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Nano Fluid Using Aluminium Oxide As Coolant To Improve Heat Transfer Rate In Automobile Radiator

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Abstract *:* Now days the demand of automobile is on prime. so it is more challenging for automobile industries to provide an efficient and economical engine. Only 25% of heat is converted to useful power & the remaining heat transfer is dissipated. If the heat dissipation is not done properly it will cause a serious damage to the engine. With the advancement of nanotechnology the new generation of heat transfer fluids nano fluids has been developed which made researchers to next level. The performance of the engine is based on fuel system, lubrication system, transmission system and cooling system etc. Cooling system is the most important factor to increase the efficiency of the engine. Heat transfer through radiator can be improved by maximizing the heat transfer area and increasing heat transfer coefficient Aluminum Oxide (Al_2O_3) in water as nanofluids was employed for heat transfer enhancement heat transfer coefficient and the heat transfer rate in cooling system of engine radiator with and without application of Nano coolants with as Nano coolants
Keywords: - Cooling system, Heat transfer, Nano particles, AL2O3

1. INTRDOUCTION

Materials with higher thermal proper_es are required to increase the performance of radiator. The use of nanofluids is one of the methods to increase heat transfer in radiators. In this research, cooling of car radiator has been invesgated by using nanofluids. Results of the research indicated that the used nanofluid can increase heat transfer up to 50%. Reduce on in size and weights of the radiators are among the achievements of this research.[1] In addition to reducing the produce on cost, better design on of cars are possible when the radiator becomes smaller in size. On the other hand, better cooling has positve effects on fuel consumption on and the amount of fuel Consumption[2]. nano fluids are potential heat transfer fluids which enhances the thermo physical properties and heat transfer performance. It can be applied in many areas for better performances for energy, heat transfer and other performances.[3] work depicts that at high speeds, about 65% of the total energy output from a truck is expended in overcoming the aerodynamic drag. This fact is partly due to the large radiator in front of the engine positioned to maximize the cooling effect of oncoming air.With the advancement of nanotechnology, the new generation of heat transfer fluids called, “Nano coolants ” have been developed and researchers found that these fluids are making higher thermal conductivity compared to that of conventional coolants. Nano fluids which consist of carrier liquids such as water, ethylene glycol are dispersed with tiny nano-scale particles known as nanoparticles. Nano fluids seem to be a potential replacement for the conventional coolants in engine cooling system for automobiles. Recently there has been considerable research findings are reported, that the superior heat transfer performances of Nano coolants [4]. Nano particles are very small in size, usually < 100 nm. Nano-fluids used many applications like microelectronics, fuel cells, pharmaceutical process, hybrid power engines, engine cooling, vehicle, thermal management, domestic refrigerator, heat exchangers, in grinding, mashing, boiler flue gas temperature reduction, geothermalextractions[5]thathottertheradiator,thebetteristheheattransferwithtsorroundingair.Withwaterasthecoolant,thehighesttemperatureradiatorcouldoperateis373K,i.e.,theboilingpointofwater.Additionofethylenwaterinasealedradiatorcansubstantiallyraisecoolantpressurealong withboilingpoint.[6]. This work is focused on the addition of AL2O3 Nano particles to coolant in an automotivecooling system. Relevant data, nano fluid properties and empirical correlations were obtained from literatures to investigate the heat transfer enhancement of an automotive or radiator operated with Nano fluid based coolants. Experimentation is donefor the comparison of overall heat transfer coefficient and the heat transfer rate of the engine cooling system with and without application of al2o3 nano fluid in base fluid .

2. COOLING SYSTEM IN AUTOMOBILE:

The two working fluids are generally air and coolant. As the air flows through the radiator, the heat is transferred from the coolant to the air. The purpose of the air is to remove heat from the coolant, which causes the coolant to exit the radiator at a lower temperature than it entered at. Coolant is passed through engine, where it is absorb heat. The hot coolant is then feed into tank of the radiator. From tank of radiator, it is distributed across radiator core through tubes to another tank on opposite side of the radiator. As the coolant passes through the radiator tubes on its way to the opposite, it transfers much of its heat to the tubes which, in turn, transfer the heat to the fins that are lodged between each row of tubes. The radiator acts as a heat exchanger, transferring excess heat from the engine's coolant fluid into the air. The radiator is composed of tubes that carry the coolant fluid, a protective cap that's actually a pressure valve and a tank on each side to catch the coolant fluid overflow. In addition, the tubes carrying the coolant fluid usually contain a tabulator, which agitates the fluid inside. This way, the coolant fluid is mixed together, cooling all the fluid evenly, and not just cooling the fluid that the sides of the tubes. By creating turbulence inside the tubes, the fluid can be used more effectively.

3. METHODOLOGY:

The amount of al2o3 nanoparticles i.e., required in preparation of Nano fluid based coolant is calculated using the law of mixture formula. A sensitive balance with a 0.1mg resolution is used to weigh the al203 nanoparticles. The weight of the nanoparticles required for preparation of 100 ml al2o3 nanofluid of a particular volume concentration, using water-propylene glycol base fluid is calculated by using the following relation below eq1

$$\% \text{ volume concentration} = \frac{\frac{W_{Al_2O_3}}{\rho_{Al_2O_3}}}{\frac{W_{Al_2O_3}}{\rho_{Al_2O_3}} + \frac{W_{bf}}{\rho_{bf}}} = \frac{\frac{W_{Al_2O_3}}{6300}}{\frac{W_{Al_2O_3}}{6300} + \frac{100}{1036}} \text{ ------------eq1}$$

The amount of TiO_2 nano particles required to prepare Nano fluids of different percentage volume concentration in a 100 ml of base fluid is summarized.table1.

Table 1 weight details on al203

S.NO.	Volume concentration (%)	Weight of nanoparticles (W_{AL2O3}) , Grams
1	0.1	0.61672
2	0.2	1.23344
3	0.3	1.85016
4	0.4	2.46688

Short description about Nano fluids The AL_2O_3 Nano particles having an average size of 30-40 nm is procured from a USA based company (Sigma-Aldrich Chemicals Private Ltd) and is used for investigation in the present experimental work. The photographic view of the nanoparticles as seen by the naked eyes is shown in the fig 1

Fig1 show al2o3 nano particles size of 1 Um

We can get/find particle size of Aluminum Oxide by using scanning electron microscope (SEM) process.

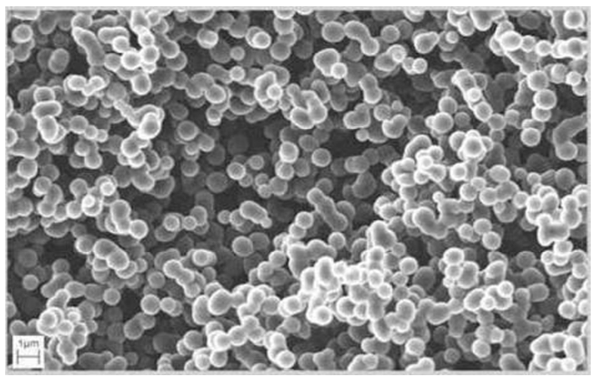

Fig 2morphlgy of al2o3 particle

In the present work, water- Aluminum Oxide mixture (70:30 by volume) is taken as the base fluid for preparation AL_2O_3 nanofluids. Basically, three different methods are available for preparation of stable nanofluids and are listed below. Mixing of Nano powder in the base liquid In this method, the nanoparticles are mixed in the base liquid and thoroughly stirred with stirrer. A Nano fluid prepared in this method giveslow suspension stability, because the nanoparticles settle down due to gravity, after sometime of Nano fluid preparation. The time of particle settlement depends on the type of nanoparticles used, density and viscosity properties of the host fluids. Water-propylene glycol based AL_2O_3Nanofluids of 0.1%, and 0.2% volume concentrations were prepared to measure the absolute viscosity. The AL_2O_3 Nano fluids thus prepared are assumed to be an isentropic and their thermo physical properties will be uniform and constant with time all through the fluid sample. These Nano fluids are assumed to act as Newtonian fluids as the concentration of nanoparticles is low. A Newtonian fluid satisfies the equation governing Newtonian behavior of fluids and is given by

T=ur----(2)

The objective of this experiment is to analyze and study the effects of the temperature and the volume concentration of AL_2O_3 Nano fluid on its absolute viscosity. The experimental setup for measurement of viscosity of AL_2O_3Nano fluids using water-propylene glycol blend as the base fluid is shown fig 2.It consists of a programmable Brook field viscometer with temperature controlled bath. The viscometer is calibrated using the standard fluids. The spindle type and its speed combinations will produce results with accuracy when the applied torque is in the range of 10% to100% and accordingly the spindle is chosen. Spindle CC45 DIN is used. The AL_2O_3 Nano fluid under test is poured in the sample chamber of the viscometer. The spindle immersed and rotated in the Nano fluid in the speed ranging from 400 to 540 rpm in steps of 12 seconds each.

4. EXPERIMENTAL SET UP FOR THERMAL CONDUCTIVITY MEASUREMENT

Nano fluids possess unique features with regard to their thermal performances. The properties of Nano fluids are different from the properties of conventional heat transfer fluids. The nanoparticles offer large total surface area as a result of which higher thermal conductivities are expected in Nano fluids. Many research finding sreveal that traditional thermo fluids in the presence of nanoparticles exhibit better thermo physical properties.

The experimental setup to measure the thermal conductivity of nanofluids is shown schematically in Fig. 3. The photographic view of the experimental set up is shown in the plate measured the thermal conductivity of the almunum oxide . Nano fluids. In the present work thermal conductivity of the CuO nano fluids is measured by using the thermal conductivity apparatus supplied by P A Hilton Ltd, England.

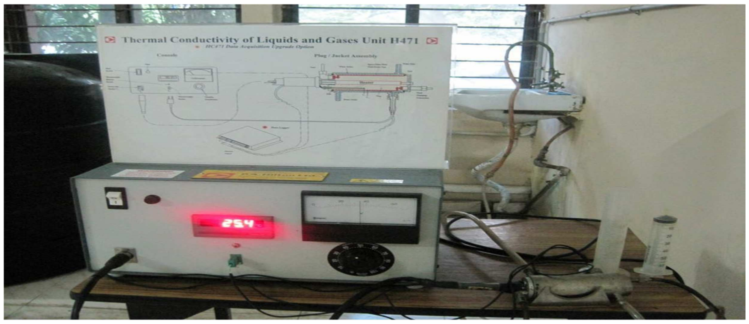

Fig 3Schematic diagram of thermal conductivity measuring experimental setup

The below fig 4 is Schematic diagram of experimental set up which consists of closed loop circuit. The experimental test rig consists of reservoir with heating element, magnetic drive pump, Rotameter, radiator fan (speed control DC motor) and Automobile radiator. Magnetic drive pump gives the flows 16-18 LPM; the flow rate of the test section is regulated by means of two globe valves which are appropriate adjustable to the recycle line as shown in fig 5. The working - fluid fills 30% of the storage tank whose total volume is 38 lit. The total volume of the circulating liquid is constant in all the experiments. The circuit include 0.30m diameter pipeline which is made of the steel pipe. A Rotameter is used to flow measurement through the test section. The specification of the Rotameter is 1001000

Fig 4 setup of experiment

Fig 4Schematic diagram of experimental setup for measuring al2o3 nanofluid dynamic viscosity
Experimental setup for radiator and flow diagram
Influence of the air Reynolds number on the thermal performance of automobile radiator .Air Reynolds number was varied in the range of 84391 and 91290 while mass flow rate of the coolant was fixed to 0.08 kg/s.

5. EXPERIMENTAL SETUP

The below fig5is Schematic diagram of experimental set up which consists of closed loop circuit. The experimental test rig consists of reservoir with heating element, magnetic drive pump, Rotameter, radiator fan (speed control DC motor) and Automobile radiator. Magnetic drive pump gives the flows 16-18 LPM; the flow rate of the test section is regulated by means of two globe valves which are appropriate adjustable to the recycle line as shown in fig 7. The working fluid fills 30% of the storage tank whose total volume is 42 lit. The total volume of the circulating liquid is constant in all the experiments. The circuit include 0.20m diameter pipeline which is made of the Pastic pipe. A Rotameter is used to flow measurement through the test section. The specification of the Rotameter is 100-1000 LPH and measurement of1/2” BSP(M). For heating the working fluid, an electric heater of capacity 2000 watt and controller were used to maintain the temperature 50^{o}-90^{o}C. Two K type thermocouples were used on the flow line to record the radiator inlet and outlet temperatures. Two thermocouples K types are installed in the radiator to measure the wall temperature of the radiator

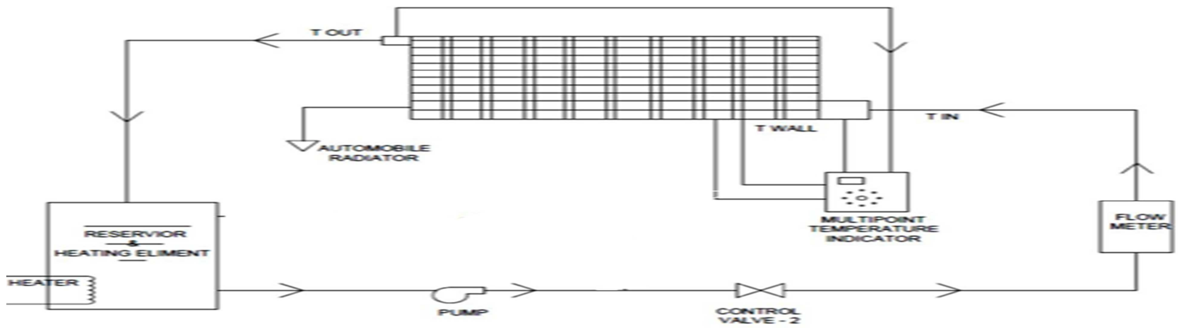

Fig 6Schematic diagram of experimental set up

The Radiator specifications given in the below table 3

Table 3 radiator specification

Sl.no.	Description	Air	Coolant
1	Fluid Inlet Temperature	20-40 (Assume T_a=24)	50-80 (Assume Ta= 60)
2	Core Width	0.35 M	0.35 M
3	Core Height	0.35 M	0.35 M
4	Core Depth	0.016 M	0.016 M
4	Tubes	0.7 Cm X 30 Cm	0.7 Cm X 30 Cm
5	Fin Thickness	0.01 Cm	0.01 Cm
6	Hydraulic Diameter	0.0007 M	0.0007 M
7	Fine Types	Ruffled	Ruffled
8	Tubes Arrangement	Staggered	Staggered

6. ANALYSES

The analysis is also done on radiator with Nano fluids at different volume fractions. This is focused on effectiveness and overall heat transfer coefficient based on the air side and total heat transfer of an automobile radiator. In this study coolant flow rate was fixed at 0.000083 m^3/s and air Reynolds number is 91190 but the volume fraction of $AL2O_3$ nanoparticles was varied. It focuses on the effects of volume fraction of $AL2O_3$& nanoparticles on the coolant pressure drop and pumping power in table 4

Table 4 thermo physical properties of al2o3

Volume Concentration, ϕ (%)	Density, ρ (kg/m^3)	Specific Heat, C (J/kg.K)	Thermal Conductivity, k (W/m.K)	Viscosity, μ (kg/m.s)
Temperature: 30°C				
0.0	1055.39	3502.0	0.413	0.00240
0.5	1071.26	3446.5	0.418	0.00251
1.0	1087.14	3392.7	0.433	0.00265
1.5	1103.01	3340.4	0.441	0.00279
Temperature: 50°C				
0.0	1045.35	3569.0	0.428	0.00157
0.5	1061.27	3511.7	0.432	0.00164
1.0	1077.20	3456.0	0.448	0.00177
1.5	1093.12	3402.0	0.488	0.00182
Temperature: 70°C				
0.0	1033.37	3636.0	0.438	0.00111
0.5	1049.35	3576.7	0.443	0.00125
1.0	1065.34	3519.1	0.462	0.00143
1.5	1081.32	3463.3	0.501	0.00148

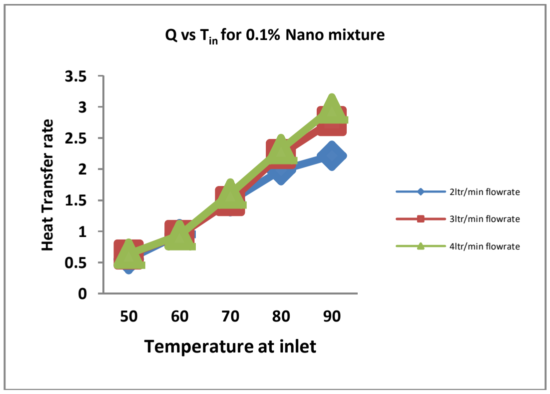

Fig .8Heat transfer rate for different flow rates of coolant with AL203 $_{0.2}$% by volume

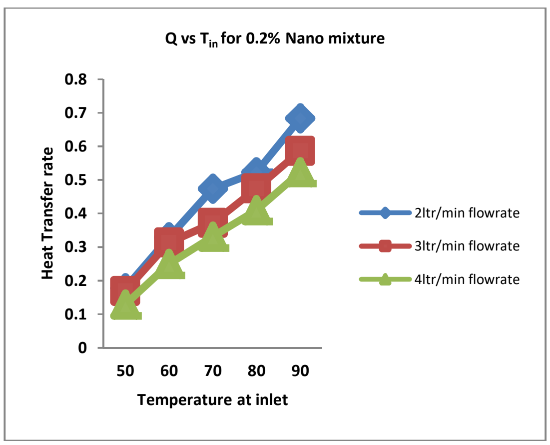

Fig .9.Heat transfer rate for different flow rates of coolant with $AL2O_3$ 0.2% by volume

7. CONCLUSION:

From the experimental data and preliminary analysis of results, it can be concluded that the Nano coolant can be effectively used as a coolant in automobile radiators. In Addition of small percentage of Al_2o_3 by volume, improves the quantity of coolant for quick dissipation of heat in an automobile radiator. Experiments are underway to quantify the fiction losses and fouling the radiator, if any, due to the addition of Nano particles.

It has been seen that addition of Nano fluids with coolants suitable for Automobile application. Nano coolants enable the potential to allow higher temperature coolants and higher heat rejection in the automotive engines. A higher temperature radiator could reduce the radiator size approximately 30%. This translates into reduced, fluid pumping and fan requirements, leading to possibly a 10% fuel savings. From the above study of Nano fluids, following brief conclusions can be drawn as 0.1% and 0.2% of AL203Nano fluid with increase in flow rate of water, the heat transfer coefficient has been increasing.

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