Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(3):686-692

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Heat transfer enhancement of thermic fluid by using nanofluids in radiator

M. Gajendiran[1*], E. Saravanakumar[1*], N. Madhan Raj[1] and N. Nallusamy[2]

[1]Department of Mechanical Engineering, Sri Venkateswara College of Engineering, Sriperumbudur-602117, Tamil Nadu, India
[2]Department of Mechanical Engineering, SSN College of Engineering, OMR, Kalavakkam-603110, Tamil Nadu, India

---

ABSTRACT

It is in practice of using water as a heat transfer agent but it is be highly recommended to use thermic fluids to get an effective heat transfer rate by using nanofluids. Water has more heat transfer rate when compared with thermic fluids. We have to increase the heat transfer rate of thermic fluids. Researchers found that nanofluids which are produced by dispersing nanoparticles show greater thermal conductivities than regular fluids. Thermal conductivity and viscosity are a function of nanoparticle concentration and temperature. It is used in printing and dyeing industry, heating equipment system high temperature thermal conductivity especially in solar thermal power generation system.

Keywords: Transformer oil, Copper Nanoparticles, Nanofluids, Radiator and Heat transfer rate

---

INTRODUCTION

The automotive industry is continuously involved in a strong competitive career to obtain the best automobile design in multiple aspects like performance, fuel consumption, aesthetics, safety etc. The air-cooled heat exchangers found in a vehicle like radiator, AC condenser and evaporator, charge air cooler, etc. have an important role in its weight and also in the design of its front-end module, which also has a strong impact on the car aerodynamic behaviour. Looking at these challenges, an optimization process is mandatory to obtain the best design compromise between performance, size or shape and weight. This optimization objective demands advanced design tools that can indicate not only the better solution but also the fundamental reason of a performance improvement. The radiator is an important accessory of vehicle engine. Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium. For this liquid-cooled system, the waste heat is removed via the circulating coolant surrounding the devices or entering the cooling channels in devices. The coolant is propelled by pumps and the heat is carried away mainly by heat exchangers. 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 a 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. Nanofluids have attracted attention as a new generation of heat transfer fluids in building in automotive cooling applications, because of their excellent thermal performance. Recently, there have been considerable research findings highlighting superior heat transfer performances of nanofluids. Day by day, the need for improving the heat transfer rate from thermal equipments has been increasing for an effective cooling process. Even though, several methods are available at present to increase the heat transfer rate like introducing fins at the outer periphery of the thermal systems, increased flow rate of coolant through the thermal systems, these methods do have their own limitations. The increased flowrate of coolant also increases pump work thus results in low cyclic efficiency. The introduction of fins leads to undesirable size increase in thermal management system. The conventional fluids like water, engine oil, refrigerants are not satisfying need of high compactness and effectiveness. In this work, the objective of increased heat transfer rate from automobile radiator was analyzed using nanofluids at different concentrations. The influence of operating parameters like varying inlet temperature, varying flow rate and different concentration of nano fluids on the effective heat transfer rate from the radiator was also studied. The heat transfer correlations for different operating parameters were also developed.

Weerapun Duangthongsuk et al [1] conducted an experimental study on forced convective heat transfer of nanofluid where the nano fluid is a blend of water and 0.2% TiO_2 under turbulent flow conditions. The final results confirmed an increased heat transfer coefficient with an increase in the mass flow rate of hot water and decrease in nano particle temperature.

Kim et al [2] investigated the effect of nanofluid on the performance of convective heat transfer coefficient of a circular straight tube having laminar and turbulent flow with constant heat flux. Authors have found that the convective heat transfer coefficient of alumina nanofluids is improved in comparison to the base fluid by 15% and 20% in laminar and turbulent flow respectively.

Rea et al [3] studied the convective heat transfer coefficient of alumina/water and zirconia /water nanofluids in a flow loop with a vertical heated tube. The heat transfer coefficient in the entrance region and in the fully developed region was found to increase by 17% and 27% respectively for alumina/water nanofluid at 6% whereas it was 2% in the entrance region and 3% in the fully developed region for zirconia/water nanofluid at 1.32% with respect to pure water.

Farajollahi et al [4] measured the heat transfer characteristics of g-Al2O3/water and TiO2/water nanofluids in a shell and tube heat exchanger under turbulent flow condition. According to their report, the maximum enhancement of the overall heat transfer co efficient of g-Al2O3/water nanofluids was approximately 20% which occurred at 0.5% volume concentration. At the Peclet number of 50,000, the enhancements of the overall heat transfer coefficient at 0.3%, 0.75%, 1%, and 2% nanoparticle volume concentrations were about 14%, 16%, 15% and 9% respectively. For TiO_2/water nanofluids the maximum enhancement was observed at 0.3% particle volume concentration.

S M Fotukian et al [5] experimentally studied convective heat transfer of diluted CuO/water nanofluids inside a circular tube. They used nanofluids with nanoparticles of volume fraction less than 0.3%. The heat transfer coefficient increased about 25% when compared to that of pure water.

Xie et al [6] demonstrated that using Al2O3, ZnO, TiO2and MgO nanofluid with a mixture of 55% distilled water and 45% ethylene glycol as the base fluid in laminar flow inside a circular copper tube with constant wall temperature could enhance the convective heat transfer. MgO, Al2O3 and ZnO nanofluids exhibited superior enhancements of heat transfer coefficient, with the highest enhancement up to 252% at a Reynolds number of 1000 for MgO nanofluid.

Leong et al [7] investigated the performance of Cu/Ethylene Glycol nanofluids in an automotive car radiator. They revealed that overall heat transfer coefficient of 164 W/m2K can be achieved for 2%. Cu/Ethylene Glycol nanofluid compared to that 142 W/m2K with the base fluid. In this work, the objective of increased heat transfer rate from automobile radiator was analyzed using different nanofluids and at different concentrations. The influence of operating parameters like varying inlet temperature, varying flow rate and different concentration of nano fluids on the effective heat transfer rate from the radiator was also studied.

He et al [8] investigated the heat transfer and flow behaviour of TiO2-distilled water nanofluids were flowing in an upward direction through a vertical pipe in both the laminar and transition flow regimes under a constant heat flux boundary condition. The results indicated that the convective heat transfer coefficient increased with an increase in nanoparticle concentration at a given Reynolds number and particle size. They also found that the pressure drop of the nanofluids was approximately the same as that of the base fluid.

Eastman et al [9] reported that the thermal conductivity of ethylene glycol nanofluids containing 0.3% volume fraction of copper particles can be enhanced up to 40% compared to that of ethylene glycol base fluid.

EXPERIMENTAL SECTION

2.1. Preparation of nanofluids

For our experimental purpose we have to add 0.1% and 0.3% of copper nanoparticle to the base transformer oil. The measurement for 0.1% is 0.549 grams and for 0.3% is 1.68 grams. Due to higher density of nanoparticle, it does not mix with transformer oil. So we used the ultrasonic vibrator for mixing action of fluid to prepare nanofluids. Ultrasonic vibrator requires 30 minutes for mixing of nanoparticle with base transformer oil. About 4.5 liters of nanofluids was prepared for the experiment.

2.2. SEM of aluminium oxide nanoparticles

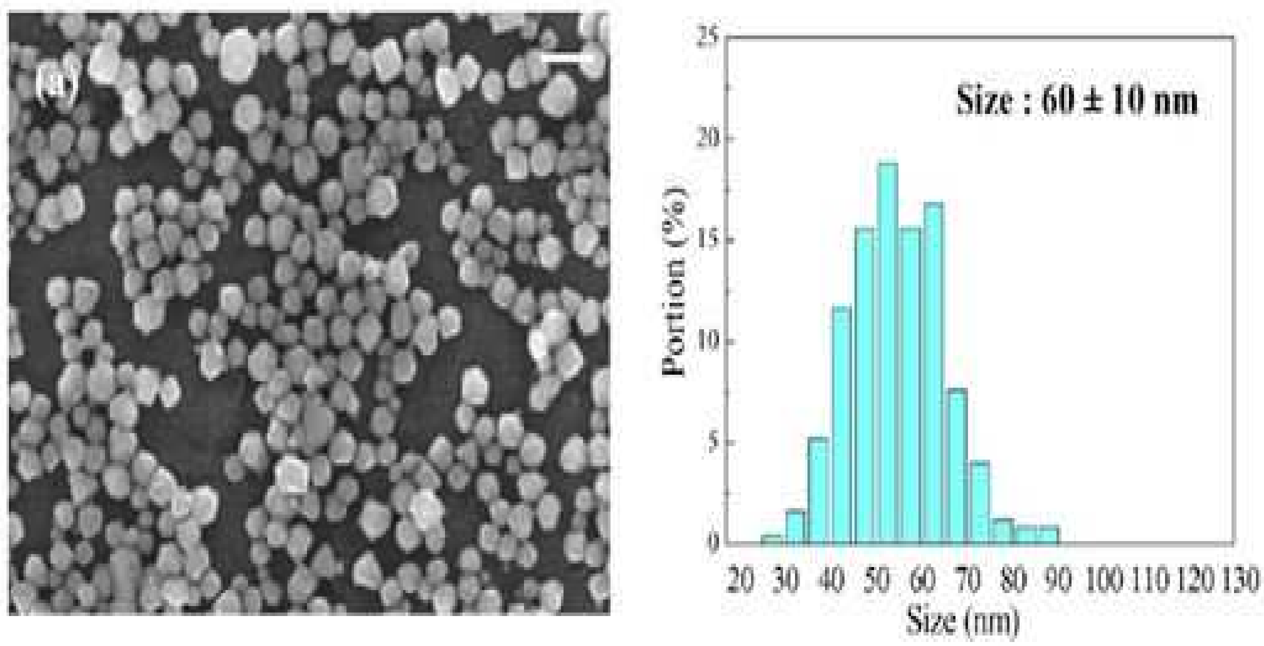

Figure 1 Structure of Nanoparticles

The SEM images showed that, most of the nanoparticles obtained from all the abated laser energies have spherical shape with a particle size of less than 100 nm. The SEM of copper nanoparticles is shown in fig 1. Surface and morphological characterization of copper nanoparticles was carried out using scanning electron microscopy. Nanosized spherical shaped copper particles obtained were confirmed. The mean size of the particles is about 60 nm.

3. EXPERIMENTAL SETUP AND TEST PROCEDURE

The experiments are conducted for various speeds like 2000 rpm, 2500 rpm and 3000 rpm. The engine was sufficiently warmed up and stabilized before taking all the readings. At different speeds the amount of fluid passing through the radiator is varied. The radiator capacity is 4.5 litres. Initially the radiator is filled with water. After that the engine is started. Then the engine changed to certain speed like 2000 rpm. By using the flow meter the amount of fluid flow through the radiator is measured. By using the temperature measuring device like infrared temperature detector the inlet flow temperature, outlet flow temperature, air inlet temperature and air outlet temperature are measured. The measurements are also taken for 2500 rpm and 3000 rpm. The same procedure is repeated for base transformer oil and nanofluids.

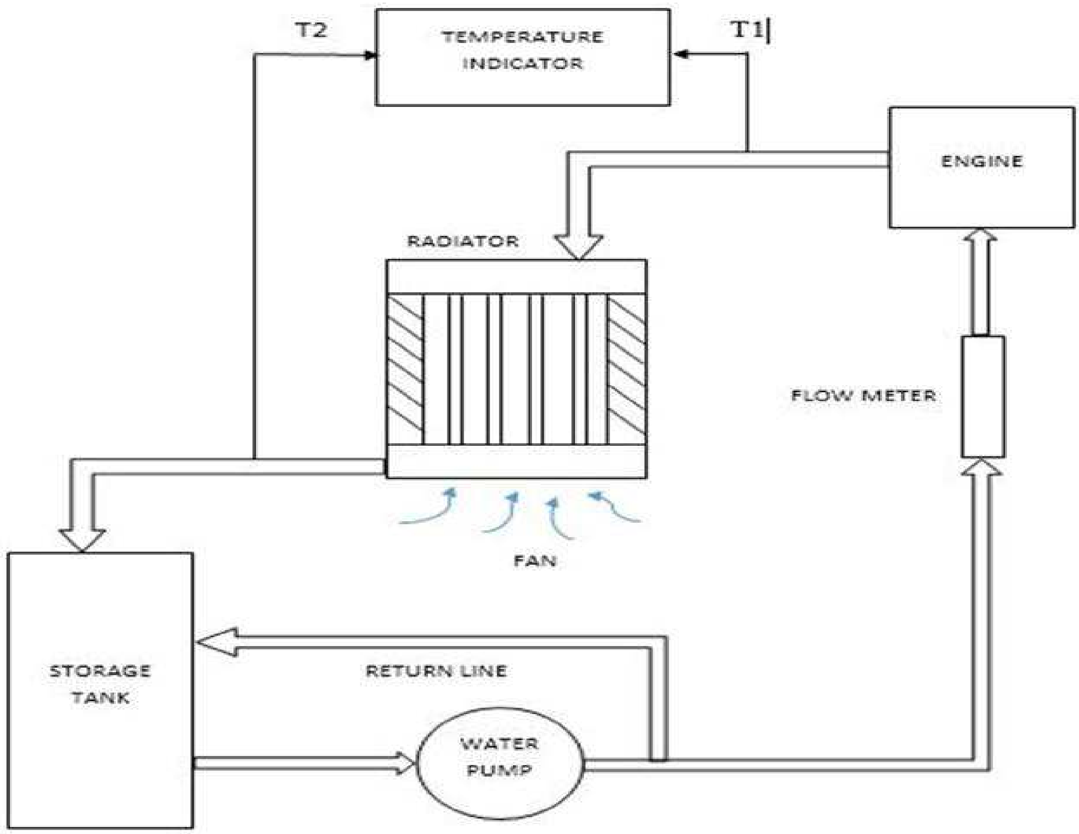

Figure 2 Experimental setup

Table 1 Radiator specification

Sl. No	Radiator Dimensions	Values
1	Radiator length	0.4572 m
2	Radiator width	0.4318 m
3	Radiator height	0.0246 m
4	Tube width	0.0246 m
5	Tube height	1.56×10^{-3} m
6	Fin width	0.0246 m
7	Fin height	0.0119 m
8	Fin thickness	2.54×10^{-5}m
9	Distance between fins	1.59×10^{-3}m
10	No. of tubes	33

RESULTS AND DISCUSSION

4.1. Heat transfer rate

Figure 3, figure 4 and figure 5 shows the heat transfer rate at various speeds like 2000 rpm, 2500 rpm and 3000 rpm for water, transformer oil and nanofluids. When we changing the speed the flow rate through the radiator is also changed. From below figure reveals the heat transfer rate of nanofluids is increased when compared with base transformer oil and water. It is due to increase of thermal conductivity.

From fig 3, we observe that the heat transfer rate of water is more than that of transformer oil because the thermal conductivity of water is more than that of transformer oil. And also the specific heat of water is more than that of oil.

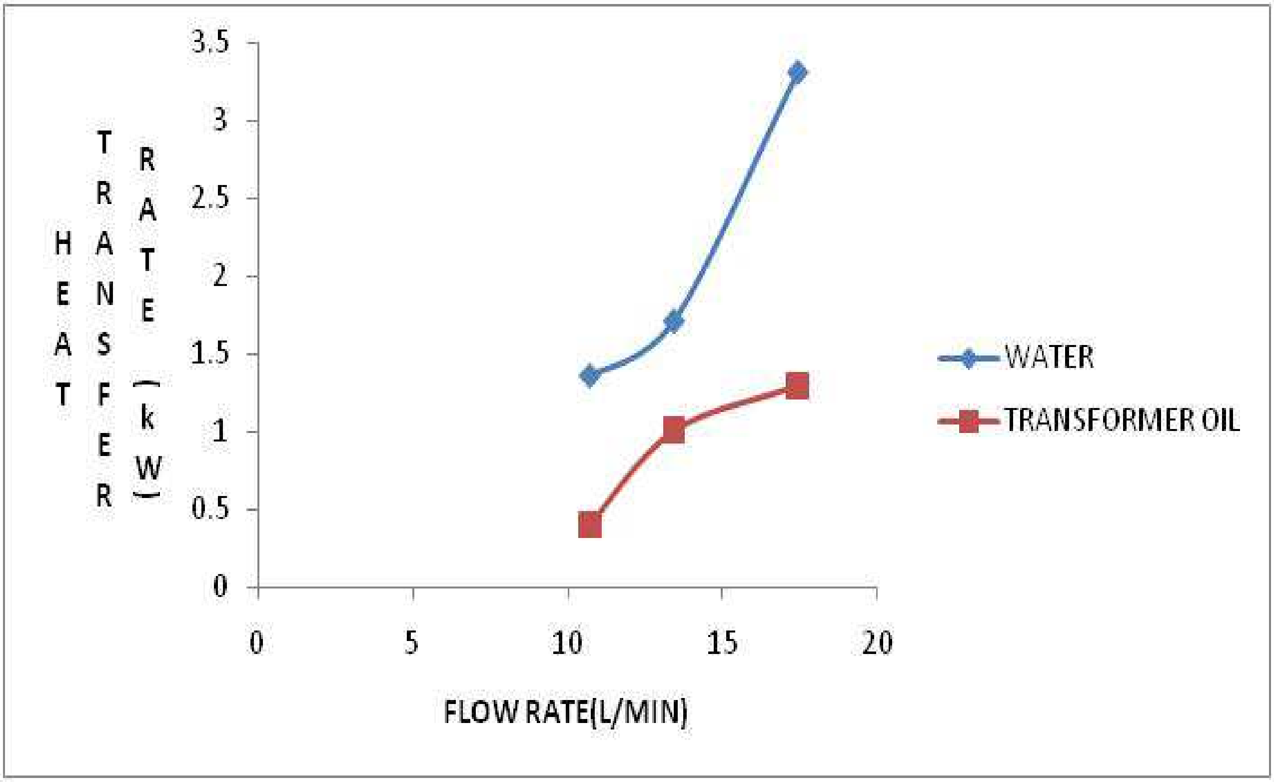

Figure 3 Variation of heat transfer rate versus flow rate for oil and water

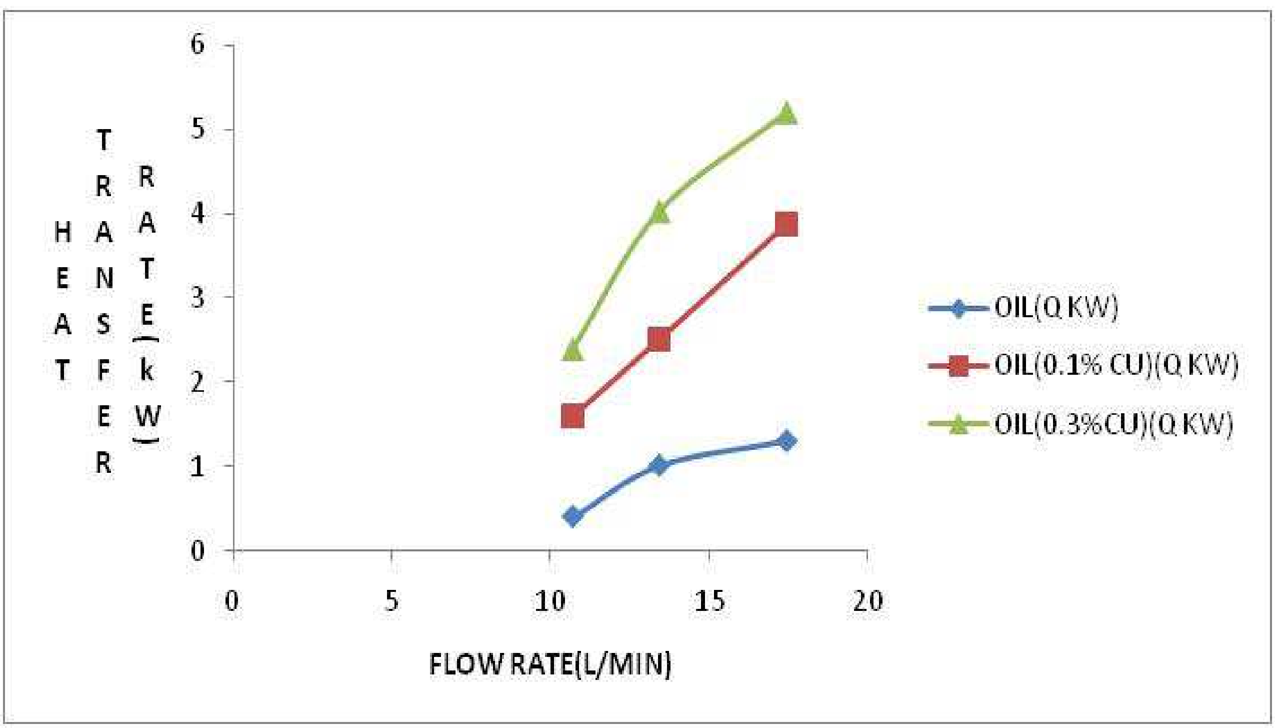

Figure 4 Variation of heat transfer rate versus flow rate for oil and Nanofluids

From the fig 4 the heat transfer rate of nanofluids is more than that of transformer oil. It is due to increase of thermal conductivity. The Nanofluids (0.3%) has more heat transfer rate than Nanofluids (0.1%). If we add more amounts of Nanoparticles it increases the pumping power.

From the fig 5 the heat transfer rate of Nanofluids is more than that of oil and water. Due to addition of nanoparticles, the heat transfer rate of base oil is increased.

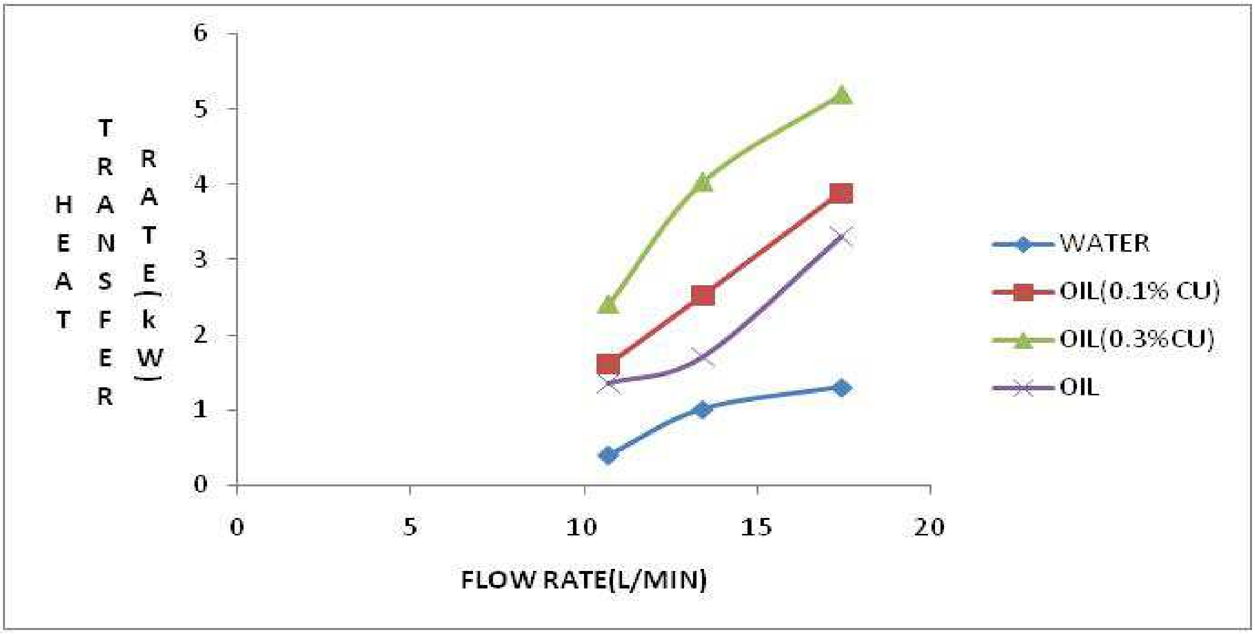

Figure 5 Variation of heat transfer rate versus flow rate for Oil, Nanofluids and water

CONCLUSION

The present study focus on the influence of Copper Nanoparticles on Transformer Oil heat transfer rate in Maruthi Suzuki Omni Engine Radiator. Based on the results of present work, following conclusion can be drawn:

- ✓ When we using the Nanofluids heat transfer rate is increased compared to water and oil.
- ✓ Heat transfer rate for Nanofluids is 15% more than that of water.
- ✓ Heat transfer rate for Nanofluids is 66% more than base transformer oil.

NOMENCLATURE	
Cu	Copper
Q	Heat transfer
kW	Kilowatt
Nm	Nanometer
Kg	Kilogram

Acknowledgement
We thank the management of Sri Venkateswara College of Engineering for providing us with the necessary experimental setup to perform this research work.

REFERENCES

[1] Weerapun Duangthongsuk et al, C Kannan. *International Journal of Thermal sciences*, **2008,** 47, 1235–1242.
[2] Kim et al *Journal on applied thermal engineering*, **2013,** 9(2), 119-123.
[3] Nguyen, Roy, Gauthier and Galanis. *Energy*, **2010**, 35, 148-157.
[4] Farajollahi et al. *Applied Energy*, **2012,** 99, 116-125.

[5] S M Fotukian et al. *Fuel*, **2008,** 87, 3497-3503.
[6] Xie et al. *International journal on applied thermal engineering*, **2014,** 5, 463-472.
[7] Leong et al. *International journal on thermal engineering*, **2015**, 30, 2685-2692.
[8] He et al. *Alexandria Engineering Journal*, **2015**. 43(5), 593-602.
[9] Eastman et al. *Journal on thermal engineering*, **2013,** 3, 3-11.