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Design and Manufacturing of Test Setup for Measuring Thermal Conductivity of Water and Nanofluids

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Abstract: *This Project is about the effective thermal conductivity of water is tested by steady state method using Fourier's law, the obtained values will be compared with the standard value of thermal conductivity of water or thermal conductivity of different nanofluids to validate the results and therefore the rest setup. Thermal conductivity of different nanofluids with different concentration levels will be obtained and also the variation of thermal conductivity of nanofluids with temperature will be studied. The effect of different salts and additives on the thermal conductivity of water will be studied. Determining the physical properties of substances is an important subject in many advanced engineering applications. The physical properties of fluids (liquids and gases), such as thermal conductivity, play an important role in the design of a wide variety of engineering applications, such as heat exchangers, we are implementing, "Design and manufacturing of Test Setup for Measuring Thermal Conductivity of Nanofluids" to calculate the thermal conductivity of different nanofluids with different concentration.*

Keywords: *Thermal Conductivity, Steady State, Fourier's Law, Nanofluids.*

I. INTRODUCTION

The technique of measuring thermal diffusivity without finding thermal conductivity and specific heat,this leads to reduce the size and the cost. Transient heat method has been developed and widely applied in heat transfer, for example, metal and alloy, non-metals, food, rock industry etc. Many techniques ofactive and passive techniques are available for determining thermal properties. Heat transfer is the study of heat energy transfer that takes place from region of lower temperature slowly due to the temperature difference between two regions. With the knowledge of thermodynamics. We can determine the amount of heat transfer of any system undergoing any process from one equilibrium state to another.

A nanofluid is a fluid containing nano-meter-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Nanofluids have novel propertiesthat make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid- powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler fluegas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid.

II.LITERATURE SURVEY

Hosni I. Abu-Mulaweh& Donald W. Mueller, Jr [01] carried out the determination of the thermal conductivity of fluids. Determining the physical properties of substances is an important subject in many advanced engineering applications. The physical properties of fluids (liquids and gases), such asthermal conductivity, play an important role in the design of a wide variety of engineering applications, such as heat exchangers. K.C. Leong [02] Investigations of thermal conductivity and viscosity of nanofluids A combined experimental and theoretical study on the effective thermal conductivity and viscosity of nanofluids is conducted. HandWiki [03] carried out the thermal conductivity measurement. There are a number of possible ways to measure thermal conductivity,each of them suitable for a limited range of materials, depending

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on the thermal properties and the medium temperature. Michael Heinrich Rausch [04] Thermal conductivity is one of the most relevant properties of nanofluids (NFs) and is influenced by shape, size, concentration and surface resistance of the NPs and by the viscosity, pH, temperature, and other characteristics of the base fluid.C. Y. Ho,R.W.Powell, and P. E. Liley [05] Thermal Conductivity of the Elements This is the abridged version of a comprehensive volume on the thermal conductivity of the elements. It contains recommended reference values resulting from critical evaluation, analysis, and synthesis of all the available data.

2.1Objectives

The objectives to be achieve d are summarized below:

- To design the setup according to the minimum gap requirement and heater dimensions andspecification.
- To model the setup in Catia V5R20 and to finalize the dimensions.
- Welding, Drilling, Tapping and Grinding processes will be required to manufacture the testsetup.
- The Assembly consists of Cartridge heater, K type thermocouple, dimmer stat, voltmeter, ammeter and two aluminium cylinders.

III.METHODOLOGY

Steady State Heat Conduction

Steady state heat conduction is the heat conduction in which the temperature and heat flow at each point does not change with time.

Fourier's Law

Fourier's law states that the negative gradient of temperature and the time rate of heat transfer is proportional to the area at right angles of that gradient through which the heat flows. Fourier's law is the other name of the law of heat conduction. The rate of conductive heat transfer is described by Fourier's law as;

$Q= -k.A.dT/dx$

Where:

Q= The amount of heat transferred.

K= Thermal conductivity of the material.

A=Square area that is perpendicular to the direction of the heat flow.

dT= Temperature difference between the two ends of the material that the heat is flowing through The amount of heat that is transferred depends upon:

- The conductivity of the material.
- A doubling of the thermal conductivity will equal a 100% increase in the amount of energy that travels through the material.

IV.PROBLEM STATEMENT

To design and manufacture a test setup to investigate the thermal conductivity of different concentration of nanofluids i.e., Aluminium Oxide (Al□O□)

V.PROJECT DESIGN

5.1SELECTION OF HEATER

Dimension of Heater:

1. Diameter: 30mm
2. Length: 150mm
3. Heater material: SS2
4. Voltage: 500W. 4Amp
5. Temperature range: 0-400°C
6. Operating range: 100°C to 300 °C

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Figure.1: Cartridge Heater

5.2 SELECTION OF THERMOCOUPLE

K-type thermocouple is made up of material constantan, coronand thermos Kandhal. Temperature range of this thermocouple = -270°C to 1260°C

Diameter of thermocouple = 0.2 mm

Advantages:

It is inexpensive, accurate, reliable. It has wide temperature range.

Figure 2: K-Type Thermocouple

5.3 DESIGN OF SETUP

Design of Internal Cylinder Outer Diameter = 40 mm Inner diameter = 30 mm

Thickness =5 mm OPERATIONS:

Facing =170 mm length Drilling = 28 mm diameter Boring= 2 mm diameter

Design of External Cylinder Outer Diameter = 60 mm Inner diameter = 50 mm

Thickness =5 mm OPERATIONS:

Facing =170 mm length Drilling = 58 mm diameter Boring= 2 mm diameter

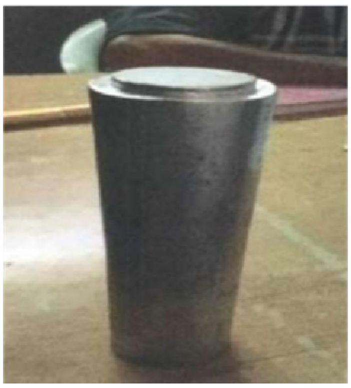

Figure 3: Fabricated Internal Cylinder

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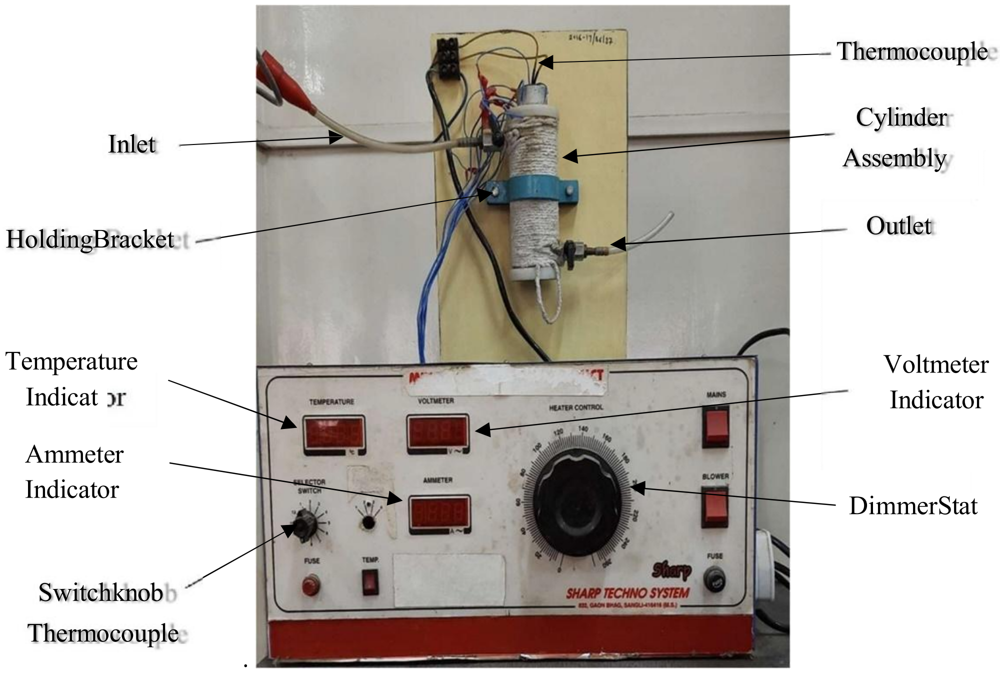
VI.PROJECT DESCRIPTION

The shape of the project setup is cylindrical. It contains 2 cylinders inner cylinder and outer cylinder. Both cylinders are made up of aluminium material. The thermal conductivity of aluminium at room temperature 204 W/mk. Because, we need high thermal conductivity so that heat is transferred effectively from inner cylinder to fluid. The gap between the two cylinders is used for filling the fluids whose thermal conductivity is to be measured.

Cartridge heater is inserted in the inner cylinder, with the help of clips. The clip is also made up of aluminium material. The material of heater is Stainless Steel 2 (ss2).

The k type thermocouple is provided in the setup. On the outer cylinder there are 4 thermocouple and on the inner cylinder 4 thermocouple is fitted. The heat transfer takes place from inside cylinder to fluid and the outer cylinder.



NANOFLUID SELECTION—ALUMINIUM OXIDE (Al□O□)

The principal parameters of nanoparticles are their shape, size, surface characteristics and inner structure. Ultrahigh performance cooling is one of the important needs of many industries. However, low thermal conductivity is a primary limitation in developing energy-efficient heat transfer fluids that are required for cooling purposes. Nanofluids are engineered by suspending nanoparticles with average sizes below 100 nm in heat transfer fluids such as water, oil, diesel, ethylene glycol, etc. Innovative heat transfer fluids are produced by suspending metallic or non- metallic nanometer-sized solid particles. Experiments have shown that nanofluids have substantial higher thermal conductivities compared to the base fluids. These suspended nanoparticles can change the transport and thermal properties of the base fluid.

The aim of this review is to summarize recent developments in research on the stability of nanofluids, enhancement of thermal conductivities, viscosity, and heat transfer characteristics of alumina (Al□O□)-based nanofluids. The (Al□O□) nanoparticles varied in the range of 13 to 302 nmto prepare nanofluids, and the observed enhancement in the thermal conductivity is 2% to 36%.

Alumina (Al□O□) is the most common nanoparticle used by many researchers in their experimental works. Many efforts have been made to study the thermal conductivity of nanofluids. Generally, thermal conductivity of the nanofluids increases with increasing volume fraction of nanoparticles; with decreasing particle size, the shape of particles can also influence the thermal conductivity of nanofluids, temperature, Brownian motion of the particle, interfacial layer, and with the additives.

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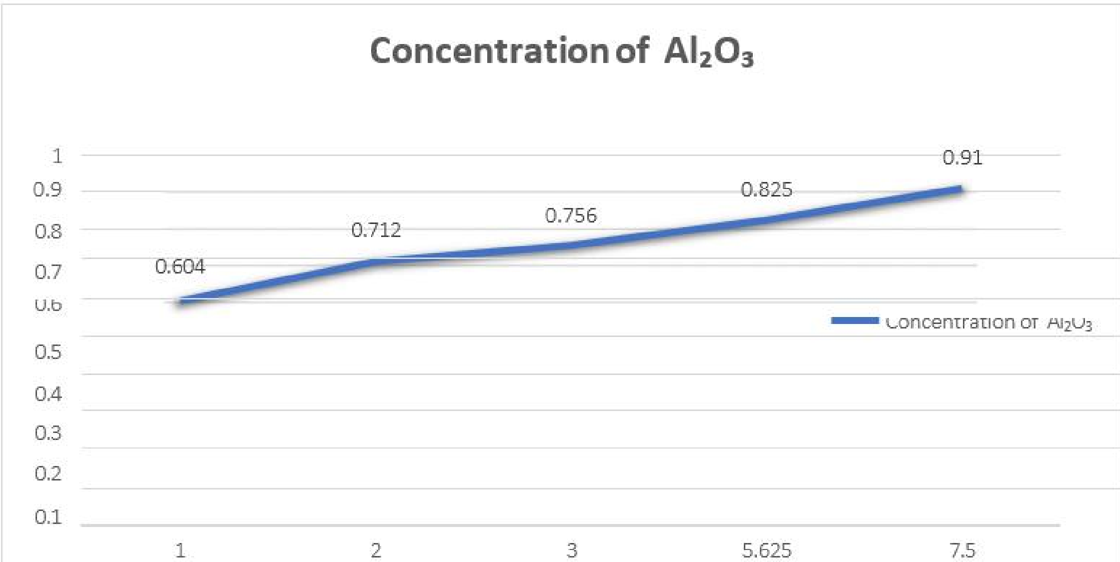
APPLICATIONS OF NANOFLUIDS

- **Electronic Cooling:** Advanced electronic devices like computers, laptops often face over heating challenges from high level of heat generation from relatively compact area.
- **Heat Exchangers and Boilers:** Nanofluid technology may help to accelerate the development of energy- efficient heat exchangers. Application of CNT-water nanofluids can increase the heat transfer rate in home commercial boilers
- **Automobiles**: Smaller coolant system results in smaller and lighter radiators which lead to decrease engine weight to some extent. Lighter engine component can also increase fuel efficiency in cars and trucks.
- **Thermal absorption systems:** Application of nanofluids in thermal absorption systems is good alternative to increase the performance of absorption system. Researchers showed that by adding nanoparticles such as Cu, CuO.
- **Solar water heater:** Nanofluid technology can also be applied in the solar water heating purpose. Efficiency of a DAC using nanofluids has 10 % higher efficiency than conventional flat plate collectors

VII.RESULT

- The obtained value of the thermal inductivity of water 0.8146 W/m K at temperature of 85°C. The standard value of the thermal conductivity of water at 85 °C is 0.71457 W/Mk
- The obtained value of thermal conductivity of Aluminium Oxide (Al□O□) at 1.0% concentration is 0.604 W/mK
- The obtained value of thermal conductivity of Aluminium Oxide (Al□O□) at 2.0% concentration is 0.712 W/mK
- The obtained value of thermal conductivity of Aluminium Oxide (Al□O□) at 3.0% concentration is 0.756 W/mK
- The obtained value of thermal conductivity of Aluminium Oxide (Al□O□) at 5.625% concentration is 0.825 W/mK
- The obtained value of thermal conductivity of Aluminium Oxide (Al□O□) at 7.5% concentration is 0.914 W/Mk



VIII.CONCLUSION

- The standard value of thermal conductivity of water is 0.8146 W/mK.
- Value of thermal conductivity of water obtained is 0.71457 W/mK.
- The thermal conductivity of Aluminium oxide is determined.
- As the time increases thermal conductivity tends to decrease.

IX.FUTURE SCOPE OF THE PROJECT

- Thermal conductivity of different nanofluids at different temperature and concentration can also be determined.
- Enhancement of thermal conductivity of water can be achieved by adding nanoparticles.
- Computational fluid dynamics analysis also can be performed.
- Improving heat transfer efficiency.

REFERENCES

[1] Hosni I. Abu-Mulaweh& Donald W. Mueller, Jr determination of the thermal conductivity of fluids.
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