Experimental Analysis Of Heat Transfer From Car Radiator Using CuO-Nanofluid, Al2O3-Nanofluid And Ethylene Glycol With Water.

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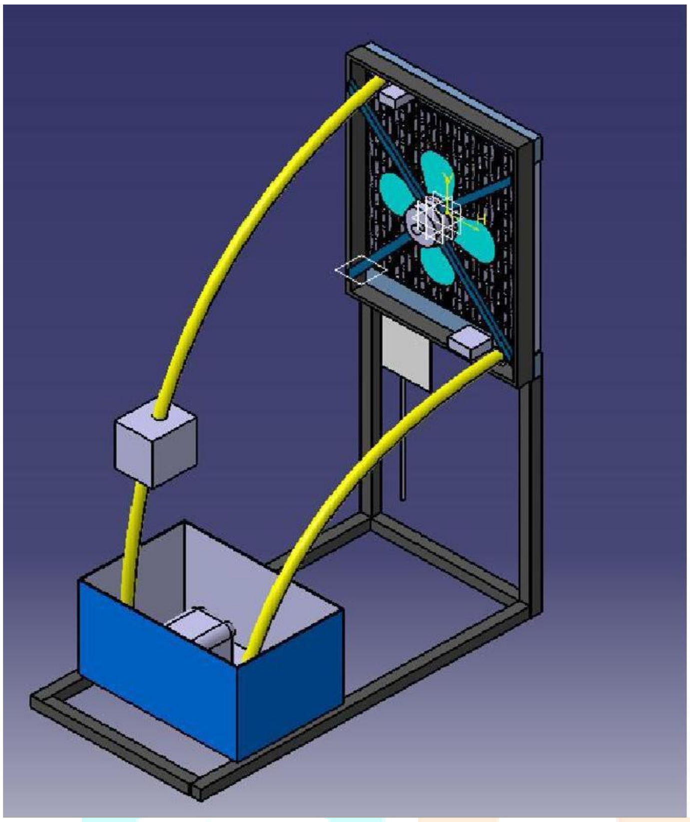
Abstract : Nanofluids are good replacements for cooling fluid in radiators and thermal exchangers. Materials with higher thermal properties are required to increase the performance of radiator.The use of nanofluids is one of the methods to increase heat transfer in radiators. In this research, cooling of car radiator has been investigated by using nanofluids. Reduction in size and weight of the radiators are among the achievements of this research. In addition to reducing the production cost, better designation of cars are possible when the radiator becomes smaller in size. On the other hand, better cooling has positive effects on fuel consumption and the amount of fuel consumption decreases.Nanofluids are produced by stable dispersing of nanoparticles in heat transfer fluids that are usually water or ethylene glycol. In this research, a system similar to car radiator cooling system has been designed and produced. Nanofluid was used instead of radiator cooling fluid. CuO-Water is used as nanoparticles in this project.CuO- nanoparticles, Al2O3 Nanoparticles consisting of 100 nm diameter particles at three different particle mass concentrations of 0.1%, 0.3% and 0.5% are used.

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. In case of the electronics industry, due to the demand for smaller and more powerful products, power densities of electronic components have increased. The maximum temperature of the component is one of the main factors that control the reliability of electronic products. Thermal management has always been one of the main issues in the electronics industry, and its importance will grow in coming decades. The use of heat sinks is the most common application for thermal management in electronic packaging. 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 aluminum and copper, heat sinks can be made of aluminum 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. Heat transfer augmentation using these methods always results in pressure drop penalties that adversely affect the aerodynamics and efficiencies. In the case of cooling of turbine blades, surface protrusions induce excessive pressure losses, which increase the compressor load. The separated flow field over ribs or pin fins can make significant non-uniform cooling, which leads to thermal stresses.

EXPERIMENTAL SETUP



The car radiator has lowered fin and 32 flat vertical Aluminum tubes with flat cross sectional area. The distances among the tube rows filled with thin perpendicular Aluminum fins. For the air side, an axial force fan (6000rpm) 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 40_o-80_oC. 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.

WORKING

The test rig in Fig. has to use to measure heat transfer coefficient and friction factor in the automotive engine radiator. This experimental setup includes a reservoir plastic tank, electrical heater, a centrifugal pump, a flow meter, tubes, valves, a fan, a DC power supply; Digital thermocouples type K for temperature measurement heat exchanger (Radiator). An electrical heater (2000W) inside a plastic storage tank (40cm height and 30 cm diameter) put to represent the engine and to heat the fluid. A voltage regular (0– 220 V) provided the power to keep the inlet temperature to the radiator from 60 to 80 C. A flow meter (0–30 LPM) and two valves have to use measure and control the flow rate. The fluid flows through plastic tubes (0.5in.) by a centrifugal pump (0.5hp) from the tank to the radiator at the flow rate range 2–8 LPM. The total volume of the circulating fluid will be 30 and constant in all the experimental steps .Two thermocouples (copper–constantan) types K have to fix on the flow line for recording the inlet and outlet fluid temperatures. Digital thermocouples type K has to fix to the radiator surface to ensure more of surface area measurement. Two thermocouples type K also fix in front of the fan and another side of radiator to measure air temperatures.

OBSERVATION TABLE

Coolant	Volume Concentration (%)	ṁ (lpm)	Ti (ºC)	To (ºC)	∆T (ºC)	Tia (ºC)	Toa (ºC)	∆T (ºC)	T (min)
Ethylene Glycol With Water	40-60	5	79.84	76.3	3.54	32.2	60	27.8	8
Al2O3 Nanofluid	0.1	5	81.24	71	10.24	32.5	58	25.5	8
Al2O3 Nanofluid	0.3	5	78.38	67	11.38	32.3	53.5	21.2	8
Al2O3 Nanofluid	0.5	5	79.71	61.5	18.21	32.4	48.7	16.3	8
CuO Nanofluid	0.1	5	80.09	66.1	13.99	32.5	51.5	19	8
CuO Nanofluid	0.3	5	81.57	61.3	20.27	32.3	47.7	15.4	8
CuO Nanofluid	0.5	5	78.00	57	21	32.2	42	9.8	8

CALCULATIONS

To calculate density and specific heat of base fluid and nanofluid ,
PV=mRT
ρ= P/(R x T)
ρ= 101325/(287 x 305.5)
ρ= 1.1556 Kg/m3
1ft=0.3048 m
CFM= 2000
ṁa= ρ*CFM
=1.1556 x 2000 x (0.3048)3/60
ṁa = 1.0907 kg/sec

Sample Calculation Of Al2O3:

Coolant: Al2O3 Nanofluid
Concentration of Nanoparticles in Nanofluid= 0.1%
$\dot{m}a = 1.0907$ kg/sec
$\rho_{nf} = (1-\phi)\ \rho_{bf} + \phi\ \rho_{nf}$
$= (1-0.1/100) \times 1000 + (0.1/100) \times 3950$

$= 1002.95$ kg/m3

$C_{nf} = \phi\ \rho_{p} + (1-\phi)\ \rho_{nf} C_{bf}\ / \rho nf$
$= 1 \times 10_{-3} \times 873.366 + (1-0.1/100) \times 1002.95 \times 4185/ 1002.95$
$= 4180.815$ J/kgK.

To calculate dynamic viscosity,
$\mu_{nf} = \mu_{bf} \times 1/ (1-\phi)2$
$= 8.90 \times 10\text{-}4 \times 1 / [1-(0.1/100)]2$
$= 0.000892$ Ns/m2.

$Q_{nf} = \dot{m}_{nf} C_{pnf} (T_{i}-T_{o})$ W
$= 5 \times 0.012 \times 4180.815 \times (81.24-71)$
$= 2568.69274$ W

$Q_{a} = \dot{m}_{a} C_{pa} (T_{oa}-T_{ia})$, W
$= 1.0907 \times 1005 \times (58-32.5)$
$= 27951.9143$ W

$\mathcal{E} = \dot{m}_{e} C_{pnf} (T_{i}-T_{o}) /\ \dot{m}a\ Cpa\ (Ti-Tai)$
$= 10 \times 0.012 \times 3347.33 \times (81.24-71) /1.49 \times 1005 \times (81.24-32.5)$
$= 0.04807899$

Sample Calculation Of CuO Nanofluid:

Coolant: CuO Nanofluid
Concentration of Nanoparticles in Nanofluid= 0.1%
$\dot{m}a = 1.0907$ kg/sec
$\rho_{nf} = (1-\phi)\ \rho_{bf} + \phi\ \rho_{nf}$
$= (1-0.1/100) \times 1000 + (0.1/100) \times 6310$

$= 1005.31$ kg/m3

$C_{nf} = \phi\ \rho_{p} + (1-\phi)\ \rho_{nf} C_{bf}\ / \rho nf$

$= 1 \times 10_{-3} \times 531 + (1-0.1/100) \times 1005.31 \times 4185 /1005.31$
$= 4021.5$ J/kgK.

To calculate dynamic viscosity,
$\mu_{nf} = \mu_{bf} \times 1/ (1-\phi)2$
$= 8.90 \times 10_{-4} \times 1 / [1-(0.1/100)]_{2}$
$= 8.916 \times 10_{-4}$ Ns/m$_{2}$.

$Q_{nf} = \dot{m}_{nf} C_{pnf} (T_{i}-T_{o})$ W
$= 5 \times 0.012 \times 4021.5 \times (80.09-66.1)$
$= 3509.37655$ W

$Q_{a} = \dot{m}_{a} C_{pa} (T_{oa}-T_{ia})$, W
$= 1.0907 \times 1005 \times (51.5-32.5)$
$= 20826.9165$ W

$\mathcal{E} = \dot{m}_{e} C_{pnf} (T_{i}-T_{o}) /\dot{m}a\ Cpa\ (Ti-Tai)$
$= 5 \times 0.012 \times 4021.5 \times (80.09-66.1) /1.0907 \times 1005 \times (80.09-32.5)$
$= 0.06727332$

RESULT TABLE

Coolant	Volume Concentration (%)	$\dot{m}$ (lpm)	Q_{nf} (W)	Q_a (W)	ε
Ethylene Glycol With Water	40-60	5	715.7880	30473.0673	0.0137
Al2O3 Nanofluid	0.1	5	2568.6927	27951.9143	0.0481
Al2O3 Nanofluid	0.3	5	2854.6605	23238.4542	0.0564
Al2O3 Nanofluid	0.5	5	4567.9585	17867.3021	0.0877
CuO Nanofluid	0.1	5	3509.3766	20826.9165	0.0673
CuO Nanofluid	0.3	5	5074.5295	16880.7639	0.0940
CuO Nanofluid	0.5	5	5304.2020	10742.3043	0.11

CONCLUSION

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

1) With Increase in Volume Concentration of Nanoparticles in the Nanofluid, temperature difference between inlet and outlet temperature of coolant increases. In the graph nanofluid is having better temperature rejection.

2) With Increase in Volume Concentration of Nanoparticles in the Nanofluid, Heat Transfer Rate also increases. In the graph nanofluid is having better Heat Transfer Rate.

3) With Increase in Volume Concentration of Nanoparticles in the Nanofluid, Effectiveness of the radiator also increases.

4) With replacing the nanofluid i.e., Al2O3 by CuO nanofluid, The Temp. Difference increases and hence Heat Transfer Rate and Effectiveness also increases.

5) If we compare the Coolants i.e., Ethylene Glycol, Al2O3 Nanofluid and CuO Nanofluid, The CuO Nanofluid has the highest value of Heat Transfer Rate and the Effectiveness and Secondly the Al2O3 Nanofluid.

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 applicati`.

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