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A Review Paper on "Analysis of heat transfer co-efficient of concentric tube type heat exchanger by using Al_2O_3 nanofluid"

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ABSTRACT

It has been found from the literature survey that the heat transfer properties of conventional fluid can be enhanced by dispersing nanometer-size solid particles. Thus the research has been concentrated on the creating nanofluids using method and metal oxide nanoparticle. Here on, Al_2O_3-water fluid is taken as nanofluid while heat exchanger is concentric tube type and the heat transfer rate is studied of different volume concentration of nanofluid.

Keywords: Al_2O_3-water Nano fluid, Convective Heat Transfer, Concentric Tube Heat Exchanger

I. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact.

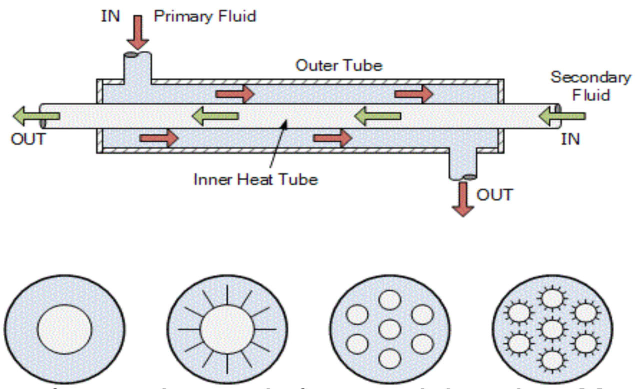

figure 1: working principle of concentric tube heat exchanger[1]

In other word we can say Fluids are often used as heat carriers in heat transferring equipment. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.

Application of the heat exchangers used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single- or multi component fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control a process fluid. Conventional fluids such as water, oil and ethylene glycol are widely used as cooling fluids. However conventional fluids are poor heat transfer fluids because of its poor conductivity [12]. But it is well known that metals in solid form have higher conductivity than liquids. Thus, the idea came into heat exchangers, but the particles must be in Nano size as mini & micro sized particles are prone to clogging into micro channels [9].

Nanofluid

Nanofluids are Nano scale colloidal suspensions containing condensed Nano materials. In other word A Nano fluid is a fluid containing Nano-meter sized particles called nanoparticles. They are two-phase systems with one phase (solid phase) in another (liquid phase) [3]. Nano fluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields [10].

Need of Nanofluids

- Due to Nano size particles, pressure drop is minimum.
- Higher thermal conductivity of Nano particles will increase the heat transfer rate.
- Successful employment of nanofluid will lead to lighter and smaller heat exchanger.
- Drastic change in the properties of the base fluid, by suspending nanofluids.
- Heat transfer rate increases due to large surface area of the Nano particles in the base fluid.
- Nanofluids are most suitable for rapid heating and cooling systems.

Due to Nano size particles, fluid is considered as integral fluid. Considering the heat transfer point of view, one of the most important challenge faced by the experts is the necessity to increase the heat flux and to reduce the size of the heat exchanger for the efficient use of the energy [10].

Nano technology is being considered for use in many applications to provide cleaner, more efficient energy utilization.

Maximizing the heat transfer area is a common strategy to improve the heat transfer and many heat exchangers such as radiators and plate and frame heat exchanger designed to maximize the heat transfer area. This strategy cannot be applied to the micro electro mechanical systems (MEMS).

Application of Nanofluids

Nanofluids can be used to improve heat transfer and energy efficiency in a variety of thermal systems. That's means can be used as a cooling fluid in many application and there is some common application:

1. Engine cooling
2. Nuclear cooling system
3. Cooling of electronic circuit
4. Refrigeration
5. Enhancement of heat transfer exchange
6. Thermal storage
7. Biomedical application
8. Cooling of microchips
9. In defence and space application
10. Transportation
11. Petroleum industry
12. Inkjet printing
13. Environmental remediation
14. Surface coating
15. Fuel additives
16. Lubricant

II. METHODS AND MATERIAL

Preparation Methods for Nanofluids

Various methods have been tried to produce different kinds of nanoparticles and nano suspensions. There are two primary methods to prepare nanofluids: A two-step method in which nanoparticles or nanotubes are first produced as a dry powder. The resulting nanoparticles are then dispersed into a fluid in a second step and Single-step nanofluid processing methods have also been developed and there is a novel method also mentioned in this section.

Two-Step Method

This method is the most widely used for preparing nanofluids. Nanoparticles, nanofibers, nanotubes, or other nanomaterials used in this method are first p reduced as dry powders by chemical or physical methods. Then, the nano-sized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, and ball milling. Two-step method is the most economic method to produce nanofluids in large scale, because Nano powder synthesis techniques have already been scaled up to industrial production levels. Due to the high surface area and surface activity, nanoparticles have the tendency to aggregate. The important technique to enhance the stability of nanoparticles in fluids is the use of surfactants. However, the functionality of the surfactants under high temperature is also a big concern, especially for high-temperature applications. Due to the difficulty in preparing stable nanofluids by two-step method, several advanced techniques are developed to produce nanofluids, including one-step method. In the following part, we will introduce single-step method.

One-Step Method

The nanoparticles may agglomerate during the drying storage, and transportation process, leading to difficulties in the following dispersion stage of two-step method. Consequently, the stability and thermal conductivity of nanofluid are not ideal. In addition, the production cost is high. To reduce the agglomeration of the nanoparticles, one-step methods have been developed. There are some ways for preparing nanofluids using this method including direct evaporation condensation [16, 17], chemical vapour condensation [18], and single-step chemical synthesis.

Other Novel Methods

Wei et al developed a continuous flow micro fluidic micro reactor to synthesize copper nanofluids. By this method, copper nanofluids can be continuously synthesized, and their microstructure and properties can be varied by adjusting parameters such as reactant concentration, flow rate, and additive. CuO nanofluids with high solid volume fraction (up to 10 vol%) can be synthesized through a novel precursor transformation method with the help of ultrasonic and microwave irradiation [19]. The precursor $Cu(OH)_2$ is completely transformed to CuO nanoparticle in water under microwave irradiation. The ammonium citrate prevents the growth and aggregation of nanoparticles, resulting in a stable CuO aqueous nanofluid with higher thermal conductivity than those prepared by other dispersing methods. Phase-transfer method is also a facile way to obtain monodisperse noble metal colloids [20]. Phase transfer method is also applied for preparing stable kerosene based Fe_3O_4 nanofluids. Oleic acid is successfully grafted onto the surface of Fe_3O_4 nanoparticles by chemisorbed mode, which lets Fe_3O_4 nanoparticles have good compatibility with kerosene [21]. In a water cyclohexane two-phase system, aqueous formaldehyde is transferred to cyclohexane phase via reaction with dodecylamine to form reductive intermediates in cyclohexane. The intermediates are capable of reducing silver or gold ions in aqueous solution to form dodecylamine-protected silver and gold nanoparticles in cyclohexane solution at room temperature. Fen get al. used the aqueous organic phase transfer method for preparing gold, silver, and platinum nanoparticles on the basis of the decrease of the PVP's solubility in water with the temperature increase [22].

Figure 2: Al_2O_3 nanoparticles (a)before sintering (b)after sintering

Experimental Setup

The system consists of a double pipe heat exchanger. The inner tube is made of copper and the outer tube is made of stainless steel. It consists of a heating unit to heat the water, and temperature measurement system. The temperature measurement system consists of 4 thermometers, placed at the inlet and outlet of the inner and outer tube respectively. The hot water flows through the inner tube and the Nano fluid/other fluid flows through the annulus. Each flow loop includes a pump with a flow control valve to maintain the required flow rate [1]. To design a project that could be used to transfer heat from hot water in a heat exchanger to Nano-fluid stored in a separate tank and make temperature calibrations for the same by employing two thermocouples. Also, flow metre will be installed in the pipes carrying Nano fluid to check its flowing rate. The complete system will be very dynamic and easy to use. Mechanical structured design is shown in Figure.

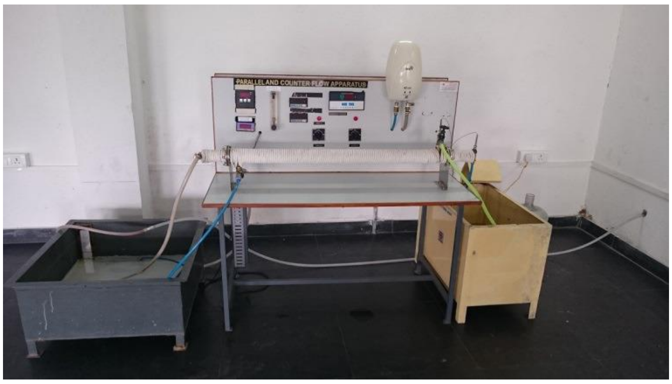

Figure 3: Experimental Setup

Experimental Procedure

The main switch is switched on and the console and heater are also turned on. The cold water from the reservoir is pumped to the heat exchanger by maintaining a constant flow rate. The hot water flow rate valve is kept open. After attaining steady state conditions, the inlet and outlet temperature readings of both the pipes are noted down from the temperature scanner which can be run manually or kept in auto mode. The flow rate of cold water is known with the help of a water flow sensor. The hot water flow rate can be adjusted according to the requirements with the help of a hot water flow meter. The readings of both hot and cold-water flow rates are noted down. This completes the first set of readings. Depending upon the requirement of the cold-water flow rate, next set of readings can be noted down.

III. LITERATURE REVIEW

1. Compression of the heat exchanger

From this literature we found out which heat exchanger we should use for our project, we read this literature to just get defined information about heat exchanger and to compare them. We came to know that under the same operating conditions, operating the same heat exchanger in a counter flow manner will result in a parallel flow. In actually most large heat exchanger are not purely parallel flow. Counter flow in cross flow they are usually combination of two or three typed of heat exchangers. The purpose behind this is to maximize the efficiency of heat placed on design.

2. A comparative study on thermal conductivity of Al_2O_3/water, cuo/water and Al_2O_3-cuo/water nanofluids

Author: (1) S. SENTHAILRAJA (2) R. GANGADEVI (3) K. VIJAYKUMAR (2015) has been identified that Thermal conductivity enhancement was observed in all type of nanofluids, so it could be said that nanofluids will be next generation heat transfer fluids. As the particle volume concentration in base fluid increases thermal conductivity is also got increased. The enhancement of thermal conductivity was about 6.1% for AL_2O_3/water nanofluid at 0.2 volt and thermal conductivity was also increased linearly with temperature.

3. Thermal property measurement of Al2O3+water nanofluid

Author: fei-duan (Year:2011) has been identified that We measured have a thermal conductivity, viscosity and surface tension of Al_2O_3+water based nanofluid. With increase in temperature thermal conductivity increase for certain volume concentration but viscosity is getting reduced. The viscosity increased up to 60% at volume concentration of 5%. The effect of particle size is on viscosity is limited. The addition of surface is believed to be reason behind the decrease in surface tension comparison with base fluid.

4. Numerical optimization of heat exchanger with circular and non-circular shape

Author: (1) Nigla E. Gharibi, (2) Abdethamid Kheiri, (3) Ryan Blanchard (Year-2015) has been identified that

Circular tube cause server separation and large works that leads to high pressure drops, non- circular tubes of streamlined shaper often relatively lower pressure drop.

From the result we could say that there is no best geometric shape valid a cross all flow conducting.

For Reynolds number Re>1.5 x 104, the circular shape can't be used a for Re>2.3 x 104 the elliptic shape is best.

5. A review on nanofluid: preparations, stability mechanism and application

Author: (1) Wei Yu (2) Hauging Xie (2011) has been identified that Nanofluids have very impressing applications but there are some vital hinders are also there which is required to be concentrated. Like increase in viscosity by the use of nanofluid is an important disadvantage because it may cause increase pumping power. It may be reduced by modifying interface properties of two face. Other one is stability of nanofluid is also debatable. Shape of additives is also the considerable factor as The properties of nanofluid depends on the shape of additives.

6. Design and construction of a concentric tube heat exchanger

Author: Folarami joshu coct (2009) has been identify that Design and construction of a concentric flow heat exchanger. in this paper the concentric tube heat exchanger was designed in order to study the process of heat transfer between 2 fluids through a solid partition.

It was designed for counter flow arrangement and LMTD method of analysis was adopted. Water was used as fluid for the experiment. The temp of hot and cold water supplied to equipment were 87 °c and 27°c respectively and the outlet temp of water after experiment was 73°c for hot &37°Cfor cold water. The heat exchanger was 74.3% efficient.

7. Evaluating performance or concentric tube heat exchanger with and without dimples by using CFD analysis

Author: Dr. syed azam pasha and undari (year-2016) has been identified that the dimpled tube concentric flow heat exchanger is more efficient than the heat exchanger without simple tube.

IV. RESULTS AND DISCUSSION

Al_2O_3-water nanofluid is prepared at different volumetric concentration by using probe sonicator. For the stability of nanoparticles. Surfactant is added to the nanofluid. The experiment is conducted before the particles are settled down for different flow rates of nanofluids and different volume fractions of nanoparticles [9]. The experimental overall heat transfer coefficients are calculated using the procedure given below:

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

Where,

$\Delta T_1 = Th_i - Tc_i$ and $\Delta T_2 = Th_o - Tc_o$; Tc_i is the cold-water inlet temperature, Tc_o is the cold-water outlet temperature, This the hot water inlet temperature and Th_o is the hot water outlet temperature the heat transfer rate (Q) can be calculated by [8],

$$Q = m_h\, c_{ph}\, (T_{h1} - T_{h2})$$

Where,

m_h= mass flow rate of hot fluid

Cp_h=Specific heat of hot fluid

It is observed that the overall heat transfer co-efficient is increased with the volume fraction of nano particles (Al_2O_3) in water [6]. It is due to thermo conductivity of water with the addition of nano particles and also due to increase in heat transfer to the cold fluid due to random motion of nanoparticles suspended in water and availability of larger surface area with nano sized particles. The thermal conductivity of nanofluid depends on thermal conductivity of both base fluid and nanoparticles material, volume fraction of nanoparticles, surface area of nanoparticles and shape of nanoparticles in the liquid. Qasim S. Mahdi and Ali Abdulridha Hussein [13] developed a model for the effective thermal conductivity of two-component mixture.

V. CONCLUSION

For the stability of nanoparticles 10% of surfactant is added to the nanofluids. The experiment is conducted in a double pipe heat exchanger [6]. Before conducting the experiment, the heat exchanger is calibrated and then Al_2O_3 nanofluid is sent through annulus and readings are noted down. The nanofluid readings are compared with base fluid readings (water). The overall heat transfer coefficient for Al_2O_3-water nanofluid is increased by 17% with the volume fraction of 0.5% of nanoparticles compared with water [7]. The increase in heat transfer coefficient is due to increase in thermal conductivity of water with the addition of nanoparticles, and also due to increase in heat transfer to the cold fluid due to random motion of nanoparticles suspended in water and availability of larger surface area with nano sized particles.

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