Investigation of cooling performance of automobile radiator with water based TiO_2nano-fluid

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Abstract- **The cooling system of car plays vital role in the performance of the engine consisting of mainly two parts fan and radiator. Radiators are compact heat exchangers optimized and evaluated by considering different working conditions hence, they can be designed and modified according to requirement . However, the following study only focuses on the performance evaluation of a particular nanofluid in a automobile radaiator . The current thesis is divided into two main sections , the first part consists of the analysis of the thermal conductivity of nanofluid and the performance of forced convective heat transfer of nanofluids. For the evaluation of thermo-physical properties, different nanofluids are tested , such as TiO2 and SiO2 with volume concentrations from 0.1%,0.3%,0.5% all of them dispersed in distilled water. The results are compared with the research paper referred for reference for validation or comparison.**

Keywords-**Radiator, TiO2 nanofluid , Thermo-physical properties , Heat transfer , Enhancement**

I. INTRODUCTION

In the past few years the world has recognized immense potential in nanotechnology which has proved its importance in automobile , computer & hardware and also in medical engineering. Nanotechnology in automobile or mechanical engineering relates to the use of nanofluids in the cooling systems and also as lubricants. It has also proved its importance in the refrigeration chambers , electronic cooling systems, data centresamd power electronics.

Just talking about the cooling systems initially water and ethylene glycol were used as coolants that would circulate in and out of the system and hence transfer heat and regulate temperature through circulation but the performance is limited regarding transfer capabilities . So nowadays, using the recent technologies the new coolants have emerged named as nano-coolants. These nano-coolants are in fact the colloidal suspensions of nano-particless(sized between 1-100nm) and the base fluids which may normally include water or ethylene glycol. Another possible way of enhancing the heat transfer is by increasing the exchange rate i.e. by increasing heat transfer area which also proves ineffective where space constraint comes into existemce (for ex. Car engine cooling system, refrigeration or air –conditioning chambers). In such cases, use of nano-fluids becomes effective in improving the efficiency of the system.Nano-Hex project is a project that KTH-Energy Technology is one of its partner and this project focus on important research about nanofluids, as is the world's largest collaborative project for development and research of nano-fluid coolants. It is expected to develop and optimize safe processes for the production of high performance nanofluids coolants for use in industrial heat management. It will be done by developing an analytical model that can20accurately predict thermal performance (thermo-physical properties and behavior in industrial applications) of such nanofluidsrefrigerants .Nanofluids was first defined by Choi in 1995 while worhing on a research project at Argonne National Laboratory.

According to bibliography, he defined it as "an innovative new class of heat transfer fluids that can be engineered by suspending nanoparticles in conventional heat transfer fluids" which are able to enhance the thermal conductivity of the base fluids. Hence it can be understood that nano-fluids are made up of two parts: nanoparticles and base fluids.

However, as stabilization of the dilution is a relevant aspect to get trustable results, sometimes additives such as dispersants are added to avoid sedimentation of particles. Standard preparation techniques assure theelliminatin of agglomeration and sedimentation. Also various facets of these fluids are analysed for ex. Effect on heat transfer on varying the volume concentration from 0.1%,0.3%,0.5% and also varying the flow rates from 3L/min,4L/min,5L/min.

Gap in the thermal conductivity occurs due to the huge thermal conductivities of metallic or non-metallic solids which turns out to be hundred times or even thousand times than the normal base fluid. For ex. Thermal conductivity of copper is about 700 times more than that of water.

II. LITERATURE SURVEY

Nor AzwadiCheSidik et al.[1] studied various experimental projects carried out regarding various nanofluids and the recent technological advancements of nanofluids in engine cooling system. He studied the works of Vajja et al., Eastman et al. , Liu et al. and derived the summary regarding various use of naofluids as coolants in automobile system their preparation methods, their influence on the efficiency of the system , various stabilizing agents and also respective thermal conductivities of various nanofluids. The research paper helped in recognizing the performance of each nanofluid including the accurate experimental results that can be used for further experimental validation.

Alhassan S. Tijani et al.[2] conducted research work with a goal to replace conventional coolants in radiators . For that he used Al2O3/CuO based nanofluid with water and ethylene glycol as basefluid . He conducted his experimental work to determine the thermos-physical properties and heat transfer characteristics of the used nanofluid. He also simulated the model using ANSYS Fluent software. The heat transfer characteristics were measured in terms of thermal conductivity , heat transfer coefficient ,Nusselt number and rate of heat transfer.Density plays a very important role in determining the thermo-physicalbehaviour of nanofluids due to its influence on Reynolds number, Nusselt number and thermal diffusivity. As described in the paper the lowest thermal conductivityof the coolant is at 0.415 W/m K for the base fluid which is in fact conventionally used and thehighest thermal conductivity observed is at 1.287 W/m K for 0.3%concentration of Al2O3 nanofluid. The nanofluids have a tremendous increase in thermalconductivity as compared with the base fluid and this is expectedto increase heat transfer enhancement in the radiator. As the concentrationof nanoparticles added to the nanofluid increases from0.05% to 0.3%, the thermal conductivity for both nanofluidsincreases as well. Comparing both nanofluids,CuOnanofluid hadlower thermal conductivity than that of Al2O3, with thermal conductivityof 1.241 W/m K and 1.287 W/m K for CuO and Al2O3nanofluidrespectively.

DevireddySandhya et al.[3] conducted work for improving the performance of radiator with ethylene glycol water based TiO2 nanofluids . The paper focuses on measuring the overall heat transfer coefficient of the two working fluids that include 40:60% EG/W and 40:60% EG/W and mixed with TiO2 nanofluid which when worked experimentally is found that the presence of TiO2 enhances the heat transfer rate. They varied various concentrations of the nanofluid to research optimum condition for obtaining the maximum performance of the radiator. It was found that at 0.5% concentration the heat transfer rate is enhanced to about 35% of the normal base fluid . The paper also concludes that on the increasing the flow rate of nanofluids through the radiator tubes increases the heat transfer coefficient.

Siraj Ali Ahmed et al.[4] too carried out work on use of nanofluids in radiator which too gives brief idea about the use of TiO2 nanofluid in radiator and helps us in reducing the focus of our work to the use of TiO2. The team concluded that overall heat transfer coefficient of TiO2 nanofluid can be experimentally used for measuring as a function of concentration and temperature. The paper concludes heat transfer coefficient improves for 0.2% nanoparticle concentration as compared to pure water which happens due to TiO2’s grater thermal conductivity, aspect ratio, lower specific gravity, thermal resistance and thermal resistance, geometry of particles and larger specific area as to compared to pure water.

K. Goudarzi et al.[5] carried out same experimental work using Al2O3-EG nanofluid in radiator with wire coil inserts. Experimental studies of heat transfer , friction factor and thermal performance of the car radiator have been studied with wire coil inserts and different concentrations of the Al2O3 nanofluids are experimentally.

Adnan M. Hussain et al.[6] studied the forced convection heat transfer enhancement by TiO2 and SiO2 suspended in water as a base fluid inside the flat copper tubes of an automotive cooling system . Maximum Nusselt number enhancements of up to 11% and 22.5% were obtained for TiO2 and SiO2 nanoparticles, respectively, in water. The experimental results showed that the Nusselt number behaviors of the nanofluids highly depended on the volume flow rate, inlet temperature and nanofluid volume concentration. The results showed that the SiO2 nanofluid produces a higher heat transfer enhancement than the TiO2 nanofluid; likewise, TiO2 nanofluid enhanced heat transfer more than pure water. The results also proved that TiO2 and SiO2 nanofluid have a high potential for heat transfer enhancement and are highly appropriate for industrial and practical applications. The study succeeded in analyzing the importance of nanofluid which in fact proves to be beneficial in many of the other industrial application.

A. *SETUP:*

The main aim is to study the effect of cooling system of radiator in car hence a theoretical model similar to that of the system is prepared which includes heater to heat the water which works as a coolant . the setup includes radiator cross-flow type, thermocouples , flow control valves , reflux lines, fan , feed pump, power source. Initially the coolant inlet temperature to the radiator is set at a desire value by means of a heater in the water tank. A reflux line connected to a valve is used to adjust the flow rate. As the hot coolant passes through the radiator flat tube, induced air is blown across it, the result is that, the coolant is cooled to a desire temperature. The cooled fluid is sent back to the water tank and the process can be repeated for different flow rates. The fins attached to the radiator flat tubes are used to increase the surface area of the heat exchange and this increases the cooling effect.

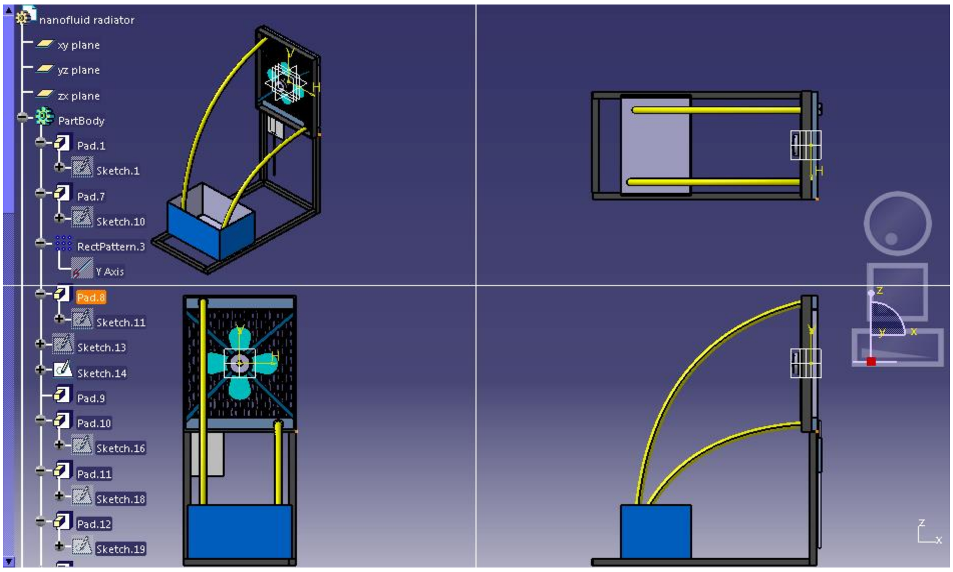

Fig. 1 CAD model of setup

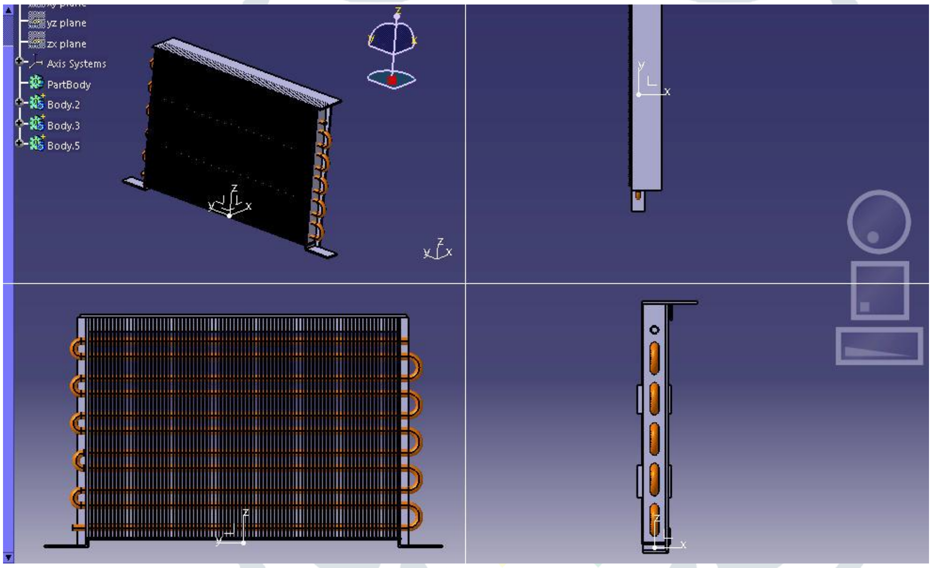

Fig 2. CAD model of radiator

B. *PREPARATION OF NANO-FLUID:*

One step method:

In this method the produce powder Nano particles is disperse directly in base fluid. This technique consist the direct evaporation. In this method, the Nano fluids are prepared by solidification phenomenon. This method is not suitable for mass production and thus not economical, not used commonly.

Two step Method:

In this method the Nano particle, Nano fibers are first produced in dry powder form by chemical or physical methods. After that it disperse with base fluids with magnetic, ultrasonic agitation high shear mixing, homogenizing, and ball milling. This method is most simple method for producing Nano fluid .so it can be used widely and for mass production it can be significantly used.

III. CONCLUSIONS

This paper recognizes the immense potential of the use of nanofluids in cooling system which turns out to be remarkably effective in improving the thermo-physical properties of coolants used in cooling system. It is found that the introduction of nano-fluids in base fluids like water improves the performance by increasing the heat transfer coefficient. The thermal conductivity increases as compared with water or ethylene glycol. The overall heat transfer rate increases to nearly 35% of the base fluid. Hence , we conclude that adding of nanofluids in conventional coolants will truly be fruitful in nearer future and has immense scope where engine design is constrained with space. Use of TiO2 is efficient considering the cost, availability and response provided by it.

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