Experimental Investigation of Radiator using TiO2 Nano fluid As Coolant

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Abstract - *cooling system plays important roles to control the temperature of car's engine. One of the important elements in car cooling system is the radiator. Radiator plays an important role in heat exchange. Conventional coolants like water, ethylene glycol are not efficient enough to improve the car's performance. To improve engine efficiency, reduce weight of vehicle and size of radiator by using the development of new technology in the field of 'Nano-materials' and 'Nano-fluids', it seems to effectively use these technologies in car radiators.*

Key Words: *Cooling System, Car engine, Heat Exchanger, Nano-Fluid, Radiator.*

1. INTRODUCTION

Automotive radiator is key component of engine cooling system. Radiators are compact heat exchangers optimized and evaluated by considering different working conditions. Coolant surrounding engine after absorbing heat from it passes through radiator. To Improving of heat transfer rate in Various applications. Nano fluid is the leading technique which has been widely used for to Improving of heat transfer rate. This paper gives review regarding properties of Nano fluids and experimental study on heat transfer rate enhancement in automobiles cooling system. Nano fluids are produced by suspending nanoparticles in base fluid. Ms. Madhura P. Jadhav, Mr. Deepak B. Jadhav, Mr.M.E.Nimgade [1] By using computational fluid dynamics we studied experimentally The effect of altering the emissivity and the roughness of a wall behind a radiator on the radiator output has been studied . To increases the wall surface emissivity which affects the surface temperature of the wall to increase, effectively creating additional convective heat transfer surface. A.K.A. Shati , S.G. Blakey, S.B.M. Beck [2] The increasing demand of Nano fluids in industrial applications has led to increased attention from many researchers. In this paper, heat transfer increases using TiO2 and SiO2 Nano particles suspended in pure water is presented. The setup includes that Automobiles fin car radiator, and the effects on heat transfer Improvement under the operating conditions are analyzed under laminar flow conditions Adnan M. Hussein, R.A. Bakar, K. Kadirgama, and K.V. Sharma [3] A complete steady-state model has been developed to determine the thermo hydraulic behavior of a loop heat pipe. The model combines a fine discretization of the condenser and the transport lines with a 2-D description of the evaporator. These original features enable to take into account heat losses to the ambient and through the transport lines as well as to evaluate the parasitic heat flux through the wick and the evaporator body. Benjamin Siedel, Valérie Sartre, Frédéric Lefèvre [4]

1.1 Research Gap

The conventional fluids (water and EG) have been used as a coolant in the automotive cooling system. However, the limited thermo-physical properties of these fluids limit heat transfer across the car radiator. The increasing demand for energy and better performance has led to the investigation of other methods. Space constraints are another key issue in the automotive cooling system. Sometimes overheating occurs in the engine because the radiator is not functioning up to the standard expectations.

1.2 Problem Statement

Improve heat transfer capacity of Radiator. Nanofluids in car radiator will increase heat transfer of the engine. The performance comparison will be made between pure water or ethylene glycol and Nanofluids tested in an automotive radiator. ¬ Finally the recommendations are made and conclusions are drawn based on the improved performance of Nanofluids in an automotive radiator.

2. Methodology

We will be using Maruti 800 CC or Indica Vista Radiator and will be using TiO2 Nano fluid as a coolant. The Nano fluid will be prepared by two step method or one step method. Nano fluid is prepared by mixing Nanoparticles in water in different compositions. Later performances of the Radiator are tested with water, ethylene glycol and TiO2 as coolant. Comparison will be made between coolant flow rates and temperature difference, coolant flow rates and average heat transfer, coolant flow rates and effectiveness, time and temperature difference, time and average heat transfer. Engine Nano-coolant is a coolant in which particles of nanometer dimensions are mixed. The preparation of Nanocoolant is an important aspect to achieve uniform and stable suspension. In the present study, TiO2 is used as a nanoparticle and engine coolant (ethylene glycol: water, 40: 60) as a base fluid. The material of nanoparticles is chosen as TiO2 because it is chemically more stable and its cost is less than their metallic counterparts.

The properties of base Fluid and TiO2 are given in below –

Table 1: Thermo physical Properties of base Fluid and nanoparticles.

Sr.no	Properties	TiO2	Water
1	Specific heat (j/kg.k)	697	4179
2	Density (mg/m^3)	4.05	9.97
3	Thermal conductivity(W/m.K)	11.8	0.613
4	Viscosity (N/sm2)	-	4.65 x10-5

2.1 Objective

An engine coolant is mixture of ethylene glycol and water in various ratios like 30:70, 40:60 and 50:50 respectively are mostly used in auto-mobiles to overcome of this ratio by mixing the nanaoparticles mixture.

- Water and ethylene glycol as conventional coolants have been widely used in an automotive car radiator for many years.
- To overcome this conventional coolant we can use the Nanofluids .

2.2 Scope of Project

- In recent years, with the advancement in nanotechnology, it has been becomepossible to produce suspension of nanoparticles based suspensions, called Nanofluids.Nanofluids term was first introduced by Choi in 1995 at the Argonne National Laboratory.
- Major properties of Nanofluids make it suitable to be used in Radiator coolant one already seen is high thermal conductivity, low viscosity, high convective heat transfer coefficient, high area per unit volume.

2. EXPERIMENTAL SETUP

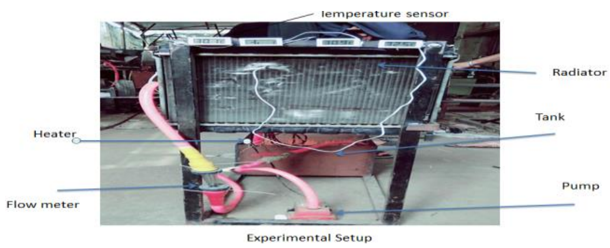


Fig no.1 Experimental diagram

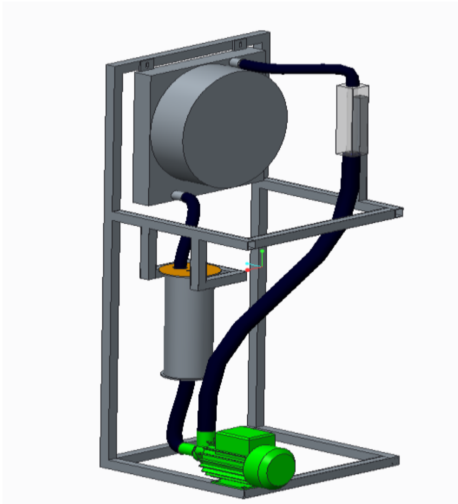


Fig. 2 Experimental Setup (Cad Model)

4. WORKING PRINCIPAL

This experimental setup contains a plastic reservoir tank, an electric heater, a centrifugal pump, a flow meter, tubes, valves, a fan, a DC power supply, ten T-type thermocouples for temperature measurement, and a heat exchanger (automobile radiator). An electric heater (1500W) is kept inside a plastic storage tank (40 cm height and 30 cm diameter) represents the engine and to heat the fluid. A voltage regulator (0–220 V) provided the power to regulate the temperature in the radiator (60–80 °C). A flow meter (0–70 LPM) and two valves measure and control the flow rate. The fluid flow was measured through plastic tubes (0.5 in.) by a centrifugal pump (0.5 hp and 3 m head) from the tank to the radiator at the flow rate range of 2–8 LPM. The total volume of the circulating fluid (3 l) was constant in all experimental steps. Two T-type thermocouples (copper–constantan) were connected to the flow line to record inlet and outlet temperatures of fluid. Eight T-type thermocouples also connected with the radiator surface for the surface area measurement. Due to the very small thickness and high thermal conductivity of the copper flat tubes, the inner and outer surfaces of the tube are equal temperature. A hand-held (−40 °C to 1000 °C) digital thermometer with the accuracy of±0.1% was used to read all the temperatures from thermocouples. Calibration of thermocouples and thermometers was carried out using a constant temperature water bath, and their accuracy was estimated to be 0.15 °C . Two small plastic tubes with a 0.25 inch diameter were connected at the inlet and outlet of the radiator and joined to U-tube mercury manometer with accurately scaled 0.5mmHg to measure the pressure drop at the inlet and outlet. The car radiator has louvered fins and 32 flat vertical copper tubes with a flat cross-sectional area. The distance between the tube rows was filled with thin perpendicular copper fins. For the Air side, an axial force fan (1500 rpm) was installed close on axis line of the radiator. The DC power supply (type Teletron10–12 V) was used instead of a car battery to turn the axial fan. (0.5 In.) By a centrifugal pump (0.5 hp and 3 m head) from the tank to the radiator at the flow rate range of 2–8 LPM. The total volume of the circulating fluid (3 l) was constant in all experimental steps. Two T-type thermocouples (copper–constantan) were connected to the flow line to record inlet and outlet temperatures of fluid. Eight T-type thermocouples also connected with the radiator surface for the surface area measurement. Due to the very small thickness and high thermal conductivity of the copper flat tubes, the inner and outer surfaces of the tube are equal temperature. A hand-held (−40 °C to 1000 °C) digital thermometer with the accuracy of±0.1% was used to read all the temperatures from thermocouples. Calibration of thermocouples and thermometers was carried out using a constant temperature water bath, and their accuracy was estimated to be 0.15 °C. Two small plastic tubes with a 0.25 inch diameter were connected at the inlet and outlet of the radiator and joined to U-tube mercury manometer with accurately scaled 0.5mmHg to measure the pressure drop at the inlet and outlet. The car radiator has louvered fins and 32 flat vertical copper tubes with a flat cross-sectional area. The distance between the tube rows was filled with thin perpendicular copper fins. For the air side, an axial force fan (1500 rpm) was installed close on axis line of the radiator. The DC power supply (type Teletron 10–12 V) was used instead of a car battery to turn the axial fan.

4.1 Observation table

Table 2 : Thermal physical properties of BF+EG+NF and Air.

Thermal physical properties	Base fluid+Ethylene glycol	Air	TiO2
Density(kg/m3)	1.064	1.1614	4.05
Specific heat (J/kg K)	3370	1.005	697
Viscosity(Ns/ m2)	4.65 x 10-5	0.000018	-
Conductivity(W/m K)	0.363	-	11.8

Table III: Observations for Water +EG+NF

$\dot{m}$ (lpm)	T (min)	ΔT_w (°C)	ΔT_e (°C)	ΔT_{nf} (°C)	Q_{avg} w (W)	Q_{avg} e (W)	Q_{avg} nf (W)	ε_w	ε_e	ε_{nf}
10	2	1.8	2.7	4.1	3896.331	5487.525	7786.54	0.04541	0.04765	0.07547
10	4	1.7	3.0	4.7	4619.934	6296.91	8056.83	0.04563	0.05365	0.08878
9	6	2.9	3.5	5.3	5821.8825	7300.5825	8819.61	0.06684	0.05453	0.08947
9	8	3.1	3.7	5.6	6241.465	7935.95	9472.82	0.06686	0.05839	0.09796
8	10	3.6	4.4	6.4	7162.5486	8498.484	9938.12	0.06805	0.06254	0.09880
8	12	3.7	4.8	6.7	8081.115	9087.2955	10510.43	0.07145	0.06690	0.10197

5. CALCULATIONS

In this point under, we take all reading water, Water + Ethylene glycol, and Water + Ethylene glycol + TiO2 Nano fluid. But here we only show the combined effect of all reading. And carried out the all calculation to calculate density and specific heat of base fluid and Nano fluid,

$\dot{m}a$ = 1.49 kg/sec

ρnf = (1-ϕ) ρbf + ϕ x ρp

= (1-0.25/100) x 1064 + 0.25/100 x 3950

= 1071.065 kg/m3

Cnf = ϕ ρp + (1-ϕ) ρnf x Cb x fρ x nf

= 2.5 x 10-3 x 873.336 + (1-0.25/100) x 1064 x 3370

X 1071.065

= 3347.33 J/kgK.

To calculate dynamic viscosity,

µnf = µbf x 1/ (1-ϕ)2

= 4.65 x 10-5 x 1 / (1-0.25/100)2

= 4.6733 x 10-5 Ns/m2.

For water + ethylene glycol + TIO2,

Qnf = $\dot{m}$nf X Cpnf (Ti-To), W

= 10 x 0.012 x 3347.33 x 4.1

= 1646.886 W.

Qa = $\dot{m}$a Cpa (Toa-Tia), W

= 1.49 x 1005 x (44.3-35)

= 13926.285 W.

Qavg = 0.5 (Qnf+Qa), W

= 7786.58 W.

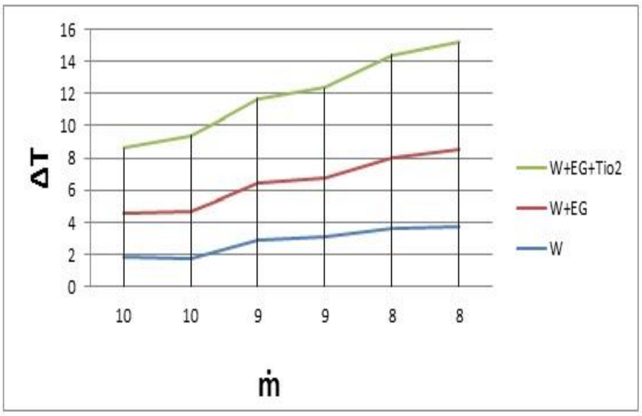
Ɛ = $\dot{m}$nf Cpnf (Ti-To) $\dot{m}$a Cpa (Ti-Tai)

= 10 x 0.012 x 3347.33 x 4.1 1.49 x 1005 x(49.5-35)

= 0.07547.

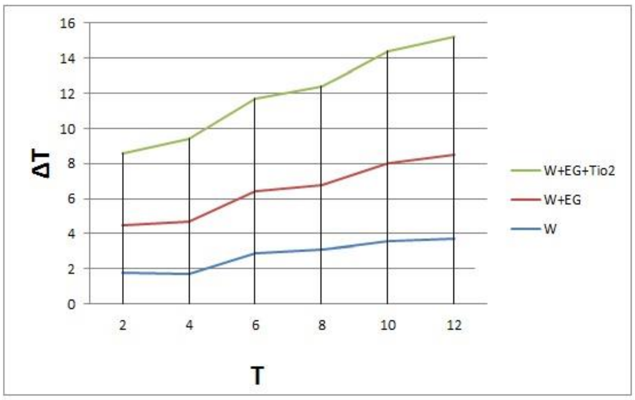
5.1 Graphs on Calculations Results –

1.Mass flow rate (lpm) vs. Temperature difference (ºC)



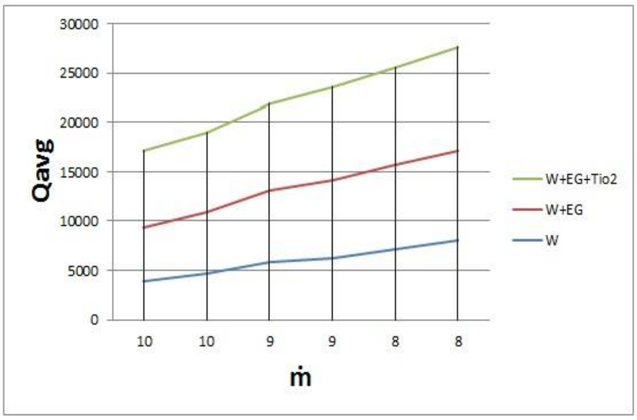
Graph nom 1. Mass flow rate (lpm) vs. Temperature difference (ºC)

2. Time (min) vs. Temperature difference (ºC)



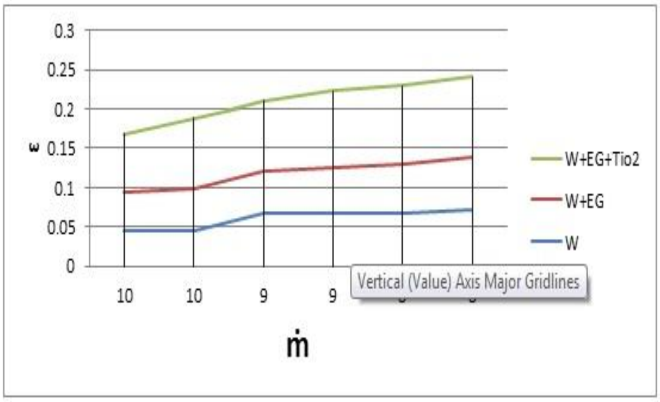
Graph No.2 Time (min) vs. Temperature difference (ºC

3)Mass flow rate (lpm) vs. Average heat transfer rate (W)



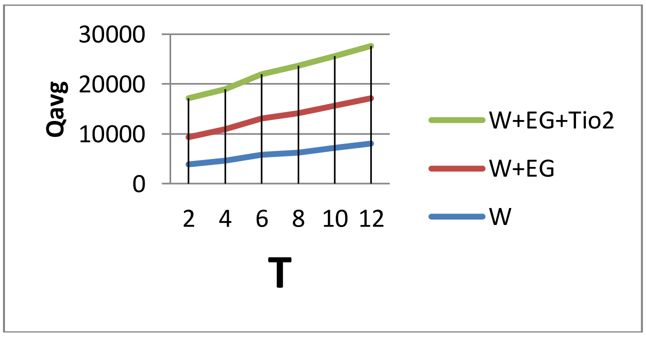
Graph no 3. Mass flow rate (lpm) vs. Average heat transfer rate (W)

4)Mass flow rate (lpm) vs. Effectiveness



Graph no.4 Mass flow rate (lpm) vs. Effectiveness

5) Time (min) Vs. Average heat transfer rate (W)



Graph. No .5 Time (min) Vs. Average heat transfer rate(W)

6. CONCLUSIONS

From the above graph following conclusions are drawn

1) With decrease in mass flow rate, temperature difference between inlet and outlet temperature of coolant increases. In the graph Nano fluid is having more temperature rejection.

2) With increase in time in min, temperature difference between inlet and outlet temperature of coolant increases. In the graph Nano fluid is having good temperature rejection.

3) With decrease in mass flow rate, average heat transfer rate of coolant increases. In the graph Nano fluid is having better average heat transfer rate as compared to water and water + ethylene glycol.

4) With below in mass flow rate, effectiveness of coolant is improved. In the graph Nano fluid is having better effectiveness as compared to water and water + ethylene glycol.

5) With increase in time in min, average heat transfer rate of Coolant increases. In the graph Nano fluid is having better average heat transfer rate as compared to water and water + ethylene glycol.

On this experiment we concluded that nano fluid can transfer good heat as compare to the water and ethylene glycol. By using nano fluid we can possible to manufacture compact radiator.

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