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Performance Testing of Automobile Radiator using Different Concentration of Nanofluids

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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. On the other hand, better cooling has positive effects on fuel consumption and the amount of fuel consumption decreases. 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. Nanofluid (2 to 8 mixture of water to CuO) was used instead of radiator cooling fluid. CuO -WATER is used as nanoparticles in this project. CuO -water nanofluids consisting of 20±2 nm diameter particles at three different particle mass concentrations of 1%, 3% and 5% are used as the working fluid.

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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 thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity and convective heat transfer coefficients compared to those of base fluids like oil or water . Owing to their enhanced thermophysical properties, nanofluids have numerous industrial, engineering and bio-medical applications such as heat transfer applications: industrial cooling, smart fluids; nanofluid coolant: vehicle cooling, electronics cooling; medical applications: magnetic drug targeting and nanocryosurgery.
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.

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 utilised 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.

1.2 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.

1.3 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.

II. LITERATURE REVIEW

Adan M. Hussein et al . works on “Heat transfer enhancement using nanofluids in an automotive”cooling system The increasing demand of nanofluids in industrial applications has led to increased attention from many researchers. In this paper, heat transfer enhancement using TiO2 and SiO2 nanopowders suspended in purewater is presented. The test setup includes a car radiator, and the effects on heat transfer enhancement under the operating conditions are analyzed under laminar flow conditions. The volume flow rate, inlet temperature and nanofluid volume concentration are in the range of 2–8 LPM, 60–80 °C and 1–2% respectively. The results showed that the Nusselt number increased with volume flow rate and slightly increased with inlet temperature and nanofluid volume concentration.

A.K.A.Shati et al.works on “The effect of surface roughness and emissivity on radiator output”. The effect of altering the emissivity and the roughness of a wall behind a radiator on the radiator heat output has been studied experimentally and by using computational fluid dynamics. The results of a 3D RNG k–ε turbulent model agree well with, and have the same trend as, the experimental results. The results indicate that the presence of large scale surface roughness and a high emissivity surface increases both the heat flow rate and the air velocity behind the radiator compared to a smooth shiny surface.

Benjamin Siedel et al works on “Numerical investigation of the thermohydraulic behaviour of a complete loop heat pipe”. A complete steady-state model has been developed to determine the thermohydraulic behaviour of a loop heat pipe. The model combines a fine discretization of the condenser and the transport lines with a 2-D description of the evaporator. These original features enable to take into account heat losses to the ambient and through the transport lines as wellas to evaluate the parasitic heat flux through the wick and the evaporator body.

C. Oliet, A. Oliva et al. works on “Parametric studies on automotive radiators” . This paper presents a set of parametric studies performed on automotive radiators by means of a detailed rating and design heat exchanger model developed by the authors. This numerical tool has been previously verified and validated using a wide experimentaldata bank. A first part of the analysis focuses on the influence of working conditions on both fluids (mass flows, inlet temperatures) and the impact of the selected coolant fluid. Following these studies, the influence of some geometrical parameters is analysed (fin pitch, louver angle) as well as the importance of coolant flow lay-out on the radiator globa performance.

III. METHODOLOGY / EXPERIMENTAL SETUP

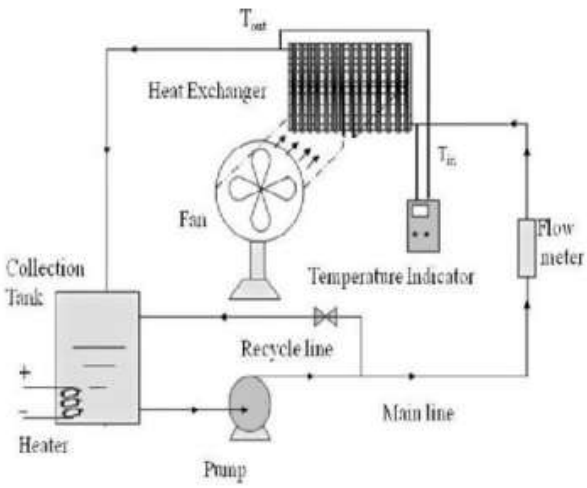
The test rig in Fig. has to use to measure heat transfer coefficient and friction factor in the automotive engine radiator. This experimental setup includes a reservoir plastic tank, electrical heater, a centrifugal pump, a flow meter, tubes, valves, a fan, a DC power supply; Digital thermocouples type 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

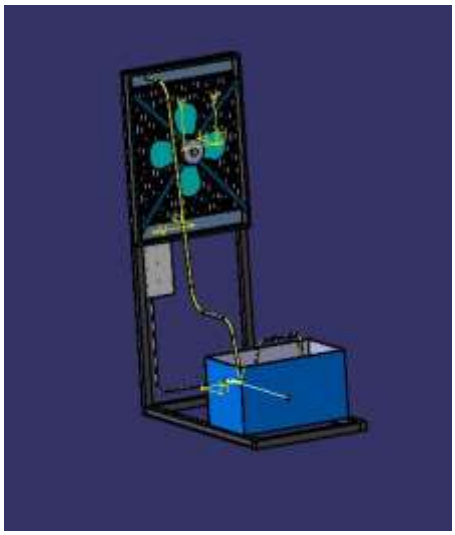
3.1 Schematic OF Experimental Set Up:

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 40°-80°C.

Two K type thermocouples have toimplement 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.

3.2 Setup Block Diagram:



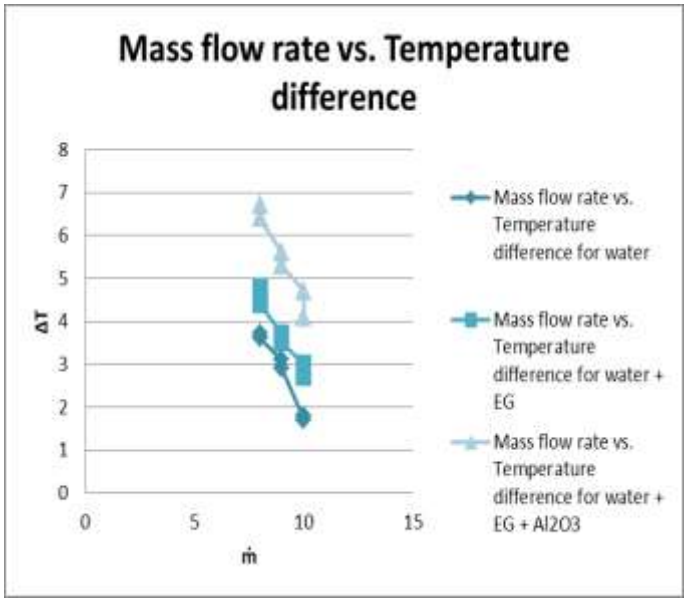


COMBINED EFFECT:

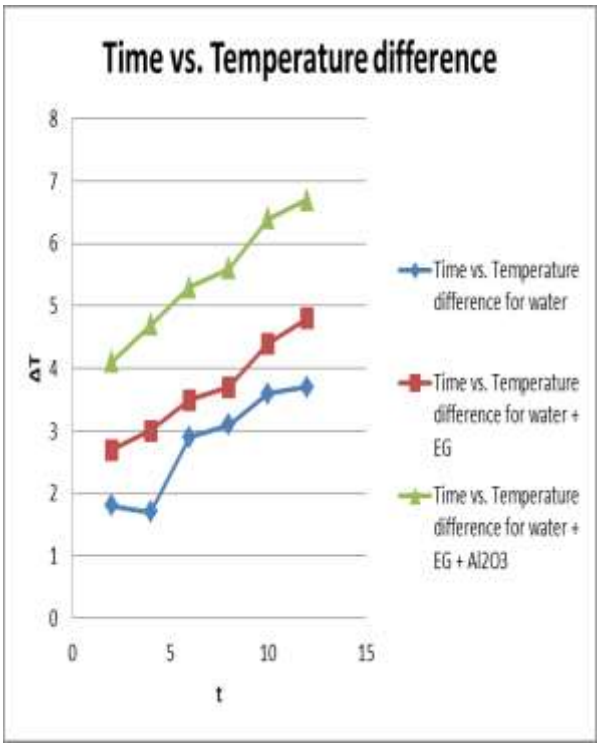
$\dot{m}$ (lpm)	T (min)	ΔT_w (°C)	ΔT_e (°C)	ΔT_{nf} (°C)	Q_{avg} w (W)	Q_{avg} e (W)	Q_{avg} nf (W)	ε_w	ε_e	ε_{nf}
10	2	1.8	2.7	4.1	3896.331	5487.525	7786.54	0.04541	0.04765	0.07547
10	4	1.7	3.0	4.7	4619.934	6296.91	8056.83	0.04563	0.05365	0.08878
9	6	2.9	3.5	5.3	5821.8825	7300.5825	8819.61	0.06684	0.05453	0.08947
9	8	3.1	3.7	5.6	6241.465	7935.95	9472.82	0.06686	0.05839	0.09796
8	10	3.6	4.4	6.4	7162.5486	8498.484	9938.12	0.06805	0.06254	0.09880
8	12	3.7	4.8	6.7	8081.115	9087.2955	10510.43	0.07145	0.06690	0.10197

Table 1: Combined results

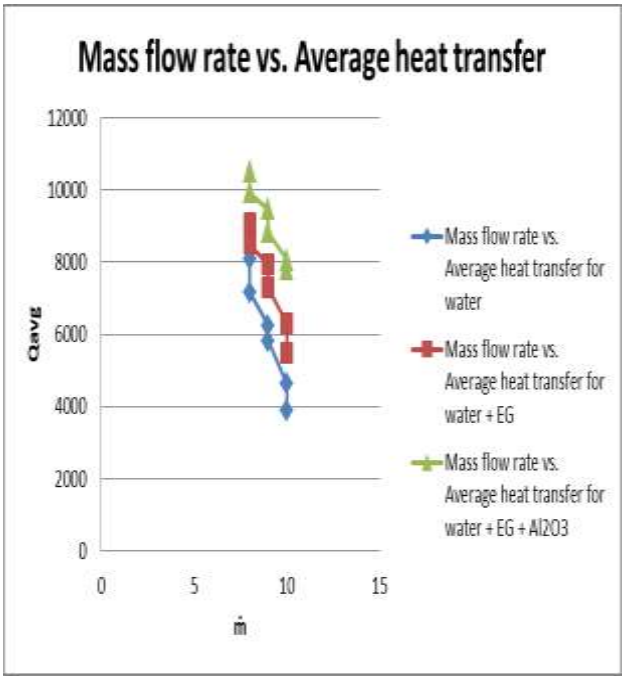
1. Mass flow rate (lpm) vs. Temperature difference (°C)



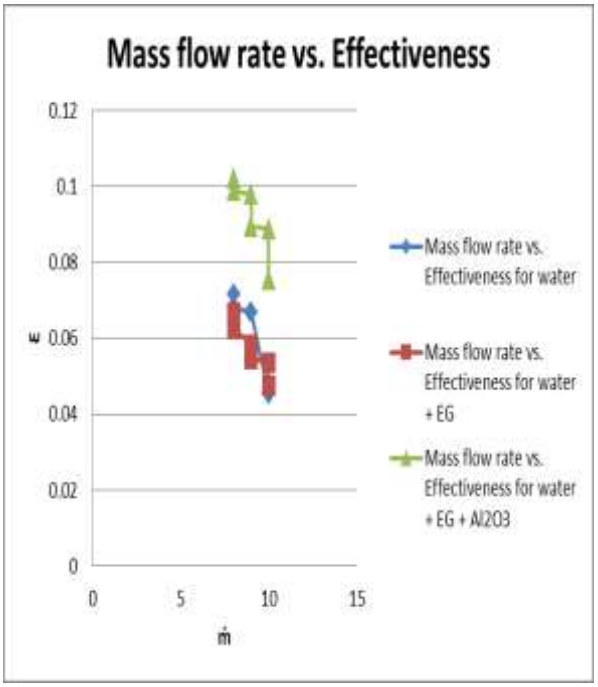
1) Time (min) vs. Temperature difference (°C)



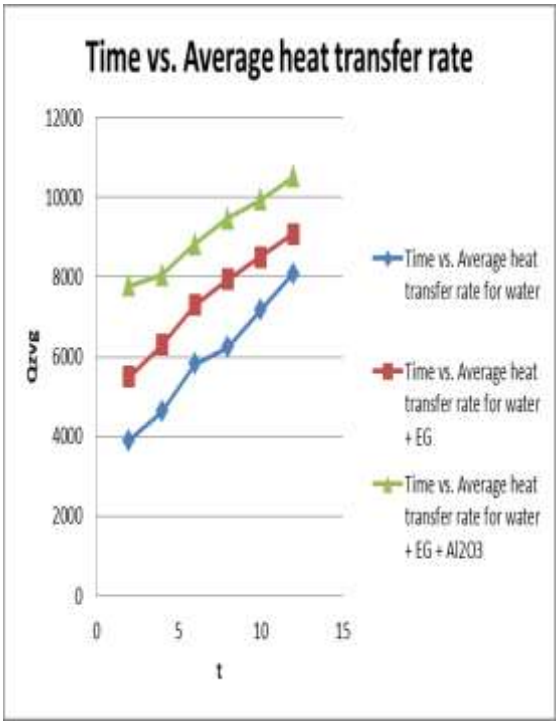
2) Mass flow rate (lpm) vs. Average heat transfer rate (W)



3) Mass flow rate (lpm) vs. Effectiveness



4) Time (min) Vs. Average heat transfer rate (W)



IV. CONCLUSION

From the above graph various conclusions can be drawn which are:

1) With decrease in mass flow rate, temperature difference between inlet and outlet temperature of coolant increases. In the graph nanofluid is having better temperature rejection.

2) With increase in time in min, temperature difference between inlet and outlet temperature of coolant increases. In the graph nanofluid is having better temperature rejection.

3) With decrease in mass flow rate, average heat transfer rate of coolant increases. In the graph nanofluid is having better average heat transfer rate as compared to water and water + ethylene glycol.

4) With decrease in mass flow rate, effectiveness of coolant increases. In the graph nanofluid is having better effectiveness as compared to water and water + ethylene glycol.

5) With increase in time in min, average heat transfer rate of coolant increases. In the graph nanofluid is having better average heat transfer rate as compared to water and water + ethylene glycol.

It is concluded that nanofluids are having better heat transfer rate as compared to other coolants and they can be considered as a potential candidate for numerous applications involving heat transfer and their use will continue to grow. It is also found that the use of nanofluids appears promising, but the development of the field faces several challenges. Nanofluid stability and its production cost are major factors in using nanofluids. The problems of nanoparticle aggregation, settling, and erosion all need to be examined in detail in the applications. We can say that once the science and engineering of nanofluids are fully understood and their full potential researched, they can be reproduced on a large scale and used in many applications.

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