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Heat analysis of radiator using Nanofluid: A Review

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ABSTRACT

The objective of this experimental study is to discuss the thermal performance of car radiator using Al2O3 nanofluid in temperature ranges from (40-75°C) under different fractions of nanoparticles from 0.5, 1, 1.5% by volume. In this study, the heat transfer with water based nanofluids was experimentally compared to that of pure water as coolant in an automobile radiator. By varying the amount of Al2O3 nano particles blended with base fluid water, three different concentrations of nano-fluid 0.5%, 1%, 1.5% (by vol.) were obtained. The size of nanoparticle used was 100 nm. Liquid flow rate has been changed in the range of 50 lph to 200 lph and air velocity in the range of 3.8 m/s to 6.2 m/s. The fluid inlet temperature was varying from 40°C to 75°C to find the optimum inlet condition. Results demonstrate that increasing coolant flow rate can improve the heat transfer performance. Also increasing the air flow rate improves the heat transfer rate. The rate of heat transfer enhancement was found 19% to 42% in comparison with pure water.

Keywords: NanoFluid, Al2O3, Radiator, Flow Rate, Cooling Performance, Heat Transfer enhancement.

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I. INTRODUCTION

Modern automotive internal combustion engines generate a huge amount of heat. This heat is created when the gasoline and air mixture is ignited in the combustion chamber. This explosion causes the piston to be forced down inside the engine, levering the connecting rods, and turning the crankshaft, creating power. Metal temperatures around the combustion chamber can exceed 538°C. In order to prevent the overheating of the engine oil, cylinder walls, pistons, valves, and other components by these extreme temperatures, it is necessary to effectively dispose of the heat. Approximately 1/3 of the heat in combustion is converted into power to drive the vehicle and its accessories. Another 1/3 of the heat is carried off into the atmosphere through the exhaust system. The remaining 1/3 must be removed from the engine by the cooling system The use of nanofluids 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 leads 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.

II. REVIEW OF WORK CARRIED OUT

Datta N. Mehtre et al., studied the total heat transfer rate from an automotive radiator is determined using two working fluids: water and water based nanofluid (Al2O3) at three different concentrations 0.5%, 1% and 1.5% on volume basis. From the experimental work, the following conclusions were made. 1)19% rate of heat transfer is increased in car radiator by addition of 0.5% Al2O3 nano powder of 100nm size in pure water at constant coolant flow rate of 200 lph and constant air flow rate of 6.2 m/s. 2) 33% rate of heat transfer is increased in car radiator by addition of 1% Al2O3 nano powder of 100nm size in pure water at constant coolant flow rate of 200 lph and constant air flow rate of 6.2 m/s.3)42% rate of heat transfer is increased in car radiator by addition of 1.5% Al2O3 nano powder of 100nm size in pure water at constant coolant flow rate of 200 lph and constant air flow rate of 6.2 m/s 4)Additon of 0.5% to 1.5% Al2O3 nanopowder in pure water gives 14% to 42 % heat transfer enhancement than pure water.

Sarit Kumar Das et al., studied detailed into investigating the increase of thermal conductivity with temperature for nano fluids with water as base fluid and particles of Al2O3 or CuO as suspension material. A temperature oscillation technique is utilized for the measurement of thermal diffusivity and thermal conductivity is calculated from it. The results indicate an increase of enhancement characteristics with temperature, which makes the nanofluids even more attractive for applications with high energy density. Thus the problems of traditional slurries can be eliminated by reducing the particles to nanometer dimensions. It must be kept in mind that the enhancement that is talked about in the above studies is only that of thermal conductivity. This makes nanofluids a prospective candidate for cooling application such as energy intensive laserand X-ray applications, super conducting magnets, high speed computing systems, fibre manufacturing processes and high-speed lubrication applications.

S.M. Peyghambarzadeh et al., they did experimental analysis of heat transfer enhancement in automobile radiator with water and ethylene glycol based Al2O3 nanofluids. They selected the range of Reynolds number 9000-23000 for water based nanofluids and 1200-2500 for ethylene glycol based nanofluids and ambient air for cooling. They select inlet temperature range from 350-500 for water based nanofluids and 450-600 for ethylene glycol based nanofluid, the fluid flowing range from 2-6 lit/min and the concentration range from 0-1 Vol. %. For avoiding the any changes in fluid property they neglect the addition of the dispersant and stabilizer to the nanofluids. They concluded that the heat transfer behaviors of the nanofluids are highly dependent on the particle concentration and weakly dependent upon the temperature.

Devdatta P. Kulkarni et al., they performed the experiment on Diesel Electrical Generator using the water based Al2O3 nanofluids as a coolant in jacket cooling fluid. They used the nanofluids with various particle concentrations of 0.5%, 1% and 1.5%. The Reynolds number varies from 200-1400, and the fluid inlet temperature varies from 200-700 C. The investigation carried out by them, they shown that applying nanofluids resulted in reduction in cogeneration efficiency due to decrease in specific heat, which influences the waste heat recovery from the engine. From that, they concluded that efficiency of waste heat recovery heat exchanger was increased for nanofluids, due to its large convective heat transfer coefficient.

Durgeshkumar Chavan et al., performed experiment on the automobile radiator with using the Al2O3/ water nanofluid as a cooling fluid. For avoiding the any changes in fluid property they neglect the addition of the dispersant and stabilizer to the nanofluids. They took the five different concentrations in range of the 0-1.0 vol. %. The test fluids flow rate was changed in the range of 3 lit/min to 8 lit/min to obtain the fully turbulent regime having Reynolds number 4000-16000. From the experimental investigation they concluded that with increase in the fluid circulating rate increased th heat transfer rate, with increase in the Reynolds number enhance the heat transfer coefficient of both water and nanofluids considerably and with addition of 1.0 Vol. % of Al2O3 nanoparticles into the pure water, the heat transfer coefficient increased about 40-45% with compare to the pure water.

Yi-Hsuan Hung et al.,did the study of the evaluating the feasibility of the alumina (Al2O3)/water nanofluid for the cooling system use in the automobile using the air-cooled heat exchanger for heat dissipation. They prepared the Al2O3/water nanofluid by using the direct synthesis method and mechanical agitations with different weight fraction of nanoparticles. They took the concentration 0, 0.5, 1.0, 1.5 % of weight fraction. The fluid inlet temperature would be 300, 400, 500 and 600. They kept the air flow rate fixed and mass floe rate of liquid side was controlled by input voltage of circulating pump. The operating range would be 1.8, 2.1 and 2.4 lit/min. For decreasing the measurement errors they measured each condition five times. From the experimentation they found result for the concentration of 0.5 % by weight and a temperature range 300-600 C, the thermal conductivity increased by 3.8-17.2%, for a concentration of 1.0 % by weight the thermal conductivity increased by 4.6-19.7%, for a concentration of 1.5 % by weight the thermal conductivity increased by 8.1-20.5% with pure water. They conclude that the maximum enhancement of heat exchange occurred compared with the distilled water was of 40% at high weight fraction (1.5 % by weight) of nanoparticles and low inlet temperature (300 C).

Rahul A. Bhogare, B. S. Kothawale et al., studied effect of adding Al2O3 nanoparticle to base fluid (mixture of EG+Water) in Automobile radiator is investigated experimentally. Improving thermal efficiency of engine leads to increase the engine's performance, decline the fuel consumption and decrease the pollution emissions. Effects of fluid inlet temperature, the flow rate and nano particle volume fraction on heat transfer are considered. Results show that Nusselt number, total heat transfer, effectiveness and overall heat transfer coefficient increases with increase , nano particle volume fraction , air Reynolds number and mass flow rate of coolant flowing through radiator.

III. CONCLUSION

Addition of various nanoparticles or additives to a liquid slightly increases the viscosity and the thermal conductivity moderately. The suspension of nanoparticles in the base liquid increases the heat transfer area and ultimately it leads to the increase in the heat transfer because the heat transfer rate depend upon the total surface area available for transferring the heat. The thermal conductivity of aluminum oxide is lower than the copper oxide, silicon oxide and titanium oxide. From the above study it is seen that with increasing the fluid flow rate, particle concentration the heat transfer rate increases with little penalty of the pressure drop.

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