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EXPERIMENTAL STUDY ON ENHANCEMENT OF HEAT TRANSFER COEFFICIENT USING CuO NANO FLUID

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KEYWORDS

GFRP, TAGUCHI method andparameters.

ABSTRACT

Nanofluids are just normal fluids with nanoparticles suspended in them. Nanofluids are a new kind of heat transfer coolant that have emerged as a result of recent advances in nanotechnology. The thermal characteristics of these fluids are bigger than those of traditional coolants. Since nanofluids provide fascinating new opportunities to improve heat transfer performance above pure liquids, they may be seen as the heat transfer fluids of the future. No such remarkable improvement is seen in particle-fluid suspensions with micrometer-sized particles. Conventional heat transfer fluids and fluids containing micro-sized metallic particles are anticipated to exhibit worse qualities when compared to nano fluids. The stability of the solution is enhanced and heat transmission capacities are substantially improved by using nanoparticles, which have a much greater relative surface area than regular particles.

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INTRODUCTION

The creation of nanofluids was driven by the need to reduce the size of heat transfer equipment by improving the heat transfer coefficient. One potential use of these fluids is as thermal fluids in heat exchangers. Thermal energy and heat exchanger materials may be better conserved with the use of nanofluids. Nanofluids' thermal conductivity, viscosity, specific heat, and density are crucial elements that impact their heat transfer qualities. The operating temperature of nanofluids is also a determinant of their thermophysical characteristics. Therefore, it is crucial to accurately quantify the temperature dependent characteristics of nanofluids. It is not possible to estimate the heat transfer coefficient or the Nusselt number without first knowing the thermophysical characteristics of the nanofluids. Colloidal suspensions of designed nanoparticles in a base fluid are known as nano fluids. Nanoparticles typically range in size from one millimetre to one hundred nanometers.If the base fluid needs a certain quality improved, the kind of nano particle employed to do so will be different.
There is a crucial length scale for every physical mechanism, and at this scale, materials' physical characteristics vary. Hence, the characteristics of particles smaller than 100 nm differ significantly from those of typical solids. Due to the high concentration of component atoms at grain boundaries, nano phase materials have a comparatively high surface area to volume ratio, which gives them their noble characteristics. Nano phase materials have better electrical, thermal, mechanical, optical, and magnetic capabilities than traditional materials with larger grain sizes.

fig1 PhotographicviewofCuOnanoparticles

PREPARATION METHODS FORNANOFLUIDS

ClassificationOfMethodsofpreparationofNanoFluid

Two -StepMethod

Nanofluids are most often prepared using a two-step process. Before using this technology, the nanomaterials (nanoparticles, nanofibers, nanotubes, etc.) are first created as dry powders using physical or chemical processes. The second phase of processing involves dispersing the nanosized powder into a fluid using a combination of ultrasonic agitation, homogenising, high-shear mixing, intense magnetic force agitation, and ball milling. The two-step process is the most cost-effective way to make nanofluids on a big scale, as nanopowder synthesis methods are already at an industrial level of production. Nanoparticles are prone to high-surface-area and surface-activity-related all things. The use of surfactants is a crucial strategy for improving the stability of nanoparticles in fluids. One major issue, particularly for high-temperature uses, is the surfactants' functionality at such conditions.

Single-StepMethod

The nanoparticles are made and distributed into the base fluid all at once in the one-step process. Blending commercially available nano particles derived from various mechanical, physical, and chemical processes—including milling, grinding, sol-gel, and vapour phase methods—with base fluids is a common two-step preparation procedure for synthesising nanofluids. For the most part, when mixing nanopowders with host fluids, an ultrasonic vibrator or other higher shear mixing device is used. Reduce particle agglomeration by often using ultra sonication or stirring. Alumina nano fluids were produced using a two-step process by Eastman et al., Lee et al., and Wang et al. Using the same procedure, Murshed et al. created a TiO2-water nano suspension. Xuan et al. synthesised water and transformer oil nanofluids using commercially accessible Cu nanoparticles. Nanofluids of CuO dispersed in ethylene glycol were prepared in two steps by Kim et al. using sonication and no stabilisers. Nanofluids based on carbon nanotubes may also be synthesised using a two-step process. After being created via the pyrolysis process, carbon nanotubes with one or more walls are suspended in base fluids, either with or without surfactants. Nanofluids containing oxide nanoparticles,

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according to some writers, are better prepared using a two-step technique than nanofluids including metallic nanoparticles. Because of the high van der Walls force among nanoparticles, powders readily agglomerate, making stability a major concern intrinsic to this process. The most cost-effective method for producing nano fluids, this technology continues to be popular despite these drawbacks.

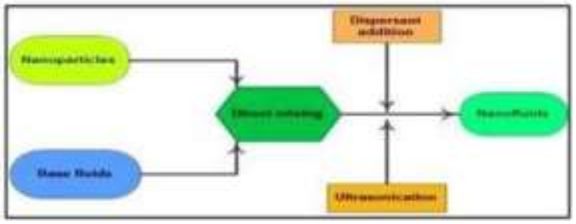

fig2StepPreparationforNanoFluids

1. LITERATUREREVIEW

The thermal performances of the nanofluids are one-of-a-kind. Compared to more traditional heat transfer fluids, nanofluids have unique characteristics. A faster heat transfer rate is anticipated in nanofluids due to the increased overall surface area that nanoparticles provide. Thermophysical characteristics of conventional thermal fluids improved when nanoparticles are included, according to many studies. A higher heat transfer rate and lower specific heats are anticipated from nanofluids compared to ordinary fluids, according to experimental investigations on the topic. Erosion of pipe materials, obstruction of flow passageways, and sedimentation owing to gravity are typical outcomes of particles suspended in fluids with a diameter of millimetres or micrometres. Macroscopically under stationary settings, studies on the effective heat transfer coefficient of nanofluids were conducted by S.U.S. Choi (1995), Masuda et al. (1993), Eastman et al. (1996), Wang et al. (1999), and Lee et al. (1999). Eastman et al. (2001), Xuan and Li (2000), Keblinski et al. (2002), Xie et al. (2002), and Wang et al. (2003) are all mentioned.Research on the real-world applications of slurry hydrodynamics and heat transmission was conducted by Ahuja (1975) and Liu et al. (1988).Nanofluids were developed at Argonne National Laboratory and proof tests were performed by Eastman et al. (1995). Modern technology allows for the production, processing, and characterization of materials with an average crystalline size below 100 nm. Nanoparticles of Al2O3 and CuO materials dispersed in mixes of glycols, oils, and water have shown an enhanced heat transfer coefficient and great dispersion quality. It is believed that the increased properties of nanofluids are due to the particles' Brownian motion and their huge surface area. Nanofluids with an average crystalline size of less than 100 nm were manufactured at Argonne National Laboratory and then tested by Eastman et al. (1995) to determine the heat transfer rate. Nanoparticles of Al2O3 and CuO materials dispersed in mixes of glycols, oils, and water have shown an enhanced heat transfer coefficient and great dispersion quality. Nanofluids are thought to have an improved heat transfer coefficient due to the particles' Brownian motion and their enormous surface area. Lee et al. (1999) measured the thermal conductivity of Al2O3 and CuO particles in ethylene glycol and water base fluids in great detail. The transient hot wire technique is used to determine the heat transfer rate of nanofluids. Researchers are encouraged to conduct heat transfer experiments on various nanofluids due to the notable improvement in heat transmission seen with these materials. A stable fluid may be produced by particles as big as 100 nm, according to a recent research by Xuan and Li (2000). A little quantity of laurite salt can be added to the base fluids for this purpose. However, what happened was experimental investigations have also shown that these dispersants impact the beneficial characteristics of nanofluids.

2. NANOFLUIDPREPARATIONUSINGCuONANO PARTICLES

The CuO nano particles having an average size of 50nm and density of 6.3 gm/cm3 is procured from aIndiabasedcompany(NanoPartechChemicalsPrivateLtd)andisusedforinvestigationinthepresent experimental work. The photographic view ofthe nanoparticles as seen by the naked eyes is showninthe plate..1.

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Fig3PhotographicviewofCuOnanoparticles

The distribution of CuO nanoparticles at Nano scalecanbeobservedunderaScanningelectronmicroscope(SEM).TheSEMimagesofCuOnanoparticlesat1mmagnificationsisshowninPlate.3.2(a)andSEMimageofCuOnanoparticleona 500 nm scale is shown in Plate.3.2(b). Preparationof Nanofluids is an important stage and Nanofluidsare prepared in a systematic and careful manner. Astable Nanofluid with uniform particle dispersion isrequiredandthesameisusedformeasuringthethermo physicalpropertiesofNanofluids.

SEM images of CuO nano particles on 1000 n m and500 nmscales.

In the present work, water-Propylene glycol mixture80:20byvolumeistakenasthebasefluidforpreparation CuO Nanofluids. Basically three differentmethodsareavailableforpreparationofstableNanofluidsandare listed below.

By mixingofnanopowderinthebaseliquid

Inthismethod,thenanoparticlesaredirectlymixedin the base liquid and thoroughly stirred. Nanofluidspreparedinthismethodgivepoorsuspensionstability, because the nanoparticles settle down due togravity, after a few minutes of Nanofluid preparation.The time of particle settlement depends on the type ofnanoparticlesused,density andviscositypropertiesofthehostfluids.

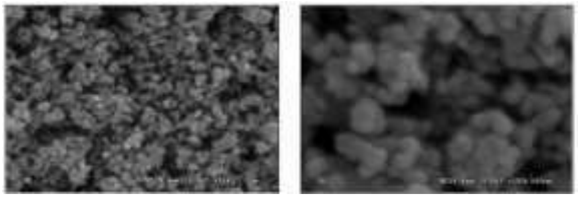
Byacidtreatmentofbasefluids

The PH value of the base fluid can be lowered byadding a suitable acid to it. A stable Nanofluid withuniformparticledispersioncanbepreparedbymixing nanoparticles in an acidtreated base fluid.But acid treated Nanofluids may cause corrosion onthepipewallmaterialwithprolongedusageofNanofluids. Hence acid treated base fluids are notpreferred for preparation of Nanofluids even thoughformation of stable Nanofluids is possible with suchbasefluids.

Byaddingsurfactantstothebasefluid

In this method a small amount of suitable surfactant,generally one tenth of mass of nanoparticles, is addedtothebasefluidandstirredcontinuouslyforfewhours.Nanofluidspreparedusingsurfactantswillgiveastable suspensionwithuniformparticledispersioninthehostliquid.Thenanoparticlesremain in suspension state for a long time withoutsettlingdownatthe bottomofthe container.

The CuO Nanofluids samples thus prepared are keptforobservationandnoparticlesettlementwasobserved at the bottom of the flask containing CuONanofluidsevenafterfour hours.



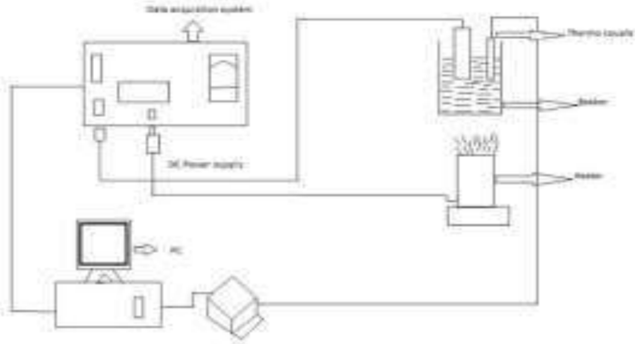


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Fig: ThephotographicviewofCuONanofluidsuspensionpreparedafter magneticstirringprocess

In the current study, surfactants were not added to the CuO nanofluids since the time needed to finish the experiment for property assessment was shorter than the time needed for the first sedimentation to occur. It is presumed that the created CuO nanofluids behave in a uniform and consistent manner throughout the fluid sample, and that they are isentropic and Newtonian in nature.

DeterminationOfCuONanoFluidProperties

Nanofluid density, heat transfer coefficient, viscosity, and specific heat are the four most critical characteristics for estimating the convective heat transfer coefficient. The experimental estimates of CuO nanofluids' thermo-properties are compared with the theoretical equations that predict these characteristics, and the findings are obtained for all concentrations.

ExperimentalSetUpForHeatTransferCoefficientMeasurementUsingTransientHeatConductionApparatus

Fig. shows a schematic representation of the experimental setup used to assess the heat transfer coefficient of nanofluids. On the plate, you can see an image of the experimental setup. our current project The transient heat conduction device is used to test the heat transfer rate of CuO nanofluids.

Fig:SchematicdiagramoftheHeattransfercoefficientmeasuringexperimentalsetup

ProceduretoPerformtheExperiment

Measure out 1000 millilitres of base fluid. 2. Separate the 1000 millilitres of nano solution into a heating and cooling portion.
Turn the power on and turn on the heater. To avoid water splashing, turn on the stirrer and adjust the speed. Take note of the test cylinder's temperature once you take it out of the bath. To.

- Set the temperature controller to a value between 0 and 70 ºC.
- Adjust the screw to the temperature you want by pressing the button. As soon as the button is let go, the controller will display the bath temperature.

Insert the cylinder into the bath and start a stop clock at the same time when the water temperature reaches the desired level. Keep track of how long it took the test cylinder to get to the desired steady state temperature (T).

- Base fluid and copper nanoparticles must be mixed thoroughly by using the appropriate stirring technique.
- After that, dip the copper cylinder into the cooled cuO solution and record the results in the same way.

Keep doing this until the temperature reaches 70 ºC, 60 ºC, or 50 ºC.

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- Repeat steps 0.05%, 0.1%, 0.15%, and 2% in the same manner.

Nanofluids containing distilled water, 20% ethylene glycol, and CuO nanoparticles at concentrations of0.05%,0.1%,0.15%, and 2% should be prepared in the same way.

SpecificationsOfExperimentalSetup

The dimensions of the copper cylinder are as follows: • 20 mm for diameter; • 70 mm for length; • 0.00439 m2 for area.

- 0.00002199 m3 is the cylinder's volume.

The density of a cubic metre of copper is 8954 kg/m3.

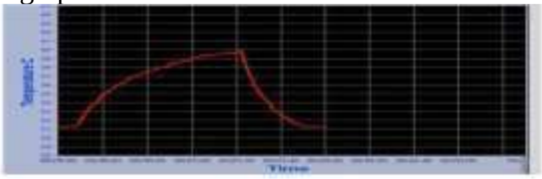
- Copper's specific heat is 0.381 kj/kg-k.

The temperature of the copper cylinder at the beginning is To, the temperature at the end is T, and the temperature of the water bath, whether hot or cold, is T∐.

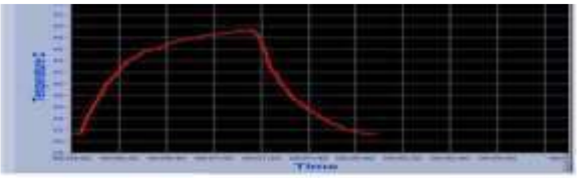
- The number of seconds it takes for the cylinder to travel from point A to point T One way to get the heat transfer coefficient is by using the following formula:

GRAPHS

GraphswereObtainedonthePcduringtheExperiment,thegraphsareplottedTime(t)vsTemperature(T)
Thegraphsareasfollowsas:-

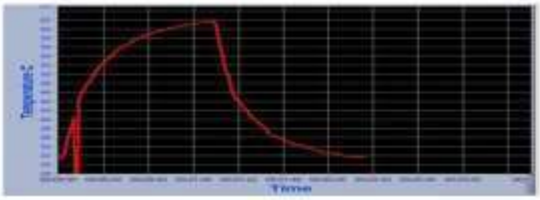


HEATING COOLINGT∞= 40.4ºC T∞ = 31.3 ºCTO =31.3ºC
TO=39.9ºC
t= 104 sec t=44sec
T=40.1ºC T=31.8ºC
h=0.5627kW/m2 ºC h = 1.10903kW/m2 ºCTRANSIENT HEAT CONDUCTION OFDISTILLEDWATERAT50ºC



HEATING COOLINGT∞= 51.4ºC T∞ = 31.3 ºCTO =31.3ºC
TO=48.5ºC
t= 89 sec t=61 sec
T=49.4ºC T=31.6ºC
h=0.4447kW/m2 ºC h=1.1384kW/m2 ºC

TRANSIENT HEAT CONDUCTION OFDISTILLEDWATERAT60ºc



HEATING COOLING
T∞= 62ºC T∞ = 31.7 ºCTO =31.4ºC TO=60.9ºC
t= 79 sec t=81sec
T=61.7ºC T=32ºC
h=0.4980kW/m2 ºC h=0.9711kW/m2 ºC

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Resultsanddiscussions

TheColumnChartShowsTemperaturevsHeatTransfer CoefficientDuringHeating.

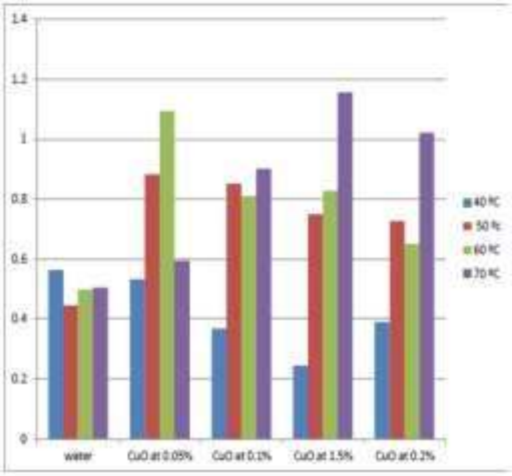

Fig11

From the above chart it has been observed that bycomparingWater, CuO at0.05% , CuO at 0.1%,CuO at 0.15% and Cuo at 0.2% During Heating HeatTransferCoefficientishighatCuoof0.15%concentration at 70 ºC with a value of h = 1.1554kW/m2 ºC

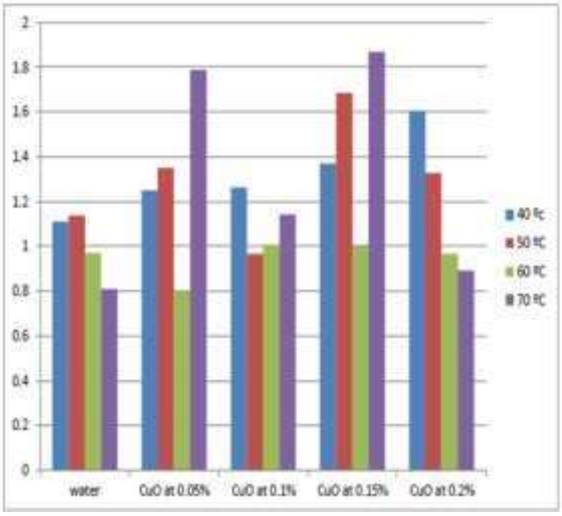

Fig12

From the above chart it has been observed that bycomparingWater, CuO at0.05% , CuO at 0.1%,CuO at 0.15% and Cuo at 0.2% During Cooling HeatTransferCoefficientishighatCuoof0.15%concentrationat 70ºCwithavalue of
h=1.8674kW/m2 ºC.

The Column Chart Shows Temperature vs HeatTransferCoefficient DuringHeating.

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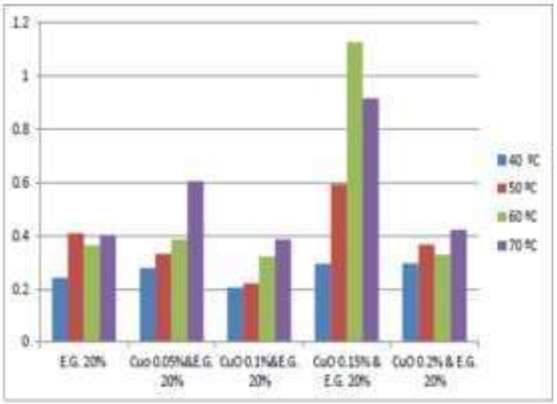

From the above chart it has been observed that bycomparing Ethyl Glycol of 20% and Water , EthylGlycol of 20% and CuO at 0.05%, Ethyl Glycol of20% and CuO at 0.15% and Ethyl Glycol of 20% andCuoat0.2%.DuringHeatingHeatTransferCoefficient is high at Cuo of 0.15% concentration at60ºCwitha value of
h=1.1671kW/m2 ºC

CONCLUSIONS

Nanofluids have been shown to have much higher heat transfer coefficients and thermal conductivities than regular fluids.
Through contrasting the HSCoV of nanofluid copper oxide with that of base fluids such as distilled water and

The copper oxide nano fluid has a high heat transfer coefficient when heated and cooled, and it also has an ethyl glycol component.Using distilled water as a base fluid, heating and cooling copper oxide at a concentration of 0.15% cuo nano particles at 70 ºC results in a high heat transfer rate.When we push it to even higher temperatures, it could show a far wider spectrum of heat transmission than regular fluids. At a concentration of 0.15% cuO nanoparticles in an ethyl glycol base fluid, the heat transfer rate is high during heating and cooling at 60 ºC; additional increases in temperature result in an even greater removal of fluid heat.The versatility of Cuo Nano fluids makes them useful in several fields, including heat transmission and detergency, among others. The biomedical profession has long made use of colloids, which are also CuO nanofluids, and this application will only increase. It has also been shown that CuO Nano fluids may be used as smart fluids. It is essential that the applications thoroughly investigate the issues of nanoparticle aggregation, settling, and erosion potential. For experimental study using CuO Nano fluids to provide the most relevant findings, it is crucial to have well-characterized fluids in terms of particle size, size distribution, form, and clustering. There will be a plethora of uses for CuO nano fluids once their engineering and science are completely understood, allowing for their mass production. Biomedical engineers and scientists will make more use of colloids, which are also Cuo nano fluids. To make CuO nano fluids work as intended, further study into their production and potential uses is required. Despite this, a lot has been found out about the properties of CuO nano fluids in the studied uses, and we are getting closer to creating smaller, more efficient systems that will make the environment cleaner and healthier.

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