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Design, Manufacture and Testing of Shell and Tube type Heat Exchanger using Nanofluid

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ABSTRACT

Cooling is indispensable for maintaining the desired performance and reliability very huge variety of product like car, computer, high power laser system. Whenever there is a increase the heat load and heat fluxes caused by more power and smaller size for these product cooling is one of the technical challenge faced by the industries like as microelectronics, transportation, manufacturing. There are many single-phase liquid cooling techniques such as micro channel heat sink and two-phase liquid cooling technology like heat pipes, thermosyphones, direct immersion cooling and spray cooling. Development of the nano materials technology has made it possible to structure a new type of heat transfer fluid formed by suspending nanoparticles (dia. < 100 nm).In conventional base fluid like water and ethylene glycol choi coined the term NANO FLUID to refer the thermal properties superior to those of their base fluids. Due to rapid fluid mixing effects strengthens the energy transport inside the nano fluids by modifying the temperature profiles. Experimental data indicates that particle size, volume fraction and properties of the nanoparticles influence the heat transfer characteristics of nano fluids. This paper shows the research work on Mini heat exchanger using Al2O3- Water Based nano fluid.

Keywords: NANO FLUID, Heat pipes, Al2O3.

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I. INTRODUCTION

Heat exchanger using nano fluid is a device in which the heat transfer takes place by using nano fluid. In this the working fluid is nano fluid. Nano fluid is made by the suspending nano particles in the fluid like water, ethylene glycol and oil, hydrocarbons, fluorocarbons etc.

1.1 Introduction to Nano Fluids

Nano fluid, first suggested by S.U.S. Choi of Argonne National Lab in 1995, innovative working fluid for heat transfer created by dispersing highly thermal conducting solid particles smaller than 50 nanometers in diameter in traditional low thermal conducting heat transfer fluids such as water, engine oil, and ethylene glycol.

1.2 Introduction to Heat Exchanger

It is an equipment which transfer the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs. The heat transfer in a heat exchanger usually involves convection on each side of fluid and conduction through the wall separating the two fluids.

1.3 Why we use nano fluid

The main goal or idea of using nano fluids is to attain highest possible thermal properties at the smallest possible concentrations (preferably<1% by volume) by uniform dispersion and stable suspension of nano particles (preferably<10 nm) in hot fluids. A nano fluid is a mixture of water and suspended metallic nano particles. Since the thermal conductivity of metallic solids are typically orders of magnitude higher than that of fluids it

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is expected that a solid/fluid mixture will have higher effective thermal conductivity compared to the base fluid.

II. LITERATURE SURVEY

[1]. L.B mapa et al: Measured enhanced thermal conductivity of Cu- Water based Nano fluid using a shell and tube heat exchanger. Where the dimensions of heat exchanger is 240X24X0.25mm, using 37 tubes. The outcome of analysis is rate of heat transfer is increases with increasing flow rate and also its concentration. By nanoparticle dispersed into de-ionized base fluid a better enhancement is achieved.

[2]. J.Koo et al: Investigated the nano particle collision and deposition in the surface wall with the help of micro channel heat sink. Which has the dimension of 1cm X 100micrometerX300micrometer; water-Cu and Cu-ethylene nanofluid are through micro channel heat sink. They are investigated the base fluid should posses high prandtle number and get enhanced heat transfer rate by minimize particle – particle, particle-wall collision. Viscous dissipation is important of narrow channel because Nusselt number high for high aspect ratio.

[3]. Shung-Wen Kang et al: Studied about the relation between thermal resistance- size of nanoparticle with the help of 211 micrometer X 2187 micrometer sized and deep grooved circular pipe and heat pipe maintain 40 temperature. They are finalized thermal resistance is directly proportional to the size of the nanparticle. Maximum reduction of the thermal resistance by using 10nm sized particle. Because particle size is increasing the walltemperature also increases. So small sized particle suitable for enhanced heat transfer rate. Thermal resistance is decreases with the increasing heat and concentration of nanoparticles.

[4] Shuichi Tori: Investigated convective heat transfer coefficient of diamond based nanofluid by using heat tube apparatus. Specification of tube is 4.3mm,4mm outer and inner diameter respectively, and applied 100W power uniformly. They are showed the heat transfer coefficient is increases with increasing concentration and Reynolds numbertofn Nano fluid, but at the same time increased the pressure drop with increasing concentration of nano particle.

[5]. S.J Kim et al: Investigated formation of porous layer and wet ability of nanofluid using critical heat flux experiment and SEM images. They are used three different types of nanoparticles with different diameters such as Al2O3 (110-220nm) SiO2(20-40nm) Zno(110-210nm). They are showed boiling is main factor to affect the heat transfer rate of nanofluid. Due to nucleate boiling nanoparticle deposited on wall, so the porous layer is formed on the wall. Porous layer directly consequence for creating wettablity, cavity and roughness of surface wall. So heat transfer rate decreased due to boiling of nanofluid.

[6]. PaisamNaphon et al: Investigated the thermal efficiency of heat pipe using titanium –alcohol Nanofluid, heat pipe dimensions are 60mm and 15mm length and outer diameter respectively. The Thermal efficiency increases with increasing tilt angle within 600 angle and concentration of nanoparitcle.

[7]. Anilkumar et al: Studied the heat transfer enhancement of fin, using Al2o3- water nano fluid analyzed using CFD. Reyleigh number increases due to Brownain motion, ballistic phonon transport, and clustering and dispersion effect of nanoparticle. At high Rayleigh number flow rate at center circulation is increasing, so temperature is drop from center of fin. Volume of the circulation increases the velocity at centre 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

[8]. Yu-Tung Chen: Investigated the thermal resistance of heat pipe using Al2O3 water nanofluid, heat pipe made as 200cmX3mm length and thickness respectively. Heat resistance is increases with increasing concentration of nano fluid up to 50ppm. Due to wet ability of nanoparticle various geometry wick is created on heat pipe.

[9]. Eed Abdel Hafez Abdel-hadi et al: Investigate the heat transfer analysis of vapour compression system using Cuo-R134a Nano fluid, test section made of copper horizontal tube and heat is applied 10-40 Kw/m Heat flux concentration and size particle is important factor to enhance the heat transfer rate of nanofluid. Heat transferrate increases with increasing heat flux, upto 55% of concentration of nanofluid and upto2.5nm sized particles.

III. HISTORY OF NANO FLUID

The twenty-first century is an era of technological advancement and has already seen dramatic changes in almost every industry.Nanotechnology is a broad and important area of research and development activity which has been growing explosively, worldwide, in the past few years. It has the potential for revolutionizing the ways in which materials and products are created and the range and nature of functionalities that can be accessed.

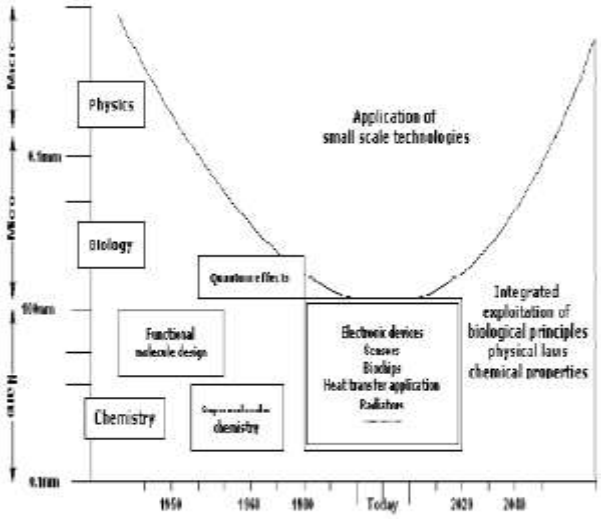

Figure 1: Small Scale Technologies and the Convergence of Sciences

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Above figure 1 shows the graph of the small scale technology and the convergence of the science which is shows that In addition, market demands for higher work load and capacity have also increased and brought about technical advances. When introducing the topic of nano scale science and nanotechnology, it is traditional quoted from the visionary lecture entitled "There's Plenty of Room at the Bottom" by the Nobel Prize-winning physicist Richard Feynman in 1959.

3.1 HISTORY OF HEAT EXCHANGER

As early as 1950, aluminium heat exchangers made moderate inroad into the automotive industry. With the introduction of the vacuum brazing technique, large scale production of aluminium-based heat exchangers began to flourish. Significant growth in the use of aluminium heat exchangers resulted from advantages of the controlled atmosphere brazing process (Nocolok brazing process introduced by ALCAN). Additional demands for aluminium heat exchangers resulted primarily from the growth of automobile air conditioning systems and new applications due to the increasing engine performance. Introduction of “long life” (highly corrosion resistant) alloys further improved performance of aluminium heat exchangers.

A heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air.

IV. SYSTEM ANALYSIS

Principle of Operation

Heat exchangers work because heat naturally flows from higher temperature to lower temperatures. Therefore if a hot fluid and a cold fluid are separated by a heat conducting surface heat can be transferred from the hot fluid to the cold fluid. Where, Nanofluids are a new class of fluids engineered by dispersing nanometer sized materials (nanoparticles, nanofibers, nanotubes, nanowires, or droplets) in base fluids.

Analysis of Heat Exchanger

The thermal analysis of heat exchanger is made by taking outlet temperature of fluid and it is then related to independent parameters as follows,

$$T_{h,o}, T_{c,o} \text{ or } q = f\{Th,i, Tc,i, Cc, Ch, U, A, \text{flow arrangement}\}$$

Six independent and one variable which may be Th,o , Tc,o,or q dependent variable as given in the above equation for a given flow arrangement transferred into two independent and one dependent groups which are dimensionless. By combining Differential energy conservation equations for the control volume we get

$$dq = q''dA = -C_h\, dT_h = \pm C_c\, dT_c\,.$$

Where, sign depends upon whether dTc is increasing or decreasing with increasing dA or Dx(i.e cross sectional surface area and length). The overall rate of heat transfer equation on a differential base for the surface area dA is

$$dq = q''dA = U(T_h - T_c)_{local}\, dA = U\Delta T dA.$$

Integrating the two above equations across the heat exchanger surface area, we get

$$q = C_h\,(T_{h,i} - T_{h,o}) = C_c(T_{c,o} - T_{c,i})$$

$$q = UA\Delta T_m = {}^{\Delta Tm}/_{Ro}$$ Where, 3rd

parameter is the actual mean temperature difference that depends upon the exchanger flow arrangement and degree of fluid mixing within each fluid stream.

Mechanisms of Heat Conduction of Nano Fluid

Nano fluid is nothing but fluid particles which are less than even a micron(nearly 10-9 times smaller) in diameter and highly reactive and efficient material which can be used to increase factor like rate of reaction, thermal conductivity of any metal or material, they are that much reactive and strong. Keblinski presented four possible methods in nano fluids which may contribute to thermal conduction.

(a) Brownian motion of nano particles.
(b) Liquid layering at the liquid/particle interface.
(c) Ballistic nature of heat transport in nano particles.
(d) Nano particle clustering in nano fluids.

Preparation of Nano Fluid

Nano fluids are mainly made up of metals, oxides, carbides and carbon nano tubes that can easily be dispensed in heat transferring fluids, such as water, ethylene glycol, hydrocarbons and fluorocarbons by addition of stabilizing agents.

V. FUTURE SCOPE

In future, the next step in the nano fluid research is to concentrate on the heat transfer enhancement and its physical mechanism, taking into consideration items such as the optimum particle size and shape, particle volume concentration, fluid additives, particle coating and base fluid. Important features for commercialization must be addressed, including particle settling, particle agglomeration, surface erosion and large scale nanofluid production at acceptable cost.

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5.1 Scope of Nanotechnology in India:
India is still in the development stage for Nanotechnology and it will take quite a few years for this field to become established in India. Research labs and institutions such as IISc, TIFR, NCBS, IITsetc are performing excellent research in India. However, when compared with countries such as UK, Germany and USA, output of high quality research pales significantly. This is due to several reasons such as lack of integration between different departments for R&D in Nanotechnology. On the other hand, students interested in working in the Nanotechnology industry have limited options.

5.2 Scope of Nanotechnology Abroad:
Nanotechnology is doing very well abroad in nations such as USA, UK, Singapore, Germany, China etc in terms of R&D. There has been significant development towards the usage of Nanotechnology in cosmetics, food and textiles. Nanomedicine is still in the R&D stage and widespread growth is yet to be expected and intensive research is being conducted in breakneck speed.

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