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IMPROVING HEAT TRANSFER RATE USING AL_20_3 BASED NANO FLUID IN AUTOMOBILE RADIATOR.

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ABSTRACT

In an automobile lot of heat is produced due to the combustion, only a portion of heat is utilized to produce the power rest of heat is wasted in the form of exhaust heat. If this excess heat is not removed, the engine temperature becomes too high which results in overheating and viscosity breakdown of the lubricating oil, wear of the engine parts, due to thermal stress of the engine components failure may occurs in engine. So that a cooling system is required. The automobile engine utilizes a heat exchanger device, termed as radiator, in order to remove the heat from the cooling jacket of the engine. The radiator considered as an important component of the cooling system of the engine. Normally, it is used as a cooling system of the engine and generally water is the heat transfer medium .For this liquid-cooled system, the waste heat is removed via the circulating coolant surrounding the devices or entering the cooling channels in devices. The coolant is propelled by pumps and the heat is carried away mainly by radiator. But for removing heat, area increasing is the limitation. To avoid this increasing area, we can use the nanofluids which increases the heat transfer rate in engine.

Keywords: **Nano particles, coolant, ethylene glycol, Aluminum oxide(AL_2O_3),Heat transfer rate, convective heat transfer coefficient.**

I. INTRODUCTION

Over several years researchers have focused to overcome the limited heat transfer capabilities of Conventional heat transfer mediums such as water, engine oil, ethylene glycol (EG). For the need of the high performance cooling, heating efficiency, energy saving, less generation of greenhouse gases nanotechnology is applied to thermal engineering. Nano fluid is Choi. In this technology requirement is addressed by two means i.e. one is geometry which tells the particle size and the second one is fluid being used. Nanofluids have unique features different from convectional solid- liquid mixtures in which mm (or) µm sized particles of metals and non-metals are dispersed. Due to their excellent characteristics, nanofluids find wide application in enhancing heat transfer characteristics namely extreme stability, ultra-high thermal conductivity.

Heat transfer surface area increases due to Brownian motion and inter particle forces so that increased thermal conductivity, increased single-phase heat transfer, increased critical heat flux occurs. Nano particles are very small in size, usually < 100 nm. The smallest nano particles, only a few thousand atoms these nano particles can possess properties that are substantially different from their parent materials. Instability of nano particles in base fluid can occur due to thermodynamics unstable Vander wall forces between nano particles. Preparation of stable nanofluids is the key issue in nanofluids research. For the preparation of stable nanofluids mainly three processes are using namely two-step process, chemical approach, laser ablation method . Nanofluids used many applications like microelectronics, fuel cells, pharmaceutical process, hybrid power engines, engine cooling, vehicle, thermal management, domestic refrigerator, chiller, heat exchangers, in grinding, mashing, boiler flue gas temperature reduction, geothermal extractions of geo thermal power and other energy sources, cryopreservation.

II. NANOFLUID

Nanofluids are a relatively new classification of fluids which consist of a base fluid with Nano sized particles (1-100 nm) suspended within them. These particles, generally a metal or metal oxide, increase conduction and convection coefficients, allowing for more heat transfer out of the coolant. There have been several advancements recently which have made the nanofluids more stable and ready for use in real world applications. Nano fluid is a fluid comprises nanometer-sized particles, known as nanoparticles. These fluids contain coolant and nanoparticles of high heat conductivity material.

Nanofluids can be used to cool automobile engines and welding equipment and to cool high heat-flux devices such as high power microwave tubes and high-power laser diode arrays. A nanofluids coolant could flow through tiny passages in MEMS to improve its efficiency. The measurement of nanofluids critical heat flux (CHF) in a forced convection loop is useful for nuclear applications. If nanofluids improve chiller efficiency by 1%, a saving of 320 billion kWh of electricity or an equivalent 5.5 million barrels of oil per year would be realized in the US alone. Nanofluids find potential for use in deep drilling application. A nanofluids can also be used for increasing the dielectric strength and life of the transformer oil by dispersing nanodiamond particles.

i.e Nano fluid = Basefluid + Nanoparticle

- Coarse particles (10,000 to 2,500 nm)
- Fine particles (2,500 to 100 nm)
- Ultrafine particles (1 to 100 nm)

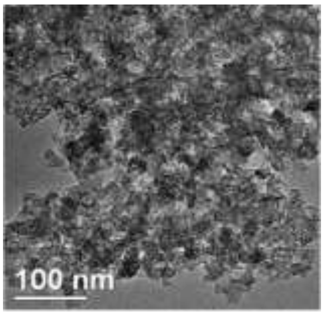


Fig.1TEM image of Al_2O_3 nanoparticles

[Andreea Kufner et al]

III. REASON FOR USING NANO FLUIDS

The main goal or idea of using nano fluids is to attain highest possible thermal properties at the smallest possible concentrations (preferably<1% by volume) by uniform dispersion and stable suspension of nanoparticles (preferably<10nm) in hot fluids. A nanofluids is a mixture of water and suspended metallic nanoparticles. Since the thermal conductivity of metallic solids are typically orders of magnitude higher than that of fluids it is expected that a solid/fluid mixture will have higher effective thermal conductivity compared to the base fluids. Nanofluids are extremely stable and exhibit no significant settling under static conditions, even after weeks or months.

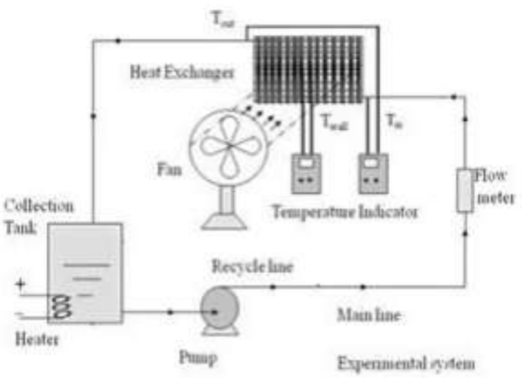
A greater temperature difference causes increase the heat flow, but it is often limited by process or materials constraints.

[B. S. Kothawale et al]

Increase the area A is a general method to increase heat transfer, but there are limitation on increasing area like aeroplane etc. and also there is increase in unnecessary weight.

Heat transfer augmentation can also be achieved by increasing the heat transfer coefficient h. The heat transfer coefficient can be increased by enhancing the properties of the coolant. Additives are added to coolants to improve its properties. The heat transfer coefficient can be improved by addition of nano particles to the liquid coolant (i.e. nanofluids).

IV.SELECTION OF MATERIALS AND SPECIFICATION



Experimental Setup

a) Radiator

For this experimental setup, we have selected a standard radiator of Maruti Suzuki 800 from the market having following standard specifications.

- Radiator core dimension =0.3x0.339x0.016m
- No. of tubes = 37
- Inner diameter of tube = 0.005 m

- Outer diameter of tube = 0.007 m
- Area = π/4 d2 =1.9634×10*5 m2
- Fan motor type = DC motor
- Fan input voltage = 20-25 V
- Fan speed = 1200-2400 rpm

Fig . Radiator

b) Pump

For the pumping purpose, we have selected a standard pump having following specifications.

- Rating Power = 0.5 HP
- Frequency = 50 Hz
- Volts = 220 V
- Maximum Discharge = 42 L/min
- Maximum Height = 38 m
- Power = 0.37 kW
- Speed of the rotor = 2850 rpm

Fig. Pump

c) Heater

- Heating capacity = 2 KW

Fig. Heater

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d) Tank

We need a collecting tank of following dimensions-

- Tank height = 0.2 m approx.
- Tank diameter =0.12 m approx.
- Tank capacity = 2 liter approx.

e) Pipe

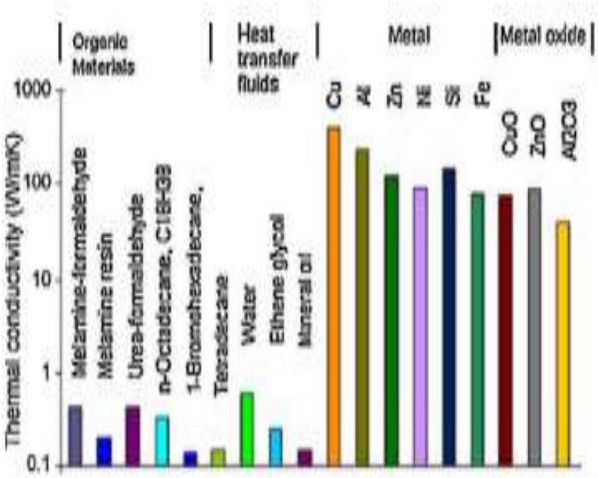
- Material = Polyester rubber.
- Inner diameter = 0.025 m
- Outer diameter = 0.030 m

f) Rotameter

- Flow rate = 1-10 Lpm.

Fig. Rotameter

V.THERMAL CONDUCTIVITIES OF NANOFLUIDS



	particle	Base fluid	Averg. Particle size	Volume fraction	Thermal conductivity enhancement
Metallic nanofluids	Cu	Ethylene	10nm	0.3% 7.5%	40% 78%
	Cu	glycol	100nm	0.55% 0.001%	21% 17%
	Fe	Water			
	Au	Ethlyene	10-20nm		
	Ag	glycol	60-80nm		
Non Metallic nanofluids	Al2O3	Water	13nm	4.3%	30%
	Al2O3	Water	33nm	4.3%	15%
	Al2O3	Water	68nm	5%	21%
	CuO	Water	36nm	3.4%	12%
	CuO	Water	50nm	0.4%	17%
	SiC	Water	26nm	4.2%	16%

VI.CALCULATION OF HEAT TRANSFER COEFFICIENT

The total heat transfer in process is calculated as

$$Q=HA\,dT$$

Where

Q= the total heat transfer rate,

h =the convective heat transfer coefficient,

A= the heat transfer area, and

dT= the temperature difference that results in heat flow.

It can be stated from this equation that increased heat transfer can be achieved by:

1) Increasing Area A

2) Increasing Convective heat transfer coefficient

3) Increasing Temperature difference dT

The heat transfer coefficient can be obtained by following procedure.
According to Newton's cooling equation:

$$Q = hA\Delta T = hA(Tb\text{-}Tw) \qquad \ldots\ldots..(1)$$

We all know that heat transfer rate Q can be calculated as follows

$$Q = mCp\Delta T = mCp\ (Tin\text{-}Tout) \qquad \ldots\ldots\ldots.(2)$$

By above two equations we can write

$$Nu=\frac{hexp*dh}{k}=\frac{m\ Cp(Ti-To)}{A(Tb-Tw)} \qquad \ldots\ldots\text{from (1) \& (2)}$$

In above equation,
Nu = average Nusselt number.
m i=mass flow rate is equal to product of density and volume flow rate of fluid,
Cp = specific heat capacity of fluid,
A = area of radiator tubes,
Ti and To=are inlet and outlet temperatures,
Tb = bulk temperature which was assumed to be the average values of inlet and outlet temperature of the fluid moving through the radiator, and
Tw = tube wall temperature which is the mean value by two surface thermocouples.
k = fluid thermal conductivity and
dh=hydraulic diameter of the tube.
(all the physical properties were calculated at fluid bulk temperature).

[S.Ravi Babu et al]

VII.RESULTS AND DISCUSSIONS

A) Mixture water &water ethylene glycol

Before conducting the experiment, some experiments withwater and ethylene glycol to check the accuracy of the experimental setup and set the base for comparing further result

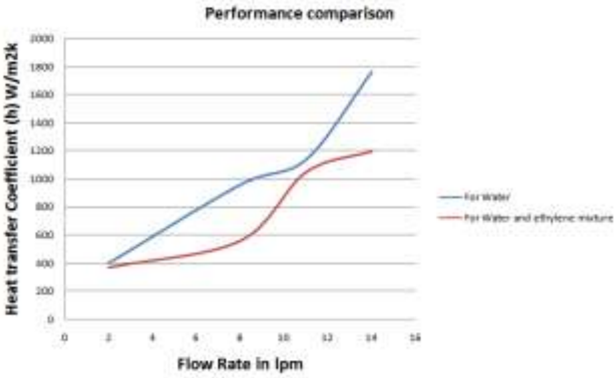


Fig 2. experimental results for water in comparison with mixture of water &ethylene glycol

fig.2 shows experimental results for constant inlet temperature of 50°c.

B) With adding Nanoparticles

The nanofluid is implemented in various Al2o3 concentrations, i.e. 0.01, 0.03, 0.05 and 0.07 vol. % and at different flow rates of 6 and 9 l/min were implemented as the base fluid.With increase of the concentration of nano particles in the coolant, viscosity of nanofluid has been increased.

Various results are as follows:

For 6 lpm:

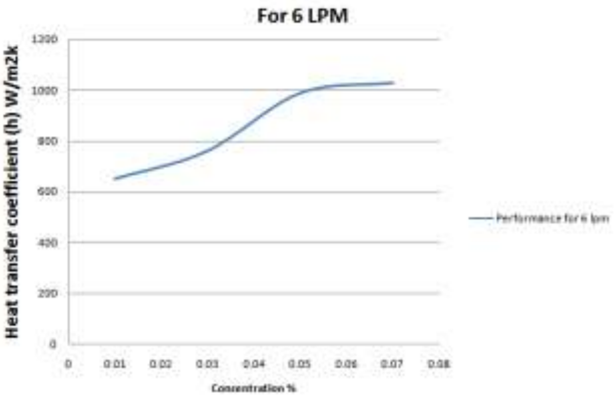


Fig 3 effect of volume concentration of Al2o3 nano particles on the heat transfer coefficient at 6 lpm

Fig 3 shows the values ofheat transfer coefficient for different volume concentrations at flow of 6 lpm of nanofluid passing through radiator. There is increase of heat transfer coefficient.

For 9 lpm:

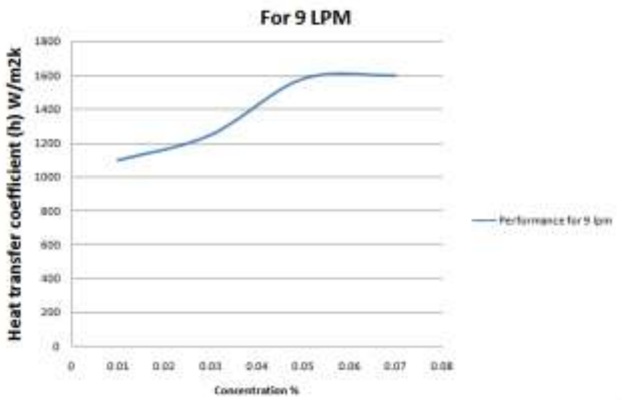


Fig 4 shows the effect of concentration of Al2o3 nano particles on the heat transfer coefficient at 9 lpm

Fig 4 represents the heat transfer coefficient gradually increasing for increasing the nano particle concentration. the physical properties of nanofluids are slightly different than the base fluid. Density and thermal conductivity increased and specific heat decreased slightly in compare to base fluid. Viscosity increases more clearly, which is undesirable in heat transfer.

VIII.FUTURE SCOPE

1) The future scope of this experiment is not yet completed there are more areas for research and working.
2) There is a great challenge in finding out more effective coolant having better thermo physical properties for the better heat transfer rate and the same time it is very important that it should be environment friendly.
3) The costs of nanoparticles are high due to expensive production procedure. Hence there is a need and more work to be carried out for less expensive nanoparticles production.

IX.CONCLUSIONS

1) The size of the radiator is reduced in the case if we want same heat transfer rate as that of the conventional coolant.
2) The No_x emission is also considerably reduced as the engine temperature is reduced below 1100^oC.
3) The degree of heat transfer enhancement depends on the amount of the nano particle added.
4) Increasing the flow rate of base fluid enhance the heat transfer coefficient for both coolant and nano fluid considerably.

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