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Abstract - Heat transfer enhancement in any system is very important, it increases the performance and also reduces all their dimensions. In the design of any system space availability is very important parameter according to this all components and their size and shape selected to make compact design always select the optimize all parameters so there performance doesn’t change and output remain same also dimension reduces means material cost and weight of this system reduces. In this paper more focused on the heat transfer enhancement of Car radiator by using nano fluid are discusses in short review. Nano fluid is the new generation fluid, it increases the transportation properties of basic fluid in which it added also some discussion of input parameters such as input temperature, input flow rate, concentration of nano fluid and their effect on heat transfers discusses. Low thermal conductivity is always the limitation to design energy efficient heat transfer fluid that are required in many industrial application. Conventional fluid such as water, engine oil and ethylene glycol is normally used as a coolant in car radiator. Although various techniques are used to increase the heat transfer rate but low heat transfer rate of this fluid is obstructs the performance and compactness of heat of heat exchanger, use of solid particles as a additives suspended in to base fluid is key idea to improve heat transfer characteristics of conventional fluid.

Key Words – Nano Fluid, Car Radiator, Heat Transfer

I. INTRODUCTION –

There has been more attention toward to increase convective heat transfer rate of nano fluid [1] particle having size less than 100nm added to base fluid to increase thermal conductivity define as a nano fluid [2] in conventional method water, ethylene glycol used as coolant in car radiator in these case nano fluid added to base fluid to increase the heat transfer rate [1-9] in case study of nano fluid in car radiator pump for force convection used and the heat transfer rate calculated at different input flow rate [1-4] this rate was compare with nano fluid used in base fluid. Effect of different nano fluid with different concentration calculated and compare with base fluid with actually performed experimental setup readings [1-10]. Different models by using different software are created and compare and verified with actual perform values [1-6] different correlation of thermal conductivity, viscosity as a function of particle temperature and concentration are used in the different papers [1-3]. Viscosity is also important parameter for performance enhancement and pressure drop is related with the pumping power and viscosity is related with viscosity as increase the viscosity it increase the pumping power so that the minimization of viscosity is also the critical facture [3-4]. It is observe that viscosity increases when concentration of nano fluid is increases[4]. Density is also one of the important properties it is also having direct effect of pumping power and pressure drop, it is not affected by size, shape and additive it is only affected by the concentration of nano fluid[4].

II. IMPORTANT FORMULAS -

According to Newton’s low of cooling Nu and Re number can calculated as [1-2,5].

Heat transfer coefficient $Q = hA\Delta T = hA(T_b - T_s)$ (1)

Bulk temperature $T_b = \frac{T_{in} + T_{out}}{2}$ (2)

Tube wall temperature $T_w = \frac{T_{in} + T_{out}}{2}$ (3)

Heat transfer rate $Q = mC\Delta T = m\frac{C}{R}(T - T_{out})$ (4)

Mass flow rate $m = \rho V$ (5)

By comparing (1)and (4) heat transfer coefficient $h$ exp $= \frac{mC(T_{in} - T_{out})}{A_s(T_b - T_w)}$ (6)

Nusselt number $Nu = \frac{h exp D_h}{k}$ (7)

Hydraulic diameter $D_h = \frac{4\cdot\text{area}}{\text{perimeters}}$ (8)

Reynolds number $Re \cdot \frac{D_h u}{\mu_{ref}}$ (9)
III. THERMAL CONDUCTIVITY -

important process in industrial application. heat transfer fluid means working fluid such as ethylene glycol, water, and mineral oil play as important role in many industrial application such as power generation, heating and cooling system. By enhancing the heat transfer rate the energy consumption is reduces. Heat transfer is and electronics cooling, low thermal conductivity is one of the obstacle in compactness of this system. the material having higher thermal conductivity called as nano particles are added in to this base fluid to increase the heat transfer rate.[28-29]

D. Viscosity -

Accurate model for viscosity calculation practically nano available but in many cases use the following correlation to calculate the Viscosity at room temperature

\[ \mu_{nf} = \mu_{bf} (1 + 39.11\phi + 539.9\phi^2) \]

E. Thermal conductivity -

Thermal conductivity of nano fluid for Al2O3+water is developed by

\[ \frac{K_{nf}}{K_{bf}} = \frac{R_{nf}}{0.177\phi^{0.5}} \left( \frac{K_{bf}}{K_{nf}} \right)^{0.224} \]

V. EXPERIMENTAL REVIEW ON HEAT EXCHANGER -

Experimental Review on nano fluid used in different heat exchanger at different concentration and size and at different base fluid (Thermal conductivity of Al2O3- based nano fluids) – from following table it is show that increase in fraction of volume of nano fluid increase the thermal conductivity. decreasing nano particle size and shape also influence the thermal conductivity the following table shows the summary of Al2o3 base fluid

IV. THERMAL PHYSICAL PROPERTIES OF NANOFLUID

Heat transfer coefficient of nano particle depend on thermal conductivity of nano fluid, heat capacity of base fluid and nano fluid. Inlet temperature, inlet flow rate, flow pattern, prantl number, Reynolds number, shape and size of nano particle so some important thermo physical properties define as [28-29]

A. Specific heat of nano fluid –

Nano fluid specific heat is define as -

\[ C_{p,nf} = \frac{\rho_p C_p + (1 - \bar{\rho}) \rho_{nf} C_{pf}}{\rho_{nf}} \]

B. Density –

Nano fluid density is the ratio of nano fluid and base fluid density -

\[ \rho_{nf} = \bar{\rho} \rho_p + (1 - \bar{\rho}) \rho_{nf} \]

C. Specific heat -

Specific heat of nano fluid is define as follows -

\[ C_{p,nf} = \frac{\rho_p C_p + (1 - \bar{\rho}) \rho_{nf} C_{pf}}{\rho_{nf}} \]

Table I. Thermal conductivity of different material

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Material</th>
<th>Form</th>
<th>Thermal conductivity W/mk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon</td>
<td>Nano tubes</td>
<td>1800-6600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diamond</td>
<td>2300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphite</td>
<td>110-190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fullerenes fluid</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>Metallic solid (Pure)</td>
<td>Silver</td>
<td>429</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper</td>
<td>401</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nickel</td>
<td>237</td>
</tr>
<tr>
<td>3</td>
<td>Non Metallic solid</td>
<td>Silicon</td>
<td>148</td>
</tr>
<tr>
<td>4</td>
<td>Material Liquid</td>
<td>Aluminum</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sodium</td>
<td>72.3</td>
</tr>
<tr>
<td>5</td>
<td>Other s</td>
<td>Water</td>
<td>0.613</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethylene Glycol</td>
<td>0.253</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engine Oil</td>
<td>0.145</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R134a</td>
<td>0.0811</td>
</tr>
</tbody>
</table>

Table II. Effect of Concentration and size on Enhancement Ratio

<table>
<thead>
<tr>
<th>Author</th>
<th>Base fluid</th>
<th>Concentration</th>
<th>Particle size</th>
<th>Enhancement ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masuda et al.</td>
<td>Water(31.85°C)</td>
<td>1.3 to 4.3</td>
<td>13</td>
<td>1.10 to 1.32</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>Water(66.85°C)</td>
<td>1.0 to 4.5</td>
<td>38.4</td>
<td>1.03 to 1.10</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>Water</td>
<td>1 to 5</td>
<td>1.03 to 1.18</td>
<td></td>
</tr>
<tr>
<td>Eastman et al.</td>
<td>Ethylene Glycol</td>
<td>2.24 to 7.70</td>
<td>1.05 to 1.30</td>
<td></td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Water</td>
<td>1.00 to 5.00</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>1.8 to 5.00</td>
<td>60.4</td>
<td>1.07 to 1.21</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>1.8 to 5.00</td>
<td>15</td>
<td>1.06 to 1.17</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>1.8 to 5.00</td>
<td>26</td>
<td>1.06 to 1.18</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>1.8 to 5.00</td>
<td>60.4</td>
<td>1.10 to 1.30</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>1.8 to 5.00</td>
<td>302</td>
<td>1.08 to 1.25</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Pump oil</td>
<td>5.00</td>
<td>60.4</td>
<td>1.39</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>5.00</td>
<td>60.4</td>
<td>1.39</td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Ethylene Glycol</td>
<td>5.00</td>
<td>1.21</td>
<td></td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Pump Oil</td>
<td>5.00</td>
<td>1.29</td>
<td></td>
</tr>
<tr>
<td>Xie et al.</td>
<td>Glycerol</td>
<td>5.00</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>Das et al.</td>
<td>Water(21°C)</td>
<td>1.00 to 4.00</td>
<td>38.4</td>
<td>1.02 to 1.09</td>
</tr>
<tr>
<td>Das et al.</td>
<td>Water(36°C)</td>
<td>1.00 to 4.00</td>
<td>38.4</td>
<td>1.02 to 1.09</td>
</tr>
<tr>
<td>Das et al.</td>
<td>Water(51°C)</td>
<td>1.00 to 4.00</td>
<td>38.4</td>
<td>1.02 to 1.09</td>
</tr>
<tr>
<td>Wen</td>
<td>Water</td>
<td>0.19 to 1.39</td>
<td>42</td>
<td>1.01 to 1.09</td>
</tr>
</tbody>
</table>
VI. EXPERIMENTAL REVIEW ON CAR RADIATOR

Table III. Experimental Review on nano fluid used in Car radiator at different concentration, different inlet temperature & different flow rate

<table>
<thead>
<tr>
<th>Ref. No.</th>
<th>Nano particles</th>
<th>Working conditions</th>
<th>Conclusion/result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SiO₂</td>
<td>concentration 1 to 2%</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow rate 2 to 8 rpm</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inlet temperature 60 to 80°C</td>
<td>Nusselt number increases</td>
</tr>
<tr>
<td>2</td>
<td>TiO₂</td>
<td>concentration 1 to 2%</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume flow rate 1 to 2%</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inlet temperature 60 to 80°C</td>
<td>Nusselt number increases</td>
</tr>
<tr>
<td>3</td>
<td>Al₂O₃/TiO₂</td>
<td>concentration 1 to 2%</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume flow rate 1 to 2%</td>
<td>Heat transfer rate increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethylene glycol/water</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
<tr>
<td>4</td>
<td>Al₂O₃/EG</td>
<td>Eff. of volume concentration on -</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Thermal conductivity</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Viscosity</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Density</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Specific heat</td>
<td>Heat dissipation rate is less than nano fluid</td>
</tr>
</tbody>
</table>

VII. EXPERIMENTAL INVESTIGATION -

A. Friction Factor and Inlet temperature

Adnan M. Hussein(2014) investigate the effect of inlet tempreture on friction factor, at diffrent flow rate and deferent inlet temperature the friction facture shown in fig. I it shows that if there is increasing the volume flow rate then friction facture factor decreases and also decreases with increasing inlet temperature [1]
B. Nusselt number at different inlet temperature-

Adnan M. Hussein (2014) investigated the effect of inlet temperature and flow rate. It shows the Nusselt Number at different inlet temperature and different Reynolds number. Fig. 2 shows that if increasing the volume flow rate and increasing the inlet temperature the Nusselt number increases [1]

B. By using inlet temperature-

Adnan M. Hussein (2014) investigated the effect of inlet temperature on Enhancement. Fig. IV shows that heat transfer rate of car radiator is dependent on nano fluid inlet temperature of car radiator. It is shows that the heat transfer enhancement from 39% to 56% from if increase the temperature from 60 to 80°C [1]
IX. EFFECT OF TEMPERATURE AND CONCENTRATION ON THERMAL CONDUCTIVITY, SPECIFIC HEAT, VISCOSITY, REYNOLDS NUMBER

A. Effect of Temperature and concentration on Thermal conductivity

Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Thermal conductivity. Fig. V shows the effect of volume concentration and inlet temperature on thermal conductivity. In this case, NC1, NC2, NC3, NC4, NC5, NC6 are the nano coolant at different concentration like 26.6%, 38.7%, 39.7%, 24.3%, 26.3%, 35.2% respectively and thermal conductivity increases from inlet temperature range 80°C to 95°C and concentration NC1 to NC6.[3]

Figure V. Thermal conductivity ratio of samples at various temperatures and concentrations.

B. Effect of Temperature and concentration on Specific heat

Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Specific heat. Fig. VI shows that effect of various temperature on specific heat over a range of 80-90°C from result it is shown that specific heat of Al2O3 NC is higher than TiO2 NC and increasing the concentration of sample the specific heat also increases but if increasing the concentration the specific heat also decreases.[3]

Figure VI. Specific heat of samples at various temperatures and concentrations.

C. Effect of Temperature and concentration on Viscosity

Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Viscosity. Fig. VII shows the viscosity increases with increasing the concentration and it is found that viscosity of TiO2 NC is higher than Al2O3 NC.[3]

Figure VII. Viscosity of samples at various temperatures and concentrations.

D. Effect of Temperature and concentration on Reynolds number

Hwa-Ming Nieh (2014) Investigate the effect of Temperature and concentration on Reynolds number. Fig. VIII shows the effect of various concentration, temperature and volumetric flow rate at 4.5, 6.5, 8.5 L/min respectively on Reynolds number. It is shown that adding the nano particle into base fluid reduce the base fluid Re and adding TiO2 influence the more Re number as compare to Al2O3.[3]
A. Effect of NC Concentration, temperature, and flow rate on Heat dissipation

Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration, temperature, and flow rate on Heat dissipation Fig.XI shows the heat capacity ratio affected by different NC concentration, heating temperature, volume flow rate. The result shows that nano particle concentration and inlet temperature not having any significance influence effect on heat dissipation capacity but high nano particle concentration and high flow rate influence the and enhance the heat dissipation capacity [3]

B. Effect of NC Concentration, temperature, and flow rate on Pressure drop

Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration, temperature, and flow rate on Pressure drop Fig. XII shows the effect on pressure drop of the Different NC Concentration, heating temperature, volumetric flow rate. Al2O3 and TiO2 shows the different result. In case of Al2O3 the pressure drop decreases when concentration increases and in case TiO2 concentration shows irregular status [3]

C. Effect of NC Concentration, temperature, and flow rate pumping power

Hwa-Ming Nieh (2014) Investigate the effect of of NC Concentration, temperature, and flow rate pumping power Fig. XIII shows the effect on pumping power because of the different nano particle concentration, heating temperature and volumetric flow rate changing pumping
power in case of both nano coolant is very small the pressure drop and pumping power shows the non linear relation because of fluid mechanical characteristic of pump [3]

![Figure III](image1)

**Figure III.** C Effect of NC Concentration, temperature, and flow rate pumping power

D Effect of NC Concentration, temperature, and flow rate Efficiency factor

Hwa-Ming Nieh (2014) Investigate the effect of NC Concentration, temperature, and flow rate Efficiency factor. Fig.XIV shows the effect on the EF ratio of the NC concentration,heating temperature and volumetric flow rate fig clearly shows that the EF of NC is higher than the base fluid and EF of Al2O3 NC is lower than the that of TiO2 NC .the Al2O3 nano fluid increases the EF by 14.4%at 95°C at 8.5volume flow rate and TiO2 by 27.2% at 95°C at 6.5 L/min with respect to EG/W [3]

![Figure IV](image2)

**Figure IV.** Effect of NC Concentration, temperature, and flow rate Efficiency factor.

**Conclusion**

This paper present the recent review on heat transfer enhancement of Car radiator by using nano fluid .heat transfer coefficient of nano fluid is always greater than base fluid like water or ethylene glycol and performance of nano fluid is affected by thermo physical properties like viscosity, density specific heat and other parameters like flow rate ,concentration and inlet temperature .heat transfer coefficient is increases with increasing concentration ,inlet temperature and flow rate .

**Nomenclature**

- C heat capacity rate, W/C
- Cp specific heat J/kg C
- h heat transfer coefficient, W/m2 C
- k thermal conductivity, W/m C
- m mass flow rate, Kg/sec
- Nu Nusselt number
- Q heat transfer rates, KW
- Re Reynolds number
- U overall heat transfer coefficient W/C
- ρ density, kg/m3
- μ dynamic viscosity, Kg/m s

**Subscripts**

- a air side
- c coolant side
- bf base fluid
- nf nano fluid
- p nano particle

**REFERENCES**


