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Enhancing the Performance of Radiator by Using Nano Fluids

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ABSTRACT: -The radiator is the most important element of the cooling system and has the critical function of reducing temperature of the passing coolant. The “cooled” coolant continues recirculating throughout the engine, removing heat waste. The coolant carrying the heat waste from the engine moves into the radiator core via the inlet hose. The function of the radiator is to transfer heat from the hot water flowing through the radiator tubes to the air flowing through the closely spaced thin plates outside attached to the tubes.A radiator consists of an upper tank, core & the lower (Collector) tank. Coolant from the engine enters the radiator at the top & is cooled by the cross flow of the air, while flowing down the radiator. The coolant collects in the collector tank from where it is pumped to the engine for cooling.In this study mixture of water and ethylene glycol coolants has been widely used in an automobile radiator for many years. These heat transfer fluids offer lower thermal conductivity. The nanotechnology of the new generation of heat transfer fluids called, "Nano fluids". Nano fluids are higher thermal conductivity as compared to conventional fluids. This review paper focus on the various research papers to improve automobile radiator efficiency. Heat transfer performance of car radiator is enhanced by using Nano fluids. An effect of different volumetric concentration of the Nano fluids in heat transfer rate is investigated experimentally.

I. INTROUDUCTION: -

Introduction to heat exchanger In waste Heat: Refrigeration of gas turbine Heat exchanger is a device which transfers the energy from a hot fluid medium to a cold fluid medium with maximum rate, minimum investment and low running costs. In the 1950s, aluminum heat exchangers made moderate inroad in the automobile industry with the invention of the vacuum brazing technique, large scale production of aluminum-based heat exchangers began to raise and grow resulting from advantages of the controlled atmosphere brazing process (Nicol brazing process introduced by ALCAN). With increasing year’s introduction of “long life” (highly corrosion resistant) alloys further improved performance characteristics of aluminum heat exchangers. In a heat exchanger, the temperature of fluid keeps on changing as it passes through the tubes and also the temperature of the dividing wall located between the fluids varies along the length of heat exchanger.

1. Examples:

*Boilers, super heaters, reheaters, air preheaters.
*Radiators of an automobile.
*Oil coolers of heat engine.
*power plant.

Recovery system

Types: 1: direct contact type of heat exchanger
2.non-contact type of heat exchanger
Direction of motion of fluid:
1.Parallel flow
2.Counter flow
3.Mixed flow

1.1 radiators : radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engine for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycle ,radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engine for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycles, stationary generating plant or any similar use of such an engine.Ic engines are often cooled by circulating a liquid called engine coolant through the engine block, where it is heated, then through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant tocirculate, and also for an axial fan to force air through the radiator. In automobiles and motorcycles with a liquid-cooled internal combustion engine, a radiator is connected to channels running through the engine and cylinder head, through which a liquid (coolant) is pumped. This liquid may be water (in climates where water is unlikely to freeze), but is more commonly a mixture of water and antifreeze in proportions appropriate to the climate. Antifreeze itself is usually ethylene glycol or propylene glycol (with a small amount of corrosion inhibitor). The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. Radiators are also often used to cool automatic transmission fluids, air conditioner refrigerant, intake air, and sometimes to cool motor oil or power steering fluid. Radiators are typically mounted in a position where they receive airflow from the forward movement of the vehicle, such as behind a front grill. Most modern cars use aluminum radiators. These radiators are made by brazing thin aluminum fins to flattenedaluminum tubes. The coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator. The tubes sometimes have a type of fin inserted into them called a turbulator, which increases the turbulence of the fluid flowing through the tubes. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So, if the fluid that is in contact with the tube cools down quickly, less heat will be transferred. By creating turbulence inside the tube, all of the fluid mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Radiators usually have a tank on each side, and inside the tank is a transmission cooler. The transmission cooler is like a radiator within a radiator, except instead of exchanging heat with the air, the oil exchanges heat with the coolant in the radiator. The radiator is the most important element of the cooling system and has the critical function of reducing temperature of the passing coolant.

*The function of the radiator is to transfer heat from the hot water flowing through the radiator tubes to the air flowing through the closely spaced thin plates outside attached to the tubes. A radiator consists of an upper tank, core & the lower (collector) tank. Coolant from the engine enters the radiator at the top & is cooled by the cross flow of the air, while flowing down the radiator. The coolant collects in the collector tank from where it is pumped to the engine for cooling.

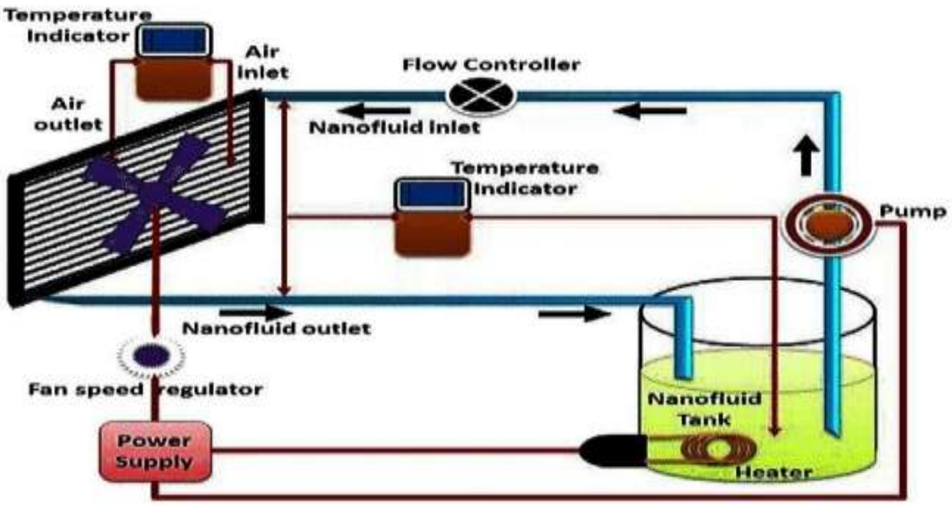
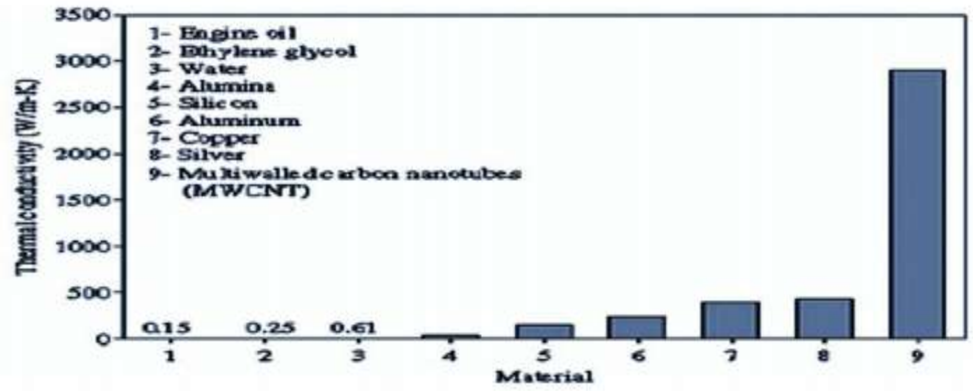


Figure 4.1 Schematic view and development rig.

diator is heat exchanger, in this case the fluids exchanging heat are on either e of dividing walls (in the form of pipes or tubes). These heat exchangers are used when two fluids cannot allow to mix i.e., the mixing is undesirable.

1.2 introduction to Nanofluids: - heat transfer fluids such as water, minerals oil and ethylene glycol play an important role in many industrial sectors including power generation, chemical production, airconditioning, transportation and microelectronics. The performance of these conventional heat transfer fluids is often limited by their low thermal conductivities. According to industrial needs of process intensification and device miniaturization, development of high-performanceheat transfer fluids has been a subject of numerous investigations in the past few decades. It is well known that at room temperature, metallic solids possess an order-of- magnitude higher thermal conductivity than fluids. For example, the thermal conductivity of copper at room temperature is about 700 times greater than that of water and about 3000 times greater than that of engine oil. Therefore, the thermal conductivities of fluids containing suspended solid metallic or non-metallic (metallic oxide) particles would be expected to be significantly higher than those of conventional heat transfer fluids. An inventive way of improving the heat transfer performance of common fluids is to suspend various types of small solid particles, such as metallic, non-metallic and polymeric particles, in conventional fluids to form colloidal. However, suspended particles of the order of mm oreven mmmay cause some problems in the flow channels, increasing pressure drop, causing the particles to quickly settle out of suspension. In recent years, modern nanotechnology has been discovered. Particles of nanometer dimensions dispersed in base liquids are called nanofluids. This term was first introduced by choir in 1995 at the Argonne national laboratory. The word nanofluid refers to a mixture in which solid particles of Nano size (generally less than 100 nm) are added to a base fluid and cause the increase of heat transfer in that mixture nanofluids are engineered by dispersion of fine metallic and non-metallic particles of Nano meter dimension in traditional host liquids which include water, ethylene glycol, propylene glycol, oil etc. Use of such nanoparticles in the base fluids increase their thermal conductivity and heat transfer performance of nanofluids. Nanofluids are new generation heat transfer fluids and can be used for heat transfer augmentations. Nanofluids have high heat transport capability and can replace traditional thermo fluids normally used for heat transfer applications in heat exchangers, chemical process plants, manufacturing processes, automotive and cooling of electronic components. Nanofluids are used in micro channel cooling without any clogging and. Such problems can be minimized by replacing micrometer sized particles by Nano sized particles. Passive heat transfer technique and active heat transfer technique. Passive heat transfer techniques can be employed by provision of rough and extended surfaces tubes and creation of swirl in the flow using inserts of certain geometrical shape



The characteristic features of the nanofluids include:

1) Significant increase in the thermal conductivity with low volume concentrations.
2) Stronger dependence of thermal conductivity on temperature than the base- fluid alone.
3) Increased critical heat flux for pool boiling scenarios.
4) Substantial increase in heat transfer coefficient.

2.preparation of nanofluids

Method of preparation of Nanofluids:-to prepare nanofluids, Al2o3nanoparticles (<50nm) supplied by sigma-Aldrich chemicals ltd, USA are used. The base fluid consists of water, 40:60% of mixture of ethylene glycol and water. The quantity of al2o3nanoparticles required for the preparation of different volume concentrations of al2o3nanofluid be calculated using equation.

Whereφ is the percentage of volume concentrations.

$\rho Al2O3$ is the density of nanoparticles (3950 kg/m3)

$Wbasefluid$is the weight of base fluid (10000)

$WAl2O3$ is the weight ofal2o3nanoparticles

One of the major difficulties experienced is to prepare a stable nanofluid. There are three methods that are established for preparation of stable nanofluids. In these methods, it will be ensured that, nanoparticles will be dispersed uniformly throughout the base fluid. The methods also prevent sedimentation or settlement of nanoparticles at the bottom of the container for an extended period of time.

Direct mixing of nanoparticles to the base fluid: - the base fluid (water, 40:60%) is taken in to a suitable container and measured quantity of nanoparticles are gradually mixed and stirred to produce the desired nanofluid. Direct mixing method is not proven to produce stable nanofluids as this method results in undesirable quick sedimentation of nanoparticles in a short period.

Procedure for mixing base fluid and nanoparticles in acidic:- in this method the ph. value of di water is altered by adding the required quantities of hydrochloric acid such that the value ph. changes from 7 to 3. Subsequently, measured quantities of nanoparticles are added and mixture is stirred thoroughly to get uniform dispersion. The nanofluid thus prepared is proven to be stable even beyond one month. However, due to acidity, these nanofluids result in corrosion of the equipment. use of surfactants in to improve uniform dispersion of nanoparticles and also enhance stability of nanofluids small quantities of surfactants are added to the base fluid prior to mixing the nanoparticles. Once the nanoparticles are added to the system, the mixture is stirred for a period of 12 to 16 hours as show in fig. 3.2. The following are most commonly used surfactants in the preparation of Nano

Ceil-trimethyl ammonium bromide (c-tab)

Procedure for preparation of Nano:- in order to prepare the desired nanofluids, with specific volume concentration, the individual quantities of (1) the base fluid (2) nanoparticles to be added and (3) the surfactant are determined. Xuan and li [2003] recommended adding 5ml of tween 80 surfactant for every (li) of base fluids. They recommended that this composition ensures stability and uniform dispersion of cue nanoparticles in cue nanofluid. Sundar et al. [2010] suggests sodium dodecyl benzene sulfonate (subs) surfactant be limited to in the1/10th of weight of cue nanoparticles for stable water basic.

Preparation of nanofluids with c-tab surfactant: it is proposed to prepare and characterize water-basedcue nanofluids with volume concentration in the range varying from 0.01 - 0.05%. To prepare such nanofluid with 0.01% volume concentration, 3.09 grams of cue nanoparticles are to be mixed for every 5000 grams of distilled water. The procedure of sunder et al. [2010] is adopted for the preparation of stable nanofluid. Before mixing the nanoparticles to the distilled water an amount of1/10th weight of nanoparticle of c-tab is added to the distilled water. With the addition of c-tab surfactant, a stable water based nanofluid is obtained and it is also observed the nanofluids are very stable (no sedimentation) up to 6 months. So, this is the enough time to complete both heat transfer and friction factor measurements in a tube with inserts. The seam image shown in establishes the uniform distribution of nanoparticles all through the fluid. Surfactant of 1/10th weight is also used for the preparation of e.g./w based nanofluid. The physical properties of different base fluids are shown in table 3.2. Cue nanoparticles of measured quantity are gradually added and the mixture is stirred continuously for 16 hours. The nanofluid thus prepared is observed for its stability and dispersion of nanoparticles. The cue required ($WCuO$)for the specific volume concentrations is estimateevaluation of properties of nanofluids in the literature few models are available for estimation of thermo-physical properties of nanofluids. These properties include thermal conductivity, density, absolute viscosity and specific heat. These properties are experimentally determined and compared with model predictions for agreement or otherwise. 1 density pack and Cho [1998] proposed a simple model given in eq. (3.2) to estimate the density of nanofluids as a function of volume concentration of nanoparticles. Table 3.5 shows the comparison of cue nanofluids between the experimental values and model predictions of Pak and Cho [1998] for water, 40:60% e.g./w based nanofluids. The comparison includes nanofluids in the range of concentration from 0.01 to 0.05%.

Absolute viscosity: glycols exhibit better heat transfer performance when the ambient temperature is below zero degrees Celsius. Viscosity of heat transfer fluids influences the pumping power requirement and also the convective heat transfer coefficient of nanofluids as Prandtl and Reynolds numbers depend on the viscosity of heat transfer fluids. This mixture is relevant in the regions of cold climates, where the atmospheric temperature is less than subs zero conditions. Under such extreme climatic conditions, it becomes essential to bring down the freezing point of radiator coolants used in automobiles. In the present work ethylene glycol and water-basedcue nanofluids with volume concentration in the range from 0.01% to 0.05% with an increment of 0.01 were prepared. It is assumed that the thermo - physical properties of the nanofluids prepared are uniform and constant with time all through the fluid under consideration. It is also assumed that the nanofluids behave like Newtonian fluids and obey the newton's law of viscosity. Newtonian fluids satisfy the eq. $T=\mu\upsilon$

In the present experimental work, the effect of temperature and volume concentration are investigated for cue nanofluids. The test setup used for measurement of viscosity as a function of temperature and volume concentration of cue nanofluids with water, water + ethylene glycol as base fluid . To vary the test sample temperature a temperature controller is used. The data on the shear strain and shear rate and temperature are recorded in the data logger

Specific heat

it is possible to estimate the specific heat of nanofluids with any concentration using the following equation which is valid for homogeneous mixtures.

3. Experimental setup and testing procedure:-

the experimental test rig is developed with commercially available car radiator. It consists of coolant storage tank, an industrial heater, a high temperature durable pump, a radiator, a fan, thermocouples, anemometer, and a temperature indicator to record the temperatures. The schematic view and the developed test . The front and rear view of experimental test rig respectively. The nanofluid is assumed to be flowing through uniform Reynolds number assuming normal distribution in the channels of the radiator. The coolant flows through the 3 rows of 104 tubes with a diameter of 5 mm and length of 0.3 m. The coolant is allowed to flow through radiator in the flow rates of 3,5, 7, 9 and 11 li/min. The velocity of air has also been varied according to three levels 2 m/s, 3m/s & 4 m/s. The necessity for varying the flow rates of coolant and air is to simulate the operating conditions of an automobile during varying engine loads. Temperature of air entering the radiator and exiting the radiator has been recorded. The heat generation is simulated by using an industrial heater where the range has been set up to 39oc to 95oc. Once the required temperature (90oc) is attained the high temperature durable coolant pump is switched on facilitating the circulation of the coolant across the heat exchanger through a non-return flow control valve. A set of 6 k-type thermocouples (−20°c to 350°c range thermo make) have been used to record the temperatures of the coolant tank, inlet chamber (collecting) of the radiator, exit chamber (collecting) of the radiator, one closely placed near the passage tubes of the radiator and two on the front and rear to record the temperature of the air. The temperature recorded by thermocouple placed near the passage tube at the center of the radiator is to assess the heat lost and to calculate the bulk temperature. All the thermocouples, the temperature recorder, and anemometer were thoroughly calibrated prior to the experimentation.

fan:-a fan is installed just behind the radiator so as to increase the cooling capacity of the radiator. When the temperature of the coolant increases because of constant acceleration the fan starts operating, sucking in the air through the fins of the radiator. This fan is controlled by arranging a switch and it rotates at speed of 2300 rpm. In the apparatus the fan runs continuously to given an effect of moving vehicle.

Tank with heating element: - in the test apparatus the hot water acting as the coolant taking heat from the engine block is provided here the help of a heating element fixed into the container. The container is 40 cm in height and 30 cm in diameter and whose total volume is 10 liters. In this container the water is heated up to the range of 60-90°c.

Thermocouples: the most common electrical method of temperature measurement uses the thermocouple. It is based upon see-back effect i.e., when two dissimilar metals are jointed, these forms two junctions and if these junctions are maintained at different temperatures than an emf is produced and this depends on the temperature difference. Therefore, in thermocouple emf plays thermometric property, the property which helps in holding in finding out the temperature is named as the thermometric property.

Testing procedure: during testing, firstly water is taken as a coolant. It is circulated at a different mass flow rate of 3 lap (liter per minute), 6 lap and 9 laps. The fan is rotated at a speed of 2300 rpm. After this the temperature of hot coolant at the outlet is recorded at particular inlet coolant temperatures. The temperature of inlet coolant is maintained at 40°c. The temperature of inlet coolant is changed to 50°c and the processor is repeated. The readings are taken at outlet coolant at 40°c, 50°c, 60°c, and 70oc. After this first round of data recording the coolant is changed. This water is replaced with a 0.01% of nanofluid. Here the mass flow rate is maintained at the same level as before and the fan is also circulated with the same speed of 2300 rpm. After the process of 0.01% nanofluid at the different mass flow rates and at different temperatures the coolant is replace by 0.01% nanofluid. The readings are recorded for 0.02% coolant as previous process at different temperatures and different flow rates. After that the coolant is replaced by third concentration of nanofluid i.e., 0.03%,0.04% and 0.05% nanofluid. The readings are recorded at different temperatures and by changing the flow rates also the readings of inlet and outlet temperatures are recorded. Now by the readings the heat transfer enhancement is calculated. After the process of 0.01% nanofluid at the different mass flow rates and at different temperatures the coolant is replace by 0.01% nanofluid. The readings are recorded for 0.02% coolant as previous process at different temperatures and different flow rates. After that the coolant is replaced by third concentration of nanofluid i.e., 0.03%,0.04% and 0.05% nanofluid.

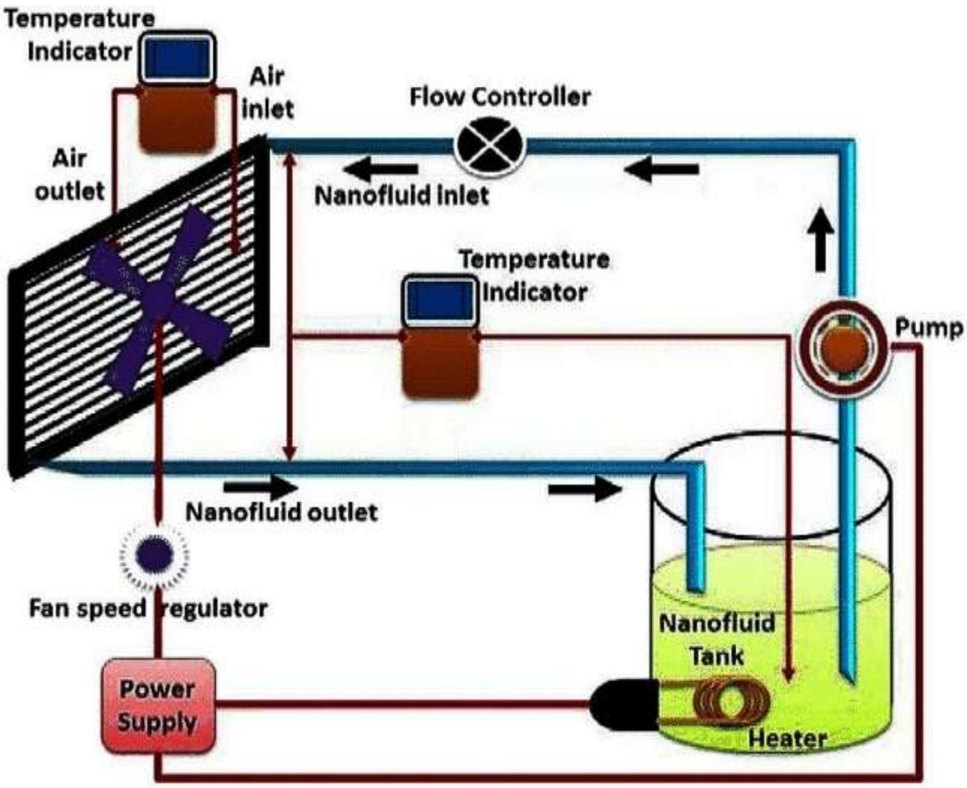


Figure 4.1 Schematic view and development rig.

4. formulae

1. Heat transfer rate

$q = m\ cp\delta t = m\ cp(tin-tout)$

m = mass flow rate = ρ×v (kg/s)

v = fluid velocity (lit/m)

tin= inlet temperature (°c)

tout =outlet temperature (°c)

q = heat transfer rate (k/s)

2. Nusselt number

3. $nu = 0.023 \times re0.8 \times pr0.3$

Pr = prandtl number

4. Reynolds number

$re = \rho nfv\ d$

ρnf= density of fluid (kg/m3)

μnf= viscosity of fluid (n-s/m2)
dh= hydraulic diameter (mm)
v=fluid velocity (lit/s)

5. Volume concentration of nanoparticles

6. wp= weight of the nanoparticle (grams)
ρp= density of the nanoparticle (kg/m3)
wf= weight of the base fluid (grams)
ρf= density of the base fluid (kg/m3)

7. Density of nanofluid
ρnf= (1-ϕ)ρf+ ϕρp
ρnf= density of nanofluid (kg/m3)
ϕ= particles volume concentration (%)
ρf= density of base fluid (kg/m3)
ρp=density of nanoparticles (kg/m3)

8. Thermal conductivity of nanofluid
Knf= thermal conductivity of nanofluid (w/m k)
knp= thermal conductivity of nanoparticle (w/m k)
kbf= thermal conductivity of base fluid (w/m k)
ϕ= particles volume concentration (%)

9. Viscosity
10. μnf= (1+2.5ϕ)μw 4.7
11. μnf= nanofluid viscosity (n-s/m2)
12. μw= water viscosity (n-s/m2)
13. ϕ= particles volume concentration (%)
14. Heat capacity of nanofluid
cpbf=heat capacity of base fluid (kj/kg k)
cpnp=heat capacity of nanoparticles (kj/kg k)
ρbf=density of base fluid (kg/m3)
ρnf= density of nanofluid (kg/m3)
ρnp=density of nanoparticles (kg/m3)
ϕ=volume concentration (%)

Correlations for Nusselt number estimation for single phase fluids from open literature:-

a) Gilinsky correlation for single phase fluid

b) tam and Hajar correlation for single phase fluid

$3 \leq LD \leq 192$; $7000 \leq Re \leq 49000$; $4 \leq Pr \leq 34$; $1.1 \leq (\mu b/\mu w) \leq 1.7$

result and discussion: - in this section the calculations for pure water (base fluids) and different percentages of nanofluids are discussed. The obtained results are tabulated and the graphs are between inlet tube temperature difference, heat transfer rate, and fin temperature difference at different temperatures on constant pm.

introduction: the automotive radiator was run at constant flow rates (11litresinin, 9 liters/min. 7litres/min, 5 liters/min and 3litres/min) at inlet temperatures 90, 80, 70, 600. A temperature difference (at) was recorder for each flow rate, respectively. These obtained results are drawn graphically.

Water in radiator

Before conducting the systematic analysis with the use of nanofluids in the radiator, some experimental runs were conducted with water in order to check the reliability and accuracy of the experimental setup. The generally used fluid in a radiator is water so we first conducted experiments on it. By conducting experiments on it we can compare the resulted values of water with nanofluid.

Table 5.1: experimental observations for water

S.no	Temperature Inlet (t in) °c	Temperature outlet (t out) °c	Fin temperature Inlet (t in) °c	Fin temperature outlet (t out) °c	Heat transfer Rate w
1	84.2	70.4	74.3	57.9	1176.49
2	76.3	64.7	64.7	49.9	1013.02
3	63.7	51.2	51.8	47	4674.065
4	58.5	46.8	45	37.8	4965.5

The water was tested in fabricated model of experimental setup at different flow rates and at different inlet temperatures. The obtained results are tabulated as below. Base fluid in the radiator (40:60%(e.g/w) after conducting the experimental analysis with the water in the radiator, then some experimental runs was conducted with ethaline glycol and water 40:60% eg/w) in order to check the reliability and accuracy of the experimental setup. In severe cold climatic conditions glycols are added to water in different proportions to reduce the freezing point of heat transfer liquids by conducting experiments on it we can compare the resulted values of water, base fluid with nanofluid.

5.4 Nano fluid inRadiation: the nanofluid is implemented in different cue and a1203 concentrations, and at different flow rates of 3, 6, and 9 lit/min were implemented as the working fluids. In order to consider the effect of temperature on thermal performance of the radiator, different inlet temperatures of the nanofluids (60, 70, 80 &90) have been applied. It is important to mention that from practical viewpoint for every cooling system, at equal mass flow rate the more reduction in working fluid temperature indicates better thermal performance of the cooling system after testing the water as base fluid the prepared nanofluids with concentration tested in fabricated model of experimental setup at different flow rates and at different inlet temperatures. The obtained results are tabulated clown.

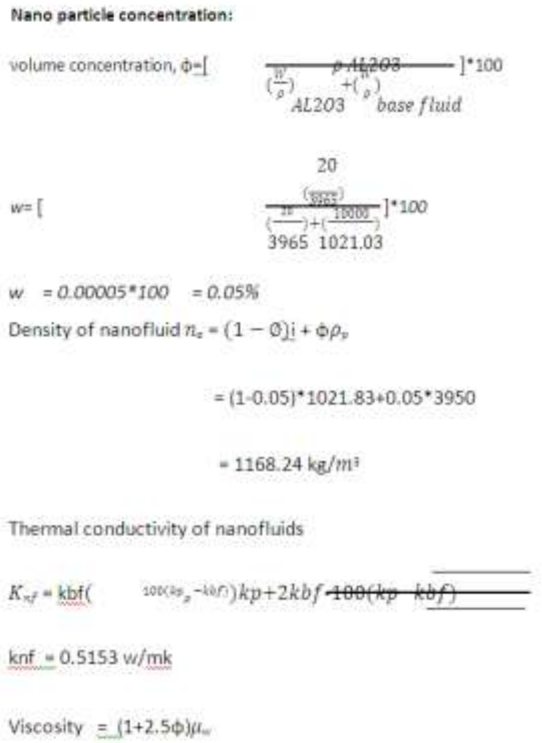
Table 5.3 experimental observations for heat transfer rate of cueNano fluid:

S.no	Temperature Inlet(t in) °c	Temperature outlet (t out) °c	Fin temperature Inlet(t in) °c	Fin temperature outlet(t out) °c	Heat transfer rate w
1	86.8	61.2	38.2	49.65	2026.61
2	77	70.4	42.6	67.55	2248.61
3	68.9	64.2	43.2	66.4	3720.73
4	59.8	56.6	39.95	58.5	2533.2

Table 5.4 experimental observations for heat transfer rate in al2o3 Nano fluid:

S.no	Temperature Inlet (t in) °c	Temperature outlet (t out) °c	Fin temperature Inlet (t in) °c	Fin temperature outlet (t out) °c	Heat transfer rate w
1	88.4	54.9	34.3	42.7	1099.75
2	78.8	51.7	38.4	45.1	1835.37
3	69.8	57.6	41.6	62.4	5974.25
4	59.7	41.4	39.95	52.1	6000.725

5.5 sample calculations



Nano particle concentration:

volume concentration, $\phi = [\frac{(\frac{w}{\rho})_{AL2O3}}{(\frac{w}{\rho})_{AL2O3}+(\frac{w}{\rho})_{base\ fluid}}]*100$

$w = [\frac{(\frac{20}{3965})}{(\frac{20}{3965})+(\frac{10000}{1021.03})}]*100$

$w = 0.00005*100 = 0.05\%$

Density of nanofluid $n_z = (1 - \emptyset)i + \phi\rho_p$

$= (1-0.05)*1021.83+0.05*3950$

$= 1168.24\ kg/m^3$

Thermal conductivity of nanofluids

K_{nf} = kbf($100(kp_z - kbf)kp+2kbf - 100(kp-kbf)$

knf = 0.5153 w/mk

Viscosity = $(1+2.5\phi)\mu_w$

$= (1=2.5*0.05)1.083*10^{3}$

$= 1.218*10^{-3}$ n-

$$c_{pnf} = (1-\varphi)\left(\frac{\rho_{bf}}{\rho_{nf}}\right)c_{pbf} + \varphi\left(\frac{\rho_{p}}{\rho_{nf}}\right)c_{pp}$$

$$=(1-0.05)\left(\frac{1021.83}{1168.24}\right)*3.84+0.05\left(\frac{3950}{1168.96}\right)*955$$

=168.657 kj/kgk

Heat transfer rate $q = mc_p\delta t = mc_p (t_{out} - t_{in})$

m = mass flow rate = $\rho * v$ (kg/s)

$q = \rho * v * c_p(t_{out} - t_{in})$

$= 1019.44 * 0.1666 * 0.168 *(83.3-65.6)$

q = 1113.176 w

II. CONCLUSION:

In the project the experimental heat transfer coefficient in the may have been measured with four working liquids the w405 gw. 400% eg/w-basedcuenanofluids, aluminum blade nanofluids an centration'sand temperatures.

1. The presence of Nano fluid in 40:60% eg/w can enhance the best de rate of the automobile radiator. The degree of the heat transfer s depends on the number of nanoparticles added to the base fluid. Ultimately, the concentration of 0.05%, the heat transfer enhancement of 40% to base fluid was observed.
2. Increasing the flow rate of working fluid (or equally re) enhances the heat transfer coefficient for both pure water and nanofluid considerably while the variation of fluid inlet temperature to the radiator (in the ring tested) slightly changes the heat transfer performance.
3. Although there are recent advances in the study of heat transfer with nanofluids, more experimental results and theoretical understanding of the mechanisms of the particle movements are needed to explain heat transfer behavior of nanofluids.

Scope of future work:-experiments can be further carried out with higher particle concentrations for measurement of heat transfer coefficients. Experiments can also be extended for different base fluids e.g. Transformer oil, etc. for investigation of heat transfer characteristics. Carbon nanotubes (cent) have very high thermal conductivity about 3000 w/m k. So, cnt/water nanofluid can be studied with surfactants at various particle concentrations. Limited work has been reported on the cooling applications of nanofluid using carbon Nano tubes (cnt). Experiments can be further carried out by adding more than 2 nanoparticles so that the thermal conductivity will increase gradually. So that the heat transfer coefficient will increases.

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