www.ierjournal.org ISSN: 2395-1621

PERFORMANCE ENHANCEMENT OF AUTOMOTIVE RADIATOR USING NANOFLUID

Kolhatkar shubham chintamani (omkarkolhatkar95@gmail.com), Korale pandit dattatray (koralepandit@gmail.com), Kumbhar rushikesh sanjay (rushikesh.kumbhar584@gmail.com), Lad suraj sanjay (Surajlad38@gmail.com), Prof. S. S. Mantati

Universal College of Engineering and Research

ABSTRACT

The demand for more powerful engines in smaller hood spaces has created a problem of insufficient rates of heat dissipation in automotive radiators. Upwards of 33% of the energy generated by the engine through combustion is lost in heat. Insufficient heat dissipation can result in the overheating of the engine, which leads to the breakdown of lubricating oil, metal weakening of engine parts, and significant wear between engine parts. To minimize the stress on the engine as a result of heat generation, automotive radiators must be redesigned to be more compact while still maintaining high levels of heat transfer performance. 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 posts . A cooling system is used to remove this excessive heat.

Most automotive cooling systems consist of the following components: radiator, water pump, electric cooling fan, radiator pressure cap, and thermostat. Of these components, the radiator is the most prominent part of the system because it transfers heat. As coolant travels through the engine's cylinder block, it accumulates heat. Once the coolant temperature increases above a certain threshold value, the vehicle's thermostat triggers a valve which forces the coolant to flow through the radiator. As the coolant flows through the tubes of the radiator, heat is transferred through the fins and tube walls to the air by conduction and convection.

I. INTRODUCTION

Modern automotive internal combustion engines generate a huge amount of heat. This heat is created when the gasoline and air mixture is ignited in the combustion chamber. This explosion causes the piston to be forced down inside the engine, levering the connecting rods, and turning the crankshaft, creating power. Metal temperatures around the combustion chamber can exceed 1000° F. In order to prevent the overheating of the engine oil, cylinder walls, pistons, valves, and other components by these extreme temperatures, it is necessary to effectively dispose of the heat. It has been stated that a typical average-sized vehicle can generate enough heat to keep a 5-room house comfortably warm during zero degree weather (and I'm not talking about using the exhaust pipe). Approximately 1/3 of the heat in combustion is converted into power to drive the vehicle and its accessories. Another 1/3 of the heat is carried off into the atmosphere through the exhaust system. The remaining 1/3 must be removed from the engine by the cooling system. Modern automotive engines have basically dumped the Air Cooled System for the more effective Liquid Cooled System to handle the job. In a liquid cooled system, heat is carried away by the use of a heat absorbing coolant that circulates through the engine, especially around the combustion chamber in the cylinder head area of the engine block. The coolant is pumped through the engine, then after absorbing the heat of combustion is circulated to the radiator where the heat is transferred to the atmosphere. The cooled liquid is then transferred back into the engine to repeat the process. Excessive cooling system capacity can also be harmful, and may affect engine life and performance. You must understand that coolant temperatures also affect oil temperatures and more engine wear occurs when the engine oil is below 190° F. An effective cooling system controls the engine temperature within a specific range so that the engine stays within peak performance.

II. THE CONCEPT OF NANOFLUID

The concept of nanofluids is developed at Argonne National laboratory (Choi, 1995) is directly related to trends in miniaturization and nanotechnology. Recent reviews of research programs on nanotechnology in the U. S., China, Europe, and Japanshow that nanotechnology will be an emerging and exciting technology of the 21st century and that universities, national laboratories, small businesses, and large multinational companies have already established nanotechnology research groups or interdisciplinary centers that focus on nanotechnology. It is estimated that nanotechnology is at a similar level of development as computer/information technology was in the 1950s. Solids have orders-of-magnitude higher thermal conductivities than those of conventional heat transfer fluids (see Fig.1.10). For example, the thermal conductivity of copper at room temperature is about 3000 times greater than that of engine oil. Therefore, solid particles in fluids are expected to enhance the thermal conductivities of fluids. In fact, numerous theoretical and experimental studies of the effective thermal conductivity of dispersions that contain solid particles have been conducted since Maxwell's theoretical work was published more than 100 years ago (Maxwell, 1873).

Fig. 1.8 shows the thermal conductivity of typical materials. Solids have thermal conductivities that are orders of magnitude greater than those of traditional heat transfer fluids.

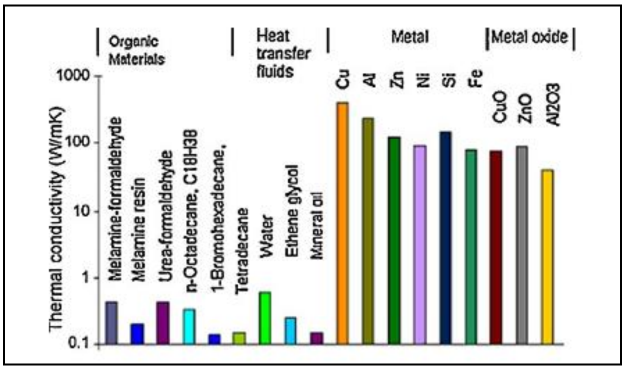

Fig. 1.8: Thermal conductivity of typical materials.

However, all of the studies on thermal conductivity of suspensions have been confined to millimeter- or micrometer-sized particles. The major problem with these particles is their rapid settling in fluids.

In recent years, nanotechnology has enabled the production of Nanoparticles with average sizes below 50 nm. Nanoparticles at this scale have unique properties. Applying this emerging nanotechnology to established thermal energy engineering, Argonne developed the concept of nanofluids (Choi, 1995), a new and innovative class of heat transfer fluids that are engineered by suspending Nanoparticles in conventional heat transfer fluids.

Maxwell's concept of enhancing the thermal conductivity of fluids by dispersing solid particles is old, but what is new and innovative with the concept of nanofluids is the idea of using the nanometer-sized particles that have become available only recently. These very small particles remain in suspension almost indefinitely and also provide high surface area densities. Because of the "square/cube law," the surface-area-to-volume ratio of nanoparticles is three orders of magnitude greater than that of micro particles. They show that "size does matter" in the concept of nanofluids. For this reason, nanofluids are a rapidly emerging field in which nanoscience and thermal engineering meet.

ADVANTAGES OF NANOFLUIDS

Nanofluids offers following advantages than other methods to improve heat transfer in conventional fluids.

- Simple manufacturing methods. The availability of simple manufacturing methods enables to produce nanofluids that meet the needs of a wide variety of current and future applications. Researchers can choose the most appropriate material to be added to a fluid currently in use. (For example, the two-step method works best with fluids that have high vapor pressure, like water.) The two-step method first produces nanoparticles and then disperses them in a base fluid. It is simple, and it is less costly and works with more fluids than the one-step method. But the one-step method, employs a direct evaporation-condensation method that results in very small, essentially no agglomerating nanoparticles that disperse well.
- Can use many particle materials. One can choose from a variety of Nanoparticle materials, which is most compatible with an already existing base fluid. One can use nonmetals when the use of metals would not be appropriate (for example, because they oxidize), and can exploit the enhanced heat transfer capabilities and stability of metal nanoparticles.
- Works with a variety of base fluids. Nanofluids work with a variety of base fluids. This feature enables them to be used in many current applications. Existing fluids can be easily improved instead of being replaced. Examples include radiators that use an ethylene glycol/water mixture and thermal systems that use synthetic fluids.
- Does not require dispersants. Nanofluids remain stable almost indefinitely without the use of dispersants. An additional benefit is that using nanofluids eliminates any time, cost, or effort that would be associated with using dispersants. (A small quantity of thioglycolic acid was added to copper nanofluids to enhance conductivity, not stability.)
- Does not settle rapidly. Nanofluids outperform existing heat transfer fluids containing solid particles in terms of long-term stability. Such stability is a requirement for enhancing heat transfer, since heat transfer occurs at the surface. Particles also need to stay suspended to ensure that the properties of the fluid do not change. Moreover, if particles settle, more particles need to be added to replace them, which represent extra time, expense, and effort.

III. THEORY OF HEAT TRANSPORT IN NANOFLUIDS

In the following articles, we examine a comprehensive list of the factors that are potentially responsible for enhanced heat conduction in nanofluid. First, we discuss the possibility that the enhancement of thermal conductivity arises from the Brownian motion of the particles. Second, we analyze how much of an increase in the thermal conductivity can be expected from molecular-level layering of the liquid at the liquid/particle interface (nanolayer). Third, we examine the nature of heat transport in nanoparticles and the validity of the key assumption of the macroscopic theory of diffusive propagation of heat in both particles and in the liquid matrix. Finally, we consider the effects of clustering of nanoparticles, both by forming direct solid-solid paths and by possible clustering effects mediated by liquid existing within the limit of a short inter-particle distance.

Models for thermal conductivity of Nanofluids

2.2.1 Brownian motion of the particles

Batchelor G. K., (1977), studied effect of Brownian motion, by which particles move through liquid and possibly collide, thereby enabling direct solid-solid transport of heat from one to another, can be expected to increase thermal conductivity. This is not, however, accounted for by the Hamilton and Crosser, (1962) theory, which assumes a static composite material. The movement of nanoparticles due to Brownian motion is too slow to transport significant amounts of heat through a nanofluid. However, Brownian motion could have an important indirect role in producing particle clustering, which could significantly enhance thermal conductivity.

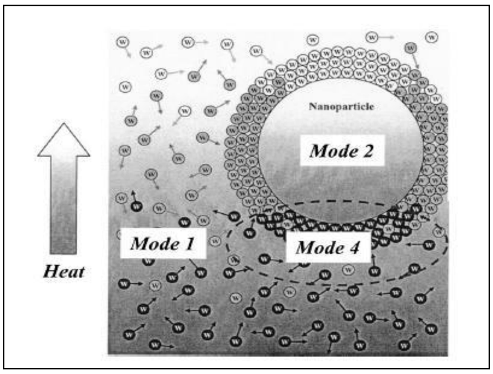

Fig 2.1: Modes of Energy Transport in Nanofluids.[5]

2.2.2 Interfacial layering of liquid molecules

Henderson and Swol (1984), investigated, in particle-fluid mixtures, the liquid molecules close to a particle surface are known to form layered structures and behave much like a solid. The thickness of this aligned solid-like layer of liquid molecules at the interface is at a magnitude of nanometre, but this nanolayer might play an important role in heat transfer from solid to adjacent liquid. For particles with micrometer size, the surface areas are small, e.g., for alumina powders with an average diameter of 10 nm, their SSA is only 0.15 m2 g-1. The effect of interfacial nanolayer is negligible. However, nanoparticles have very large specific surface area, e.g., for alumina powders with an average diameter of 10 nm, their SSA is as great as 151 m2g-1, much larger than that of micro-sized particles. Therefore, the aligned solid/liquid interfacial shell in nanoparticle suspension would make heat transfer across the interface effective.

In order to find the effect of nanolayer, let us consider a Nanoparticle liquid mixture with monosized spherical inclusions of radius d and particle volume concentration Vp. Fig. 2.2 denotes the schematic structures of a nanoparticle with an interfacial nanolayer when the nanoparticle is dispersed in a fluid. The alignment of the liquid molecules inside the solid-like interfacial nanolayer of thickness δ is more ordered than that of bulk liquid.

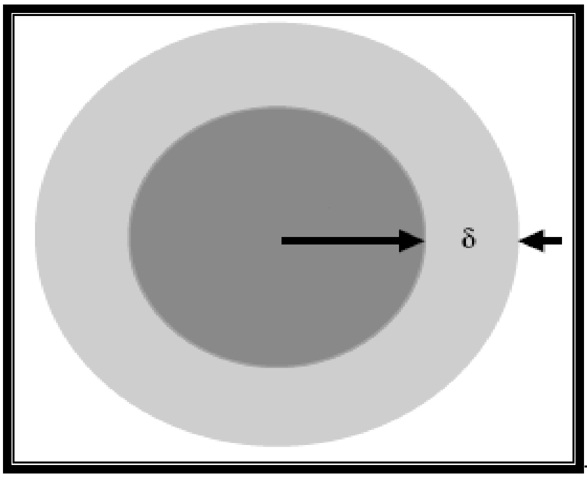

Fig 2.2: Schematic structures of nanoparticle and interfacial nanolayer. Particle: dark; layer: gray.[5]

The physicochemical properties of this nanolayer are highly depended on the suspended nanoparticles, the base fluid, and the interaction between them. Therefore, the thermo physical behaviors of this interfacial nanolayer may be investigated by carefully analyzing the above-mentioned factors. The solid-like nanolayer would be expected to have an intermediate thermal conductivity between that of the bulk liquid (kf)and that of the nanoparticles (kp)because the layered molecules are in an intermediate physical state between a bulk liquid and a solid. The Xie et al. (2005), has given the expression for the thermal conductivity of this interfacial nanolayer as

$$k_n = \frac{k_f M^2}{(M-\gamma)\ln(1+M)+\gamma M} \quad (2.1)$$

where

$$M = \frac{k_p}{k_f}(1+\gamma)-1 \quad (2.2)$$

and

$$\alpha = \frac{\delta}{d} \quad (2.3)$$

In equation (2.1),the average thermal conductivity of nanolayer depends on the thermal conductivity of fluid, the reduced thermal conductivity of nanoparticle and ratio of the nanolayer thickness to the original particle radius. Figure 2.2 shows the thermal conductivity ratios of the nanolayer, k_n/k_f in ethylene glycol (EG) based nanofluids containing copper nanoparticles. k_n/k_f is shown to be strongly dependent on the particle size and the thickness of nanolayer. With an increase in the thickness of nanolayer or a reduction in particle size, k_n/k_f increases. A much steeper change can be seen at small particle size range, which indicates that the impact of nanolayer would be more effective when the particle is small whilst the nanolayer is thick.

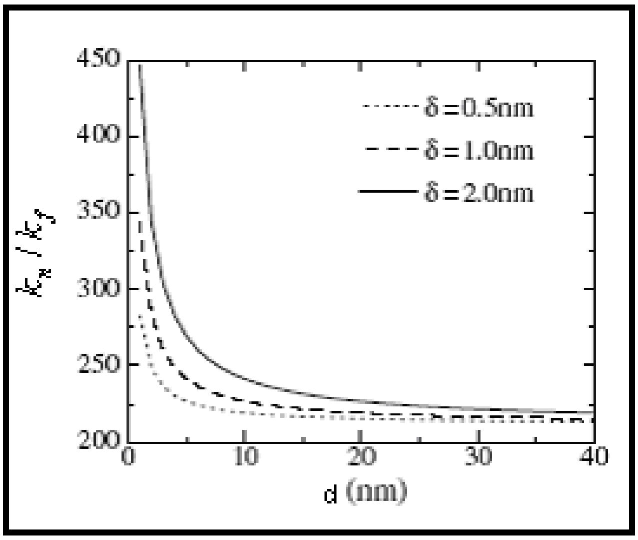

Fig. 2.3: Thermal conductivity ratio of nanolayer as a function of diameter d.[6]

2.2.3. Nature of Heat transfer in Nanoparticles

In crystalline solids, such as those used in nanofluids, heat is carried by phonons, i.e., by propagating lattice vibrations. Such phonons are created at random, propagate in random directions, are scattered by each other or by defects, and thus justify the macroscopic description of heat transport. In metals, the heat is primarily carried by electrons, which also exhibit diffusive motion at the microscopic level.

However, other ballistic phonon effects could lead to a significant increase in thermal conductivity. In particular, if the ballistic phonons initiated in one particle can persist in the liquid and reach a nearby particle, a major increase of thermal conductivity is expected. Because the phonon mean free path is much shorter in the liquid than in the particle, such an effect may only operate if the separation between particles is very small, likely on the order of the thickness of the layered liquid (≈l-2 nm). As illustrated in Figure 2.4 the particles in a nanofluid are surprisingly close together even at relatively low packing factions. For example, the surfaces of 10 nm particles are, on average, only separated by 5 nm at a 5% packing fraction.

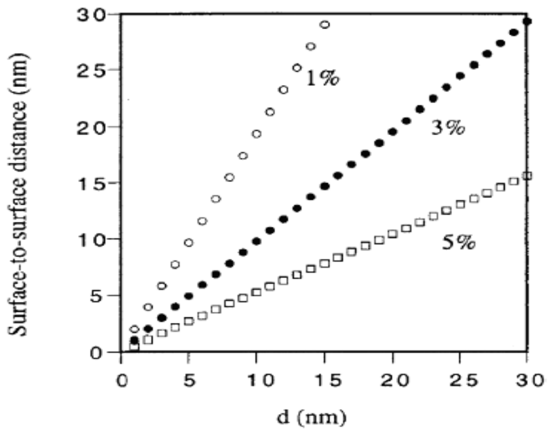

Fig. 2.4: Average surface-to-surface distance between particles for three particle volume fractions as a function of particle diameter d.[6]

Moreover, because particles move constantly due to Brownian motion, locally, they may be much closer and thus enhance coherent phonon heat flow among the particles.

2.2.4 Nanoparticle clusters

Nanoparticles forms cluster in fluids, by creating paths of lower thermal resistance, clustering of particles have a major effect on the effective thermal conductivity. However, such large clusters would most likely settle out of the fluid. The effective volume of a cluster, i.e., the volume from which other clusters are excluded, can be much larger than the physical volume of the particles. Since within such clusters, heat can move very rapidly, the volume fraction of highly conductive phase is larger than the volume of solid and may significantly increase thermal conductivity. The effect of clustering is illustrated in Figure 2.5, which shows the excess thermal conductivity enhancement k originating from the increased effective volume of highly conducting clusters, as a function of the packing fraction of the cluster φ (ratio of the volume of the solid particles in the cluster to the total volume of the cluster). With decreasing packing fraction, the effective volume of the cluster increases, thus enhancing thermal conductivity. Even for a cluster of closely packed spherical particles, ≈25% volume of the cluster consists of liquid filling the space between particles, which increases the effective volume of a highly conductive region by ≈30% with respect to a dispersed nanoparticles system. For more loosely packed clusters the effective volume increase will be even larger.

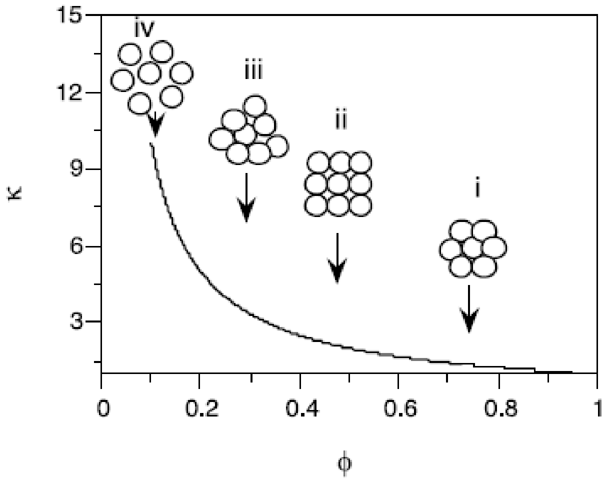

Fig. 2.5: Excess thermal conductivity enhancement κ due to increased effective volume ϕ of highly conducting clusters.[6]

A further dramatic increase of k can take place if the particles do not need to be in physical contact, but just within a specific distance, allowing rapid heat flow between them. Such "liquid-mediated" clusters exhibit a very low packing fraction and thus a very large effective volume and, in principle, are capable of explaining the unusually large experimentally observed enhancements of thermal conductivity. However, in general clustering may exert a negative effect on heat transfer enhancement, particularly at low volume fraction, by settling small particles out of the liquid and creating large regions of "particle free" liquid with high thermal resistance.

IV. LITERATURE REVIEW

PRESEANT THEORY AND PRACTICES

The following is a brief description of the work and research completed by some prominent researchers in the field of nanofluids, specifically related to this work. This review illustrates the current schools of thought on the factors involved in influencing the properties of nanofluids.

Hamilton and Crosser [10] performed research on the thermal conductivity of two-component systems in order to develop an understanding of the basis of many current modeling equations for nanofluid thermal conductivity. This research dealt specifically with identifying how the shape of the components of a system affected the thermal properties of that system.This experiment provided data supporting the shape effect of metal particles on conductivity.

Lee et al. [9] performed research specifically on nanofluids with oxide particles at Argonne National Laboratory. This experiment examined Al2O3 and CuO nanoparticles dispersed in both demonized water and ethylene glycol and their related thermal conductivities as measured by the transient hot-wire method. A strong dependence on particle size and an almost linear increase of conductivity with volume fraction of the particles were found. CuO nanoparticles were found to have a greater heat transfer effect than Al2O3 particles, which was suggested to be due to the CuO particles being smaller.

Wang et al. [11] examined the thermal conductivity of Al2O3 and CuO nanoparticles dispersed in various base fluids, including water, ethylene glycol, engine oil and vacuum pump fluid. Thermal conductivity was measured by the use of the one-dimensional, steady-state parallel plate method. This experiment resulted in data that suggests a possible relation between thermal conductivity and the size of the nano particles, as well as the method of dispersion used.

Yang et al. [12] researched the effect of nanoparticles on convective heat transfer under a laminar flow regime. This research entailed experiments in a piping system of disc shaped graphite nanoparticles dispersions in two different base fluids. The goal was to test the theory of increased heat transfer capabilities without a significant change in flow characteristics such as viscosity. The experiments resulted in data that supports this idea as well as suggesting a number of factors that play a role in the convective heat transfer capabilities of these fluids. However, the correlations used to predict the results were not accurate. Therefore, it has been suggested that further research is needed.

Keblinski et al. [13] performed research involving a theoretical explanation of the possible reasons for the departure of experimental results from predicted results of thermal conductivities of nanofluids. The authors explain the macroscopic theory of heat transport in composites which is based on the diffusive nature of heat transport and note the mechanisms of enhanced heat conduction such as Brownian motion. There is also a description of the ballistic nature of heat transport which is suggested will better explain the experimental evidence. Research was supported by atomic-level molecular dynamics simulations.

Buongiorno [14] conducted research on the convective heat transfer properties of nanofluids and the factors affecting these properties. The purpose of this research was to test the theory that the effects on heat transfer that are not explained by the thermal conductivity characteristics are attributed to the turbulence induced by the motion of the nanoparticles and the dispersion methods. Xuan and Li [15] studied the single phase flow heat transfer performance of nanofluids in turbulent flow regimes. The nanofluid used was Cu particles dispersed in water. Substantial increases in the convective heat transfer rates were noted while also noting that the flow characteristics closely resemble those of the base fluid, which suggests that there will be no adverse pumping power requirements associated with the use of nanofluids.

Das et al. [16] conducted experiments to determine the temperature dependence of thermal conductivity of nanofluids. It was found that the thermal conductivity increased with temperature from 21 to 51oC, which suggests a possible use as a cooling mechanism in devices with high energy densities.

A comprehensive literature review on the applications and challenges of nanofluids has been provided by Saidur et al. [1].

Choi et al.[5] reported a project to target fuel savings for the automotive industries through the development of energy efficient nanofluids and smaller and lighter radiators. A major goal of the nanofluids project is to reduce the size and weight of the vehicle cooling systems by greater than 10% despite the cooling demands of higher power engines. Nanofluids enable the potential to allow higher temperature coolants and higher heat rejection in the automotive engines. It is estimated that a higher temperature radiator could reduce the radiator size approximately 30%. This translates into reduced aerodynamic drag and fluid pumping and fan requirements, leading to perhaps a 10% fuel savings. It is interesting idea in these years which humans involved in the energy and fuel shortage crisis. According to this idea, scarce experimental and theoretical studies were performed to analyze the application of nanofluids in the car radiator.

Leong et al. [17] attempted to investigate the heat transfer characteristics of an automotive car radiator using ethylene glycol based copper nanofluids numerically. Thermal performance of an automotive car radiator operated with nanofluids has been compared with a radiator using conventional coolants. Vajjha et al. [18] have been numerically studied a three-dimensional laminar flow and heat transfer with two different nanofluids, Al2O3 and CuO, in the ethylene glycol/water mixture circulating through the flat tubes of an automobile radiator to evaluate their superiority over the base fluid. Convective heat transfer coefficient in the developing and developed regions along the flat tubes with the nanofluid flow showed considerable improvement over the base fluid.

Khan et al. [19] have experimentally studied forced convection cross-flow heat transfer of hot air over an array of cold water carrying elliptic tubes. Their experimental investigation was restricted to water as the coolant. Cuevas et al. [20] have studied the heat transfer performance of a louvered fin and flat tube heat exchanger. Mixture of ethylene glycol and water was circulated .Through the tubes at a supply temperature of 900C. This fluid was cooled with ambient air at temperature of 200C. The thermo hydraulic performance (calculation of heat transfer coefficient and friction factor) of the heat exchanger has been compared with the classical correlations given in the literature. Avramenko et al. [21] made theoretical estimation of the heat transfer enhancement in laminar flow of a nanofluid over a flat plate. For 1% concentration of nanoparticles, the respective increase in the Nusselt number reaches up to 5%.

Peyghambarzadeh et al. [22] have recently investigated the application of Al2O3/water nanofluids in the car radiator by calculating the tube side heat transfer coefficient. They have recorded the interesting enhancement of 45% comparing with the pure water application under highly turbulent flow condition. In the other study, Peyghambarzadeh et al. [23] have used different base fluids including pure water, pure ethylene glycol, and their binary mixtures with Al2O3 nanoparticles and once again it was proved that nanofluids improves the cooling performance of the car radiator extensively. In the two latter studies, tube side heat transfer coefficient was calculated according to the temperature measurement at the thin walls of the radiator flat tubes. It is very hard to accurately measure the temperature at the wall and therefore, the data may have not adequate accuracy.

Y.Vermahmoudia et al.[24] performed Experimental investigation on heat transfer performance of Fe2O3/water nanofluid in an air-finned heat exchanger the maximum enhancements of the overall heat transfer coefficient and heat transfer rate compared with base fluid (distilled water) are respectively equal to 13% and 11.5% which is occurred at the concentration of 0.65 vol.%.

COMMENTS FROM LITERATURE REVIEW:-

- Heat transfer of coolant flow through the automobile radiators is of great importance for the optimization of fuel consumption.
- Application of nanofluids instead of water enhances thermal performance of the automobile cooling system.
- Al2O3 / Water Nanofluid with low concentrations (0.1 vol.%) can enhance heat transfer efficiency up to 25% in comparison with pure water.
- Copper oxide (CuO) and Iron oxide (Fe2O3)/Water nanofluid with concentrations 0.15, 0.4, and 0.65 vol.% increases the overall heat transfer coefficient in comparison with water up to 9%.
- Increasing the nanoparticle concentration, air velocity, and nanofluid velocity enhances the overall heat transfer coefficient.
- This new working fluid with higher heat transfer performance would promote the car engine performance and would reduce fuel consumption.

Therefore, it can be followed by other investigators to optimize the parameters related to nanofluid (nanoparticle material, size, volume concentration, base fluid etc) and eliminate the probable deficiencies using CuO/Water nanofluid for industrialization in the car industries.

V. DEVELOPED SYSTEM

In actual set up we have used collector tank and heater assembly as an engine of automobile. So as to run the setup 3 phase, 6000 watt heater is started which heats the water or nanofluid up to required temperature. In the tank RTD is used to sense the temperature to control it by using temperature controller within required range of 55 to 75C.

After achieving required value of temperature the hydraulic pump is started to carry out the circulation of fluid for the automatic radiator cooling system. The pump supplies fluid to the radiator with constant flow rate which is controlled by flow control valve which is fitted on pump discharge line. The flow rate is measured by Rotameter in flow line and control is done by passing the fluid through bypass line. The bypass line is further connected to tank.

The required constant volume flow is passed through rotameter. Then the Inlet temperature of fluid entering into radiator is recorded by RTD. RTD is fitted on inlet of the radiator. Due to high heat transfer rate and thermal conductivity of radiator tubes the maximum temperature difference is achieved with effective cooling of fluid.

The temperature difference is calculated with measuring temperature of outlet fluid with using RTD of outlet port of radiator. The another RTDs are fixed on the surface of radiator tube walls to calculate average wall temperature of radiator during various flow rates of circulating fluid. The whole setup of radiator is cooled with forced circulation air cooled method. To achieve the forced circulation the automatic radiator fan is fitted on the radiator. The forced circulation is having the major role in radiator cooling of fluid with convective and radiative heat transfer technique.

The outlet of radiator is having cold fluid with minimum temperature is supplied to tank for cooling of engine in actual automobile cooling system using flexible hose pipe connections. Circulation of fluid continues with varying flow rates using flow control valve from 100 LPH to 600 LPH with temperature variation of 55C to 75 C for pure water, 0.1%, 0.2%, 0.3% concentration of Nanofluid as a working fluid. Tin & Tout are measured respectively from two channel temperature indicator.

NANOFLUID PREPARATION

Modern fabrication technology allows the fabrication of materials at the nanometer scale. Nanoparticles are a class of materials that exhibit unique physical and chemical properties compared to those of larger (micron scale and larger) particles of the same material. Nanoparticles used in nanofluids have been made out of many materials, and the fabrication of nanoparticles can be classified into two broad categories: physical processes and chemical processes.

Some nanoparticles materials that have been used in nanofluids are oxide ceramics (Al203, Cu0), nitride ceramics (AIN, SiN,BN), carbide ceramics (SiC, TiC), metals (Ag, Au, Cu, Fe), semiconductors (Ti02), single, double or multi-walled carbon nanotube (SWCNT, DWCNT, MWCNT), and composite materials such as nanoparticles core-polymer shell composites. Nanoparticles of various materials have been produced by physical or chemical synthesis techniques. Typical physical methods include the mechanical grinding method and the inert-gas condensation technique. The later was developed by Granqvist and Buhrman of Cornell University (Granqvist and Buhrman 1976). Chemical methods for producing nanoparticles include chemical precipitation, chemical vapor deposition, micro-emulsions, spray pyrolysis, and thermal spraying. Current processes specifically for making metal nanoparticles include mechanical milling, inert-gas-condensation technique, chemical precipitation, spray pyrolysis, and thermal spraying.

Nanoparticles in most materials discussed are most commonly produced in the form of powders. In powder form, nanoparticles can be dispersed in aqueous or organic

ISSN: 2395-1621

host liquids to form nanofluids for specific applications. To date, many types of host liquids have been used, but ethylene glycol and water mixtures are the most desirable for automotive applications. Several materials for the nanoparticles seem to have good potential for such applications.

Nanofluids have been produced by two techniques: the two-step technique and the single-step technique. The two-step technique starts with nanoparticles, produced by one of the physical or chemical synthesis techniques described previously, and proceed to disperse them into a base fluid. The single-step simultaneously makes and disperses the nanoparticles directly into a base fluid. Most of the nanofluids containing oxide nanoparticles and carbon nanotube reported in the open literature are produced by the two-step process.

In the present work, nanofluids are prepared by two step method. Copper oxide (CuO) nanopowder are purchased from Sisco Research Laboratory Pvt. Ltd.. Mumbai. The average particle size (APS) of CuO nanopowder is 80 nm and this nanopowder was mixed in 0.1%, 0.2%, 0.3% proportion in 45 Litres of distilled water. We added 40gm of in 45 Litres of distilled water every time to achieve required concentration of nanofluid with distilled water. Then the nanofluid was stirred well for proper mixing of nanopowder. The prepared nanofluid was then filled into a tank.

Fig.: CuO Nanopowder & CuO-Water nanofluid

	
Fig 4.12 CuO Nanopowder	Fig 4.13.CuO/Water Nanofluid

VI. RESULT AND PERFORMANCE COMPARISON

PLOTS OF FLOW RATE Vs OUTLET TEMPERATURE

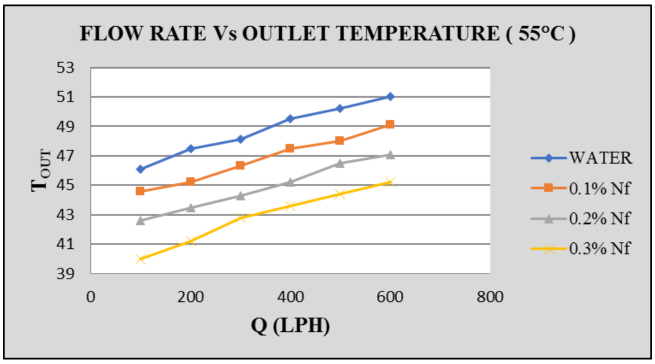

Fig.6.1.: *Plot of Flow rate Vs outlet temperature (55 C)*

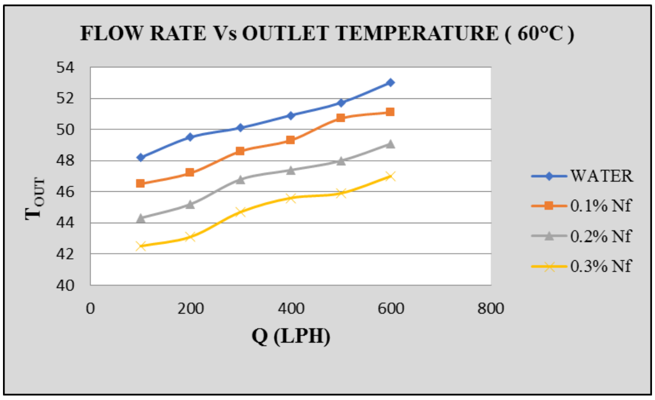

Fig.6.2.: *Plot of Flow rate Vs outlet temperature (60 C)*

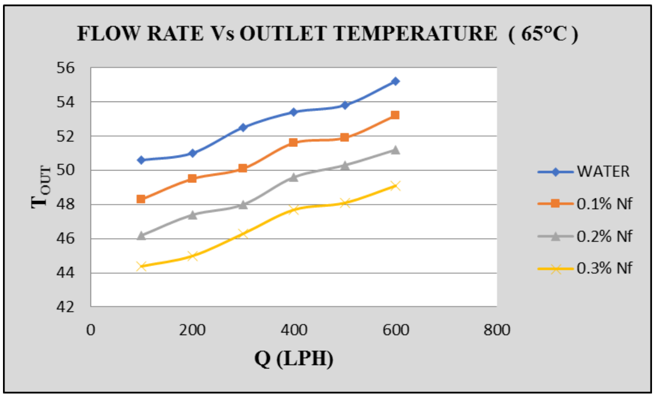

Fig.6.3.: *Plot of Flow rate Vs outlet temperature (65 C)*

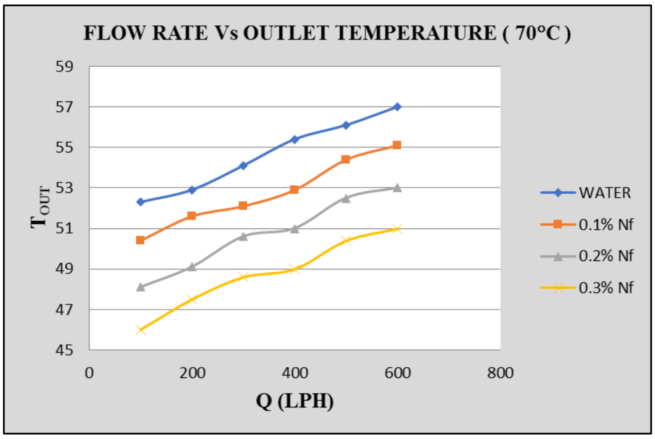

Fig.6.4.: Plot of Flow rate Vs outlet temperature (70 C)

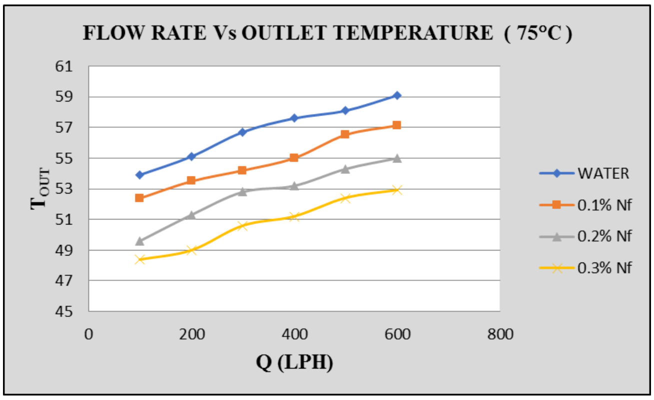

Fig.6.5.: *Plot of Flow rate Vs outlet temperature (75 C)*

Fig. 6.1 to 6.5 shows the radiator outlet temperature, Tout, as a function of fluid volume flow rate circulating in the radiator. Three series of data shown in this figure belong to pure water and also three different concentrations of nanofluids. It should be noted that all the data in Fig. obtained when the fluid inlet temperature to the radiator was 55°C,60°C,65°C,70°C,75°C. One can clearly observe that fluid outlet temperature has decreased with the augmentation of nanoparticle volume concentration.

PLOTS OF FLOW RATE Vs NUSSELT NUMBER

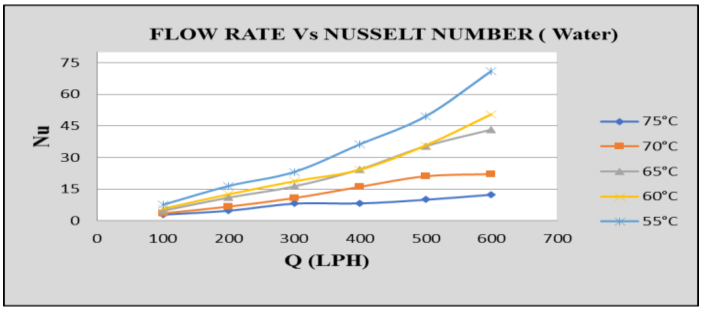

Fig.6.6.: *Plot of Flow rate Vs Nusselt number (Water)*

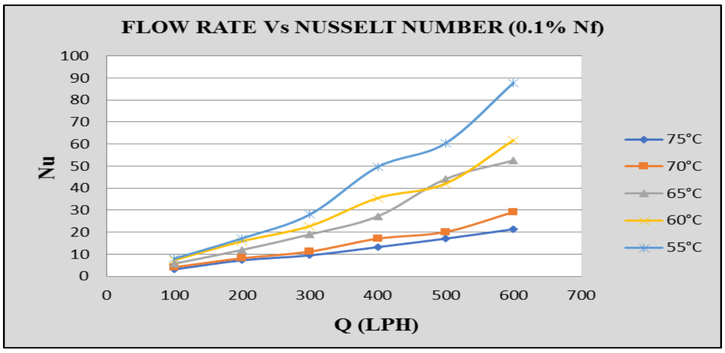

Fig.6.7.: *Plot of Flow rate Vs Nusselt number (0.1 % Nanofluid)*

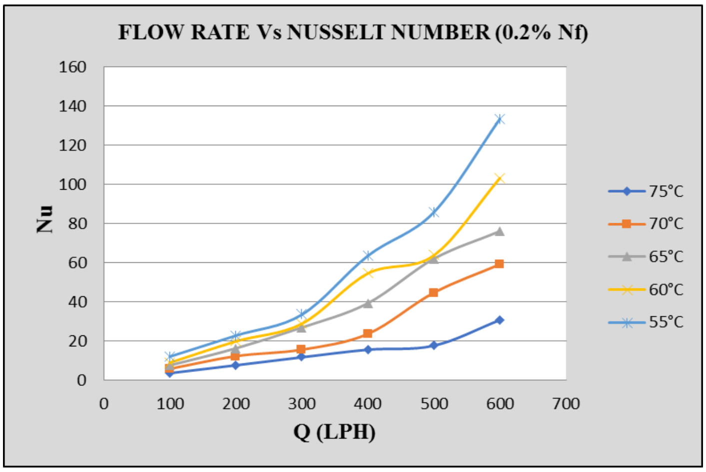

Fig.6.8.: *Plot of Flow rate Vs Nusselt number (0.2 % Nanofluid)*

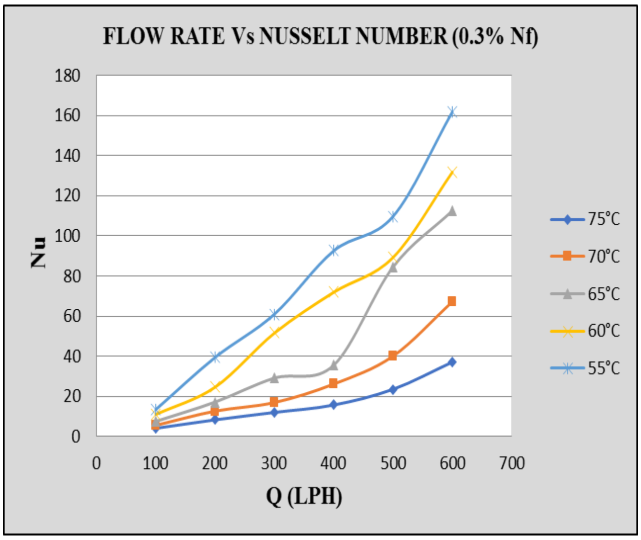

Fig.6.9.: *Plot of Flow rate Vs Nusselt number (0.3 % Nanofluid)*

As per Fig. 6.6 to 6.9 Nu number in all the concentrations has increased by increase in the flow rate of the fluid and consequently Re number. Additionally, the concentration of nanoparticle plays an important role in the

 ISSN: 2395-1621

heat transfer efficiency. It can be shown that when-ever the concentration becomes greater, heat transfer coefficient becomes larger. By the addition of only 0.1%, 0.2%, 0.3% vol. of Cuo nano particle into the pure water, an increase of about 10-15% in comparison with the pure water heat transfer coefficient was recorded. It should be mentioned that the trend of the curves at the other fluid inlet temperatures, i.e.55°C,60°C,65°C,70°C,75°C.

6.3 PLOTS OF REYNOLDS NUMBER Vs NUSSELT NUMBER

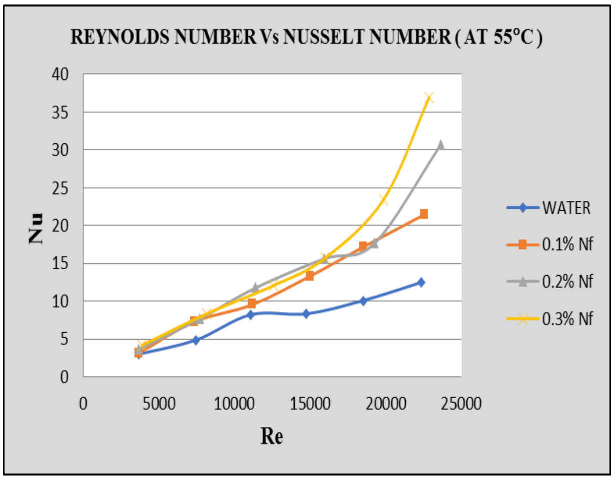

Fig.6.10.:-Plot of Reynolds number Vs Nusselt number (at 55 0C)

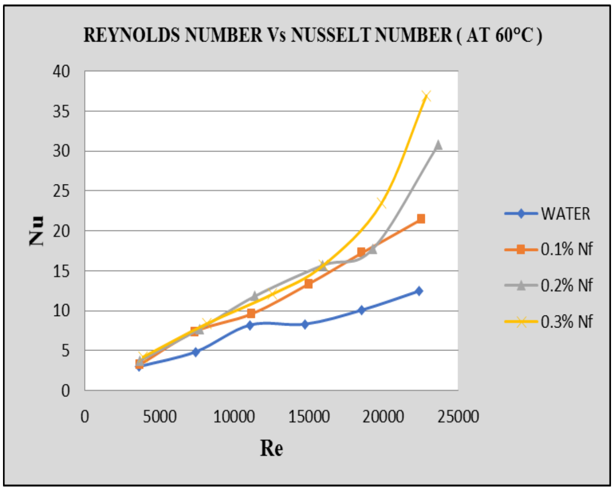

Fig.6.11.:-Plot of Reynolds number Vs Nusselt number (at 60 0C)

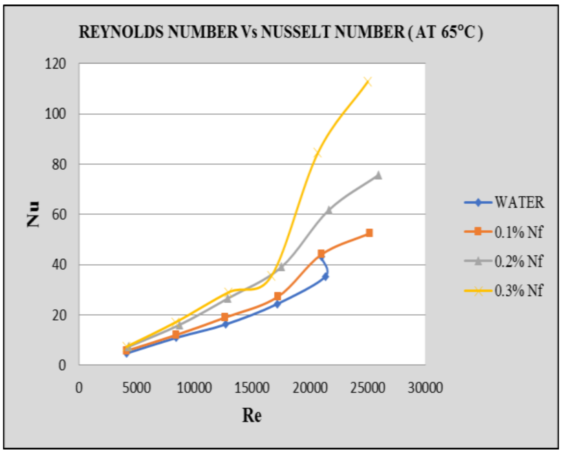

Fig.6.12.:-Plot of Reynolds number Vs Nusselt number (at 65 0C)

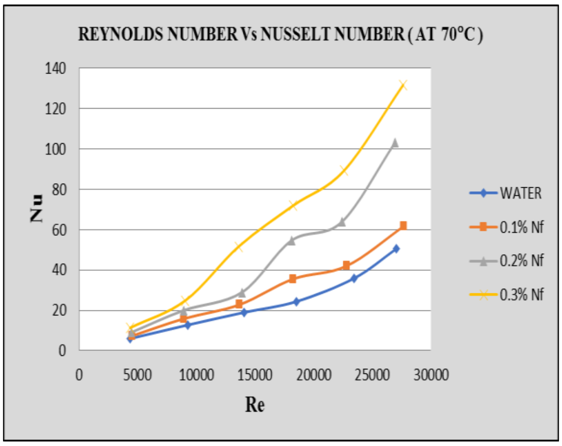

Fig.6.13.:-Plot of Reynolds number Vs Nusselt number (at 70 0C)

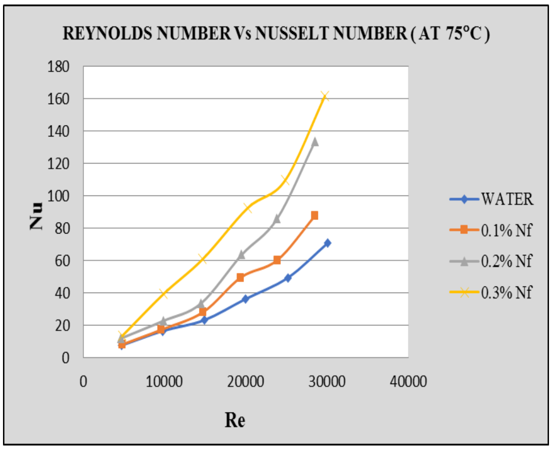

Fig.6.14.:-Plot of Reynolds number Vs Nusselt number (at 75 0C)

Fig. 6.9 to 6.13 compares the results for nanofluid at the concentration of 0.1%, 0.2%, 0.3% volume at different inlet temperatures in order to analyze the effect of temperature variation on heat transfer performance of the automobile radiator. It is clear from Figure that an increase in the fluid inlet temperature (in the range of our experiments) slightly improves the heat transfer coefficient. Inspecting the results reveals that increasing the inlet temperatures 55°C,60°C,65°C,70°C,75°C can enhance Nu number about 6%. This small variation in Nu may be attributed to the effect of temperature on the physical properties and also to the increased effect of radiation.

VII. SCOPE FOR FUTURE WORK

There can be many promising techniques and research areas for enhancing thermal performance of Automotive cooling systems. Improvement in current technique by experimentations may also prove beneficial. Some of the possible improvements and future developments are stated below:

- Innovation of new heat transfer enhancement techniques.
- Use of new efficient, minimum global warming potential and eco friendly fluids and refrigerants.
- Develop Mathematical model considering multiple factors so that experimental investigation can be minimized.
- Develops methods of producing non agglomerating Nanoparticles measuring < 10 nm in size and preventing oxidations of metallic nanoparticles. One of the challenges is to improve dispersion stability without affecting the thermal properties.
- Measure and predict the transport properties (thermal conductivity and viscosity) of nanofluid.
- Develop nanofluids that are environmental friendly and wear resistant.
- Nanofluids can be utilized where straight heat transfer enhancement is paramount as in many industrial applications, nuclear reactors, transportations, electronics as well as biomedicines and foods.

VIII. CONCLUSION

The experimental heat transfer coefficients in an automobile radiator have been measured with two distinct working liquids: pure water and water based nanofluid (small amount of CuO nanoparticle in water) at different concentrations (0.1%,0.2% & 0.3% by volume) and temperatures and the following conclusions were made.

1. The presence of CuO nanoparticle in water can enhance the heat transfer rate of the automobile radiator. The degree of the heat transfer enhancement depends on the amount of nanoparticle added to pure water. Ultimately, at the concentration of volume 0.1%,0.2%,0.3% ,the heat transfer enhancement of 15%-20% compared to pure water was recorded.
2. Increasing the flow rate of working fluid enhances the heat transfer coefficient for both pure water and nanofluid considerably while the variation of fluid inlet temperature to the radiator slightly changes the heat transfer performance.
3. It seems that the increase in the effective thermal conductivity and the variations of the other physical properties are not responsible for the large heat transfer enhancement. Brownian motion of nanoparticles maybe one of the factors in the enhancement of heat transfers. Although there are recent advances in the study of heat transfer with nanofluids, more experimental results and theoretical understanding of the mechanisms of the particle movements are needed to explain heat transfer behavior of nanofluids.
4. This new working fluid with higher heat transfer performance would promote the car engine performance and would reduce fuel consumption. Therefore, it can be followed by other investigators to eliminate the probable deficiencies for industrialization in the car industries. Some associated problems like stability and sedimentation should be studied with details.

IX. REFERENCES

1. Saidur,R.,Leong,K.Y.,Mohammadc,H.A., “A review on applications and challenges of nanofluids”, Renewable and Sustainable Energy Reviews,15,2011
2. Available from:- http://www.carparts.com/classroom/coolingsystem.
3. Available from:- http://www.autocorner.ca/pages/radiators.html
4. Available from:- http://help.solidworks.com/2012/English/SolidWorks/cworks/IDH_Analysis_Background_Convection.htm
5. Batchelor, G.K., “The effect of Brownian motion on the bulk stress in suspension of spherical particles”, Journal of Fluid Mechanics, 83 ,1977
6. Henderson, J.R., Vanswol,F., “On the interface between a fluid and a planar wall: Theory and simulations of a hard sphere fluid at a hard wall”, Journal of Mol. Physics, 51, 1984
7. ZeinaliHeris,S., Nasr Esfahany,M., Etemad,S.Gh., “Experimental investigation of convective heat transfer of Al2O3/water nanofluid in circular tube” ,International Journal of Heat and Fluid Flow,28,2007
8. Eastman, J.A., Choi, S.U.S., Yu, S. Li. W., Thompson, L.J., “Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles”,Journal of Applied Physics,78,2001
9. Lee, J.K., Lee, C.H., Jung, Y.M., Cheong,S.I., Lee,C.G., “Stability and thermal conductivity characteristics of nanofluids”, Thermochimica Acta,455,2007
10. Hamilton, R.L., Crosser, O.K., “Thermal Conductivity of Heterogeneous Two-Component Systems”, I & EC Fundamentals, 1(3), 1962.
11. Lee, S., Choi, S.U.S, Li, S., Eastman, J.A., “Measuring Thermal Conductivity of Fluids Containing Oxide Nanoparticles”, Journal Of Heat Transfer, 121, 1999.
12. Wang, X., Xu, X., Choi, S.U.S., “Thermal Conductivity of Nanoparticle-Fluid Mixture”, Journal of Thermo physics and Heat Transfer, 13(4), 1999.
13. Yang, Y., Zhang, Z., Grulke, E., Anderson, W., Wu, G., “Heat Transfer Properties of Nanoparticle-In-Fluid Dispersions(Nanofluids) In Laminar Flow”, International Journal of Heat and Mass Transfer, 48(6), 2005.
14. Keblinski, P., Phillpot, S.R., Choi, S.U.S., Eastman, J.A., “Mechanisms of Heat Flow in Suspensions of Nano-Sized Particles (Nanofluids)”, International Journal of Heat and Mass Transfer, 45(4), 2002.
15. Buongiorno, J., “Convective Transport in Nanofluids”, Transactions of the ASME, 128,2006.

16. Das, K.S., Putra, N. Thiesen, P., Roetzel, W., "Temperature Dependence of Thermal Conductivity Enhancement for Nanofluids", Transactions of the ASME, 125, 2003.

17. Xuan, Y., Li, Q., "Investigation on Convective Heat Transfer and Flow Features of Nanofluids", Journal of Heat Transfer, 125(1), 2003

18. Leong, K.Y., Saidur,R., Kazi, S.N., Mamunc, A.H. , "Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator)", Applied Thermal Engineering,30,2010

19. Prasad,R.V., Jayandakumar,T., "Al2O3 Nanofluids as Heat Transfer Liquids in Automotives", International Journal of Mechanical and Industrial Engineering,2(4),2012

20. Salvio Chacko, Shome Biswadip, KumarVinod, Agarwal ,A.K.,Katkar,D.R., "Numerical Simulation for Improving Radiator Efficiency by Air Flow Optimization" Engineering Research Center, Tata Motors Limited, Pune, India, 2012

21. Peyghambarzadeh , S.M., Hashemabadi , S.H., Seifi Jamnani , M., Hoseini, S.M., "Improving the cooling performance of automobile radiator with Al2O3/water Nanofluid", Applied Thermal Engineering, 31, 2011

22. Peyghambarzadeh , S.M., Hashemabadi, S.H., Naraki, M., Vermahmoudi, Y., "Experimental study of overall heat transfer coefficient in the application of dilute nanofluids in the car radiator ", Applied Thermal Engineering, 52 ,2013

23. Vermahmoudia, Y., Peyghambarzadeha,S.M., Hashemabadib, S.H., Naraki,"M., "Experimental investigation on heat transfer performance of Fe2O3/water nanofluid in an air-finned heat exchanger", European Journal of Mechanics,44,2014