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EXPERIMENTAL ANALYSIS OF I.C ENGINE RADIATOR WITH Al2O3 NANO FLUID

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Abstract

In cooling system of automobile IC engine the water plays important role for cooling also evaporate at high temperature, so we need to add water and also water is low capacity of absorb heat. By using Al2O3 nano fluids in radiator instead of water, we can improve the thermal efficiency of radiator. So cooling effect of the radiator is improved and the overall efficiency of engine will increased.

***Keywords**: Al2O3 Nano Fluid, Radiator, Cooling, Engine, Base fluid (Water)*

1. INTRODUCTION

A Nano fluid is a fluid containing nanometer-sized particles, called nano particles. The main objective of the project is to improve the efficiency of the radiator cooling system in IC engine. Efficiency of the cooling system can increase by mixing the Al2O3 nano fluids with the base fluids Water. Nano fluid is mixed with the base fluid. The base fluid used in radiator is Water and other coolants. Conventional heat transfer fluids such as Water, mineral oil, and ethylene glycol play an important role in many industries including power generation, chemical production, air conditioning, transportation, and micro electronics. However, their inherently low thermal conductivities have hampered the development of energy-efficient heat transfer fluids that are required in a plethora of heat transfer applications. This new type of heat transfer suspension is referred to herein as a nano fluid. In particular, aluminum oxide tube-containing nano fluids provide several advantages over conventional fluids, including thermal conductivities far above those of traditional solid/liquid suspensions, a nonlinear relationship between thermal conductivity and concentration, fully temperature-dependent thermal conductivity, and a significant increase in critical heat flux. An emerging and new class of coolants is nano fluids which consist of a carrier liquid, such as water, dispersed with tiny nano-scale particles known as nano particles. Purpose-designed nano particles of e.g. alumina, ti oxide, carbon nano tubes, silica, or metals e.g. copper, or silver nano rods dispersed into the carrier liquid the enhances the heat transfer capabilities of the resulting coolant compared to the carrier liquid alone.

The experiments however do not prove so high thermal conductivity improvements and also efficiency Of IC engine, but found significant increase of the critical heat flux of the coolants.

Therefore, this study attempts to investigate the heat transfer characteristics of an automobile radiator using mixture of water and based Al2O3 nano fluids as coolants. Thermal performance of an automobile radiator operated with nano fluids is compared with a radiator using water based coolants. The effect of volume fraction of the Al2O3 nano particles with base fluids on the thermal performance and potential size reduction of a radiator were also carried out. Al2O3 nano particles were chosen in this study.

2. SETUP FOR EXPERIMENT

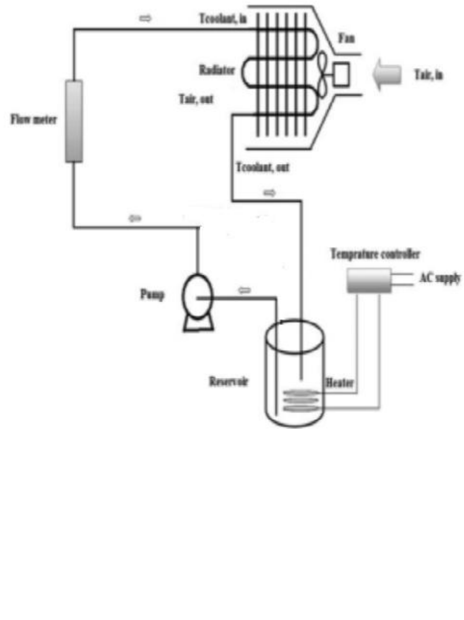

Fig 1.Experimental model [1]

System is shown in fig. it contains.

1. Radiator
3. Fan
4. Pump
5. Heating Element
6. Rota meter
7. Battery
8. Inlet and Outlet tubes.
9. Water + Concentration of nano fluid.

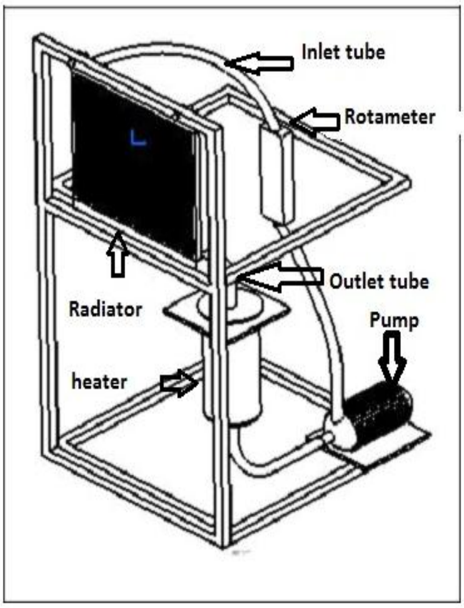

Fig2. Schematic diagram for experimental model

3. COOLING PROCESS [2]

The radiator is part of the cooling system of the IC engine in Automobile radiators mostly a cross flow heat exchanger. The two working fluids are generally air and coolant nano fluid + water. As the air flows through the radiator, the heat is transferred from the coolant to the air. The flow of the air on radiator is to remove heat from the coolant, which causes the coolant to exit the radiator at a lower temperature than it entered at. Coolant is passed through engine, where it is absorb heat. The hot coolant is then feed into tank of the radiator. From tank of radiator, it is distributed to the radiator upper storage tank through tubes to another tank on opposite bottom side of the radiator. As the coolant passes through the radiator tubes on its way to the opposite tank, it transfers much of its heat to the tubes which, in turn, transfer the heat to the fins that are lodged between each row of tubes. The radiator acts as a heat exchanger, transferring excess heat from the engine's coolant fluid into the air.

The below figure 2 shows schematic diagram of experimental set up which consists of closed loop circuit. The experimental test rig includes and heating element, drive pump, Rota meter, radiator fan(speed control DC motor) and Automobile radiator. drive pump gives the flows 1-10 LPM, the flow rate of the test section is regulated by valve which is appropriate adjustable to the recycle line as shown in fig 1. The total volume of the circulating liquid is constant in all the experiments. The circuit include 0.030m diameter pipeline which is made of the rubber pipe. A Rota meter is used to measure the flow through the test section. The specification of the Rot meter is 1-10LPH . For heating the working fluid an electric heater of capacity 2000 watt. Two K type thermocouples were implemented on the flow line to record the radiator inlet and outlet temperature

The results obtained are based on the following assumptions:

A) Velocity and temperature at the entrance of the radiator core on both air and coolant sides are uniform.
B) There is no phase change (condensation or boiling) in all fluid streams during experiment.
C) Fluid flow rate is uniformly both side inlet and outlet of radiator. No stratification, flow bypassing, or flow leakages occur in any stream.
D) The flow condition is characterized by the more speed at any cross section.
E) The temperature of each fluid is uniform over every flow cross section, so that a single bulk temperature applies to each stream at a given cross section. Heat transfer area is distributed uniformly on each side Both the inner dimension and the outer dimension of the tube are assumed constant.
F) The thermal conductivity of the tube material is constant in the axial direction. No internal source exists for thermal-energy generation.
G) There is no heat loss or gain external side or body of radiator and no axial heat conduction in the radiator.

4. PREPARATION OF NANO FLUID [3]

4.1 Single step methods

The single-step method is a process combining the preparation of nano particles with the synthesis of nano fluids, for which the nano particles are directly prepared by physical vapour deposition PVD technique or liquid chemical method. In this method the processes of drying, storage, transportation, and dispersion of nano particles are avoided, so the agglomeration of nano particles is minimized and the stability of fluids is increased. But a disadvantage of this method is that only low vapour pressure fluids are compatible with the process. This limits the application of the method . In the previous researches, used a one-step physical method to prepare nano fluids, in which Cu vapour was directly condensed into nano particles by contact with a flowing low vapour pressure liquid ethylene glycol. copper dioxide nano fluids by a single-step method called SANSS. The established SANSS demonstrated to be effective in avoid particle aggregation and producing uniformly distributed and well-controlled size of CuO nano particles dispersed in a deionised water suspension. Presented a novel one-step chemical method for preparing copper nano fluids by reducing $CuSO_4\cdot 5H_2O$ with $NaH_2PO_2\cdot H_2O$ in ethylene glycol under microwave irradiation. Non-agglomerated and stably suspended Cu nano fluids were obtained.

4.2 Two-step methods

The two-step method for preparing nanofluids is a process by dispersing nano particles into base liquids. Nanoparticles, nano fibers or nanotubes used in this method are first produced as a dry powder by inert gas condensation, chemical vapour deposition, mechanical alloying or other suitable techniques, and the nanosized powder is then dissolve into a fluid in a second processing step. This step-by-step method isolates the preparation of the nanofluids from the preparation of nanoparticles. As a result, agglomeration of nanoparticles may take place in both steps, especially in the process of drying, storage, and transportation of nanoparticles. The collection of particle will not only result in the settlement and clogging of micro channels, but also decrease the thermal conductivity. Simple techniques such as ultrasonic agitation or the addition of surfactants to the fluids are often used to minimize particle aggregation and improve dispersion behaviour. Since nano powder synthesis techniques have already been scaled up to industrial production levels by surfactants and ultrasonic agitation were employed. 2002 prepared Al_2O_3/H_2O, Al_2O_3/EG, Al_2O_3/PO nanofluids by two-step method, and intensive ultrasonication and magnetic force agitation were employed to avoid nanoparticle aggregation. Most few companies there are potential economic advantages in using two-step synthesis methods that depends on the use of such powders. But an important problem that needs to be solved is the stabilization of the suspension prepared.

Base Fluid

1. Water
2. Mineral oil
3. Vegetable Oil, natural oil
4. Synthetic oils

Following methodology is followed during the process of Experiment:

1. Development of model heat exchanger.
2. Development of experimental set up.
3. Testing or Experimentation.
4. Software analysis using ANSYS software.
5. Comparison of results for water coolant and Al_2O_3 nano fluid for checking Performance and improvement.

Experimental Results for temperature

We take fluid flow rate 7 litre/minute and time duration 5 minute to take each reading.

We take initial temperature 60 deg.c for experiment for all four readings the results shown as follows:

GRAPH SHOWING TEMPERATURE DIFFERANCE BETWEEN INLET TEMPERATURE AND OUTLET TEMPERATURE:

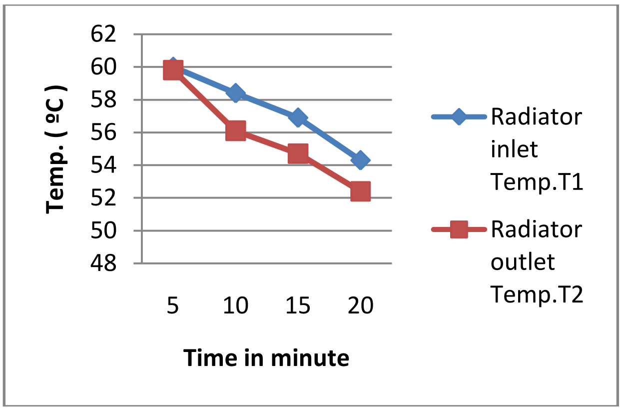

Fig 3. Temperature difference of water through the system

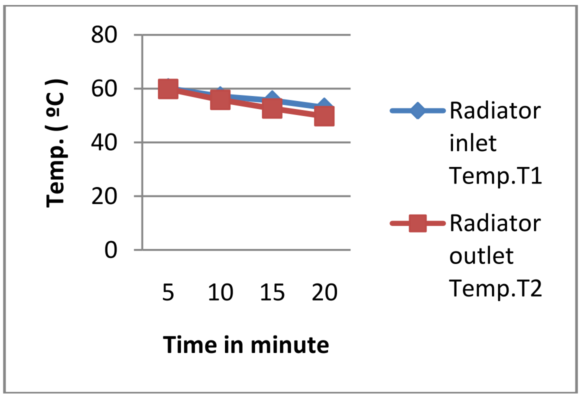

Fig 4. Temperature difference Concentration 0.1% nano fluid through the system.

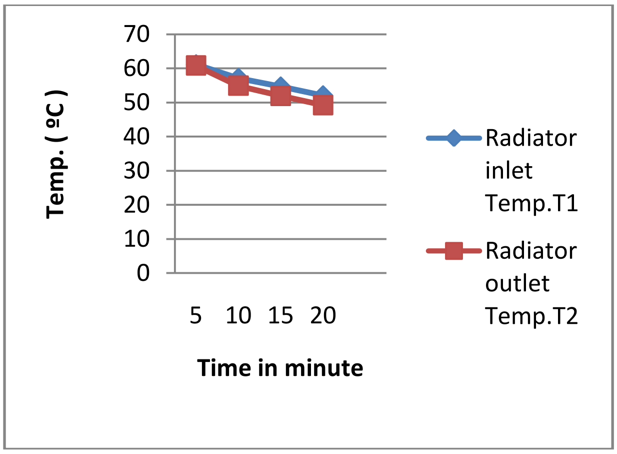

Fig5. Temperature difference Concentration 0.3% nano fluid through the system

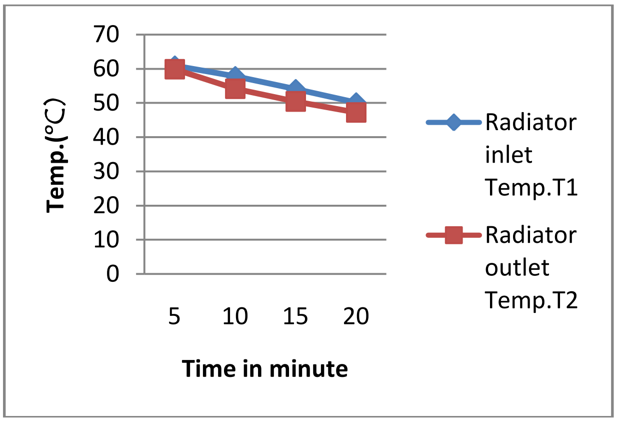

Fig 6. Temperature difference Concentration 0.5% nano fluid through the system.

ANSYS Results For Temperature difference:

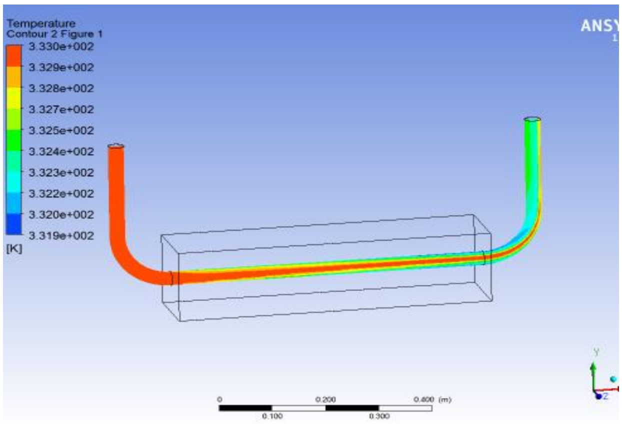

Fig 7. Temperature reading of water through the system

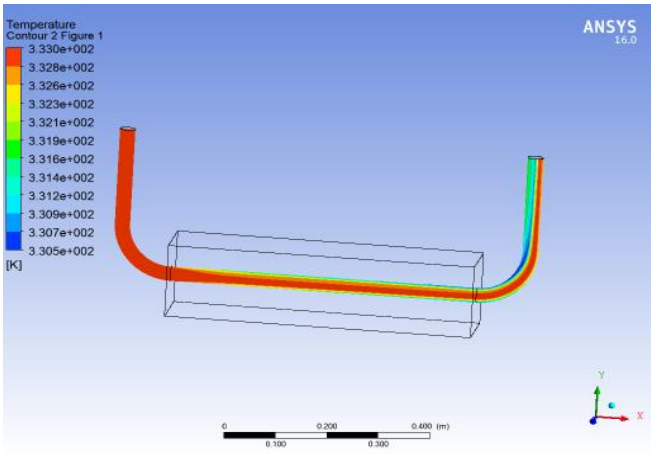

Fig 8. Temperature reading of Concentration 0.1% nano fluid through the system

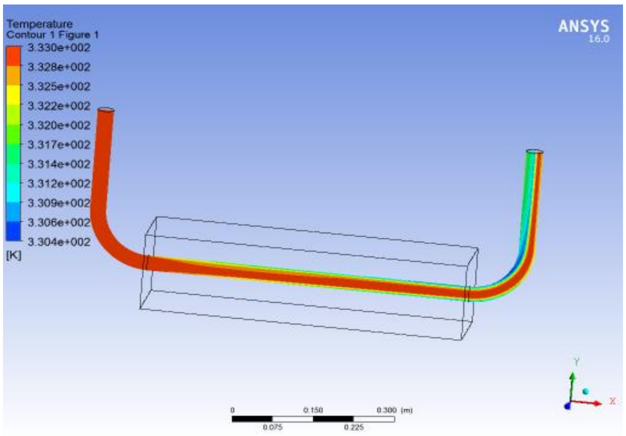

Fig 9 Temperature reading of Concentration 0.3% nano fluid through the system

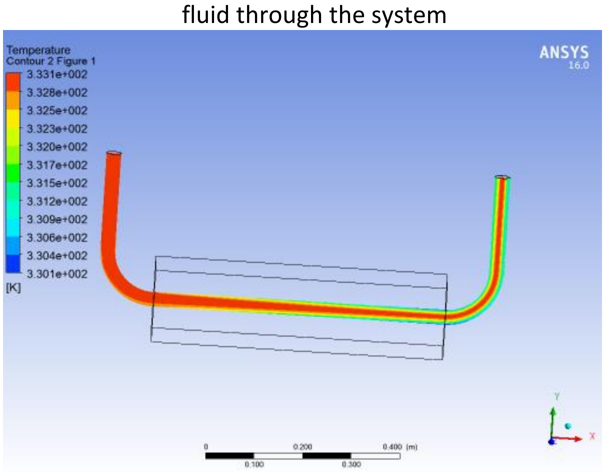

Fig 10. Temperature reading of Concentration 0.5% nano fluid through the system

5. CALCULATION PARAMETER

Factor Considered in Design of Radiator

Radiator core dimension = 0.365×0.348×0.016 m
Inner diameter of tube = 0.005 m
Outer diameter of tube = 0.007 m
Number of tubes=37
Tank height = 0.2 m
Tank diameter =0.12 m
Tank capacity = 2 liter

Thermo physical properties of base fluid and nano fluid:

Table 1: Thermo physical properties of base fluid and nano fluid

Sr.No	Properties	Al2O3	Water
1	Densitykg/m^3	3950	1000
2	Specific heat(J/Kg)	873.336	4187
3	Thermal conductivity	31.922	0.561
4	Viscosity(N/m^3	-	4.068*10^3

The air-side and coolant side heat transfer rates can be calculated as:

$$Q_a = m_a * C_{pa} * (\Delta ta) \quad (1)$$

$$Q_c = m_c * C_{pc} * (\Delta tc) \quad (2)$$

The mass flow rates are calculated as:

$$m_c = \rho_c * V_c * A_{tubes} \quad (4)$$

$$m_a = \rho_a * V_a * A \quad (5)$$

The Effectiveness of the radiator is given below

Effectiveness of fin = $\frac{Actual\ heattransfer}{maximum\ \ heattransfer}$

$$\varepsilon = \frac{mcCpc\ (\Delta t)}{maCpa\ (\Delta t)} \quad (6)$$

$$C_{min} = m_a * C_{pa} \quad (7)$$

Total Heat Transfer in radiator is:

$$Q_T = \quad \varepsilon C_{min} * (Tc\text{-Ta}) \quad (8)$$

Overall Heat Transfer coefficient based on the air side can be express below:

$$U=\frac{Qt}{A(Tc-Ta)} \quad (9)$$

Air Heat transfer coefficient can be expressed as follows:

$$h_a = \frac{J_a * G_a * C_{pa}}{{P_{ra}}^{\frac{2}{3}}} \quad (10)$$

Where,

$$J_a = \frac{0.774}{R^{0.333}{}_{ea}}, \quad G_{a=}\frac{R_{ea}\mu_a}{D_{ha}}$$

Pressure drop modelling:

$$\boldsymbol{\Delta P_{nf}} = \frac{2XG_{nf}{}^{2}Xf_{nf}XH}{\rho_{nf}XD_{hnf}X(\frac{\mu_{nf}}{\mu_{bf}})^{0.25}} \quad (11)$$

$$G_{nf} = \frac{R_{ef}X\ \mu_{nf}}{D_{nf}} \quad (12)$$

Pumping Power is given by:

$$P=V_{nf}X \bigtriangleup P_{nf} \quad (13)$$

6. CONCLUSION

1. It has been seen that nanofluids can be considered as a potential candidate for Automobile application.

2. For base fluid water, radiator temperature decreases by 7.4ºC for trial of 5 minute to 20 minute.

3. For concentration of 0.1% nano fluid the temperature decreases by 10.1 ºC for trial of 5 minute to 20 minute.

4. For concentration of 0.3% nano fluid the temperature decreases by 11.6 ºC for trial of 5 minute to 20 minute.

5. For concentration of 0.5% nano fluid the temperature decreases by 12.6 ºC for trial of 5 minute to 20 minute.

6. Heat transfer rate is increased with increase in volume concentration of nanoparticles (ranging from 0.1% to 0.5%).heat transfer enhancement was

achieved with addition of 0.1% to 0.5% Al2O3 particles at 84391 air Reynolds number and constant mass flow rate (1 Kg/s) .

7. Overall heat transfer based on air side increased up with addition of 0.1% to 0.5% Volume Al2O3 particles than the base fluid at constant air Reynolds number and constant mass flow rate.

8. Effectiveness of the radiator increased with addition of Al2O3 particles than the base fluid at constant air Reynolds number and constant mass flow rate.

References

1] Golakiya Satyamkumar, Sarvaiya Brijrajsinh, Makwana Sulay,Thumar Ankur, Rathwa Manoj. Mechanical Department, Parul Institute of Technology, Limda, Vadodara India. “ANALYSIS OF RADIATOR WITH DIFFERENT TYPES OF NANO FLUIDS”

2] Rahul A. Bhogare1, B. S. Kothawale(2014) Department of Mechanical Engineering ,MITCOE,Pune Head of Mechanical Engineering MITCOE , Pune, India “Performance investigation of automobile radiator operated with Al2O3 nano fluid”

3] Sayantan Mukharjee,(sep 2013) Somjit paria, school of mechanical engineering KIIT University , Bhubaneswar-751024,odisa, india, ,”Preparation and stabity of nano fluid”

4] Parashurama M S, Dr. Dhananjaya D A, Naveena Kumar R “Experimental Study of Heat Transfer in a Radiator using Nanofluid” IJEDR2015 , Volume 3,

5] Jaafar Albadr , Satinder Tayal , Mushtaq Alasadi, “Heat transfer through heat exchanger using Al2O3 nanofluid at different concentrations” ,science direct journal homepage: www.elsevier.com/locate/csite

6] Heat and mass transfer data book, C.P .Kothandaraman,S.Subramanyan page no [152 and 153].

7]W.M. Kays, A.L. London, Compact Heat Exchanger, third ed. McGraw-Hill, Inc., United States, 1984.