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Heat Analysis of Radiator Using Nano Fluid

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ABSTRACT

Nanofluids are good replacements for cooling fluid in radiators and thermal exchangers. Materials with higher thermal properties 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 investigated by using nanofluids. Results of the research indicated that the used nanofluid can increase heat transfer up to 50%. Reduction in size and weight of the radiators are among the achievements of this research. In addition to reducing the production cost, better designation of cars are possible when the radiator becomes smaller in size. Nanofluids are produced by stable dispersing of nanoparticles in heat transfer fluids that are usually water or ethylene glycol. In this research, a system similar to car radiator cooling system has been designed and produced.

Keywords: Nanofluids, Car Radiator, Magnetic Stirrer.

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I. INTRODUCTION

Convectional heat transfer fluids such as water, minerals oil and ethylene glycol play an important role in many industrial sectors including power generation, chemical production, air-conditioning, transportation and microelectronics. Although various techniques have been applied to enhance their heat transfer capabilities, their performance is often limited by their low thermal conductivities which obstruct the performance enhancement and compactness of heat exchangers. With the rising demand of modern technology for process intensification and device miniaturization, there was a need to develop new types of fluids that are more effective in terms of heat exchange performance. To achieve this, it has been recently proposed to disperse small amounts of nanometer-sized (10–50 nm) solid particles (nanoparticles) in base fluids, resulting in what is commonly known as nanofluids. The term nanofluid was coined by Choi who was working with the group at the Argonne National Laboratory (ANL), USA, in 1995. The nanoparticles used are ultrafine; therefore, nanofluids appear to behave more like a single-phase fluid than a solid–liquid mixture. The commonly used materials for nanoparticles are metals (Al, Cu, Ag, Au, Fe), nonmetals (graphite, carbon nanotubes), oxides ceramics (Al2O3, cuo, tio2, sio2), carbides (sic), nitrides (ain, sin), layered (Al+ Al2O3, Cu+C), PCM and functionalized nanoparticles. The base fluid is usually a conductive fluid, such as water (or other coolants), oil (and other lubricants), polymer solutions, bio-fluids and other common fluids, such as paraffin. Investigations have shown that nanofluids possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity and Convective heat transfer coefficients compared to those of base fluids like oil or water. In recent years, heat transfer has received many engineering applications such as heat exchanger, piping system, solar collectors and electric conductors. Some of these applications depend on natural convection for heat transfer mechanism, while others depend on forced convection for heat removal in the systems. However, it is quite evident that appropriate convective heat transfer fluids are necessary. The use of nanofluids as coolants would allow for smaller sized and better positioning of the radiators. Owing to the fact that there would be less fluid due to the higher efficiency, coolant pumps could be shrunk and truck engines could be operated at higher temperatures allowing for more horsepower while still meeting stringent emission standards. Future engines designed using nanofluids cooling properties will run at more optimal temperatures allowing for increased power output. With a nanofluid engine, components would be smaller and weigh less allowing for less fuel consumption, saving consumers money and resulting in fewer emissions for a cleaner environment. Singh et al., researchers at argonne national laboratory assessing the applications of nanofluids for transportation, determined that the use of high-thermal conductive nanofluids in radiators can lead to a reduction in the frontal area of the radiator by up to 10 %. This new aerodynamic automotive design which minimizes the aerodynamics drag not only leads to fuel saving of up to 5 % but also reduces emissions as well. The use of nanofluid also leads to a reduction of friction and wear, reducing parasitic losses, operation of components such as pumps and compressors and hence more than 6 % fuel savings. It can be concluded that the use of nanofluids will enhance the efficiency and economic performance of car engines, as well as greatly influence the structural design of automotives, such as smaller and lighter engine radiators cooled by a nanofluids which can be placed elsewhere in the vehicle as Opposed to the front of the car. By reducing the size and repositioning the radiator, a reduction in weight and wind resistance could enable greater fuel efficiency and subsequently lower exhaust emissions.

A specific component for heat transfer mechanism in automobile engine block is the radiator. It is a form of heat exchanger used for cooling the internal combustion engines, mainly in automobiles and in piston engine of aircrafts, locomotives (trains), motorcycles and stationary generating plants. It circulates liquid through the engine block where it is heated, then pumped through the radiator where it loses heat to the atmosphere via fins and lastly returns to the engine block. In this regard, there is a need to improve the technical parts of a car engine to attain high efficiency, to achieve optimal fuel consumption, to increase working life and to reduce pollution. Reducing the weight of a car with optimal design of its radiator is a necessity. Adding fins and fan is one way to increase the rate of cooling in automobile radiators in which a larger surface area for heat transfer is created and air convection is utilized to enhance heat transfer. However, with the advent of nanofluids, the rate of heat transfer in radiators can be improved by the employment of a coolant fluid with enhanced thermal conductivity. The most commonly used coolant fluids are water or ethylene glycol whose thermal conductivity coefficient is very low. However, as earlier pointed out, their heat transfer performance is often limited by their low thermal conductivities which obstruct the performance enhancement and compactness of heat exchangers. Wang and Mujumdar investigated heat transfer characteristics of nanofluids and recommended further research on the main parameters affecting their heat transfer properties. Das et al. Investigated utilization of nanofluids in heat exchangers and

Realized a significant possibility for use in cooling and related technologies. Thermal conductivity of metallic liquids is much greater than that of non-metallic liquids. It is then expected that the thermal conductivities of the fluids with metallic nanoparticles should be significantly higher. Nguyen et used Al2O3/water nanofluids in cooling system of electrical devices and they observed a lot of improvement of heat transfer coefficients for a low level volume fraction of nanoparticles. Leong et al. Investigated the performance of ethylene glycol/copper nanofluids and reported an enhanced heat transfer rate. Research undertaken by [has shown that dispersing nanoparticles of copper (Cu), copper oxide (cuo), aluminium oxide (Al2O3), titanium oxide (tio2) lead to an anomalously increased thermal physical properties of ethylene glycol-based nanofluids.

On the other hand, magneto hydrodynamic (MHD) boundary layer flow of an electrically conducting viscous fluid with a convective surface boundary condition is frequently encountered in many industrial and technological applications such as extrusion of plastics in the manufacture of Rayon and Nylon, the cooling of reactors, purification of crude oil, textile industry, polymer technology, and metallurgy. According to Mutuku and Makinde, nanofluids are highly susceptible to the effects of magnetic field compared to conventional base fluid due to the complex interaction of the electrical conductivity of nanoparticles with that of base fluid.

Despite nanofluids' copious applications with regard to heat transfer, it is evident from the literature herein that limited research has focused on the comparison of the heat transfer enhancement to base fluids due to the presence of different nanoparticles. Also, it is evident that most studies considered water as the base fluid. The motivation of the current study is thus to investigate the thermal performance of nanofluids coolant in a car radiator using ethylene glycol (EG) as a base fluid and employing three nanoparticles: Al2O3, tio2, and cuo. EG is an organic liquid of low viscosity and low volatility, which is completely miscible with water, thus it can be used as a base fluid on its own or mixed with water to form EG–water base fluid.

II. INTRODUCTION TO NANO FLUIDS

Heat exchanger using nano fluid is a device in which the heat transfer takes place by using Nano fluid. In this the working fluid is nano fluid. Nano fluid is made by the suspending nano particles in the fluid like water, ethylene glycol and oil, hydrocarbons, fluorocarbons etc. Nano fluid, first suggested by S.U.S. Choi of Argonne National Lab in 1995, innovative working fluid for heat transfer created by dispersing highly thermal conducting solid particles smaller than 50 nanometers in diameter in traditional low thermal conducting heat transfer fluids such as water, engine oil, and ethylene glycol.

Why we use nano fluid

The main goal or idea of using nano fluids is to attain highest possible thermal properties at the smallest possible concentrations (preferably<1% by volume) by uniform dispersion and stable suspension of nano particles (preferably <10 nm) in hot fluids. A nano fluid is a mixture of water and suspended metallic nano particles. Since the thermal conductivity of metallic solids are typically orders of magnitude higher than that of fluids it is expected that a solid/fluid mixture will have higher effective thermal conductivity compared to the base fluid.

III. PROBLEM STATEMENT

Behaviour of nanofluids and modeling during radiator is still in the early stages of development and therefore has not been fully investigated. Research is needed to advance nanotechnology and to determine heat transfer applications in radiator for nanoparticles/nanofluids. Research will help to understand the relationship of nanofluids and heat transfer rates at various operational conditions. Experiments will also help to understand the relationship of deposition of nanoparticles and its effect on heat transfer rates. The research being conducted in this study to analyses the behavior of cuo nanofluids at different concentrations, temperatures, and at different flow rates Experiments are carried out for One nanofluids in Radiator. The purpose of this project is to determine the effect nanoparticles have on heat transfer rates along with the effect deposition has on heat transfer rates using nano fluids at different concentrations, different flow rates, and at different temperatures.

IV. OBJECTIVES AND SCOPE OF WORK

An engine coolant is mixture of ethylene glycol and water in various ratios like 30:70, 40:60 and 50:50 respectively are mostly used in auto-mobiles. Water and ethylene glycol as conventional coolants have been widely used in an automotive car radiator for many years. These heat transfer fluids offer low thermal conductivity. An innovative way of improving the heat transfer performance of common fluids is to suspend various types of small solid particles (metallic, nonmetallic and polymeric particles) in conventional fluids to form colloidal. Therefore certain alternative engine coolant are required to be used which will reduce the problem associated with suspended particles also it will improve the heat transfer rates, improve engine efficiency and reduce the size of the radiator. The nanofluids project will help to reduce the size and weight of the vehicle cooling systems by greater than 10% despite the cooling demands of higher power engines. Nanofluids can help to enable the potential to allow higher temperature coolants and higher heat rejection in the automotive engines. It is estimated that a higher temperature radiator could reduce the radiator size approximately by 30%. This translates into reduced aerodynamic drag and fluid pumping and fan requirements, leading to perhaps a 10% fuel savings. It is interesting idea in these years which humans involved in the energy and fuel shortage crisis.

V. METHODOLOGY AND PROCEDURE

The test rig in Fig. Has to use to measure heat transfer coefficient and friction factor in the automotive engine radiator. This experimental setup includes a reservoir plastic tank, electrical heater, a centrifugal pump, a flow meter, tubes, valves, a fan, a DC power supply; Digital thermocouples type K for temperature measurement heat exchanger (Radiator). An electrical heater (2000W) inside a plastic storage tank (40cm height and 30 cm diameter) put to represent the engine and to heat the fluid. A voltage regular (0–220 V) provided the power to keep the inlet temperature to the radiator from 60 to 80 C. A flow meter (0–30 LPM) and two valves have to use measure and control the flow rate. The fluid flows through plastic tubes (0.5in.) By a centrifugal pump (0.5hp) from the tank to the radiator at the flow rate range 2–8 LPM. The total volume of the circulating fluid will be 30 and constant in all the experimental steps .Two thermocouples (copper–constantan) types K have to fix on the flow line for recording the inlet and outlet fluid temperatures. Digital thermocouples type K has to fix to the radiator surface to ensure more of surface area measurement. Two thermocouples type K also fix in front of the fan and another side of radiator to measure air temperatures. A hand held (-40 C to1000 C) digital thermometer with the accuracy will use to read all the temperatures from thermocouples. Calibration of thermocouples and thermometers carried out by using a constant temperature water bath and their accuracy estimation should be 0.15 C

SCHEMATIC OF EXPERIMENTAL SET UP

The car radiator has louvered fin and 32 flat vertical Aluminium tubes with flat cross sectional area. The distances among the tube rows filled with thin perpendicular Aluminium fins. For the air side, an axial force fan (1500rpm) installed close on axis line of the radiator .The DC power supply Adaptor convert AC to DC. For heating the working fluid an electric heater of capacity 2000 watt and controller were used to maintain the temperature 40o-80oc.Two K type thermocouples have to implement on the flow line to record the radiator inlet and outlet temperature. Two thermocouples K types have to install in the radiator to measure the wall temperature of the radiator

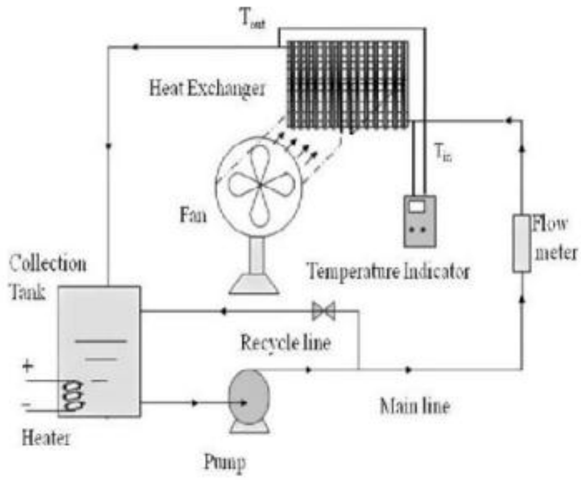

Figure 1: Experimental Setup

VI. LITERATURE REVIEW

Shuichi Tori: Investigated convective heat transfer coefficient of diamond based nanofluid by using heat tube apparatus. Specification of tube is 4.3mm, 4mm outer and inner diameter respectively, and applied 100W power uniformly. They are showed the heat transfer coefficient is increases with increasing concentration and Reynolds numbertofn Nano fluid, but at the same time increased the pressure drop with increasing concentration of nano particle.

S.J Kim et al: Investigated formation of porous layer and wet ability of nanofluid using critical heat flux experiment and SEM images. They are used three different types of nanoparticles with different diameters such as Al2O3 (110-220nm) sio2 (20-40nm) Zno (110-210nm). They are showed boiling is main factor to affect the heat transfer rate of nanofluid. Due to nucleate boiling nanoparticle deposited on wall, so the porous layer is formed on the wall. Porous layer directly consequence for creating wettability, cavity and roughness of surface wall. So heat transfer rate decreased due to boiling of nanofluid.

L.B mapaet al: Measured enhanced thermal conductivity of Cu- Water based Nano fluid using a shell and tube heat exchanger. Where the dimensions of heat exchanger is 240X24X0.25mm, using 37 tubes. The outcome of analysis is rate of heat transfer is increases with increasing flow rate and also its concentration. By nanoparticle dispersed into de-ionized base fluid a better enhancement is achieved.

Paisam Naphon et al: Investigated the thermal efficiency of heat pipe using titanium –alcohol Nanofluid, heat pipe dimensions are 60mm and 15mm length and outer diameter respectively. The Thermal efficiency increases with increasing tilt angle within 600 angle and concentration of nanoparticle

Anilkumar et al: Studied the heat transfer enhancement of fin, using Al2o3- water nano fluid analyzed using CFD. Rayleigh number increases due to Brownian motion, ballistic phonon transport, and clustering and dispersion effect of nanoparticle. At high Rayleigh number flow rate at center circulation is increasing, so temperature is drop from center of fin. Volume of the circulation increases the velocity at center is increases as the result of increasing the solid fluid heat transportation. Low aspect ratio fin is suitable for heat transfer enhancement, because heat affected zone is less.

J.Koo et al: Investigated the nano particle collision and deposition in the surface wall with the help of micro channel heat sink. Which has the dimension of 1cm X 100micrometerx300micrometer; water-Cu and Cu-ethylene nanofluid are through micro channel heat sink. They are investigated the base fluid should possess high prandtle number and get enhanced heat transfer rate by minimize particle, particle-wall collision. Viscous dissipation is important of narrow channel because Nusselt number high for high aspect ratio.

Shung-Wen Kang et al: Studied about the relation between thermal resistance- size of nanoparticle with the help of 211 micrometer X 2187 micrometer sized and deep grooved circular pipe and heat pipe maintain 40 temperature. They are finalized thermal resistance is directly proportional to the size of the nanoparticle. Maximum reduction of the thermal resistance by using 10nm sized particle. Because particle size is increasing the wall temperature also increases. So small sized particle suitable for enhanced heat transfer rate. Thermal resistance is decreases with the increasing heat and concentration of nanoparticles.

Yu-Tung Chen: Investigated the thermal resistance of heat pipe using Al2O3 water nanofluid, heat pipe made as 200cmx3mm length and thickness respectively. Heat resistance is increases with increasing concentration of nano fluid up to 50ppm. Due to wet ability of nanoparticle various geometry wick is created on heat pipe.

Eed Abdel Hafez Abdel-hadi et al: Investigate the heat transfer analysis of vapour compression system using Cuo-R134a Nano fluid, test section made of copper horizontal tube and heat is applied10-40 Kw/m Heat flux concentration and size particle is important factor to enhance the heat transfer rate of nanofluid. Heat transfer rate increases with increasing heat flux, up to 55% of concentration of nanofluid and upto2.5nm sized particles.

EXTENSIVE LITERATURE REVIEW

Practical applications of nano fluids: Discussed above are decided by the thermo physical characteristics of nano fluids. In the last decade, significant Amounts of experimental as well as theoretical research were done to investigate the thermo physical behavior of nano fluids. Initial work on nano fluids was focused on thermal conductivity. Measurements as a function of concentration, temperature, and particle size. Measurements of the thermal conductivity of nano fluids started with oxide nano particle (Masuda et al.5.6, 1993; Lee et al.5.3, 1999) using transient hot wire (THW) method.

Effect of particle material: Most of the studies show that particle material is an important parameter that affects the thermal conductivity of nano fluids. For example, Lee et al. 5.3 (1999) considered the thermal conductivity of nano fluids with Al2O3 and cuo nano particle. They found that nano fluid with cuo nano particle showed better enhancement compared to the nano fluids prepared by suspending Al2O3 nano particle in the same base fluid. Authors explain this behavior as due to the formation clusters of cuo nano of particle in the fluid.

Effect base fluid:

According to the conventional effective medium theory (Maxwell.5.9,.1873), as the base fluid thermal conductivity decreases, the effective thermal conductivity of a nano fluid increases. Most of the experimental reports agree with the theoretical values given by this conventional mean field model. As per Wang et al.5.10 (1999) results on the thermal conductivity of suspensions of Al2O3 and cuo nano particle in several base fluids such as water, ethylene glycol, vacuum pump oil and

Engine oil, the highest thermal conductivity ratio was observed when ethylene glycol was used as the base fluid. EG has comparatively low thermal conductivity compared to other base fluids. Engine oil showed somewhat lower thermal conductivity ratios than Ethylene Glycol. Water and pump oil showed even smaller ratios respectively. However, cuo/EG as well as cuo/water nano fluids showed exactly same thermal conductivity enhancements at the same volume fraction of the nano particle.

Effect of particle volume fraction: Particle volume fraction is a parameter that has been investigated in almost all of the experimental studies and most of the results are generally in agreement qualitatively. Most of the research reports show an increase in thermal conductivity with an increase in particle volume fraction and the relation found is, in general, linear. There are many studies in literature on the Masuda et al.5.6 (1993) measured the thermal conductivity of water based nano fluids consisting of Al2O3 (13nm), sio2 (12nm) and tio2 (27nm) nano particle, the numbers in the parenthesis indicating the average diameter of the suspended nano particle. An enhancement up to 32.4% was observed in the effective thermal conductivity of nano fluids for a volume fraction about 4.3% of Al2O3 nano particle. Lee et al.5.3 (1999) studied the room temperature thermal conductivity of water as well as ethylene glycol (EG) based nano fluids consisting of Al2O3 (38.5nm) and cuo (23.6nm) nano particle. In this study a high enhancement of about 20 % in the thermal conductivity was observed for 4% volume fraction of cuo in cuo/EG nano fluid. Later Wang et al.5.10 (1999) repeated the measurement on the same type of nano fluids based on EG and water with Al2O3 (28nm) as well as cuo (23nm) as inclusions. The measurements carried out by these groups showed that for water and ethylene glycol-based nano fluids, thermal

Conductivity ratio showed a linear relationship with particle volume fraction and the lines representing this relation were found to be coincident. Effect of particle volume fraction on the thermal conductivity of nano fluids.

Effect of particle size: The advent of nano fluids offers the processing of nano particle of various sizes in the range of 5-500 nm. It has been found that the particle sizes of nano particle have a significant role in deciding the effective thermal conductivity of nano fluids. There are many studies reported in literature

Regarding the dependence of nano particle size on effective thermal conductivity of nano fluids. Chopkar et al.5.11 (2006) studied the effect of the size of dispersed nano particle for Al70Cu30 /EG nano fluids by varying the size of Al70Cu30 nano particle in the range from 9 nm to 83 nm. In another study on water and EG based nano fluids consisting of Al2Cu and Ag2Al nano particle, Chopkar et al.5.11 (2008) also investigated the effect of particle size on effective thermal conductivity of nano fluids. In all these cases it has been found that the effective thermal conductivity of a nano fluid increases with decreasing nano particle size. Also, the results of Eastman et al5.3. (2001) and Lee et al.5.3 (1999) support this conclusion drawn by Chopkar et al. 5.11. (2008) on the particle size effect on the effective thermal conductivity of nano fluids. In another study of the effect of particle size on the thermal conductivity of nano fluids, reported by Beck et al. (2009) in water as well as EG based nano fluids consisting of Al2O3nano particle, the normalized thermal conductivity of nano fluids vary in such a way that it decreases with decreasing the size. Thus conflicting reports have appeared in literature on the dependence of particle size on the thermal conductivity of nano fluids.

Effect of particle shape: For experimentation, spherical as well as cylindrical shaped nano particle are commonly used for nano fluid synthesis. The cylindrical particles have larger aspect ratio (length to diameter ratio) than spherical particles. The wide differences in the dimensions of these particles do influence the enhancement in effective thermal properties of nano fluids. Xie et al.5.10 (2002a) measured the thermal conductivity of water as well as EG based nano fluids consisting of both cylindrical as well as spherical sic nano particle. It was observed that in water based nano fluids, the cylindrical suspensions had higher thermal conductivity enhancement of about 22.9% than the spherical particles for the same volume fraction (4.2%). Also the theoretical values based on Hamilton-Crosser model (1962f) are found to be in good agreement with this comparatively higher enhancement for cylindrical particle suspensions. Another experimental study reported by Murshed et al.5.2 (2005) in water based nano fluids consisting of spherical as well as rod shaped tio2 nano particle showed a comparatively higher enhancement for rod shaped particles (32.8%) than spherical particles (29.7%) at a volume fraction of 5%. The temperature of a two component mixture, such as a nanofluid, depends on the temperature of the solid component as well as that of the host media. In a nano fluid the increase in temperature enhances the collision between the nano particles (Brownian motion) and the formation of nano particle aggregates (Li et al., 2008a), which result in a drastic change in the thermal conductivity of nano fluids.Masuda 5.6 et al. (1993) measured the thermal conductivity of water-based nano fluids consisting of Al2O3, sio2, and tio2 nano particle at different temperatures. It was found that thermal conductivity ratio decreased with increasing temperature. But the experimental results of others have been contradictory to this result. The temperature dependence of the thermal

Conductivity of Al2O3 /water and cuo/water nano fluids, measured by Das et al.5.5 (2003), have shown that for 1 vol. % Al2O3/water nanofluid, thermal conductivity enhanced from 2% at 210 C to 10.8% at 510 C. Temperature dependence of 4 % Al2O3 nano fluid was much more significant, an increase from 9.4% to 24.3% at 510C. The investigations of Li et al.5.12 (2006) in cuo/water as well as Al2O3/water reveal that the dependence of thermal conductivity ratio on particle volume fraction get more pronounced with increasing temperature.

VII. APPLICATIONS

Some of the main cooling applications by using Nanofluids in radiator

- Space and defense
- Heat transfer intensification
- Transportation
- Electronic applications
- Nuclear systems cooling
- Industrial cooling

VIII. FUTURE SCOPE

- Radiator using different nano fluid can be obtain.
- Metallurgical properties of the nano material used for Radiator can be studied.
- The analysis can be done with different Radiator size.

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