Heat Transfer Enhancement in Car Radiator by Using Nano Fluid

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Abstract:**The present paper presents review on heat transfer enhancement in car radiator by using various types of nano fluid like Al_2O_3, MgO, SiO_2, TiO_2 etc. using the automobile and tractor industries. In the current world we require more and more powerful water cooled engines inmodern car and tractors. But it created problems of insufficient rate of engine cooling. Due to this, we require a compact design of a radiator which having small in size and equivalent capacity of engine cooling. There are number of ways from which we can minimize the size of radiators like Changing the fin design, Changing the radiator shape, Changing the tube type, Changing the flow arrangement, Changing the fin material, Increasing the surface area to coolant ratio, Changing the different types of fluid and mixture concentration. For increasing cooling capacity there are lots of approaches used in fin design and there is no more scope in this area to enhance heat transfer. So there is need to look in something new technology which have large potential of heat transfer enhancement. It is seen that nano fluid is potential candidate for automobile sector and in field of agriculture such as tractor where need to cool engine very fast for continuous use. Heat transfer coefficient of nanofluid is more than conventional fluids.This reduced or compact shape may results in increasing the fuel economy and reduces the weight of vehicle. So it is Possible to design the more powerful engine of a car in smaller hood space.**

Keywords: Radiator,Automobile, Tractor, Nano fluid

I. INTRODUCTION:

Radiators are heat exchanger which is used to transfer heat and thermal energy from one medium to another for the cooling or heating purpose.In automobile radiator is used to cool the system in which heat from system is transfer to the fluid in radiator which further transfers to the outside air. For the high HP tractors there is need to cool engine very rapidly for continuous use. The radiator efficiency can be increased by modern fin design in which increases the surface area by attaching extended surfaces to the surface and material of fin from copper to very high conductive material such as aluminum. Previously parallel flow arrangement are used, in current status cross flow or counter flow arrangement are used. Another method is to enhance the heat transfer coefficient (h)of fluid in the radiator. Radiator assembly consist of radiator, electric cooling fan, water pump, thermostat and radiator pressure cap.

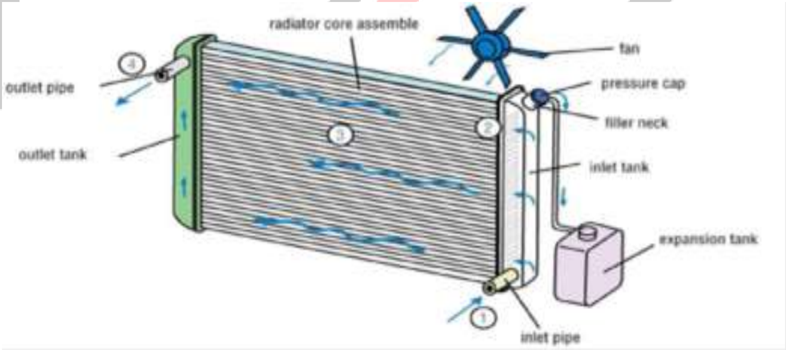

Figure 1: Automobile Radiator

Cooling fan maintains the flow of air through the radiator to dissipate the excess heat to atmosphere. Water pump circulates the coolant by pushing it through the engine passages and radiator. Thermostat valves allow the flow of coolant to radiator only when working temperature is attained after starting the engine. Radiator pressure cap maintains a constant high pressure in the cooling system, which increases the boiling temperature of the engine coolant. Insufficient heat dissipation in car and tractors radiator results in overheating of engine, cylinder deformation and wear between engine parts. To overcome this problem of high power generation requirement and less radiator size, the automotive radiator must be redesigned to become more compact but still maintaining high level of heat transfer performance. [34-44].

II. LITERATURE REVIEW

Yiding Cao et al. [1]they introduce application of heat pipe in automobile industry. In this application heat pipe is introduced in the automotive radiator to enhance heat transfer. The use of heat pipe increases the automobile radiator efficiency and reduces cooling fan power consumption. Heat pipes are wickless heat pipes and basically two- phase closed thermosyphons. The working fluids inside the heat pipe are different than the engine coolant. The effectiveness of heat pipe is hundred times higher than the copper. The gravity is used to assist the return fluid. Air is evocated from container and container is sealed. Heat was applied to the evaporator section, which causes the liquid to vaporize. The vapor then flows from the hotter section due to the higher vapor pressure to the colder section of the heat pipe, where it was condensed. The liquid condensate then returns to the evaporator section from the condenser section under the assistance of gravity.

Sadik Kakac, et al [2] in his literature survey showed that nanofluids significantly improve the heat transfer capability of conventional heat transfer fluids such as oil or water by suspending nanoparticles in these base liquids. The understanding of the fundamentals of heat transfer and wall friction is prime importance for developing nanofluids for a wide range of heat transfer application. He concluded that although there are recent developments in the study of heat transfer with nanofluids, more experimental results and the theoretical understanding of the mechanisms of the particle movements are needed to understand heat transfer and fluid flow behavior of nanofluids.

Devireddy Sandhya, et al. [3] studied that the performance of ethylene glycol and water based TiO_2 nanofluids as an automobile radiator coolant is determined experimentally. Nanofluids were prepared taking 40% ethylene glycol and 60% water with volume concentrations of 0.1%, 0.3% and 0.5% of TiO2 nano powder. Experiments were conducted in the range of Reynolds numbers from 4000 to 15,000. At the concentration of 0.5% enhancement in heat transfer rate up to 37% with respect to base fluid. The variation of fluid inlet temperature to the radiator (in the range tested) slightly influences the heat transfer performance. Brownian motion of nanoparticles may be one of the major factors in the enhancement of heat transfers.

Jama et al. [4]the air flow distribution and non-uniformity across the radiator of full size Australian made ford falcon was tested in industrial wind tunnel. The cooling air intake of the vehicle were shielded by a quarter, one half and three quarter and fully blocked. The best method to shield front end is to employ horizontal method. This shielding method produces the more uniform cooling airflow distribution compared to other methods. Non uniformity index increased significantly as the front end air intake area was shielded. It is reduced the cooling capacity of the vehicle. These shielding methods also produced higher average velocity across the radiator which is analogous to better cooling.

Ramgopal Ramaraju [5] Heat transfer enhancement in water and coolant based system is done by using Carbon Nanotubes (CNTs). In the present study, the effect of nano-fluid heat transfer to enhance in water andcoolant based systems with multi walled carbonnanotubes has been investigated. The improvement ofheat transfer when compared to water, coolant (water +ethylene glycol 60:40) and water with MWCNTS andcoolant with MWCNTS has been studied.It has been observed that there is an enhancement of heat transfer up to 30% when coolant and CNTS areused as a cooling medium.

III. PROBLEM DESCRIPTION

From the law of thermodynamics, we know that as we increase the area of radiator the heat transfer enhancement also increases. But as demand of more powerful engines in smaller hood space has created problem of insufficient rate of heat dissipation in automobile radiator. As result, many radiators are redesigned more compactly but having the same rate of heat transfer dissipation.

A. Methods

Heat transfer enhancement methods are generally classified into three categories:
1) Active method 2) Passive method 3) Compound method

i. Active Method

Active heat transfer enhancement methods require external power input, it is done using the mechanical aids.

ii. Passive Method

While in passive method of heat transfer enhancement does not require any external power input. One of the ways in passive method to enhance heat transfer is to increase the effective surface area and resistance time of the heat transfer fluid.

iii. Compound Method

When both active technique and passive technique are used simultaneously for increasing heat transfer of any devices, which is greater than by using any one method at a time, then this term is known as the compound method. Uses both external power sources and geometry design changes

B. Methods of Heat Transfer Enhancement in Radiator

There are several different approaches that can be used to optimize heat transfer performance of smaller radiator design. These are 1) Changing the fin design 2) Changing the radiator shape 3) Changing the tube type 4) Changing the flow arrangement 5) Changing the fin material 6) Increasing the surface area to coolant ratio 7) Changing the different types of fluid and mixture concentration.

i. Changing The Fin Design

In engine cooling system fins are used in radiator assembly to increases the contact area of heat transfer so it increases the exchanger efficiency.


Figure 2: ZIGZAG type fins**Figure 3:** Helical fins

The design modification is done on a coolant tube and fin. In the previous design the fin ids revolved around the tube. Due to this, the area of contact is decreased. But in this design modification, the fins are placed in between the two tubes. The one face of the helical fin is dimpled in the tube. The air swirl is done when the helical fins are place in between the tubes. The air swirl greatly increased the air contact area between the fins[6].

ii. Changing The Radiator Shape

In early use of cooling system in automobile the radiator are made vertical in shape. The changes in shape of radiator are showed for the ford cars as shown in fig.For horizontal radiator it is more uniform air flow distribution throughout the radiator. So it is adopted the horizontal or rectangular radiator in all modern automotive [4].

Other theories explained conventional radiator size is rectangular which is difficult for circular fan to cover whole surface area. It creates lower velocity zones at corners giving less heat transfer. So it proposed to eliminate corners and develop circular shape radiator which is compact, more efficient and leads to minimum power consumption to drive a fan and maximum utilization of air flow. [7].

Figure 4: Vertical shape radiator**Figure 5:** Horizontal shape Radiator

iii. Changing The Tube Type

There are various parameters in designing of tube which can be helpful to enhance the heat transfer rate in heat exchanger. One of them is giving the angles at various degrees to baffle to increase the air circulation rate in radiator which increase the efficiency of radiator. [8]. another one is to change the tube pitch arrangement as square or triangular. The tube passes can be increased from 1 to16 which adds the area and time to of coolant flowing in the tubes [9].

iv. Changing The Flow Arrangement And Fin Material

Flow arrangement of fluid inside the tube and outside air coming to tube arrangement is arranged in number of ways. In that counter or cross flow arrangement is preferred for high efficiency of radiator. In early use of heat radiator fins are made from copper and brass. In now days instead of copper and brass it is made from very high very high thermal conductive material such as aluminum. It is low cost and weight than brass.

v. Other

There are also some small things which can be added their influence in heat transfer enhancement such as welding technology. There are various precious welding technologies available which can be used in supporting the radiator frame. It is also important in the while mounting the fins in between the tubes. By using modern and precious welding technology weight can be reduced. [10-33].

vi. **Changing The Different Types Of Fluid And Mixture Concentration**

It is the one area where large scope of heat transfer enhancement is possible by using the nanofluid in the radiator. Nanofluid is new kind of fluid which contains very small sized metal or non-metal particles are added in the base fluid. The base fluid is pure water or mixture of water and ethylene glycol. Variety of nanofluid is available out of which frequently used are Al_2O_3, CuO, MgO, SiO_2, TiO_2.Thermal conductivity of these metal particles is much higher than the water so when we added these particles in the base fluid the rate of heat transfer are enhanced. The schematic cross section of nanofluid structure is shown in figure below.

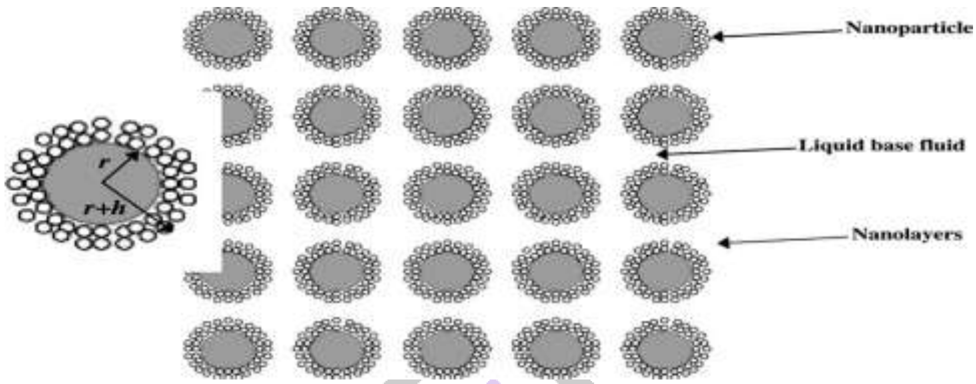

Figure 6: Cross section of nanofluid structure [46]

IV. RESULTS AND DISCUSSION

The use of nanofluid in automobile radiator is dependent on a number of parameters such as concentration, Reynolds number and temperature. The effect of variation of these parameters in the use of nanofluid is discussed in below:

A. Effect of nanoparticle concentration on Nusselt number

Nusselt number is directly proportional to the coefficient of heat transfer,

$$N_u = \frac{hd}{k}$$

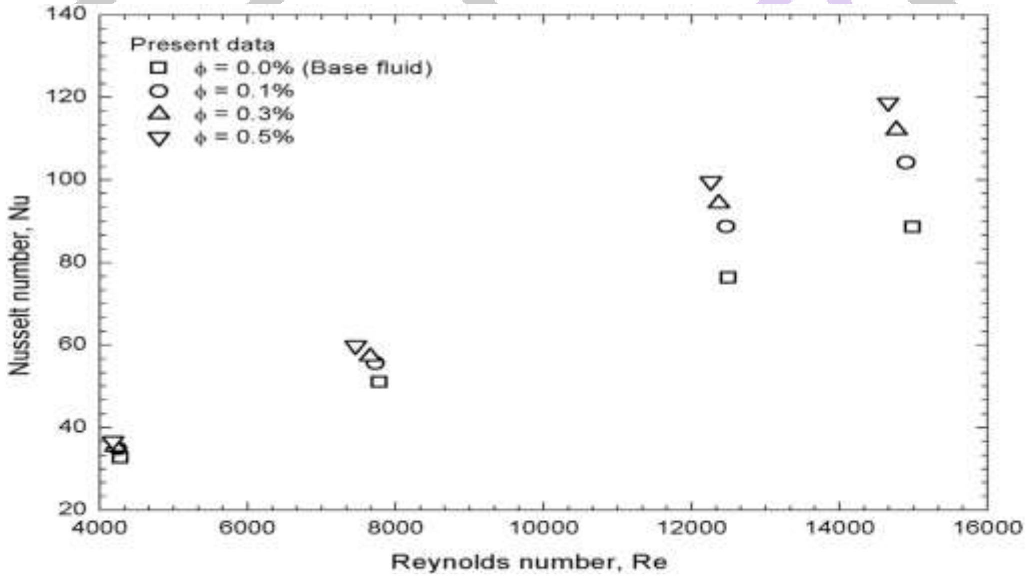

Figure 7: Variation of Nusselt number for nanofluids at different concentrations as a function Of Reynolds number (Tin= 35 °C).[47]

As coefficient of heat transfer (h) increases the rate of heat transfer also increases. From the graph of figure (7) it is shown that as concentration increases the Nusselt number also increases with varying of Reynolds number. For higher concentration it gives higher Nusselt number. [35].

B. Effect of nanofluid concentration on temperature

Radiator cooling performance is depends on the outlet temperature of radiator. The graph for cooling performance of radiator is shown below.

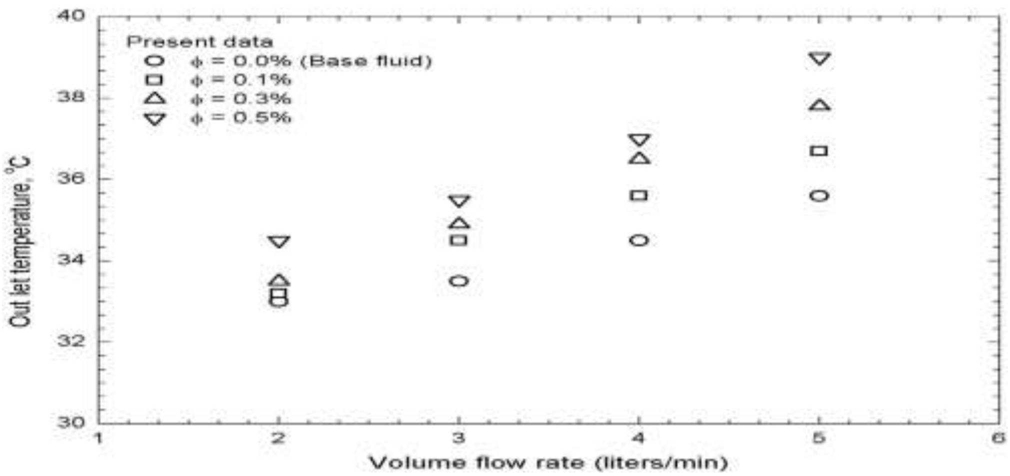

Figure 8: Comparison of the radiator cooling performance when using nanofluid (0.1%, 0.3% and 0.5%) and base fluid [47]

From the graph it is seen that as concentration of nanofluid increases the outlet temperature increases which gives the decent radiator cooling performance.

C. Comparison of various nanofluid results

There are lots of parameters on the basis of these the nanofluid is selected for particular application. Here the comparison of various nanofluids for enhancement in thermal conductivity at specified concentration is shown in Table below

Table 1: Thermal conductivity of various materials at 300K [48]

Material	Form	Thermal Conductivity(W/mK)
Carbon	Nanotubes	1800-6600
	Diamonds	2300
	Graphite	110-190
	Fullerenes Film	0.4
Metallic Solids(Pure)	Silver	429
	Copper	401
	Nickel	237
Non Metallic Solids	Silicon	148
Metallic Liquids	Aluminum	40
	Sodium at 644 K	72.3

V. CONCLUSION

- Efficiency of radiator increases by inserting heat pipe in radiator core.
- For heat transfer enhancement in radiator design there is limitation on increasing number of fins and current technology gets it at maximize level.
- By using precious welding technology the efficiency of radiator increases.
- It is seen that nano fluid is potential candidate for automobile sector. Heat transfer coefficient of nanofluid is higher than water or water - ethylene glycol mixture.
- As heat transfer can be improved by number of different ways (one of emerging is use of nanofluid) in Automobile radiators can be made energy efficient and compact.
- Possible to design the more powerful engine of a car in smaller hood space.

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