

# Heat Transfer Study on Fan Coil Unit Of Water Chiller With Nanofluid $Al_2O_3$ as Chilled Water

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**Abstract**— Heat exchanger has wide use in many application such as in food industries, chemical, transportation, and refrigeration and air conditioning. Fan coil unit (FCU), one class of heat exchanger which is heat transfer occur by chilled water flowing across a series of finned tube bank for decreasing the air temperature to be cooled. Thermal conductivity of working fluid in heat exchanger was the main issue recently. Enhancement of convective heat transfer and thermal conductivity of working fluid made possible by mixing nanosize particle into base fluid. The aims of this research is to revealed the enhanced of heat transfer by nanofluid  $Al_2O_3$  on FCU unit of chiller system. 0,2% of nanoparticles were added to chilled water. The analysis shows that added small part of nanoparticles induced heat transfer. The total heat transfer enhancement of nanofluid chilled water was about 8.0% - 11.1% compare to that of chilled water without nanoparticles. Finally, the application of nanoparticles give benefit of heat transfer process.

**Keywords**— FCU; heat transfer; nanoparticles;  $Al_2O_3$ -water nanofluid

## I. INTRODUCTION

Heat exchanger plays an important role in energy transfer, conservation, conversion and recovery. Their function for handling the thermal energy in many industrial applications, such as refrigeration and air conditioning power plants, waste heat recovery, chemical, automotive, food handling and many other application [1-3]. Inlet and outlet temperature of heat exchanger and mass flowrate of each fluid became two important parameters to see the heat exchanger performance. Another reason to consider the heat exchanger application is ratio of heat transfer and dimension of itself. Special attention has been given to designing small but efficient methods of heat transfer [4-5]. To accomodate this reason, many technique has been developed especially passive technique. One of this method is suspended small part of nanoparticles to the basic fluid became nanofluid. As a new form of fluid, nanofluid can be defined as a fluid in which solid particles with the sizes 1-100 nm are suspended and dispersed uniformly in a base fluid such as water, oil, ethylene glycol [6]. Nanofluid increase the thermal conductivity of basic fluid and growth the energy transfer of heat exchanger [7-10]. Many researchers observed the phenomenon of higher thermal conductivity of various nanofluids compared to that of the base fluids [11-13].

In the refrigeration, heating, ventilating and air conditioning (RHVAC), it is challenging to optimize the energy consumption for all of equipment facilities [14]. Fan coil unit (FCU) is one of the heat exchanger equipment in water chiller air conditioning system that consist of fan and a series of finned tube bank, for decreasing the air temperature [15]. For fan coil units, load of the system induced degradation in the water temperature difference across the fan coil, which results in inefficiencies of heat transfer and unnecessary pump power consumption [16]. To apply the nanofluid (alumina-water) to practical heat transfer processes, more studies on its flow and heat transfer feature are needed, [17] in their studies with alumina water water nanofluids in a turbulent flow. Rea et al. [18] observed up to 27% enhancement with 6% volume fraction alumina–water nanofluid. [19] investigated thermal performances of nanofluids silicone dioxide –water on various concentration in industrial type heat exchangers.

From the literature above known that nanofluid plays important role to increase heat transfer in heat exchanger. This study fills an important gap in the literature for heat exchanger application of nanofluid especially alumina-water in fan coil unit (FCU). The objective of this investigation is to evaluate the amount of heat transfer between ambient air and chilled water (alumina-water) by fan coil unit.

## II. EXPERIMENTAL APPARATUS AND METHOD

The experimental apparatus is manufacture for analysis purpose. Figure 1 shown the schematic of the experiment apparatus. It consist four major component of refrigeration namely compressor, condenser, thermostatic expansion device, evaporator. The auxiliary component i.g. fan coil unit (FCU) and pump for pumping the alumina-water suspension as chilled water of the water chiller. Rotameter used to control the volume flowrate of chilled water.

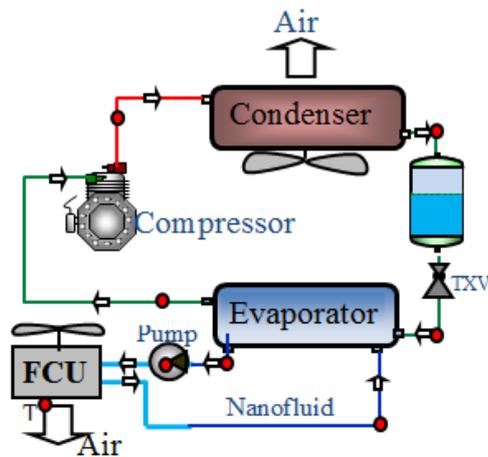


Fig. 1. The experimental apparatus

The specification of refrigeration system component are listed on table 1.

TABLE I. TEST RIG SPECIFICATION

No	Equipment	Description
1	Compressor	Hermetically sealed, Rotary 2 pk, R22 refrigerant
2	Condenser	Air cooled, finned coil.
3	Expansion device	Capillary tube 0.7 mm; thermostatic expansion valve.
4	Evaporator	Shell and tube heat exchanger
5	Fan coil unit (FCU)	Finned coil
6	Pump	Centrifugal, 125 W

The  $\gamma$   $Al_2O_3$  nanoparticles size of 20-50 nm were used. Nanofluid was prepared by dispersing  $Al_2O_3$  nanoparticles in distilled water as base fluid. The mechanical mixer (magnetic-stirring) and ultrasonic processor was used for dispersing nanoparticles. In this study, the  $Al_2O_3$  - water nanofluid particles volume concentration of 0.1% is used to evaluate the heat transfer performance of chilled water in the fan coil unit.

#### A. Instrumentation

The temperatures of refrigerant R-22, the ambient air temperatures and nanofluid temperatures were measured by k-type thermocouples, attached to the copper pipe wall, inlet outlet side of the FCU and nanofluid chilled water. The pressure of the refrigeration system were measured by pressure gauge which placed at four point of refrigeration cycle system. The temperatures data were digitalized using data logger and recorded in computer memory and the current of compressor was measured by digital ampere meter.

#### B. Data processing

The aim of this current investigation is to determine the real amount of heat transfer in the fan coil unit (FCU) of the water

chiller air conditioning. The most important parameters of interest is heat transfer (Q) describe below,

$$Q = \dot{m} \cdot C_p \cdot \Delta T \quad (1)$$

Effectiveness follow the equation as,

$$\varepsilon = \frac{1 - \exp[-NTU(1 - c)]}{1 - c \exp[-NTU(1 - c)]} \quad (2)$$

### III. RESULTS AND DISCUSSIONS

Preliminary experiments were done using no nanofluid as chilled water. This data was then used as a comparison to that of nanofluid as chilled water.

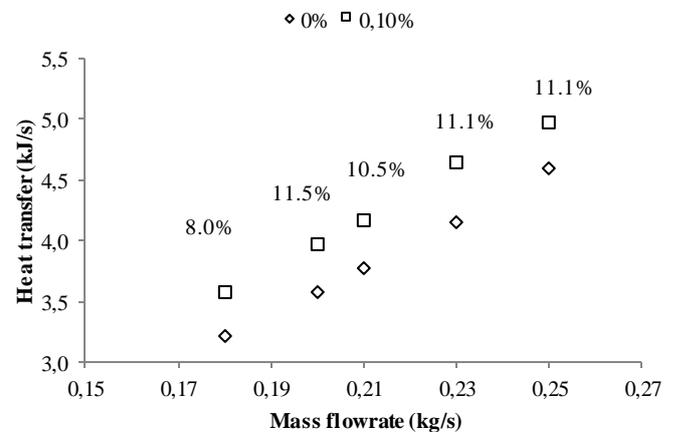


Fig. 2. Real heat transfer of each mass flowrate

Figure 2 shows the overall heat transfer at various mass flowrate of chilled water. The result indicates that the average convective heat transfer increased by increasing the mass flowrate of chilled water. It can be observed that the application of alumina-water as chilled water lead to a significant increase on heat transfer about 8% to 11.5% compared to that of chilled water with no nanofluid. The process of energy transport between pipe wall and flowing nanoscopic particles mostly affected by the type and size of particles. Alumina with particles size 20-50 nm greatly increase the energy transport in fan coil unit. Nanofluid provided the enhancement in the heat transfer by increasing the thermal conductivity of chilled water.

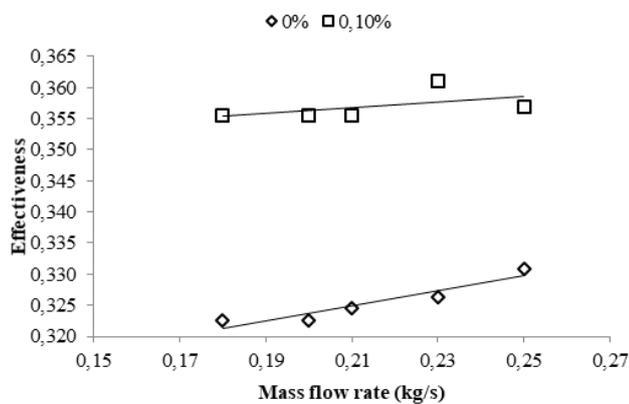


Fig. 3. Effectiveness of the heat transfer of each mass flowrate

The mass flowrate and effectiveness relationship of the investigation were presented in Figure 3. The effectiveness of the nanofluid chilled water were compared to that of the no nanofluid chilled water. It was found out that the mass flowrate and the presence of nanofluid influenced the effectiveness. Figure 3 shows that the increases mass flowrate cause a increase in effectiveness. At the same mass flow rate, the effectiveness of nanofluid chilled water were higher than those of the no nanofluid chilled water. The increase of effectiveness is indicated by the increased rate of the actual heat transfer (see fig.2). The alumina nanoparticles lead to increase thermal conductivity of chilled water and made the FCU more effective

### III. CONCLUSION

An experimental investigation was carried out for heat transfer enhancement by Alumina-water nanofluid, effectiveness ( $\epsilon$ ) and overall heat transfer of fan coil unit of water chiller AC. The main objective of this study was to compare with/without nanofluid chilled water. The result can be summarized as,

- The heat transfer increased with increase of mass flowrate of chilled water. At a specified mass flowrate, the heat transfer enhancement of nanofluid chilled water about 8.0 – 11.1% compare to that of no nanofluid chilled water.
- The effectiveness increased with increase of mass flowrate. The effectiveness of nanofluid chilled water have a good agreement with heat transfer enhancement.

### LIST OF SYMBOLS

$\dot{m}$	mass flowrate [kg/s]
$\Delta T$	temperature difference of hot/cold fluid in time period [ $^{\circ}\text{C}\cdot\text{s}$ ]
$Q$	heat transfer [J]
$C_p$	specific heat [J/kg $^{\circ}\text{C}$ ]
$\epsilon$	effectiveness
$c$	heat capacity ratio
$NTU$	number of transfer unit

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