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Research Paper

TO CONDUCT THE PERFORMANCE TEST ON CHILLER UNIT BY USING NANOFLUID COOLED CONDENSER

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Now a day's man needs a sophisticated life with minimal economy and Branded materials made up of high précised components cost more which replicate the price of the machine/ components. Low cost with high performance is the most expected from all categories of people. Industries also follow the same concept of cost cutting and moves to material selection which gives high economic turn over. The Nano component promises the above concept. They are various researches on Nano materials gave way to improve the quality of existing working equipment's. In this work the performance test of chiller unit by using Nano fluid (TiO_2) and water cooled condenser. The Water and Nano fluid (TiO_2) served as the working fluid with the concentrations by volume 2 g/L. The condenser is double tube type condenser the outer shell is made by the PVC pipe and inner tube is made by copper. It contains eight shells and one pass. The performance was checked by varying the flow rate of water and Nano fluid in the condenser.

Keywords: Nano materials, Nano fluid (TiO_2-Titanium oxide), Water, Condenser, Chiller

INTRODUCTION

Nano fluids are a new class of fluids engineered by dispersing nanometre-sized materials (nanoparticles, Nano fibres, nanotubes, nanowires, Nano rods, Nano sheet, or droplets) in base fluids. In other words, Nano fluids are Nano scale colloidal suspensions containing condensed nanomaterial. They are two-phase systems with one phase (solid phase) in another (liquid phase). 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.

In this paper, we will review the new progress in the methods for preparing stable Nano fluids and summarize the stability mechanisms. In recent years, Nano fluids have

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attracted more and more attention. The main driving force for Nano fluids research lies in a wide range of applications. Although some review articles involving the progress of Nano fluid investigation were published in the past several years (Wei Yu andHuaqing Xie, 2012; Adnan Hussein *et al.*, 2013; Akhtari *et al.*, 2013; Jaafar Albadr *et al.*, 2013; Sayantan Mukherjee and Somjit Paria, 2013; and Senthilraja and Vijayakumar, 2013), most of the reviews are concerned of the experimental and theoretical studies of the thermo physical properties or the convective heat transfer of Nano fluids.

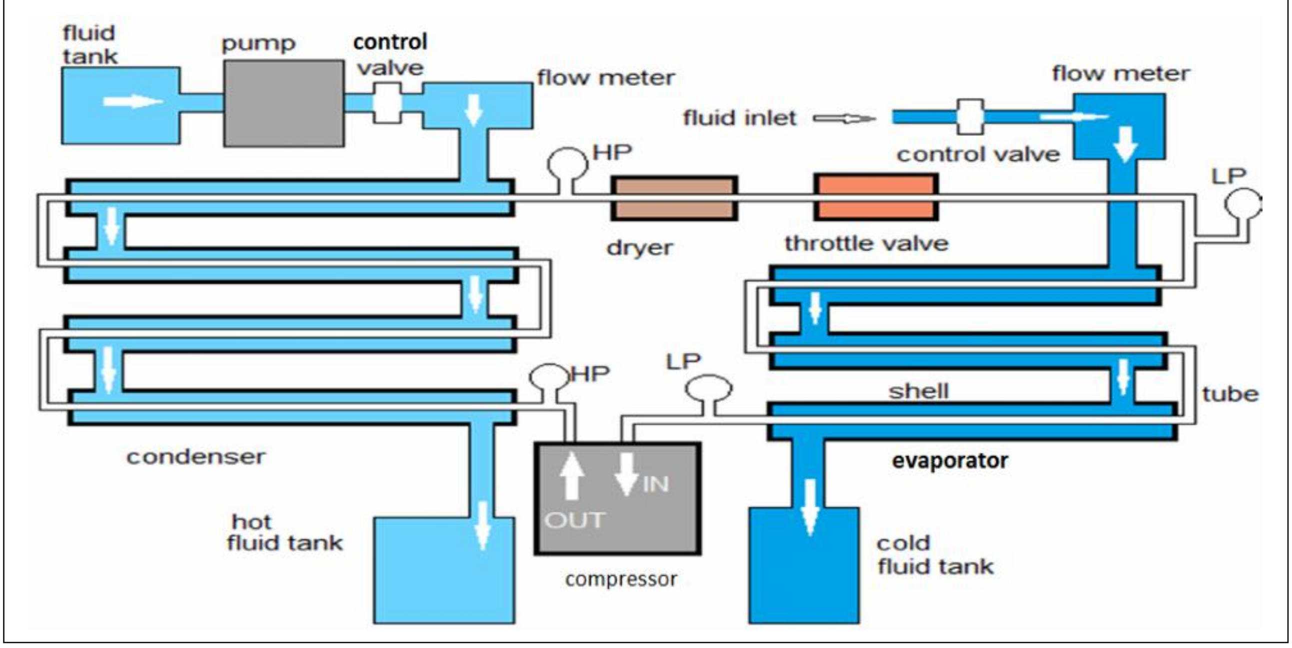
The purpose of this paper will focuses on the new preparation methods and stability mechanisms, especially the new application trends for Nano fluids in addition to the heat transfer properties of Nano fluids. We will try to find some challenging issues that need to be solved for future research based on the review on these aspects of Nano fluids.

EXPERIMENTAL SETUP

The figure shows a schematic diagram of the experimental setup. It consists of double pipe condenser and double pipe evaporator. The condenser and evaporator consist of single pass and eight shells. The condenser and evaporator shell is made by PVC pipe, copper tube pass inside the shell. The counter flow arrangement is passed to the shell. The fluid will flow inside the shell it should be controlled by control valve and its flow measured by the flow meter. The pump is sucks the fluid in the tank and it passed to the shell. The refrigerant 134a is used as a refrigerant it will compressed by compressor, the refrigerant was flow with high temperature and pressure. The temperature and pressure should be measured by pressure sensor and temperature sensor.

The evaporator section water will flow inside the shell, due to the forced convection process it will release the heat to the refrigerant and

Figure 1: Layout of the Experimental Setup



water becomes cooled and it will store in the tank. The condenser unit TiO_2 and water based Nano fluid is used to absorb the heat from the refrigerant. The inlet and outlet temperature of shell should be measured by temperature sensor.

PREPARATION OF NANO FLUID (TIO_2)

- Preparation of Nano lubricants is the first step in the experimental studies on Nano refrigerants. Nano fluids are not simply liquid solid mixtures. Special requirements are even, stable and durable suspension, negligible agglomeration of particles, and no chemical change of the fluid. Nano fluids can be prepared using single step or two step methods.
- In the present study two step procedures is used. Commercially available nanoparticles of Titanium oxide (manufactured by Sigma Aldrich) with average size <50 nm and having density 0.26 g/cc were used for the preparation of Nano lubricant. Mass fraction of nanoparticles in the nanoparticle-lubricant mixtures is 0.06%.
- An ultrasonic vibrator (Micro clean 102, Oscar Ultrasonic) was used for the uniform dispersion of the nanoparticles and it took about 24 hours of agitation to achieve the same.
- Experimental observation shows that the stable dispersion of alumina nanoparticles can be kept for more than 3 days without coagulation or deposition.

THEORETICAL ANALYSIS

In order to estimate the heat transfer coefficient in the refrigerant side of the evaporator the thermophysical properties of the nano refrigerant have to be calculated are given below,

Figure 2: Photographs of Nano Fluid: (a) Mixture of TiO_2 and Base Fluid in Conical Chamber, (b) Ultrasonic Vibrator Experiments

(a) (b)

Heat Transfer Coefficient in Refrigerant Side

The heat transfer coefficient of the hot solvent flowing inside the tube under the turbulent region

From Dittus-Boelter equation, fully developed flow:

$$Nu_h = 0.023 Re_{Di}^{0.8} Pr^n \quad ...(1)$$

$n = 0.4$ for heating the fluid

$n = 0.3$ for cooling the fluid

From the previous equation the Reynolds number and prandtl number are calculated considering the hot solvent properties as follows:

$$Re_h = (°_h\, v_h\, di)/«_h \quad ...(2)$$

$$Pr_h = («_h\, c_{p,h})/k_h \quad ...(3)$$

$$Nu_h = (h_h\, d_0)/k_h \quad ...(4)$$

Properties

The volume concentration of nanoparticle:

Volume concentration = $(w_{tio2}/°_{tio2})/(w_{tio2}/°_{tio2} + w_{bf}/°_{bf})$

The weight of titanium oxide = 25 gram

The weight of base fluid = 6 litre

Volume concentration = 0.1%

Thermo physical properties

The density of Nano fluid = 1326 kg/m^3

The specific heat of Nano fluid = 4.95 kJ/kg k

Viscosity of Nano fluid =1.252 × 10^{-3} kg/ m^{-1}s^{-1}

Thermal conductivity of Nano fluid = 0.75 w/mk

Heat Transfer Coefficient of Water Side

The heat transfer coefficient of the cold solvent flowing inside the tube under the turbulent region

From Dittus-Boelter equation, fully developed flow

$$Nu_c = 0.023 Re_{(Do-Di)}^{0.8} Pr^n \quad ...(5)$$

$n = 0.4$ for heating the fluid

$n = 0.3$ for cooling the fluid

From the previous equation the Reynolds number and prandtl number are calculated considering the hot solvent properties as follows:

$$Re_c = (°_c\, v_c (d_o - d_i))/«_c \quad ...(6)$$

$$Nu_c = h_c (d_o - d_i)/k_c \quad ...(7)$$

$$Pr_c = («_c c_{p,c})/k_c \quad ...(8)$$

C.O.P is Calculated

The theoretical C.O.P is calculated using the equation

$$C.O.P_{th} = (h_1 - h_4)/(h_2 - h_1) \quad ...(9)$$

h_1 – enthalpy of refrigerant at the inlet of the compressor

h_2 – enthalpy of refrigerant at the outlet of the compressor

h_4 – enthalpy of refrigerant at the inlet of the evaporator

- The values of the enthalpy are taken from refrigerant tables.
- The actual C.O.P is calculated using relation $C.O.P_{act} = cooling\ load/power\ input$

RESULTS

In the present experimental study are have been considered

Table 1: The Condenser will Cooled by Nano Fluid

Parameter	Performance-1	Performance-2	Performance-3
Temp of refrigerant compressor outlet (°C)	52	50	47
Temp of refrigerant compressor inlet (°C)	11	11	12
Nanofluid inlet temp in condenser (°C)	28	28	28
Nanofluid outlet temp in condenser (°C)	33	32.9	31.5
Flow rate of water (lit/hr)	200	300	400
Temp of refrigeration before throttling (°C)	41	39	38
Temp of refrigeration after throttling (°C)	6	5	3

Table 2: The Condenser will Cooled by Water

Parameter	Performance-1	Performance-2	Performance-3
Temp of refrigerant compressor outlet (°C)	50	47	45
Temp of refrigerant compressor inlet (°C)	10	13	15
water inlet temp in condenser (°C)	30	30	30
water outlet temp in condenser (°C)	34	32.8	32
Flow rate of water (lit/hr)	200	300	400
Temp of refrigeration before throttling (°C)	43	40	38
Temp of refrigeration after throttling (°C)	7	5	3

They are different set of readings are note down for the tabular column are given below the condenser was cooled by Nano fluid and water.

Figure 3: Flow Rate vs h_o

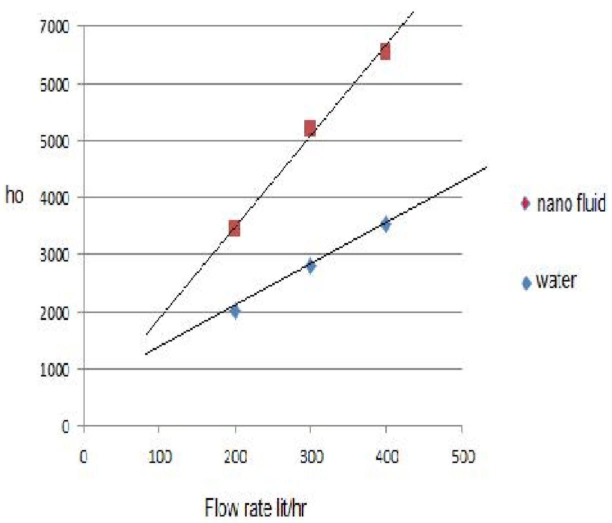


Figure 4: Nu vs Re

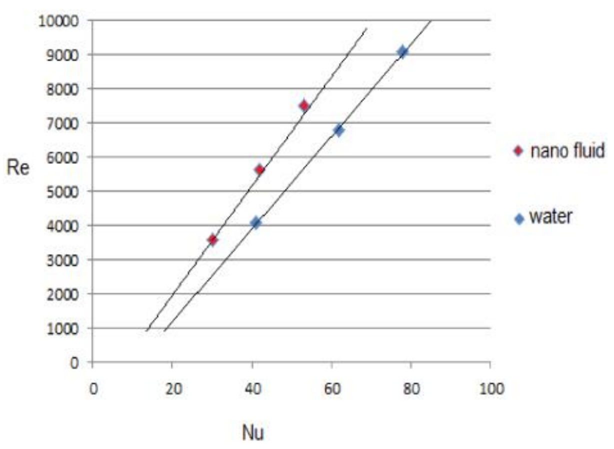
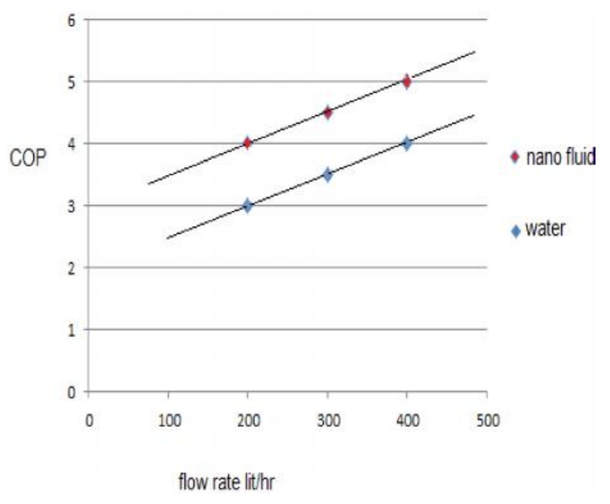


Table 3: COP

S. No.	Flowrate	Cop (Nanofluid)	Cop (Water)
1.	200	3.5	3
2.	300	4.2	3.3
3.	400	5	4

Figure 5: Flow Rate vs COP



CONCLUSION

The performance test of chiller was conducted by using Nano fluid and water cooled condenser. TiO_2 Nano powder 100nm was mixed with distilled water by using sonication process. The titanium oxide water based Nano fluid was properly stabilized. The experimental result shows the COP of chiller unit is increased when using Nano fluid compared to the base fluid. The flow rate is increases and performance also is increases.

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APPENDIX

Nomenclature	
K	Thermal conductivity
r_o	Outer radius of tube
r_i	Inner radius of tube
L	Length of the tube
h_o	Heat transfer coefficient outer surface
h_i	Heat transfer coefficient inner surface
Nu	Nusselt number
Re	Reynolds number
Pr	Prandtl number