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Heat Reduction FromIc Engine By Using Al_2o_3Nanofluid In Engine Cooling System

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***Abstract:* -**Cooling system plays important roles to control the temperature of car's engine. One of the important elements in the car cooling system is cooling fluid. The usage of wrong cooling fluid can give negatives impact to the car's engine and shorten engine life. An efficient cooling system can prevent engine from overheating and assists the vehicle running at its optimal performance. With the development of new technology in the fields of 'nano-materials' and 'nano-fluids', it seems very promising to use this technology as a coolant in the internal combustion engines. In this study, a nano-fluid (Al2O3-Water/Ethylene Glycol (EG)) is used as an engine coolant along with an optimized heat exchanger to reduce the warm-up timing. The effect of nano-fluid concentration is considered here by using their corresponding governing equations, such as momentum and energy. The engine coolant thermal behaviour calculation is carried out based on the lumped method. The obtained results indicated that using different percentage of nano-fluid mixtures (by volume), such as Al2O3-Water/EG as engine coolant enhances the heat transfer coefficient and reduces the warm-up timing which, in turn, results in reduced emissions and fuel consumption.

Keywords:* -Ethylene Glycol, Nanofluid, Aluminium Oxide, Internal Combustion Engine, Emission.*

I. INTRODUCTION

Conventional oils shows poor heat transfer characteristics compared to coolants and engine oil. It has been investigated that their performance can be increased by adding nanoparticles and these nanomaterial based oils have great potential to meet out the lubrication and cooling requirements of the given system. The concept of Nano fluid was proposed by Choi and his team by dispersing nanoparticle of higher thermal conductivity in to the base fluid [1]. Earlier investigations shows that dispersion of millimetre or micrometre size particles in to the base fluid which causes particle agglomeration and settling, block the channels in which such type of fluid are used. Moreover, their pumping power is increased and because of these problems with a mixture millimetre or micrometre based fluids was never been a good choice for heat transfer applications. Investigations on Nano fluids show that they have potential to overcome these problems. Main function of the Nano transformer oil is to avoid excessive heating caused by overloading conditions on transformer. It is required that in addition to good heat transfer properties transformer oil should have good electrical insulating property which insulate the primary winding from secondary winding. Agglomerations and settling of Nano fluids which is a major challenge to make stable Nano fluid can be avoided by using proper dispersing techniques and by adding surfactants which thereby help in improving the stability of nano-transformer oil. Few Studies have already been performed on oil based Nano fluids. Xie.H et al. [2] measured thermal conductivity of Nano fluids containing Al2O3, nanoparticles with two different base fluids: ethylene glycol and pump oil. Results showed a 30 % & 40 % improvement in the thermal conductivity as compared to the corresponding base fluids for 5 vol. % of nanoparticles and the size of the nanoparticles used with both the fluids is 60 nm.

Investigations are carried out by various researchers at different temperatures to see the effect on thermal conductivity of Nano transformer oil by using CuO, A12O3, Cu, Al nanoparticles of 45, 31, 80, 60 nm sizes respectively. Conductivity enhancement was found to be by 7.5, 6, 5, 3, and 4 % respectively [3]. Xie et al. [7] had also investigated the thermal conductivity of pump-oil by using A12O3 nanoparticles. The size of nanoparticle used was 60 nm and the conductivity enhancement was found to be 11 %. Xuan et al. [8] studied thermal conductivity of Cu and Transformer oil at 100 nm size and found a 6% enhancement in the thermal conductivity. A limited literature is available about viscosity of oil based Nano fluids. Therefore, our attempt is to see the performance of oil based Nano fluids. Reported research shows that water and ethylene glycol have been used widely as a host/ base fluids in making Nano fluids. The objective of this experimental study is to discuss the dependence of thermal conductivity and viscosity of Al2O3–nanotransformer oil in temperature ranges from (20-500 C) under different weight fractions of nanoparticles from 0.1, 0.3 & 0.5 % (vol.) in subsequent sections the preparation and characterization of Nano fluids along with results have been discussed in detail.

II. OBJECTIVES AND SCOPE OF WORK

The use of Nano fluids has the potential to improve the engine cooling rates. These improvements can be used to remove engine heat with a reduced size cooling system. Smaller cooling system lead to use of smaller and lighter radiators which in turn will lead to better performance and increased efficiency. Alternatively, improved cooling rates can be used to remove more heat from higher horsepower engines with same size of cooling system.

The IC engine temperature in an automobile is maintained by circulating a cooling fluid through the cooling circuit. Ethylene glycol and water mixture, the nearly universally used automotive coolant, is a relatively poor heat transfer fluid compared to water alone. Aim is mainly to maintain the coolant in single-phase throughout the cooling system. So engines with higher horsepower will lead to heavier and bigger cooling systems which may hamper the overall efficiency.

III. EXPERIMENTAL SETUP AND PROCEDURE

Nano Fluid Preparation

Nano fluid is a fluid in which Nano-meter sized particles are suspended.

- Argonne National Laboratory.

Nanoparticles are a class of materials that exhibit unique physical and chemical properties compared to those of larger physical and chemical properties compared to those of larger particles of same material. Experiments remain the primary source of information when complex flow situations such as multiphase flows, boiling or condensation are involved. The two-step method employs a two-step process to make Nano fluids in which Nanoparticles are first produced as a dry powder and the as-prepared Nanoparticles are then dispersed into a base fluid in a second processing step. A certain degree of agglomeration may occur in the Nanoparticle preparation, storage and dispersion processes, it is well known that these agglomerates require very little energy to break up into smaller constituents. And thus it is possible that even agglomerated Nanocrystalline powders can be successfully dispersed into fluids and result in good properties. This two-step process works well in many cases, especially for oxide and nonmetallic Nanoparticles.

In this experimentation a two step procedure was used for preparing the Nanofluid.A measured quantity of nanoparticle was taken. It was mixed thoroughly in the 50/50 water-ethylene glycol. Mechanical stirrer was used to mix it uniformly. It was kept in the sonicator and subjected to vibrations so as to reduce to problem of agglomeration. It Nanofluid was kept still for two days to check for sedimentation. Even after two days there was no appreciable sedimentation and the important fact is that the moment it was stirred again it turned into a uniform fluid with evenly suspended nanoparticles in it.

Block Diagram of Experimental Setup

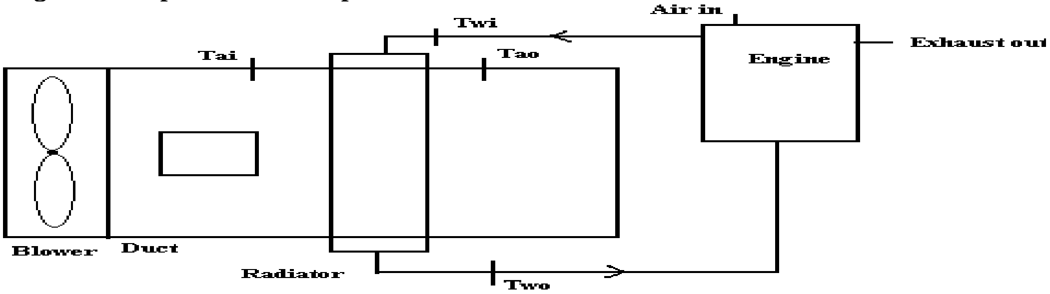


Figure-1

Specifications

The specification of the equipments used in the experiment are:

Engine	4-strock, 4-cylinder petrol engine	Thermocouple	4 in number of range 0-200 oC
Make	Maruti 800	Volume of coolant	3.5 litre
Radiator size	335mm x 300mm x 17mm	Dynamometer	Eddy current
Tube side area	330905.3mm^2	Dynamometer constant	2000
Fin side are	2310000mm^2	Nanoparticles	Al2O3 nano powder dispersible in water
Blower	Axial fan with 3 speeds	Purity	80 %
Duct	335mm x 300mm x 1500rpm	Water dispersibility	more than 95 %

System Assembly

- The apparatus is assembled following the schematic of the apparatus setup.
- The open circuit of the engine cooling system is converted to closed circuit by first disconnecting the calorimeter.
- The outlet those of the engine is connected to the inlet of the radiator and the outlet pipe of the radiator is connected to inlet of the coolant circulating pump of the engine.
- All the thermocouples are properly installed according to the apparatus set up and tested to be in good condition.
- One thermocouple gives the air temperature before the radiator and another gives the air temperature after the radiator. Similarly one thermocouple gives the water temperature entering the radiator and another gives the water temperature leaving the radiator.
- The blower is mounted on the duet and fixed properly. Electrical connections to the blowers are given.
- The radiator is mounted on the duct as per the schematic of experimental set up.

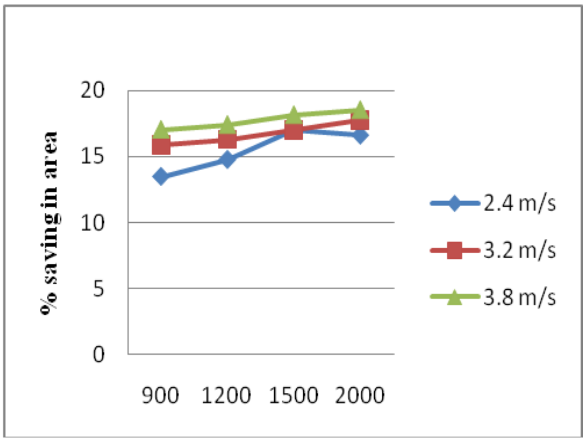
Sample Filling

- In all three coolants, viz water, 50/50, water-ethylene glycol mixture and Nanofluid are used.
- The required quantity of coolant is filled in the radiator.
- Precaution is taken to avoid any air pocket in the cooling system.
- After loading the coolant the radiator cap is to be closed tightly.
- Thereon, all the pipes, hoses etc are checked for leakages and problems, if any are resolved before proceeding with the experimentation.

IV. RESULTS AND DISCUSSIONS

At 20% Load

N	u m/s	Re	Nu	h	Area	Saving in area	%
900rpm	2.4	441.18	9.16	8.266	2.284	0.356	13.48
	3.2	590	10.94	99.65	2.221	0.419	15.87
1200rpm	2.4	439.9	9.14	83	2.25	0.39	14.77
	3.2	588.24	10.94	99.29	2.21	0.43	16.3
1500rpm	2.4	438.6	9.12	82.73	2.23	0.41	17.04
	3.2	586.25	10.9	98.91	2.19	0.45	17.04
2000rpm	2.4	437.34	9.11	82.44	2.21	0.43	16.3
	3.2	584.8	10.88	98.65	2.17	0.47	17.8



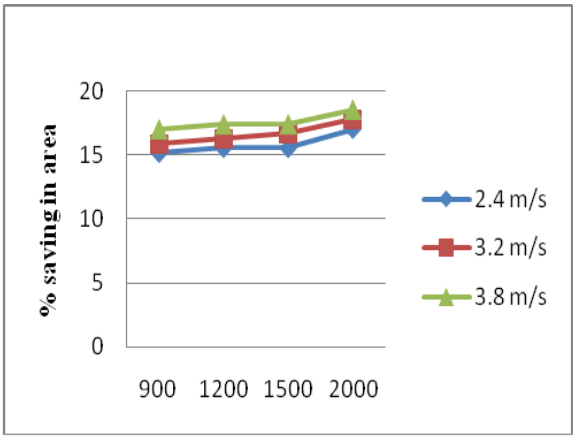


Figure 2: Speed vs % Saving in Area at 20% Load Figure 3: Speed vs % Saving in Area at 40% Load

There is an appreciable savings in surface area when Nanofluid is used instead of 50/50 water ethylene glycol mixture. When compared to 50/50 water ethylene glycol mixture, the % saving in area at higher speeds of the Nanofluid is considerably more.

V. CONCLUSIONS

- A savings of 12-18 % of surface area can be seen by use of Nanofluids.
- As the load on the engine and the speed of the engine increases the percentage savings of surface area also increases.
- The thermal conductivity of Nanofluid is temperature dependent. As the temperature increases at higher load and speeds the heat carrying capacity of Nanofluids increases. This is advantageous when engine is running at high speed and load.
- At higher air velocity the % savings in surface area is more.It means that at higher vehicle speed the use of Nanofluid has a lot of advantage.
- The use of Nanofluid makes it possible to design the system with higher power- size ratio.
- With increase in air velocity the dimensionless numbers and heat transfer coefficient increases.
- For the same air velocity, the dimensionless numbers and the heat transfer coefficient go on decreasing with increase in load and speed of engine.
- The heat carrying capacity of Nanofluids as compared to 50/50 water-ethylene mixture is more but relatively less compared to water alone.
- The surface area required for the given amount of heat to be transferred is less when Nanofluid is used as a coolant in comparison to the 50/50 water-ethylene glycol mixture but when compared to water the surface area required is more.As the surface area required in case of Nanofluid is less, the volume occupied by the cooling system also reduces.
- It is seen that the heat carrying capacity of the Nanofluid increases with increase in engine speed. This is advantageous particularly when the engine is running at high speed and more heat is to be rejected out. The use of Nanofluid helps to use a smaller cooling system.
- To increase the boiling point, normally the entire cooling system is maintained at positive pressure. Use of Nanofluids allows the cooling system to be operated at atmospheric pressures and the advantages associated with it.
- The weight of the heat transfer equipment and the entire cooling system as such will be reduced when Nanofluid is used as coolant.
- As less coolant is needed to be circulated, due to the enhanced heat carrying capacity of the Nanofluid, the pumping power required will also be reduced.
- In case of vehicles, the reduced weight, reduced volume, reduced pumping power, will eventually increase the engine efficiency.
- When the radiator size, volume and weight is reduced, it will reduce the drag force experienced by the frontal area of the vehicle.
- All these factors give the designers additional versatility from the ergonomic and aesthetic point of views when designing the vehicle.
- Reduction in size or the simplification in designing the cooling system decreases the manufacturing and also the maintenance cost of the cooling system equipments.
- It was also seen that the metallic Nanoparticles in the coolant helped to warm-up the engine quickly when started from cold condition.

VI. FUTURE SCOPE

Studying the Nanofluids to validate their properties from theoretical point of view is fine but the focus should beto to try to extract whatever advantage can be had by their use. It will be worthwhile to workout with various permutationsand combinations of the Nanoparticles and base fluids which might help to develop the science related to Nanofluid.

Many glycol based coolant base have merits but there are a few out there in the market that are more aboutmarketing than science. New fanciful coolants such as 50/50 mixture of water ethylene glycol are good regions heretemperature below 0oC. But as we can understand, other than a few northern states, in most part of India atmospherictemperature rarely goes below 0oC. So with addition of corrosion inhibitors it will be quite beneficial to go for water to beused in the cooling system. So it becomes important to study the behavioral characteristics of the water based Nanofluidsmore extensively

VII. CHALLENGES AND BARRIERS

By using the Nanofluids the general trends for an enhanced heat transfer were observed but also areas of discrepancies do exist. The inaccuracies encountered are mainly due to poor characterization of Nanofluids which are experimented upon. It is difficult to measure and quantify the size, shape and distribution of Nanoparticles in fluids. Viscosity measurement of Nanofluids could be a important parameter which will be helpful when comparing Nanofluid results. A major apprehension while using any particle laden flow is the effect of erosion of the material surfaces due to the fluid motion. The Nanoscale of the particles involved in Nanofluidstend to mitigate the particle erosion problems. Also Nanoparticles tend to follow the fluid streamlines better than larger particles in flows.

Nanofluids have been mainly produced in small quantities. This is adequate for research work, but large scale production of well dispersed Nanofluids at low cost is required for commercial applications. This is a serious barrier for use of Nanofluids in cooling system of vehicles.

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