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Research Article

Enhancing Heat Extraction Rate in Automobile Radiator with the Help of Al_2O_3 Based Nano-Fluid.

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Abstract

Nanofluids are a relatively new classification of fluids which consist of a coolant with nanosized particles of metal oxides (1-100 nm) mixed within them. These addition of metal oxides increase conduction and convection coefficients, so heat transfer rate is increases .In an automobile sector, lot of heat is generated due to the combustion. If this heat is not removed from the engine, temperature becomes too high which causes overheating and decrease in viscosity of the lubricating oil, wear of the parts of engine, failure of engine components may occurs due to high thermal stresses. The automobile engine uses a heat exchanger device, called as radiator to remove the heat from the engine. But for removing heat, area increasing is the limitation. To avoid this increasing area, we can use the nanofluids which increases the heat transfer rate in engine

Keywords: *Nano particles, coolant, ethylene glycol, Aluminium oxide (AL_2O_3),Heat transfer rate, convective heat transfer coefficient.*

1. Introduction

The radiator considered as an important component of the cooling system of the engine. Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium .For this liquid-cooled system, the waste heat is removed via the circulating coolant surrounding the devices or entering the cooling channels in devices. The coolant is propelled by pumps and the heat is carried away mainly by radiator.

Nowadays, aluminium is most widely used oxides due to its use in many areas such as thin film coatings, heat-resistant materials etc. Improved devices using nanoscale structures requires the good knowledge of thermal ,& mechanical properties of nanomaterials involved and also their manufacturing process. Our task is to design an automotive radiator work with nanofluids.

Nanofluids are a relatively new classification of fluids which consist of a base fluid with nanosized particles (1-100 nm) suspended within them. These particles, generally a metal or metal oxide, increase conduction and convection coefficients, allowing for more heat transfer out of the coolant, So overall heat transfer rate increases.

2. Nanofluid

Nano fluid is a fluid comprises nanometer-sized particles, known as nanoparticles. Thesefluids contains coolant and nanoparticles of high heat conductivity material. i.e Nanofluid = coolant + Nanoparticle

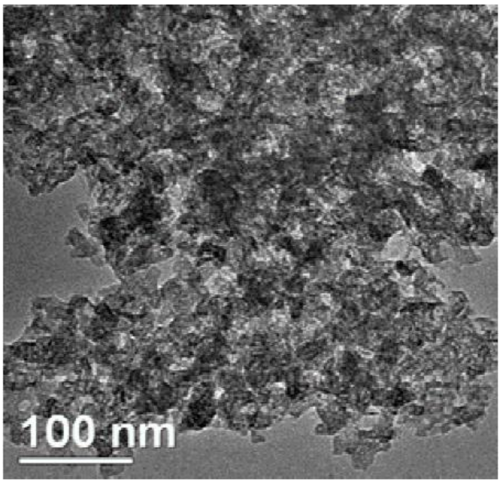

Fig.1TEM image of Al2O3 nanoparticles [Andreea Kufner *et al*]

3. Why nano fluids

The total heat transfer in process is calculated as

Q=HA dT

Where
Q= the total heat transfer rate,

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h =the convective heat transfer coefficient,
A= the heat transfer area, and
dT= the temperature difference that results in heat flow.

It can be stated from this equation that increased heat transfer can be achieved by:

1) Increasing Area A
2) Increasing Convective heat transfer coefficient
3) Increasing Temperature difference dT

A greater temperature difference causes increase the heat flow, but; it is often limited by process or materials constraints. [B. S. Kothawale *et al*].

Increase the area A is a general method to increase heat transfer, but there are limitation on increasing area like aeroplane etc and also there is increase in unnecessary weight.

Heat transfer augmentation can also be achieved by increasing the heat transfer coefficient h. The heat transfer coefficient can be increased by enhancing the properties of the coolant. Additives are added to coolants to improve its properties.The heat transfer coefficient can be improved by addition of nano particles to the liquid coolant (i.e. nanofluids).

%Volume Concentration = (WAl2o3 / ρAl2o3) / [(WAl2o3 / ρAl2o3) + (Wbf /ρbf)]

Where,

WAl2o3 = Weight of aluminum oxide nano particles. ρ Al2o3 = Density of aluminum oxide nano particles =3600kg/m3.
Wbf = Weight of base fluid.
ρbf = Density of base fluid. =1064kg/m3

From the volume concentration equation finds out the requirement of nanoparticle to add the base fluid. The resulting mixture was first sonicated at 28 °c for 1 hr using ultrasonic vibration at sound frequency of 20 kHz.

4 .Calculation of heat transfer coefficient

The heat transfer coefficient can be obtained by following procedure.

According to Newton's cooling equation:

$$Q = hA\Delta T = hA(Tb-Tw) \quad (1)$$

We all know that heat transfer rate Q can be calculated as follows

$$Q = mCp\Delta T = mCp\ (Tin-Tout) \quad (2)$$

By above two equations we can write

$$Nu=\frac{hexp*dh}{k}=\frac{m\ Cp(Ti-To)}{A(Tb-Tw)} \quad \text{.......from (1) \& (2)}$$

In above equation,
Nu = average Nusselt number.
m i=mass flow rate is equal to product of density and volume flow rate of fluid,
Cp = specific heat capacity of fluid,
A = area of radiator tubes,
Ti and To=are inlet and outlet temperatures,
Tb = bulk temperature which was assumed to be the average values of inlet and outlet temperature of the fluid moving through the radiator, and
Tw = tube wall temperature which is the mean value by two surface thermocouples.
k = fluid thermal conductivity and
dh=hydraulic diameter of the tube.
(all the physical properties were calculated at fluid bulk temperature).[S.Ravi Babu et al]

5. Results

A) Mixture water &water ethylene glycol

Before conducting the experiment, some experiments withwater and ethylene glycol to check the accuracy of the experimental setup and set the base for comparing further result

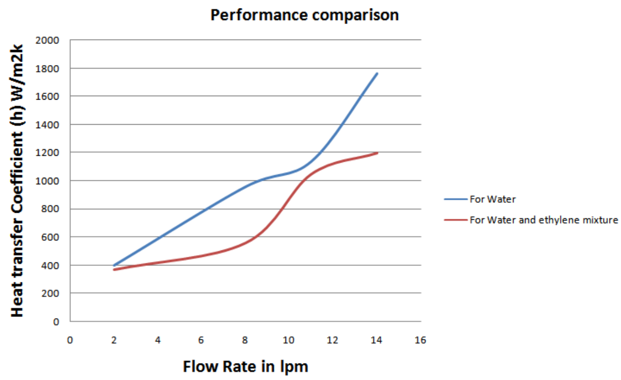

Fig 2 Experimental results for water in comparison with mixture of water &ethylene glycol

Fig.2 shows experimental results for constant inlet temperature of 50°c.

B) With adding Nanoparticles

The nanofluid is implemented in various Al2o3 concentrations, i.e. 0.01, 0.03, 0.05 and 0.07 vol. % and at different flow rates of 6 and 9 l/min were implemented as the base fluid. With increase of the concentration of nano particles in the coolant, viscosity of nanofluid has been increased. Various results are as follows:

For 6 lpm:

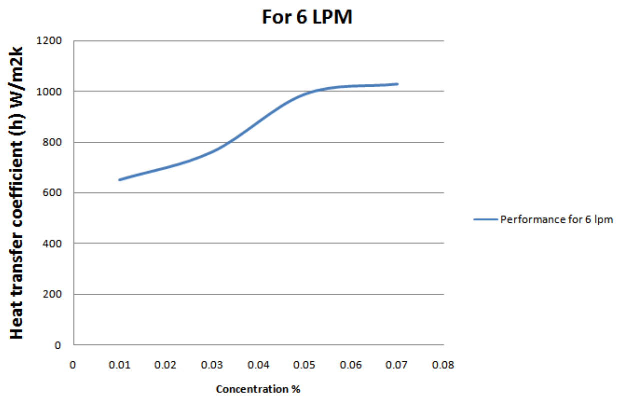

Fig.3 Effect of volume concentration of Al2o3 nano particles on the heat transfer coefficient at 6 lpm

Fig 3 shows the values of heat transfer coefficient for different volume concentrations at flow of 6 lpm of nanofluid passing through radiator. There is increase of heat transfer coefficient.

For 9 lpm:

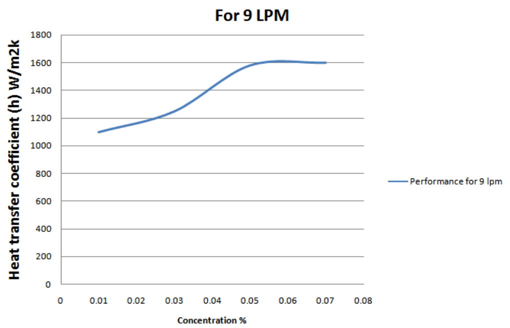

Fig.4 Effect of concentration of Al2o3 nano particles on the heat transfer coefficient at 9 lpm

Fig 4 represents the heat transfer coefficient gradually increasing for increasing the nano particle concentration. the physical properties of nanofluids are slightly different than the base fluid. Density and thermal conductivity increased and specific heat decreased slightly in compare to base fluid. Viscosity increases more clearly, which is undesirable in heat transfer.

Conclusions

1) From above result we can conclude that After adding nano particles of aluminium oxide Al_2O_3 to the coolant, there is markedly increase in heat transfer coefficient.
2) The degree of heat transfer enhancement depends on the amount of the nano particle added.
3) Increasing the flow rate of base fluid enhance the heat transfer coefficient for both coolant and nano fluid considerably.

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