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Research Paper Engineering

Experimental Performance Evaluation of Heat Transfer Rate in Automobile Radiator Using Nanoparticles (Al_2o_3)

* Pratik Kikani ** Priyanka Jhavar *** Dr.G.R. Selokar

* M.Tech Thermal, 42, Yogeshwar Society, Near Airport main gate, Rajkot-360007

** H.O.D.SSSIST, Sehore, C/O PRATIK KIKANI, 42, Yogeshwar Society, Near Airport main gate, Rajkot-360007

*** Principal.SSSIST,Sehore, C/O PRATIK KIKANI 42, Yogeshwar Society, Near Airport main gate, Rajkot-360007

ABSTRACT

In This paper using four stroke four cylinder engines as an experimental set up. In this project, different proportions of Al2O3 nanoparticles by weight have been added to conventional fluid (water), and based on that the enhancement in heat transfer rate has been found out by taking readings & calculating heat transfer rate.

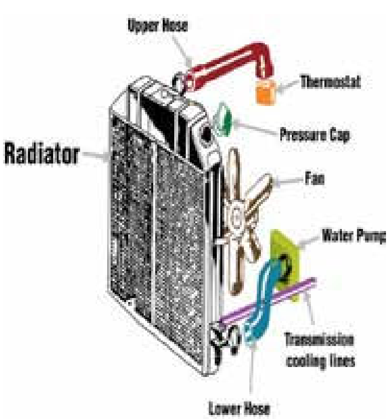
Keywords : Heat transfer rate, energy efficiency, Alumina powder, automotive radiator, thermocouple, dynamometer, Anemometer

1. Introduction

An automobile's cooling system is the collection of parts and substances (Coolants) that work together to maintain the engine's temperature at optimal levels. While it is running, an automobile engine generates enormous amounts of heat. Hence, it is imperative to remove the waste heat

The cooling system essentially comprises passages inside the engine block and heads, a pump to circulate the coolant, a thermostat to control the flow of the coolant, a radiator to cool the coolant and a radiator cap controls the pressure within the system.

In order to achieve the cooling action, the system circulates the liquid coolant through Passages in the engine block and heads. As it runs through, the coolant absorbs heat before returning to the radiator, to be cooled itself. Next, the cooled down coolant is recirculated and the cycle continues to maintain the engine's temperature at the right levels.



2. Experimental Set Up and Procedure

Minimum equipment required for experimental set up:

As per the schematic diagram shown below, following are the equipments (minimum) required for the set-up like Automobile radiator (Working apparatus), Water Pump, measuring instruments and Necessary piping and auxiliaries.

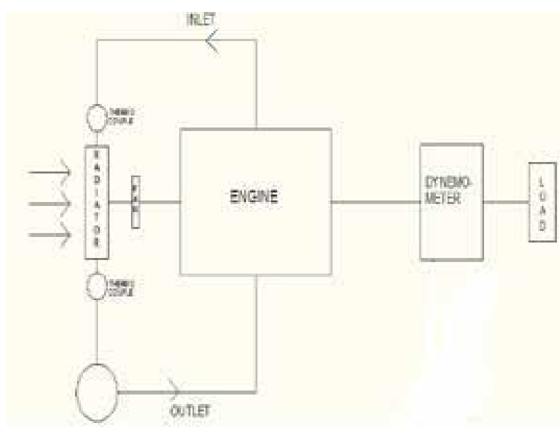


TABLE 1 Engine Specification

Make & Model	Mahindra Engine MDI-3200
General Details	Four stroke, Four cylinder, Vertical, Compression Ignition, Water cooled, Direct injection.
Bore	90.9mm
Stroke	92.4mm
Lubricating Oil	SAE 20 / SAE 40

Max. Power	40 B.H.P. @ 3000 rpm.
Water flow (lpm)	10
Velocity of air (m/s)	3.5
Tube size	Height 9.15 mm Diameter 3.30 mm Thick 0.3 mm
Fin size	Length 134.1 mm Width 43.15 mm Thick 0.33 mm
No of Tubes	117
No of Fins	108
Water inlet temp	90° c
Air inlet temp	35° c

Measurement and Instrumentation
Thermo couple
Hydraulic dynamometer
Anemometer
Measuring Parameters
Temperature of water and air circuit.
Power of engine output
Engine speed

2. Experimental Procedure
Reading Taken at constant speed, constant flow rate & variable load

Speed = 1200 rpm
Flow rate = 10 lpm
Velocity of Air = 3.5 m/s
Various Load 8 kg, 16 kg, 24 kg, 32 kg

Coolant – Pure water

Load Kg	Inlet Temp. Of Air	Out let Temp. of Air	Diff. in Temp. of Air	Avg.temp. of Air	Inlet Temp. of Coolant	Outlet temp. of coolant	Diff. In Temp.	Avg. Temp. Of Coolant
8	35	46	11	11.33	81	73	8	8.33
	36	47	11		82	73	9	
	35	47	12		82	74	8	

Coolant – Pure water +

(2%) Nanoparticles of Al_2O_3

Load Kg	Inlet Temp. Of Air	Out let Temp. of Air	Diff. in Temp. of Air	Avg. temp. of Air	Inlet Temp. of Coolant	Outlet temp. of coolant	Diff. In Temp.	Avg. Temp. Of Coolant
8	35	47	12	13.66	86	76	10	9.33
	35	47	12		86	77	9	
	35	48	13		86	77	9	

Coolant – Pure water +

(4%) Nanoparticle of Al_2O_3

Load Kg	Inlet Temp. Of Air	Out let Temp. of Air	Diff. in Temp. of Air	Avg. temp. of Air	Inlet Temp. of Coolant	Outlet temp. of coolant	Diff. In Temp.	Avg. Temp. Of Coolant
8	35	48	13	12.66	90	78	12	11.33
	35	47	12		88	77	11	
	35	48	13		89	78	11	

Coolant – Pure water +

(6%) Nanoparticle of Al_2O_3

Load Kg	Inlet Temp. Of Air	Out let Temp. of Air	Diff. in Temp. of Air	Avg.temp. of Air	Inlet Temp. of Coolant	Outlet temp. of coolant	Diff. In Temp.	Avg. Temp. Of Coolant
8	35	48	13		91	77	14	14
	35	49	14	13.33	90	76	14	
	35	48	13		91	77	14	

Likewise for various load reading is taken.

3. Sample calculation for the water as Coolant
The average heat transfer rate is

$$Qavg = \frac{(Qa + Qc)}{2}$$

Where Qa and Qc are the heat transfer rates at the air and the coolant stream, respectively.

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

$$Qa = ma\ Cpa\ (\Delta ta)$$

(For Air Side)

$$Qc = mc\ Cpc\ (\Delta tc)$$

(For Coolant Side)

$$Qa = ma\ Cpa\ (ta2 - ta1)$$

$$Qa = 1.3 \times 1.007 \times (44 - 35)$$

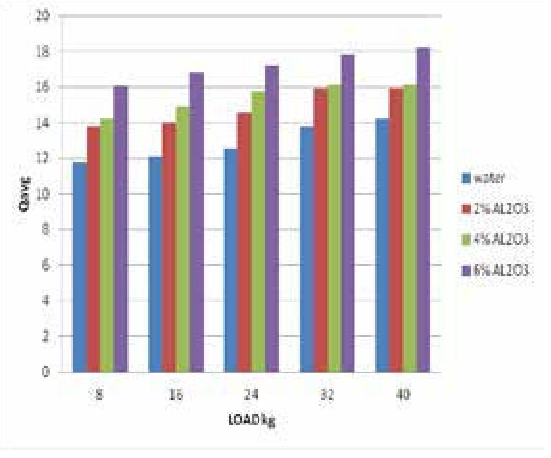
$$\boldsymbol{Qa = 11.65\ KW}$$

For Coolant (Water) side

$$Qc = ma\ Cpc\ (tc2 - tc1)$$

$$Qc = 0.25 \times 4.187 \times (90 - 82.6)$$

$$\boldsymbol{Qc = 7.85\ KW}$$



Percentage of Heat Transfer rate vs. Load Coolant used Different Volume Fraction of Al_2O_3

RESULT TABLE

Sr. No	Coolant rate	Load	Heat transfer rate (KW) Water	Water+ 2% Al_2O_3	Water + 4% Al_2O_3	Water + 6% Al_2O_3
1	10	8	11.77	13.82	14.21	16.04
2	10	16	12.16	13.99	14.95	16.83
3	10	24	12.56	14.56	15.74	17.18
4	10	32	13.82	15.91	16.13	17.83
5	10	40	14.21	15.91	16.13	18.22

conclusion :

EFFECT ON HEAT TRANSFER RATE

The heat transfer rate in automobile radiator increases by adding nanoparticles of Al_2O_3 in water. The heat transfer rate in radiator, using water as coolant is 8 kg load at coolant flow rate of 10 lpm. Whereas heat transfer rate is 11.77 KW now adding 2% volume fraction Al_2O_3 in water.

heat transfer rate increase 14% compare to water.Simontanously adding 4% volume fraction of Al_2O_3 in water heat transfer rate increase 17% and adding 8 % volume fraction of Al_2O_3 in water There is an increase of about 26% in heat transfer rate in automobile radiator compare to use water as coolant.

EFFECT ON COST

By adding nanoparticles to the water, the heat transfer rate in automobile radiator is increased. So for the same heat transfer radiator capacity, we can reduce the material of tubes and fins which will ultimately lead to the reduction in overall cost of the system

EFFECT ON WEIGHT AND SPACE

By using nanofluid, we get better heat transfer, so we can design compact and lighter heat exchange system with same heat transfer capacity.

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