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HEAT TRANSFER RATE ENHANCEMENT IN OF AUTOMOBILE RADIATOR USING NANOFLUID

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ABSTRACT

Radiator is one of the important component in the automobile's cooling system; it cools the coolant coming from the engine. The radiator specifications and the coolant are responsible for the efficiency of the radiator. The fluid that is most widely as coolant is water + ethylene glycol solution. The water + ethylene glycol based coolants looks green and have anti-freezing properties, it keeps the water from freeze below 0 degree Celsius. The water + ethylene glycol coolants have certain low value of thermal conductivity which result into the limited heat transfer effect. The field of NanoFluidhas been booming quite a lot in recent years, nanoparticles and NanoFluids are been used in many different applications and fields, ranging from medicine to the industrial applications. The objective of the process is the get to know the work done in the nano-particle based coolants and come up with a best possible solution to the problem.

***Keywords**: NanoFluid, Heat Transfer, CuO, Water + Ethylene Glycol, Thermal Conductivity*.

I. INTRODUCTION

The efficiency of the radiator depends on many factors such as the length of the radiator tubes, diameter of the radiator tubes, flow rate of fluid it carries and also on the fluid itself. The fluid's properties plays an important role in the cooling process that is carried out in the radiator. The fluids with less thermal conductivity result in lower heat transfer between the coolant and air. As it said that "need is the mother of inventions" the drawbacks in the current coolants used has created a need to find something better.

The research is being conducted with different nanoparticles based coolants. Nanoparticles are basically particles of various compounds that are made in the nano size, the compound may comprise of a metal or a non-metal. Stephen U.S. Choi work on the advanced fluid gave birth to NanoFluid. He and his team in the 1993 developed NanoFluid which were seen to have high thermal conductivities. The research further sowed a seed of interest in young mind which resulted in NanoFluid getting accepted in many different fields because of its better properties. When used in the coolants nanoparticles increase the surface area for heat transfer and help in absorbing more heat from the heated part.

II. LITERATURE SURVEY

The research work has been done for different NanoFluid based components at different concentrations and temperatures, leading to the comparison between the available alternatives.

Jaafar albadr, satinder tayal, mushtaq alasadi[1], conducted an experiment with Al2O3with as the addictive in water for the concentration ranging from 0.2% to 2%. Showing the heat transfer coefficient resulting from NanoFluid is a bit more than that of the water for the similar mass flow. The experimental performance also showed that the heat transfer coefficient changes with the change are concentration and mass flow rate. But as the concentration of the nanoparticles increases so does the friction in the fluid system. The complete experiment was carried out using a horizontal shell and tube type of heat exchanger.

Shuichi tori[2], used an unusual combine of fluid for their study. Nanoparticles of diamond were used in the study he conducted. The concentrations being 0.1%, 0.4% and 1%, it was that there was a considerable amount of increase in the heat transfer rate. With sphericity assumed as 1, the thermal conductivity and other properties of the NanoFluid were found by using the imperial relation. The flow of the fluid is the system was between laminar and turbulent, the same was varied to find out the effect of the change in Reynolds number on the heat transfer properties of the fluid. It was seen that the heat transfer properties increased to a certain limit.

Yimin Xuan and Qiang Li [3], made a test rig, to investigate the heat transfer properties and the flow properties of the NanoFluid in the base of water. The experiment was conducted in order to provide with a new correlation consisting of nusselt number, Reynolds number, prandtl number, specific heat, volume fraction and certain variable for correct calculation of heat transfer due to NanoFluid. The correlation took into account all the fractors responsible for the heat transfer. It was also found that the friction factor for Cu based fluid was almost same as that of the base fluid which was pure water.

P. Mounika, Rajesh K Sharma and P. S. Kishore[4], analyzed radiator for the performance characteristic with different air flow rate and ethylene glycol based coolant as the fluid for cooling. The turbulent flow of air was provide which changed the Reynolds number from 14000 to 71000. They concluded that at high speed the efficiency of the radiator fins is reduced as a lot of heat is produced due to more fuel consumption and friction in the engine. For the radiator to work properly at high speed the fin efficiency has to be compromised.

S.M. Peyghambarzadeh, S.H. Hashemabadi, S.M. Hoseini and M. Seifi Jamnami[5], with the commonly used anti-freeze coolant, i.e. ethylene glycol based the thermal conductivity is limited. Therefore they added $Al2O3$as an additive and preformed calculations for different concentrations on the nanopartciles. The of the fluid was varied between 2-6 litre per minute. They also conducted the same experiment with $Al2O3$and water as the fluid. The result showed them that there is 40% up gradation in the value of Nusselt Number. They concluded that heat transfer between the Nanofluids is mostly depended on the concentration and flow rate of the NanoFluid. They also stated that the NanoFluid as the coolant is very suitable for the application in automobiles.

K.Y. Leong, R Saidur, S.N. Kazi and A.H. Mamun[6], states the ethylene glycol and water based coolants are widely used the automobile industry but they have some cons and as the advancement is being in advanced fluid field , nanotechnology has came out to be solutions for many problems. Their study was based on copper oxide based NanoFluid coolant. The concentration of the CuO was upto 2% and it was observed that there was 3.8% increase in the heat transfer that they got from the base fluid used alone. They finally stated that the frontal air exposed can be reduced to have same heat transfer as that of ethylene glycol based coolants.

Minli Bai, Zhe Xu and Jizu Lv [7], they conducted a CFD analysis to study the characteristics of the Cu and water based NanoFluid. They found that the heat rejection using radiator changes with the change in the concentration of the nano-particles. The study showed that with the concentration of the particles has 5% upto 44.1% heat rejection capacity can be improved with a certain increase in the pump load because as the concentration is increased, the density of the fluid is also increased considerably.

III. FORMULAS USED FOR CALCULATION

As per the newton's law the heat transfer coefficient can be found as, [8]

$Q=h\ A\ \Delta T = h\ As\ (Tb-Ts)$ (1)

Where, As is the surface area of the tube which is exposed for heat transfer, Tb is bulk temperature which can be found as,

$Tb = (Tin + Tout)/2$ (2)

Tin and Tout are the inlet and outlet temperatures of the fluid passing through radiator, Ts is the temperature measured at the surface of the tubes which is given as,

Ts = (T1+T2+…….+Tn)/n (3)
Where n is no. of observations
The heat transfer rate is calculated as,

$$Q = m^* \, Cp \, \Delta T = m^* \, Cp \, (Tin - Tout) \quad (4)$$

m* which is mass flow rate expressed as,

$$m^* = \rho \, V^* \quad (5)$$

V* is discharge m3/sec
The heat transfer coefficient for the experiment can be found by equating eqns. (1) and (4),

$$hexp = m^* \, Cp \, (Tin - Tout) / As \, (Tb - Ts) \quad (6)$$

The formula for nusselt number can be given as,

$$Nu = hexp \, Dh / k \quad (7)$$

Where Dh is hydraulic diameter and k is thermal conductivity of the fluid.

$$Dh = 4 \times area / perimeter \quad (8)$$

The thermal properties of the NanoFluid can be found by using imperial relation:

The density of the NanoFluid is given as, [5]
$\rho_{nf} = \rho_p \varphi + (1- \varphi) \, \rho_{bf}$

Thespecific heat of the NanoFluid can be found as,
$(Cp)_{nf} = (1- \varphi) \, (\rho \, Cp)_{bf} + (\rho \, Cp)_p \varphi \, / \, (1- \varphi) \, \rho_{bf} + \rho_p \, \varphi$

The thermal conductivity is given as,
$K_{nf} = k_p + (\phi-1)k_{bf} - \varphi(\phi-1) \, (k_{bf}-k_p) \, / \, k_p + (\phi-1)k_{bf} + \varphi \, (k_{bf}-k_p)$
Where, $\phi=3/\psi$
Ψ is sphericity and for copper oxide, it is considered as 1.

IV. RESULT

Author(S)	Fluid Used	Conclusion
Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi	Al2O3 + water	The heat transfer rate increases with increase in the concentration
Shuichi tori	Diamond + water	Found a considerable change in heat transfer of the base fluid.
P. Mounika, Rajesh K Sharma And P. S. Kishore	EG + water	The radiator doesn't cool efficient at high speed
S.M. Peyghambarzadeh, S.H. Hashemabadi, S.M. Hoseini and M. Seifi Jamnami	Al2O3 + water and Al2O3 + water + EG	The value of nusselt number increases upto 40%
K.Y. Leong, R Saidur, S.N. Kazi and A.H. Mamun	CuO + water	The heat transfer increases to 3.8%

V. CONCLUSION

- The coolants that are currently used aren't that efficient when it comes to working at high speeds.
- The heat transfer rate of the NanoFluid mostly depends on the mass flow rate of the fluid and the concentration of the nanoparticles.
- NanoFluid based coolant have high heat transfer rate than that of the conventional coolants.
- The properties of the base fluid are considerably changed by adding the nanopartciles.
- The heat transfer in nanofluids is more because of the surface area provided by the nanoparticles.
- The NanoFluid based coolants are very well suited for automotive applications.

VI. FUTURE SCOPE

- The radiator cooling setup can be tested for the different ambient temperature.
- The economical NanoFluid based coolant is to be made.
- Using NanoFluid the dimension of the radiator can also be changed

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