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Research Article

Comparing Cooling Performance of Radiator With Cu_2O Based Nanofluid.

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Abstract

In an automobile lot of heat is produced due to the combustion, 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. The automobile engine utilizes a heat exchanger device, termed as radiator, in order to remove the heat from the cooling jacket of the engine. But for removing heat, area increasing is the limitation. To avoid this increasing area, we can use the nanofluids. Nano fluid is a fluid containing nanometer-sized particles, called nanoparticles which consist of a coolant with nanosized particles of metal oxides added within them. These addition of metal oxides increase conduction and convection coefficients, so that there is increase in the heat transfer rate. Among all the metal oxides copper oxide nanomaterials have unique thermal properties

Keywords: *Nano particles, coolant, ethylene glycol, Copper oxide (Cu_2O),Heat transfer rate, convective heat transfer coefficient.*

1. Introduction

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 automotive industry is continuously involved in a strong competitive career to obtain the best automobile design in multiple aspects (performance, fuel consumption, safety, etc.). The air-cooled heat exchangers found in a vehicle (radiator, AC condenser and evaporator, etc.) have an important role in its weight and also in the design of its frontal area. The use of nanofluids as coolants would allow for smaller size and better weight reduction of the radiators. The use of high-thermal conductive nanofluids in radiators can lead to a reduction in the frontal area of the radiator up to 10%. The fuel saving is up to 5% due to the reduction in aerodynamic drag.

Nanofluids are a relatively new classification of fluids which consist of a base fluid with nanosized particles (1-100 nm) suspended within them. [P.Suganya *et al*]

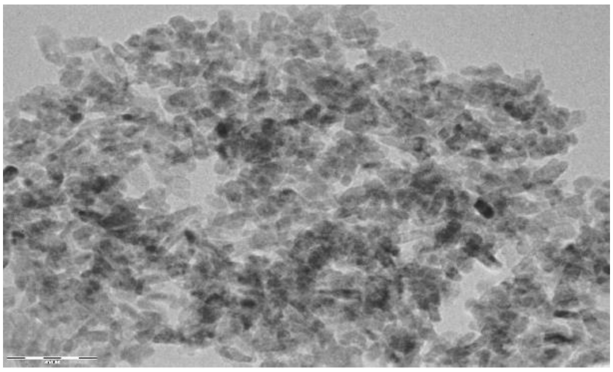

Fig.1 TEM image of Cu_2O nanoparticles [Sanjay Srivastava *et al*]

3. Why nano fluids

The total heat transfer in process is calculated as

Q=HAdT

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:

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1) Increasing Area A, 2) Increasing Temperature difference dT&3) Increasing Convective heat transfer coefficient [B. S. Kothawale *et al*]

Maximizing the heat transfer area A is a common way to improve heat transfer, but there are limitation on increasing area like aeroplane etc. and also there is increase in unnecessary weight.

Heat transfer improvements 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 for a given method of heat transfer. Additives are often added to liquid coolants to improve specific properties. For example, glycols are added to coolant to depress its freezing point and to increase its boiling point. The heat transfer coefficient can be improved via the addition of nano particles to the liquid coolant (i.e. nanofluids). [Rahul A. Bhogare *et al*, B. S. Kothawale *et al*]

4. Production of Nanoparticles

There are two basic methods to obtain nanofluids:

Single-step direct method: In this method, the direct evaporation and condensation of the nanoparticulate materials in the base liquid are obtained to produce stable nanofluids.

Two-step method: In this method, first the nanoparticles are obtained by different methods and then are dispersed into the base liquid. [Psuganya *et al]*

5. Calculation of heat transfer coefficient

The heat transfer coefficient can be obtained by following procedure performed.

As per Newton's cooling law:

Q = hAΔT = hA(Tb-Tw)

Heat transfer rate Q can be calculated as follows

Q = mCpΔT = mCp (Ti-To)

In above equation

m=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.
(all the physical properties were calculated at fluid bulk temperature).[D.Tirupati Rao *et al*]

6. Results

A. For Pure Water

Air temperature Ta= 20°c
U = 21.98m/s
Diameter = 0.006m
Length = 1.5m
Radiator surface Temperature(Tw) = 60°C
Film temperature (Tf) = $\frac{(Tw + Ta)}{2} = \frac{60+20}{2}$ =40°C

Properties of air at 40°C, HMT data book p.no:34
Density (ρ) = 1.128kg/m3
Kinematic viscosity (v) = 16.96X10-6m2/s
Prandtl number (pr) = 0.699
Thermal conductivity (k) = 0.02756w/mk

Reynolds number (Re) = $\frac{UD}{v} = \frac{(21.98X0.3)}{96 X 10^{-6}}$
Re = 3.88X10^5

Nusselt Number (Nu) = c(Re)m(Pr)0.333
From HMT data book page No 1.116 for Re value is 3.88X105, corresponding C value is 0.989 and m value is 0.330

Nusselt Number Nu = (0.989)X(3.88X105)0.330X(0.699)0.333
Nu = 61.336
Nu = $\frac{hD}{K}$
61.336 = (h*0.3)/0.02756
h = 667.66 w/m2k
Heat Transfer(Q) = hA(Tw-Ta)
= 667.66X(3.14X0.006X1.5)X(60-20)
Q = 755.11w
[psuganya et al]

B) With Nanofluids

Air temperature T∞ = 20°c
U = 21.98m/s
Diameter = 0.006m
Length = 1.5m
Radiator surface temperature (Tw) = 50°C
Film temperature (Tf) $\frac{(Tw + Ta)}{2} = \frac{50+20}{2}$
= 35°C
Properties of air at 35°C, HMT data book p.no:34
Density (ρ) = 1.1465kg/m3
Kinematic viscosity (v) = 16.48X10-6m2/s
Prandtl number (p r) = 0.7
Thermal conductivity(k) = 0.027155w/mk
Reynolds number (Re) = = $\frac{UD}{v}$
= (21.98X0.3)/(16.48X10-6)
Re = 4.001X105
Nusselt Number (Nu) = c(Re)m(Pr)0.333

From HMT data book page No 1.116 for Re value is 4.001X105, corresponding C value is 0.911 and m value is 0.385

Nusselt Number

Nu = (0.911)X(4.001X105)0.385X(0.7)0.333

Nu = 116.08

$Nu = Nu = \frac{hD}{K}$

116.08 = (h*0.3)/0.027155

h = 1282.41 w/m2k

Heat Transfer (Q) = hA(Tw-T∞)

= (1282.41)X(3.14X0.006X1.5)X(50-20)

Q = 1087.78w [P.Suganya *et al*]

Conclusions

1) From above result we can conclude that After adding nano particles of Copper oxide $Cu_2O$to the water ,there is markedly increase in heat transfer rate by 44%
2) Reduced pumping power as compared to pure liquid to achieve equivalent heat transfer intensification.

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