Experimental Investigation of Water Based Copper and Aluminium Particles Nano Fluid

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ABSTRACT

In this paper, study over water-aluminium-copper nano fluid is presented. The specific thermal capacity of aluminium and copper is 900 J/kg °C and 385 J/kg °C. For Different volume fractions of aluminium and copper nano particles in water (base fluid) were experimentally studied for their heat transfer performance. An experimental setup was prepared for testing which resembles a heat exchanger. Hot water and nano fluid were used as tube side and shell side fluids respectively. Volume fractions of 5%, 10%, 15%, 20% and 25% were studied. Relationship between specific heat capacity and volume fraction of nano particle in nano fluid has been explored. When volume fraction increases specific heat capacity of nano fluid also increases.

Keywords:

1. INTRODUCTION

Nano fluid research is increased day by day. Literature review shows that research over nano fluid is in heat transfer applications such as condenser, evaporator and refrigeration. Nano fluid is made of liquids and nano particles of metals, metal oxides and non-metals. Liquids in which nano particles are added is called base fluid. Liquids such as water, coolant oils, ethylene glycol and refrigerants are used as base fluids in literatures. Copper oxide, alumina, silver and platinum nano particles are studied. Metal particle fluids give better results than metal oxide fluids [1]. Steel, copper, brass and aluminium are readily available metals.Aluminium and copper oxides are studied in literatures [2], [6], [12].

Silver and platinum metals also studied in some literatures [7], [8], [9] and [11]. They are costlier.Therefore, this work is for studying performance of aluminium and copper nano particles in water based nano fluid.Some of metal oxides are used along with other metal oxides in nano fluid research [1]. Here, copper and aluminium particles are mixed in water simultaneously in equal fractions. Nano particles are increasing heat transfer performance of base fluid, it is proven thing. Therefore, properties of nano fluids are concern of latest researches. Here, we have focused on specific heat capacity of water-copper-aluminium nano fluid.

2. LITERATURE REVIEW

Jacqueline Barber et. al presented a review on heat transfer enhancement with nano fluids. This paper presents recent advances in nano fluid research. It provides table of summary of nano fluid research regarding type of nano particles, base fluids and their properties with performance. It reviews papers from year 2003 to 2010 [1]. Bang I.C. et. al presented studies over alumina-water nano fluid for different volume fractions and compared with boiling characteristics of pure water.The experimental results show that these nano-fluids have poor heat transfer performance compared to pure water in natural convection and nucleate boiling. On the other hand, CHF has been enhanced in not only horizontal but also vertical pool boiling [2].

Chopkar M. et. al studied pool boiling heat transfer characteristics of ZrO_2–water nano fluids from a flat surface in a pool. In case of pool boiling, increase in volume concentration of nano particles decreases heat transfer [3].Das S.K. et. alsaid that with lower size and fractions of nano particles the thermal conductivity and convective heat transfer capability of these suspensions are significantly enhanced without the problems encountered in common slurries such as clogging, erosion, sedimentation and increase in pressure drop. Nano fluids aren't suitable for two phase flows. Therefore, it results in poor pool boiling characteristics [4].

Kim H.D. et. al studied CHF characteristics of nano-fluids such as TiO_2 and Al_2O_3 particles in water [5].Kannadasan N. et. al presented Comparison of heat transfer and pressure drop in horizontal and vertical helically coiled heat exchanger with CuO/water based Nano fluids. Experiments are conducted with 0.1 and 0.2% volume concentrations. The experimental results show that there is no much difference between horizontal and vertical arrangements in the enhancement of convective heat transfer coefficient and friction factors of Nano fluids compared to water [6]. Kimura Y. et. al presented synthesis of platinum nano-particles in high-temperature and high-pressure fluids [7]. Kang S.W. et. al presented experimental investigation of silver nano-fluid on heat pipethermal performance[8].

Lin Y.H. et. al studied effect of silver nano-fluid on pulsating heat pipe thermal performance [9].Li D. et. al presented properties and preparation of copper nano fluid with based fluid as oil [10].Li D. et. al presented another work of preparation and stability of silver/kerosene Nano fluids [11].Raveshi M.R. et. al presented experimental investigation of pool boiling heat transfer enhancementof alumina–water–ethylene glycol Nano fluids. Six different volume concentrations of the Nano fluids have been used to evaluate the impact of nano particles on nucleate boiling heat transfer of binary mixture of water and ethylene glycol with a same volume concentration. The results show the high effectiveness of the nanoparticles on heat transfer coefficient. In addition, the experimental results indicate that there is an optimum volume concentration of nanoparticles, in which the heat transfer coefficient has its maximum value. Furthermore, the optimum volume concentration of nano particle and the maximum increment of boiling heat transfer coefficient in the present study are 0.75% and 64%, respectively [12].

3. EXPERIMENTAL TESTING

3.1 Methodology

For our study, an experimental setup is fabricated. Nano fluid is in stagnated state and water is pumped thorough a closed circuit by electric pump. Flow of water is controlled by flow control valve and rate is measured by calculating time of filling of a container. Inlet and outlet temperature of water is measured using thermo couples to calculate heat transfer using following formula:

$$Q = m_w * C_{pw} * (Tw_1 – Tw_2)$$

Q – Heat transfer

m_w – mass flow rate of water (Kg / s)

C_{pw}– Specific heat capacity (KJ / Kg.°C)

Tw_1 – Inlet Temperature of water (°C)

Tw_2– Outlet Temperature of water (°C)

From this heat transferfrom per kilogram water is found out. Initial and final temperature of nano fluid is measured on each experiment. These data are enough to find specific heat capacity of each volume fractions of nano fluid. Mass of Nano fluid is known. Therefore, specific heat capacity of nano fluid is found from following formula:

$$Q / (T_{nf\,1} - T_{nf\,2}) = C_{pnf}$$

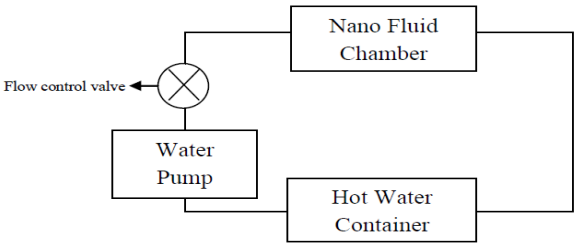
Q – Heat transfer

C_{pnf}– Specific heat capacity (KJ / Kg.°C)

$T_{nf\,1}$ – Initial Temperature of Nano Fluid (°C)

$T_{nf\,2}$ – Final Temperature of Nano Fluid (°C)

3.2 Experimental Setup



Fiureg3.1 Experimental Setup – Block Diagram

Figure3.2 Experimental setup

Centrifugal pump is used for circulate water, it collects hot water from container and circulates through pipe. Then, water is delivered to cold water tank. Pump configuration for experiment is as follows:

Speed (S) : 2880 Rpm

V & I : 230Volt @ 3.2 Amps (Current)

Power (P) :0.5HP

Head (H) :20m

Discharge (Q) :16 LPM

Valve is used to control the flow in the pipes. An open type ball valve will be used in this experiment. In this experiment, flow rate is reduced for stagnating water in Nano-Fluid chamber. Same flow rate will be used for all experiments. GI pipes with 1 inch diameter are used to circulate the water. Pipe joints and fittings are used wherever required. Pipe line will go through Nano-Fluid chamber to transferring heat from hot water to Nano-fluid. It contains Nano-Fluid made up of water, copper and aluminium. Nano-fluid is static in it and absorbs heat from water which circulated through pipe. Dimensions of chamber are 457.2mm * 228.6mm *304.8 mm. It is made up of galvanized iron.

Hot water is stored in a container. Water is travelled in a closed circuit while experiment. Thermo couple is used to measure temperatures wherever required. Nano-fluid is prepared by mixing nano particle of size 95nm with water in a proportion. Nano particles are made up of aluminium and copper. Nano-particle fractions are 5%, 10%, 15%, 20% and 25% of volume of water. Electrical heating coil with maximum capacity of 1500 W is used to heat water which is to be pumped. Water is heated up to 60°C because there will be chance to boiling nearby heating coil in water if we like to increase temperature more.

3.3 Testing

Water was filled in the container which has heating coil to heat water. After water reached 60°C, pump is switched on to circulate hot water through nano fluid chamber. Initially, nano fluid's initial temperature is measured before circulate hot water. Hot water is circulated for 5 min to all experiments. Inlet and outlet temperature of water at nano fluid chamber is measured. Then, circulation is stopped and final temperature of nano fluid is measured. To prevent deposition of nano particle in chamber, stirring was done during experiment using stirring stick.

3.4 Nano Fluid Preparations

Nano fluid is prepared by mixing nano particles of aluminium and copper with water. Nano particle size of 700nm is used in this experiment. Nano fluid container size is 6 in * 7 in * 7 in. It contains 4.8 litters of water. Mass of particles is taken which is equal in volume fraction as mentioned 5-25% because density of powder is known.

Table 1 Quantity of Copper Particle Used

V.F (%)	Density (Kg/m^3)	Volume in litters	Volume in m^3 / s	Mass Equivalent to Volume Fraction (grams)
5	1618	0.24	0.00024	388.32
10	1618	0.48	0.00048	776.64
15	1618	0.72	0.00072	1164.96
20	1618	0.96	0.00096	1553.28
25	1618	1.2	0.0012	1941.6

Table 2Quantity of Al Particle Used

V.F (%)	Density (Kg/m^3)	Volume in litters	Volume in m^3 / s	Mass Equivalent to Volume Fraction (grams)
5	705	0.24	0.00024	169.2
10	705	0.48	0.00048	338.4
15	705	0.72	0.00072	507.6
20	705	0.96	0.00096	676.8
25	705	1.2	0.0012	846

Figure3.3 Copper Powder

Figure3.4 Aluminium Powder

4. RESULT AND DISCUSSION

Experimental data is used to find specific heat capacity of nano fluid.5% of volume fraction gives poor result than water. When volume fraction increases specific heat capacity of nano fluid also increases. It is given in tables. Specific heat capacity of copper and aluminium is lower than water but nano fluid gives better result than water. Volume fractions of 5%, 10%, 15%, 20% and 25% were studied.

Table 3Heat transfer Vs Volume fractions

Heat Transfer (J/Kg)	Volume Fraction (%)
8240	5
11124	10
13184	15
16068	20
17716	25

Table 4Specific Heat Capacity Vs Volume fractions

Volume Fraction (%)	Specific Heat Capacity (J/Kg.K)
5	2942.85
10	4836.52
15	6278.095
20	9451.76
25	13627.69

Curve fitting is done using experimental data in scientific computing tool MATLAB. From that, specific heat capacity of water-copper-aluminium nano fluid as a function of volume fraction of nano particles in base fluid is obtain.Fitted curve and function is given below. In this relation x is volume fraction and f(x) is the dependent specific heat capacity of nano fluid, the coefficient are determined to polynomial curve fitting method with R-Square equal to 1. This function can be used to find specific heat capacity of nano fluid from range of 5% - 25%.

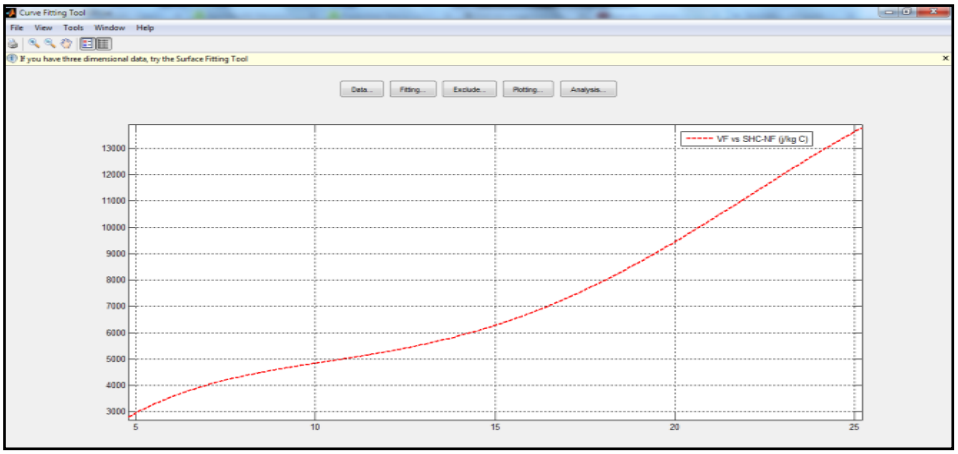


Fig. 3 Volume Fraction Vs C_p of Nano fluid (fitted curve)

$$F(x) = p_1x^4 + p_2x^3 + p_3x^2 + p_4*x + p_5$$

Coefficients:

p1 = -0.1943

p2 = 12.63

p3 = -266.4

p4 = 2529

p5 = -4501

5. CONCLUSION

In this paper, study over water-aluminium-copper nano fluid is presented. Different volume fractions of aluminium and copper nano particles in water (base fluid) were experimentally studied for their heat transfer performance. Due to the increase of surface area of the nanoparticles added, the specific heat capacity is also increased and thus higher heat is transferred. When volume fraction increases specific heat capacity of nano fluid also increases. It is tiny step in hybrid metal nano fluid research. Here, specific heat capacity is explored through experiment. Other properties of nano fluid are future concern of this project.

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