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Nanofluid Assisted Cooling Of Automobile Radiator

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Abstract: Cooling of engine is vital for the effective performance of an automobile. Many types of engine cooling were demonstrated by researchers across the world. 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 nanotechnology, the new generation of heat transfer fluids called, "Nanofluids" have been developed. Researchers found that these fluids offer higher thermal conductivity compared to that of conventional coolants. This study focused on the application of ethylene glycol-water based copper oxide nanofluids in an automotive cooling system. Two different concentrations of nanofluids in the range of 0.1 vol % and 0.05 vol % have been prepared by the addition of CuO nanoparticles into the water-ethylene glycol (80:20) ratio. Thermo-physical properties of prepared nanofluids and conventional coolant have been estimated experimentally. The efficacy of the nanoparticles assisted coolant towards heat removal in automobile radiator is evaluated. The heat removed by the conventional radiator coolant and prepared nanofluid has also been estimated by varying the temperature in the range of 40°- 60°C and at various velocity of air at the radiator frontal area.

Index Terms **- Engine, nanofluid, radiator.**

I. INTRODUCTION

Continuous technological development in automotive industries has increased the demand for high efficiency engines. A high efficiency engine is not only based on its performance but also for better fuel economy and less emission. Reducing the vehicle weight by optimizing design and size of a radiator is a necessity for making the world green. Addition of fins is one of the approaches to increase the cooling rate of the radiator. It provides greater heat transfer area and enhances the air convective heat transfer coefficient. However, traditional approach of increasing the cooling rate by using fins and micro channel has already reached to their limit.
Engine oils, automatic transmission fluids, coolants, lubricants and other synthetic high-temperature heat transfer fluids found in conventional truck thermal systems radiators, engines, heating, ventilation and air-conditioning (HVAC) have inherently poor heat transfer properties. These could benefit from the high thermal conductivity offered by nanofluids that resulted from addition of nanoparticles.

Modern automotive internal combustion engines generate a huge amount of heat. This heat is created when the fuel 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 537°C. 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. 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.

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, it 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.

Recent advances in nanotechnology have allowed development of a new category of fluids termed nanofluids. Such fluids are liquid suspensions containing particles that are significantly smaller than 100 nm, and have a bulk solids thermal conductivity higher than the base liquids [1]. Nanofluids are formed by suspending metallic or non-metallic oxide nanoparticles in traditional heat transfer fluids. These so called nanofluids display good thermal properties compared with fluids conventionally used for heat transfer and fluids containing particles on the micrometre scale [2]. Nanofluids are the new window which was opened recently and it was confirmed by several authors that this working fluid can enhance heat transfer performance. Pak and Cho [3,4] presented an experimental investigation of the convective turbulent heat transfer characteristics of nanofluids (Al_2O_3ewater) with 1-3 vol %. The Nusselt number for the nanofluids increases with the increase of volume concentration and Reynolds number.

II. MATERIALS AND METHODS

As shown in Fig. 1, the experimental system used in this research includes flow lines, a storage tank, a heater, a small submersible pump, a flow meter, a forced draft fan and a cross-flow heat exchanger (an automobile radiator). The pump gives a constant flow rate of l00 l/hr; the flow rate to the test section is regulated by appropriate adjusting of a globe valve line. The working fluid fills 25% of the storage tank whose total volume is 5 l (height 220 mm and diameter 190 mm). The total volume of the circulating liquid is constant in all the experiments. 9mm copper tubes insulated with foam material have been used as connecting lines.

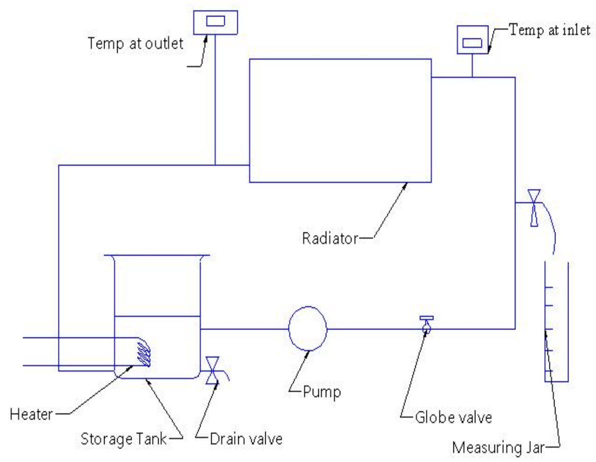

Fig.1 Schematic diagram of experimental setup

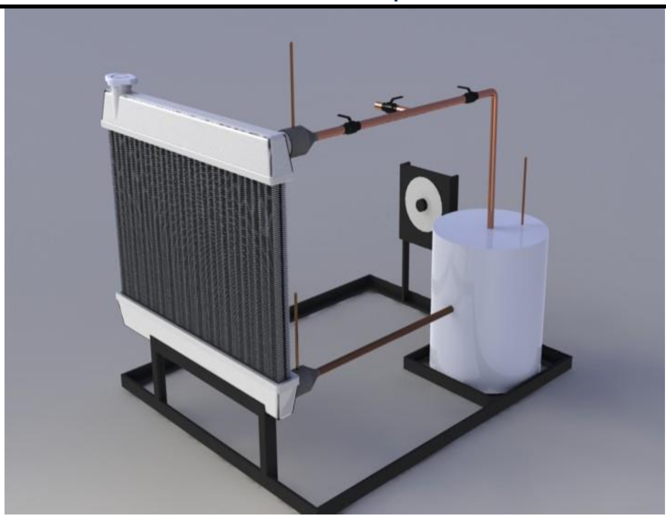

Fig 2. Proposed Experimental setup to test the various coolants.

An electrical heater is used to heat the radiator coolant. Two Digital thermometers were implemented on the flow line to record radiator fluid inlet and outlet temperatures. The configuration of the automobile radiator used in this experiment is parallel fin type. The fins and the tubes are made with aluminum. For cooling the liquid, a forced fan was installed close and face to face to the radiator and consequently air and water have indirect cross flow contact and there is heat exchange between hot water flowing in the tube-side and air across the tube bundle.

The test liquids are water-ethylene glycol based nanofluids and conventional coolant. Nanofluids consist of water, ethylene glycol and small amount (0.1 vol % & 0.05 vol %) of copper oxide nanoparticle. The mean grain size of copper oxide nanoparticle is less than 100 nm. There was no dispersant or stabilizer added to nanofluid. This is due to the fact that the addition of any agent may change the fluid properties [5,6].

2.1 Copper Oxide Nanofluid Preparation

The Copper oxide nano particle is prepared by solid-sol method. The prepared Copper oxide nanoparticle is dispersed in water-ethylene glycol mixture (80:20) ratio by sonication process. The size of the copper oxide nanoparticle is less than 100 nm.

2.2 Physical Properties of Copper oxide nanofluid and conventional coolants

The most important properties needed for estimation of convective heat transfer coefficient of nanofluids are its density, viscosity and specific heat. The thermo-properties properties of CuO nanofluids and conventional coolant are estimated experimentally.

2.2.1 Density

Density of various coolant is measured by using the mass/volume formula and compared with the Pak & Cho theoretical density of nanofluids

By Pak & Cho relation, $\rho_{nf} = \phi\, \rho_p + (1-\phi)\rho_{bf}$ [3]

ρ_{nf} - Density of CuO nanofluid. (kg/m^3)
ϕ - Volume Fraction in percentage.
ρ_{bf} -Density of base fluid (kg/m^3)
ρ_p -Density of CuO nanoparticles. (kg/m^3)

Table 1. Density of various radiator coolants

Radiator Coolants	Theoretical Density kg/m^3	Experimental Density kg/m^3
Conventional coolants	-	1015.54
CuO nanofluid (0.05%vol)	1039.82	1041.27
CuO nanofluid (0.1% vol)	1042.45	1044.64

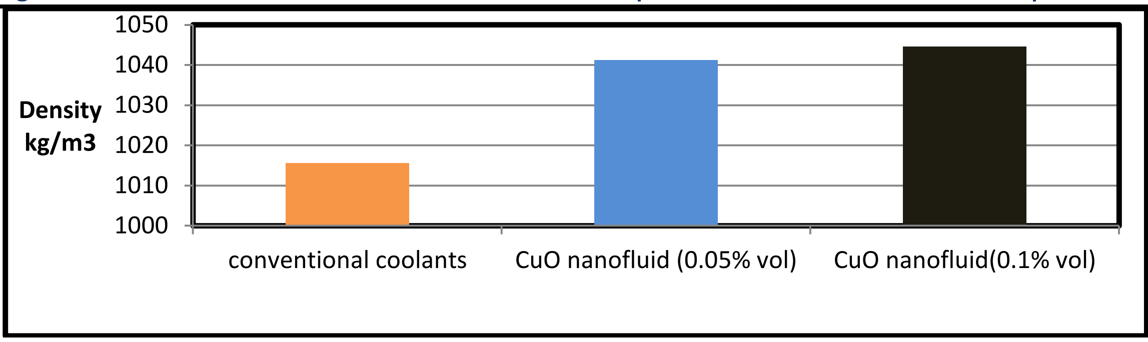

Fig 3. Comparison of Density of various coolants

The above graph shows that there is no abrupt change in density of prepared nanofluids when compared with conventional coolants. Density of nanofluids increases with increase in their volume concentration.

2.2.3 Relative viscosity

Relative viscosity is measured by means of Ostwald viscometer. The time required for the test liquid to flow through a capillary of known diameter between two marked points is measured. Here water is taken as a reference fluid.

$$\text{Relative Viscosity, } \eta_{nf} = \frac{\rho_{nf}\, t_{nf}\, \eta_g}{\rho_g\, t_g}$$

ρ_{nf} - Density of CuO nano fluid(g/cm^{3})

t_{nf} - Outflow time of the CuO nano fluid from the capillary (sec)

ρ_g – Density of reference fluid, water (g/cm^3)

t_g - Outflow time of the water(sec)

Table 2. Relative viscosity of various coolants

Coolants	Relative viscosity
conventional coolants	1.2
CuO nanofluid (0.05% vol)	1.426
CuO nanofluid (0.1% vol)	1.47

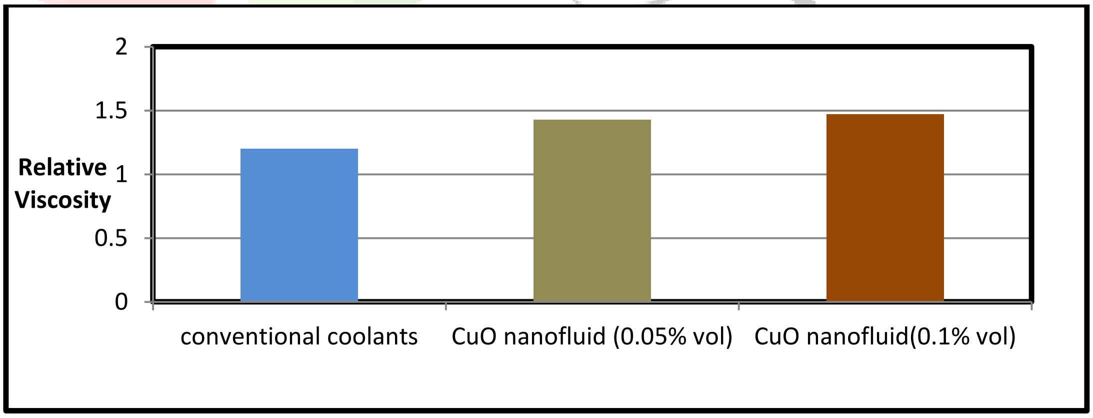

Fig 4. Comparison of Relative viscosity of various coolants

The above graph shows that viscosity of nanofluid is slightly greater than conventional coolant. Hence the usage of nanofluid as a coolant in automobile will not increase the pumping power. It also shows that viscosity increases with increase in volume concentration of nanofluid.

2.2.4 Specific Heat

The method of mixture based on the fact that when a hot substance is mixed with a cold substance, the hot body loses heat and the cold body absorbs heat until thermal equilibrium is attained. At equilibrium, final temperature of mixture is measured. The specific heat of the liquid is calculated with the help of the law of heat exchange using known solid.
According to the law of heat exchange,

Q lost by the known solid= Q gained by the liquid + Q gained by the calorimeter

Table 3. Specific heat of various coolants

Coolants	Specific heat(J/kg.K)
conventional coolants	3674.77
CuO nanofluid (0.05% vol)	3008.76
CuO nanofluid (0.1% vol)	2897.98

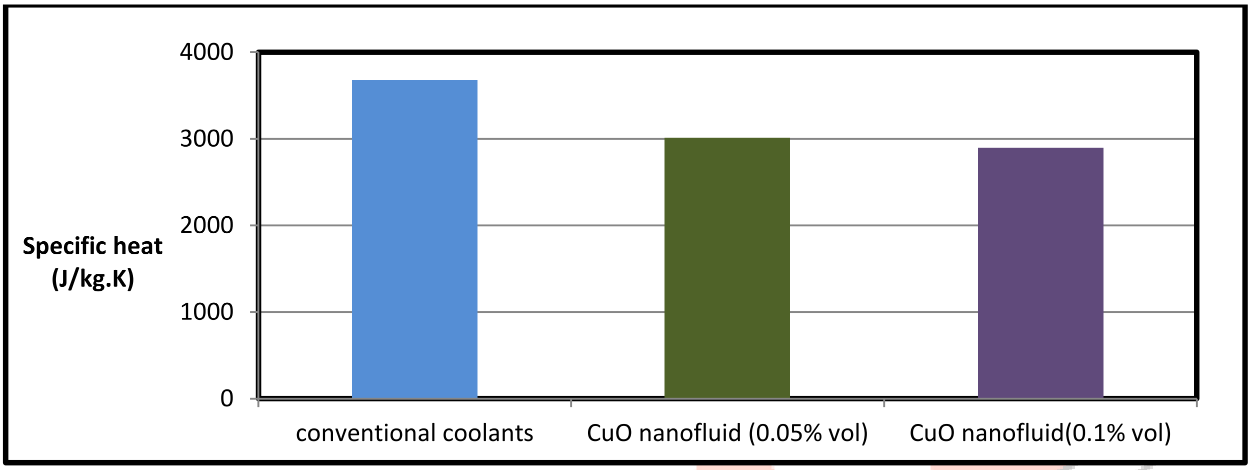

Fig 5. Comparison of Specific heat capacity of various coolants

The above graph shows that specific heat decreases with increase in volume concentration of nanofluid. The thermal conductivity of nanofluid increases with decrease in specific heat capacity. Hence the heat removed by the nanofluid increases with increase in volume concentration of nanofluid.

III. RESULTS AND DISCUSSION

3.1 Estimation of heat transfer in Experimental setup

The heat removed by the conventional radiator coolant and prepared nanofluid has been estimated by varying the temperature in the range of 40°- 60°C, at various velocity of air at the radiator frontal area and at constant flow rate of coolant in the prepared experimental setup.

Heat removed by coolant, $Q = m\,c\,(T_i - T_0)$, J/s

Where, m- Mass flow rate of coolant, kg/sec

C-Specific heat of coolant, J/kg.k

T_i- Radiator inlet temperature, °C

T_o- Radiator outlet temperature °C

3.2 Heat removed by conventional coolant

The graph shows that heat removed by conventional coolant increases with increase in velocity of air at frontal area. As inlet temperature increases heat removed by coolant also increases. Maximum heat removed by coolants occurs at 5.56 m/sec, 60˚C

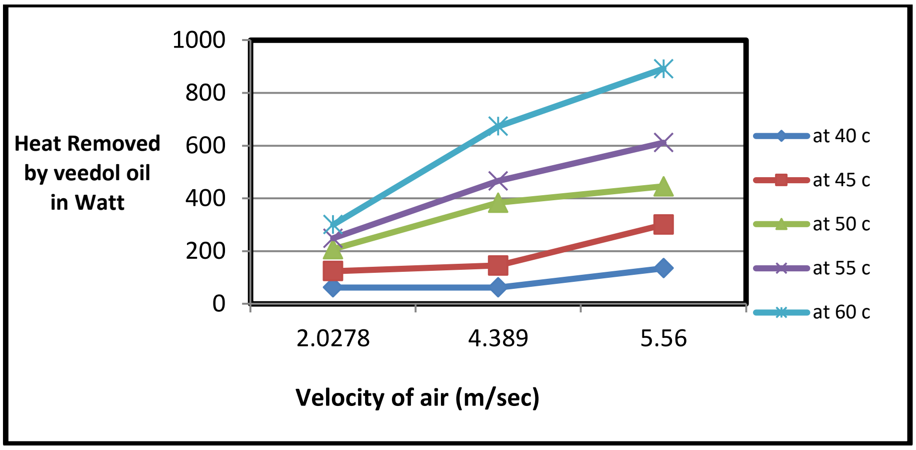

Fig 6. Heat removal by conventional coolant at various velocities air and inlet temperature

3.3 Heat removed by CuO Nanofluid 0.05 vol%

The graph shows that heat removal increases with increase in inlet temperature. At 5.56 m/sec, 60°C heat removed is 956.81 J/sec.

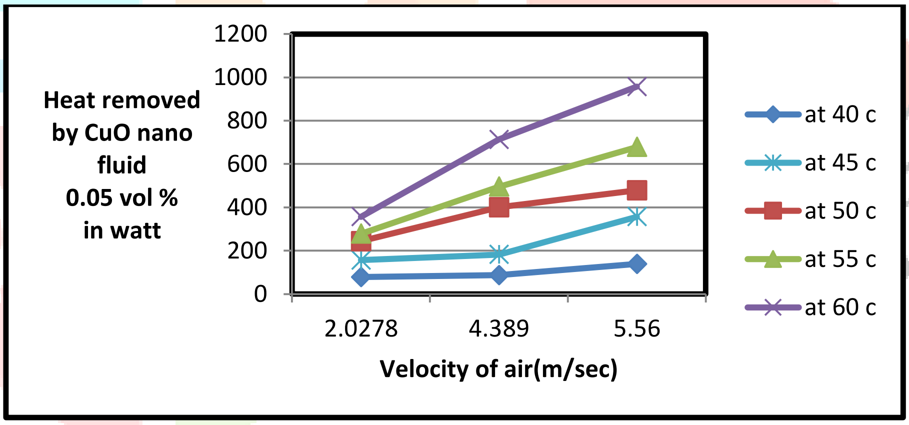

Fig 7 Heat removed by nanofluid 0.05 vol% at various velocities of air and inlet temperature

3.4 Heat removed by CuO Nanofluid 0.1 vol%

The graph shows that heat removed by nanofluid Increases with increase in inlet temperature. At 5.56 m/sec,60˚C heat removed is 1000.08 m/sec

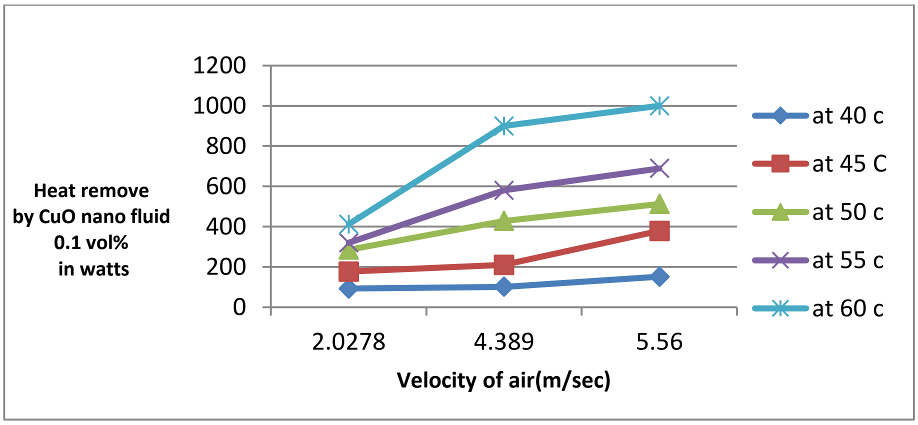

Fig 8 Heat removed by nanofluid 0.1vol% at velocity of air and inlet temperature

3.5 Comparative analysis

The following graph shows that heat removed increases with increase in inlet temperature at maximum flow rate. Superior heat transfer properties of nanofluids may also result in lower liquid flow rate for a given rate of heat transfer, yielding a reduction in the liquid pumping power consumed compared to the conventional coolant.

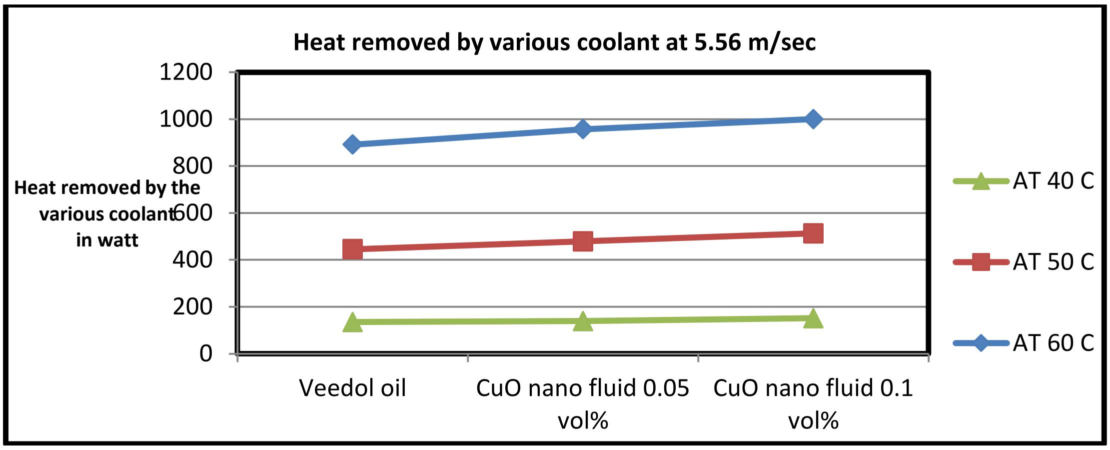

Fig.8. Comparison of various coolants at maximum flow rate

IV. CONCLUSION

The heat generated during the combustion of fossil fuels inside the engine cylinder has to be removed to prevent overheating of different components and to ensure the safe operation of the vehicle. In this work, the effective removal of heat generated is achieved by employing nanofluid with varying percentage of nanoparticles and the efficacy of the nanoparticles assisted cooling over the conventional coolant is demonstrated.

V. ACKNOWLEDGMENT

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REFERENCES

1) D. Wen, Y. Ding, Experimental investigation into convective heat transfer of nanofluids at the entrance region under laminar flow conditions, International Journal of Heat and Mass Transfer 47 (2004) 5181-5188.
2) M.S. Liu, M.C.C. Lin, I.T. Huang, C.C. Wang, Enhancement of thermal conductivity with CuO for nanofluids, Chemical Engineering and Technology 29 (1) (2006) 72e77.
3) B.C. Pak, I.Y. Cho, Hydrodynamic and heat transfer study of dispersed fluids with sub-micron metallic oxide particles, Experimental Heat Transfer 11 (1998) 151-170.
4) V. L. Bhimani, Dr. P. P. Rathod, Prof. A. S. Sorathiya, “Experimental study of heat transfer enhancement using water based nanofluid as a new coolant for car radiator”, june 2013, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 6, pp: 295-3-2.
5) Golakiya Satyamkumar, Sarvaiya Brijrajsinh,Makwana Sulay,Thumar Ankur, Rathwa Manoj “Analysis of radiator with different types of nanofluids”, Jan.-March, 2015, Journal ofEngineering Research and Studies, Vol. VI Issue I pp:1-2.
6) Archit Deshpande, Viraj Patil, Rohit Patil,*“Experimental Analysis of Automobile Radiator using MWCNT-Water Nanofluid”*, November-2016, International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 11,pp:97-101.