

Effect of nano fluid in multi-cylinder four stroke petrol engine: Review

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Abstract - Now days the demand of automobile vehicles is on peak. The performance of an engine depends and affects by various systems like cooling systems, fuel supply systems, lubrication system, transmission system etc. The radiator is an important accessory of vehicle cooling system in the engine. Normally, it is used as a cooling system of the engine and generally, the water is the heat transfer medium. Nanofluids have attracted attention as a new generation of heat transfer fluids in automotive cooling applications because of their excellent thermal performance. The use of additives is a technique applied to enhance the heat transfer performance of base fluids. The fluids with these nanometer-sized particles suspended in them which are metallic or nonmetallic nanoparticles change the transport properties and heat transfer characteristics of the base fluid. One of important applications of nanofluid is for automotive cooling system. This review summarizes recent developments in research on automotive cooling system using nanofluid as a coolant.

Key Words: Nano-fluid, Radiator, Heat transfer, I.C.engine, Cooling, Thermal conductivity.

1. INTRODUCTION:

Efficiency of the cooling system can increase by mixing the nano fluids with the base fluids in some ratio. The base fluid used in radiator is Water, Ethylene- or ethylene glycols and other coolants. A Nanofluid is a fluid containing nanometer-sized particles, called nanoparticles. The main objective of the project is to improve the efficiency of the radiator cooling system. Conventional heat transfer fluids such as Water, mineral oil, and ethylene glycol play an important role in many industries including power generation, chemical production, air conditioning, transportation, and microelectronics. This new type of heat transfer suspension is referred as a nano fluid. In particular, carbon nano tube-containing nano fluids provide several advantages over conventional fluids, including thermal conductivities far above those of traditional solid/liquid suspensions, a nonlinear relationship between thermal conductivity and concentration, strongly temperature-dependent thermal conductivity, and a significant increase in critical heat flux. An emerging and new class of coolants is nano fluids which consist of a carrier liquid, such as water, dispersed with tiny nano-scale particles known as nanoparticles. Purpose-designed nanoparticles of e.g. CuO, alumina, titanium dioxide, carbon nano tubes, silica, or metals (e.g. copper, or silver nano rods) dispersed into the carrier liquid the enhances the heat transfer capabilities of the resulting coolant compared to the carrier liquid alone. The enhancement can be theoretically as high as 350% [1]. The experiments however did not prove so high thermal conductivity improvements, but found significant increase of the critical heat flux of the coolants.

2. Types of Nano fluid:

Nanomaterials can be classified generally into: Natural and Artificial

Natural nanomaterials: materials having biological systems for example viruses (capsid), substances in our bone matrix, etc.

Artificial nanomaterials: These are the ones that are fabricated by different experiments. They can further sub-divided into 4 classes:

1. **Carbon Based:** These nanomaterials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes. Spherical and ellipsoidal carbon nanomaterials are referred to as **fullerenes**, while cylindrical ones are called nanotubes (**carbon nanotubes** (CNTs)).

2. **Metal Based:** These nanomaterials include quantum dots, nanogold, nano-silver and metal oxides, such as Al₂O₃, TiO₂, etc.

3. **Dendrimers:** These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. Also, because three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery.

4. **Composites:** Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. The composites may be any combination of metal based, carbon based or polymer based nanomaterials with any form of metal, ceramic, or polymer bulk materials

2.1 Properties of the Nano fluid:

Table -1 [Properties of the Nano Fluid]

| No | Nano Particals | Partical size (nm) | Thermal conductivity (W/m ⁰ K) | Density (g/cc) |
|----|------------------------------------|----------------------|---|------------------|
| 1 | Al ₂ O ₃ [3] | 20 - 50 | 25 - 35 | 3.7 - 3.9 |
| 2 | Bi ₂ O ₃ | 30 -60 | 4 - 10 | 6.5 - 8.1 |
| 3 | CuO[4] | 20 - 60 | 20 - 28 | 6.3 - 6.49 |
| 4 | TiO ₂ [15] | 10 - 100 | 7 - 12 | 4.1 - 4.29 |
| 5 | ZnO [16] | 15 - 40 | 20 - 25 | 5.2 - 5.7 |

As shown in table we can choose aluminium oxide coating because it has high thermal conductivity compare to other nano-fluid which can improve the heat transfer rate during working operation of engine.

2.2 Effect of Nano fluid on various Parameter [20][21] :

- **Effect of particle volume fraction :**

The research reports show an increase in thermal conductivity with an increase in particle volume fraction and the relation found linear [7].

- **Effect of particle material:**

Most of the studies show that particle material is an important parameter that affects the thermal conductivity of nano fluids.

- **Effect of base fluid :**

According to the conventional effective medium theory as the base fluid thermal conductivity [11] decreases, the effective thermal conductivity of a nanofluid increases.

- **Effect of particle size :**

Different types of nanofluids offers the processing of nanoparticles of various sizes in the range of 5-500 nm. It has been found that the particle sizes of nanoparticles have a significant role in deciding the effective thermal conductivity of nanofluids.

- **Effect of particle shape :**

We know that 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 nanofluids.

- **Effect of temperature :**

In a nanofluid the increase in temperature enhances the collision between the nano particles and the formation of nanoparticle aggregates which result in a drastic change in the thermal conductivity of nanofluids.

- **Effect of sonication time :**

The ultrasonic vibration technique is the most commonly used technique for producing highly stable, uniformly dispersed nano suspensions by two step process. It has been found that the duration of the application of the ultrasonic vibration [10] has a significant effect on the thermal conductivity of nanofluids since it helps to reduce the clustering of nanoparticles.

3. Literature Review:

- 1. Analysis of radiator with Different types of Nano Fluids : Golakiya Satyamkumar, Sarvaiya Brijrajsinh, Makwana Sulay, Thumar Ankur, Rathwa Manoj / (2013) [1]**

In cooling system of automobile engine the water is evaporate at high temperature, so we need to add water and also water is low capacity of absorb heat. By using nano fluids in radiator instead of water, we can improve the thermal efficiency of radiator. So cooling effect of the radiator is improved and the overall efficiency of engine will increased.
- 2. Heat transfer and pressure drop characteristics of CeO₂/water nanofluid in plate heat exchanger : Arun Kumar Tiwari, Pradyumna Ghosh, Jahar Sarkar / (2013) [19]**

Experimental investigations have been taken to explore the heat transfer and pressure drop characteristics in a plate heat exchanger using CeO₂/water nanofluid as the coolant. The experiments were aimed for determining the heat transfer and pressure drop performance at the wide range of concentrations (0.5, 0.75, 1.0, 1.25, 1.5, 2.0 and 3 vol. %) for various fluid flow rates (1.0, 2.0, 3.0, 3.5, and 4.0 lpm). It was found that the nanofluid in plate heat exchanger has maximum of 39% higher heat transfer coefficient compared to water at optimum concentration of 0.75 vol. %. The heat transfer coefficient of the nanofluid increases with an increase in the volume flow rate of the hot water and nanofluid. Nanofluid yields significant heat transfer improvement with negligible rise in pressure drop at optimum concentration.
- 3. Heat transfer study on concentric tube heat exchanger using TiO₂-water-based nanofluid : Rohit S. Khedkar, Shriram S. Sonawane, Kailas L. Wasewar / (2014) [16]**

The heat-transfer characteristics of TiO₂-water nanofluids as a coolant in concentric tube heat exchanger are presented. The heat exchanger is fabricated from copper concentric inner tube. The results obtained from the nanofluids cooling in concentric tube heat exchanger are compared with those from base fluids as coolant. It is observed that the average heat transfer rates for nanofluids as a cooling media are higher than those for the water which is also used as cooling media, and this increases with concentration of nanofluid composition. The results of this study have technological importance for the efficient design of concentric tube heat exchanger to enhance cooling performance at low heat flux cooling systems.
- 4. Experimental investigation of convective heat transfer augmentation for car radiator using ZnO-water nanofluids : Hafiz Muhammad Ali, Hassan Ali, Hassan Liaquat, Hafiz Talha Bin Maqsood, Malik Ahmed Nadir / (2015) [15]**

ZnO nanoparticles have been added into base fluid in different volumetric concentrations (0.01%, 0.08%, 0.2% and 0.3%). The effect of these volumetric concentrations on the heat transfer performance for car radiator is determined experimentally. Fluid flow rate has been varied in a range of 7-11 LPM (liter per minute) (corresponding Reynolds number range was 17,500-27,600). Nanofluids showed heat transfer enhancement compared to the base fluid for all concentrations tested. The best heat transfer enhancement up to 46% was found compared to base fluid at 0.2% volumetric concentration. A further increase in volumetric concentration to 0.3% has shown a decrease in heat transfer enhancement compared to 0.2% volumetric concentration. Fluid inlet temperature was kept in a range of 45-55 °C.
- 5. Improving the cooling performance of automobile radiator with ethylene glycol water based TiO₂ nanofluids : Devireddy Sandhya , M. Chandra Sekhara Reddy, Veeredhi Vasudeva Rao / (2016) [14]**

In this paper, the performance of ethylene glycol and water based TiO₂ nanofluids as an automobile radiator coolant is determined experimentally. Nanofluids were prepared taking 40% ethylene glycol and 60% water with volume concentrations of 0.1%, 0.3% and 0.5% of TiO₂ nano powder. All the experiments were conducted in the range of Reynolds numbers from 4000 to 15,000. In all the experiments the nanofluids made to flow through the radiator tubes with elliptical cross section and airflows with constant speed in the crosswise direction in between the tubes of a tube bundle. Results demonstrate that increasing the fluid circulation rate can improve the heat transfer performance while the fluid inlet temperature to the radiator has little or no effect. Nanofluids investigated in the present work with low concentrations enhanced the heat transfer rate up to 37% in comparison with base fluid.
- 6. Experimental investigation of heat transfer enhancement in helical coil heat exchangers using water based CuO nanofluid : P.J. Fule, B.A. Bhanvase, S.H. Sonawane / (2017) [17]**

The present work deals with the study of heat transfer enhancement using water based CuO nanofluids in the helical coil heat exchanger. Nanofluids with various volume percentage between 0 and 0.5 of CuO nanoparticles and their flow rate between and LPH (Reynolds number ranging from 812 to 1895, Laminar flow regime) were considered in the present study. It has been found that the increase in the loading of CuO nanoparticles in base fluid shows a significant enhancement in the heat transfer coefficient of nanofluid. In the present study, at 0.1 vol% concentration of CuO nanoparticles in nanofluid, enhancement in heat transfer coefficient was 37.3% as compared to base fluid while at 0.5

vol%, it is as high as 77.7%. Also with the increase in the flow rate of the CuO nanofluid, significant increase in heat transfer coefficient was observed.

- 7. Discrete phase numerical model and experimental study of hybrid nanofluid heat transfer and pressure drop in plate heat exchanger : Atul Bhattad, Jahar Sarkar[✉], Pradyumna Ghosh / (2017) [13]**
In the present study on the plate heat exchanger using hybrid nanofluid (Al₂O₃ +MWCNT/water) at different concentration to investigate its effect on heat transfer and pressure drop characteristics. By using hybrid nanofluid, heat transfer coefficient enhances by 39.16% (merit) with negligible increase in pumping power of 1.23% (demerit). An enhancement in heat transfer and pressure drop characteristics; and hence on the effectiveness of plate heat exchanger has been observed while using hybrid nanofluids instead of base fluid.
- 8. Thermos-physical properties and heat transfer characteristics of water/ anti-freezing and Al₂O₃/CuO based nanofluid as a coolant for car radiator : Alhassan Salami Tijani, Ahmad Suhail bin Sudirman / (2017) [4]**
The use of nano-sized (1–100 nm) solid particles as an additive suspended in the base fluid is one of the technique to enhancement heat transfer. For the based fluid, a mixture of water and Ethylene Glycol were used with concentration of 50% for each of the fluid. Al₂O₃ and CuO nano particles of concentration 0.05% , 0.15% and 0.3% were added to the base fluid and then evaluate the heat transfer characteristics of the nanofluid. The mass flow rate of nanofluid in the flat tube was kept constant. It was found that the nanofluid that exhibited the highest heat transfer performance was the CuO nanofluid. The heat transfer coefficient was recorded at 36384.41 W/m² K, the thermal conductivity was 1.241 W/m K, Nusselt number was 208.71 and the rate of heat transfer was at 28.45 W.
- 9. Experimental investigation of heat transfer potential of Al₂O₃/ Water-Mono Ethylene Glycol nanofluids as a car radiator coolant : Dattatraya G. Subhedara, Bharat M. Ramani, Akhilesh Gupta / (2017) [3]**
In this research, the heat transfer potential of Al₂O₃/Water-Mono Ethylene Glycol nanofluids is investigated experimentally as a coolant for car radiators. The base fluid was the mixture of water and mono ethylene glycol with 50:50 proportions by volume. The stable nanofluids obtained by ultra-sonication are used in all experiments. In this study nanoparticle volume fraction, coolant flow rate, inlet temperature used in the ranges of 0.2–0.8%, 4–9.1 per minute and 65–85 °C. The results show that the heat transfer performance of radiator is enhanced by using nanofluids compared to conventional coolant. Nanofluid with lowest 0.2% volume fraction 30% rise in heat transfer is observed. Also the estimation of reduction in frontal area of radiator if base fluid is replaced by Nanofluid is done which will make lighter cooling system, produce less drag and save the fuel cost.
- 10. Turbulent flow of Al₂O₃-water nanofluid through plate-fin heat exchanger (PFHE) with offset-strip channels : Morteza Khoshvaght-Aliabadi, Majid Salami / (2018) [2]**
The forced convective turbulent flow of Al₂O₃-water nanofluid through the offset strip channel is studied numerically. The mixture model is applied to model the Al₂O₃-water nanofluid flow. The studied parameters are the channel height (5, 10, and 15 mm), channel length (50, 100, and 150 mm), Reynolds number (6000–22,000), and nanoparticles concentration (0–4%). It is found that the channel height has the greatest effect on thermalhydraulic performance of the offset-strip channel, and the strip thickness comes in the second. Also, the nanofluid shows a better performance in comparison with the base fluid. Some equations are developed for the Al₂O₃-water nanofluid flow across the offset-strip channel, as function of Reynolds number, nanoparticles concentration, and geometrical parameters.

4. Research Gap:

- Nanofluids seem to be potential replacement of conventional coolants in engine cooling system. Recently there have been considerable research findings highlighting superior heat transfer performances of nanofluids.
- Nanofluids can be used for a wide variety of industries, ranging from transportation to energy production and in electronics systems.
- Here we are trying to increase heat transfer rate in car radiator with nanofluid like Al₂O₃ and Bi₂O₃.

5. Objectives of Present study:

The objective of present study is to increase the Heat transfer as well as reuse the hot water which comes from the engine outlet to prevent the loss of water in the engine by using nano fluid which increases the rate of heat transfer during the working operation of engine.

6. Conclusions:

- It has been seen that nanofluids can be considered as a potential candidate for Automobile application.
- As heat transfer can be improved by nanofluids, in Automobile radiators can be made energy efficient and compact.
- Reduced or compact shape may results in reduced drag, increase the fuel economy, reduce the weight of vehicle.
- The average heat transfer rates for nanofluids as a cooling media are higher than those for the water which is also used as cooling media, and this increases with concentration of nanofluid composition.
- Heat-transfer characteristics of nanofluids improve with Reynold's number and concentration of nanofluid significantly as compared to base fluids.

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