Performance, Analysis and Simulation of a Typical Fan Coil Unit at Science & Technology Complex, UiTM Shah Alam

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Abstract - **Fan Coil Unit (FCU) is used to provide human thermal comfort by providing a comfortable environment within the space. This paper presents the performance and analysis of a FCU system at Science and Technology (S&T) Complex, UiTM Shah Alam. In this paper, FCU system has been identify for furher understanding about the system. The data obtained are taken using HOBO data logger. The performance of FCU system has been evaluated due to the temperature and relative humidity of the sample location. Based on simulation done using Microsoft Visual Basic 6.0, the results were analyzed and discussed. Finally some conclusions and recommendations for future work are indicated.**

Keywords - **FCU, psychrometric chart, Predicted Mean Vote (PMV), Predicted Percentage Dissatisfied (PPD), thermal comfort.**

I. INTRODUCTION

The purpose of air conditioning is to provide a comfortable thermal feeling for the occupants within the conditioned area. Air conditioning is define as the simultaneous control of temperature, humidity, radiant energy, air motion, and air quality within the space for the purpose of satisfying the requirements of comfort or a process [1]. Air conditioning unit are called air handling unit (AHU) for the larger system and fan coil unit (FCU) for the smaller system.

FCU is a part of Heating, Ventilating and Air Conditioning (HVAC) system. An HVAC system is simply a group of components working together to remove heat [2].

HVAC at S&T Complex consists of [3]:-

(i) Chiller - a machine that produce chilled water
(ii) Cooling Tower - to reject heat from chiller to outdoor
(iii) Ice Cell - to provide chilled water
(iv) Heat Exchanger – to remove the heat from the chilled water and the chilled water to be maintain

Usually, FCU system is installing in a ceiling space to provide comfort conditioning at the specified environment condition and it is widely use in hotels, motels, apartments and offices [4]. The main purpose of FCU is to exchange cool or thermal energy with indoor air of rooms. The cooling or thermal capacity of FCU are influenced by many factors such as the temperature and the flux of medium, the velocity of air passing FCU transversely and the properties of indoor-air, and so on [5].

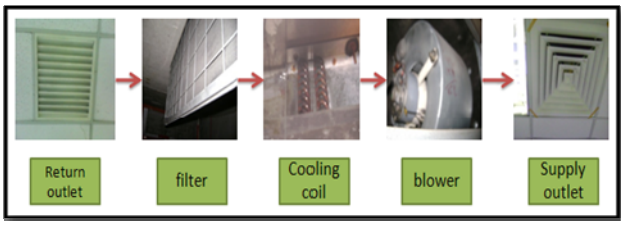

Figure 1: FCU system

The main pieces of equipment in the FCU system are the return outlet, filter, cooling coil, blower and supply outlet. The functions of equipments are [6]:-

(i) The return Outlets allow air to pass from the room.
(ii) The filter cleans the air by removing dust and dirt particles.
(iii) The cooling coil cools and dries the air.
(iv) The blower moves air to and from an enclose space.
(v) The supply outlet helps to distribute the air evenly in a room.

A. *Objective*

The objective of the study is to:-

- Understand the air conditioning system of a typical FCU at S&T Complex, UiTM Shah Alam.
- Evaluate the performance of the system.
- Simulate the performance of the system by using visual basic 6.0 (VB) programming.

B. *Scope of Work*

This research is to study and understand the process of FCU system. The data was collect at the chosen location by using HOBO data logger on the several days. The location was recommended by the maintenance department based on its history performance. Data collected are based on the thermal comfort requirements which are the data of temperature and relative humidity of the conditioned area. Comparisons are made by simulate the data using visual

basic 6.0 programming to evaluate the performance and analysis of the FCU system. The psychrometrics chart were used to visualized and determine the comfort level by using the data taken from the data collected. The chart was used to indicate the comfort level based on ASHRAE standard.

C. Malaysian Standard (MS 1525:2001)

Malaysian Standard is purposely draw to advancing the national economy, promoting industrial efficiency and development, benefiting the health and safety of the public, protecting the consumers, facilitating domestic and international trade and furthering international cooperation in relation to standards and standardizations [7].

Regarding to Malaysian Standard (MS) 1525:2001, the suitable ranges for thermal comfort would be:

- Recommended design dry bulb temperature 23 ° C – 26°C
- Minimum dry bulb temperature 22 ° C
- Recommended design relative humidity 60 % – 70 %
- Minimum relative humidity 55 %

D. Psychrometric chart

The FCU performance can be evaluate using psychrometric chart. Psychrometric chart is a chart where the parameter through normal range of HVAC system operations can be found such as temperature (dry bulb temperature and wet bulb temperature), relative humidity, humidity ratio, specific volume and enthalpy [3].

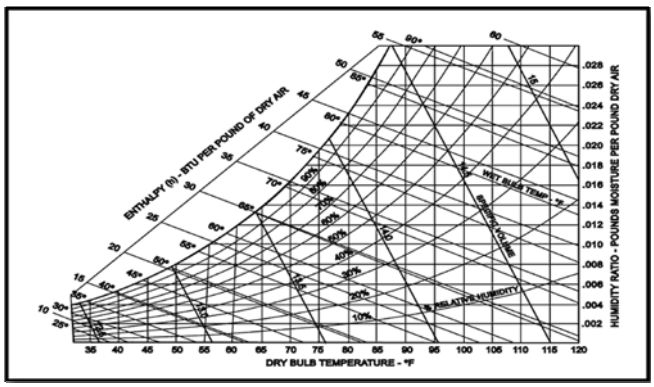

Figure 2: Psychrometric chart [8].

(i) Dry bulb temperature of air when it is saturated dew point temperature. The relative humidity is 100%.
(ii) Wet bulb temperature is influence of temperature where moisture center of the air saturated and it cause less water content in the air.
(iii) Relative humidity expressed the percentage of the actual amount of water vapor to the potential amount of water vapor at saturation.
(iv) Humidity ratio is the ratio of the weight of water vapor to the weight of dry air.
(v) Specific volume of dry air varies with the temperature, humidity and atmospheric pressure.
(vi) Enthalpy is the sum of latent and sensible heat of the air

E. Predicted Mean Vote (PMV) Index

PMV (Predicted Mean Vote) is an index that expresses the quality of the thermal environment as a mean value of the votes of a large group of persons on the ASHRAE seven-point thermal sensation scale (+3 hot, +2 warm, +1 slightly warm, 0 neutral, –1 slightly cool, –2 cool, –3 cold) [9].

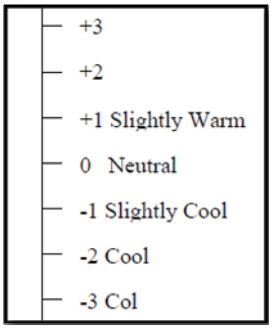

Figure 3: ASHRAE Sensational Scale [10]

$$PMV = (0.303 \exp(-0.036M) + 0.028) L \quad [11]$$

Where:

M = metabolic rate
L = thermal load defined as the difference between the internal heat production and the heat loss to the actual environment for a person hypothetically kept at comfort values of skin temperature and evaporative heat loss by sweating at the actual activity level

F. Predicted Percentage Dissatisfied (PPD) Index

PPD (Predicted Percentage Dissatisfied) is an index expressing the thermal comfort level as a percentage of thermally dissatisfied people, and is directly determined from PMV. The PPD index is based on the assumption that people voting ±2 or ±3 on the thermal sensation scale are dissatisfied, and the simplification that PPD is symmetric around a neutral PMV (=0). Both PMV and PPD are based on general (whole body) thermal comfort [9].

$$PPD = 100 - 95 \exp(-0.03353\ PMV^4 - 0.2179\ PMV^2) \quad [11]$$

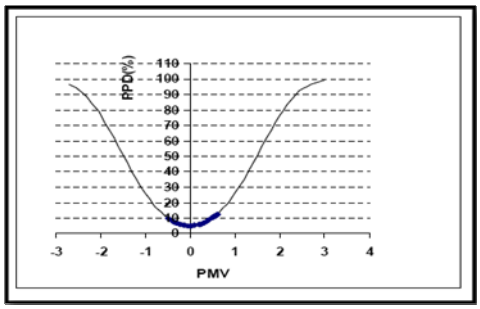

Figure 4: PPD graph [12]

The comfort range was taken to be the conditions when the PMV has the values between –0.5 and +0.5. Using Visual Basic, data can be evaluated using several strategies of graphical drawing such as normal graphing and psychrometric chart.

II. METHODOLOGY

The research evaluates the performance and analysis of the FCU system. The data are taken from selected locations, basically locations that should provide a thermal comfort condition for the occupants within the conditioned area. The selected locations represent the end result of the whole system placed at the end point of the system which is the fan coil unit (FCU).

Data obtained using HOBO data logger. It is use to sensed and detects the temperature and relative humidity within the area of location. To acquire the data needed, HOBO data logger is placed at B4-A10-1(classroom) as an example location. Three HOBOs are placed in the same classroom.

(i) Room temp – located in at the wall of the room.
(ii) Supply air temp – located at the air distribution panel.
(iii) Return air temp – located at the air return panel.

From the data acquired, analyses are made to determine the thermal condition of the location evaluated. Data acquired are recorded and analyzed from a psychrometric chart sketch using a Visual Basic 6.0 programming. All the information required which has been programmed will also automatically shown when the programmed had run. Comparisons are made between the data taken and Malaysian Standard MS 1525:2001 to determine the thermal comfort. From the assessment, figures of each data were discuses and conclusions are made.

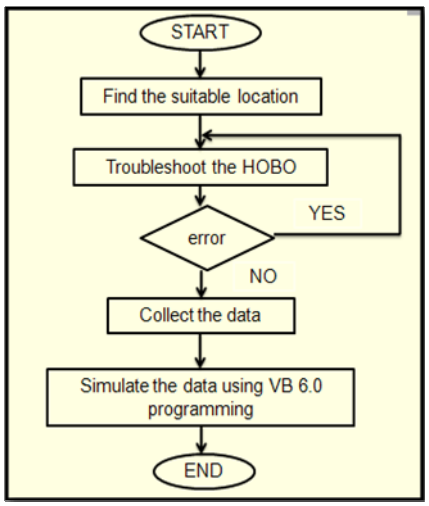

Figure 5: Step of data acquisition and analysis

III. RESULTS AND DISCUSSIONS

Combining with six faculties, S&T Complex are a building occupied with countless number of user daily. The main purpose of S&T Complex is to provide a thermal comfort study environment for the student.

A. The Psychrometric Chart, Wave Form and FCU Model on 16 FEB 09 at B4-A10-1A.

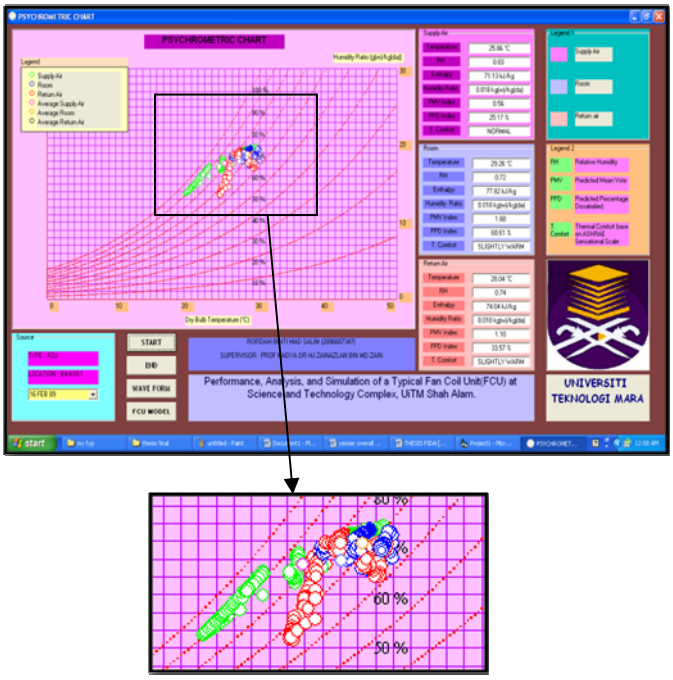

Figure 6: The psychrometric chart

From the figure above, the psychrometric chart shows that the average temperature is 29.26 ^{0}C and the average relative humidity in that room is 72%. Thermal comfort based on the ASHRAE Sensational Scale, the condition of the room is slightly warm. So, the room is not thermally comfortable.

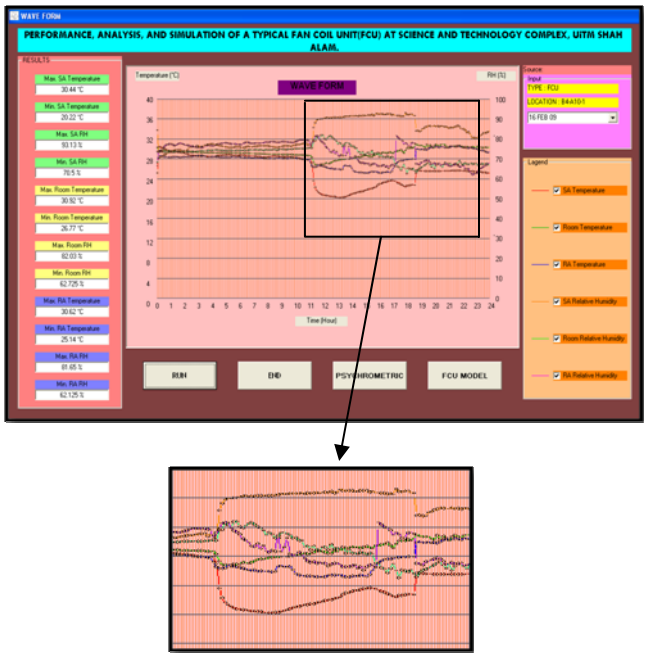

Figure 7: The Wave Form

The result from the figure 7 represents the FCU provided for the classroom shows that the temperature and relative humidity is higher compared to the Malaysian Standard. The suitable temperature and relative humidity ranges for thermal comfort are 23-26 ^{0}C and 60-70% respectively [9]. So, the thermal comfort environment in the room will not be achieved.

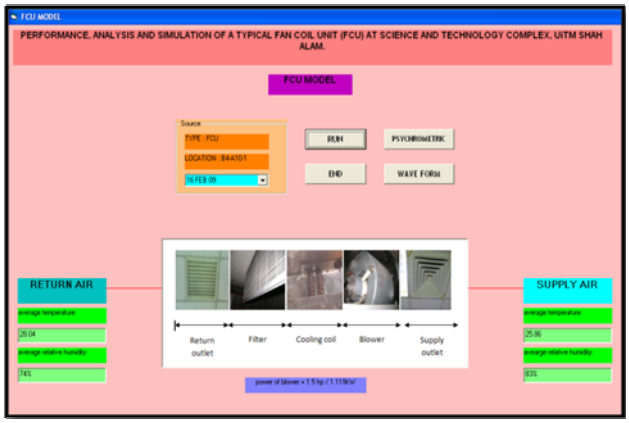

Figure 8: The FCU Model

The figure above shows that the FCU system model. The average temperature and relative humidity of the return and supply air will be shown depends on the date. Base on the model, we can see clearly the flow of the air moving from return outlet to supply outlet.

B. The Psychrometric Chart, Wave Form and FCU Model on 27 FEB 09 at B4-A10-1A.

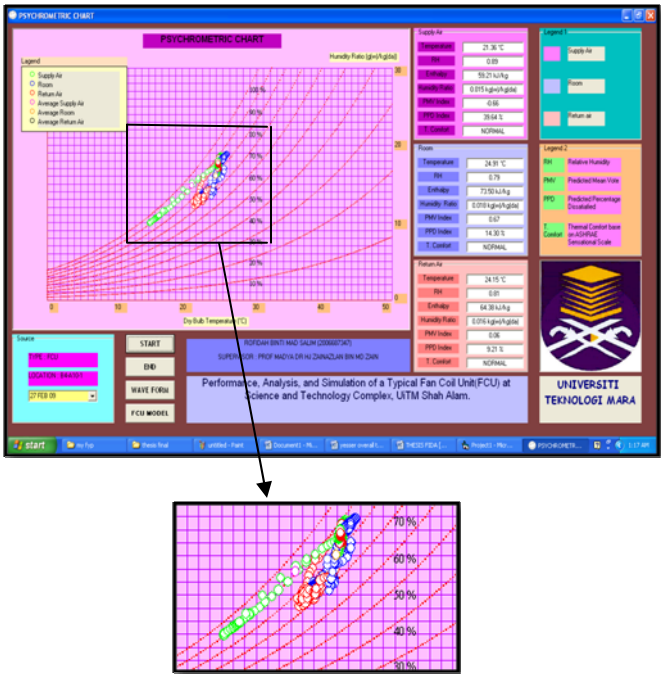

Figure 9: The psychrometric chart

The psychrometric chart show that the average temperature is 24.91 ^{0}C and the average relative humidity of the air contained in the room is 79%. This value represents the actual thermal conditions of the room. Thermal comfort based on ASHRAE Sensational Scale, the condition of the room is normal.

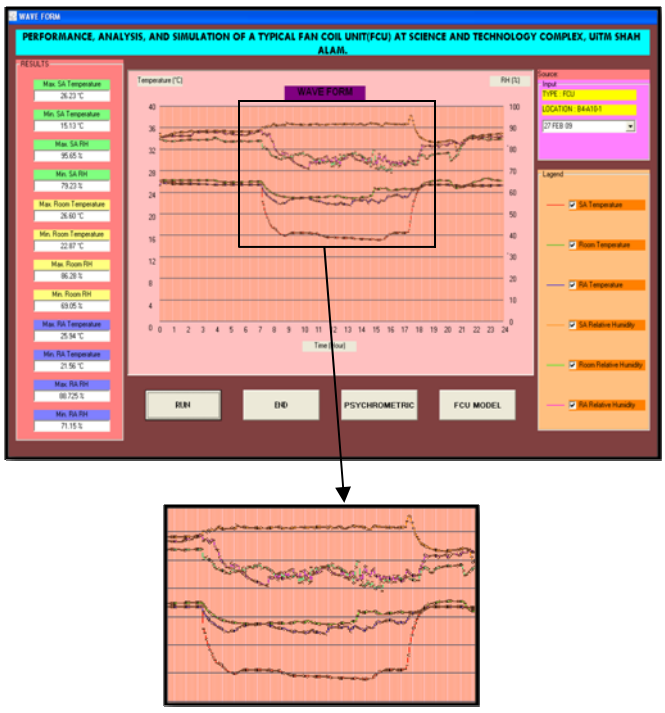

Figure 10: The Wave Form

Figure above shows, even the temperatures are in the set point range, the relative humidity still exceed the recommended range. The higher relative humidity will cause the side effect such as fungus exists in damp environment. Beside that, it also will affect the occupants comfort.

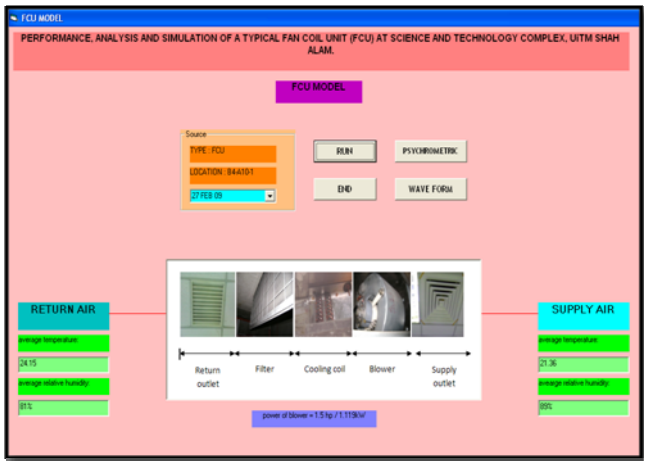

Figure 11: The FCU Model

The FCU system model show that the average temperature and relative humidity at B4-A10-1 on 27 FEB 09. The data shown based on the result from the psychrometric chart in figure 9.

IV. CONCLUSION

The project was successfully done and has achieved all the objectives. The FCU System has been identifying for further understanding about the system. From the data analysis and the results obtained, the performance of FCU system between 7 a.m. to 6 p.m. at B4-A10-1 in S&T Complex, UiTM Shah Alam does not provide the requirement of thermal comfort. Eventhought the ranges of the temperature lies within the standard specification, the relative humidity was high compared with the Malaysian Standard (MS 1525:2001) weather all the equipments of the FCU system are in a good condition.

Malaysia is a hot and humid country where the moisture content is very high. For a tropical climate condition, the moisture level is very high. From that, the nature of such contaminants in such kind of liquid, solids or gases (vapor) with higher concentration can pose of health risks, certain fungus and others impurities. All this kind of mechanism will give big impact for future generation if not take it seriously. The higher moisture content of air also will affect the occupants' health such as fever or flu. The temperature and relative humidity also are depends on the weather condition at that day.

Therefore it can conclude that the performance of air conditioning system of a typical FCU in S&T Complex does not fulfill the standards requirements.

V. RECOMMENDATION

Since the performance of FCU system in S&T Complex does not fulfilled the standards requirements, some recommendations are made to improve the system to generate the required conditions of air conditions.
Improvement can be achieved by several ways such as continuous maintenance the equipment involves related to the system such as always clean the filter, monitor the cooling coil so that no leakage occurs and clean the blower.
One major problem that occupants do not realize is the enclosure of the room. When applying an air conditioning system, the rooms have to be in a close to outside air except for ventilations.
Beside that, up grade the system in order to the specification of the room. This can reduce the cost of energy demanded and can avoid unwanted condition of hazard. The consideration on the material that are use also play important subject such as wall, roof and location of room facing sunrise and down should be included in the calculation. Beside that the new standards of temperature and relative humidity have to come out according to the recent situation.

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