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# PERFORMANCE AND ANALYSIS OF RADIATOR COOLANT USING WATER WITH NANO FLUID $AL_2O_3$

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*Abstract*— The heat generated in an automobile engine needs to be extracted and dissipated for its efficient working. The objective of this experiment was to improve the thermohydraulic performance of the radiator which can be achieved by using nanofluids as engine coolant for increasing the heat rejection capacity on the coolant side. The present study investigates the performance of AL2CO3 water nanofluid at different temperatures (50, 60, and 70oC). The results indicate that maximum increase in thermal capacity was observed to be 32% at 50oC (0.2% particle concentration).

## 1. Introduction

- The present study investigates the performance of AL2CO3 water nanofluid at different temperatures (50, 60, and 70oC). The results indicate that maximum increase in thermal capacity was observed to be 32% at 50oC (0.2% particle concentration).
- Nanofluids exhibit enhanced thermal conductivity and the convective heat transfer as they are prepared by dispersing metallic and nonmetallic nano sized particles in base fluid.
- Thus these fluids can be studied for their effective use in the conventional radiator.

## 2.Solution Proposed:

- The proposed model discloses improved results in nusselt number, Reynolds number and heat transfer coefficient of the coolant. To increase the performance of the heat dissipation of the engine, two methods can be used either by adding Nano-particles in the coolant so that the heat carrying capacity of the coolant is enhanced or by increasing the rate at which coolant is circulated in the radiator [2]. Experiment was conducted at different flow rates [3] and concentrations to obtain the most efficient heat transfer coefficient at a particular flow rate and concentration of nano Received (May 30, 2017), Review Result (September 30, 2017), Accepted (October 5, 2017) International Journal of Control and Automation Vol. 10, No. 11 (2017) 12 Copyright © 2017 SERSC Australia particles [4]. In total the experiment was conducted at 3 different flow rates (2.27lt/min,3.41lt/min,4.0lt/min) and 3 different concentration(0.1%,0.15%,0.2%). A permutation of flow rates and concentrations were made so that the result can be obtained for every flow rate at all the 3 concentrations.

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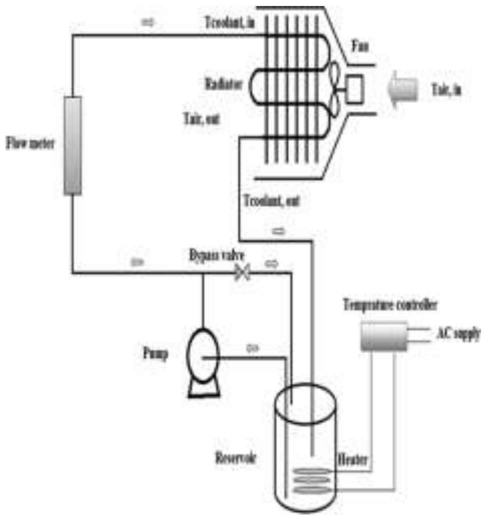
3. Experimental Setup:

- The constructional features have been shown in the form of a line diagram for better understanding of the constructional features and working of the rig in Figure 1. There are several components attached to the setup which is explained below. The objective is to analyze and study the effect of nano-particles on the heat transfer rate of the coolant in the radiator and hence to find out the optimum parameters for maximum efficiency [5]. Experimental setup consists of aluminium sheets ducts, 1000 cc car radiator, thermocouples, pump, heating element, fan and storage tank.




3.1. Reservoir:

A plastic bucket was used as a reservoir for storing the coolant. The same was used for mounting pump, agitator & the heating element.

3.2. Agitator Agitator is used for proper suspension and mixing of nano-particles in the base fluids. It is shown in Figure 3. The nano-particles are suspended in the base fluids. These particles are settled down in the reservoir and in the pipes. Agitator fixes this problem of choking the pipe. It mixes the nano-particles in the base fluids.

3.3. Heating:

Element Electric rod is used as a heating element for the experimentation and is shown in Figure 4. Power consumption of the rod is 1500 W. It is made of copper tube with nickel plating. This type of heating element is used for water and other fluids.

3.4. Pump The pump shown in Figure 5 is used in experimental setup to circulate the hot nanofluid. Agitator was fitted in storage tank to mix and circulate the water in tank itself because when nano-fluid was suspended, it remains in suspension in base fluid. It avoids evaporation and local heating of fluid near and across the surface of heating rod.

3.5. Control Valve:

Control valve shown in Figure 6 controls and regulate the inlet flow to the radiator. The different flow can be adjusted with the help of a control valve.

3.6. Radiator:

Test section contains 1000 cc car radiator which was made of copper fins and brass tubes. Radiator shown in Figure 7 was attached with a duct at one end and other end; it was attached with a force draft fan, whose speed was constant. There were 25 tubes in one row and there were 2 rows presented in radiator. Hot fluid entering from upper side pipe and was flowing in downward direction and it was collected in base of radiator.

Radiation areas Tube 0.208 m2 Airways 1.69 m2 Total 1.9 m2 Front face area Total 0.03 m2 Length of fin 1740 mm Width of fin 30 mm Thickness of fin 0.05 mm Fin type Corrugated fins Tube rows 2 Tubes 50 Tube thickness 0.15 mm Tube space 7.33 mm

3.7. Fan:

A fan shown in Figure 8 is used for cooling the nano-fluid in the radiator. Fan is operated at dc supply with the automobile battery (220v).

3.8. Duct Duct:

shown in Figure 9 was fabricated from GI sheet of 18 gauges. Duct was sealed to eliminate air leakage from any joint made in duct with White stiff. There was fabricated a honey comb structure placed to achieve uniform flow inside the duct. Structure or radiator was placed where the converging part met.

4. Flow Chart:

of Proposed Solution The flow chart of the solution is demonstrated

1. First the fluid is prepared by mixing nano particles ($Al_2O_3$) in three different concentrations (0.1%, 0.15%,0.2%) with distilled water(10Lts).

2. For proper mixing of the nano particle and distilled water an agitator is employed.

3. The prepared fluid is heated to a temperature of 50o c with the help of an immersion rod.

4. For proper circulation of the nano fluid a centrifugal pump is installed.

5. To check the flow rate, a flow meter is installed and the flow control unit is used to alter the flow rate of the nano fluid.

6. To check the temperature of the nano fluid temperature sensors (PT-100) are used at the inlet, outlet, front side, back side of the radiator.

7. The radiator fan is switched on and the fluid passes in the radiator at three different flow rates. The temperature of the fluid decreases as a result of forced convection and conduction.

8. The temperature dip is recorded by the sensors and tables are plotted.

5. Experimental Calculations:

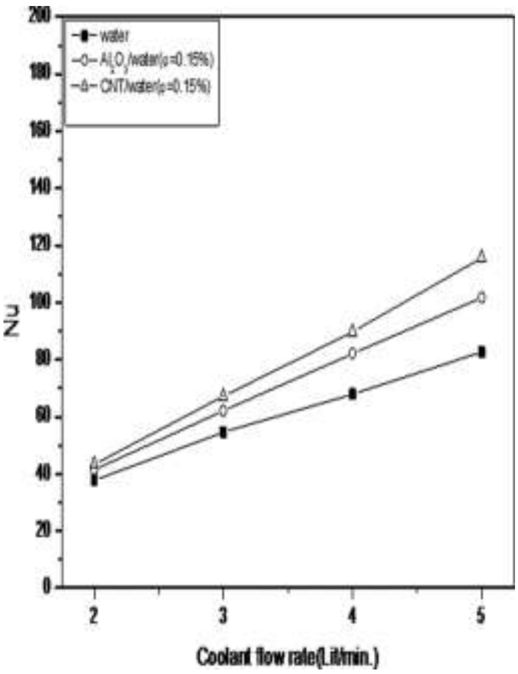
In this experiment, heat transfer rate is analysed by using three parameters i.e. heat transfer coefficient (h), Reynolds number(Re), nusselt number(Nu)[9]. These parameters are evaluated by calculating Density and specific heat capacity[10], by using the following formulas. Density of the nano-fluid (ρnf) is calculated by using the given formula[11]:- ρnf = φρp + (1 − φ)ρw (1) Where ρw = density of water (1000kg/m3 ) *ρ*p = density of Al2O3 (3900 kg/m3 ) **φ**= Nano Fluid volume concentration % (at three different values 0.1%, 0.15% and 0.2%) ρnf = density of Nano fluid (kg/m3 ) Now, the specific heat capacity of the Nano- coolant is calculated as[12]: Cnf = (1−φ)(ρC)w+ φ(ρC)p (1−φ)(ρC)w+φρp (2) Cnf= specific heat capacity of the nano coolant(J/Kgk) Cw= Specific heat capacity of water(4180 J/kgk)

Cp= Specific heat capacity of Al2O3 (880 J/kgk) Heat transfer rate is calculated as by given equation: Q = $mCnf(Tin - Tout)$ (3) Where, m = mass flow rate [13]of the nano-coolant(Kg/min) Tin= Inlet temperature (o c) Tout= outlet temperature (o c) Heat transfer coefficient is calculated by using the given equation From Newton's law of cooling: Q = hA(Tb − Ts) (4) Where Q is the heat transfer rate(watt) h = heat transfer coefficient($w/m2k$) A is the surface area of the tube of radiator (217cm2 ) Tb is the bulk temperature ( o c) which is calculated by taking the average of Tin and Tout Tb = Tin+Tout 2 (5) Ts is the average wall temperature of the radiator measured from various transverse and longitudinal locations of radiator(o c) hexp = mCnf(Tin−Tout) nA(Tb−Ts) (6) Where n = number of tubes (50) The average Nusselt number can be calculated as: Nu = hDh k (7) Where Dh= hydraulic diameter of the tube and is calculated as Dh = 4[ πd 2 4 + (D−d)d] πd+2(D−d) (8) D and d are the width and height of radiator tube.

Here d=1.8 mm; D=15.5mm. Finally the Reynolds number can be calculated as: Re = ρnfvDh μ (9) Whereρnf =density of nano-fluid (kg/m3 ) μ = dynamic viscosity of the nano coolant (Ns/m2 ) v= Fluid velocity (m/s)

5.1. Observations

The analysis of Reynolds vs. Nusselt number for Al2O3 based nano-fluid is shown in Table 3. Results are deduced for three different flow rates at different concentrations of nano-fluid. From the observation Table 3, it has been found that at 0.15% concentration (**φ**) of Al2O3 in water at a flow rate of 4lt/min, the efficiency parameters of the radiator (h, Nu, Re) are found to be more efficient than other concentrations and flow rates. In Figure 11, graph for Reynolds number vs. Nusselt number at three different concentrations & flow rates is plotted.




Now the inlet temperature, outlet temperature and temperature of front (wall 1) and rear wall (wall 2) is measured at different flow rates and volume concentrations. The Table 4 and Figure 12 represents the reading of temperature and time for Al2O3 at 2.7 l/min flow rate and 0.10% volume concentration at regular time intervals. From the Table, it is clear that it took approx 17 minutes to attain inlet temperature 30 o c, wall 1 and wall 2 temperatures as 22 o c and outlet temperature 25.9oc.

The figure represent the reading of temperature and time for Al2O3 at 3.4 l/min flow rate and 0.10% volume concentration at regular time intervals. . From the table, it is clear that it took approx 16 minutes to attain inlet temperature 30 o c, wall 1 temperature as 24.20 c and wall 2 temperatures as 24.6 o c and outlet temperature 26.20 c.

ADVANTAGES:

- Increasing the concentration of AL2CO3 nanoparticles increases the capacity of radiator.
- The viscosity of nanofluid is greater than that of base fluid.
- Capacity of radiator is directly proportional to temperature.

6. Conclusion: The following conclusions have been made by an iterative method. 1. After conducting experiment it has been found that at 0.15% concentration(**φ**) of Al2O3 in water and at a flow rate of 4lt/min the efficiency parameters of the

radiator(h, Nu, Re) are found to be more efficient than other concentrations and flow rates. 2. It is also found that at 0.15% volume concentration of Al2O3 in water and at a flow rate of 4lt/min, the coolant took least time(15.51min) to dissipate heat from 50o c to 30o c as compared with other flow rates and concentrations.

REFERENCES:

1. Teng et al.: "Performance evaluation on an air-cooled heat exchanger for alumina nanofluid under laminar flow". Nanoscale Research Letters 2011 6:488.
2. Ramgopal Varma Ramaraju et al. "Enhancement of Heat Transfer Coefficient in an Automobile Radiator Using Multi Walled Carbon Nano Tubes (MWCNTS)" ASME 2014 International Mechanical Engineering Congress and Exposition IMECE2014.

LITERATURE SURVEY:

- Tun-Ping Teng et al. [1] analyzed the characteristics of Al2O3-water nanofluid produced by the direct synthesis method at three different concentrations (0.5, 1.0, and 1.5 wt. %). Experimental results show that the nanofluid as a coolant has higher heat transfer capacity than water and a higher concentration of nanoparticles provides an even better ratio of the heat exchange. The maximum enhanced ratio of heat transfer and pressure drop for all the experimental parameters in this study was about 39% and 5.6%, respectively.
- Varma Ramaraju et al. [2] observed in "SUZUKI (800 cc) CAR RADIATOR", cooling circuit using different nanofluids to replace the conventional engine coolant. In the study, the effect of nano-fluid heat transfer to enhance in water and coolant based systems with multi walled carbon nanotubes was investigated and enhancement of heat transfer up to 30% when coolant and CNTS are used as a cooling medium.
- Navid Bozorgan et al. [3] numerically investigated in a radiator of Chevrolet Suburban diesel engine under turbulent flow conditions. He investigated with CuO-water nanofluid having particle size of 20 nm and a particle concentration of 2%. The heat transfer relations between airflow and nanofluid coolant have been obtained to evaluate local convective and overall heat transfer coefficients and also pumping power for nanofluid flowing in the radiator with a given heat transfer capacity.