© 2016 IJEDR | Volume 4, Issue 2 | ISSN: 2321-9939

Improving Performance in Engine Cooling System using Nanofluid-Based Coolant

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***Abstract* – In this paper the experimental analysis of the thermal behavior of the single phase flows through an automobile radiator. The radiator is an important accessory of vehicle cooling system in the engine. Normally, it is used as a cooling system of the engine and generally, the water is the heat transfer medium. For this liquid-cooling system, the heat is removed via the circulating coolant surrounding the devices or entering the cooling channels in devices. Nanofluids have attracted attention as a new generation of heat transfer fluids in automotive cooling applications because of their excellent thermal performance. This paper attempts to improve the heat transfer characteristics of a vehicle cooling system using water combination based Graphene nanofluids as coolant. The thermal performance of a radiator operated with nanofluids is compared with a radiator using conventional coolant.**

***Index Terms* – Radiator, Nanofluids, Graphene, Carbon nanotube, Heat transfer performance.**

I. INTRODUCTION

Improving the fuel economy for automotive applications has a higher priority this decade. The driver of this strong focus is concern over Global Warming and the connection between fuel consumption and emission of the greenhouse gas, carbon dioxide, etc. The European Automotive Manufacturers required the average emissions for new cars reduced to 130 g/km by 2015. This implies a reduction in fuel consumption of more than 25% from a 1995 baseline. An even more stringent CO2 target of 95 g/km is under consideration for 2021.

The advancement in technology in the automotive industry has increased the need for high performance engines. The engine performance is based on the fuel economy and less emission. Reducing the vehicle weight by optimizing design and size of a radiator is a necessity for making the world green. By using the nanofluid high thermal conductivity coolant increase the performance more 50% compared to conventional coolant.

Nanofluids (Graphene) have attracted attention as a new generation of heat transfer fluids in vehicle cooling system because of their excellent thermal performance.

II. COOLING SYSTEM INVESTIGATION

The experimental study figure 2.1 represents the changing material of coolant and radiator tube. Normally, radiator ethylene glycol as coolant and aluminum tubes is used low thermal conductivity compared to graphene nanofluids and CNT's. The thermal conductivity measurement of nanofluids was the main focus in the early stages of nanofluid research. Recently studies have been carried out on the heat transfer coefficient of nanofluids in natural and forced flow. Most studies carried out to date are limited to the thermal characterization of nanofluids without phase change. However, nanoparticles in nanofluids play a vital role in two-phase heat transfer systems and there is a great need to characterize nanofluids in boiling and condensation heat transfer. In any case the heat transfer coefficient depends not only on the thermal conductivity but also on the other properties such as the specific heat, density and dynamic viscosity of a nanofluid (table 2.1).

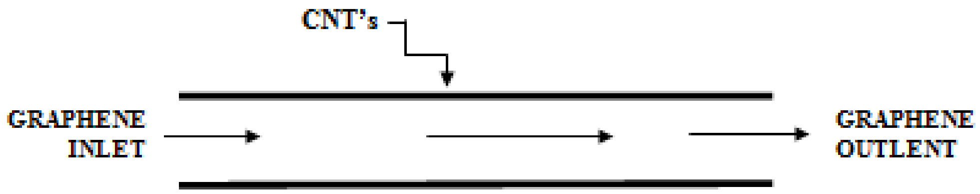

Figure 2.1 Concept of modification

Table 2.1: Properties of coolants and tubes

Property	Graphene	Carbon nanotubes	water
Thermal conductivity	500-600 w/mk	>3000 w/mk	0.605 w/mk
Density	1500 kg/m³	1000 kg/m³	997.1 kg/m³
Specific heat	1900 j/kgk	1300 j/kgk	4195 j/kgk

III. NOMENCLATURE

A - Total area heat transfer, m^2
C - Specific heat, J/kg k
di - Inner diameter of the tube, m
do - Outer diameter of the tube, m
K - Thermal conductivity, w/m k
L - Length, m
Q - Heat transfer rate, kw
T - Temperature, k
U - Fluid velocity, m/s
CNT's - Carbon nanotube,
ρ - Density, kg/m^3
v - Viscosity, m^2/s
m - Mass flow rate, kg/s
V - Velocity, kg/m^2 s
Re - Reynolds number,
Pr - Prandtl number,
Nu - Nusselt number,

IV. EXPERIMENTAL HEAT TRANSFER CALCULATION

Experimental analysis is taken from mathematical formulation. In this paper a comparison is made between the heat transfer performance of radiator by operating with conventional and nanofluids coolants. It highlights not only the influence of nanofluids but also volume fraction of graphene particles to the heat transfer rate of a radiator.

Table 4.1Experimental of coolant

Coolant	Air velocity m/s	Mass flow rate Kg/s	Inlet temperature ˚C	Outlet temperature ˚C	Heat transfer rate Kw
Water	22	0.487	120	30	12.65
	22	0.490	120	30	11.5
	22	0.623	120	30	11.8
Graphene + Water[15%]	22	0.386	120	30	18.2
	22	0.410	120	30	18.5
	22	0.433	120	30	19.3
Graphene + Water[50%]	22	0.345	120	30	30.0
	22	0.450	120	30	29.5
	22	0.489	120	30	29.3

4.1 Mathematical Formulation

The parameters needed for nanofluid side calculation are nanofluid heat transfer coefficient, nanofluid heat capacity rate, heat exchanger performance, heat transfer coefficient based on air side, total heat transfer rate.

Density of nanofluids, $\rho = [1-\Phi S]\ \rho_f + \Phi S\ \rho_p$
Specific density, $c = [1-\Phi S]\ \rho_{f\,Cf} + \Phi S\ \rho_{p\,Cp} / \rho$
Mass flow rate, $m = \rho.A.V$
Reynolds number, Re = ud/v, Re <2*10^5 [**Laminar flow**]
Nusselt number, Nu = 3.66 + [0.104.Re.Pr.{d/l}]/[1+0.16Re.Pr.{d/l}^0.8]
Heat transfer co-efficient, h = Nu.k/d
Heat transfer, $Q = h\ A\ \Delta T$
Percentage of area reduction = Ac-An/Ac * 100
Outlet temperature of hot fluid, Tho = Thi – [Q/Ch]

Table 4.2 Experimental reading of temperature

Mass flow rate [kg/sec]	Inlet temperature [˚C]	Outlet temperature [˚C]	Ambient temperature [˚C]
0.345	120	30	30

V. EXPERIMENTAL RESULTS AND DISCUSSION

In this section, analysis of thermal performance of an automotive radiator single phase heat transfer at constant Reynolds number of coolant and air have been carried out. With the result temperature flow in the radiator was calculated using by NX-Nastran (figure 5.1). This parameters influences heat transfer in an automotive radiator. The heat transfer rate in automobile radiator increases by adding nanoparticles of Graphene in water. The heat transfer rate in radiator, using water as coolant is 7.5 kg load at coolant flow rate of 10 l pm whereas heat transfer rate is 12.65 KW now adding 0.5% volume fractions Graphene in water.

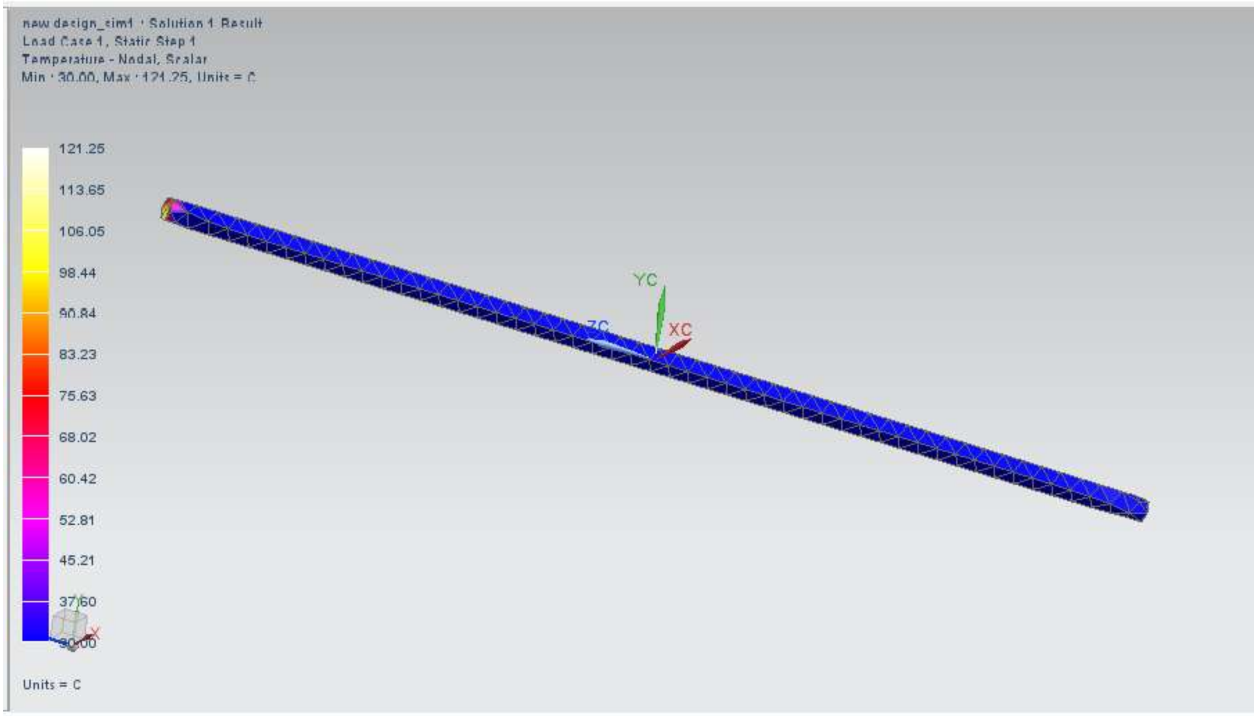

Figure 5.1 Fluid flow analysis

Heat transfer rate increase 50-70% compare to water. Simultaneously adding 0.5% volume fraction of Graphene in water heat transfer rate is increased. There is an increase of about 50-70% in heat transfer rate in automobile radiator compare to use water as coolant. Table 4 shows the comparison of area previous and optimized radiator

Table 5.1 Comparison of area

Heat transfer rate Q [kw]	Area m²		
	Previous radiator	Optimized radiator	
		15% Graphene	50% Graphene
12.652	1.871	1.333	0.723

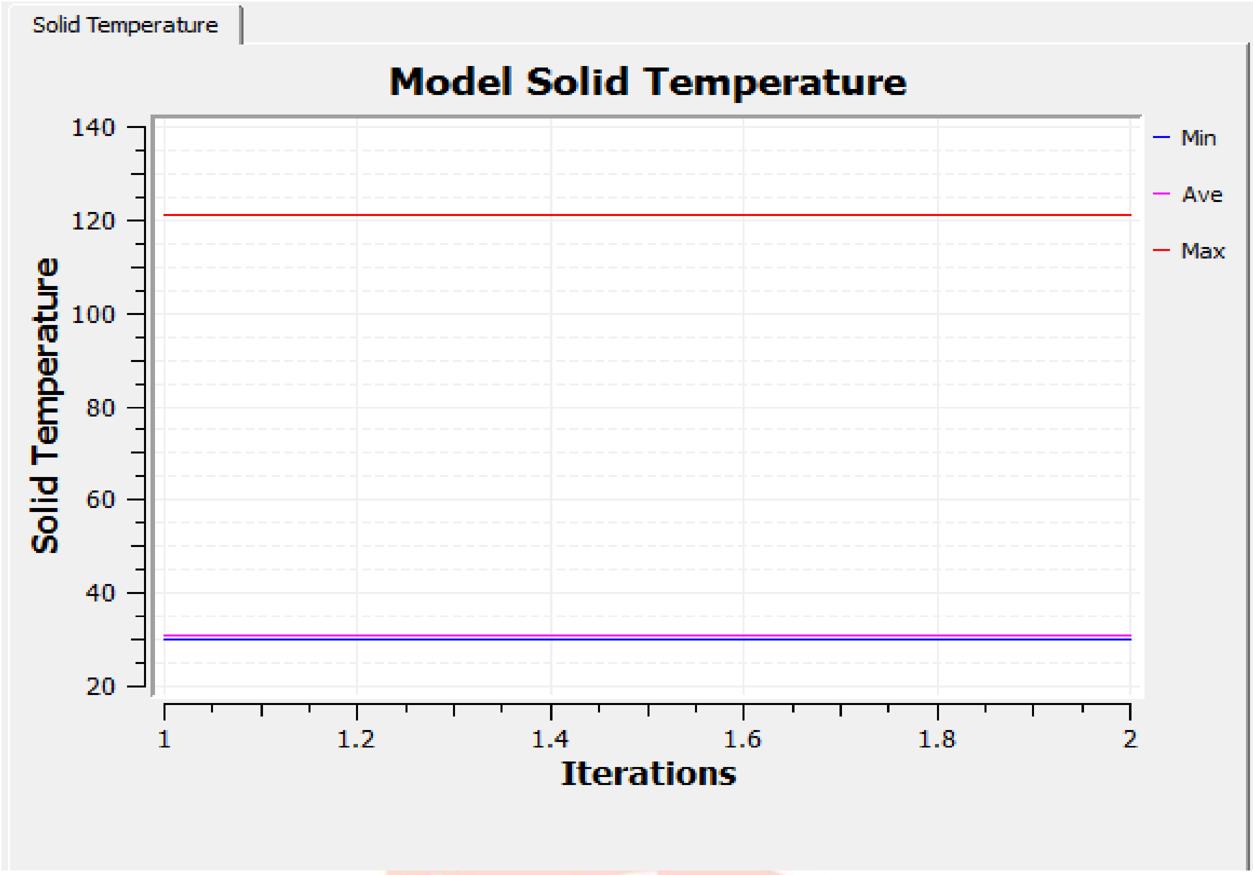

Figure 5.2 Model solid temperature

Iterations	Solid Temperature ˚C	
	Maximun	Minimum
1	121	30
1.2	121	30
1.4	121	30
1.6	121	30
1.8	121	30
2	121	30

From the above graphs shows using Graphene /water nanofluid as a coolant and optimum performance of radiator can be performed. For each iteration, experiments are conducted for one complete cycle of solid temperature. The results show that the nanofluids have large thermal conductivity than the original base fluids.

VI. CONCLUSION

This paper presents an experimental analysis of the graphene nanofluids as coolant in vehicle engine cooling system. Heat transfer rate and effectiveness is increased with increase in volume concentration of nanoparticles (ranging from 0 to 0.5). About 61% heat transfer enhancement and effectiveness were achieved with addition of Graphene particles at Reynolds number and constant mass flow rate (0.345Kg/s).Thermal performance of a radiator using nanofluids + water (50 Volume concentrations) coolant is increased with air Reynolds Number. About 50- 70 % increment in the total heat transfer and overall heat transfer coefficient based on the air side at constant mass flow rate (0.345 Kg/s) and variable Reynolds number. Thermal Conductivity increased by 61.05 % with increase in the volume concentration of Graphene particles in Base Fluid.

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