National Conference in Mechanical Engineering Research and Postgraduate Students (1st NCMER 2010)
26-27 MAY 2010, FKM Conference Hall, UMP, Kuantan, Pahang, Malaysia; pp. 555-563
ISBN: 978-967-5080-9501 (CD ROM); Editors: M.M. Rahman, M.M. Noor and K. Kadirgama

THERMAL COMFORT IN A CLOSED AIR CONDITIONED ICT LABORATORY AT UNGKU OMAR POLYTECHNIC MALAYSIA

A. R. Ismail[1], S. Singh[2] and C. W. Goh[3]

[1]Faculty of Mechanical Engineering
Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia
Email: arasdan@gmail.com
[2]Politeknik Ungku Omar, Ipoh, Perak, Malaysia
Phone: +605-5457622 ext 1160, Fax: +605-5471162
[3]Faculty of Engineering and Built Environment
Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

ABSTRACT

This paper presents an integrated experimental study of the environmental comfort in a Closed Air Conditioned ICT Laboratory at Ungku Omar Polytechnic, Malaysia. The ICT laboratory is considered as an indoor environment. The study had been carried out by the use of custom made Thermal Comfort Measurement (TCM) equipment in order to investigate the level of thermal in this laboratory, level of CO_2, pressure, humidity, wind speed, ambient temperature and globe temperature. All the simultaneous parameters measured were then compared to the standard or guidelines produced by National Institue Of Safety and Health (NIOSH) as well as American Conference of Governmental Industrial Hygienists (ACGIH). The study revealed that the level of CO_2 in ICT Laboratory exceeded the hazardous level thus can produce the negative impact to the productivity of the users.

Keywords: Thermal comfort; environment, measurement; standard.

INTRODUCTION

A certain rate of air exchange is essential to healthy indoor enviroment. Most laboratories are not equipped with suitable devices for natural or mechanical ventilation where air changes are only due to air infiltration through the cracks and the frames of windows and doors. When the amount of fresh air supplied by air infiltration is not enough to assure a satisfactory indoor comfort, the students themselves will at times, operate a control by means of window or door opening. The window opening is not only useful for energy saving, by reducing the need for mechanical cooling but also provides beneficial interaction between the indoor and the outdoor environments [1]. The main objectives of this study are as follows:

1) To evaluate the indoor thermal comfort indices of CO_2, pressure, humidity, wind speed, ambient temperature and globe temperature.
2) To determine whether or not there are relationships between thermal comfort and the factor describe in (1).

The study of indoor thermal comfort is very important because it is correlated not only with students' comfort, but also with the energy consumption. Indoor air quality

(IAQ) and thermal comfort are two important aspects of indoor enviromental quality that need attention [2]. Poor air quality and thermal conditions can lead to dissatisfaction and discomfort, a reduction in work performance and a greater incidence of absenteeism [1]. Poor conditions can also effect students health, creating physical symptoms such as headaches, nose, throat, eye and skin irritation, nausea and drowsiness.

Ventilation is crucial to the indoor air quality. A certain rate of air exchange is essential for healthy indoor enviroment. Sometimes most ICT laboratories tend to be more over populated. This situation can influence the amount of heat and contaminants produced in the given space[5]. When the amount of fresh air supplied by air infiltration is not enough to assure a satisfactory indoor comfort, the students themselves will at times open the windows or doors. In temperature climates the window is possibly the most thermal control device in any building. The window opening is not only useful for energy saving, by reducing the need for mechanical cooling but also provides for beneficial interaction between the indoor and the outdoor environments [3].

Human thermal comfort has been the subject of considerable previous study and much of the available information was documented and codified in the literature [4]. Malaysia, is considered as a hot and humid tropical country that has a yearly mean temperature of between 26˚C to 27˚C and has high daytime temperatures of 29˚C to 34˚C and relative humidity of 70 to 90% throughout the year. With the emergence of energy shortage, climatic changes and sick building syndromes associated with the common usage of air-conditioning, natural ventilation can be an appropriate solution for these deteriorating problem. Result of these studies suggest a wider thermal comfort range for these regions that are proposed by international standards, i.e., ASHRAE Standard 55, which indicates that Malaysians are acclimatized to much higher environmental temperatures.

METHODOLOGY

Experiment work was conducted in a closed air conditioned ICT Laboratory at Ungku Omar Polytechnic, Malaysia. This lab was selected due to the maximum capacity students is 50 at one time and is equiped with 6 units of air condition (2Hp each) and 8 wall mounted fans. The schedule for this laboratory is for lectures, where the timetable for the students is depending on their lecture hours on a given day. The first class from 8.00 am to 5.00 pm daily (Monday to Friday), and it has a schedule of 2 hours lecture per session. The schedule for the class is shown in table 1.

Table 1: The occupancy of the laboratory

No	Lecture Hour	No of Students
1	8.00 – 10.00 am	38 students
2	10.30 – 11.30 am	26 students
3	11.30 am – 1.30 pm	40 students
4	2.30 pm – 3.30 pm	35 students

The advantages of Themal Comfort Measurement(TCM) equipment is that it enables all the 6 parameters were collected simultaneously with the frequency of 5 minutes each. For this assessment, there are 6 parameters were selected which are: level of CO_2, pressure, humidity, wind speed, ambient temperature and globe temperature.

Therefore, one of the laboratories selected, which in turn would refect the entire senario of other laboratories at Politeknik Ungku Omar. The size of the laboratory is approximately 44 feet in length and 33 feet in width, with a standard height of 10 feet. Figure 1 shows the layout of the laboratory and the location of Thermal Comfort Measurement instrument.

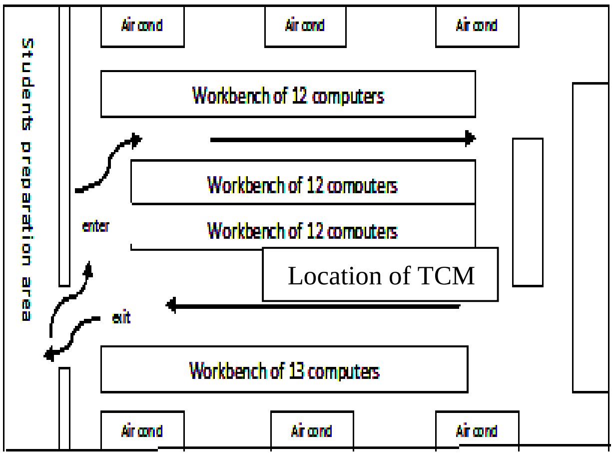

Figure 1: Layout of the TCM in the laboratory

The situation of the laboratory consist of movement from the students and lecturers on every interval. The students would be in the class for a 2 hour interval. Figure 2 shows the location of Hypermedia Laboratory. Based on the obervation done during this experimental study, the lights and air conditions were left on for the entire lecture hours eventhough there was a 10 minutes gap between lectures. The only time the aircondition is turned off is during lunch hours which is approximately 1 hours.

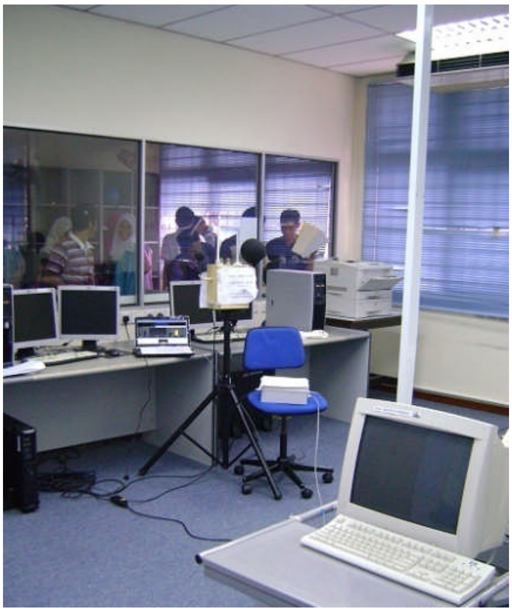

Figure 2: Location of the hypermedia laboratory

RESULTS

The data for all the 6 parameters was collected and plotted into graph. The main 6 important parameters in evaluating the thermal comfort and air quality in the room measured are the CO_2 ppm, humidity, ambient temperature, wind speed and globe temperature. Figure 3 to 8 shows the result from each 6 measured parameters. These results were collected can deduce the appropriate set up of this laboratory. Besides that other primary factors that affect thermal comfort are metabolic rate and clothing insulation. Table 1 shows the maximum, minimum and mean value of all the 6 parameters that were recorded by the Thermal Comfort Measurement instrument.

Table 2: The minimum, maximum and mean reading of the measured parameters.

No	Measured Criteria	Minimum	Maximum	Mean
1	Carbon Dioxide	793.13	1578.44	1266.79
2	Pressure	101.10	101.56	101.38
3	Humidity	36.14	54.23	38.75
4	Wind Speed	0.00	0.45	0.15
5	Ambient Temperature	23.29	24.13	24.20
6	Globe Temp.	24.44	26.66	25.50

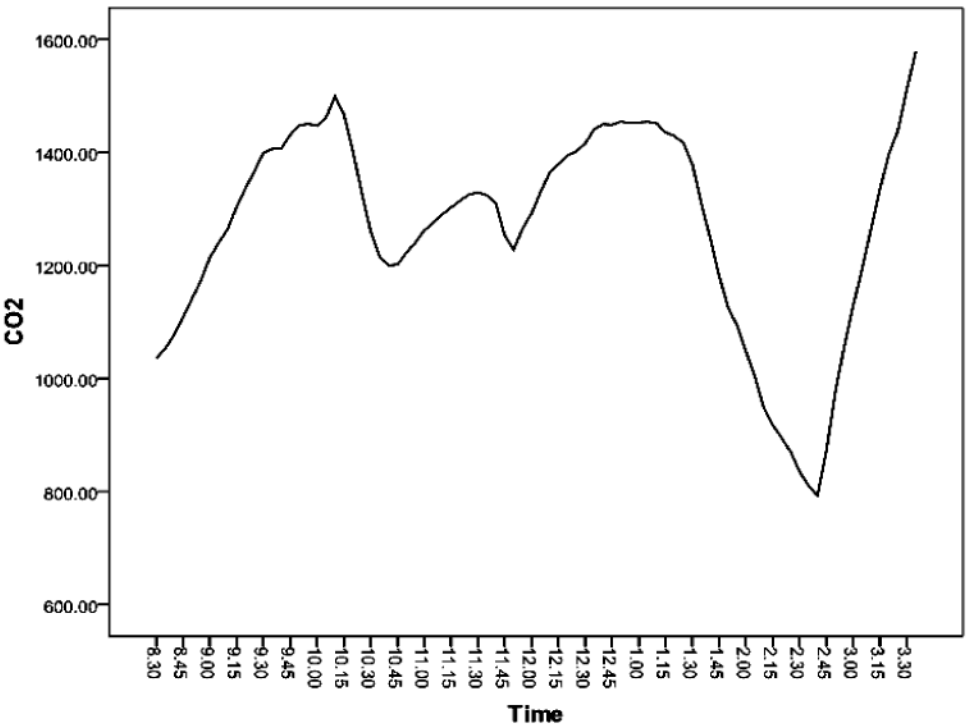

Figure 3: Level of CO_2 (ppm) over time

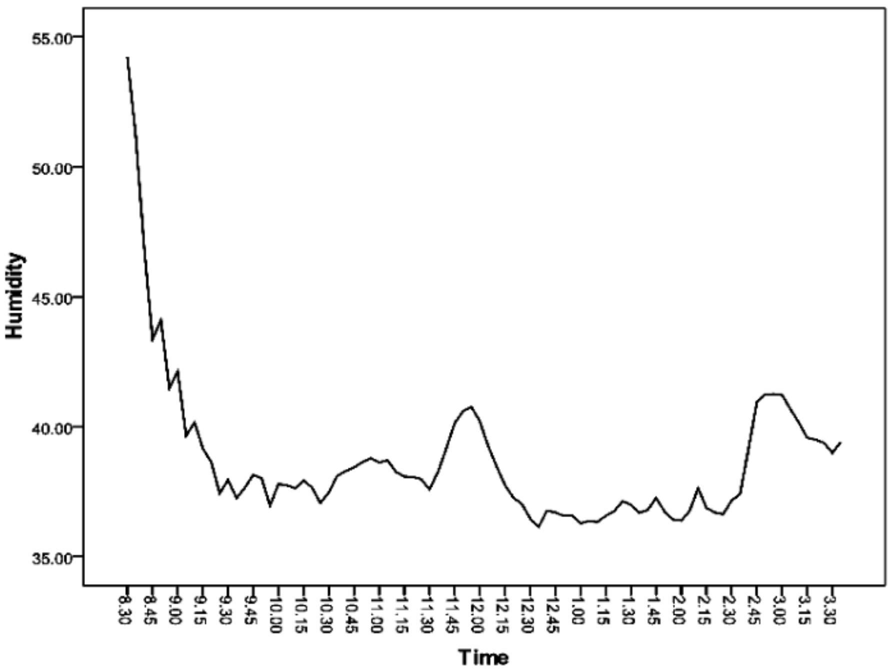

Figure 4: Humidity over time

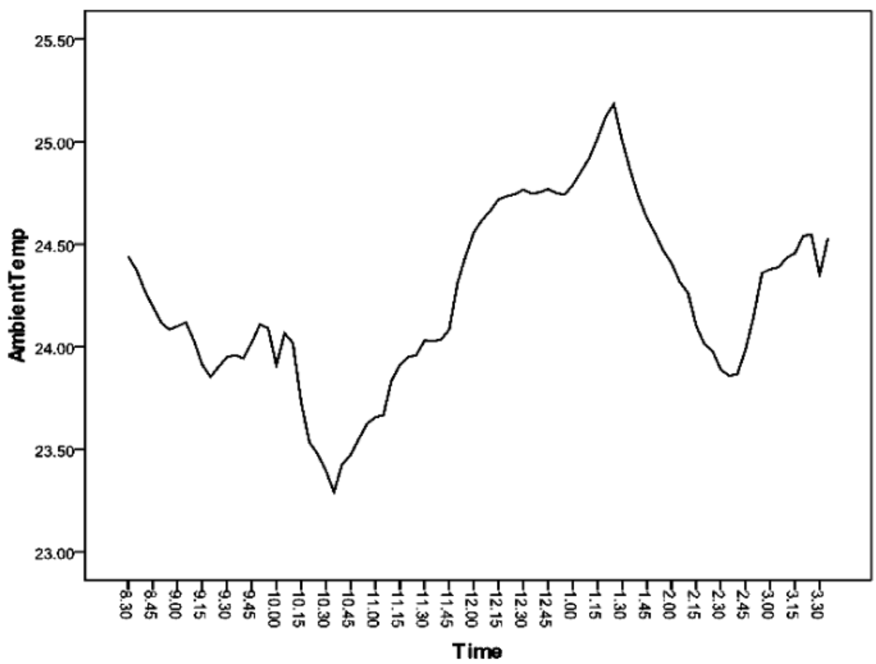

Figure 5: Ambient Temperature over time

DISCUSSION

From Figure 3, it shows the level of CO_2 is high throughout the 7 hours when the data was collected. It was quite surprising to know that the CO_2 contents surpass 1000 ppm in the morning when the lab is still empty. According to ASHRAE Standard 55-2004, defines that optimum level of CO_2 should be below 800 ppm at all time. The only time where the CO_2 is below 1000 ppm is from 2.00pm to 2.40pm is when the class is unoccupied. This high CO_2 concentration can be an indirect indication of poor ventilation and contaminant build-up [3]. The level CO_2 at an average of 1200 parts per million (ppm), can cause the students to experience decreases in satisfaction and faster level of boredom due to the perceptions of poor air quality. Based on the IRC research [3], the level of satisfaction improved as CO_2 concentrations decreased from the range 1100 to 470ppm. More people will be satisfied than were dissatisfied when CO_2 concentrations were less than 650 ppm (see figure 6)[2]. There are few solutions to this CO_2 problem. One is to have better air ventilation system by using exaust fan after every lecture hours can be one of the answer. This indoor air need to be ventilated with sufficient outdoor air to dilute contaminants and provide students with enough oxigen (O_2) for breathing. By adding a indoor plant can also be one of the answer to reduce the CO_2 problem as plant will use up CO_2 during process photosynthesis and release O_2 in return. Besides that, the use of an exhaust fan that switch on every 30 minutes for a duration of 5 minutes can also solve the problem of excess carbon dioxide in the room.

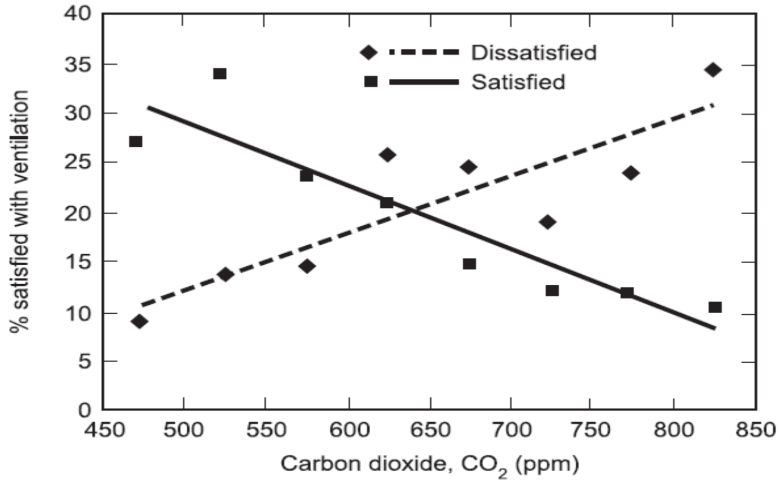

Figure 6: Shown percentage of occupants that were satisfied or dissatisfied with ventilation at each level of CO_2 concentration[5].

Low humidity can cause specific problem, like dry skin, dry eyes and static electricity. Figure 4 show the drastic drop in the percentage of the humidity start from 8.30am until 9.15am. One of the factor could be due to the increase of the outside temperature as the sun start to heat up the room.The second factor that contributes to the drop of humidity could be the number of student that start to fill the laboratory. The heat generated from the student can contribute to lower humidity. However, low humidity does not generally cause thermal discomfort. ASHRAE Standard 55-2004 does not define minimum humidity as an issue of thermal discomfort, nor does it address those individuals who have severe responses to low humidity. Figure 4 shows, the maximum humidity ratio for comfort at 0.012lb/lb. This level of moisture in the air can also cause serious mold problems in the building and to its contents, since it is equivalent to 100% relative humidity at 62˚F.

Figure 5 show the graph for ambient temperature that does not fluctuate much in bigger scale. Although there is a drop in the temperature from 10.15am to 10.45am but the difference is only 1.5^{o}C compared to 1.30 pm. Table 1 shows the mean comfortable temperature is approximately 24^{0}C. However, this standard only addresses thermal comfort in a steady state. Students who have prior exposure to different enviromental conditions or activity levels may not find the conditions allowed in this standard comfortable upon entry to the space. The effect of prior exposure or activity may affect comfort perception. Variables such as metabolic rate and clothing insulation may be non-uniform over a student's body and this non-uniformity may be an important consideration in determining thermal comfort.

In occupied spaces, clothing acts as an insulator, slowing the heat loss from the body. To predict thermal comfort, one must have an idea of the clothing that will be worn by the students. Due to the large variety of materials, weights and weave of fabrics, clothing estimates are just rough estimates. Each article has an insulating value, unit "clo.". For instance in this case, the operation tempetarue was set to 25 degree celcius and the mean humidity ratio was taken as 38.75 %RH, therefore the suggested clothing level can be determined based on the ASHRAE 55 standard handbook. Figure 7 shows the acceptable range of operative temperature and humidity for spaces that meet the comfort criteria. The suggested humidity ratio can be determined for better comfort of students in the class based on Figure 7.

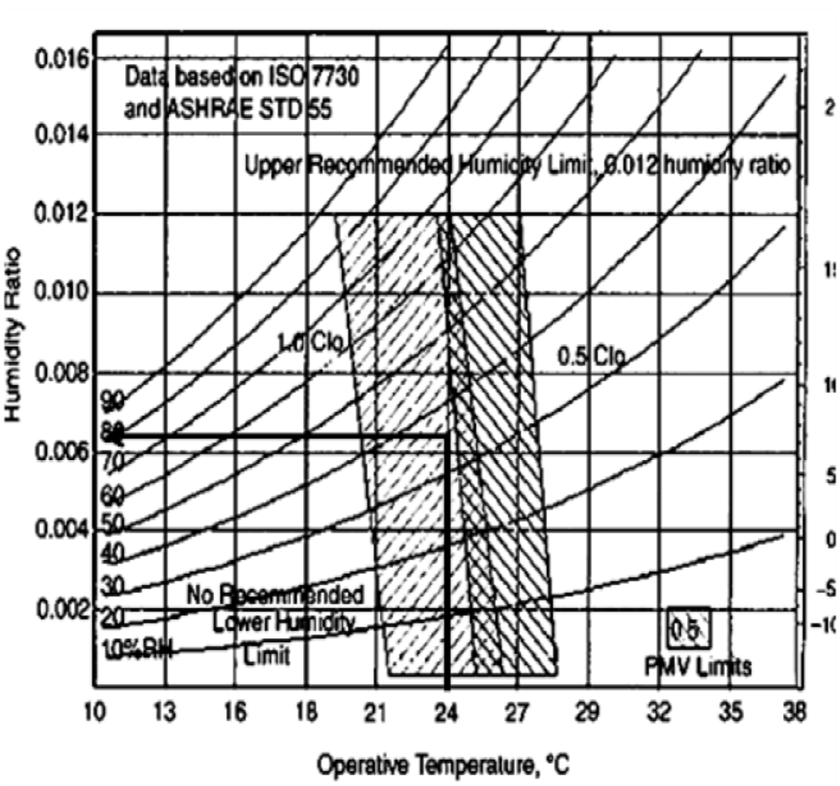

Figure 7: Acceptable range of operative temperature and humidity that meet the comfort criteria. [4]

Table 2 shows the comparison done based on the the ASHRAE 55 Standards to elobarate more on the condition of the laboratory . A comparison was done with the study from Optimization on Environmental Factors: A study at Malaysian Automotive Industries [2], the major 5 paramaters that affect the thermal comfort is inline with the study done before for a Malaysian environment but in different situations.

Table 3: The mean and standard deviation of the measured parameters.

No	Measured Criteria	Mean	Standard Deviation	Suggestion
1	Carbon Dioxide	1266.8	183.09	High
2	Humidity	38.8	2.90	Medium
3	Amb. Temperature	24.2	0.44	Medium
4	Wind Speed	0.152	0.105	Low
5	Globe Temperature	25.52	0.59	Good

CONCLUSION

Based on this study, it was found that the level of CO_2 should be reduce to prevent the level of discomfort in the laboratory The relationship between the effects of carbon dioxide towards the level of pressure, humidity, wind speed, ambient temperature and globe temperature is very important as this is to assess the environmental conditions required for a comfortable learning and teaching laboratory. The level of carbon dioxide is very high and should be reduced to the minimum level as it would produce a more conducive environment for learning. This study is related to the condition of mind that expresses satisfaction with the thermal environment based on the level of carbon dioxide. There are large variations, both physiologically and psychologically, from person to person, which makes it difficult to satisfy everybody in a space. The criteria of determining the thermal comfort of the room to make it a more condusive place of learning can be improved futher. However, extensive laboratory and field data have been collected that provided the necessary statistical data to define conditions that a specified percentage of students will find thermally comfortable.

ACKNOWLEDGMENT

All the members of this group would like to thank to all those participated in this study, thanks to the Tn. Hj. Mohamad Jayus b. Hj. Bunasir, Director of Politeknik Ungku Omar and Pn. Basariah bt. Idris the Head of the ICT Department for allowing us to conduct the study and to all students and parties who involved in the thermal comfort assessment. Lastly, many thanks to P.M Dr. Hj Baba Md Deros for guidance and support during this study.

REFERENCES

[1] Lipin, W. and Hien, W.N. 2007. Applying natural ventilation for thermal comfort in residential buildings in Singapore. Architectural Science Review, 50(3): 224-233.

[2] Chubaj, C.A. School Indoor Quality. Journal of Instructional Phychology. 29: 317-321.

[3] Huizenga, Abbaszadeh, Zagreus and Arens, University of California, “Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Enviromental Quality Survey”, Proceeding of Healthy Buildings, 3: 393-397, 2006.

[4] ASHREA STANDARD "Thermal Environmental Conditions for Human Occupancy", Feb 2003.

[5] Roonak Daghigh, Nor Mariah Adam and Barkawi Saharib, University Putra Malaysia "The Effect of Air Exchange Rate on Human Thermal Comfort in an Air-Conditioned Office Under Different Opening Arrangements", European Journal of Scientific Research, 25(2): 174-191, 2009.

[6] Gail S. Brager, Gwelen Paliaga and Richard de Dear,University of California "Operable Windows, Personal Control, and Occupant Comfort", American Society of Heating, Refrigeration and Air Conditions Engineers, Vol 110 part 10, 2004.

[7] A.R. Ismail, N. Jusoh, R. Zulkifli, K. Sopian, and B. M. Deros, University Kebangsaan Malaysia, "Thermal Comfort Assessment: A Case Study at Malaysian Automotive Industry", American Journal of Applied Science, 6(8): 1495-1501, 2009.

[8] A.R. Ismail, M.R.A. Rani, Z.K.M. Makhbul, K. Sopian, M.M.Tahir, J.A.Ghani, C. Meier, "Optimization of Enviromental Factors: A Study at Malaysian Automotive Industry", European Journal of Scientific Research, 27(4): 500-509, 2009.

[9] A.R. Ismail, M.R.A. Rani, Z.K.M. Makhbul, M.J.M. Nor and M.N.A. Rahman, "A Study of Relationship between WBGT and Relative Humidity to Worker Performance", World Academy of Science, Engineering and Technology, 2009.