International Journal of Mechanical and Industrial Technology **ISSN 2348-7593 (Online)**
Vol. 7, Issue 2, pp: (32-37), Month: October 2019 - March 2020, Available at: www.researchpublish.com

Effect of nano fluid in cooling systems

Rudradeep Goutam[1], Mayank Sharma[2], Dr D N Naresh[3]

[1]UG student, Mechanical Engineering Department, SMCET, Sawai Madhopur

[2]Assistant Professor, Mechanical Engineering Department, SMCET, Sawai Madhopur

[3]Principal, SMCET, Sawai Madhopur, mjrptech@gmail.com

Abstract: **Automobile is an important sector of engineering. As the vehicles demand increase it will become more necessary to make advancements in technologies. Petrol engine have various systems like cooling system, lubricating system, fuel supply system which affects the efficiency and performance of an engine directly or indirectly. Cooling system is an important part of engine. Basically radiators are used in engines for cooling purpose, in which water is used as coolant or heat transfer medium. Water has a very good heat carrying capacity but it has some limitations. It have been seen that some nano particles have excellent properties to work as coolant in automobile technologies. Use of nano fluids as a coolant will help to overcome from various limitations of base fluid and also enhance the performance of radiator. Various studies have been conducted on the performance of nano fluids as coolants in automobile radiators. This paper summaries the review about uses of nano particles or nano fluids as a coolant in automobile system.**

Keywords: **Radiator, Nano-fluid, I.C.engine, Thermal conductivity Cooling, Heat transfer.**

1. INTRODUCTION

In 1872, American George Brayton invented the first commercial liquid-fueled internal combustion engine. After this the improvement in the generation of engines will starts. The main objective was to increase the performance of the engine. In this series Nikolas Otto, worked with Gottlieb Daimler and Wilhelm Maybach and patented compressed charged four stroke cycle engine in 1876 and so on. It is well known that there are various systems in an engine which requires for conducting the engine work. Advancements in these systems are quiet necessary to fulfill the requirement and increase the efficiencies of an engine. There are various factors in which cooling system is also one which affects the engine performance. Cooling system is used in a system to remove heat from the system and removal of heat will results as increment in engine performance with increment in life of engine. Efficiencies of these cooling systems can be increased by using nano fluids with the base fluids in same ratio. Nano fluid is the fluid containing nano sized particles called nano particles. Normally water, Ethylene- or ethylene glycols and other coolants are used as a base fluid in radiators. These conventional fluids like water, mineral oil, and ethylene glycol play an important role in many industries including power generation, chemical production, air conditioning, transportation, and microelectronics. The nano fluid exhibits different thermo physical properties than the base fluid. Generally thermal conductivity of nano fluids is higher than the base fluid which increases the heat transfer rate. The heat transfer enhancement using nano fluid mainly depends on type of nano particles, size of nano particles and concentration of nano particles in base fluid. 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%. The experiments however did not prove so high thermal conductivity improvements, but found significant increase of the critical heat flux of the coolants.

2. APPLICATION OF NANOFLUID IN AUTOMOTIVE RADIATOR

Coolant must have good thermal properties such as coolant have high thermal conductivity, low freezing point and high boiling point can be used in radiators for cooling purpose. Conventional coolants used in radiators are water or mixture of water and ethylene glycol with certain additives, since these conventional coolant have very low thermal conductivity hence heat transfer rate from radiator is very low due to which we need to increase the surface area to get required heat

transfer rate, this makes the radiator bulky, increase the material cost and also occupies large space in automobile, hence aesthetically vehicle not looking good. From above discussion we conclude that there is a need of new type of coolant in automotive cooling system. From the last decade researchers try to use nanofluid as a coolant in automotive radiator and very good results are obtained from their work. As we know that metals or metal oxides have good thermal conductivity compared to liquids so if we mix the nano sized metals or metal oxides particles in base fluid then the resultant mixture expected to have larger thermal conductivity than the base fluid hence we get a good heat transfer rate. Due to the use of nano sized particles the problem related to sedimentation and pressure drop is negligible and hence nanofluid is able to use as a coolant in automobile radiators.

3. TYPES OF NANO MATERIALS

Nano materials can be classified into two categories:

1. Natural nanomaterials:- These are nano materials which are obtained directly form nature. Simply these are obtained from biological systems like viruses (capsid), substances in our bone matrix, etc.
2. Artificial nanomaterials:- These are nano material which are obtained by research and development in laboratories. These are man made and further divided into 4 different catagories:-

(a) Carbon based: The nano materials having carbon as their main constituents are called carbon based artificial nano materials. Commonly taken in the form of a hollow sphere, ellipsoids, or tubes. These nano materials (hollow sphere and ellipsoids) are referred as fullerenes, whereas cylindrical ones are called carbon nanotubes(CNTs).

(b) Metal based: The nano materials having metals as their main constituents are called metal based artificial nano materials. These are including nanogold, quantum dots, nano-silver and metal oxide such as such as Al2O3, TiO2, etc.

(c) Dendrimers: The nano materials having nanosized polymers built from branched units as their main constituents are called dendrimers. The surface of a dendrimer has chain ends, which can be tailored to perform specific chemical functions. Three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery. This property could also be useful for catalysis.

(d) 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.

4. PROPERTIES OF THE NANO FLUID

Properties of some nano materials are as follows as given in table below:

No	Nano Particals	Partical size(nm)	Density (g/cc)	Thermal conductivity (W/m0K)
1	ZnO	15-40	5.2 – 5.7	20-25
2	TiO2	10-100	5.2 – 5.7	7-12
3	Bi2O3	30-60	6.5 – 8.1	4-10
4	CuO	20-60	6.3 - 6.49	20-27
5	Al2O3	20-50	3.7 - 3.9	25-35

From the above table we can say that aluminum oxide (Al2O3) can be used as nano fluid for cooling purpose in the engine because it has highest thermal conductivity which will increase the cooling rate of radiator.

5. EFFECT OF NANO FLUID ON VARIOUS PARAMETER

(a) 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.

(b) 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.

(c) Effect of particle material: Most of the studies show that particle material is an important parameter that affects the thermal conductivity of nano fluids.

(d) 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.

(e) Effect of base fluid: According to the conventional effective medium theory as the base fluid thermal conductivity decreases, the effective thermal conductivity of a nanofluid increases.

(f) 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.

(g) 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 has a significant effect on the thermal conductivity of nanofluids since it helps to reduce the clustering of nanoparticles.

6. LITERATURE REVIEW

(a) Heat transfer and pressure drop characteristics of CeO2/water nanofluid in plate heat exchanger : Arun Kumar Tiwari, Pradyumna Ghosh, Jahar Sarkar / (2013)

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.

(b) Analysis of radiator with Different types of Nano Fluids : Golakiya Satyamkumar, Sarvaiya Brijrajsinh, Makwana Sulay, Thumar Ankur, Rathwa Manoj / (2013)

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.

(c) Heat transfer study on concentric tube heat exchanger using TiO2–water-based nanofluid : Rohit S. Khedkar, Shriram S. Sonawane, Kailas L. Wasewar / (2014)

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.

(d) 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)

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 ºC.

(e) Improving the cooling performance of automobile radiator with ethylene glycol water based TiO_2 nanofluids : Devireddy Sandhya , M. Chandra Sekhara Reddy, Veeredhi Vasudeva Rao / (2016)

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.

(f) 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)

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.

(g) 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)

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.l 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.

(f) 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)

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.

(g) Thermos-physical properties and heat transfer characteristics of water/ anti-freezing and Al_2O_3/CuO based nanofluid as a coolant for car radiator : Alhassan Salami Tijani, Ahmad Suhail bin Sudirman / (2017)

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.

(h) Turbulent flow of Al_2O_3-water nanofluid through plate-fin heat exchanger (PFHE) with offset-strip channels : Morteza Khoshvaght-Aliabadi, Majid Salami / (2018)

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.

7. FUTURE SCOPE

Nano fluids seem to a potential replacement of conventional coolant in engine and other cooling system. There are various researches conducting globally to know about the impacts of nano fluids as coolant in radiators. The studies have been proved that these nano fluids can increase heat transfer rate due to their high thermal conductivity. Nanofluids can used widely in the industries, in various transportation system, energy production and electronic systems. Here we have studied that in car radiator the the heat transfer rate can be increased with nanofluid like Al2O3 and Bi2O3. The main reason for the heat transfer enhancement of nanofluids is that the suspended nanoparticles increase the thermal conductivity of the fluids, but exact mechanism of heat transfer enhancement is still unclear so that further studies must be required

8. CONCLUSIONS

From the different reviewed literature we can conclude that:-

- The nanofluids have high potential for heat transfer enhancement and are highly suited for automotive cooling system.
- Reduced and compact shape can reduce drag, reduced the weight of vehicle and increase the fuel economy.
- The main reason for the heat transfer enhancement of nanofluids is that the suspended nanoparticles increase the thermal conductivity of the fluids, but exact mechanism of heat transfer enhancement is still unclear so that further studies must be required.
- Heat-transfer characteristics of nanofluids improve with Reynold's number and concentration of nanofluid significantly as compared to base fluids.

REFERENCES

[1] Stephen U. S. Choi, J.A. Eastman, “Enhancing thermal conductivity of fluids with nanoparticles,” Energy technology division and Material science division Argonne National Laboratory, Argonne IL60439, January 1955.

[2] A.E. Kabeel, T. Abou El Maaty, Y. El Samadony, “The effect of using nano-particles on corrugated plate heat exchanger,” International Journal of Applied Thermal Engineering 52, 2013.

[3] S. Zeinali Heris, M. Nasr Esfahany, S.Gh. Etemad, “Experimental investigation of convective heat transfer of Al_2O_3/water nanofluid in circular tube, International Journal of Heat and Fluid Flow 28, 2007.

[4] Golakiya Satyamkumr, Sarvaiya Brijrajsinh , Makwana Sulay ,Thumar Ankur , Rathwa Manoj - Analysis of Radiator with different types of Nano fluids, Journal of Engineering Research and Studies E-ISSN0976-7916.

[5] Morteza Khoshvaght-Aliabadi , Majid Salami - Turbulent flow of Al2O3-water nanofluid through plate-fin heat exchanger (PFHE) with offset-strip channels, Thermal Science and Engineering Progress 6 (2018) 164–176.

[6] Rahul Tarodiya, Jahar Sarkar - Cooling of an internal combustion engine using nanofluids: A review National Conference on "Advances in Thermal Engineering" Paper Code- 2.2.

[7] Dattatraya G. Subhedar , Bharat M. Ramani , Akhilesh Gupta Experimental investigation of heat transfer potential of Al2O3/ Water-Mono Ethylene Glycol nanofluids as a car radiator coolant, Case Studies in Thermal Engineering 11 (2018) 26–34.

[8] Rahul Tarodiya, Jahar Sarkar, Jeewan Vachan Tirkey - Performance of flat fin tube automotive radiator using nanofluids as coolants, National Conference on Emerging Trends in Mechanical Engineering (ETME – 2012).

[9] R.B. Ganvir, P.V. Walke, V.M. Kriplani - Heat transfer characteristics in nanofluid - A review Renewable and Sustainable Energy Reviews 75 (2017) 451–460.

[10] Parashurama M, Dr. Dhananjaya D, Naveena Kumar R - Experimental Study of Heat Transfer in a Radiator using Nanofluid, 2015 IJEDR | Volume 3, Issue 2 | ISSN: 2321-9939.

[11] Ummal Salmaan N, Senthilnathan A K, Suseendran K. - Improving Performance in Engine Cooling System using Nanofluid-Based Coolant, 2016 IJEDR | Volume 4, Issue 2 | ISSN: 2321-9939.

[12] Dr. Channankaiah, D. Arunpandiyan - A Review of Automotive Radiator Performance, IJIRST Volume 2 | Issue 10 ISSN (online): 2349-6010.

[13] Virendra R. Patil, Samip S. Patil, Vishal Kumbhar, KishoreKolhe - Review of Problems of Heat Transfer in Car Radiator and Suggested Solutions, 2017 IJSDR | Volume 2, Issue 1 ISSN: 2455-2631.

[14] JP Yadav, Bharat Raj Singh - Study on Performance Evaluation of Automotive Radiator, S-JPSET : ISSN : 2229-7111, Vol. 2, Issue 2.

[15] Atul Bhattad, Jahar Sarkar, Pradyumna Ghosh - Discrete phase numerical model and experimental study of hybrid nanofluid heat transfer and pressure drop in plate heat exchanger, International Communications in Heat and Mass Transfer 91 (2018) 262–273.

[16] Lazarus Godson, B. Raja, D. Mohan Lal, S. Wongwises, "Enhancement of heat transfer using nanofluids-An overview," International Journal of Renewable and Sustainable Energy Reviews 14, 2010

[17] S. Senthilraja, KCK. Vijayakumar, "Analysis of Heat Transfer Coefficient of CuO/Water Nanofluid using Double Pipe Heat Exchanger," International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 6, Number 2013.

[18] Hafiz Muhammad Ali, Hassan Ali, Hassan Liaquat, Hafiz Talha Bin Maqsood, Malik Ahmed Nadir - Experimental investigation of convective heat transfer augmentation for car radiator using ZnO water nanofluids Energy 84 (2015) 317e324.

[19] Nor Azwadi Che Sidik , H.A. Mohammed, Omer A. Alawi, S. Samion - A review on preparation methods and challenges of nanofluids International Communications in Heat and Mass Transfer 54 (2014) 115–125.

[20] Purna Chandra Mishra, Santosh Kumar Nayak, Pratik M, Sayantan Mukherjeitra - Application and Future of Nanofluids in Automobiles: An Overview on Current Research.