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Experimental Investigation of Heat Transfer Rate In Automobile Radiator Using Nanofluid

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Abstract

Continuous technological development in automobile industries has increased the demand for high efficiency engines. A high efficiency engine is not only based on its performance but also for better fuel economy and less emission. Reducing a vehicle Weight by optimizing design and size of a radiator is a necessity for making the world green. There are several different approaches and any one of these can take to optimize the heat transfer performance of radiator design, include by changing the fluid. Heat transfer fluids have inherently low thermal conductivity that greatly limits the heat exchange efficiency. While the effectiveness of extending surfaces and redesigning heat exchange equipment to increase the heat transfer rate has reached a limit, many researchers made an attempt to improve the thermal transport properties of the fluids by adding more thermally conductive solids into liquids. Liquid dispersions of nanoparticles, which have been termed "nanofluids", exhibit substantially higher thermal conductivities than those of the corresponding base fluids. By using different proportions of Al_2O_3 nanoparticles by weight have been added to conventional fluid (water), and based on that the enhancement in heat transfer rate has been found out by taking readings & calculating heat transfer rate.

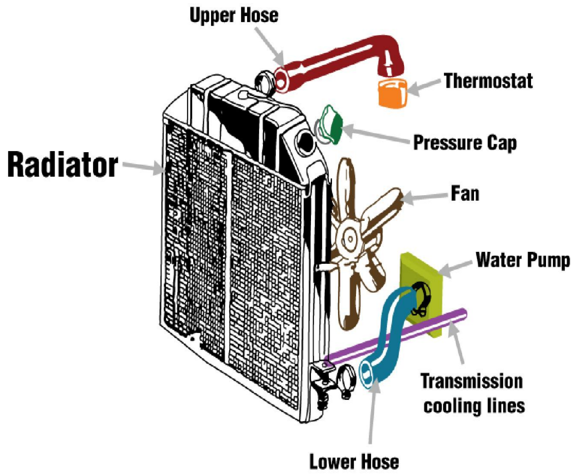
Keywords-Nanofluid, Thermal Conductivity, Al_2O_3, Radiator

Introduction

An engine coolant is a fluid which flows through the engine and prevents it from overheating by transferring the heat generated by the engine to other components that either make use of it or dissipate it. A feature of an ideal coolant entails a low viscosity, high thermal capacity, has chemical inertness and is low-cost. Further, it should neither cause nor promote corrosion of the cooling system. The most common coolant is water. Its high heat capacity and low cost makes it a suitable heat-transfer medium. It is usually used with additives, like corrosion inhibitors and antifreeze. Antifreeze, a solution of a suitable organic chemical (most often ethylene glycol, diethylene glycol, or propylene glycol) in water, is used when

The water-based coolant has to withstand temperatures below 0 °C, or when its boiling point has to be raised. An emerging and new class of coolants is nanofluids which consist of a carrier liquid, such as water, dispersed with tiny nano-scale particles known as nanoparticles. Purpose-designed nanoparticles of e.g. Copper Oxide, alumina, titanium dioxide, carbon nanotubes, silica, or metals dispersed into the carrier liquid the enhances the heat transfer capabilities of the resulting coolant compared to the carrier liquid alone.

Radiator- A water cooling system accomplishes the cooling action with the help of water. There are various components that make up the cooling system and they are the Air Blower, Cooling Fans, Radiator Pressure Caps, Water Pipes, Coolant Hoses, Radiator Parts, Radiators and Water Pumps. Each of these components plays an essential role .For instance, the radiator cools the coolant so that it can be reused, the water pump pumps the coolant through the system via water pipes, the Air Blower draws air through the radiator to achieve the cooling action, etc.



1.1 Radiator components

Nanofluids - Nanofluids is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water and ethylene glycol .Nanofluids have novel properties that make them potentially useful in many applications in heat transfer including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid.

Benefits of nanofluids - When the nanoparticles are properly dispersed, nanofluids can offer numerous benefits besides the anomalously high effective thermal conductivity. These benefits include:

a) Improved heat transfer and stability - Because heat transfer takes place at the surface of the particles, it is desirable to use particles with larger surface area. The relatively larger surface areas of nano particles compared to micro particles provide significantly improved heat transfer capabilities. Because the nanoparticles are small, gravity becomes less important and thus chances of sedimentation are also less, making nanofluids more stable.

b) Micro channel cooling without clogging - Nanofluids will not only be a better medium for heat transfer in general, but they will also be ideal for Micro channel applications where high heat loads are encountered.

c) Reduction in pumping power - To increase the heat transfer of conventional fluids by a factor of two, the pumping power must usually be increased by a factor of 10. It was shown that by multiplying the thermal conductivity by a factor of three, the heat transfer in the same apparatus was doubled. Thus, very large savings in pumping power can be achieved if a large thermal conductivity increase can be achieved with a small volume fraction of nanoparticles.

Development and concept of nanofluids - It is well known that at room temperature, metallic solids possess an order-of-magnitude higher thermal conductivity than fluids. The thermal conductivity of various materials is given by Table. The thermal conductivity of copper at room temperature is about 700times greater than that of water and about 3000 times greater than that of engine oil. Therefore, the thermal conductivities of fluids containing suspended solid metallic or on-metallic (metallic oxide) particles would be expected to be significantly higher than those of conventional heat transfer fluids. The main problems of using such suspensions are the rapid setting of particles, clogging of flow channels and increased pressure drop in the fluid. In contrast, nanoparticles due to their high surface to volume ratio can remain in suspension and thereby reduce erosion and clogging.

Thermal Conductivity - The rate of heat transfer through a unit thickness of the material per unit area per unit temperature difference.

Thermal conductivity of various Materials (at 300ºK)

Material	Form	Thermal Conductivity (W/mºK)
Carbon	Nanotubes Diamond Graphite Fullerenes film	1800-6600 2300 110-190 0.4
Metallic solids (pure)	Silver Copper Nickel	429 401 237
Non-metallic solids	Silicon	148
Metallic liquids	Aluminium Sodium at 644 ºK	40 72.3

Equations

The average heat transfer rate is following:

$$Qavg = 0.5(Qa + Qc)$$

Qa and Qc are the heat transfer rates at are and coolant stream, The air side and heat transfer rates can be calculated,

$Qa = ma\ Cpa\ (ta_2 - ta_1)$ Eq. 1

$Qc = mc\ Cpc\ (tc_2 - tc_1)$ Eq. 2

Results

Figure1.2 shows the graphical representation of total average heat transfer rate (air + water) Q vs. constant load & pure water as coolant. Figure 1.3, 1.4, 1.5shows graphical representation of total average heat transfer rate (air + water) Q vs. constant load & different percentage of volume Fraction of Al_2O_3 added in water (by weight).we can compare the experimental result coolant used as water & different percentage of Al_2O_3. It is observed that the heat transfer rate increases with the increase in the volume fraction of Al_2O_3 in water at constant flow rate (10 lpm). As the volume fraction of Al_2O_3 was increased beyond 6%, the nanoparticles were getting settled at the bottom of tank. Due to this limitation we used nanoparticles up to 6% only which was in good agreement with the experimental data.

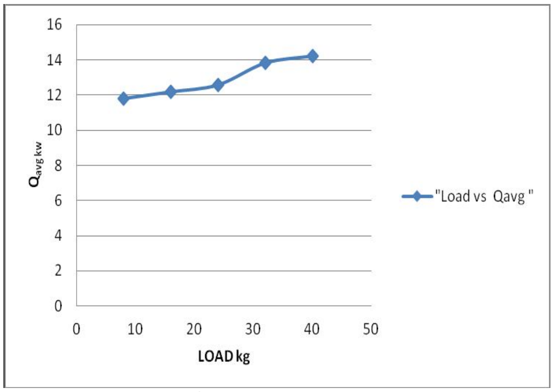


Figure 1.2. Heat Transfer rate vs. Load Coolant used pure water.

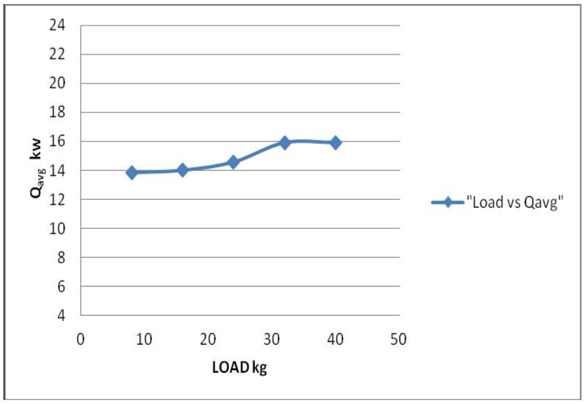


Figure 1.3 Heat Transfer rate vs. Load Coolant used water + 2% (Al_2O_3).

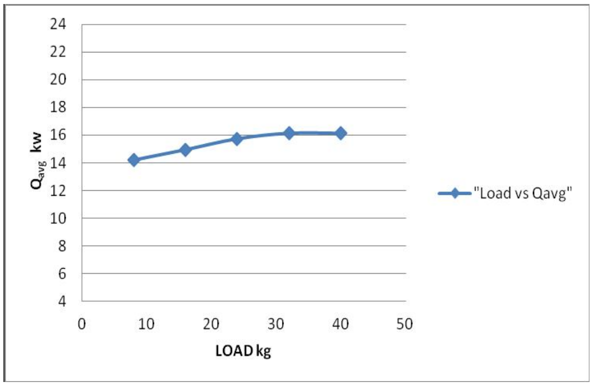


Figure 1.4 Heat Transfer rate vs. Load Coolant used water + 4% (Al_2O_3).

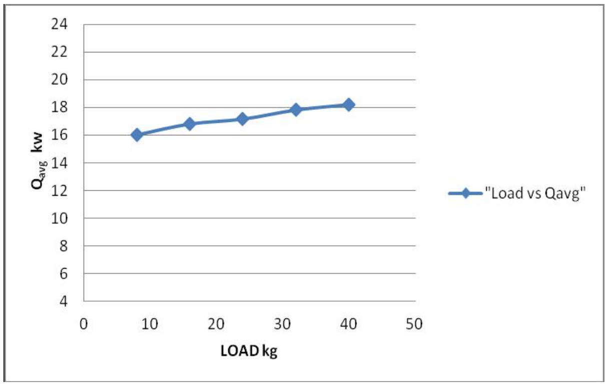


Figure 1.5 Heat Transfer rate vs. Load Coolant used water + 6% (Al_2O_3).

Figure 1.3, 1.4, 1.5 shows the graphical comparison of heat transfer rate of coolant at constant mass flow rate when different volume fraction of Al_2O_3 nanoparticle was added to the water. It was observed that as volume of fraction of Al_2O_3 in water added the heat transfer rate increased for a given volume fraction of Al_2O_3 in water. At 10 lpm mass flow rate of coolant, at load 8 kg the value of heat transfer rate is 11.77 KW and 16.04 KW for 2 %, volume fraction of Al_2O_3at same flow rate heat transfer rate is 13.82 KW, for 4% volume fraction heat transfer is 14.21 KW, for 4% volume fraction heat transfer is 16.04 KW. Different volume fraction of Al_2O_3 added in water give increase in heat transfer rate shown in figure 1.6 its give clear idea how much heat transfer is increase. Figure 1.7 shown how much percentage of heat transfer rate increase compare to water & different volume of Al_2O_3 added in water.

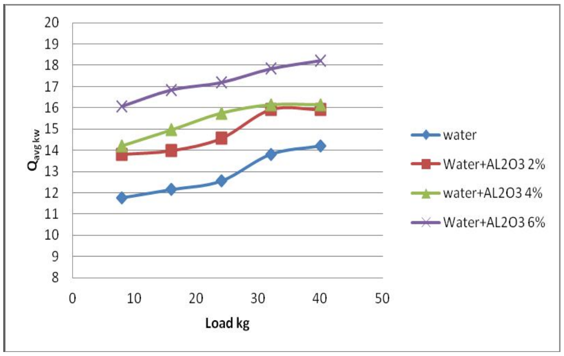


Figure 1.6 Heat transfer rate vs. Load Coolant used Different Volume Fraction of Al_2O_3

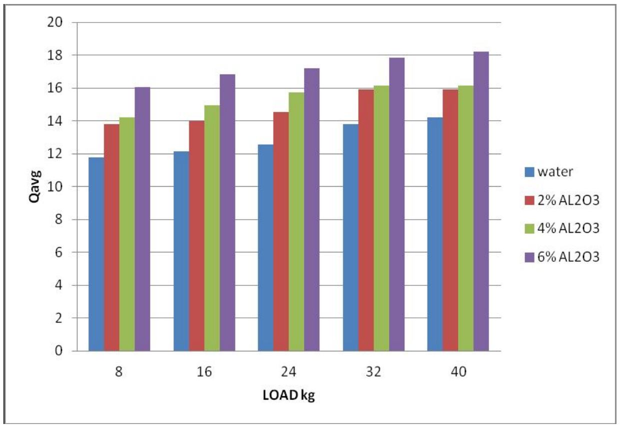


Figure 1.7 Percentage of Heat Transfer rate vs. Load Coolant used Different Volume Fraction of Al_2O_3.

Conclusion

The heat transfer rate in automobile radiator increases by adding nanoparticles of Al_2O_3 in water. The heat transfer rate in radiator, using water as coolant is 8 kg load at coolant flow rate of 10lpm. Whereas heat transfer rate is 11.77 KW now adding 2% volume fractions Al_2O_3 in water heat transfer rate increase 14% compare to water. Simultaneously adding 4% volume fraction of Al_2O_3 in water heat transfer rate increase

17% and adding 8 % volume fraction of Al_2O_3 in water there is an increase of about 26% in heat transfer rate in automobile radiator compares to use water as coolant

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