



## NANO TECHNOLOGY IN VEHICLE COOLING SYSTEM

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**Abstract**— The forced convection heat transfer enhancement by TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> suspended in water as a base fluid inside the flat copper tubes of an automotive cooling system has been measured. Significant heat transfer enhancement was observed and was associated with the concentration of the nanoparticles. Maximum Nusselt number enhancements of up to 11% and 22.5% were obtained for TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> nanoparticles, respectively. The experimental results showed that the Nusselt number behaviors of the nanofluids highly depended on the volume flow rate, inlet temperature and produces a higher heat transfer enhancement than the TiO<sub>2</sub> nanofluid; likewise, TiO<sub>2</sub> nanofluid enhanced heat transfer more than pure water. The results also proved that TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> nanofluid have a high potential for heat transfer enhancement and are highly appropriate for industrial and practical applications.

**Keywords**— Nanofluids, Nusselt number, heat transfer, automotive cooling system.

### I. INTRODUCTION

Conventional coolants have been widely employed to dissipate heat in majority of the engineering applications. Typical coolants include matter in all three states namely solid, liquid and gas based on the requirements of application and possible mode of heat transfer. However, with the latest technological advancements, an emerging class of new coolants namely nano-coolants (coolants with dispersed nano-particles) finds their applications in a variety of engineering applications and is expected to replace conventional coolants in the near future. A typical nano fluid is prepared by dispersing certain types of select nano particles in a suitable base fluid (water, ethylene glycol and coolant) different volume concentrations, some of the specific advantages of nano fluids include enhanced thermal properties when compared to the base fluid. Mixing of additives in coolants has been in use from decades to enhance the heat transfer and reduce the pressure drop along the flow. However, enough care is to be exercised when additives are employed since they not only improve the heat transfer but also responsible to reduce the life of the components by fouling and other factors like increased pressure drop and sedimentation. With the increased demand for higher power and clean exhaust gas regulations necessity for hybrid vehicles and vehicles with higher power are increasing enormously. On the other hand only 60% of the heat developed during combustion is utilized for generating useful power and remaining heat is rejected to exhaust.

Hence there is a necessity to regulate this heat and maintain the temperature of the engine so as to enhance the performance. Common additives used in cooling system of an automobile include ethylene glycol which improves the properties of water such as Freezing point and boiling point. Majority of the automobile radiators uses a liquid cooling system where water with ethylene glycol is employed as cooling medium to transfer the excess heat from the engine. However, such conventional coolants provide inadequate heat transfer and therefore a necessity for high performance thermal systems arise. This can be achieved by increasing the size of the thermal system/cooling system Due to the stringent design conditions, increased frontal areas, drag coefficients, in an automobile, the necessity for improving the heat transfer phenomenon in the cooling medium is becoming essential.

### II. PREPARATION OF NANO FLUID

Two step process: This technique is also known as Kool-Aid method which is usually used for oxide nano particles. In this technique nano particles are obtained by different methods (in form of powders) and then are dispersed into the base fluid. The main problem in this technique is the nano particle agglomeration due to attractive Van der Waals forces. One step process: In this process the dispersion of nano particles is obtained by direct evaporation of the nano particle metal and condensation of the nano

particles in the base liquid and is the best technique for metallic nano fluids such as Cu nanofluids. The main problems in this technique are low production capacity, low concentration of nano particles and high costs. While the advantage of this technique is that nano particle agglomeration is minimized.

The suspensions obtained by either case should be well mixed, uniformly dispersed and stable in time. Also it should be noted that the heat transfer properties of nano fluids could be controlled by the concentration of the nanoparticle and also by the shape of nano particles. Overall we can say that the smaller the size the greater the stability of colloidal dispersion, the greater the stability of colloidal dispersion the greater the probability of interaction and collision among particles and collision among particles and fluid and the greater the effective heat energy transport inside the liquid (Xue 2003). Thermal conductivity enhancement ratio ( $K_{\text{effective}} = K_{\text{nanofluid}} / K_{\text{basefluid}}$ ) And the parameters that most affect the thermal conductivity of nano fluids are: Particle volume fraction, Particle material, Base fluids Particle size, Nature.

### III. EXPERIMENTAL SETUP AND PROCEDURE

The experimental test rig is developed with commercially available car radiator. It consists of coolant storage tank, an industrial heater, a high temperature durable pump, a radiator, and a fan. Instrumentation involves a set of thermocouples, anemometer, and a temperature indicator to record the temperatures and fluid flow rate. The schematic view of the developed test rig is shown in Fig.6.1.1. The front view and rear view of experimental test rig are shown in Fig. 6.1.2 and 6.1.3 respectively. The coolant in the tank is heated up to the desired temperature and the pump is switched on allowing the coolant to flow through the radiator and the fan is switched on to absorb heat from the hot fluid and subsequently dissipate to the environment. The temperatures are recorded at the inlet and outlet of the radiators collecting chamber. The nano fluid is assumed to be flowing with a uniform Reynolds number assuming normal distribution in the channels of the radiator. The coolant flows through the 3 rows of 104 tubes with a diameter of 5 mm and length of 0.3 m.

The coolant is allowed to flow through radiator with flow rates of 2, 3, 4 and 5 l/min. Three different air velocities at 2, 3 and 4 m/s are used to cool the tubes through which hot fluid gets circulated. The necessity for varying the flow rates of coolant and air is to simulate in service working conditions to the possible extent. Temperature of air entering and exiting the radiator has been recorded. The heat generation is simulated by using an industrial heater where the range has been set up to 39 °C to 95 °C. Once the required temperature (95 °C) is attained the high temperature durable coolant pump is switched on facilitating the circulation of the coolant across the heat exchanger. A set of 6 K-type thermocouples (–20 °C to 350 °C range Thermo Make) has been used to record the temperatures of the coolant tank, inlet chamber (collecting) of the radiator, exit chamber (collecting) of the radiator, one closely placed near the passage tubes of the radiator and two on the front and rear to record the temperature of the air. The temperature recorded by thermocouple placed near the passage tube at the centre of the radiator is to assess the heat lost and to calculate the bulk temperature. All the thermocouples, the temperature recorder, and anemometer were calibrated prior to the experimentation.

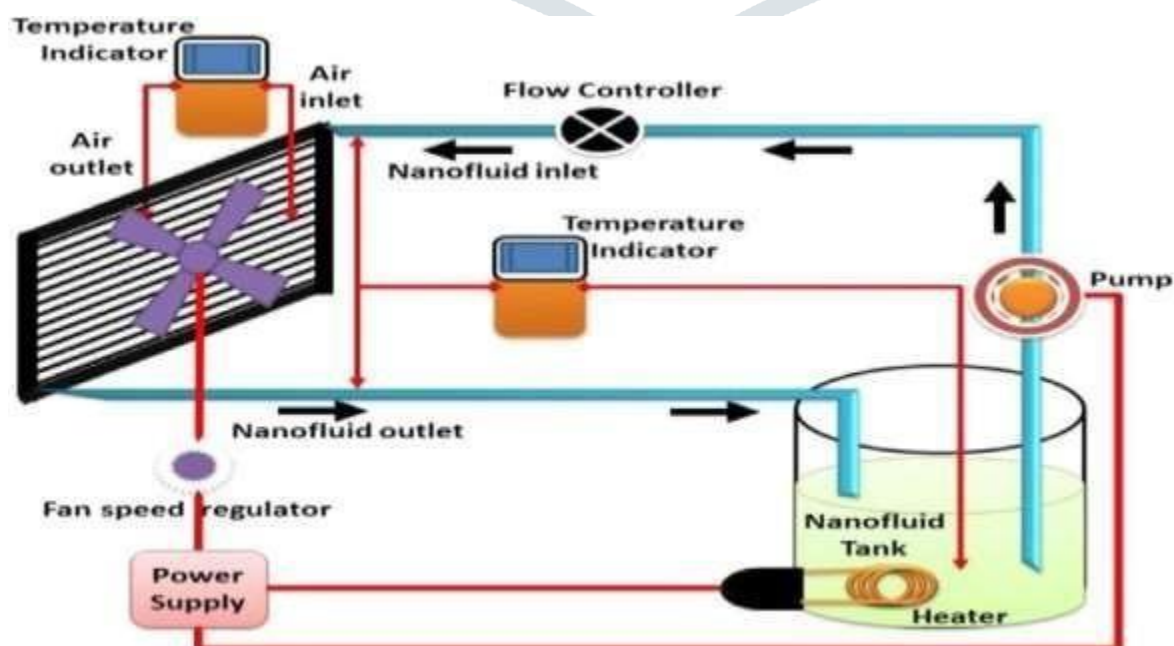


Fig.1 Schematic representation of experimental setup



Fig. 2 Front and Side view of test rig

### III. OBSERVATION AND RESULT:-

In this point under, we take all reading Water + Ethylene glycol + TiO<sub>2</sub>/ AL<sub>2</sub>O<sub>3</sub> Nanofluid and water, Water + Ethylene glycol Readings are taken from reference, But here we only show the combined effect of all reading. And carried out the all calculation to calculate density and specific heat of Nano fluid,

Table 1 Property of nanoparticles and base fluids

Materials	Density (Kg/m <sup>3</sup> )	Specific heat (J/kg 1°C)	Thermal conductivity (W/m 1°C)	Viscosity (Pa s)
AL <sub>2</sub> O <sub>3</sub>	2220	745	1.4	—
Pure water	998	4180	0.6067	0.0014
TiO <sub>2</sub>	4260	697	1.8	
Base fluid +Ethylene glycol	1055.39	3370	0.363	4.65 x 10 <sup>-5</sup>
Air	1.225	1005	0.02435	-

For Water + Ethylene glycol + TiO<sub>2</sub> nanofluid

Table 2.Observation For WATER + EG + NF (TiO<sub>2</sub>)

M (lpm)	T (min)	T <sub>i</sub> (°C)	T <sub>o</sub> (°C)	Δ T <sub>nf</sub> (°C)	T <sub>ia</sub> (°C)
10	2	49.5	45.4	4.1	35
10	4	49.1	44.4	4.5	35
9	6	49	44.0	5	35
9	8	48.8	43.2	5.6	35
8	10	48.9	42.5	6.4	35
8	12	49.1	42.4	6.7	35

#### IV. CONCLUSION:-

- 1) The forced convection heat transfer enhancement by TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> suspended in water as a base fluid inside the flat copper tubes of an automotive cooling system has been measured.
- 2) Significant heat transfer enhancement was observed and was associated with the concentration of the nanoparticles. Maximum Nusselt number enhancements of up to 11% and 22.5% were obtained for TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> nanoparticles, respectively, in water.
- 3) The experimental results showed that the Nusselt number behaviors of the nanofluids highly depended on the volume flow rate, inlet temperature and produces a higher heat transfer enhancement than the TiO<sub>2</sub> nanofluid; likewise, TiO<sub>2</sub> nanofluid enhanced heat transfer more than pure water.
- 4) The results also proved that TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> nanofluid have a high potential for heat transfer enhancement and are highly appropriate for industrial and practical applications.
- 5) The input and output parameters have been tabulated to develop statistical models of cooling system components. These models have been obtained from statistical software using multiple linear regression methods and factorial methodology (FM).
- 6) The statistical models deduced defined the degree of influence of the volume flow rate, inlet temperature and volume concentration on the Nusselt number. Significant heat transfer augmentation of the cooling system may be achieved by using the highest values of parameters that produce high values of the Nusselt number.
- 7) The observed heat-transfer enhancements using TiO<sub>2</sub>-W and Al<sub>2</sub>O<sub>3</sub>-W in the cooling system were in good agreement with the experimental data reported by and correlate with that of with a deviation of approximately 2–4%.

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26. “Trace Elements and Nanoparticles (Nanotechnology Science and Technology)” by Igor A Khlusov his full wave bridge rectifier operation is divided into two-cycle which are positive half-cycle and negative half-cycle. The four diodes labelled D1 to D4 are arranged in “series pairs” with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are in OFF condition as they are now in reserve biased and the current flows through the two capacitors. During the negative half cycle of the supply, diodes D3 and D4 conduct in series as they are in forward biased, but diodes D1 and D2 are in reverse biased. The current flowing through the capacitors is the same direction as before. One of the capacitor acts as smoothing filter and another one acts as storage element. Both of them are connected in parallel. The voltage in the AC form is being rectified in the DC form in full bridge rectifier circuit, then it goes to the smoothing capacitor to remove any ripple factor that still left in the DC voltage form after the rectifier process. Lastly, the output from the piezoelectric tile is stored in the storage capacitor and ready to be used by another low power devices. The experiment setup of the piezoelectric tile as shown in Figure 2.

## I. RESULTS AND ANALYSIS

The piezoelectric transducer output is in AC waveform. The output of the transducer needs to be rectified and filtered before being used to the storage or to the DC loads. Figure 3 shows the output of the piezoelectric transducer before being inserted to the full bridge rectifier.

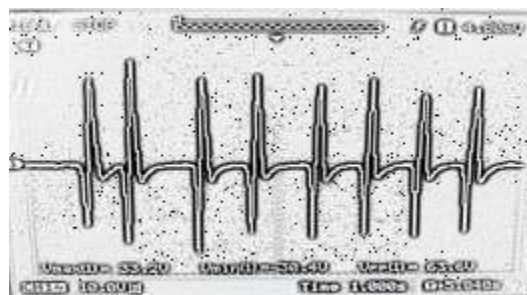


Figure 3. The output of the piezoelectric transducer before being rectified

### i. Connection of Piezoelectric

The piezoelectric transducer was connected in series and parallel connection. Before using the piezoelectric transducer to generate electric energy, the connection needs to be determined to choose the better output from the piezoelectric transducer. Figure 4 shows three piezoelectric transducers were connected in series. Figure 5 shows, three piezoelectric transducers are connected in parallel connection. Two sets of three piezoelectrics that connected in series were attached in parallel for series-parallel connection as shown in Figure 6. The multimeter was connected to the piezoelectric transducers to measure the voltage and current across the connection. A double-sided tape 3mm is placed on

the top and the bottom of the piezoelectric transducer to maximize the output of this transducer. Figure 7 and Figure 8 shows the output of the piezoelectric based on the connection that being done.

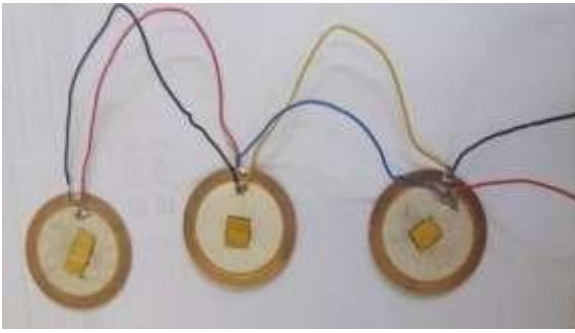


Figure 4. The series connection of piezoelectric transducer

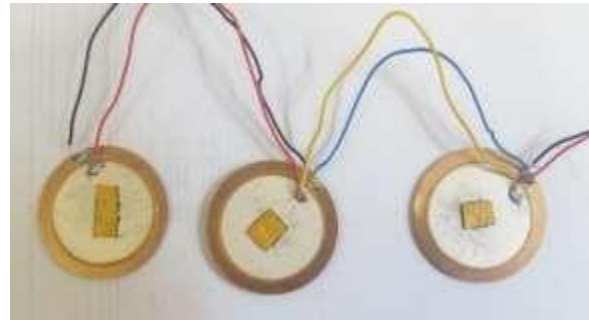


Figure 5. The parallel connection of piezoelectric transducer

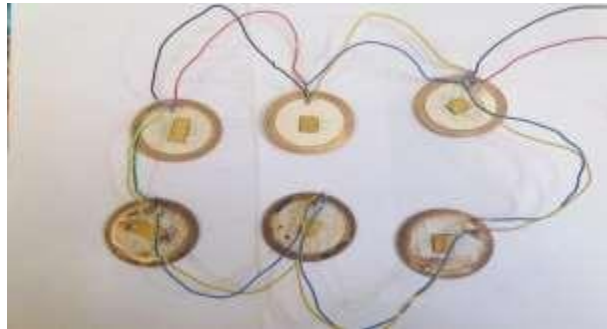


Figure 6. The series-parallel connection of piezoelectric transducer

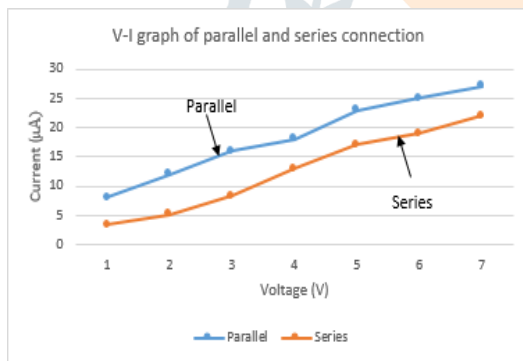


Figure 7. Voltage – Current graph of parallel and series connection of piezoelectric

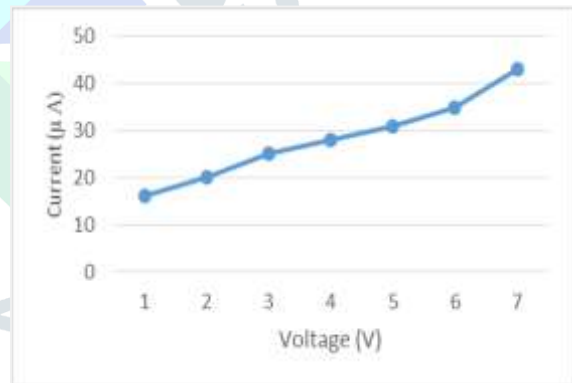


Figure 8. Voltage – Current graph of series-parallel connection of piezoelectric

Figure 7 shows that when the piezoelectric are connected in series the output voltage is high but the output current is low. However, vice versa happened for the parallel connection of the piezoelectric transducer. It give high current but low output voltage. In order to solve this problem, the combination of thisconnection needs to carry out. Two set of three piezoelectric transducers that connected in series was attached together in parallel to form series-parallel connection. The value of voltage as well as current output are both satisfactory.

ii. **Analysis on the Piezoelectric Tile**

The piezoelectric tile that show on the Figure 9 is used for foot press or pumping activites in order to collect the voltage. The 6 cell of piezoelectric transducers is placed between the upper and lower of this piezoelectric tile. This piezoelectric tile is design in a square shape with wood block. This tile are screw at its four edge and combine with thespring to make the upper tile bounce back after the person step on it. The piezoelectric transducer is placed between the gaps of the two tiles. The subjects are asked to do the foot press or pumping activities on this piezoelectric tile to collect the voltage produced by the 6 cell piezoelectric transducers during that activities. Figure 10 show the model of the piezoelectric tile from front, side and inside view.



Figure 9. The piezoelectric tile that used for foot press activities

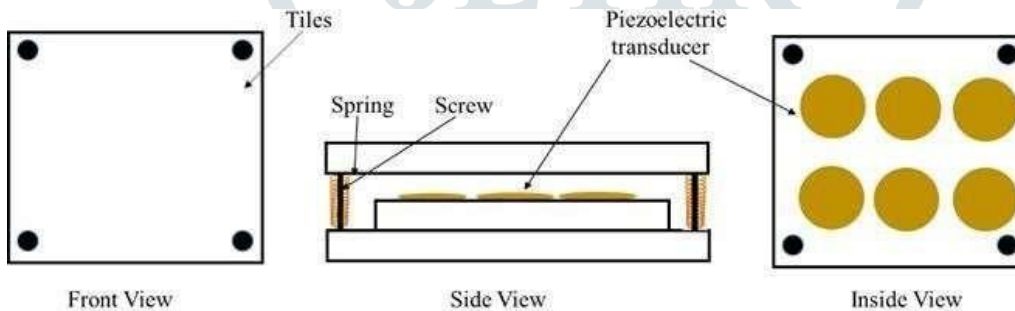


Figure 10. Model of piezoelectric tile with 6 cell of piezoelectric tile

Table 1. The Weight and the Voltage Taken based on the Jump on the Piezoelectric

Subject	Weight (kg)	Time (sec)			
		5 sec	10 sec	15 sec	20 sec
Subject 1	45	1.98 V	2.15 V	2.80 V	3.78 V
Subject 2	50	0.83 V	1.23 V	2.38 V	3.12 V
Subject 3	55	1.76 V	2.73 V	4.66 V	5.65 V
Subject 4	60	2.75V	4.59 V	5.31 V	6.06 V

Study using foot press or pumping is conducted to determine the voltage output of a 6 cell of the piezoelectrictransducer that connected in series-parallel connection. Table 1 shows subject with 45 kg,50 kg, 55 kg and 60 kg body weight are used to test the piezoelectric tile. They are asked to step on the tilesto do the foot press or pumping activities to test the voltage generating capacity of the piezoelectric tile.

The voltage generated is based on the time recorded which are 5 sec, 10 sec, 15 sec, and 20 sec. The relation between the time taken and the voltage being generated is plotted in the graph for each weight. From Figure 11, it can be seen that maximum voltage is generated when the person pumps about 20 seconds on the piezoelectric tile. It also can be concluded that the force that is applied by every subject are variant. The voltage generated depends on the force that being applied to the piezoelectric tile. In theory when a bigger person pump on this piezoelectric tile, the voltage that is generated is higher compared to the smaller person. There are a linear relation between the force and the voltagegenerated. Figure 11 shows that the theory is proved. The weight of subject 4 is bigger than other subjects so it the voltage that generates by this subject is the highest when the subject pump on the tile.

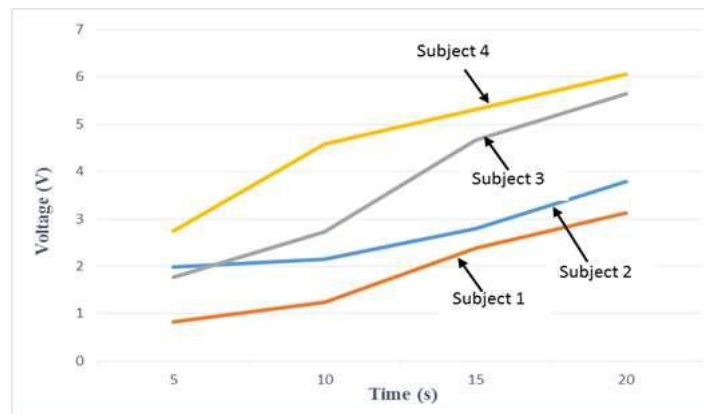


Figure 11. Voltage against time measured during subject press on the piezo tile

## II. CONCLUSION

A piezoelectric tile is capable of generating more voltage when longer the time taken. The longer the time taken means more footstep/force are applied on the tile. The linear relation is found between the voltage generated and the time taken. This piezoelectric are specifically suitable for the implementation in the crowded area such as pavement street, train ticket counter, stairs and dance floor. The piezoelectric tile is also suited for the exercise tile such as for skipping or on the treadmill. The power that is generated from this piezoelectric tile can be used to power up the light street, light along the stairs and also low power appliances.

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