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Experimental Research of Heat Transfer using Nano – Fluid in Radiator

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Abstract - *In this research, the heat transfer potential of Al_2O_3/Water nano fluids is investigated experimentally as a coolant for car radiators. Water is used as a base fluid in this experiment work. In this study nano particle volume fraction, coolant flow rate used in the ranges of 0.025%–0.1%, 50–60 LPM. The results show that the heat transfer performance of radiator is enhanced by using nano fluids compared to conventional coolant. Nano fluid with lowest 0.025% volume fraction 8.47% rise in heat transfer is observed and for maximum volume fraction 36% heat transfer increases.*

Key Words: Car radiator, Nano fluid, Nusselt number, Heat transfer co-efficient, Multi cylinder petrol engine

1. INTRODUCTION

It may be noted that particle size is an important physical parameter in nano fluids because it can be used to tailor the nano fluid thermal properties as well as the suspension stability of nano particles. Researchers in nano fluids have been trying to exploit the unique properties of nano particles to develop stable as well as highly conducting heat transfer fluids. The key building blocks of nano fluids are nano particles; so research on nano fluids got accelerated because of the development of nano technology in general and availability of nano particles in particular. Compared to micrometer sized particles, nano particles possess high surface area to volume ratio due to the occupancy of large number of atoms on the boundaries, which make them highly stable in suspensions. Thus the nano suspensions show high thermal conductivity possibly due to enhanced convection between the solid particle and liquid surfaces. Since the properties like the thermal conductivity of the nano sized materials are typically an order of magnitude higher than those of the base fluids, nano fluids show enhancement in their effective thermal properties. Due to the lower dimensions, the dispersed nano particles can behave like a base fluid molecule in a suspension, which helps us to reduce problems like particle clogging, sedimentation etc. found with micro particle suspensions. The combination of these two features; extra high stability and high conductivity of the dispersed nano species make them highly preferable for designing heat transfer fluids. The stable suspensions of small quantities of nano particles will possibly help us to design lighter, high performance thermal management systems. Cooling is indispensable for maintaining the desired performance and reliability of a wide variety of industrial products such as computers, power electronic circuits, car engines, high power lasers, X-ray generators etc. With the unprecedented increase in heat loads and heat fluxes caused by more power in miniaturized products, high tech industries such as microelectronics, transportation, manufacturing, metrology and defence face cooling as one of the top technical challenges. For example, the electronics industry has provided computers with faster speeds, smaller sizes and expanded features, leading to ever increasing heat loads, heat fluxes and localized hot spots at the chip and package levels. Such thermal problems are also found in power electronics, devices etc. So the enhanced heat transfer characteristics of nano fluids may offer the development of high performance, compact, cost effective liquid cooling systems.

2. EXPERIMENTAL SETUP

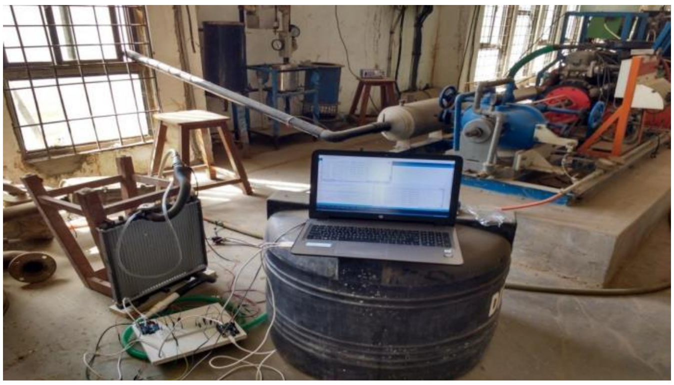

Figure:1 Experimental setup

2.1 Components

- Radiator
- Radiator fan

- Coolant Reservoir
- Pump
- Heating Element
- Arduino and circuit

2.2 Experiment Method

In the test apparatus the engine will be acting as a source of heat which will heat continuously. This heating element will heat up the coolant. After heating, the hot water is pumped with the help of a pump in to the radiator. At the outlet of the pump a flow control valve is installed to measure the mass flow rate of the hot coolant. The flow is controlled by a controlling valve, which helps in obtaining different mass flow rate of the hot coolant. Then the inlet temperature to radiator is calculated by installing one thermocouple at inlet and is digitalized by Arduino circuit. The hot water then flows through the radiator core. Here with the help of a fan cold air is sucked in, which helps in decreasing the temperature of the coolant flowing through the radiator. Then, the temperature at outlet is measured by a second thermo couple. After this the coolant from outlet is returned to the reservoir where it again becomes hot by the action of heating element and is re-circulated in the flow circuit to maintain the continuity of flow. During testing, firstly water is taken as a coolant. It is circulated at a mass flow rate of 50, 55, and 60 LPM (litter per minute). The fan is rotated at a constant speed. After this the temperature of hot coolant at the outlet is recorded at particular inlet coolant temperature. After this first round of data recording the coolant is changed. This time water is replaced with a mixture containing Al_2O_3/Water nano fluid in water. Here the mass flow rate is maintained at the same level as before and the fan is also circulated with the same speed. The temperature of the hot coolant at the inlet is also maintained at the previous values and the corresponding temperature values of the hot coolant at the outlet are recorded. After this second round of data recording the coolant is changed. This time a mixture vol. % change of Al_2O_3/Water Nano fluid in water is taken. Here the mass flow rate is maintained at the same level as before and the fan is also circulated with the same speed. The temperature of the hot coolant at the inlet is also maintained at the previous values and the corresponding temperature values of the hot coolant at the outlet are recorded. Same as data recording for mixture containing different four vol. % of Al2O3/Water Nano fluid with different mass flow rate.

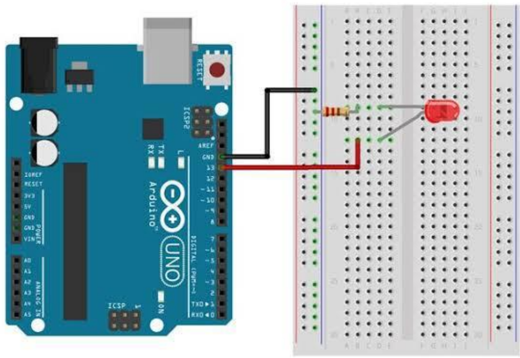

Figure:2 Arduino

The Arduino UNO is an open-source microcontroller board. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits with has Operating Voltage of 5 Volts and Input Voltage of 7 to 20 Volts.

3. EXPERIMENTAL CALCULATIONS

1. Concentration Percentage of Nano Particles:

$\varphi = [(w_p{*}\rho_p)(w_p{*}\rho_p)+(w_{bf}{*}\rho_{bf})] \times 100$

Where, w is weight, ρ is Density; φ is concentration of Nano - particles by volume. p = particles, bf = base fluid, nf = Nano - fluid.

2. Density of Nano Fluid:

$\rho_{nf} = \varphi\rho_p + (1 - \varphi)\ \rho_{bf}$

3. Specific Heat of Nano Fluid:

$C_{p(nf)} = [\varphi\rho_p{*}C_{p(p)} + (1-\varphi)\rho_{bf}{*}C_{p(bf)}]/\rho_{nf}$

Where, Cp is Specific Heat

4. Mass flow rate of Nano fluid

$m = Flow\ rate\ in\ m^3/s \times Density\ in\ kg/m^3$

Where, m = Mass flow rate

5. Viscosity of nano fluid

$\mu_{nf} = \mu_{bf}\ (1 + 2.5\varphi)$

Where, μ is Viscosity

6. Heat transfer rate

$Q = mC_p\,(T_{in} - T_{out})$

Where, Q = Heat transfer rate

7. Heat transfer co-efficient

$h = Q/A(T_b - T_w)$

Where, h = Heat transfer co-efficient

8. Nusselt number

$Nu = hD_h/k$

Where, Nu is Nusselt number and Dh is Hydraulic diameter

9. Prandalt Number

$Pr = \mu C_p/k$

Where, Pr is Prandalt number

$Nu = 0.023Re^{0.8}Pr^{0.3}$

4. RESULTS AND DISCUSSION

4.1 Heat transfer co-effcient VS Nusselt number

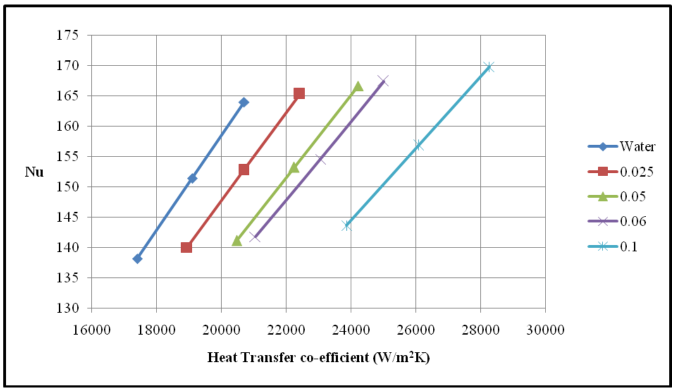

Chart:1 Heat transfer co-effcient VS Nusselt number

Chart:1 shows that heat transfer co-efficient increases with concentration of nano particles. Heat transfer co-efficient is directly proportional to nusselt number so with increases in heat transfer co-efficient nusselt number increases which is shown in the graph. For pure water heat transfer co-efficient at 60LPM flow rate is 20697.28 W/m²K at nusselt number 163.98 and for 0.1% of concentration heat transfer co-efficient at 60LPM flow rate is 28261.85 W/m²K at nusselt number 169.83. Also nusselt number doesn't change much with increase in concentration for same flow rate.

4.2 Concentration of nano fluid VS Nusselt number

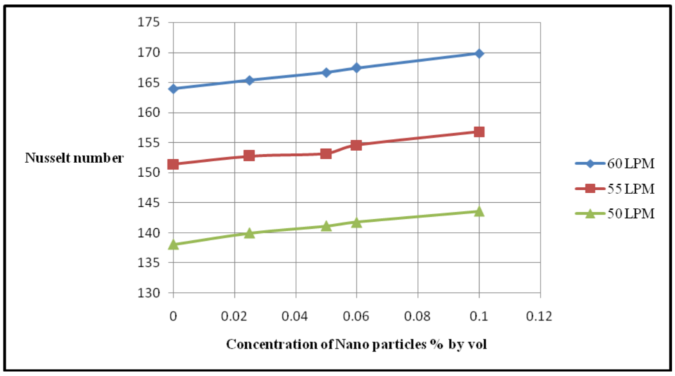

Chart:2 Concentration of nano fluid VS Nusselt number

As mention above chart:2 shows that there is not much changes in nusselt number with increase in concentration of nano particles. For 60LPM flow rate at 0% concentration nusselt number is 163.98 and at 0.1% concentration nusselt number value is 169.83.

4.3 Mass flow rate VS Heat transfer co-efficient

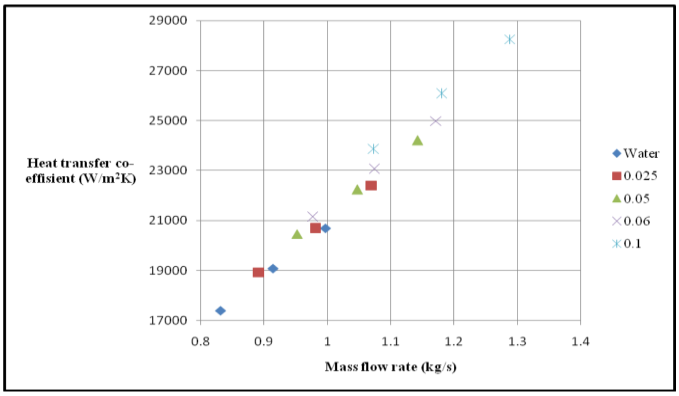

Chart:3 Mass flow rate VS Heat transfer co-efficient

As shown in above graph chart:3 heat transfer co-efficient increase with increase in mass flow rate because with increase in concentration mass flow rate increases and the reason for that is mass flow rate is directly proportional to density of nano fluid so with increase in density mass flow rate increases. For pure water mass flow rate is 0.9971 for 60LPM flow rate and heat transfer co-efficient is 20697.28 W/m²K and for 0.1% concentration at same condition mass flow rate is 1.28 and heat transfer co-efficient is 28261.86 W/m²K.

5. CONCLUSION

It has been seen that nano fluids can be considered as a potential candidate for Automobile application. As heat transfer can be improved by nano fluids, in Automobile radiators can be made energy efficient and compact. We can see from the results that we get 8.47%, 17.03%, 20.80%, and 36.74% heat transfer co-efficient increment for 0.025%, 0.050%, 0.060%, 0.1% concentration by volume of Nano particles respectively. The average heat transfer rates for nano fluids as a cooling media are higher than those for the water which is also used as cooling media, and this increases with concentration of nano fluid composition. Also we get 0.213 increment in thermal conductivity value.

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