Effect of Nanofluid on Cooling System of Engine

Laxman P. Dhale, Pravin B. Wadhave, Dnyaneshwar V. Kanade, Y.S.Sable

***Abstract*— An automobile radiator is used for the cooling purpose of the engine. The cooling system of an engine plays an important role in its performance for these reason researchers are using different types of Nano fluids as coolant which increases the effectiveness of radiator, increases the performance of an engine and decline the fuel consumption. In this study 1.2% volume concentration of Al_2O_3 nano particles water based nano fluid is used and observes that effectiveness of an automobile radiator enhance up to 23% at constant mass flow rate.**

***Index Terms*—Nanofluid, Automobile Radiator, Effectiveness.**

I. INTRODUCTION

In an automobile engine, the power is generated by using mixture of fuel and air through combustion. Some amount of total generated power is supplied to wheel through transmission system and remaining power is wasted in the form heat and emission. This waste heat cause the overheating and viscosity breakdown of lubricating oil and over heat of engine parts. For this reason the cooling system of an engine is needed.

The cooling system is consisting radiator, water pump, electric cooling fan, radiator pressure cap etc. The most important part in the cooling system of an engine is Radiator. The coolant flows through radiator tubes, heat is dissipated through the tube walls and fins due to flow of air through conduction and convection. The conventional fluids used for heat transfer in radiator are water, coolants, engine oil, ethylene glycol etc. They give less effectiveness. So as to obtain more effectiveness, different additives are added in cooling fluids. Since 20 years, many researchers are doing a study of properties of nano fluid. Due to better thermal performance compare to that of traditional cooling fluids.
Nano technology has recently developed a new category of fluid term as Nano fluid such as (Al2O3, ZnO, SiO2, TiO2, CuO, Fe3O4 etc.). The particles are smaller than 100 nm solid particle size. They have higher thermal conductivity than base fluid. Rahul Bhogare,B.S Kothawale [1] found that by addition of 1% Al2O3 water+EG base Nano fluid. They found that the overall heat transfer on air side increased upto 36%. S Niranjal Kumar,P Gopal [2] found that by adding 0.25% to 0.5% volume fraction of Al2O3 Nano fluid. The total heat was increased by 24% to 49% respectively at constant mass flow rate. V.L Bhimani *et al* [3] found that by addition of 0.1% to 1% of TiO2 Nano fluid. The enhance heat transfer rate is increased by 40-45% as compare to pure water at 90-120 LPM mass flow rate. Dr.G.R.Selokar [4] found that by adding 4 % volume fraction of Al2O3 Nano fluid. The effectiveness of radiator increases up to 17 % and that by using 8 % Al2O3 volume fraction in a base fluid effectiveness increases up to 26 % as compared to use of water as coolant. Paresh Machhar and Falgun Adroja [5] observed that in forced connective heat transfer, five different concentration of 0.1 to 1% volume concentration will be prepared by addition of TiO2 Nano particle in to water. They found that the application of nano fluid with low concentration can enhance heat transfer efficiency up to 45 % in comparison of pure water. Vikas Sharma *et al* [6] found that by the addition of Al2O3 water+EG base Nano fluid at 0.1 %, 0.3% and 0.5% volume concentrations. They made cooling system compact. K Krishnakumar *et al* [7] found that by the addition of 2% of CuO water base Nano fluid. The overall heat transfer coefficient and pumping power is increased up to 10% and 23% respectively. Rupesh Kumar, Harish Kumar [8] found that the addition of 1 to 6% of Al2O3 Nano fluid. The thermal conductivity is increased by 20% by addition of 6% of Al2O3 Nano fluid.

Therefore this study attempts to know the effect of Nano fluid on cooling system of engine using water based Al2O3 Nano fluids as coolant. The effect of volume fraction of Al2O3 nanoparticles with base fluid on the thermal performance and potential size reduction of radiator is also carried out. Al2O3 nanoparticles were chosen in this study.

II. EXPERIMENTAL SETUP

A. Experimental test rig

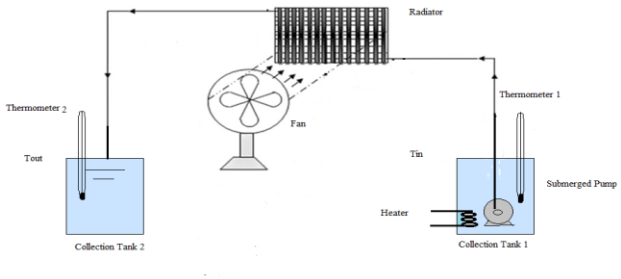

Fig01.Experimental Setup

The figure 1 shows schematic diagram of experimental set up. It consists of automobile radiator, submerged water pump, radiator fan, electric heater, blower fan, storage reservoir and two thermometers. The all arrangement forms a close circuit. The water submerged pump has constant mass flow rate of 10.LPM. [liters per minute]. The total volume of working fluid is 10 liters. The total volume of cooling fluid is kept constant all experiment. The circuit includes 15 mm diameter pipeline. The flow rate is kept constant.

An electric heater having capacity of 2000 watt is used for heating the working fluid and temperature is kept constant at

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85 C. Two thermometers are used to record the radiator inlet and outlet temperatures.

B. Experimental procedure

The Automobile radiator specification and thermo physical properties of base fluid and nano particle are shown in table 1 and 2 respectively. By using experimental setup the comparison of heat transfer enhancement of automobile radiator between the water and Al_2O_3 nano fluid is perform. The base fluid is flowing through radiator at constant mass flow rate 10 LPM. However, the concentration of Al_2O_3 nano particles is 1.2 % with this total heat transfer and effectiveness of radiator were determined.

Specifications of Radiator:-

Packaging height	10 cm
Packaging width	42 cm
Packaging length	44 cm
Depth	34 mm
Core Dimensions	300 x300x 34 mm
Weight	2.1 kg
Width	300 mm
Length	340 mm
No. Of Tubes	48

Table01. Radiator specifications.

Internal diameter:	6 mm
External diameter:	6.82 mm
Thickness of the tube:	0.41 mm
Length of the tube:	340 mm
Material of the tube:	Aluminium
Inner surface area:	6408.73 mm^2
Outer surface area:	7284.73 mm^2

Table02. Tube specifications.

Sr. No	Properties	Al_2O_3	Water
1.	Density (Kg/m^3)	3950	1064
2.	Specific Heat (J/Kg K)	873.336	4187
3.	Thermal Conductivity	31.9220	0.6294
4.	Viscosity (N/sm^2)	-	8.90×10^{-5}

Table03. Thermo physical Properties of base Fluid and Nano Particles

The analysis also includes the comparison of thermal performance and effectiveness of radiator by using water and Al_2O_3 nano fluid.

III. ASSUMPTIONS FOR TEST CONDITION

The results obtained are based on the following assumptions:

1. Assume that the vehicle is moving in 45 km/hr speed that's why the velocity of air is 12.5 m/s, and temperature at the entrance of the radiator core on both air and coolant sides are uniform.
2. There are no phase changes (condensation or boiling) in all fluid streams.
3. Fluid flow rate is uniformly distributed through the core in each pass on each fluid side. No stratification, flow bypassing, or flow leakages occur in any stream.
4. Heat transfer area is distributed uniformly on each side both the inner dimension and the outer dimension of the tube are assumed constant.
5. The thermal conductivity of the tube material is constant in the axial direction. No internal source exists for thermal-energy generation.
6. There is no heat loss or gain external to the radiator and no axial heat conduction in the radiator.
7. Room temperature is 35^0C.

IV. CALCULATIONS

In this paper a comparison is made between the heat transfer performance of radiator by operating with mixture of water and nano fluid coolant. Described equations are being incorporated to aid the comparison.

The characteristics of nano particles and base fluid used in this study are summarized in Table 03. The necessary thermo physical properties in this paper are density, and specific heat. In this paper, density (ρnf) and special heat capacity (Cpnf) of Al2O3/water nano fluid have been calculated based one empirical correlation as shown in follow.

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

$$C_{nf} = \frac{\varphi\rho_p + (1-\varphi)\ \rho_{bf}\ C_{bf}}{\rho_{nf}} \qquad (2)$$

Where f is nano particle volume concentration and ρp, ρbf and Cp,p, Cbf are the densities and the specific heats of the nano particles and base fluid, respectively.

A. Heat transfer modeling

The rate of heat transferred between nano fluid coolant and airflow in the radiator can be written as follows:

$$Q = m_{nf}\ C_{nf}\,(T_{nfi} - T_{nfo}) = m_a\ C_{pa}\,(T_{ai} - T_{ao}) \qquad (3)$$

Where nf and ai denote the relevant parameters of nanofluid coolant and airflow respectively. The mass flow rates are calculated based on the pump for mixture of water + nanofluid and the speed and frontal area for the air as follows.

$$m_{nf} = \rho_{nf} V_{nf} A_{tubes} \qquad (4)$$

$$m_a = \rho_a A_a V_{fr} \qquad (5)$$

The Effectiveness of the radiator is given below

Effectiveness of the Fin = Actual Heat Transfer / Maximum Heat Transfer

$$\epsilon = \frac{m_{nf}\ C_{nf}\,(T_{nfi} - T_{nfo})}{m_a\ C_{pa}\,(T_{nfi} - T_{ai})} \qquad (6)$$

V. RESULT AND DISCUSSION

In the present paper thermal performance of the Automobile radiator at constant air Reynolds number

(84391) and constant mass flow rate (0.167 Kg/s) have been carried out.

A. For water

The first test of this experiment is conduct on pure water. In which the water is passed through the pipes in the radiator with inlet temperature 85^0C. The outlet temperature of water after flowed through radiator at constant mass flow rate is 72^0C. And the air temperature is 36^0C. After this the effectiveness is calculated by using Eq. (6).

B. For Nanofluid

The water based Al_2O_3 nanofluid is implemented with 1.2% of volume concentration at constant mass flow rate 0.167 Kg/s were implemented as the working fluid. The inlet temperature of the nanofluid is also 85^0C. The outlet temperature of nanofluid is 62^0C after flowed through radiator at constant mass flow rate with atmospheric temperature of 36^0C. After this the density (ρnf) and special heat capacity (Cpnf) of Al2O3 water based nano fluid have been calculated by using Eq. (1) & Eq. (2) respectively. The effectiveness is calculated by eq. (6).

The below graph indicates the behavior of coolant (i.e Nanofluid and water) at the various temperature with respect to time at constant mass flow rate.

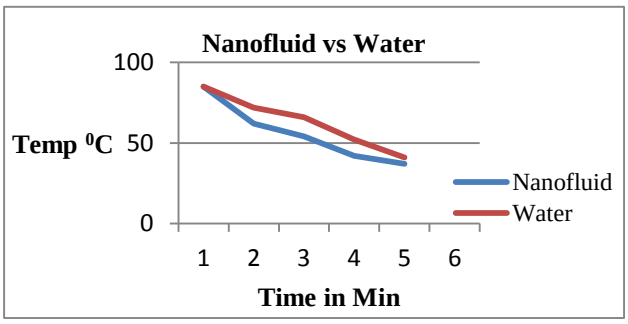

Fig02.Nanofluid vs Water

VI. CONCLUSION

1. Heat transfer rate is increased with increase in volume concentration of nanoparticles (ranging from 0% to 1%). About 40% heat transfer enhancement was achieved with addition of 1% Al2O3 particles at constant mass flow rate (0.167 Kg/s).

2. Effectiveness of the radiator increased up to 24% with addition of 1.2 % volume fraction of Al2O3 particles than the base fluid at constant air Reynolds number and constant mass flow rate.

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