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Review of Experimental Study of Heat Transfer in Car Radiator Using Al2O3 Nanofluid

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Abstract: Heat transfer in various heat exchanger using suspensions of nano meter–sized solid particles in base liquids have been investigated in recent years by various researchers across the world for finding new opportunities. The suspended nanoparticles effectively enhance the transport properties and heat transfer characteristics of base fluids in heat exchanger. In this article, we overview of performance of nanofluid in automobile radiator. The study reveals an improvement in the thermal efficiency and reduction in the thermal resistance of automobile radiator with nanofluids, then that of conventional working fluids. This paper reviews and summarizes recent research on fluid flow and the heat transfer characteristics of Al_2O_3 nanofluids in radiator with different concentration of nanoparticle in base fluid.
Keywords- Al_2O_3, Nano Coolant(NC), Nanofluid, Nusselt number, Thermal conductivity

I. INTRODUCTION

The radiator is an important accessory of vehicle engine. Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium. For this liquid-cooled system, the waste heat is removed via the circulating coolant surrounding the devices or entering the cooling channels in devices. The coolant is propelled by pumps and the heat is carried away mainly by heat exchangers. Continuous technological development in automotive industries has increased the demand for high efficiency engines. A high efficiency engine is not only based on its performance but also for better fuel economy and less emission. Reducing a vehicle weight by optimizing design and size of a radiator is a necessity for making the world green. Addition of fins is one of the approaches to increase the cooling rate of the radiator. It provides greater heat transfer area and enhances the air convective heat transfer coefficient. However, traditional approach of increasing the cooling rate by using fins and micro-channel has already reached to their limit. Nanofluid is one of the nanotechnology applications which created by suspensions of nanoparticles (1-100) nm of high thermal conductivity materials into base fluid (water, oil) to improve the overall thermal conductivity and the convective heat transfer characteristics of the base fluid. Nanoparticles shapes are spherical or cylindrical. The advantages of nanofluid are Higher thermal conductivity, excellent stability, little penalty due to an increase in pressure drop and little damage in pipe wall due to increase of suspensions nanoparticles abrasion. Nanofluids have attracted attention as a new generation of heat transfer fluids in building in automotive cooling applications, because of their excellent thermal performance. Recently, there have been considerable research findings highlighting superior heat transfer performances of nanofluids.

A. Preparation of Nano fluid:

There are two fundamental method to obtain nanofluids:

1) Single-step direct evaporation method: In this method, the direct evaporation and condensation of the nanoparticulate materials in the base liquid are obtained to produce stable nanofluids.
2) Two-step method: In this method, first the nanoparticles are obtained by different methods and then are dispersed into the base liquid.

II. LITERATURE SURVEY

S.M. Peyghambarzadehet al(2011)[1]used the Al_2O_3-Y water nanofluid, 0-1% vol. concentration, of 20nm particle size, illustrated that fluid outlet temperature has decreased with the augmentation of nanoparticle volume concentration that as increasing volume concentration. Increasing the flow rate of working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and nanofluid considerably. It] shows that results for nanofluid at the concentration of 1 vol.% at different inlet temperatures in order to analyze the effect of temperature variation on heat transfer performance of the automobile radiator. It also shows that an increase in the fluid inlet temperature slightly improves the heat transfer coefficient. Inspecting the results reveals that increasing the inlet temperature from 37˚C to 49˚C can enhance Nussle number about 6%. This small variation in Nusselt number may be

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attributed to the effect of temperature on the physical properties and even to the increased effect of radiation. They also conclude that variation of fluid inlet temperature to the radiator (in the range tested) slightly changes the heat transfer performance.

S.M. Peyghambarzadehet al[2] experiment the heat transfer performance of pure water and pure EG and compared their performance with their binary mixtures. Furthermore, different amounts of Al_2O_3 nanoparticle have been added into these base fluids and its effects on the heat transfer performance of the car radiator have been determined experimentally. The nanofluid is implemented in different Al_2O_3 concentrations, i.e. 0.1, 0.3, 0.5, 0.7, and 1 vol.% and at different flow rates of 2, 3, 4, 5 and 6 l per minute. To consider the effect of temperature on thermal performance of the radiator, different inlet temperatures have been applied for each concentration. The inlet temperatures include 35, 45, and 50 °C for the water based nanofluids and 45, 50, and 60 °C for EG based nanofluids. By the addition of only 1 vol.% of Al_2O_3 nanoparticle into the water or EG, an increase of about 40% in comparison with the pure water and pure EG Nusselt number was recorded. It was shown that when small amounts of Al_2O_3 nanoparticles are added to the base fluid, the density and the thermal conductivity increase and the specific heat decreases slightly while the viscosity increases more markedly compared to the base fluid . These variations, however, are too small (of about 4%) to explain heat transfer enhancement of up to 40% gained in this study. Inspecting the results reveals that increasing the inlet temperature of water based nanofluids from 35°C to 50°C can enhance Nusselt number up to 16%. For EG based nanofluids, the temperature elevation from 45 to 60°C creates maximum enhancement of 7%. This variation in Nusselt number may be attributed to the effect of temperature on the physical properties and even to the increased effect of test liquid radiation to the internal wall of the tubes. Also three different concentrations of water/EG binary mixtures which include 5, 10, and 20 vol.% EG were prepared as the base fluids. Four different values of Al_2O_3 nanoparticle (0, 0.05, 0.15, and 0.3 vol.%) were added to each concentration of water/EG mixtures and finally the effect of flow rate on the heat transfer performance was studied for each case. due to the large variations in the physical properties of the base fluids, it is not possible to imply Nusselt number as a function of Reynolds number. Reynolds number greatly reduced when EG concentration enhances. At extreme conditions, Reynolds number changes between 9000 and 23,000 for water based nanofluids while it changes between 1200 and 2500 for EG based nanofluids. Conclude that the addition of nanoparticles to the coolant has the potential to improve automotive and heavy-duty engine cooling rates or equally causes to remove the engine heat with a reduced-size cooling system. Smaller cooling systems result in smaller and lighter radiators, which in turn benefit almost every aspect of vehicle performance and lead to increased fuel economy.

Sandesh S. Chougule, S.K. Sahuet al(2014)[3] in the paper, four different concentrations of nanofluid in the range of 0.15–1 vol.% were prepared by the additions nanoparticles into the water as base fluid. The coolant flow rate is varied in the range of 2 l/min–5 l/min. Show, the maximum heat transfer performance for 1.0 vol.% nanoparticle concentration were found to be 52.03% higher for Al_2O_3-water, compared with water. Concluded that with the increase in the coolant flow rate, the heat transfer performance increases for various coolants, also the effective thermal conductivity of nano coolant increases with the increase in nanoparticles concentration, which consequently, increases the cooling performance in automobile radiator. It was also found that absolute viscosity of nanofluid increases with particle volume concentration at different volume concentrations and temperatures.

Rahul A. Bhogare et al (2014)[4] can observe in that increasing the concentration above 1% shows diminishing performance and above 3% even Al_2O_3 and SiO_2nanofluids do not show a reduction in pumping power over the base fluid. The 1% concentration seems to increase the thermal conductivity sufficiently, without increasing the viscosity much. The Al_2O_3nanofluid shows mild change with increasing the concentration, while CUO nanofluid is greatly affected by particle concentration, with losing about half of its performance gain from 1% to 2% concentration. Inthis paper they resulted, the reductions in pumping power and volumetric flow rate for 1% concentration of nanoparticles under the same surface area and heat transfer rate. The nanofluids exhibit better thermal performance at higher temperatures. Lower volumetric flow by all three nanofluids, as much as 18%, in comparison to the base fluid achieve the same objective. According to them, Al_2O_3 shows the best performance with a significant pumping power reduction of about 36%. For Al_2O_3nanofluid, changing the inlet temperature from 323K to 383K reduces the pumping power 33% and 36%, respectively. Also show, how temperature affects the heat transfer performance of nanofluid under a constant pumping power condition, the heat transfer coefficient of nanofluids increase dramatically from about 19–30% for Al_2O_3. This is due to the increase in thermal conductivity from the Brownian motion with increase in coolant inlet temperature. Furthermore, the viscosity decreases with an increase in temperature causing the Reynolds number to rise, which leads to an increase in Nusselt number.

Dustin R. Ray and Debendra K. Das et al [5]they blended Al_2O_3nano particles with base fluid water, for two different concentrations of nanofluids 0.25 % and 0.5 % (by vol.), flow rate ranges from 0.05 to 0.15 kg/s. and inlet temperature was varying from 35°C to 59°C, in this increased thermal conductivity due to the addition of nano particles in the base fluid water. The thermal conductivity was increased 0.7% and 1.4% for 0.25% and 0.50% nanofluid concentrations respectively. Also conclude that, out of the three

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operating parameters considered, total amount of heat transferred was much dominated by nanofluid concentration rather than the other two operating parameters: flow rate and inlet temperature of coolant.

Bhogale, Kothawale, Bokale and Gawaliet al (2014)[6]this study attempts to investigate the heat transfer characteristics of an automobile radiator using mixture of ethylene glycol + water (50:50) combination based Al_2O_3nanofluids as coolants. An overall heat transfer coefficient 711 w/m^{2}k can be achieved for 1% Al_2O_3+ mixture of EG/water (50% volume concentration) nanofluid compared 428 w/m^{2}k for based fluid. It showed that it increased overall heat transfer coefficient based on air side up to 66% from above figure at constant air Reynolds number (84391) and constant mass flow rate (0.08 kg/s). It investigates about 70% of heat transfer improvement can be achieved with addition of 1% Al_2O_3 particles at 91290 and 39343 Reynolds number for air and coolant respectively. Thermal conductivity increased by 3.05% with increase in the volume concentration of Al_2O_3 particles in base fluid. If we increase the volume concentration of the Al_2O_3 particles in the base fluids with 1%. It increases the effectiveness of the radiator. The result also show that pressure drop of 3059.142 N/m^2 by adding 1 % Al_2O_3 particles compared to pressure drop 2979.009 N/m^2 for a based fluid which means with increase in the volume fraction of Al_2O_3 Particles in nanofluid pumping power and pressure drop increased.

Hwa-Ming Tun-Ping Tenget al (2014)[7],This study adopts a nano-coolant (NC) to examine the thermal performance of a vehicle cooling system at a temperature of 80- 95°C to refer the general engine temperature of the coolant. The Al_2O_3 nanoparticle concentration and increased sample temperature caused the thermal conductivity of the nano coolant to increase, and the dispersant caused the thermal conductivity of EG/W to decrease. Increasing both the nanoparticle concentration and the sample temperature raises the probability of nanoparticle liquid collisions producing a quasi-convection phenomenon to enhance the thermal conductivity of the nano coolant. The dispersant coated on the nanoparticle surface also increased the thermal resistance between the nanoparticles and the base liquid, which led to a decreased thermal conductivity of the NC because the dispersant has a lower thermal conductivity than EG/W. Therefore, the amount of added dispersant must rely on the type of dispersant and the suspension conditions of the NC. Unless the thermal conductivity of the added dispersant is greater than EG/W, the amount of increased dispersant may enhance the thermal conductivity of the NC. This experiment measure the thermal conductivity, viscosity, and specific heat of NC with different weight fractions and sample temperatures, and then evaluate the overall efficiency of the heat dissipation system using the EF, which combines heat dissipation capacity and pumping power. The experimental results show that the heat dissipation capacity and the EF of NC are higher than EG/W, Compared with EG/W, the maximum enhanced ratios of heat dissipation capacity, pressure drop, pumping power, and EF for all the experimental parameters in this study are approximately 25.6%, 6.1%, 2.5%, and 27.2%, respectively.

M.R.Kohale, S.P. Chincholkaret al (2016)[8]shows as Al_2O_3 nanoparticles with an average diameter of 50 nm was dispersed in demineralized water at different volume concentrations (0.1,0.2 & 0.3 vol.%) without any dispersant or stabilizer. Flow rate is varied in the range of 2 l/min – 5 l/min and inlet coolant to the radiator has a constant temperature which is changed at 50, 60 and 70°C. The concentration of nanoparticle plays an important role in heat transfer efficiency. Increasing the flow rate of working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and nanofluid considerably. As concentration increases the heat transfer coefficient also increases.

Apurva R. Pendbajeet al(2016)[9]experimentally study heat transfer coefficients in the automobile radiator by have been measured with two different working liquids, pure water and water based nanofluids at different concentrations and temperatures.In presence of 13nm sized alumina nanoparticles in water enhances the heat transfer rate of the automobile radiator. At the concentration of 2 vol% the heat transfer enhancement of 35% compared to pure water is recorded. 2. Increasing the Reynolds number of working fluid enhances the heat transfer coefficient for both pure water and nanofluids reasonably. Also concluded that the increase in thermal conductivity is about 6% and the variation of the other thermophysical properties are not responsible for the large heat transfer enhancement.

K. Goudarzia et al [10], in this experimental study, Aluminums Oxide (Al_2O_3) in Ethylene Glycol (EG) as nanofluid was used for heat transfer enhancement in car radiator together with wire coil inserts. Two wire coils insert with different geometry and nanofluids with volume concentrations of 0.08%, 0.5% and 1% were investigated. The results indicated that the use of coils inserts enhanced heat transfer rates up to 9%. In addition, the simultaneous use of the coils inserts with the nanofluid with concentration of 0.08%, 0.5% and 1% resulted the thermal performance enhancement up to 5% as compared to the use of coils inserts alone, show that the thermal performance enhancement up to 14%. With increasing speed of cooling fan, Nusselt number at Reynolds numbers increased. The results show that the Nusselt number increased with increasing Al_2O_3 concentration and all Al_2O_3/EG nanofluids gave higher Nusselt number than EG as the based fluid. The main reasons for this increase are the ability of suspended nanoparticles enhancing thermal conductivity and movement of nanoparticles carrying energy exchange.

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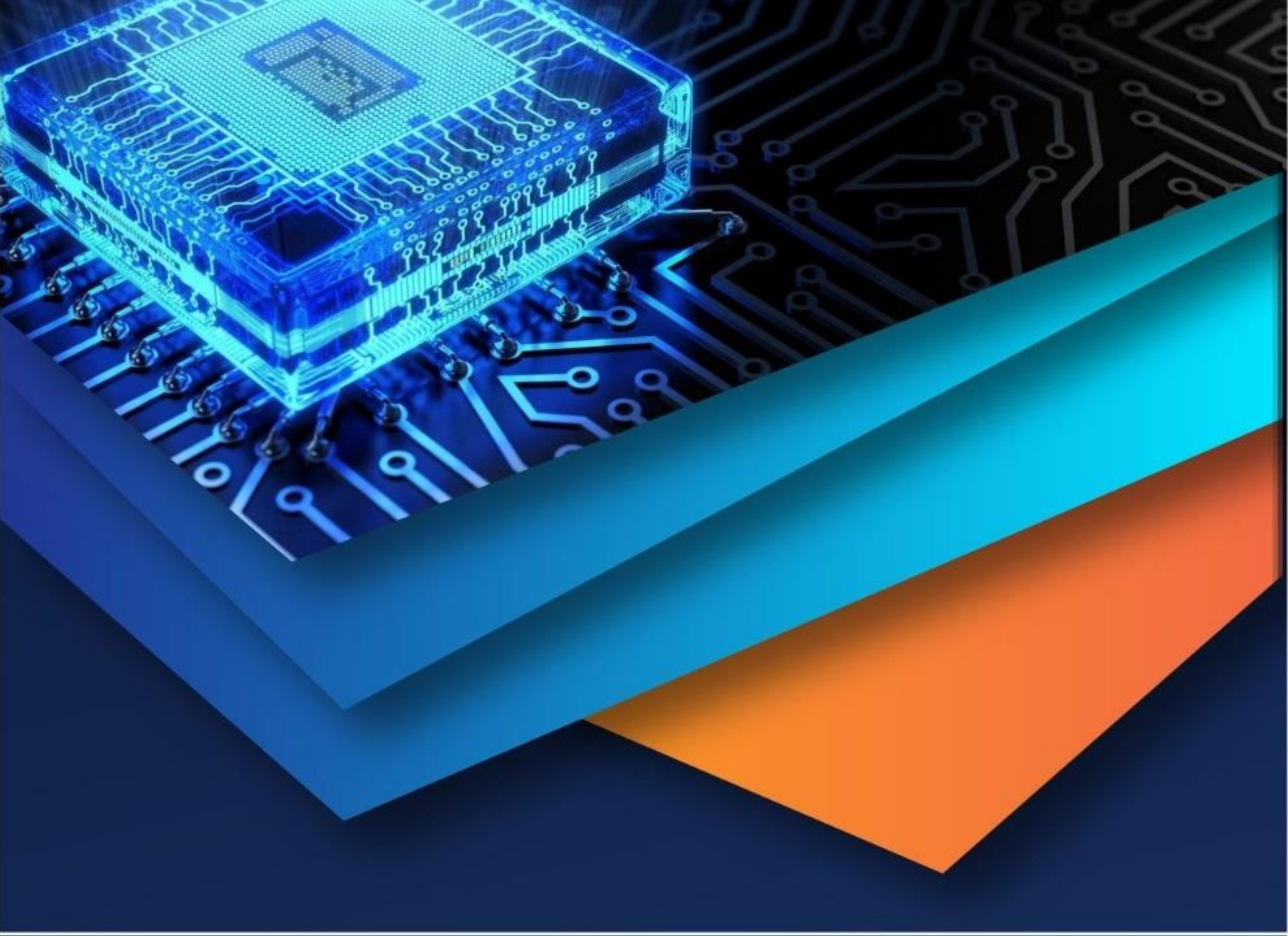

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