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Application of Nano fluids in Vehicle Engine Cooling System: A Review

M.Tech. Scholar Atulya Agrawal Professor Deo Kumar Singh

Department of Mechanical Engineering

PCST, Bhopal MP, India.

Abstract

This paper reviewed the application of nano fluids in vehicle engine cooling system. So far, nano particles have been used in engine oil, transmission oil, and radiator coolant to enhance heat transfer removal from vehicle engine. The heat transfer performance of nano fluids has been reported to perform better compared to pure fluid. This review focused on the experimental and numerical studies by previous researchers and their suggested amount of nano particles for optimum performance in vehicle engine cooling system. Finally, the conclusions were presented according to the data collected.

Keywords: Nanofluid, Engine oil, Radiator coolant, Cooling system, Nano particle volume fraction.

I. INTRODUCTION

A wide variety of industrial processes involve the transfer of heat energy. Throughout any industrial facility, heat must be added, removed, or moved from one process stream to another and it has become a major task for industrial necessity. These processes provide a source for energy recovery and process fluid heating/cooling. The enhancement of heating or cooling in an industrial process may create a saving in energy, reduce process time, raise thermal rating and lengthen the working life of equipment.

Some processes are even affected qualitatively by the action of enhanced heat transfer. The development of high performance thermal systems for heat transfer enhancement has become popular nowadays. A number of work has been performed to gain an understanding of the heat transfer performance for their practical application to heat transfer enhancement. Thus the advent of high heat flow processes has created significant demand for new technologies to enhance heat transfer. Heat transfer performance of liquids is limited by their low thermo-physical properties compared with those of solids. The primary reason behind adding solid particles less type of fluid is called a Nano fluid. glycerol, has become an interesting topic recently [1–5]. Base fluids have been used as conventional coolants in automobile radiators for many years; however, these fluids have low thermal conductivities. The low thermal conductivities have thus prompted researchers to search for fluids with higher thermal conductivities than that of conventional coolants. Therefore, Nano fluids have been used instead of the commonly used base fluids [6, 7].Thermal properties of fluids has a major role in temperature controlling applications in every industrial procedures.

Heat transfer performance is dependent on thermal conductivity of the fluids. Traditional heat transfer fluids have poor thermal conductivity which makes them less preferred for majority of cooling applications. Researchers' have tried to improve the inherently mediocre thermal conductivity of these Traditional fluids used for heat transfer by adding minute solid particles as per the classical effective medium theory (Maxwell, 1873) properties of mixtures. The nano particles are the basic building blocks of Nano fluids in particular. In comparison with particles sized micrometer, nano particles possess high surface area to volume ratio it is due to presence of large number of atoms on the boundaries. Thus it makes them highly stable in suspensions. There is a high convection rate between solid particle surface and liquid which improve the thermal properties such as thermal conductivity. Nanofluids have unusual properties that make them a game changer in many applications of heat transfer, including engine cooling, in grinding, vehicle air conditioning management ,microelectronics, mining, hybrid-powered engines, defense, pharmaceutical industry, in space technology, large scale refrigeration systems, solar cell, chiller, heat exchanger, nuclear reactor coolant and aero planes. They show improvement in thermal conductivity and the heat transfer coefficient in comparison with the normal fluid. More research needs to be done to decide their applicability for heat transfer applications.

II. NANO FLUID

The new heat transfer fluids obtained by the addition of the Nano scaled solid particles (copper, silver, aluminum, etc.)into the traditional heat transfer fluid are named "Nano fluid"[1, 2]. Nano fluids are thought by researchers to be appropriate for practical applications, as they cause very little increase in the pressure drop with regard to base liquid. Once the Nanosized solid particles (16–60 nm) are perfectly suspended into the base fluid, the obtained fluid behaves as a single phase fluid rather than a solid-liquid mixture [3].

Researches related to the enhancement of convection heat transfer by the addition of the metal solid particles into the base fluid have been proceeding for the last two decades [4]. In the last studies that were conducted by the Nano-fluids named liquid-solid suspension in the beginning, it has been seen that the Nano scaled particles enhance the heat transfer and convection characteristics [5]. The heat transfer characteristics of the fluid used in the practical applications under take the key role. As the classical fluids such as ethylene glycol, water, and oil limit the heat transfer capacity, alternative solutions should be developed [6, 7].

In order to enhance the heat transfer capacity, the metal solid particle additioninto the classical fluids with limited thermal conductivities one of the major efforts [8]. Before the development of nano technology, experiments have resulted in failure, as the particles in millimeter ormicrometre dimensions subsided in the base fluid and caused more increase in pressure drop than that of the base fluid [9, 10].

III. THERMO PHYSICAL PROPERTIES OF NANOFLUIDS

Thermo physical properties of the nano fluids are quite essential to predict their heat transfer behavior. It is extremely important in the control for the industrial and energy saving perspectives. There is great industrial interest in nano fluids. Nano particles have great potential to improve the thermal transport properties compared to conventional particles fluids suspension, millimeter and micrometer sized particles. In the last decade, nano fluids have gained significant attention due to its enhanced thermal properties. Experimental studies show that thermal conductivity of nano fluids depends on many factors such as particle volume fraction, particle material, particle size, particle shape, base fluid material, and temperature. Amount and types of additives and the acidity of the nano fluid were also shown to be effective in the thermal conductivity enhancement.

The transport properties of nano fluid: dynamic thermal conductivity and viscosity are not only dependent on volume fraction of nano particle, also highly dependent on other parameters such as particle shape, size, mixture combinations and slip mechanisms, surfactant, etc. Studies showed that the thermal conductivity as well as viscosity both increases by use of nano fluid compared to base fluid. So far, various theoretical and experimental studies have been conducted and various correlations have been proposed for thermal conductivity and dynamic viscosity of nano fluids. However, no general correlations have been established due to lack of common understanding on mechanism of nano fluid.

IV. APPLICATIONS OF NANO FLUIDS

The novel and advanced concepts of nano fluids offer fascinating heat transfer characteristics compared to conventional heat transfer fluids. There are considerable researches on the superior heat transfer properties of nano fluids especially on thermal conductivity and convective heat transfer. Applications of nano fluids in industries such as heat exchanging devices appear promising with these characteristics. Kostic reported that nano fluids can be used in following specific areas:

- Heat-transfer nano fluids
- Tribological nano fluids
- Surfactant and coating nanofluids. Chemical nano fluids.
- Process/extraction nano fluids.
- Environmental (pollution cleaning) nano fluids.
- Bio- and pharmaceutical-nano fluids.
- Medical nano fluids (drug delivery and functional tissue–cell interaction).

Nanofluids can be used to cool automobile engines and welding equipment and to cool high heat-flux devices such as high power microwave tubes and high-power laser diode arrays. A nanofluid coolant could flow through tiny passages in MEMS to improve its efficiency. The measurement of nanofluids critical heat flux (CHF) in a forced convection loop is useful for nuclear applications. Nanofluids can effectively be used for a wide variety of industries, ranging from transportation to energy production and in electronics systems like microprocessors, Micro-Electro-Mechanical Systems (MEMS) and in the field of biotechnology. Recently, the number of industrial application potential of nanofluids technology and their focus for specific industrial applications is increasing.

V. HEAT TRANSFER APPLICATIONS

The increases in effective thermal conductivity are important in improving the heat transfer behavior of fluids. A number of other variables also play key roles. For example, the heat transfer coefficient for forced convection in tubes depends on many physical quantities related to the fluid or the geometry of the system through which the fluid is flowing.

These quantities include intrinsic properties of the fluid such as its thermal conductivity, specific heat, density, and viscosity, along with extrinsic system parameters such as tube diameter and length and average fluid velocity. Therefore, it is essential to measure the heat transfer performance of nano fluids directly under flow conditions. Researchers have shown that nano fluids have not only better heat conductivity but also greater convective heat transfer capability than that of base fluids.

VI. LITERATURE REVIEW

Research on nano fluids has progressed rapidly since its enhanced thermal conductivity was first reported about a decade ago, though much controversy and inconsistency have been reported, and insufficient understanding of the formulation and mechanism of nano fluids further limits their applications. This chapter presents a critical review of research on heat transfer applications of nano fluids with the aim of identifying the limiting factors so as to push forward their further development. The last few decades have witnessed vast research on the new types of heat transfer fluids, namely nano fluids. A nano fluid is a fluid which contains nanometer-sized solid particles.

Nano fluids were introduced by Choi (1995) and they have been proven to provide efficient heat transfer compared to conventional fluids. Detailed reviews on the physical and thermal properties of nano fluids have been reviewed by several authors. Since its first introduction to actual engineering applications, a nano fluid has been successfully applied to enhance heat transfer in many applications such as electronic components, nuclear reactor, building heating and cooling systems, water boiling, and many more. Said et al. (2019) suggested best practice for analyzing the usage of nanofluids in heat transfer applications is presented, specifically for an actual car radiator. This work investigates the use of aluminum oxide (Al2O3) and titanium dioxide (TiO2) nano particles dispersed in DW and EG at 50:50 volumetric proportions.

The choice of these oxide-based nano fluids is motivated by their anti-corrosive properties that are usually not analyzed or discussed in most of the articles.Gakare et al. (2019) highlighted on the research and numeric carried out from pre-researchers on metallic/non-metallic oxide nano coolant, which was separated with various nano coolants like CuO, Al2O3, TiO2, and SiO2.

This review is focused on the required volumetric concentration of nano particles, flow and heat transfer performance of nano fluids used by researchers. The review, which is focused on recent applications, will be useful for researchers working on nano coolants as their field of research. Kumar et al. (2019) summarized and talk over radiator cooling of engine in vehicles using nanofluids. The nano particles present in the nanofluids have higher thermal properties which contribute to higher heat transport. The article opens with the introduction of the nanofluids, coolants and a summarized evolving history of a car radiator. The next sections include the overview of synthesis and characterization of nano fluids based on engine coolant followed by the heat transfer analysis.Palaniappan et al. (2019) presented the thermodynamic performance of automobile radiators using water (60%), ethylene glycol (40%)—fly ash nano fluids.

The influence of nano fluid flow rate and concentration of fly ash on heat transfer parameters (such as overall heat transfer coefficient and heat transfer), energy transfer parameters (such as pumping power and performance index) and energy performance parameters (such as energy destruction rate and energy efficiency) are studied. Xian et al. (2019) attempted to present a recent review on the consequences of implantation of nanofluid, especially in vehicle engine cooling system and other heat transfer applications such as solar collector, electronics cooling system, flow boiling and thermal energy storage system. Thermo physical properties and heat transfer performance of nano fluids obtained in simulation, test rigs and even real vehicle engine experiments are discussed thoroughly. Models and correlations used by past researchers to compute thermo physical properties are also included.

Saxena et al. (2018) focused on the experimental and numerical studies carried out by previous researchers on metallic/non-metallic oxide nano coolant, which are segregated with different nano coolant as CuO, Al2O3, TiO2, and SiO2. The review focuses on suitable volumetric concentration, sizes of nano particles used by researchers and applications for analysis. This review will be useful for researchers and scholars working in the field of applications of nano technology for enhancement of heat transfer fluid. However, lots of researcher work is still needed in the field of preparation and stability, characterization and applications to overcome the challenges.Micali et al. (2018) experimental campaign has been carried out on a 4-strokes single cylinder engine, aimed to assess whether the use of nano fluids, instead of water, could be a valuable solution to reduce peak engine temperature. Such nano fluids were characterized by higher thermal conductivity compared to conventional fluids, due to CuO nano particles added at different concentrations within the base fluid.Boopathi et al. (2018) firstly preparation of novel composite fly ash nano fluid was made for 0.2-2.0% volume concentration of fly ash particles and mass density, thermal conductivity, specific heat, dynamic viscosity of fly ash nano fluid were measured using standard methods and compared with thermo-physical properties of Alumina (Al2O3), Copper Oxide (CuO), Ferrous Oxide (Fe2O3), Silicon Oxide (SiO2), Titanium Oxide (TiO2) nanofluids for the same % volume concentration.

The average grain size of the nano particles taken for study was 50nm. Two step method was used to prepare the fly ash nanofluid. A mixture of 60% deionized water 40%ethylene glycol was used as base fluid and sodium dodecyl benzyl sulfate as surfactant for stabilizing the nano particles. According to Asli et al. (2018) the analytic hierarchy process is used to structure the decision problem and to attribute weights to criteria. Three types of nano fluid (Cu-water, NiO-water, and CuO-water) were evaluated. Among the thermo physical properties of nano fluid, the most important one is calculated as the thermal conductivity and also the Cu-water is determined as the most suitable coolant in terms of thermo physical properties among the evaluated nano fluid.

According to Shete et al. (2018) the performance of an automotive system needs to be enhanced in order to minimize its environment impact and reduce global fuel consumption. Implementing nano fluid technology using nano lubricants inside various subs systems of automobile provides a new foundation for technological integration and innovation. The presence of nano particles in nano fluids contributes better flow of mixing and higher thermal conductivity compared to pure fluid.

Wong et al. (2017) focused on presenting the broad range of current and future applications that involve nano fluids, emphasizing their improved heat transfer properties that are controllable and the specific characteristics that these nano fluids possess that make them suitable for such applications.Sidik et al. (2017) reviewed begins with the overview of preparation methods and thermal conductivity improvement of fluids with nanoparticles. Then, the thermal performance of vehicle engine using nano fluids is highlighted. It has also given emphasis on the major applications of nanofluids in radiator system and as lubricants for improving heat removal efficiency from vehicle engine. According to YuanLi et al. (2017) to improve thermal conductivity of the microcapsule, a composite microcapsule phase change material (CMPCM) was also prepared by inlaying grapheme into urea-formaldehyde resin shell. By dispersing microcapsule in water, microcapsule slurries were prepared.

To analyze the feasibility in engine cooling system, an experimental study on the flow resistance characteristics of microcapsule slurries in a circular tube was conducted. The pressure drops of slurries for turbulent flow were measured and the effects of such facts as the concentration and flow velocity were discussed. According to Molana et al. (2017) Radiators are often air-cooled heat exchangers to transfer the heat from the engine to fresh air.

In an automobile, fuel and air produce power within the engine through combustion. Only a portion of the total generated power actually supplied to the automobile with power, the rest is wasted in the form of exhaust and heat. If this excess heat is not removed, the engine temperature becomes too high which results in overheating and viscosity breakdown of the lubricating oil, metal weakening of the overheated engine parts, and stress between engine parts resulting in quicker wear, among the related moving components.

VII. CONCLUSION

This paper presented an inclusive review on the application of nano fluids for cooling engine vehicles. A vast number of available references howed that nano fluids have a great application prospect in the development of modern engines. For engine cooling system, nano particles can be dispersed in the engine oil to enhance the thermal conductivity of the liquid. In addition, the presence of nano particles in engine oil will also improve the performance of lubricants and reduce friction. However, the optimum amount of nano particles in engine oil still remains unknown. Another method for cooling the engine system is by dispersing nano particles in a conventional coolant radiator. Heat transfer coefficient can be improved up to 50% compared to the original coolant; however, the problem of pressure drop limits the efficiency factor of the cooling system. For this case, most researchers agree that the optimum performance of cooling system can be achieved at low volume fraction of nano particles (b1%). At the same time, there are still some problems and challenges regarding the mechanisms of heat transfer enhancement and the actual applications on engine vehicle. Current research on nano fluids for engine cooling system is still at its initial stage and needs further development.

REFERENCES

[1]. Said, Z., Assad, M. E. H., Hachicha, A. A., Bellos, E., Abdelkareem, M. A., Alazaizeh, D. Z., & Yousef, B. A. (2019). Enhancing the performance of automotive radiators using nanofluids. Renewable and Sustainable Energy Reviews, 112, 183-194.

[2]. Gakare, A., Sharma, A., & Saxena, G. (2019). Review on Recent Automotive Experimental Applications of Nano Coolants. Journal of Nano science Nan engineering and Applications, 9(1), 1-10.

[3]. Kumar, A., & Subudhi, S. (2019). Preparation, characterization and heat transfer analysis of nanofluids used for engine cooling. Applied Thermal Engineering, 114092.

[4]. Palaniappan, B., & Ramasamy, V. (2019). Thermodynamic analysis of fly ash nanofluid for automobile (heavy vehicle) radiators. Journal of Thermal Analysis and Calorimetry, 136(1), 223-233.

[5]. Xian, H. W., Sidik, N. A. C., & Najafi, G. (2019). Recent state of nanofluid in automobile cooling systems. Journal of Thermal Analysis and Calorimetry, 135(2), 981-1008.

[6]. Saxena, G., & Soni, P. (2018). Nano Coolants for Automotive Applications: A Review. Nano Trends-A Journal of Nano Technology & Its Applications, 20(1), 9-22.

[7]. Micali, F., Milanese, M., Colangelo, G., & de Risi, A. (2018). Experimental investigation on 4-strokes biodiesel engine cooling system based on nanofluid. Renewable energy, 125, 319-326.

[8]. Boopathi, P., Venkatachalam, R., Nedunchezhian, N., Subramanian, R., Manikalithas, P., & Bharathiraja, M. (2018). A Novel Fly ash Nano fluid for Automobile Engine Cooling Applications-Preparation and Comparative Studies on Properties.

[9]. Shete, D. S., Powar, R. S., & Desai, N. S. Potential of Use of Nanoparticle in Automotive System-A Review.

[10]. Wong, K. V., & De Leon, O. (2017). Applications of nanofluids: current and future. In

Nanotechnology and Energy (pp. 105-132). Jenny Stanford Publishing.

[11]. Sidik, N. A. C., Yazid, M. N. A. W. M., & Mamat, R. (2017). Recent advancement of nanofluids in engine cooling system. Renewable and Sustainable Energy Reviews, 75, 137-144.

[12]. Li, L., Zou, D., Ma, X., Liu, X., Hu, Z., Guo, J., & Zhu, Y. (2017). Preparation and flow resistance characteristics of novel microcapsule slurries for engine cooling system. Energy conversion and management, 135, 170-177.

[13]. Molana, M. (2017). On the nanofluids application in the automotive radiator to reach the enhanced thermal performance: a review. American Journal of Heat and Mass Transfer, 4(4), 168-187.

[14]. Sahoo, R. R., & Sarkar, J. (2017). Heat transfer performance characteristics of hybrid nanofluids as coolant in louvered fin automotive radiator. Heat and Mass Transfer, 53(6), 1923-1931.

[15]. Bigdeli, M. B., Fasano, M., Cardellini, A., Chiavazzo, E., & Asinari, P. (2016). A review on the heat and mass transfer phenomena in nanofluid coolants with special focus on automotive applications. Renewable and Sustainable Energy Reviews, 60, 1615-1633.

[16]. Devireddy, S., Mekala, C. S. R., & Veeredhi, V. R. (2016). Improving the cooling performance of automobile radiator with ethylene glycol water based TiO2 nanofluids. International communications in heat and mass transfer, 78, 121-126.

[17]. Soltanimehr, M., & Afrand, M. (2016). Thermal conductivity enhancement of COOH-functionalized MWCNTs/ethylene glycol–water nanofluid for application in heating and cooling systems. Applied Thermal Engineering, 105, 716-723.

[18]. Li, X., Zou, C., & Qi, A. (2016). Experimental study on the thermo-physical properties of car engine coolant (water/ethylene glycol mixture type) based SiC nano fluids. International Communications in Heat and Mass Transfer, 77, 159-164.

[19]. Mutuku, W. N. (2016). Ethylene glycol (EG)-based nanofluids as a coolant for automotive radiator. Asia Pacific Journal on Computational Engineering, 3(1), 1.

[20]. Sidik, N. A. C., Yazid, M. N. A. W. M., & Mamat, R. (2015). A review on the application of nano fluids in vehicle engine cooling system. International Communications in Heat and Mass Transfer, 68, 85-90.

[21]. Islam, M. R., Shabani, B., Rosengarten, G., & Andrews, J. (2015). The potential of using nanofluids in PEM fuel cell cooling systems: A review. Renewable and Sustainable Energy Reviews, 48, 523-539.

[22]. Naik, R. G., Mohite, A. S., & Dadi, J. F. (2015, November). Experimental evaluation of heat transfer rate in automobile cooling system by using nanofluids. In ASME 2015 International Mechanical Engineering Congress and Exposition. American Society of Mechanical Engineers Digital Collection.

[23]. Baskar, S., & Rajaraman, R. (2015). Airflow Management in Automotive Engine Cooling System Overview. International Journal of Thermal Technologies, 5(1), 1-8.

[24]. Bupesh Raja, V. K., Unnikrishnan, R., & Purushothaman, R. (2015). Application of Nanofluids as Coolant in Automobile Radiator– An Overview. In Applied Mechanics and Materials (Vol. 766, pp. 337-342). Trans Tech Publications.