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Analysis of IC Engine Performance Using Nano Fluid as Coolant in Radiator – A Review

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Abstract : *Looking into the present day need of automobile heat disposal methods, many researchers are exploring the best means to absorb and dissipate the heat from an engine in an efficient manner. Many automobile giants have invested enormous time and money in this field to analyze overall heat transfer coefficient with variety of fluids. The recent developments were use of nano particles in the base fluids as heat transfer medium. Water and ethylene glycol as conventional coolants have been widely used in an automotive car radiator for many years. These heat transfer fluids offer low thermal conductivity. With the advancement of nano technology, the new generation of heat transfer fluids called, "nano fluids" have been developed and researchers found that these fluids offer higher thermal conductivity compared to that of conventional coolants.*

Nano fluid is a new type of heat transfer fluid with superior thermal performance characteristics, engineered by dispersing metallic or non-metallic nano particles with a typical size of less than 100 nm in the conventional heat transfer fluids. Their use remarkably augments the heat transfer potential of the base liquids. In this paper, many papers of cooling using nano fluids made of different nano particles have been studied to check the possibilities of using these nano fluids in the IC engine radiator cooling. It is found that Nano fluid is very effective in cooling than the conventional cooling fluid and using these coolants in the IC Engine Radiator, good results of IC engine performance can be obtained.

Keywords— *Nano Particles, Nano fluid, Heat transfer coefficient, TiO_2, Al_2O_3, CuO, MWCNT, ZnO, SiO_2, EG.*

I. INTRODUCTION

Cooling is one of the top technical challenges to obtain the best automotive design in multiple aspects (performance, fuel consumption, aesthetics, safety, etc.). Automotive radiator is an important part of the engine cooling system. Due to limited space at the front of the engine, the size of the radiator is restricted and cannot be essentially increased. Therefore, it is necessary to increase the heat transfer capabilities of working fluids such as water and ethylene glycol in radiators because of their low thermal conductivity. A recent advancement in nano technology has been the introduction of nano fluids, *i.e.* colloidal suspensions of nanometer-sized solid particles instead of common working fluids.

Effect of coolant Temperature on bsfc

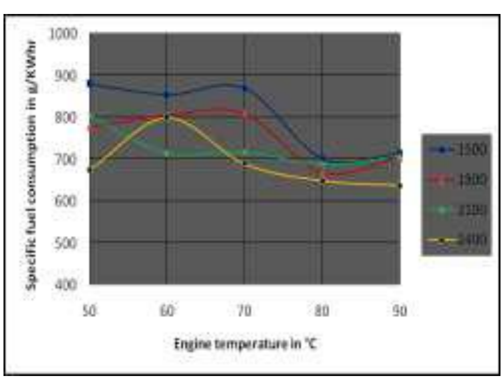

Fig. 1 Effect of engine temperature on specific fuel consumption with varying engine speed on 6 Kg load

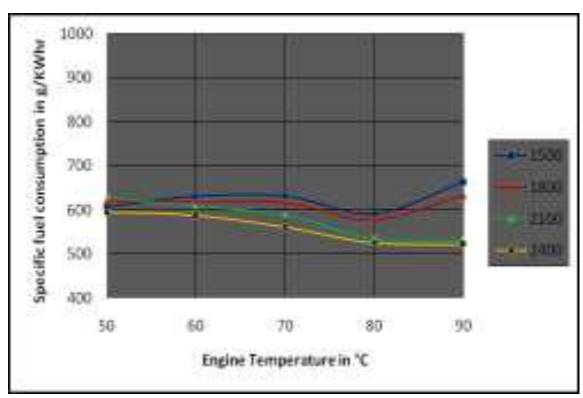

Fig 2 Effect of engine temperature on specific fuel consumption with varying engine speed and at 15 Kg load

Fig. 1 & 2 indicates that as the engine coolant temp. increases sfc decreases at almost all speeds and all loads. **[26]**

Effect of coolant Temperature on bhp

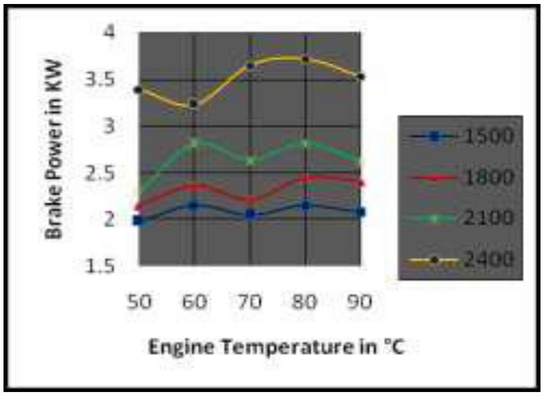

Fig-3 Effect of engine temperature on brake power with varying engine speed and at 6 Kg Engine Load

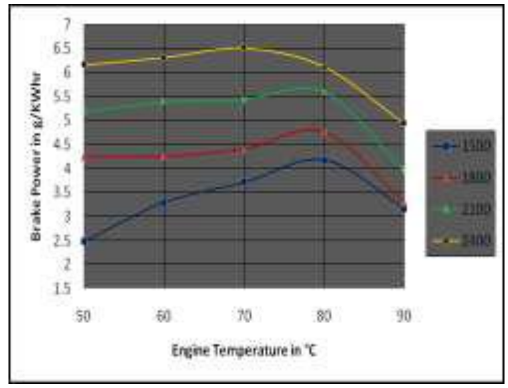

Fig-4 Effect of engine temperature on brake power with varying engine speed and at 12 Kg Engine Load

Fig.-3& 4 indicates that bhp of SI engine increases upto some limits of engine cooling than bhp decreases. **[26]**

Effect of coolant Temperature on emission

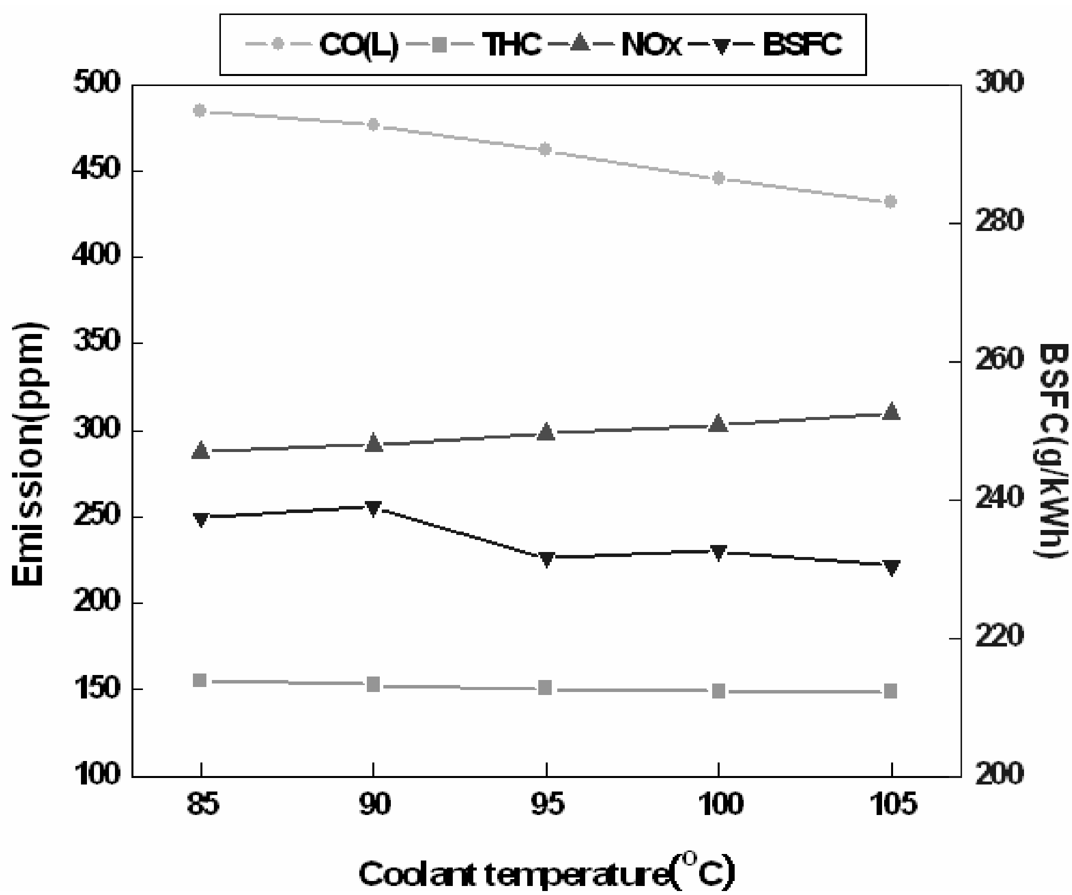

Fig. 5. Effect of coolant temperature on emission characteristics of diesel engine and BSFC.

For multi cylinder CI Engine, Fig.-5 shows that emission of CO decreases, emission of NOx slightly increases while emission of HC remains unaffected with cooling the engine From the Fig, it can also be obsereved that the for multi cylinder diesel engine, bsfc too decreases as the engine cooling increases.**[4]**

Nano fluids were first invented by **[1]** at the Argonne National Laboratory, USA. Compared with traditional solid-liquid suspensions containing millimeter or micrometer sized particles, nano fluids as coolants in the heat exchangers have shown better heat transfer performance because of small size of suspend solid particles. It causes that nano- fluids have a behavior similar to base liquid molecules. Because of their excellent thermal performance, nano- fluids have attracted attention as a new generation of heat transfer fluids in building heating, in heat exchangers, in chemical plants and in automotive cooling applications. Recently there have been considerable research findings highlighting superior heat transfer performances of nano fluids.

Heat transfer coefficient of different nano fluid is higher than that of the base liquid and increase with increasing the Reynolds number and particle concentrations. For the pressure drop, it is also shown that the pressure drop of nano fluids was slightly higher than the base fluid and increases with increasing the volume Concentrations. [6,7,9,15]. Internal combustion engine performance will be improved by 5-10% by using Nano particle suspended commercial engine coolant.[5].Viscosity of the nano fluid increases with increasing nano particle concentration and decreases with increase in temperature.[8,13]. The heat transfer enhancement of about 40% with Al_2O_3 nano fluid can be obtained compared to the base fluids.[10].Thermal conductivity of nano fluids with MWCNT can be increased up to 150%[11]. For CuO-water nano fluid at 2% volume concentration, the overall heat transfer coefficient and pumping power are more than that of base fluid.[12].Both relative viscosity and thermal conductivity ratio of dispersions of sub-micron TiO_2 particles vary linearly with particle concentration. By increasing the time of ultrasonication, sub-micron dispersions of lower relative viscosity and higher thermal conductivity ratio can be produced.[14].Nano coolant of MWCNT has a higher heat exchange capacity and efficiency than EG/W[16].Heat transfer rate and effectiveness is increased with increase in volume concentration of nano particles (ranging from 0% to 1% of Al_2O_3). More pumping power is needed for a radiator using nano fluid compared to that radiator using only base fluid.[18]. CFD Analysis results matches fairly with the experimental results of nano fluid performance in automobile radiator[19]. Thermal conductivity, viscosity, and density of the nano fluid increase with the increase of volume concentrations. However, specific heat of nano fluid was found to be decreased with the increase of nano particle volume concentrations. Moreover, by increasing the temperature, thermal conductivity and specific heat were observed to be intensified, while the viscosity and density were decreased.[21],[22]. There is increase in thermal conductivity and reduction in viscosity with ZnO–EG nano fluids compared to their respective base fluids.[20] The average heat transfer rates for TiO_2 nano fluids as a cooling media are higher than those for the water which is also used as cooling media, and this increases with concentration of nano fluid composition[24].The heat dissipation capacity and the EF of the NC are higher than EG/W, and that the TiO_2 NC is higher than the Al_2O_3 NC according to most of the experimental data.[25]

Advantages Of Nano Fluid

Nano fluid has the following advantages compared to base fluid:

- (i) high dispersion stability with predominant Brownian motion of particles
- (ii) reduced particle clogging as compared to convention slurries, thus promoting system miniaturization
- (iii) reduced pumping power as compared to pure liquid to achieve equivalent heat transfer intensification
- (iv) adjustable properties, including thermal conductivity and surface wet-ability, by varying particle concentrations to suit different applications
- (v) High specific surface area and therefore more heat transfer surface between particles and fluids
- (vi) Low Cost compared to EG base fluid

II. REVIEW OF LITERATURE:

The literature reviews with this topic is in below table with chronological order.

Table 2.1 ***Review of Various Literatures***

Sr. No.	Investigator	Year of publication	Investigation Parameter	Objective of the research	Conclusion
1	Stephen U. S. Choi and J. A. Eastman	ASME 1995	Enhancing thermal conductivity of fluids With nano particles	To propose an innovative new class of heat transfer fluids engineered by suspending metallic nano particles in conventional heat transfer fluids.	The feasibility of the concept of high-thermal-conductivity nano fluids has been demonstrated The resulting "nano fluids" are expected to exhibit high thermal conductivities compared to those of currently used heat transfer fluids, and they represent the best hope for enhancement of heat transfer.
2	Mohammad Mamun Dr. Md. Ehsan	International Conference on Mechanical Engineering, 2001	Effect of coolant temperature on performance of a SI Engine	To investigate the effect of variation of coolant temperature ranging from 45-85°C, thus effecting the heat removal rate, on the performance of an automotive SI engine.	-The change of water outlet temperatures in the range of 60-85°C did not show significant change on the power produced by the engine but some improvement was evident on the brake specific fuel consumption rate. - There were some variations in CO formation accompanied by small changes in CO_2 produced during combustion, as the water temperature was elevated.
3	Wenhua Yu, David M. France,Jules L. Routbor, And Stephen U. S. Choi,	Taylor and Francis Group,2008	Review and Comparison of Nano fluid Thermal Conductivity and Heat Transfer Enhancements	To study the enhancement of the thermal conductivity and convective heat transfer of nano fluids relative to conventional heat transfer fluids, and to make assessments of pertinent parameters of particle volume concentration, particle material, particle size, particle shape, base fluid material, temperature, additive and acidity.	Problems of nano particle agglomeration, settling, and erosion potential all need to be addressed in detail. Nano fluids used in experimental research need to be well characterized with respect to particle size, size distribution, and shape in order to make the results most useful. These aspects of nano fluid technology continue to be developed; however, the results to date are sufficient to identify some trends and magnitudes in nano fluid heat transfer enhancement.
4	Kyung-Wook Choi, Ki-Bum Kim and Ki-Hyung Lee	Journal of Mechanical Science and Technology ,2009	Investigation of emission characteristics affected by new cooling system in a diesel engine	To investigate the engine performance with change in coolant temperature	-THC and CO were reduced by approximately 10 % and 4%, respectively. when the coolant temperature was higher than 85°C. - In the case of decreasing coolant flow, THC and CO were reduced down to 20% during NEDC drive cycle.

					- In addition, the BSFC was reduced by approximately 3%. However, NOx emission was observed to increase
5	S. Senthilraja, M. Karthikeyan and R.Gangadevi	Nano-micro letters 2010	Nano fluid Applications in Future Automobiles: Comprehensive Review of Existing Data	To create the awareness on the promise of nano fluids and the impact it will have on the future automotive industry. Also to presents a comprehensive data of nano fluids application in automobile for various aspects.	1. The internal combustion engine performance will improve by 5-10% by using Nano particle suspended commercial engine coolant. 2. The vehicle life as well as the performance can be increased by enhancing the tribological properties (such as load carrying capacity, wear resistance and friction reduction between the moving components) of nano particle suspended lubricants. 3. The combustion of the fuel can improve and reduce the exhaust emission by using a nano particle catalyst °commercial fossil fuel
6	Weerapun Duangthongsuk, Somchai Wongwises	International Journal of Heat and Mass Transfer 2010	An experimental study on the heat transfer performance and pressure drop of TiO2-water nano fluids flowing under a turbulent flow regime	To study the heat transfer coefficient and friction factor of the TiO2-water nano fluids flowing in a horizontal double tube counter-flow heat exchanger under turbulent flow conditions, experimentally.	The results show that the heat transfer coefficient of nano fluid is higher than that of the base liquid and increase with increasing the Reynolds number and particle concentrations. For the pressure drop, the results show that the pressure drop of nano fluids was slightly higher than the base fluid and increases with increasing the volume Concentrations.
7	K.Y. Leong , R. Saidur , S.N. Kazi , A.H. Mamun	Applied Thermal Engineering, 2010	Performance investigation of an automotive car radiator operated with nano fluid-based coolants (nano fluid as a coolant in a radiator)	To study the application of ethylene glycol based copper nano fluids in an automotive Cooling system. Also to investigate the heat transfer enhancement of an automotive car radiator operated with nano fluid-based coolants.	It was observed that, overall heat transfer coefficient and heat transfer rate in engine cooling system increased with the usage of nano fluids (with ethylene glycol the Base fluid) compared to ethylene glycol (i.e. base fluid) alone. It is observed that, about 3.8% of heat transfer enhancement could be achieved with the addition of 2% copper particles in a base fluid at the Reynolds number of 6000 and 5000 for air and coolant respectively. In addition, the reduction of air frontal area was estimated.
8	Madhusree Kole, T.K. Dey.	Experimental Thermal and Fluid Science 2010	Viscosity of alumina nano particles dispersed in car engine coolant.	To describes experimental results on the viscosity of the nano fluid prepared by dispersing Alumina nano particles (<50 nm) in commercial car coolant.	While the pure base fluid display Newtonian behavior over the measured temperature, it transforms to a non-Newtonian fluid with addition of a small amount of alumina nano particles. Our results show that viscosity of

					the nano fluid increases with increasing nano particle concentration and decreases with increase in temperature.
9	Ravikanth S. Vajjha, Debendra K. Das, Praveen K. Namburu	International Journal of Heat and Fluid Flow,2010	Numerical study of fluid dynamic and heat transfer performance of Al_2O_3 and CuO nano fluids in the flat tubes of a radiator	To study a three-dimensional laminar flow and heat transfer with two different nano fluids, Al_2O_3 and CuO, in an ethylene glycol and water mixture circulating through the flat tubes of an automobile radiator numerically and to evaluate their superiority over the base fluid.	Convective heat transfer coefficient in the developing and developed regions along the flat tubes with the nano fluid flow showed marked improvement over the base fluid. Results for the local and the average friction factor and convective heat transfer coefficient show an increase with increasing particle volumetric concentration of the nano fluids. The pressure loss increases with increasing particle volumetric concentrations of nano fluids; however, due to the reduced volumetric flow needed for the same amount of heat transfer, the required pumping power diminishes.
10	S.M. Peyghambarzadeh, S.H. Hashemabadi , S.M. Hoseini, M. Seifi Jamnani	International Communications in Heat and Mass Transfer, 2011	Experimental study of heat transfer enhancement using water/ethylene glycol based nano fluids as a new coolant for car radiators	To determine the effect of Al_2O_3 nano fluid coolant on the heat transfer performance of the car radiator and to compare that with the the heat transfer performance of pure water and pure EG as base fluid	The results demonstrate that nano fluids clearly enhance heat transfer compared to their own base fluid. In the best conditions, the heat transfer enhancement of about 40% compared to the base fluids has been recorded. Results indicate that nano fluids have great potential for heat transfer enhancement and are highly suited to apply in practical heat transfer processes. This provides promising ways for engineers to develop highly compact and effective radiators for cars.
11	R. Saidura, K.Y. Leong, H.A. Mohammad	Renewable and Sustainable Energy Reviews 2011	A review on applications and challenges of nano fluids	To review and present Challenges and future directions of applications of nano fluids.	It was found that thermal conductivity of nano fluids with MWCNT can be increased up to 150% • As heat transfer (i.e. conduction, convective, boiling) can be enhanced by nano fluids, heat exchanging devices can be made energy efficient and compact. Reduced or compact shape may results in reduced drag for example in automobile and similar applications. • Nano fluids stability and its production cost are major factors that hinder the commercialization of nano fluids. By solving these challenges, it is expected that nano

					fluids can make substantial impact as coolant in heat exchanging devices.
12	Navid Bozorgan, Komalangan Krishnakumar2, Nariman Bozorgan1	Modern Mechanical Engineering 2012,	Numerical Study on Application of CuO-Water nano fluid in Automotive Diesel Engine radiator.	To investigate the application of CuO-water nano fluid with size of the nano particles of 20 nm and volume concentrations up 2% numerically in a radiator of diesel engine under turbulent flow conditions. The effects of the automotive speed and Reynolds number of the nano fluid in the different volume concentrations on the radiator performance are also to be investigated.	The results show that for CuO-water nano fluid at 2% volume concentration circulating through the flat tubes with *Renf* = 6000 while the automotive speed is 70 km/hr, the overall heat transfer coefficient and pumping power are approximately 10% and 23.8% more than that of base fluid for given conditions, respectively.
13	I.M.Mahbubul, R. Saidur, M.A. Amalina	International Journal of Heat and Mass Transfer, 2012	Latest developments on the viscosity of nano fluids.	To find the viscosity of various nano fluid with different concentration	The existing experimental results about the nano fluids viscosity show clearly that viscosity augmented accordingly with an increase of volume concentration and decreased with the temperature rise. Moreover, it is shown that particle size has some noteworthy effects over viscosity of nano fluids.
14	M. Silambarasan,S. Manikandan, K.S. Rajan	International Journal of Heat and Mass Transfer 2012	Viscosity and thermal conductivity of dispersions of sub-micron TiO2 particles in water prepared by stirred bead milling and ultrasonication	To study the effects of particle concentration (0.27–1.39 vol%), ultra sonication time (0–7 h) on viscosity and thermal Conductivity. Also to investigate the effect of temperature (29–55 °C) on viscosity.	The results showed that both relative viscosity and thermal conductivity ratio were found to vary linearly with particle concentration. By increasing the time of ultrasonication, sub-micron dispersions of lower relative viscosity and higher thermal conductivity ratio can be produced.
15	Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi.	Case Studies in Thermal Engineering, 2013	Heat transfer through heat exchanger using Al_2O_3 nano fluid at different concentrations	To study the forced convective heat transfer and flow characteristics of a nano fluid consisting of water and different volume concentrations (0.3–2)% of Al_2O_3 nano fluid (30 nm dia.) flowing in a horizontal shell and tube heat exchanger.	The results show that the convective heat transfer coefficient of nano fluid is slightly higher than that of the base liquid at same mass flow rate and at same inlet temperature. The heat transfer coefficient of the nano fluid increases with an increase in the mass flow rate, also the heat transfer coefficient increases with the increase of the volume concentration of the Al_2O_3 nano fluid, however increasing the volume concentration cause increase in the viscosity of the nano fluid leading to increase in

					friction factor.
16	Tun-Ping Teng, Chao-Chieh Yu	Experimental Thermal and Fluid Science 2013	Heat dissipation performance of MWCNTs nano-coolant for vehicle	To study the heat dissipation performance of a motorcycle radiator filled with multiwalled Carbon nano tubes (MWCNTs) nano-coolant (NC).	Experimental results show that the NC1 has a higher heat exchange capacity and EF than EG/W. The maximum enhanced ratios of heat exchange, pumping power, and EF for all the experimental parameters in this study were approximately 12.8%, 4.9%, and 14.1%, respectively, compared with EG/W. NC with high concentrations of MWCNTs cannot achieve a better heat exchange capacity because the uneven density of NC in the flow state increases the thermal resistance of the solid–liquid interface, effectively decreasing the contact area between the MWCNTs and the EG/W.
17	A.A. Abbasian Arani, J. Amani	Experimental Thermal and Fluid Science 2013	Experimental investigation of diameter effect on heat transfer performance and pressure drop of TiO_2–water nano fluid	To investigate the convection heat transfer characteristics in fully developed turbulent flow of TiO_2–water nano fluid. To study The effect of mean diameter of nano particles on the convective heat transfer and pressure drop at nano particle volume concentration from 0.01 to 0.02 % by volume	The results indicated higher Nusselt number for all nano fluids compared to the base fluid. It is seen that the Nusselt number does not increase by decreasing the diameter of nano particles generally. The results show that nano fluid with 20 nm particle size diameter has the highest thermal performance factor in the range of Reynolds number and volume concentrations were studied
18	Rahul A.Bhogare, B.S.Kothawal, Priti Pramod Bodkhe and Amol Gawali	International Journal of Thermal Technologies, 2014	Performance investigation of Automobile Radiator operated with Nano fluids Based Coolant	To observe the heat transfer performance of binary mixture EG+ water (50 %) volume concentration. Furthermore, to check the effect of different amounts of Al_2O_3 nano particle added into these base fluids on the heat transfer performance of the Automobile radiator.	Heat transfer rate and effectiveness is increased with increase in volume concentration of nano particles (ranging from 0% to 1%). Thermal performance of a radiator using nano fluid or mixture ethylene glycol+water (50% Volume concentration) coolant is increased with air Reynolds Number. Additional 3% pumping power is needed for a radiator using nano fluid of 1% Al_2O_3 particles at 0.000083 m3/s coolant volumetric flow rate compared to that of the same radiator using only pure ethylene glycol coolant. Thermal Conductivity increased by 3.05 % with increase in the volume concentration of Al_2O_3 particles in Base Fluid.
19	J.R. Patel, A.M.	IJRET, 2014	Effect of nano fluids and mass flow rate	To make Computational Fluid Dynamics (CFD)	Using CuO /water nano fluid as a coolant and 4 Kg/s mass flow rate

	Mavani		of air on heat transfer rate in automobile radiator by CFD analysis	modeling simulation of mass flow rate of air passing across the tubes and coolants in to the tubes of an automotive radiator.	of air optimum performance of radiator can be performed. CFD Analysis results fairly matches with the experimental results which show that CFD analysis is a good tool for avoiding costly and time consuming experimental work.
20	K.S. Suganthi, V. Leela Vinodhan, K.S. Rajan	Applied Energy, 2014	Heat transfer performance and transport properties of ZnO–ethylene glycol and ZnO–ethylene glycol–water nano fluid coolants	To carry out an experiments on preparation and characterization of ZnO–ethylene glycol (EG) and ZnO–Ethylene glycol–water nano fluids and to analyze their performance as coolants.	ZnO–EG nano fluids containing 4 vol. % nano particles showed thermal conductivity enhancement of 33.4% and viscosity reduction of 39.2% at 27°C. Similarly, 2 vol. % ZnO–EG–water nano fluids showed thermal conductivity enhancement of 17.26% and viscosity reduction of 17.34% at 27°C.Disturbance of hydrogen bonding network of ethylene glycol by ZnO nano particles resulted in reduced dispersion viscosity. Transient heat transfer experiments showed that ZnO–EG and ZnO–EG–water nano fluids had better heat absorption characteristics compared to their respective base fluids.
21	M.M. Elias, I.M. Mahbubul, R. Saidur, M.R. Sohel, I.M. Shahrul, S.S. Khaleduzzaman, S. Sadeghipour	International Communications in Heat and Mass Transfer 2014	Experimental investigation on the thermo-physical properties of Al_2O_3 Nano particles suspended in car radiator coolant.	To present new findings on the thermal conductivity, viscosity, density, and specific heat of Al_2O_3 nano particles dispersed into water and ethylene glycol based coolant used in car radiator.	It was found that thermal conductivity, viscosity, and density of the nano fluid increased with the increase of volume concentrations. However, specific heat of nano fluid was found to be decreased with the increase of nano particle volume concentrations. Moreover, by increasing the temperature, thermal conductivity and specific heat were observed to be intensified, while the viscosity and density were decreased
22	Salma Halelfadl, Thierry Maré, Patrice Estellé	Experimental Thermal and Fluid Science 2014	Efficiency of carbon nano tubes water based nano fluids as coolants.	To study the thermo-physical properties of water-based nano fluids containing carbon nano tubes, experimentally. To investigate the effect of low nano particle volume fraction on density, thermal conductivity and viscosity of nano fluids.	Based on these experimental results, the following conclusions are drawn: – The density is independent of temperature and increases with particle volume fraction. A similar trend is reported for the relative density. – The relative thermal conductivity increases with nano particle volume fraction and temperature. – The relative viscosity of nano fluids is affected by both the increase in nano particle volume fraction and shear rate.

23	M. Ebrahimi, M. Farhadi, K. Sedighi, S. Akbarzade	International Journal of Engineering,2014	Experimental Investigation of Force Convection Heat Transfer in a Car Radiator Filled with SiO_2-water Nano fluid	To investigate experimentally the effect of adding SiO_2 nano particle to base fluid (water) in car radiator is	Results show that Nusselt number increases with increase of liquid inlet temperature, nano particle volume fraction and Reynolds number.
24	Rohit S. Khedkar, Shriram S. Sonawane, Kailas L. Wasewar	International Communications in Heat and Mass Transfer 2014	Heat transfer study on concentric tube heat exchanger using TiO_2–water based nano fluid	To study the heat-transfer characteristics of TiO_2–water nano fluids as a coolant in concentric tube heat exchanger.	It is observed that the average heat transfer rates for nano fluids as a cooling media are higher than those for the water which is also used as cooling media, and this increases with concentration of nano fluid composition.
25	Hwa-Ming Nieh, Tun-Ping Teng, Chao-Chieh Yu	International Journal of Thermal Sciences 2014	Enhanced heat dissipation of a radiator using oxide nano-coolant	To measure the thermal conductivity, viscosity, and specific heat of the NC with different concentrations of nano particles and sample temperatures, and then to evaluate its heat dissipation capacity, pressure drop, and pumping power under different volumetric flow rates and heating temperatures in an air-cooled radiator.	The experimental results show that the heat dissipation capacity and the EF of the NC are higher than EG/W, and that the TiO_2 NC is higher than the Al_2O_3 NC according to most of the experimental data. The maximum enhanced ratios of the heat dissipation capacity, pressure drop, pumping power, and EF for all the experimental parameters are approximately 25.6%, 6.1%, 2.5%, and 27.2%, respectively, compared with EG/W. Overall, the NC improves the heat dissipation capacity and EF of the cooling system; however, the enhanced ratio of the pressure drop and pumping power is not obvious in this study.
26	Sunil Choudhary, A.C. Tiwari, Ajay Vardhan, Arvind Kaushal	International Journal of Engineering Research and General Science, 2014	The Effect of Engine Temperature on Multi Cylinder SI Engine Performance with Gasoline as a fuel	To examine engine performance parameter specific fuel consumption (SFC), brake power (BP) and with varying engine temperature and at different engine speed in rpm with respect to different engine loads in Kg.	It is concluded that if engine temperature is increased there is some fall in specific fuel consumption but brake power is unaffected but when increase in engine speed there is some decrement in specific fuel consumption and brake power is increased. It is also affected by applying different load on the engine.

III. CONCLUSION

In this review article, Following results were obtained.

1. The use of **TiO2**- water nano fluid gives significantly higher heat transfer coefficients than those of the base fluid. At 1.0 vol. %, the heat transfer coefficient of nano fluids was approximately 26% greater than that of pure water.

2. Heat transfer rate is increased with increase in volume concentration of nano particles (ranging from 0% to 2%). About 3.8% heat transfer enhancement was achieved with addition of 2% **coppe**r particles. Estimated 18.7% reduction of air frontal area is achieved by adding 2% copper nano particles.
3. For a 10% **Al_2O_3** nano fluid, the percentage increase in the average heat transfer coefficient over the base fluid is 94% for a 10%,
4. For a 6% **CuO** nano fluid, the percentage increase in the average heat transfer coefficient over the base fluid is 89%.
5. The thermal conductivity of nano fluids with **MWCNT** can be increased up to 150%
6. **ZnO**– EG nano fluids containing 4 vol. % nano particles showed thermal conductivity enhancement of 33.4% and viscosity reduction of 39.2% at 27^{o}C. Similarly, 2 vol.% ZnO–EG–water nano fluids showed thermal conductivity enhancement of 17.26% and viscosity reduction of 17.34% at 27^{o}C

From the above results it can be concluded that using nano coolant in car radiator, leads to higher heat transfer performance, reduced radiator size, reduced bsfc, higher thermal efficiency and that would reduce fuel consumption. This also reduces the exhaust emission.

IV. ACKNOWLEDGEMENT

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REFERENCES

[1] Stephen U. S. Choi and J. A. Eastman, "Enhancing thermal conductivity of fluids With nano particles", ASME 1995
[2] Mohammad Mamun, Dr. Md. Ehsan "Effect of coolant temperature on performance of a SI Engine", International Conference on Mechanical Engineering,(2001)/pp. III 235-241
[3] Wenhua Yu, David M. France, Jules L. Routbor, and Stephen U. S. Choi," Review and Comparison of Nano fluid Thermal Conductivity and Heat Transfer Enhancements" Taylor and Francis Group, 2008
[4] Kyung-Wook Choi, Ki-Bum Kim and Ki-Hyung Lee, "Investigation of emission characteristics affected by new cooling system in a diesel engine", Journal of Mechanical Science and Technology 23 (2009) 1866~1870
[5] S. Senthilraja, M. Karthikeyan and R.Gangadevi," Nano fluid Applications in Future Automobiles: Comprehensive Review of Existing Data" Nano-micro letters, Vol. 2, No.-4, (2010) 306-310
[6] Weerapun Duangthongsuk, Somchai Wongwises," An experimental study on the heat transfers performance and pressure drop of TiO2-water nano fluids flowing under a turbulent flow regime", International Journal of Heat and Mass Transfer 53, (2010) 334–344
[7] K.Y. Leong, R. Saidur, S.N. Kazi, A.H. Mamun," Performance investigation of an automotive car radiator operated with Nano fluid-based coolants (nano fluid as a coolant in a radiator)", Applied Thermal Engineering 30 (2010) 2685-2692
[8] Madhusree Kole, T.K. Dey," Viscosity of alumina nano particles dispersed in car engine coolant.", Experimental Thermal and Fluid Science 34 (2010) 677–683
[9] Ravikanth S. Vajjha, Debendra K. Das, Praveen K. Namburu," Numerical study of fluid dynamic and heat transfer performance of Al_2O_3 and CuO nano fluids in the flat tubes of a radiator", International Journal of Heat and Fluid Flow 31 (2010) 613–621
[10] S.M. Peyghambarzadeh, S.H. Hashemabadi, S.M. Hoseini, M. Seifi Jamnani," Experimental study of heat transfer enhancement using water/ethylene glycol based Nano fluids as a new coolant for car radiators", International Communications in Heat and Mass Transfer 38 (2011) 1283–1290
[11] R. Saidura, K.Y. Leong, H.A. Mohammad," A review on applications and challenges of nano fluids", Renewable and Sustainable Energy Reviews 15 (2011) 1646–1668
[12] Navid Bozorgan, Komalangan Krishnakumar, Nariman Bozorgan, "Numerical Study on Application of CuO-Water Nano fluid in Automotive Diesel Engine Radiator." Modern Mechanical Engineering, 2, (2012) 130-136
[13] I.M.Mahbubul, R. Saidur, M.A. Amalina," Latest developments on the viscosity of nano fluids." International Journal of Heat and Mass Transfer 55 (2012) 874–885

[14] M. Silambarasan, S. Manikandan, K.S. Rajan," Viscosity and thermal conductivity of dispersions of Sub-micron TiO2 particles in water prepared by stirred bead milling and ultrasonication", International Journal of Heat and Mass Transfer 55 (2012) 7991–8002

[15] Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi.," Heat transfer through heat exchanger using Al_2O_3 Nano fluid at different concentrations", Case Studies in Thermal Engineering1(2013) 38–44

[16] Tun-Ping Teng, Chao-Chieh Yu," Heat dissipation performance of MWCNTs nano-coolant for vehicle", Experimental Thermal and Fluid Science 49 (2013) 22–30

[17] A.A. Abbasian Arani, J. Amani," Experimental investigation of diameter effect on heat transfer performance and pressure drop of TiO_2–water nano fluid", Experimental Thermal and Fluid Science 44 (2013) 520–53

[18] Rahul A.Bhogare, B.S.Kothawal, Priti Pramod Bodkhe and Amol Gawali," Performance investigation of Automobile Radiator operated with Nano fluids Based Coolant", International Journal of Thermal Technologies Vol.4, No.2 (June 2014)

[19] J.R. Patel, A.M. Mavani," Effect of nano fluids and mass flow rate of air on heat transfer rate in automobile radiator by CFD analysis", International Journal of Research in Engineering and Technology (2014) eISSN: 2319-1163 | pISSN: 2321-7308

[20] K.S. Suganthi, V. Leela Vinodhan, K.S. Rajan," Heat transfer performance and transport properties of ZnO–ethyleneglycol and ZnO–ethylene glycol–water nano fluid coolants", Applied Energy 135 (2014) 548–559

[21] M.M. Elias, I.M. Mahbubul, R. Saidur, M.R. Sohel, I.M. Shahrul, S.S. Khaleduzzaman, S.Sadeghipour," Experimental investigation on the thermo-physical properties of Al2O3 Nano particles suspended in car radiator coolant." International Communications in Heat and Mass Transfer 54 (2014) 48–53

[22] Salma Halelfadl, Thierry Maré, Patrice Estellé," Efficiency of carbon nano tubes water based nano fluids as coolants", Experimental Thermal and Fluid Science 53 (2014) 104–110

[23] M. Ebrahimi, M. Farhadi, K. Sedighi, S. Akbarzade "Experimental Investigation of Force Convection Heat Transfer in a Car Radiator Filled with SiO2-water Nano fluid" International Journal of Engineering Vol. 27, No. 2, (February 2014) 333-340

[24] Rohit S. Khedkar, Shriram S. Sonawane, Kailas L. Wasewar," Heat transfer study on concentric tube heat exchanger using TiO2–water based nano fluid", International Communications in Heat and Mass Transfer 57 (2014) 163–169

[25] Hwa-Ming Nieh, Tun-Ping Teng, Chao-Chieh Yu," Enhanced heat dissipation of a radiator using oxide nano-coolant", International Journal of Thermal Sciences 77 (2014) 252e261

[26] Sunil Choudhary, A.C. Tiwari, Ajay Vardhan, Arvind Kaushal, "The Effect of Engine Temperature on Multi Cylinder SI Engine Performance with Gasoline as a fuel", International Journal of Engineering Research and General Science Volume 2, Issue 5, 2014, ISSN 2091-2730

