International Journal of Engineering Innovation & Research
Volume 3, Issue 5, ISSN: 2277 – 5668

Performance Evaluation of Heat Transfer Rate in Automobile Radiator using Nano Particles

Ramesh Bhoi
Assistant Professor, Mechanical Engineering Deptt.
Parul Polytechnic Institute
Email: rhbhoi@gmail.com

Chetan Jaiswal
Associate Professor, Mechanical Engineering Deptt.
Aravali Institute of Technical Studies,
Email: chetanjaiswal20@gmail.com

***Abstract* – Continuous technological development in automobile industries has increased the demand for high engine efficiency. A high efficiency of IC engine is not only based on its performance but also for better fuel economy and low emission. Lower a vehicle weight by use of optimum 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. extending surfaces and redesigning heat exchange equipment to increase the heat transfer rate has reached a limit, many researchers works to try and 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", reveal largely higher thermal conductivities than those of the corresponding base fluids.**

***Keywords* – Nanofluids, Heat Transfer, Radiator, Nano Particles, Thermal Conductivity, Automobile Engine, Al_2O_3, Volume Fraction, Coolant.**

I. 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 entail 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 are 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. CuO, 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.

One of the most significant scientific challenges in the industrial area is cooling, which applies to many diverse productions, including microelectronics, transportation and manufacturing. The conventional method for increasing heat dissipation is to increase the area available for exchanging heat to use a better heat conductive fluid. However, this approach involves an undesirable increase in the size of a thermal management system; therefore, there is an urgent need for new and novel coolants with improved performance. The innovative concept of 'nanofluids' – heat transfer fluids consisting of suspension of nanoparticles – has been proposed as a prospect for these challenges.[4]
Nanofluids is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal

Table 1: Thermal conductivity of material (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
Metallic liquids	Aluminum Sodium at 644 ºK	40 72.3
Others	Water Ethylene Glycol Engine Oil R134a	0.613 0.253 0.145 0.0811

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.[5]

Thermo physical properties of nanofluid

It is expected that the heat transfer coefficient of the nanofluid will depend on the thermal conductivity and the heat capacity of the base fluid and nanomaterials, flow pattern, Reynolds and Prandtl numbers, temperature, the volume fraction of the suspended particles, the dimensions and shape of the particles. So, some of the thermo physical properties used in this paper are defined as:

Density

The nanofluid density 'ρnf' is the average of the nano-particles and base fluid densities.

$$\rho_{nf} = \phi \rho_p + (1-\phi)\rho_{bf}$$

Specific heat

The nanofluid specific heat is

$$Cp_{nf} = \frac{\phi \rho_p Cp_p + (1-\phi)\rho_{bf} Cp_{bf}}{\rho_{nf}}$$

Viscosity

General and accurate models for prediction of viscosity of a nanofluid, μ, are not available at this time. However, the room temperature viscosity measured by Pak and Cho [8] can be correlated by means of the following equation.

$$\mu_{nf} = \mu_{bf}(1 + 39.11\phi + 533.9\phi^2)$$

Thermal conductivity

Thermal conductivity of nanofluid for Al2O3+water is developed by [9]

$$\frac{k_{nf}}{k_{bf}} = Re_{nf}^{.175}\, \phi^{.05} \left(\frac{k_p}{k_{bf}}\right)^{.2324}$$

Two techniques are used to make nanofluids: the single-step direct evaporation method, which simultaneously makes and disperses the nanoparticles directly into the base fluids. And the two-step method which first makes nanoparticles

and then disperses them into the base fluids. In either case, a well-mixed and uniformly dispersed nanofluid is needed for successful reproduction of properties and interpretation of experimental data. For nanofluids prepared by the two-step method, dispersion techniques such as high shear and ultrasound can be used to create various particle/fluid combinations.

Table 2: Engine Specification

Make & Model	**Mahindra Engine MDI-3200**
General Details	Four stroke, Four cylinder, Vertical, Compression Ignition, Water cooled, Direct injection.
Max. Power	40 B.H.P.@ 3000 rpm.
Water flow (lpm)	60
Air flow (kg/s)	8
Tube size	Height 9.15 mm Diameter 3.30 mm Thick 0.3 mm
Fin size	Length 134.1 mm Width 43.15 mm Thick 0.33 mm

Fig.1. Experimental set-up

Multi cylinder, four stroke, water cooled, direct injection CI engine is used for experimental purpose. Figure 1 shows the position of radiator in experimental setup. Table 3.1 shows details of engine specification and other details of engine. Cooling water is circulated at constant flow rate.

Experimental Procedure

Experiments are carried out at variable engine speed and Load which varied by hydraulic dynamometer. Starting from different load and speed, observations are taken at time when inlet coolant temperature remains steady. Various performances measured at each load and speed test. Using measured data, heat transfer rate are calculated for different variable parameter.In this project, different proportions of Al_2O_3 nanoparticles by weight has been added to conventional fluid (water), and based on that the enhancement in heat transfer rate has been found out.

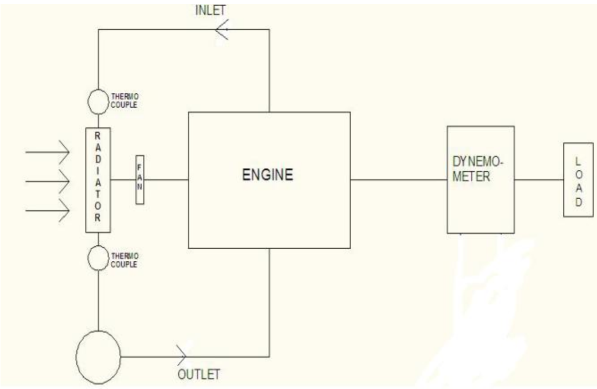

Fig.2. Schematic diagram of the experimental set up

II. Result

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 10 lpm. Whereas heat transfer rate is 11.77 KW now adding 2% volume fraction 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 compare to use water as coolant.

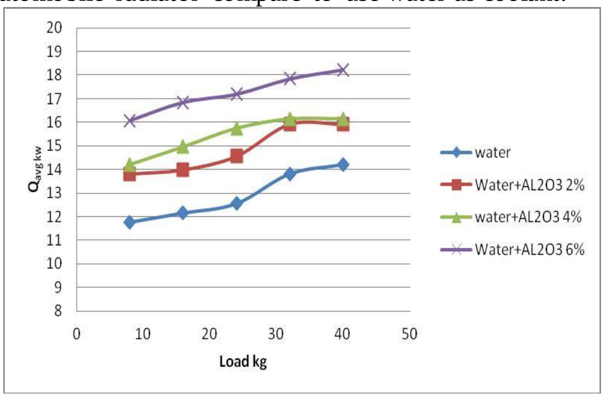

Fig.3. Heat transfer rate vs. Load Coolant used Different Volume Fraction of Al_2O_3

III. CONCLUSION

Recently there have been considerable research findings highlighting superior heat transfer performances of nanofluids. As per based on researches & reported that about 15 to 40% of heat transfer enhancement can be achieved by using various types of nanofluids. With these superior characteristics, the size and weight of automobile car radiator can be reduced without affecting its heat transfer performance. This translates into a better aerodynamic feature for design of an automobile car frontal area.It required further research.

REFERENCES

[1] Akoh, H., Tsukasaki, Y., S.Yatsuya, and Tasaki, A. Magnetic properties of ferromagnetic ultrafine particles prepared by vacuum evaporation on running oil substrate. Journal of Crystal Growth,45, 495–500 (1978).

[2] Wagener, M., Murty, B. S., and Gunther, B. Preparation of metal nanosuspensions by high pressure DC-sputtering on running liquids. In Komarnenl, S., Parker, J. C., and Wollenberger, H. J. (Editors), Nanocrystalline and Nanocomposite Materials II, volume 457, 149–154. Materials Research Society, Pittsburgh PA (1997).

[3] Eastman, J. A., Choi, U. S., Li, S., Thompson, L. J., and Lee, S. Enhanced thermal conductivity through the development of nanofluids. Volume 457 of Materials Research Society Symposium - Proceedings, 3–11. Materials Research Society, Pittsburgh, PA, USA, Boston, MA, USA (1997).

[4] Zhu, H., Lin, Y., and Yin, Y. A novel one-step chemical method for preparation of copper nanofluids. Journal of Colloid and Interface Science, 227, 100–103 (2004).

[5] Lee, S., Choi, S. U. S., Li, S., and Eastman, J. A. Measuring thermal conductivity of fluids containing oxide nanoparticles. Journal of Heat Transfer, 121, 280–289 (1999).

[6] Wang, X., Xu, X., and Choi, S. U. S. Thermal conductivity of nanoparticle-fluid mixture. Journal of Thermophysics and Heat Transfer, 13, no. 4, 474–480 (1999).

[7] B.C.Pak and Y.Cho, 1998, "Hydrodynamic and heat transfer study of dispersed fluids with submicron metallic oxide particles", J. of Experimental heat transfer, vol. 11, No. 2, pp 151-170.

[8] Vasu, V., RamaKrishna, K., Kumar, A.C.S. 2007. Exploitation of Thermal properties of fluids embedded with nanostructured materials, International energy Journal 8: 181-190.

[9] S.Zeinali Heris et al,"Cuo/Water Nanofluid Heat transfer Through traiangular Ducts," Iranian journal of Chemical Engineering (IAChE) Vol.9,No.1(Winter),2012.