. Al_2O_3/water nanofluid is used because it is boardly used in the research area due to requirements such as homogeneity and continuous suspension without any chemical change of the base fluid. In this work two step method is used for preparation of the nanofluid. Al2O3 nanoparticles with an diameter of 50 nm was dispersed in pure water at different volume concentrations (0.1 & 0.2 vol. %) without any dispersant or stabilizer. Flow rate is varied in the range of 2 lit/min to 5 lit/min and inlet coolant to the radiator has a constant temperature which is changed at 50, 60 and 70 degree celsius. The results we get that the convective heat transfer coefficient is more with nanofluid. And the heat transfer coefficient increases with increase in flow rate and with increase in nanoparticle concentration.**

***Index Terms* - Convective heat transfer coefficient, Nanofluids, Automotive car radiator, Al_2O_3 nanoparticles.**

I.INTRODUCTION

When the temperature of engine is high there is chances of Dissociation and also loss of lubricating effect, due to which the efficiency of an engine reduces. Hence temperature range must be maintained properly for increasing the efficiency and reduces the fuel consumption. Radiator is compact type of heat exchanger having area density nearly 1000 m2 /m3. Radiator is placed on front side. if the size of radiator is big, then it produce more drag, increase weight of vehicle and also affect look of vehicle. The conventional coolants used in automobile radiators are water are water and ethylene glycol, these coolants have very low thermal conductivity, hence more area is needed to achieve required heat transfer 3 rate. This problem may be solved if coolant which have high thermal conductivity will be used. The term nanofluid was first suggested by by choi at Argonne National laboratory in 1995. Most researchers has proven that nanofluids are best compared to conventional fluids as a heat transfer agent

Radiators: Radiator is a heat exchanger device used for cooling IC engines. IC engines are cooled by a liquid called engine coolant, the coolant absorbes heat and then through a radiator it loses heat to the atmosphere, and then returned to the engine. Engine coolants are water or oil. a pump force the engine coolant to circulate, and an axial fan is used to force air through the radiator. The radiator absorbes the heat from the coolant and transfers the heat to the air outside, which results in cooling the engine.

Nanofluids: Nanofluids are a colloidal mixture of nanoparticles (1– 100 nm) and a base fluids (water, ethylene glycol, engine oil and transmission oil). Compared to micron-sized particles, nanoparticles are engineered to have larger relative surface areas, less particle momentum, high mobility, and better suspension stability than micron-sized particles and importantly increase the thermal conductivity of the mixture. Hence the nanofluids are best coolants. Nanofluids are the best coolant for increasing the rate of heat transfer.

II. OBJECTIVES

1) To prepare Nanofluid.
2) To find out behaviour of Nanofluid at different inlet temperature of coolent.
3) To investigate the performance of automobile radiator on the basis of different heat transfer fluid those heat transfer fluids are water and nanofluids.

4) To investigate experimentaly under real conditions using different volume concentration and flow rates of nanofluids.
5) To calculate the convective heat transfer coefficient of radiator using nanofluid.
6) To study the effect of increase in flow rate on outlet temperature and heat transfer coefficient.

III. NANOFLUID PREPARATION

Preparation of a nanofluid is of great importance in heat transfer applications. There are two methods to produce nanofluids, by a one-step method or a two-step method. The one-step method disperses the nanoparticles directly into the base fluid, in the two-step method the nanoparticles are made and then dispersed in the fluid. It is very difficult to suspend nanoparticles uniformly into the base fluid due to the presence of strong attractive forces between them that lead to colliding and aggregation effects. So different techniques are used for proper dispersion of nanoparticles into the base fluid. magnetic stirring, Ultrasonication, and pH adjustment are the techniques used most commonly for two-step process. In Ultrasonication Method applying ultrasonic sound waves of frequency greater than 20 kHz to agitate the nanoparticles into the base fluid that reduces nanosized cluster formation by breaking intermolecular interactions.

Fig. 1 : Ultrasonicator for preparation of nanofluid

As for the Al2O3/water nanofluid, samples of 0.1% and 0.2% weight Aluminium oxide in base fluid (water) were prepared using ultrasonicator for about 8 hours. The nanoparticles were dispersed in water and ultrasonicated to obtain the solution of Al2O3/water nanofluid. The ultrasonication process prevente particle agglomeration. Figs. 2 and 3 depict the dispersion of nanoparticles in base fluid before and after sonication. we see the particles are homogenously dispersed throughout the base fluid in an acceptable fashion.

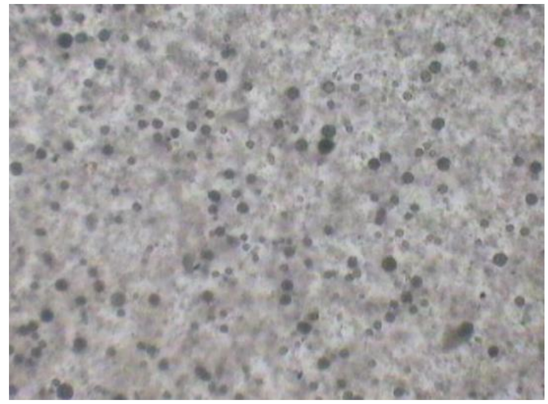

Fig. 2 : Before Sonication

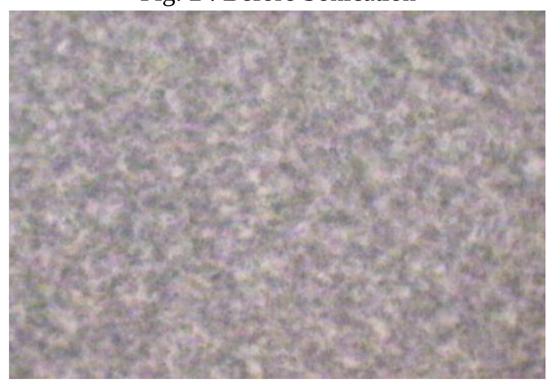

Fig. 3 : After Sonication

IV. METHODOLOGY

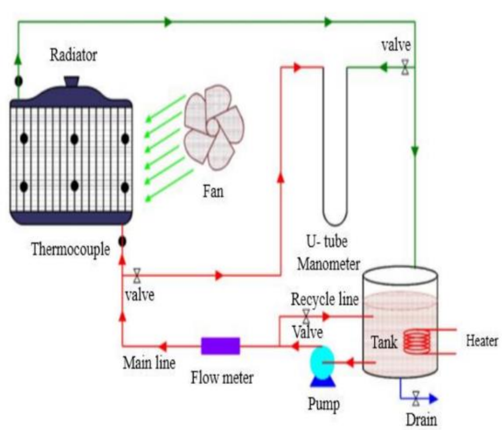

Fig. 4 : Schematic diagram of an experimental setup

The test rig in above fig. 4 has been used to measure convective heat transfer coefficient in diesel engine radiator. This experimental setup includes a reservoir steel tank, electrical heater, a centrifugal pump, a flow meter, tubes, valves, a power supply; 8 thermocouples for temperature measurement, manometer tube with mercury and car radiator. An electrical heater inside a steel storage put to represent the engine and to heat the fluid. A flow meter of capacity 0 - 600 LPH used to measure the flow rate and two valves used to control the flow rate. The fluid flows through plastic tubes with the help of centrifugal pump from the tank to the radiator. The total volume of the circulating fluid is 3-lit and constant in all the experimental steps. Two thermocouples were fixed on the flow line for determining inlet and outlet fluid temperatures. 6 thermocouples are fixed to the radiator surface to measure wall temperature. To measure all the temperatures of thermocouples a DTI is provided. The speed of a fan was kept constant throughout the experiment. Before conducting the experiment on the Al2O3/water nanofluids in the radiator, first the experiment were run on pure water in order to check reliability and accuracy of the experimental setup. After that experiment is carried out on 0.1% Øv nanofluid and 0.2% Øv nanofluid. Hence we have to run the experiment on 3 different coolant they are pure water, 0.1% Øv nanofluid and 0.2% Øv nanofluid. For all 3 different coolant flow rate is varied in the range of 2-5 LPM and measured with the help of Rota meter. The average wall temperature of radiator can be calculated by measuring temperature of radiator at six different places. Inlet and outlet temperature of coolant are measured with the help of thermocouple. After obtaining the readings of flow rate, inlet & outlet temperature of coolant and the average wall temperature of radiator then we can calculate the convective heat transfer coefficient of the radiator.

V. CALCULATION OF HEAT TRANSFER COEFFICIENT

To obtain heat transfer coefficient following procedure has been used.

Heat transfer rate can be calculated as

$$Q = mC_p\Delta T = mC_p\,(T_{in} - T_{out}) \qquad (1)$$

Where, Q is heat transfer rate, m is mass flow rate, C_p is specific heat capacity, T_{in} and T_{out} are inlet and outlet temperatures.

According to Newton's law of cooling

$$Q = hA\Delta T = hA(T_b - T_w) \qquad (2)$$

Where, h is heat transfer coefficient, A is the peripheral area of radiator tubes, T_b is a bulk temperature which is assumed to be average values of inlet and outlet temperature of fluid moving through the radiator and T_w is tube wall temperature which is the average value of six thermocouples placed on the surface of radiator. Now by equating equation (1) and (2) we obtain heat transfer coefficient as shown below in the equation (3)

$$h = Q / A(T_b - T_w) \qquad (3)$$

Area of Radiator:

The radiator consist 36 vertical tubes of and diameter of tube is 8 mm, so to find out convective heat transfer coefficient total area of radiator is calculated as follows.

Total Area of Radiator

$$= \pi \text{ x D x L x No. of tubes} \qquad (4)$$

$$A = \pi \text{ x } 8 \text{ x } 10^{-3} \text{ x } 30 \text{ x } 10^{-3} \text{ x } 36$$

$$A = 0.2714 \text{ m}^2$$

VI. RESULTS AND DISCUSSION

Before conducting the experiment on the Al2O3/water nanofluids in the radiator, initially the experiment were run on pure water in order to check reliability and accuracy of the experimental setup. For three different coolants those are pure water, 0.1% Øv nanofluid and 0.2% Øv nanofluid, flow rate is varied in the range of 2-5 LPM and measured with the help of Rota meter. The average wall temperature of radiator can be calculated by measuring temperature of radiator at six different places. Inlet and outlet temperature of coolant are measured by placing thermocouple. Following are the results obtained by using pure water, 0.1% Øv nanofluid and 0.2% Øv nanofluid.

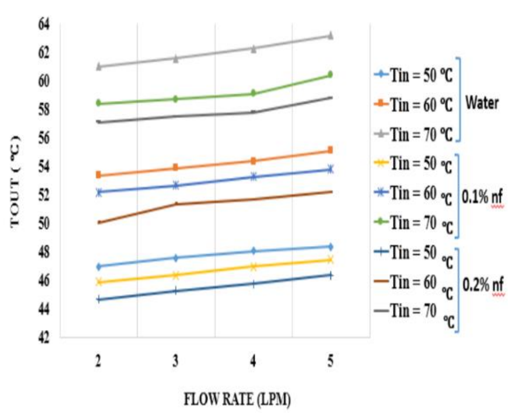

Fig. 5 : Effect of Increase in Flow Rate on Outlet Temperature at Different Volume Concentration and at Different Inlet Temperatures

The above Fig. 5 shows the graph plotted between outlet temperature and flow rate. From this graph we comes to know that the outlet temperature has increased by increase in both flow rate as well as inlet temperature of coolant. It can be clearly seen that the fluid outlet temperature for 0.1% Øv Nanofluid is less then that of pure water as fluid. Simillarly the fluid outlet temperature for 0.2% Øv Nanofluid is less then that of 0.1% Øv Nanofluid. Thus we comes to know that the fluid outlet temperature decreased by increasing the volume concentration. It is also seen that nanofluid concentration plays an important role for decreasing the fluid outlet temperature. By addition of 0.2 vol. % Al_2O_3 in pure water fluid outlet temperature decreased by 4.1 % compared with pure water at 50℃ inlet temperature.

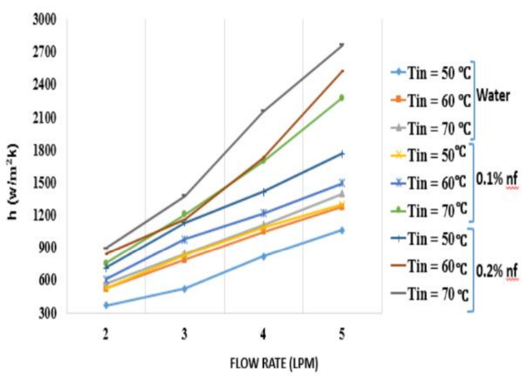

Fig. 6 : Effect of Increase in Flow Rate on Heat Transfer Coefficient at Different Volume Concentration and at Different Inlet Temperatures

The above Fig. 6 shows the graph plotted between heat transfer coefficient and flow rate. From this graph we comes to know that the heat transfer coefficient has increased by increase in both flow rate as well as inlet temperature of coolant. It can be clearly seen that the heat transfer coefficient for 0.1% Øv Nanofluid is more then that of pure water as fluid. Simillarly the heat transfer coefficient for 0.2% Øv Nanofluid is more then that of 0.1% Øv Nanofluid. Thus we comes to know that the heat transfer coefficient increased by increasing the volume concentration. It is also seen that nanofluid concentration plays an important role for increasing the heat transfer coefficient. By addition of 0.2 vol. % Al_2O_3 in pure water heat transfer coefficient increased by 47% compared with pure water at 50℃ inlet temperature.

VI. RESEARCH GAP

Previously ethylene glycol and water were used as conventional coolants in automotive car radiators, but these coolants offers low thermal conductivity than required. Hence by adding nanoparticles in coolants increases the thermal conductivity of coolants, which results in fast cooling of high temperature engine.

VII. CONCLUSIONS

The presence of Al2O3 nanoparticle in water enhance the heat transfer rate of the automobile radiator. Increase in heat transfer enhancement depends on the amount of nanoparticle added to pure water. As heat transfer rate can be improved by nanoparticle based nanofluid, then the Efficiency of radiator increases.

By the application of nanofluid instead of water enhances the heat transfer capacity of cooling system for automobile.

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