Performance Testing of Automobile Radiator Using the Concentration of Nanofluid

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Abstract— The importance of heat transfer enhancement has gained greater significance in areas such as micro electric cooling especially in central processing units' macro and micro scale heat exchangers, gas turbine internal aerofoil cooling, and radiators. A tremendous amount of effort has been devoted to develop new methods to increase heat transfer from fined surface to the surrounding flowing fluid. Rib tabulators, an array of pin fins, and dimples have been employed for this purpose. An investigation was conducted to determine whether dimples on a heat sink fin can increase heat transfer for turbulent airflows.

Keywords: Nanofluids, Automobile Radiators, Heat Transfer Enhancement

I. INTRODUCTION

A tremendous amount of effort has been devoted to developing new methods to increase heat transfer from fined surface to the surrounding flowing fluid. Rib turbulators, an array of pin fins, and dimples have been employed for this purpose Heat sink performance can be evaluated by several factors: material, surface area, flatness of contact surfaces, configuration, and fan requirements. Aluminium is the most common material because of its high conductivity (205W/mK), low cost, low weight, and easiness with respect to manufacturability. Copper is also used for heat sinks because of very high conductivity (400W/mK), but its disadvantages include high weight, high price, and fewer choices as far as production methods. To combine the advantages of aluminium and copper, heat sinks can be made of aluminium and copper bonded together. To improve performance, heat sinks should be designed to have a large surface area since heat transfer takes place at the surface. In addition, flatness of the contact surface is very important because a nominally flat contact area reduces the thermal interface resistance between the heat sink and heat source. A heat sink must be designed to allow the cooling fluid to reach all cooling fins and to allow good heat transfer from the heat source to the fins. Heat sink performance also depends on the type of fluid moving device used because airflow rates have a direct influence on its enhancement characteristics. One method to increase the convective heat transfer is to manage the growth of the thermal boundary layer. The thermal boundary layer can be made thinner or partially broken by flow disturbance. As it is reduced, by using interrupted and/or patterned extended surfaces, convective heat transfer can be increased. Dimples, protruding ribs (turbulators), louvered fins, offset-strip fins, slit fins and vortex generators are typical methods. The pattern and placements are suitably chosen based on the required cooling.

II. OBJECTIVE

An engine coolant is mixture of ethylene glycol and water in various ratios like 30:70, 40:60 and 50:50 respectively is mostly used in auto-mobiles. Water and ethylene glycol as conventional coolants have been widely used in an automotive car radiator for many years. These heat transfer fluids offer low thermal conductivity. An innovative way of improving the heat transfer performance of common fluids is to suspend various types of small solid particles (metallic, non-metallic and polymeric particles) in conventional fluids to form colloidal. However, suspended particles of the order of um or even mm may cause some severe problems in the flow channels like; increased pressure drop, quickly settling of particles suspension, erosion etc. Therefore, certain alternative engine coolant is required to be used which will reduce. The problem associated with suspended particles also it will improve the heat transfer rates, improve engine efficiency and reduce the size of the radiator

III. PROBLEM STATEMENT

1) We intend to reduce the size of the radiator using nanoparticles. Reducing radiator size hence reducing fuel consumption and higher efficiency.
2) Improve heat transfer capacity of Radiator. Nanofluids in car radiator will increase heat transfer of the engine.
3) The performance comparison will be made between pure water or ethylene glycol and Nanofluids tested in an automotive radiator.

IV. WORKING

The water is heated by the heater and the pump circulates water in the setup. There is gradual increase in temperature of water in the setup which is indicated on the temperature sensor. There is heat transfer between the system and the surrounding by natural convection. When the radiator fan is switched on, there is forced convection between system and the surrounding i.e., there is increased heat transfer rate. The fins of the radiator also play an important role to increase the heat transfer rate of the radiator the coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement in radiator. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator. The tubes have a type of fin inserted into them called a turbulator, which increases the turbulence of the fluid flowing through the tubes. If the fluid flows very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So, if the fluid that is in contact with the tube cools down quickly, less heat will be transferred by creating turbulence inside the tube, all of the fluid mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Ethylene glycol added has good heat transfer properties, adding Ethylene glycol with water further enhance heat transfer. Al_2O_3 added have better heat transfer rate than Ethylene glycol, the nanoparticles used are of size

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20 nm. But for proper heat enhancement proper suspension of nanofluid is required in the base fluid. The air inlet and outlet temperature, water inlet and outlet temperature are observed and calculations are carried out.

V. DESIGN OF PROPOSED WORK

The car radiator has louvered fin and 32 flat vertical Aluminium tubes with flat cross-sectional area. The distances among the tube rows filled with thin perpendicular Aluminium fins. For the air side, an axial force fan (1500rpm) installed close on axis line of the radiator. The DC power supply Adaptor convert AC to DC. For heating the working fluid an electric heater of capacity 2000 watt and controller were used to maintain the temperature 40º-80ºC. Two K type thermocouples have to implement on the flow line to record the radiator inlet and outlet temperature. Two thermocouples K types have to install in the radiator to measure the wall temperature of the radiator.

VI. METHODOLOGY

We will be using Maruti 800 CC or Indica Vista Radiator and will be using Al2O3 Nanofluid as a coolant. The Nanofluid will be prepared by two step method or one step method. Nanofluid is prepared by mixing Nanoparticles in water in different compositions. Later performances of the Radiator are tested with water, ethylene glycol and Al2O3 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 nanometre dimensions are mixed. The preparation of nano-coolant is an important aspect to achieve uniform and stable suspension. In the present study, Al2O3 is used as a nanoparticle and engine coolant (ethylene glycol: water, 40: 60) as a base fluid. The material of nanoparticles is chosen as Al2O3 because it is chemically more stable and its cost is less than their metallic counterparts. The properties of Al2O3 and ethylene glycol are given in Tables I

Sr.no	Properties	Al2O3	Mixture of water + Ethylene glycol
1	Density (Kg/m^3)	3950	1064
2	Specific heat (J/kgK)	873.336	3370
3	Thermal conductivity	31.922	0.363
4	Viscosity (N/sm^2)	-	4.65 x 10^{-5}

Table I: Thermo physical Properties of base Fluid and nanoparticles

VII. DESIGN

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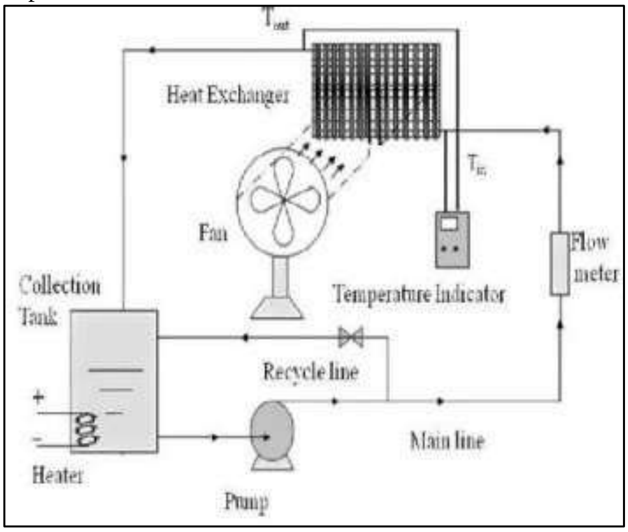

Fig. 1: Experimental Setup

A. RADIATOR

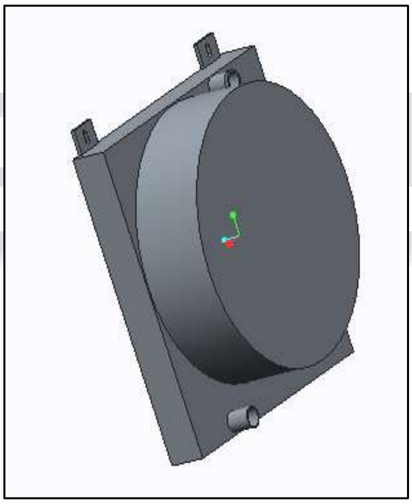

Fig. 2: CAD Model of Radiator

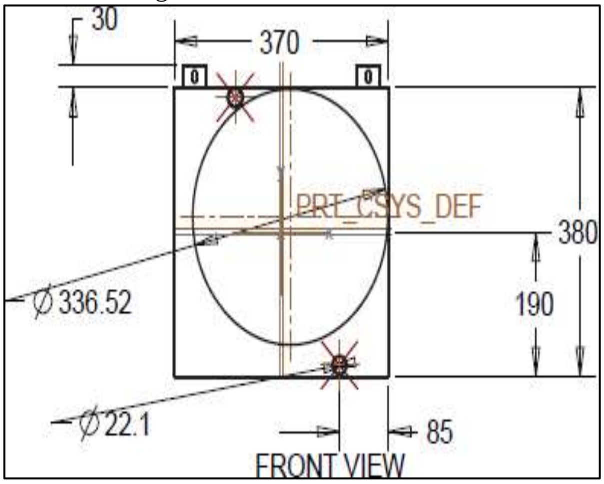

Fig. 3: Draft of Radiator

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B. Analysis of RADIATOR

1) Dimensions of Tube:

Internal Diameter: 6 mm
External Diameter: 6.82 mm
Thickness of tube: 0.41 mm
Length of Tube: 340 mm
Material of the tube: Aluminium
Total No tubes used: 49 (25 in one column & 24 in second column)
Inner surface area: 6408.73 mm^2
Outer Surface Area: 7284.73 mm^2

2) Dimensions of Turbulator:

Material: Aluminium
Pitch: 2.8 mm
Coil Dia.: 5.25 mm
Wire Dia.: 0.71 mm
Pitch: 2.8 mm
D_{hc}: 5.29 mm

3) Dimensions of Fin:

Material of fins: Al foil
Thickness: 0.21 mm
Total no of fins used: 227
Length of fin: 350 mm
Width: 28 mm
Pitch: 14 mm
Transverse pitch: 12.82 mm
Staggered offset: 7 mm
Single Fin Area: 6873.51 mm^2
Surface area of single fin: 14380.9 mm^2
Total surface area of 227 fins (A_f): 3264464.3 mm^2
A_f =3264464.3 mm^2
A_f = Total surface area of 227 fins
A_w =Surface area of the tube between the fins = $N_f \times \Pi \times D_r \times l_{eff}$
N_f = No. of fins=227
L_{eff} = 290-(.21×227) =242.33mm
A =1178602.307 mm
$A = A_f + A_w$ = 4443066.607mm^2
A =the total external area of the tube without fins
$A_t = N_t \times L \times \Pi \times D_r = 49 \times 300 \times \Pi \times 6.82$
=314957.2299mm^2
V_a = 17m/s

VIII. EXPERIMENTATION AND RESULT

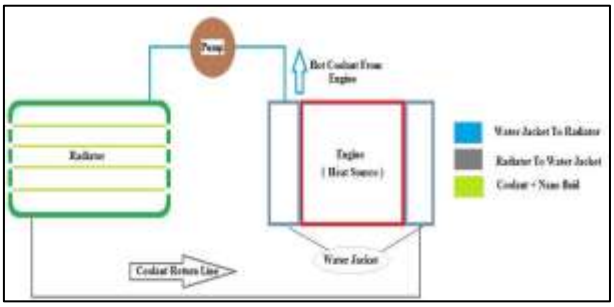

Fig. 4: Working of Setup

A. For Water,

1) Obesrvation Table

ṁ (lpm)	T_i (°C)	T_o (°C)	ΔT (°C)	T_{ai} (°C)	T_{ao} (°C)	t (min)
10	48.3	46.5	1.8	35	39.6	2
10	47.5	45.8	1.7	35	40.6	4
9	48.1	45.2	2.9	35	41.9	6
9	49.0	45.9	3.1	35	42.4	8
8	49.2	45.6	3.6	35	43.6	10
8	48.9	45.2	3.7	35	44.8	12

Table 2: Observation Table for Water

2) Result table

ṁ (lpm)	Q_w (W)	Q_a (W)	Q_{avg} (W)	ε
10	904.392	6888.27	3896.331	0.04541
10	854.148	8385.148	4619.934	0.04563
9	1311.36	10332.405	5821.8825	0.06684
9	1401.80	11081.13	6241.465	0.06686
8	1447.0272	12878.07	7162.5486	0.06805
8	1487.22	14675.01	8081.115	0.07145

Table 3: Result Table for Water

B. For Water + Ethylene glycol,

1) Observation Table

ṁ (lpm)	T_i (°C)	T_o (°C)	ΔT (°C)	T_{ai} (°C)	T_{ao} (°C)	t (min)
10	50.3	47.6	2.7	35	41.6	2
10	50.1	47.1	3.0	35	42.6	4
9	50.6	47.1	3.5	35	43.9	6
9	50.4	46.7	3.7	35	44.7	8
8	50.2	45.8	4.4	35	45.4	10
8	50.5	46.3	4.8	35	46.1	12

Table 4: Observations for Water +EG

2) Result table

ṁ (lpm)	Q_w (W)	Q_a (W)	Q_{avg} (W)	ε
10	1091.88	9883.17	5487.525	0.04765
10	1213.2	11380.62	6296.91	0.05365
9	1273.86	13327.305	7300.5825	0.05453
9	1346.65	14525.265	7935.95	0.05839
8	1423.48	15573.48	8498.484	0.06254
8	1552.89	16621.695	9087.2955	0.06690

Table 5: Results for Water + EG

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C. *For Water + Ethylene glycol + Al2O3 nanofluid,*

1) *Observation Table*

ṁ (lpm)	T_i (°C)	T_o (°C)	ΔT (°C)	T_{ai} (°C)	T_{ao} (°C)	t (min)
10	49.5	45.4	4.1	35	44.3	2
10	49.2	44.5	4.7	35	44.5	4
9	49.3	44.0	5.3	35	45.5	6
9	48.8	43.2	5.6	35	46.3	8
8	48.9	42.5	6.4	35	46.9	10
8	49.1	42.4	6.7	35	47.6	12

Table 6: Observation Table for Water + EG +Al2O3

2) *Result Table*

ṁ (lpm)	Q_{nf} (W)	Q_a (W)	Q_{avg} (W)	ε
10	1646.886	13926.285	7786.54	0.07547
10	1887.894	14225.775	8056.83	0.08878
9	1916.011	15723.225	8819.61	0.08947
9	2024.465	16921.185	9472.82	0.09796
8	2056.599	17819.655	9938.12	0.09880
8	2153.002	18867.87	10510.43	0.10197

Table 7: Results for Water+ EG+NF

D. *Combined Effects*

ṁ (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

Table 8: Combined results

IX. CONCLUSION

From the above graph various conclusions can be drawn which are:

1) With decrease in mass flow rate, temperature difference between inlet and outlet temperature of coolant increases. In the graph nanofluid is having better temperature rejection.
2) With increase in time in min, temperature difference between inlet and outlet temperature of coolant increases. In the graph nanofluid is having better temperature rejection.
3) With decrease in mass flow rate, average heat transfer rate of coolant increases. In the graph nanofluid is having better average heat transfer rate as compared to water and water + ethylene glycol.
4) With decrease in mass flow rate, effectiveness of coolant increases. In the graph nanofluid 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 nanofluid is having better average heat transfer rate as compared to water and water + ethylene glycol.

It is concluded that nanofluids are having better heat transfer rate as compared to other coolants and they can be considered as a potential candidate for numerous applications involving heat transfer and their use will continue to grow. It is also found that the use of nanofluids appears promising, but the development of the field faces several challenges. Nanofluid stability and its production cost are major factors in using nanofluids. The problems of nanoparticle aggregation, settling, and erosion all need to be examined in detail in the applications. We can say that once the science and engineering of nanofluids are fully understood and their full potential researched, they can be reproduced on a large scale and used in many applications.

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