International Journal of Engineering Research & Management Technology

ISSN: 2348-4039

November- December 2023 Volume 10, Issue-6

Email: editor@ijermt.org www.ijermt.org

UTILIZING NANOFLUID FOR EXPERIMENTAL STUDY OF CONVECTIVE HEAT TRANSFER IN RADIATOR

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Abstract: -

Nowadays, automakers are constantly striving to innovate in new ways, and one such area is the vehicle radiator. Research shows that as compared to conventional coolants, nano fluids have superior heat conductivity. Utilizing those Nano fluids in a car radiator will break down various heat exchange effects. Heat exchangers play a crucial role in the maintenance, transformation, and recovery of vitality. Numerous studies have focused on direct exchange type heat exchangers, in which heat exchange between liquids occurs transiently into and out of a divider or through an isolating divider. A heat exchanger has two essential wonders: the flow of liquids through channels and the exchange of heat between liquids and channel dividers. Improvements to warm exchangers can therefore be achieved by strengthening the processes taking on inside those units. Conversely, nanofluids exhibit far superior heat transfer properties than traditional heat-transfer liquids. The term "nanofluids" refers to specially formulated liquids that include suspended nanoparticles with a typical size of less than 100 nm in common heat-exchange liquids, such as water, oil, and ethylene glycol. Various nanomaterials are being developed for the construction industry. Nanomaterials are the genuine deal in the designing industry these days. Numerous current studies concentrate on nano fluid used in warmth exchange applications that incorporate a variety of nanoparticles with varying sizes and volume fixations. In addition to being naturally appealing, nano liquid provides superior performance compared to current liquids. A colloidal mixture of nano-measured particles in a base liquid is called nano liquid, and its purpose is to enhance the properties of heat exchange suitable for practical use.

Keywords: *Nanofluid, Friction factor, Nusselt number Turbulent Convective Heat Transfer, Car radiator*

I. Introduction

Day today the people's needs own automotive vehicle to make their work faster and simpler. So by seeing the increasing demand of vehicle, automotive industries continuously doing development for makinghigh efficient and economical engines which consumes less fuel to attract the customers. There are various waysto increase the efficiency of engine like by using optimized design of engine which reduce the weight of automotive and efficient engine cooling system which will increase the performance of vehicle. Use of optimized designed fins and micro size tube is most conventional way to increase the performance of radiator is now reached to its limit. Another way of enhance the cooling effect is use of efficient coolant in the vehicle radiator. As conventional coolant is the mixture of water and ethylene glycol as anti-freeze agent to increase the boiling point and reduce the freezing point of water. By adding the anti-freeze in water make it possible to use water for wide range of temperature but for that we have to compromise the heat transfer performance of the radiator as the heat capacity of mixture is less that of water. Solid particles having size less than 100 nm has different thermal properties than the conventional solid particles. As nanometer size particles has large surface area as compare to micro size powder which enhance heat transfer rate. Choi proposed the concept of adding thenanometer sized solid particles in conventional heat transfer fluid and by preparing stable fluid can enhance the heat transfer characteristics which he named as Nano fluids at Argonne National Laboratory of USA. Enhancement in thermal properties is depends on the method of preparation, particle size, type of particle etc. Now a day's researchers also start investigating the potential in hybrid Nano fluid to get more benefit in heat transfer rate. Che Sidikhas discussed the challenges to preparation of stable hybrid Nanofluid and enhancement in the thermal properties. Subhedar and Ramani [also observed that thermal conductivity of Nanofluid is increases linearly as the volume concentration is increases, with 0.8% volume fraction of Al_2O_3 nanoparticlesof size 20 nm in water/MEG base fluid 8.5% enhancement in thermal conductivity is observed.

Nomenclature

K	Thermal Conductivity, W/m-K
Cp	Specific heat J/kg-K
Q	Heat transfer by coolant, Watt
Re	Reynolds number
Nu	Nusselt number
m	Mass flow rate of coolant kg/s
T	Temperature, K
Dh	Hydraulic diameter, m
H	Convective heat transfer coefficient, W/m2 K
As	Surface Area of coolant tube, m2
Pr	Prandtl number
L	Tube length, m
Pe	Peclet number
EG	Ethylene Glycol
MEG	Mono-Ethylene Glycol

Greek Letter

μ	Viscosity, Pa-s
ρ	Density, kg/m3
φ	Volume fraction of nanoparticles Subscripts
bf	Base fluid
nf	Nanofluid
P	Nanoparticle

Research Gap:-

The conventional fluids (water and EG) have been used as a coolant in the automotive cooling system. However, the limited thermo-physical properties of these fluids limit heat transfer across the car radiator. The increasing demand for energy and better performance has led to the investigation of other methods. Space constraints are another key issue in the automotive cooling system. Sometimes overheating occurs in the engine because the radiator is not functioning up to the standard expectations.

Problem Statement:-

Issue Statement Improve heat exchange limit of Radiator. Nanofluids in vehicle radiator will expand heat exchange of the motor. The execution correlation will be made between unadulterated water or ethylene glycol and Nanofluids tried in an car radiator. Finally the proposals are made and ends are drawn dependent on the improved execution of Nanofluids in a car radiator.

II. Methodology:-

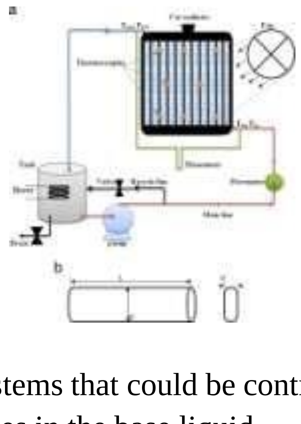
We will utilize Maruti 800 CC or Indica Vista Radiator what's more, will utilize CuO Nano liquid as a coolant. The Nano liquid will be set up by two stage technique or one stage technique. Nano

liquid is set up by blending Nanoparticles in water in various sytheses. Later exhibitions of the Radiator are tried with water, ethylene glycol and CuO as coolant. Examination will be made between coolant stream rates and temperature distinction, coolant stream rates and normal warmth exchange, coolant stream rates and viability, time and temperature distinction, time and normal warmth exchange. Motor Nano-coolant is a coolant in which particles of nanometer measurements are blended. The planning of Nanocoolant is a vital angle to accomplish uniform and stable suspension. In the present examine, CuO is utilized as a nanoparticle and motor coolant
(ethylene glycol: water, 40: 60) as a base liquid**.**

Experimental Setup: -

To investigate the heat transfer potential of Nano fluids as Car radiator coolant the test rig is developed This test rig contains the coolant storage tank, coolant heating element, centrifugal pump, flow measuringinstrument, piping network, ball valve to bypass the flow, needle valve to provide precision to flow stability,Pressure transducer to record the inlet and outlet pressure of coolant in radiator, resistance temperature detector to record inlet and outlet temperature of coolant in radiator, anemometer to record velocity of air, J- thermocouples to note down the surface temperature of radiator tube and flow lines. The Radiator was installed inside the air flow duct. The specifications of the radiator used for the research is mentioned.
Coolant passes through the 36 vertical tubes of Radiator. For cooling the coolant, 24″ Axial flow fan is used which has capacity to produce flow with 6500 CFM. Dimmer is used to vary the air flow. Fan is installed at the beginning of the test section duct in such a way that the air and coolant flow have indirect cross flow contact anddue to that the heat exchange takes place between hot coolant flowing in the vertical tubes and air passing over the tubes.

The inlet air temperature was about 34 °C + − 0.1 °C in the complete research. The centrifugal thermic pump is used which gives a constant flow rate of 0.9 m3 /h, to vary the flow rate globe valve is used. In the test rig the coolant is stored in the storage tank of volume 33 l (36.83 cm × 31.75 cm × 28.48 cm) and heated withthe electric heater (two immersion rod heater of capacity 3000 W each) fixed inside the reservoir. The controlleris used to maintain the temperature between 40 °C to 90 °C. The coolant is filled 25–30% of the tank volume so the total volume of the circulating



Preparation Of Nanofluids:-

There are clarified three systems that could be controlled while planning nano liquid.
(1) Proper scattering of nano particles in the base liquid.
(2) Control of pH esteem.
(3) Addition of surface activators to maintain a strategic distance from sedimentation there by strength of the colloidal blend can be accomplished. Scatter the nano molecule in base liquid was accomplished by ultrasonic vibration subsequent to including surface activators. Nanophase Technologies

Corporation was delivered nano particles utilizing vapor union technique. A Nano molecule free agglomerates and moves toward becoming micrometer measured particles as appeared in figure

1. Anyway they can be scattered in the liquids effectively which brings about breaking of the agglomerates to some degree giving particles of nanometer run. The particles of the nanopowder demonstrate a lognormal estimate appropriation. The size dispersion of run of the mill test is appeared in figure

2. The normal estimation of molecule distance across for Al2O3 was 38.4mm and for CuO was 28.6mm by volume weighted methodology. Complete scattering of nano particles in the base liquid can be affirmed by review littler nano particles after scattering.

NANOMATERIAl	K(W/MK)	TEMPERATURE(0C)
1. Water	0.61	250C
2. Ethylene glycol(EG)	0.26	250C
3. Al2O3	35	250C
4. CuO	20	250C
5. ZrO2	2	250C
6. SiO2	1.4	250C
7. Fe3O4	9.7	250C
9. Ag	429	250C
10. Al	237	250C
11. Fe	80.2	250 C
12. Carbon nanotubes	2000	250C
13. Diamond	600	250 C

Legitimate scattering was accomplished by

(1) First blending nano powder with refined water.

(2) Using ultrasonic vibration until legitimate scattering is gotten. The volume of the strong blended with thebase liquid was dictated by

(1) Considering genuine thickness to discover proportional load of the strong

(2) That weight was utilized to made the suspension.

(3) Then ultrasonic vibration was allowed for 12 hours to get total scattering. For about next 12 hours no sedimentation was watched and from that point it was demonstrated that no sedimentation was watched for 1% and 2% volume suspensions. In any case, minor sedimentation was seen on account of 3% and 4% volume suspensions. Be that as it may, in handy applications it is beyond the realm of imagination to expect to balance out the particles with no third operator like oleic corrosive or laurate salts. Be that as it may indeed, even the warm conductivity of the base liquid might be affected because of the expansion of third operator. Yet, the creators have directed explore different avenues regarding in 1.5 to 2 hours with no sedimentation without including any third specialist. They have assessed the warm conductivity depends on vitality condition for conduction is given by.

The experiment was conducted on Al2O3 and CuO nano particles with water as base fluid at various particle volume concentrations. Room temperature was maintained throughout the experiment and the result is represented in figure 3. Subsequently the temperature was altered with different particle concentration of Al2O3-water and CuO-water nano fluids. Comparison was made for 1% and 4% volume concentrations. But only about 2% enhancement was observed at 210C with 1% particle concentration but at 510C the enhancement value was increased about 10.8%. They concluded that the heat transfer depends on the addition of nano particles.When temperature increases from room temperature the dynamic viscosity of a base fluid is decreased and Brownian motion of nano particles is increased. The nano convection term is increased resulting from the above two facts and also decreasing of nano particles size which increases Brownian motion. Due to these factors the effectiveness of the thermal conductivity is high.

The heat transfer characteristics such as convective heat transfer coefficient, effectiveness LMTD and pressure drop were studied under the influence of mass flow rate, inlet temperature and volume concentration of the nano particles. Xuan and Roetze calculated viscosity of nano fluid by using Einstein's equation.

$(\mu nf)/(\mu w)= (1.005+0.497\varphi-0.1149\varphi 2)$ (2)

It has calculated the thermal conductivity and density as follows:-

$= (0.9692\varphi+0.9508)$ (3)

$\rho nf = \varphi \rho p+(1-\varphi)\rho w$ (4) $\mu nf =$
$(1+2.5\varphi)\mu w$ (5)

$(\rho cp)nf = \varphi(\rho cp)p +(1-\varphi)(\rho cp)w$

The experimental Nusselt number values were compared with the predicted Nusselt number Dittus- Boeltercorrelation shown in figure 4 and deviation of 9.2% was observed which confirms the experimental test facility. The exit temperature of the hot fluid coming out from the heat exchanger increases as the mass flow rate increases and the exit temperature inversely decreases with the increase in the particle volume concentration. The authors also has observed the following

(1) Nusselt number increases with the increase in particle concentration.

(2)Logarithmic Mean Temperature Difference (LMTD) decreases as the volume concentration and Reynolds numberincreases.

(3) The overall heat transfer coefficient is found to be increased when silver nano particle concentration varies upto 0.04%.

(4) Pressure drop also found increases along with heat transfer characteristics when volume concentration of silver nano particle increases. And also higher pressure drop was found in silver nano fluid when compared to that of pure water. More pumping power is required to compensate pressure drop which leads to poor efficiency of the system.

Classical problem in fluid mechanics was analysed by who have used similarity transformation to reduce the Navier-strokes equations governing the flow into an third order ordinary differential equation and non-linear equations were treated numerically using boundary conditions. The heat transfer is very important in many engineering applications such as condenser, evaporator, solar radiation, design of bearings, radial diffuser etc, involves boundary layer flow. Massoudi esolved heat transfer in stagnation point flow of non-Newtonian fluid. But it can be used only for the small values of the parameter to determine the behaviour of non-Newtonianfluid. And also in their later researc a new solution was found for all values of non-Newtonian fluid usingPseudo-similarity solution by computing flow characteristics numerically.We studied the heat transfer of incompressible two dimensional, non-Newtonian, stagnation point flow through a porous medium under laminarflow. It was found that porosity in the porous medium increases the wall shear stress there by heat transfer is increased.Due to solar energy the thermal stratification over a porous wedge sheet of unsteady state Hiemenz flow of copper nano fluid was studied by using Lie group transformation. Temperature variation due to radiationdepends on angle of inclination of porous wedge. The buoyancy force due to thermal diffusion decreases by a factor of cos Ω/2 as the angle of inclination increases, where Ω is angle of inclination of wedge. When the angle of inclination increases it affects the fluid flow thereby the temperature absorption is more as the density of nanofluid is higher than the pure water. The unsteady parameter directly influence the Prandtl number within the boundary layer. As the velocity of the flow decreases the nanofluid temperature increases with increase of unsteady parameter. As the porous medium contains porosity which increases the fluid resistance thereby velocity of the flow is abruptly reduced imitations of using nano fluid.

III. Theoretical Analysis

PHYSICAL MODEL

It shows the automobile radiator used in this study, which consists of a flat tube with a length (L=500mm) and hydraulic diameter (Dh=4.5 mm).

The Reynolds number was calculated based on the hydraulic diameter (Dh):

$D_h = 4 \times \frac{Area}{Perimeter}$

$D = 4 \times [\pi d + (D-d) \times d] \,/\, [\Pi \times d + 2 \times (D - d)]$

Reynolds number (Re) is determined as:

$Re_d = \frac{\rho \times D \times u}{\mu}$

A few suppositions were made on the working states of the car cooling framework, Enduring state, incompressible and Newtonian violent liquid streams with consistent thermophysical properties of the nanofluidaccepted. Also, heat conduction in the hub course and divider thickness of the cylinders was disregarded.

System and Components:

1. **Radiator:-**

The shell & tube heat exchanger was the component that we found hard time providing. After long search we found the smallest industrial use shell & tube heat exchanger of stainless steel type 100 L, 158 mm long consisting of 37 tubes. The tube diameter is 2.2 mm with a tube wall thickness of 0.19 mm, and area of 0.05 m2 as shown in figure

2. **Plumping System: -**

The flow loops are two thermo-couples tubes with removable bulbs which are inserted onthe heat exchanger to measure the bulk temperatures of inlet and outlet fluid streams. Suction pipe 1 inch. The pipes are used with maximum capacity 44 (L/min), and total heat head max 38 (m) as illustrated in the figure.

3. **Water Pump:-**

The pump we used was purchased locally, and its specifications as shown in table.and figure outperforms the other available pumps. The pump as illustrated in figure was also reasonable for its performance and its quality. The pumps we used before either broke down orcouldn't give us the required pumping power.

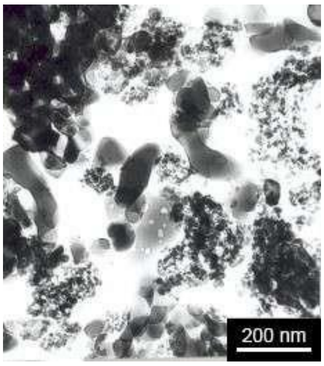
4. Fan:-

A 220V fan has been used as shown in fig and air flow power is approximately 116.7 m/min to enhance morepower to cool down water inside the radiator. And for more specifications and features, shown in table.

Our instrument included several gauges namely: temperature controller "thermometer" shown in figure(3.13) and pressure gauges' figure. The availability and the reading ranges of the instruments were all selected based on the specific specifications.

5. Fluid:-

Aluminum Oxide (Al2O3) Nano powder / Nanoparticles Dispersion (Al2O3 Nanoparticles Aqueous Dispersion,Alpha, 20wt%, 30nm) "120ml/120g".



Copper Nanoparticles / Nano powder (Cu Nanoparticles with 5.2wt% Cu2O coated, 30 nm) "100g".

Working Principle: -

This exploratory setup contains a plastic store tank, an electric radiator, an outward siphon, a streammeter, tubes, valves, a fan, a DC control supply, ten K-type thermocouples for temperature estimation, and awarmth exchanger (car radiator). An electric warmer (2000W) is kept inside a plastic stockpiling tank (40 cmtallness and 30 cm distance across) speaks to the motor and to warm the liquid. A voltage controller (0– 220 V)gave the ability to control the temperature in the radiator (60– 80 °C). A stream meter (0– 70 LPM) and twovalves measure and control the stream rate. The liquid stream was estimated through plastic cylinders (0.5 in.)by an outward siphon (0.5 hp and 3 m head) from the tank to the radiator at the stream rate scope of 2– 8 LPM.The absolute volume of the flowing liquid (3 l) was consistent in every exploratory advance. Two T- typethermocouples (copper– constantan) were associated to the stream line to record gulf and outlet temperatures of liquid. Eight T-type thermocouples additionally associated with the radiator surface for the surface regionestimation. Due to the little thickness and high warm conductivity of the copper level cylinders, the inward and

external surfaces of the tube are equivalent temperature. A hand-held (−40 °C to 1000 °C) advanced thermometer with the precision of±0.1% was used to peruse every one of the temperatures from thermocouples. Adjustment of thermocouples and thermometers was completed utilizing a consistent temperature water shower,and their exactness was evaluated to be 0.15 °C. Two little plastic cylinders with a 0.25-inch breadth wereassociated at the bay and outlet of the radiator and joined to U-tube mercury manometer with precisely scaled0.5mmHg to measure the weight drop at the bay and outlet. The vehicle radiator has louvered blades and 32level vertical copper tubes with a level cross-sectional zone. The separation between the tube columns wasloaded up with meager opposite copper blades. For the Air side, a pivotal power fan (1500 rpm) was introducedclose on pivot line of the radiator. The DC control supply (type Teletron10– 12 V) was utilized rather than avehicle battery to turn the pivotal fan. (0.5 In.) By a radial siphon (0.5 hp and 3 m head) from the tank to the radiator at the stream rate scope of 2– 8 LPM. The all out volume of the coursing liquid (3 l) was steady in all trial steps. Two T-type thermocouples (copper– constantan) were associated with the stream line to record channel and outlet temperatures of liquid. Eight T-type thermocouples moreover associated with the radiator surface for the surface zone estimation. Because of the little thickness and high warm conductivity of the copper level cylinders, the internal also, external surfaces of the cylinder are equivalent temperature. A hand-held (−40
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hub fan.

IV. Conclusion

From the above graph following conclusions are drawn

1) With decrease in mass flow rate, temperature difference between inlet and outlet temperature of coolantincreases. In the graph Nano fluid is having more temperature rejection.

2) With increase in time in min, temperature difference between inlet and outlet temperature of coolantincreases. In the graph Nano fluid is having good temperature rejection.

3) With decrease in mass flow rate, average heat transfer rate of coolant increases. In the graph Nano fluid ishaving better average heat transfer rate as compared to water and water + ethylene glycol.

4) With below in mass flow rate, effectiveness of coolant is improved. In the graph Nano fluid is having bettereffectiveness as compared to water and water + ethylene.

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