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Enhancement in heat transfer rate in diesel engine radiator using nano fluid

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ABSTRACT

A high efficiency engine is based on its performance and also based on better fuel economy and less emission. By optimizing design and size of a radiator thereby reducing a vehicle Weight is a necessity for making the world green. There are several different approaches and any one of these can be taken to optimize the heat transfer performance of radiator design, include by changing the fluid. Conventional coolant fluids have inherently low thermal conductivity that greatly limits the heat exchange efficiency. In last 10 years Nano fluids have emerged as a promising substitute for conventional engine coolants. A rigorous study is going on this field for improving engine performance. The aim of the presentct work is study the methods available in the literature to enhance heat transfer rate in diesel engine radiator using Nano Fluid and suggest a novel methodology to increase it further.

Keywords: Nano fluid, Radiator, Thermal Conductivity, SiO2.

INTRODUCTION

Thermal fluid systems have number of applications including automotive cooling system. A coolant is a fluid which flows through engine and prevents it from overheating. Base fluids like water, ethylene glycol, and glycerol are known as conventional coolants and used in automobile radiator for many years. These fluids have low thermal conductivity which prompted the research to search for the fluids with higher thermal conductivities than conventional coolants.

In earlier investigations dispersion of millimeter or micrometer size particles into base fluid causes particle agglomeration and settling and their pumping power is increased. This leads to investigation on Nano Fluid. The concept of Nano Fluid was proposed by Choi. Nano fluid contains nanometer- sized particles, called nanoparticles. These fluids are suspensions of nanoparticles in a base fluid. The nanoparticles of Nano fluids are typically made of metals, carbides, oxides or carbon nanotubes. Common base fluids used are water and ethylene glycol. Nano fluid exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. They have micro channel cooling without clogging and also reduce the pumping power.

REVIEW OF LITERATURE

Most of the literature studies available on enhancement in heat transfer rate have been carried out experimentally, by using different types of Nano fluids like CuO,Al2O3,SiO2,TiO2 etc. With

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water or ethylene glycol as base fluid. Enhancement of heat transfer rate has been studied under different conditions like by varying load on engine, at different volume concentration of Nano fluid, for different flow rate of Nano fluid, for different types of flow like laminar or turbulent, for different particle size of Nano fluid. The results were analyzed using CFD.

A numerical study presented by Vajjha et al. on laminar heat transfer using CuO and AL_2O_3-thylene glycol and water inside a flat tube of a car radiator.

Naraki ET AL [7] investigated overall heat transfer coefficient experimentally for laminar regime. The results showed that overall heat transfer increases with enhancement in the Nano fluid concentration from 0 to 0.4%.

Adnan M. Husse, R.A. Bakar, K. Kadirgama [1] Studied "forced convection Nano fluid heat transfer in the automotive cooling system. The result reveled that application of SiO_2 Nano fluid with low concentration enhance heat transfer rate up to 50% as comparison with pure water. The simulation results with experimental data shows good agreement.

Jaafar Albadr, Satinder Tayal, Mushtaq Alasadi [2] in "Elsevier"–case studies in thermal engineering studied "Heat transfer through heat exchanger using Al_2O_3 nano fluid at different concentrations. The results shows increase in heat transfer coefficient with increase in volume concentration as well as mass flow rate but at the same time friction factor also increases.

"B. Kirubadurai "et al: [4] In his paper shows varying factor affecting the thermal conductivity of Nano fluid at different conditions. They tried to increase the heat transfer rate by considering thermal conductivity Nano fluid. Thermal conductivity is increased with increasing concentration of metal particle within critical limit.

Thermal conductivity is affected by various parameters like shape, size, clustering, collision, melting point of nanoparticles etc. Controlling this type of parameters to increase the thermal conductivity of nano fluid.

S.M. Peyghambarzadeh, S.H. Hashemabadi, M. SeifiJamnani, S.M. Hoseini, [6] "Improving the cooling performance of automobile radiator with Al_2O_3/water nano fluid". In this paper, forced convective heat transfer rate with Nano fluid increases with increasing fluid circulating rate in comparison with pure water.

"Sidi El BecayeMaiga , Samy Joseph Palm , Cong Tam Nguyen ,Gilles Roy , Nicolas Galanis [5] "Heat transfer enhancement by using nanofluids in forced convection flows.

They investigated the laminar convective heat transfer for two Nano fluid water- Al_2O_3, Ethylene Glycol- Al_2O_3. Among the two mixtures Ethylene Glycol- Al_2O_3 has better heat transfer enhancement than that of water.

Somchaiwongwises et al: [11] Investigated heat transfer enhancement and flow characteristic of Al_2O_3-Water Nano fluid using micro channel heat sink. The test section dimension was 5x5mm and 50W heat was applied. Heat transfer enhanced at high Reynolds number and high concentration of Nano fluid, because at high Reynolds number wall temperature decreases and pressure drop was increased.

Shuichi Torri: [9] Investigated convective heat transfer coefficient of diamond based Nano fluid by using heat tube apparatus. Tube Specification is 4.3mm outer and 4mm inner diameter and 100W power applied uniformly. The heat transfer coefficient is increases with increasing concentration and Reynolds number of Nano fluid. But at the same time increased the pressure drop with increasing concentration of Nano particle.

Anil Kumar et al:[10] studied the heat transfer enhancement of fin, utilizing AL_2O_3 -Water Nano fluid analyzed using CFD. Rayleigh number increases due to Brownian motion, ballistic phonon transport, clustering and dispersion effect of nanoparticle. At high Rayleigh number flow rate at Centre of the circulation is increasing, so temperature is drop from center of fin. Volume of the circulation increases the velocity at center is increases as the result of increasing the solid-fluid heat transportation. Low aspect ratio fin is suitable for heat transfer enhancement, because heat affected zone is less.

Mohamed hadi et al: In this paper enhancement of heat transfer rate by considering clustering effect of nanoparticle has been studied. The heat transfer rate is increases with increasing the concentration of

nanoparticle, but due to high concentration clustering is occur. Clustering increased the heat transfer rate of Nano fluid at certain contact time of particle, but cluster causes the problem of agglomeration. Agglomeration can reduce to use micro sized particle.

Ravi Adwani et al. [3] Experimentally investigated heat transfer rate in Automobile Radiator using Nano Fluid. It is observed that the heat transfer rate increases with increase in volume fraction of Al2O3 in water at constant flow rate. When volume fraction increases beyond 6%, the nanoparticles were settled at the bottom.

As per cited papers it is observed that if the concentration of fluid increases beyond certain volume fraction heat transfer rate increases, however it becomes difficult to prevent settling of Nanoparticles at such high concentration. In this paper we are trying to reduce the settling problem of Nano particles (Al2O3) by providing stirring mechanism. Further details are explained in following article by providing adequate data.

IMPORTANT FORMULAE

According to Newton's law of cooling heat transfer coefficient and corresponding Nu number can be calculated as [1]

$Q = h A \Delta T = h As (Tb-Ts)$ (1)

As is the surface area of the tube , Tb is the bulk temperature,

$Tb = (Tin + Tout) / 2$ (2)

Tin and Tout are inlet and outlet temperatures respectively and Ts is the tube wall temperature which is the mean value by two surface thermocouples as

$Ts = (T1 + ……..+Tn) / n$ (3) And heat transfer rate calculated by

$Q = m C \Delta T = m C (Tin – Tout)$ (4) m is mass flow rate which is determined as

$m = \rho V$ (5)

The heat transfer coefficient can be evaluated by combining eqs. (1) and (4)

$hexp = m C (Tin – Tout) / As (Tb – Ts)$ (6) and the Nusselt number can be calculated as

$Nu = hexp Dh / k$ (7) Dh is the hydraulic diameter

$Dh = 4\times$ Area / perimeter. (8) Reynolds number (Re) is determined as

$ReD = \rho nf Dh u / \mu nf$ (9)

THERMO PHYSICAL PROPERTIES OF NANO FLUID

Some important themo-physical properties of Nano fluid on which heat transfer coefficient of Nano particle depends are given below [8]

A. Specific heat of Nano fluid is define as
$Cpnf = \Phi\ \rho p\ Cpp + (1-\Phi)\ \rho bf\ Cpbf / \rho nf$

B. Density of Nano fluid is define as $\rho nf = \Phi\ \rho p + (1-\Phi)\ \rho bf$

C. Viscosity at room temperature is calculated by using following relation
$\mu nf = \mu bf\ (1+39.11\Phi+533.9\Phi^2)$

D. Thermal conductivity of Nano fluid for Al2O3 + Water is developed by
$Knf / Kbf = Renf^{0.175}\Phi^{0.5}(Kb / Kbf)^{0.232}$

EXPERIMENTAL REVIEW ON CAR RADIATOR

Table.1

Autho r	Nano Particle	Working Conditions	Result/Conclusion
Adan Hussein	SiO_2	Four different Concenration1- 2.5%	1. Heat transfer rate increases with concentration. 2. Fricition Factor increases.
		Flow rate 2 to 8 lpm	1. Heat transfer rate increases with increase in flow rate.

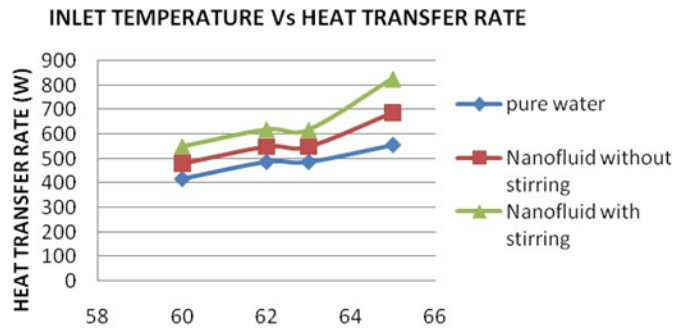
		Reynolds number 500- 1750	Friction factor decreases with increase in flow rate.
		Inlet temperature	Nusselt number increases.
S.M. Hoseini	Al_2O_3 + Water	Concentration	Heat transfer rate increases with increase in volume concentration.
		Flow rate	With increase in flow rate heat transfer increases.
M. Naraki,	CuO /Water	Concentration 0- 0.4%	Overall heat transfer coefficient increases with Increase in
		Inlet temperature 50- 80˚C	Heat transfer rate decreases with increase in inlet temperature.
Ravi Adwani	Al_2O_3	Concentration 2%,4%,6%	With increase Concentration heat transfer increases.
		Different Load Condition	With increase in load heat transfer increases.

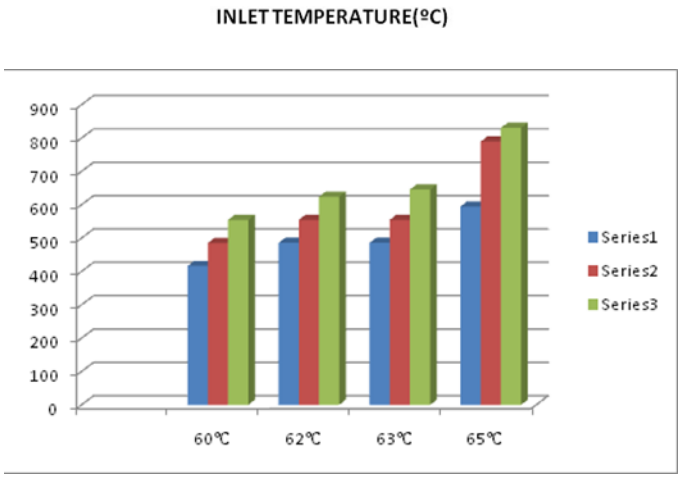
			Nano particle CuO, Fe_2O_3	Fe_2O_3 has high heat transfer capacity
			Concentration	Heat trans.fer rate increases with increase in concentration.
Peyghamba-rzadeh	CuO	And Fe_2O_3	Inlet temperature	With increase in inlet temperature heat transfer decreases.
			Air velocity	With increase in air velocity heat transfer rate increases.
			Flow rate	Heat transfer rate increases with flow rate.

RESULT & CONCLUSION

- Heat transfer fluids used in radiators have inherently low thermal conductivity and redesigning heat exchangers to increase radiators effectiveness limits.
- Nano-fluids can be employed to system requiring rapid heating and cooling. Due to nano-size the powder is considered as the integral fluid.
- Lot of changes occurs in the properties of working fluid in radiator due to inserting Nano particles. Heat transfer increases due to large surface area of Nano particles in Nano fluids.
- Heat transfer rate increases of Nano fluid is affected by number of parameters like volume concentration, flow rate, Inlet temperature specific heat capacity of Nano particle, Density, viscosity, thermal conductivity , Size and Shape of Nano particle.
- Heat transfer rate increases with increase in concentration and flow rate but decreases with increase in inlet temperature.
- Clustering and collision of nanoparticles is main factor to affect the heat transfer rate of Nano fluid.
- Due to limitations on addition of Nano particles in base fluid beyond certain limit [3] a specific need arises of using novel methodology like stirring mechanism for reducing particle settlement problem.

- The convective heat transfer performance of SiO_2 Nano fluid flowing on diesel engine radiator has been experimentally investigated. Experiments have been carried out under turbulent conditions. The effect of particle concentration and inlet temperature has been determined. Comparison of heat transfer in water and in Nano fluid without stirring action and with stirring action is done from readings by plotting Graph.





Graph showing enhancement in Heat transfer

FUTURE OBJECTIVE

The present system has some limitations.

- To enhance the heat transfer through the diesel engine radiator using Nano fluids.
- The objective is orientated towards experimentation on Diesel Engines radiator using water based SiO_2 Nano fluid as coolant.
- The main objective of this project is to arrive at optimal mix of Nano fluids into the base (Water) coolant and trying to reduce the settling problem of Nano particles by providing stirring mechanism.

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