Journal of Mechanical Science and Engineering 3(1) 13-19, 2016
ISSN 2354-9467

ANALISYS OF EFFECT OF OUTSIDE AIR SPEED TO AIR HUMIDITY AND REFRIGERATOR COEFFICIENT OF PERFORMANCE

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ABSTRACT

Air conditioning is essential for most humans and are associated with human thermal comfort. At conditioned room where the condition can occur outside air (atmosphere) into the room. Althouht the author was interested in researching this influx of outside air. The aims of this research would be able to examine the effect of the entry of outside air to the room air humidity and refrigerator coefficient of performance. The method used is to perform laboratory-scale experiment with conditioned room with air conditioning or no air conditioning which then incorporate outside air into the room. From this experiment would get experimental result, the result of theoretical calculation, and the result of calculation by using the simulator program. By entering the outside air was obtained that the outside air increases the humidity in the room and affect refrigerator coefficient of performance. The experimental results showed that the average maximum condition occurs at a speed of 1 m/s and at 20 minutes. It can be concluded that the outside air entering the room using the air conditioner would improve indoor air humidity and increase the cooling load means affect refrigerator coefficient of performance. And in a room without air conditioner caused indoor air humidity getting closer to the comfort zone.

Keywords: air conditioning, air mixing, air humidity, coefficient of performance

1. INTRODUCTION

Air conditioning is a field of science that was included in the science of refrigeration. At conditioned room, where the evaporator of the indoor unit as a tool that serves to absorb heat from the room air which is taken to the outdoor unit is the condenser to be discharged into the environment. In progress, it has been studies discussed the air conditioning. Venkataiah and Rao (2014) analyzed the performance of eight alternative to R22 refrigerant used in air conditioning with program simulation. Pande and Patil (2014) analyzed the heat exchanger that function as an evaporator. Ali (2007) obtained the evaporator performance of wet coil condition higher then dry coil condition.
Air conditioning can not be separated from the conditioned air quality resulting thermal comfort. One important factor to obtain thermal comfort is air humidity condition. And there are some studies on air humidity. Salokhe et al. (2005) studied the relationship between the distribution of air humidity on the condition of natural opening ventilation. Mustafa (2011) conducted an experiment to determine the effect of steam in the air to the humidification process parameters. Venkatesh et al. (2014) conducted experiments with laboratory scale way of process modeling and control humidity with 3 kinds of controllers, namely Ziegler Nichols Proportional Integral (ZNPI), Direct Synthesis Proportional Integral (DSPI), Internal Model Control Proportional Integral (IMCPI). Thomas Alsmo and Catharina Alsmo (2014) to test airflow through natural ventilation and mechanical ventilation and get on Natural Ventilation RH value is greater than in Mechanical Ventilation.

From the reviews that the researches was done in the field of air conditioning. Every result of this study could be use as a reference and further development. The author was also

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interested did the research in air conditioning field, particularly relate to air humidity and refrigerator coefficient of performance.

2. Literature Review

2.1. Refrigeration System

Refrigeration system is a process related to heating and cooling process. The application of refrigeration is a cooling process, which is for air conditioning (Stoecker and Jones, 1982). Air conditioning is a field that is interesting to study. Taras (2006) analyzed a variety of mechanical concept of a reheat/dehumidification and highlight the profit-making and loss on the air conditioner, and analyze the general trend of the performance characteristics and evaluate the sensitivity of the system design of the tool conditions such as humidity and temperature conditions of the room. In general, the refrigeration system consists of a cooling device and a conditioned room. Differences and linkages between them can be illustrated in Figure 2.1. On the visible image processes such as vapor compression refrigeration cycle and the cycle of air flow in the space conditioning.

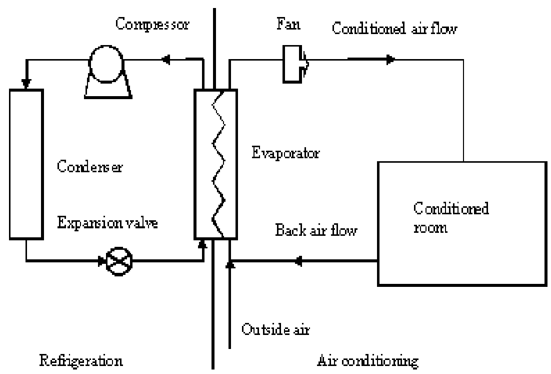

Figure 2.1. Air conditioning system schematic. (Zakaria, 1991)

In the cooler tool, the author analyzed relating to refrigerator coefficient of performance, using the formula below:

1. Refrigeration effect

$$Q_e = (h_1 - h_4) \quad (2.1)$$

2. Heat equivalent required for compression work

$$W_{in} = (h_2 - h_1) \quad (2.2)$$

3. Condenser heat load

$$Q_k = (h_2 - h_3) \quad (2.3)$$

Thus, the coefficient of performance (COP) is the heat absorbed by the evaporator divided by the heat equivalent to that required for the work of compression.

At conditioned room authors conducted an analysis related to indoor air humidity. In analyzing the author used psychrometry diagram and the general using formula. Psychrometry diagram is a diagram showing the thermodynamic properties of moist air. Seven thermodynamic properties of moist air is dry bulb temperature and wet bulb, the partial pressure of water vapor, a comparison of moisture, relative humidity, specific volume, wet air dew point temperature, and enthalpy.

2.2. Cooling with dehumidification

In the conditioning space, warm air would be sucked or cooled through the evaporator coil. This air contained water vapor was called humid air. After going through the evaporator coil, the air temperature would be lower and the moisture in the air would undergo condensation process so it would be water. Water condensation process results would be accommodated in a container of water and then discharged into the environment, this means a change in the level of RH. Temperature and RH would lead a comfortable level.

Theories and equations of cooling process with dehumidification was used in this study, which was looking after the RH air through the evaporator coil. This process was described using psychrometry diagram. The steps could be seen in Figure 2.2. From the figure could be seen that, the first step to make the line AB which forwarded to the point C (the temperature of the evaporator coil). A point was a condition in which the air before through the evaporator coil and point B was the air after going through the evaporator coil. At point A the data obtained were temperature and RH, and at point B was the temperature data obtained whereas RH searched using the equation ratio BC line to the AC line.

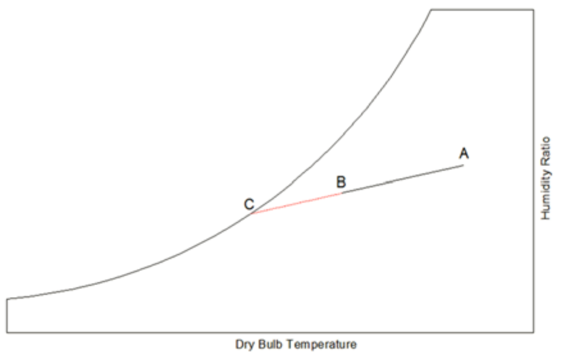

Figure 2.2. Cooling with dehumidification process. (Cengel and Boles, 2006)

2.3. Air flow mixing

The process of two air flow mixing was often found in air system. Schematically, this mixing process could be described as in figure 2.3.

From the figure could be seen the flow of air under two conditions (conditions 1 and 2). Each of these conditions had different mass flow rate, temperature, enthalpy and humidity ratio. After these two streams mix then produce new condition (condition 3).

The formula used in the mixing of the air flow (figure 2.3), were:

a. Dry air mass flow rate:

$$\dot{m} = \frac{V}{v} \quad (2.4)$$

b. Mass of dry air:

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3 \quad (2.5)$$

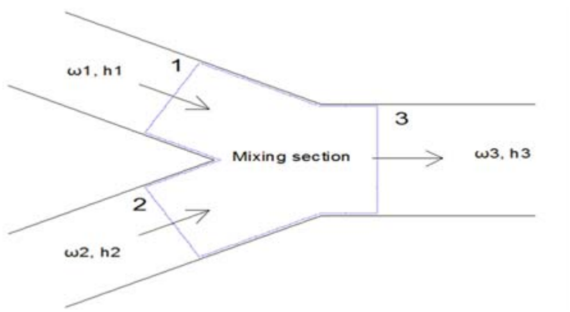

Figure 2.3. Mixing of two airflow.(Cengel and Boles, 2006)

c. The mass of water vapor:

$$\dot{m}_1\omega_1 + \dot{m}_2\omega_2 = \dot{m}_3\omega_3 \quad (2.6)$$

d. Energy:

$$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3 \quad (2.7)$$

e. Equation of humidity ratio and enthalpy of the mixture:

$$\frac{\dot{m}1}{\dot{m}2} = \frac{\omega 2 - \omega 3}{\omega 3 - \omega 1} = \frac{h2 - h3}{h3 - h1} \quad (2.8)$$

By using the formula of air mixing above it would get the value of w_3 and h_3. From these values, then saw at the diagram Psychrometry obtained mixture temperature value (T_3), RH_3 and V_3.

3. Research Methodology

The method used in this research was conducted in the laboratory experimental. Experiments carried out by mixing outside air (atmosphere) in the conditioning room. In the conditioning space made of two circumstances, the first air conditioner switched off (AC off) and the second air conditioner turned on (AC on), with the fan still alive in both conditions. From the experimental results would be the data obtained experimental results was used for the calculation and experimental results of reading a measuring tool that could be used for comparison between the experimental results, the results of the theoretical calculations and the results of calculations using the simulator program. The third difference in these results must be less than 10%, so it was considered valid.

3.1. Testing installation

The equipment used in this study was a recirculating air conditioning (figure 3.1), with the following specifications:

One (1) unit of the air conditioner, with voltage 380-415 VAC, 3-phase, 50 Hz, 22 A maximum current, refrigerant capacity is 1.5 kg, and compressor power required was smaller than 2 kW.

One (1) unit of air conditioning space in which there were evaporator as a heat absorber and a fan that could generate air flow rate in the range from 0 to 2.8 m/s.

Instruments and measuring devices used in this research were,

1. The temperature sensor was used to measure temperature.
2. The humidity sensor (hygrometer) was used to measure the relative humidity (RH).
3. Air velocity sensor was used to measure the air flow rate.

Journal of Mechanical Science and Engineering 3(1) 13-19, 2016
ISSN 2354-9467

4. Refrigerant flow meter sensor was used to measure the flow rate of refrigerant.
5. Pressure gauge was used to measure the pressure.

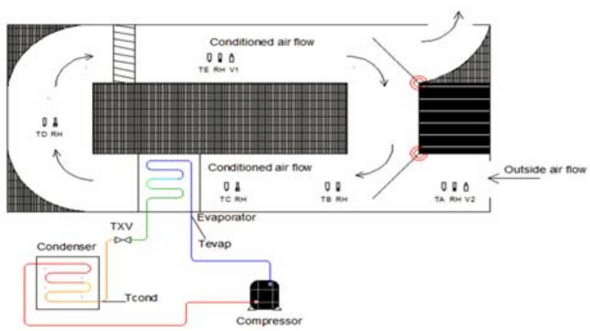

Figure 3.1. Testing installation. (Labtech, 2014)

3.2. Data Collection Procedures

Data collection was performed by adjusting the indoor air velocity v = 2.65 m/s, temperature of the room in a state of conditioned life at T = 23 °C, outdoor air speed variant of the system (atmosphere) entering the conditioning room at 0.4 m/s , 0.6 m/s, 0.8 m/s and 1 m/s with time variant of 1, 5, 10, 15 and 20 minutes. By order of the research data collection procedures as follows:

Setting up a research tool.Seeing the operating conditions were already running normally.
Setting the temperature of the evaporator as necessary testing (for AC live).Wait until the room temperature according to the temperature setup (for AC live).Setting the flow rate of air entering the conditioned space.Mixing the outside air (atmosphere) into the space conditioning, for an air conditioner was turned off, the outside air could be mixed directly without setting the room temperature.Noting the room air temperature data, refrigerant temperature, RH, and the flow rate of refrigerant. The data obtained from the measurements were processed to obtain the value of the air humidity and coefficient of performance (COP).

4. Results and Discussions

From the experimental results obtained laboratory data used for comparison between the experimental results, theoretical calculations and calculations using the simulator program, then the results obtained as below,

4.1. Comparative calculations on the fan on and AC off for air mixing

A. The temperature of the mixture
Figure 4.1 showed the difference in the temperature of the mixture between the experimental results and theoretical calculations. With the speed variance of 0.4 m/s, 0.6 m/s, 0.8 m/s, 1 m/s and time variant of 1 - 20 minutes. Found that the average difference below 1%. This means that the difference was not over the limit of 10%. Limitations of this difference was less than ± 20% difference limit proposed by Chandra and Chhabra (2012).

B. The RH of the mixture
Figure 4.2 showed the difference RH mix between experimental results and theoretical calculations. With the speed variance of 0.4 m/s, 0.6 m/s, 0.8 m/s, 1 m/s and time variant of 1 - 20 minutes. Found that the average difference below 1%. This means that the difference was not over the limit of 10%. Limitations of this difference was less than ± 20% difference limit proposed by Chandra and Chhabra (2012).

C. V_3 comparative results of theoretical calculations and experimental results
Comparison of the latter was in figure 4.3 shows the differences in the results of theoretical calculations and experimental results. With the speed variance of 0.4 m/s, 0.6 m/s, 0.8 m/s, 1 m/s. Overall there was an increase V_3 during the speed range of 0.4 m/s to 1 m/s. And the length of time entry does not affect the volume flow rate. It was found that differences in the highest at 6.9%.

4.2. Comparative calculations on the fan on and AC on for air mixing

A. The RH of the mixture
Figure 4.4 showed the difference of RH_{out} between the theoretical calculations and software. With the speed variance of 0.4 m/s, 0.6 m/s, 0.8 m/s, 1 m/s and time variant of 1 - 20 minutes. Found that the average difference below 1%. This means that the difference was not over the limit of 10%. Limitations of this difference was less than ± 20% difference limit proposed by Chandra and Chhabra (2012).

B. COP_R

Figure 4.5 shows the difference between the theoretical calculations and software. With the speed variance of 0.4 m/s, 0.6 m/s, 0.8 m/s, 1 m/s and time variant of 1 - 20 minutes. Found that the average difference below 1%, except for v = 0.4 m/s and time at 15 minutes and 20 minutes differences below 2%. This means that the difference was not over the limit of 10%. Limitations of this difference was still smaller than the difference ± 20% limit proposed by Chandra and Chhabra (2012).

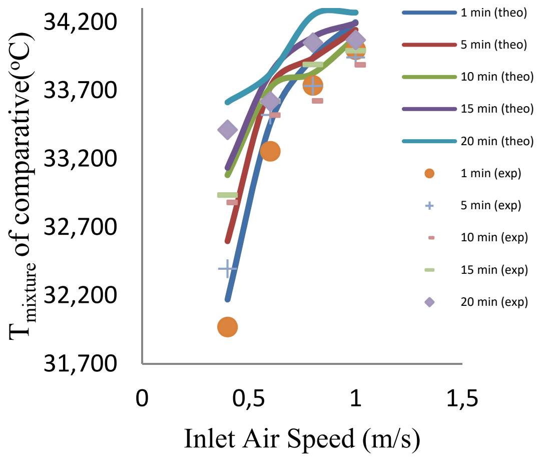

Figure 4.1. The difference between $T_{mixture}$ experimental and theoretical

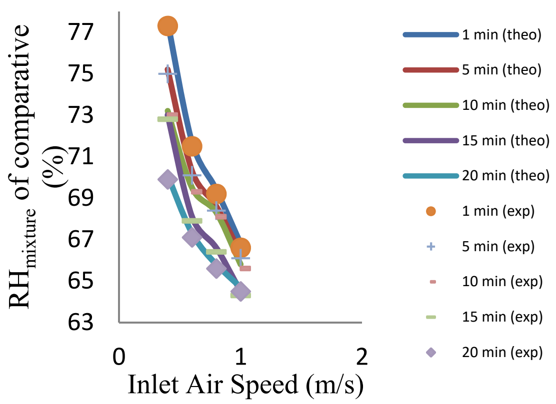

Figure 4.2. The difference between $RH_{mixture}$ experimental and theoritical

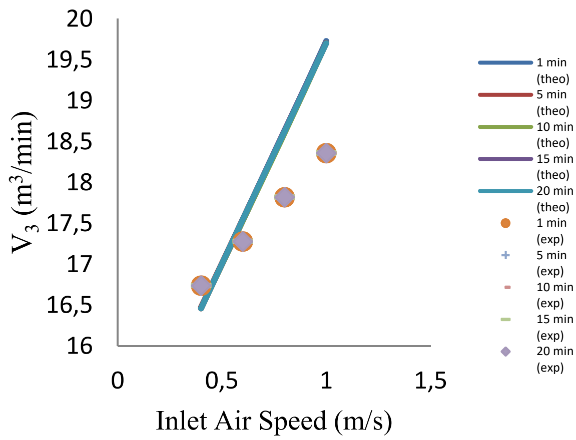

Figure 4.3. The difference between V_3 experimental and theoretical

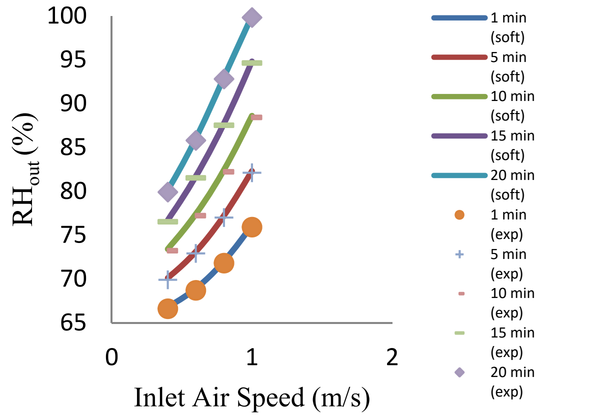

Figure 4.4. The difference between RH_{out} experimental and *software*

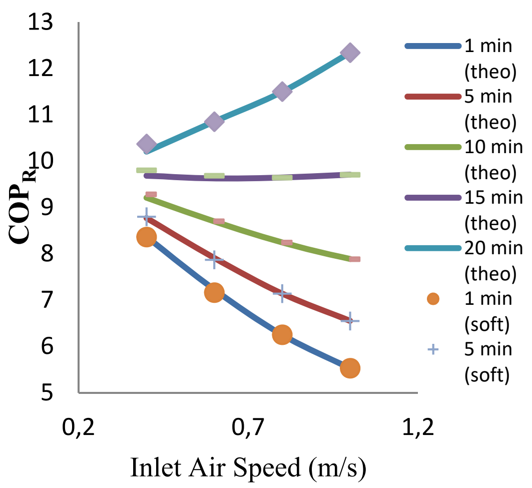

Figure 4.5. The difference between COP_R theoritical and *software*

5. CONCLUTION

Processing and discussion of the results, it could be concluded: The results showed that the relative indoor humidity conditioning declined, and this decline was a symptom that was good because the relative humidity level to the comfort zone.

The results showed that the relative humidity of the conditioning room has increased. The results showed that the coefficient of performance (COP_R) refrigeration machine has increased after t = 15 minutes. This means that the longer the discharge time the heat in the evaporator would increase COP_R. It can be concluded that the average ratio of below 1% and a maximum of below 6.9%. This means that the differences in the calculation results were still below 10%.

ACKNOWLEDGEMENT

For Dr. Fajri Vidian, ST, MT, as thesis supervisor in finish the Master in mechanical engineering program of sriwijaya university for your guidance and suggestion to the writing of this paper

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