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IMPROVING PERFORMANCE OF AUTOMOBILE RADIATOR BY ADDING AL2O3(ALUMINA)NANOFLUID TO ETHYLENE GLYCOL BASED FLUID COOLANT

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ABSTRACT

In this paper, we observed that the enhancement of forced convective heat transfer rate of aluminium automobile radiator after using Al2O3 nano fluid with ethylene glycol base fluid coolant. In this experimental investigation , we consider volume fraction and the flow rate of coolant as parameters. we take volume concentration of Al2O3 nanoparticles in the range of 0.01 to 0.12 % and base fluid is 15 liters. We have chosen sonication process to mix Al2O3 nanoparticle with water using ultrasonic sonicator for 2 hours for getting stable suspension in water. Heat transfer rate were increased by increasing the volume concentration and flow rate .we observed that Maximum heat transfer rate occurred at 0.08% volume concentration i.e. 45 % higher compared to water. After increasing the volume concentration heat transfer rate is just increased compare with previous heat transfer values values. The coolant flow rate is varied from 3 lpm to 15 lpm.

KEYWORDS: Aluminum flat tube radiator, Forced convection heat transfer rate, Al2O3 nano fluid, Water+ethylene glycol base fluid

INTRODUCTION

Engine is a power generator of automobile and supply that power in the form of heat energy some portion of heat energy developed in engine is utilized to run the wheels and rest liberated to surroundings.But the waste heat energy should be removed at fast rate to avoid overheating and viscosity breakdown of the lubricating oil, wear of the engine parts e.t.c., hence radiator nothing but heat exchanger is used to supply the required cool water to remove heat.This equipment circulating coolant surrounding the devices or entering the cooling channels in devices. The coolant is propelled by pumps . For the purpose of producing high efficiency engine we need look at reducing a vehicle weight by optimizing design and size of a radiator is a necessity for making the new design model of radiator. Over several years researchers have focused to overcome the limited heat transfer capabilities of conventional heat transfer mediums such as water, engine oil, ethylene glycol (EG and the second one is fluid being used. Nano particles are very small in size, usually < 100 nm .Nanofluids have unique features different from convectional solid- liquid mixtures in which mm (or) µm sized particles of metals and non metals are dispersed. Due to their excellent characteristics, nanofluids find wide application in enhancing heat transfer characteristics namely extreme stability, ultra-high thermal conductivity. Heat transfer surface area increases due to Brownian motion and inter particle forces so that increased thermal conductivity, increased single-phase heat transfer, increased critical heat flux occurs [2].

Now a days the researchers using the alumina ,copper oxides e.t.c as coolants in base fuids .brownian motion vander wal force to be considered for using this fluids with base fluids.

LITERATURE SURVEY

Xiaohao Wei et al [4] presented The effect of reactant molar concentration and nanofluid temperature on thermal conductivity. Nano particles shape is (spherical to octahedral)variable by adjusting some synthesis parameters such that enhance thermal conductivity up to 24%. Cu2O nanofluids can be synthesized by using the chemical solution method.

Pooyan Razi et al [5] assessed Nan foluids with different particle weight concentration passing through the flatend copper tubes and heated by an electrical heating coil and created fully developed flow. Study the effect of different parameters on heat transfer coefficient and pressure drop flow is studied. The results show down a maximum increase of 16.8% in heat transfer coefficient for a range of Reynolds numbers between 10 to 100 is obtained for nanofluid flow with 2% wt. concentration inside the round tube, while, the increases of 20.5% and 26.4 are obtained for this fluid flow inside the flattened tubes with internal heights of 8.3 and 6.3 mm at nearly the same Reynolds numbers range, respectively.

M.pirhayati et al [6] Studied convective heat transfer of nanofluid flow inside an inclined copper tube and created. Laminar and hydro dynamically fully developed flow inside round tube. different weight fractions of nano fluid and the study of effect of different parameters increasing the heat transfer coefficient. Inclined tube at 30° exhibit most heat transfer enhancement amongst other tube inclination.

Weerapun Duangthongsuk et al[7] examined Comparing the heat transfer coefficient and friction factor for different volume % passing through the horizontal double tube counter flow heat exchanger under turbulent flow conditions. Aida Nasiri et al[8] assessed Preparing nanofluids with three different dispersion methods namely ultrasonic bath, ultrasonic probe, functionalization. among three functionalization method gives that the best stability and thermal conductivity. K.B Anoop[9] et al presented Two particle sizes were used one with average particle size of 45nm to 150nm. 45nm particle showed higher heat transfer coefficient than that 150nm particles. Heat transfer coefficient show higher enhancement than in the developed region. S.M.S Murshed et al [10] examined Particle size and shape also have effects on the enhancement of thermal conductivity. The PH value and viscosity of the nanofluids are also characterized.

M. chandrasekar et al [11] implemented nanofluid Prepared by microwave method assisted chemical precipitation method. Different volume concentrations at room temperature were used for investigation conclude that the viscosity increase is substantially higher than the increase in the thermal conductivity. Patricia E [12] studied The effect of particle diffusion in a temperature field on the aggregation and transport and the predicted thermal conductivity and viscosity enhancements are compared to determine the favourability of aggregation nanofluid. Eiyad Abu nada et al [13] performed By taking account the solid particle dispersion the angle of inclination is used as a control parameter for flow and heat transfer varied from o° to 120° the governing equation are solved with finite volume technique.

S.k sahu and S. Chougule [14] has been studied experimentally inside an automobile radiator. Heat removal rate of the coolant flowing through the automobile radiators is of great importance for the optimization of fuel consumption. Four different concentrations of nanofluids in the range of 0.15–1 vol. % were prepared with the addition of CNT nanoparticles into water. The CNT nanocoolants are synthesized by functionalization (FCNT) and surface treatment (SCNT) method. The effects of various parameters, namely synthesis method, variation in pH values and nanoparticle concentration on the Nusselt number are examined through the experimental investigation. Nanocoolants exhibit enormous change Nusselt number compared with water. The results of functionalized CNT nanocoolant with 5.5 pH exhibits better performance compared to the nanocoolant with pH value of 6.5 and 9.

NANOFLUIDS PREPARATION

NANOLABES supplied the Al_2o_3 nanoparticles with of size 30 to 50nm with density3.5-3.9g/cm3. The base fluid should be free from dispersant/surfactant .As the provided nanoparticles had a hydrophobic surface,first the base fluid is subjected to magnetic stirring for few hours and then mixed nanofluid with base fluid to obtain required nano coolant first we have take 10.5 litres of distilled water and 4.5 litres of ethylene glycol mix with each other this is used as base fluid. Moreover,. In addition of any agent may change the fluid properties

%volume concentration = $(W_{Al2o3} / \rho_{Al2o3}) / [(W_{Al2o3} / \rho_{Al2o3}) + (W_{bf} / \rho_{bf})]$
W_{Al2o3} = Weight of aluminum oxide nano particles.
ρ_{Al2o3} = Density of aluminum oxide nano particles =3600kg/m3.
W_{bf} = Weight of base fluid.
ρ_{bf} = Density of base fluid. =1064kg/m3

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we can calculate required quantity of nano powder to be add to base fluid by using the above volume concentration equation The sonication process takes place at ambient temperature 28oc for 1 hour using the ultrasonic vibration sonicator power is 500W at sound frequency of 20 kHz. Repeat for 3–5 h to obtain uniform suspensions.

Fig 1. Oscar ultra sonicator, Pr-1000

NANOFLUIDS PROPERTIES

Be sure the Nano particles well suspended in base fluid Here the nanofuid properties.
The density of nano fluid is calculated by the mixing theory as:

$$\rho = \text{Ø}\rho p + (1-\text{Ø})\ \rho bf$$

The specific heat capacity of nanofluid can be calculated based on the thermal equilibrium model as follows

$$C = (\text{Ø}\rho pcp + (1-\text{Ø})\ \rho bf\ cbf)/\ \rho nf$$

Thermal conductivity of nanao fuid

$$Knf = \frac{kv+(n-1)Kbf - \text{Ø}(n-1)(Kbf-kv) \times Kbf}{kv+(n-1)Kbf - \text{Ø}(n-1)(Kbf-kv)}$$

viscosity of nano fluid

$$Unf = Ubfx1/(1-\text{Ø})2$$

Specification of nanoparticles
Chemical name: Aluminum Oxide
Purity: 99%
Appearance: white
Odor: Alcoholic
Average particle size: 30-50nm
Density: 3.5-3.9 g/cm3 or 3950 kg/m3
Specific heat: 873.36 J/kgK
Thermal Conductivity: 31.992 W/mK

Specification of base fluid(ethylene glycol + water)70:30

Density: 1064 kg/m3
Specific heat: 3370 J/kgK
Thermal Conductivity: 0.363 W/mK

EXPERIMENTAL TEST RIG AND PROCEDURE

Components in rig

1) Radiator (34 tubes,2mm width)
2) water pump(0.25hp and 4m head & 3-15lpm)
3) Fan(1500 rpm)
4) Heater(2000W)
5) Thermo couples (6 no's)
6) plastic tank(50liters capacity)
7) Pipes (0.75inch)
8) Flow meter
9) control valves
10) Temperature controllers

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Assumptions for test condition

A) Velocity and temperature at the entrance of the radiator core and airside are uniform
B) There are no phase changes (condensation or boiling) in all fluid streams.
C) Fluid flow rate is uniformly distributed through the core in each pass on each fluid side.
D) The flow condition is characterized by the bulk speed at any cross section.
E) The temperature of the fluid is uniform at every flow cross section, so that a single bulk temperature applies to each stream at a given cross section. Heat transfer area is distributed uniformly on each side Both the inner dimension and the outer dimension of the tube are assumed constant.
F) The thermal conductivity of the tube material is constant in the axial direction.
G) Room temperature is 28°c. The configuration of the automobile radiator used in this experiment is of the louvered fin-and tube type, with 34 vertical tubes with stadium-shaped cross section. The fins and the tubes are made with aluminum. For cooling the liquid, a forced fan was installed close and face to face to the radiator and consequently air and water have in direct cross flow contact and there is heat exchange between hot water flowing in the tube-side and air across the tube bundle.

Fig 2 Schematic of experimental set up.

CALCULATION OF HEAT TRANSFER COEFFICIENT

To obtain heat transfer coefficient and corresponding Nusselt number, the following procedure has been performed.
According to Newton's cooling law:

$$Q = hA\Delta T = hA(T_b - T_w)$$

Heat transfer rate can be calculated as follows

$$Q = mC_p\Delta T = mC_p(T_{in} - T_{out})$$

Regarding the equality of Q in the above equations

$$Nu = \frac{h_{exp} d_{hy}}{K} = \frac{m c_p (T_{in} - T_{out})}{A(T_b - T_w)}$$

Nu =Nusselt number for the whole radiator,
m = mass flow rate which is the product of density and volume flow rate of fluid,
Cp =specific heat capacity of fluid,
A = peripheral area of radiator tubes,
T in and Tout = inlet and outlet temperatures,
Tb = bulk temperature which was assumed to be the average values of inlet and outlet temperature of the fluid
T_w =Tube wall temperature which is the mean value by two surface thermocouples.

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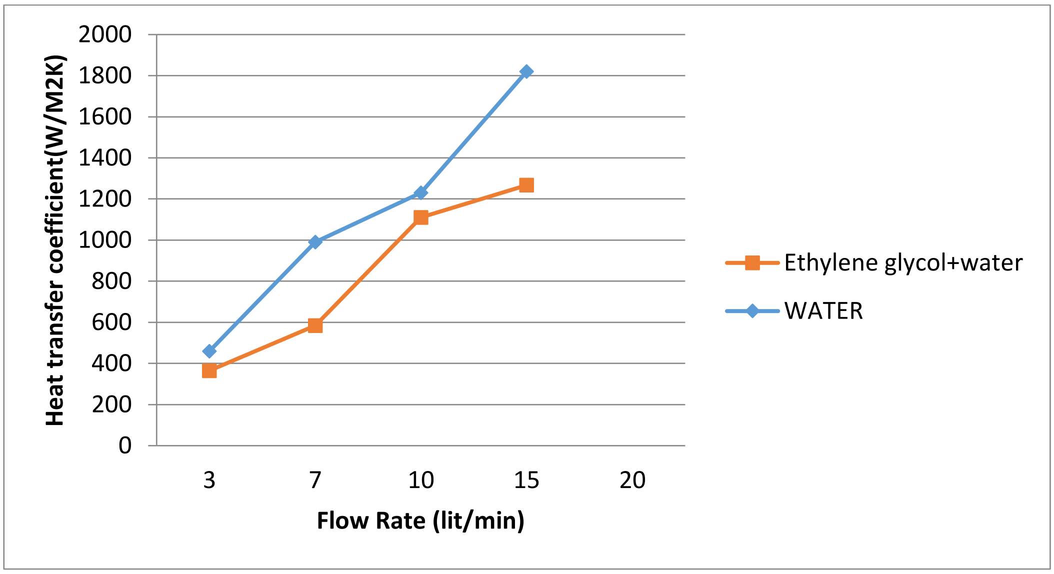
K= Thermal conductivity
d_{hy} =Hydraulic diameter of the tube.

RESULTS AND DISCUSSIONS

A) Heat transfer coefficient graph between Base fluid water -ethylene glycol (70:30) and pure water

First we conducted experiment with pure water and then with ethylene glycol base fluid in order to check the reliability and accuracy of the experimental setup.

Inlet temperature 55°c is constant for all the fluids through out experiment



Graph 1: comparison of heat transfer coefficient between water+ ethylene glycol and pure water

Graph1: shows experimental results of heat transfer coefficient for water + ethylene glycol and pure water. Among These two fluids ethylene glycol posses poor heat transfer performance than pure water because of lower thermal conductivity.

B. AL_2O_3 Nanofluid

We implemented **AL_2O_3 Nanofluid** in different concentrations, i.e. 0.01, 0.02, 0.05 , 0.08,0.1,0.12 vol. % and at different flow rates of 3,7,10 and 15 LPM were implemented and ethylene glycol as the base fluid. It is important to maintain equal mass flow rate, constant air Reynolds number, less base fluid temperature for better thermal performance of the cooling system. Increase of the volume concentration of nano particles in the base fluid leads to increase in viscosity of nano fluid

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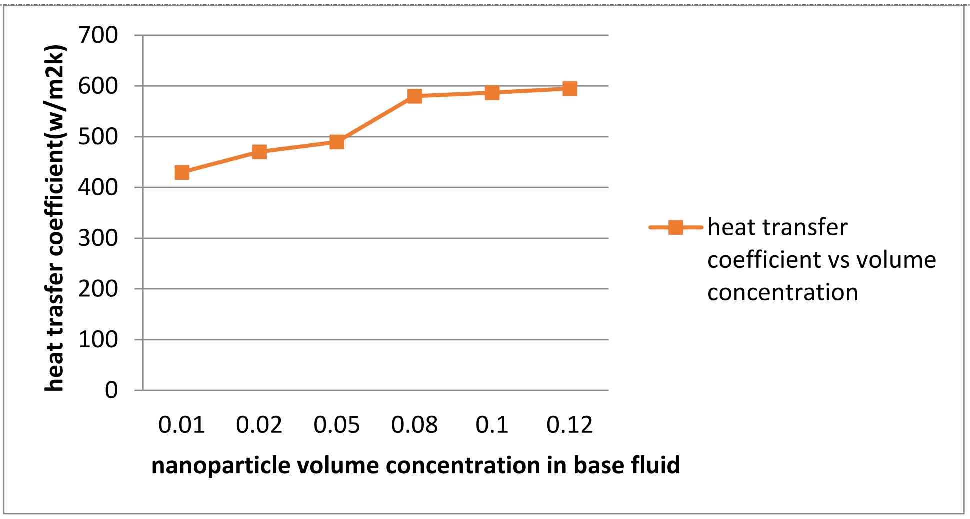
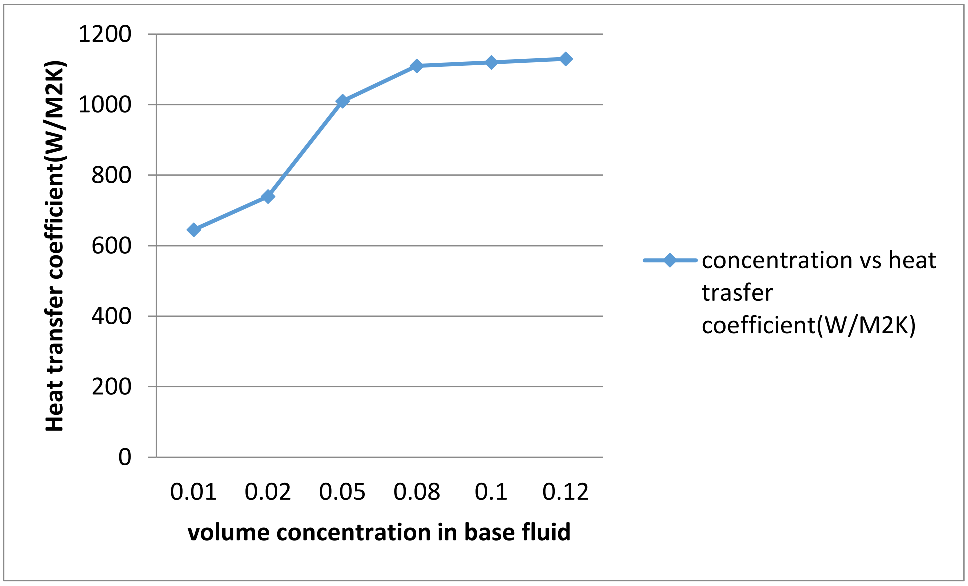


Graph 2 Heat transfer coefficient at different volume concentrations of AL_2O_3 nanofluid at 3 lpm

Graph 2: From the above graph observed that the heat transfer coefficient enhanced from 3.5% to 21% for different volume concentrations at constant flow rate is 3LPM when compared with pure water. The Heat transfer coefficient value is in the range between 430 W/m2K to 595 W/m2K.



Graph 3 Heat transfer coefficient at different volume concentrations of AL_2O_3 nanofluid at 7 lpm

Graph 3: From the above graph observed that the heat transfer coefficient enhanced from 2% to 13% for different volume concentrations at constant flow rate is 7LPM when compared with pure water. The Heat transfer coefficient value is in the range between 645 W/m2K to 1130 W/m2K.

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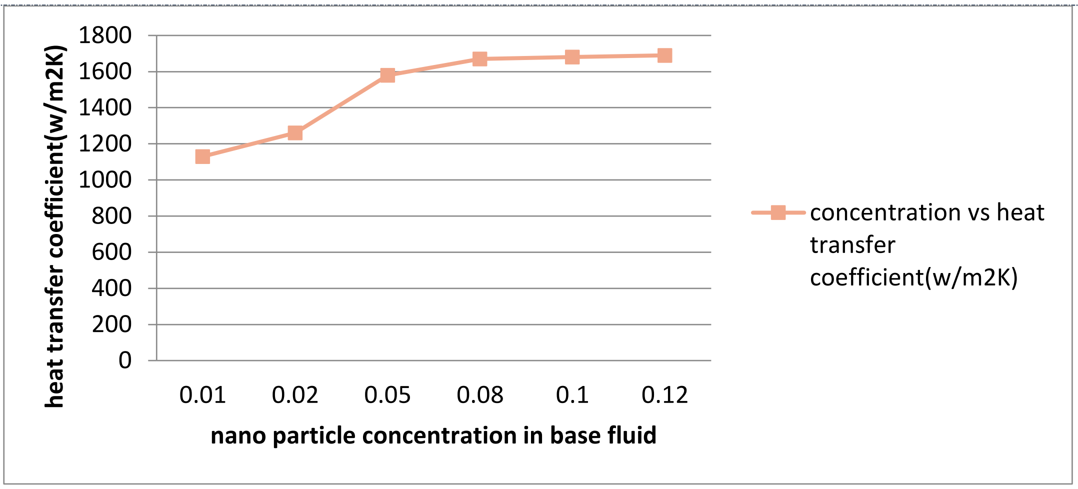
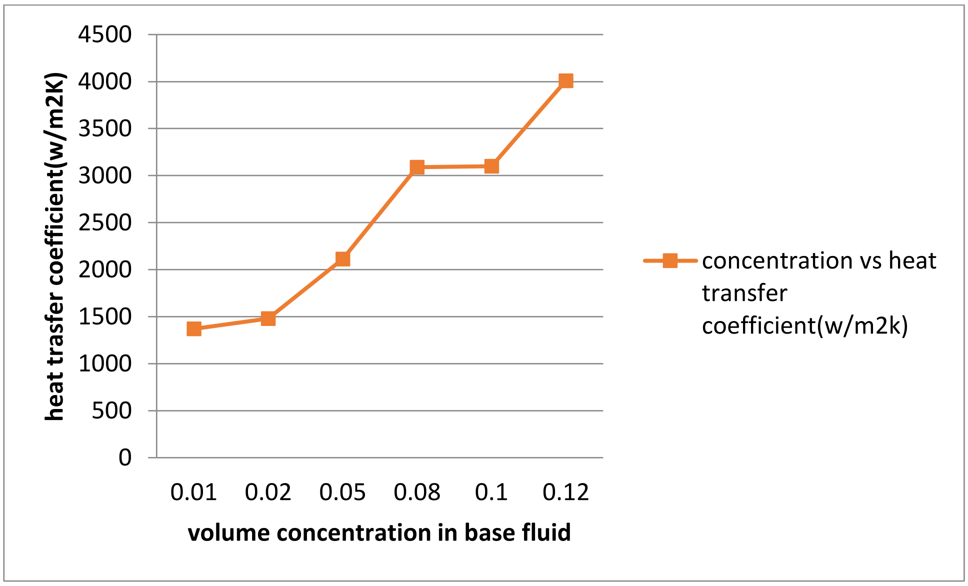


Graph 4 Heat transfer coefficient at different volume concentrations of AL_2O_3 nanofluid at 10 lpm
Graph 4 : From the above graph observed that the heat transfer coefficient enhanced from 4.7% to 28% for different volume concentrations at constant flow rate is 10LPM when compared with pure water. The Heat transfer coefficient value is in the range between 1130 W/m2K to 1690 W/m2K.



Graph 5: Heat transfer coefficient at different volume concentrations of AL_2O_3 nanofluid at 15 lpm
Graph 5: From the above graph observed that the heat transfer coefficient enhanced from 14% to 45% for different volume concentrations at constant flow rate is 15LPM when compared with pure water. The Heat transfer coefficient value is in the range between 1370 W/m2K to 4010 W/m2K.

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 markedly, which is unfavorable in heat transfer.

These higher heat transfer coefficients obtained by using nanofluid instead of water allow the working fluid in the automobile radiator to be cooler. The addition of nanoparticles to the water has the potential to improve automotive and heavy-duty engine cooling rates or equally causes to remove the engine heat with a reduced-size coolant system. Smaller coolant systems result in smaller and lighter radiators, which in turn benefit almost every aspect of car and truck performance and lead to increased fuel economy

CONCLUSION

The above experiment reveals that the increase in volume concentration (range 0.01%-0.12%) of AL_2O_3 nano particle in water+ethylene glycol basefluid(70:30) increases heat transfer coefficient and increase in flow rate(3-15LPM) also enhance thermal performance of base fluid. By the addition of 0.08% AL_2O_3 nano particle in base fluid the heat transfer coefficient enhances upto 45% when compared with pure water and ethylene glycol+ water base fluid.It seems that the increasing in the effective thermal conductivity and the variation of the other physical properties are not responsible to enhance heat transfer Brownian motion of nano particles may be enhance of the heat transfer.

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