A Comparative Study of Performance of Heat Transfer Function of a Radiator using Water, Coolant and Nanofluid

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Abstract: In the present work, heat transfer performance of radiator (Heat Exchanger) was studied as a function of heat transfer by using water, engine coolant and Al₂O₃-water nanofluid. The Al₂O₃-water nanofluid was characterized by X-ray diffraction, scanning electron microscope and ultraviolet-visible spectroscopy. The Al₂O₃ nano particles with specification of 2.5 wt% concentration, cubic size and 60 min. probe sonication were used. The mass flow rate of all the three coolants is kept in the range of 0.5 to 5 lit/min, regulated by Rotameter. Temperature difference at inlet and outlet of Radiator (Heat Exchanger) is recorded for all the three coolants with the help of Thermostat. The temperature difference versus discharge graph plotted for water, engine coolant and nanofluid revealed that the highest heat transfer (thermal conductivity) is for Nanofluid followed by coolant and water. The enhancement in thermal conductivity reflects that the nanofluids could be appropriate for cooling applications.

Keywords- Heat Transfer; Nanofluid; Ultrasonication

I. INTRODUCTION

The boom in advanced technological applications and its miniaturization in the field of electronics and thermal systems, sought the need of efficient heat transfer systems. The optimized design and improved thermal properties of fluid can provide the positive solution in improving efficiency. Heat transfer is an important area of study in thermal engineering. Selection of a suitable heat transfer fluid for heat dissipation is an important consideration in the thermal design of heat exchangers. Heat transfer of fluid is one of the critical parameters which affect the cost and size of heat exchanger systems. Conventional fluids like water and oil have limited heat transfer capabilities. The need for development of new kinds of fluids with improved heat transfer capabilities is being felt by different research groups across the world. The advances in nanotechnology have made it possible to manufacture metal and metal oxide particles on nano dimensional scale. Nano particles are considered to be new generation material having potential applications in the area of heat transfer.

The nanofluids on the other hand offer many advantages over the single phase pure fluids and suspensions with micro particle. The problems of particle sedimentation due to gravity, clogging of micro channel passage, and erosion of tube material are minimized to a great extent when nanofluids are used in heat exchangers. Besides, nanofluids form stable suspensions with uniform dispersion of nano particles in the base fluid. Thermo physical properties of single phase heat transfer fluids such as water, oils and glycols are well established and are available in literature and hand books. The thermo physical properties of two phase nanofluids are not explored much. Nanofluids are considered to be an alternate and new generation liquids for transport of heat energy and can be employed as heat transfer fluids in heat exchangers in place of pure single phase fluids. The applications of nanofluid in heat transfer include radiators in automotive, chemical engineering and process industries, solar water heater, refrigeration, cooling of electronics devices. The main objective of obtaining heat transfer enhancement using nanofluids is to accommodate high heat fluxes and hence to reduce the cost and size of the heat exchangers which in turn results in conservation of energy and material.

II. EXPERIMENTAL SETUP

In the present work, distilled water and engine coolant were purchased from the market and Al₂O₃ nano particles were procured from the Sigma-Aldrich (India) of analytical grade and used without further purification. The nanofluids were prepared by ultrasonication technique (PGC-750F). The Al₂O₃ dispersed water samples were kept for the different interval of time under ultrasonication. Figure 1 shows the schematic diagram of Radiator as a Heat Exchanger.

Instrumentation system was designed to measure fluid discharge, temperature of inlet and outlet fluid, water quantity etc. Figure 2 shows the pictorial view of the designed instrumentation for experimental set up. Fluid Pump, Thermocouples, Radiator Fan, Rotameter, Switch Board, Heater, Radiator and Water Tank are used as standard instrumentation.

The graph of ΔT and discharge is plotted and is shown in fig. 3.
III. EXPERIMENTAL PROCEDURE

Here, Radiator as a Heat Exchanger experimental setup uses water, engine coolant and Al₂O₃-water nanofluid one by one as fluid under investigation. Mass flow rate readings are taken in the range of 0.5 to 5 lit/min (with the step of 0.5). The brief procedure is as under:

1. Readings of temperature difference ΔT are taken for water, engine coolant and nanofluid.
2. Readings for Al₂O₃-water nanofluid at 0.5, 1.0, 1.5, 2.0 and 2.5 wt % concentration, 60 min. probe sonication (for size) and cubic shape nanoparticles are tabulated.
3. Readings for Al₂O₃-water nanofluid at 2.5 wt % concentration, cubic shape nanoparticles at 15, 30, 45 and 60 min probe sonication (size) are tabulated.
4. Readings for Al₂O₃-water nanofluid at 2.5 wt % concentration, 60 min probe sonication (size) and cubic, spherical and cylindrical (rod) shape nanoparticles are tabulated.

The present work is focussed on the first part only i.e. the values of temperature difference (ΔT) are recorded for the three coolants (Water, Engine Coolant and Al₂O₃-water nanofluid) at different values of coolant discharge ranging from 0.5 to 5 lit/min (with the step of 0.5).
IV. RESULTS AND DISCUSSION

The experimentation was carried out and the various readings of temperature were recorded at sink (acts as engine) inlet and outlet of radiator. This is done in all the three cases of coolant that is water, engine coolant and Nano fluid. The observations are recorded in table 1 shown below.

The table 1 shows that the values of temperature difference decrease with the increase in coolant discharge for all the three coolants (Water, Engine Coolant and Al₂O₃-water Nano fluid) under consideration for investigation. Fig.3 reveals that the curves drawn in grey, red and blue color indicate three coolants under consideration i.e. water, engine coolant and Al₂O₃-water Nano fluid respectively. These curves also indicate that the temperature difference ΔT values are maximum for Nano fluid followed by coolant and water. Another discussion which comes to the fore from these curves is that the highest value of ΔT is recorded at mass flow rate of 0.5 lit/min and lowest at 5 lit/min in all the three cases. The discussion on results shown in table 1 and figure 3 give an important finding that the highest heat transfer (thermal conductivity) is because of Nano fluid followed by coolant and water.

Table 1. Water, Coolant & Nanofluid Average ΔT Vs Discharge

<table>
<thead>
<tr>
<th>DISCHARGE</th>
<th>AVERAGE OF DIFFERENCE OF TEMP</th>
<th>WATER</th>
<th>COOLANT</th>
<th>NANO FLUID (2.5 wt%, 60 MIN, CUBIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>8.56</td>
<td>9.45</td>
<td>16.52</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>8.2</td>
<td>8.62</td>
<td>13.26</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>7.14</td>
<td>8.52</td>
<td>13.5</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>6.66</td>
<td>6.82</td>
<td>12.9</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>5.78</td>
<td>5.88</td>
<td>10.4</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>4.94</td>
<td>6.04</td>
<td>9.26</td>
</tr>
<tr>
<td>7</td>
<td>3.5</td>
<td>5.15</td>
<td>5.62</td>
<td>9.04</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4.34</td>
<td>4.6</td>
<td>7.58</td>
</tr>
<tr>
<td>9</td>
<td>4.5</td>
<td>4.38</td>
<td>4.42</td>
<td>7.1</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>3.9</td>
<td>4.26</td>
<td>6.62</td>
</tr>
</tbody>
</table>

Figure 3. Graph Showing ΔT Vs Discharge.

V. CONCLUSIONS

Table 1 depicts the average values of inlet and outlet (radiator) temperature difference against the mass flow rate (0.5 to 5 lit/min) for Water, Coolant and Nanofluid. Fig.3 reveals that:

1. The temperature difference ΔT values are maximum for nanofluid followed by coolant and water.
2. The highest value of ΔT is observed at mass flow rate of 0.5 lit/min and lowest at 5 lit/min in all the three cases.

These two statements conclude that the highest heat transfer (thermal conductivity) is because of Nanofluid followed by coolant and water.
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