THERMAL COMFORT STUDY FOR STUDENT LABORATORY

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This report is submitted as partial requirement for the completion of the Bachelor of Mechanical Engineering (Thermal Fluids) Degree Program

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SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal Fluids)”.

Signature: ……

Supervisor: ……

Date: ……

DECLARATION

“I hereby declare that the work in this report is my own except for summaries and quatations which have been duly acknowledge.”

Signature: ……

Author: ……

Date: ……

ABSTRACT

Thermal comfort can be defined as a state of mind that expresses satisfaction toward the surrounding thermal environment. There are several parameters that can affect a persons' perception in terms of thermal comfort mark. European Standard ISO 7730 stated that thermal comfort is a combination of four environmental parameters such as air temperature, relative humidity, air velocity, and mean radiant temperature, and plus two personal factors that is clothing (the clothes that occupants wear during the experiment being conducted) and metabolic rate (the activity of occupants during the experiment). This study aims on measurement of thermal comfort at faculty mechanical engineering laboratory. There are two different laboratories that will be conducted in this experiment, one with an air-conditioning system where as another one with no air-conditioning system. The procedure to determine occupants' responses toward thermal comfort in student laboratory is through observation method associated with a survey. Measurement of actual thermal comfort in student laboratory is accomplished through technical measurement associated with a thermal comfort monitor and correlation of Predicted Thermal Votes (PTVc), Predicted Airflow (PAF), Preferred Airflow (PRAF), Skin Dryness (SD) and etc. The result for experimental laboratory with air conditioning system is 23.4°C to 23.9°C, relative humidity of 58.2% to 60.1%, and air velocity of 0.01 m/s to 0.08 m/s. Whereas fabrication laboratory with no air conditioning system recorded a temperature of 31.3°C to 32.9°C, relative humidity of 63.6% to 68.7%, and air velocity of 0.13 m/s and 0.34 m/s.

ABSTRAK

Keselesaan termal boleh ditakrifkan sebagai keadaan minda yang menyatakan kepuasan terhadap persekitaran termal. Terdapat beberapa parameter yang boleh menjejaskan persepsi seseorang terhadap keselesaan termal. Piawaian Eropah ISO 7730 menyatakan bahawa keseleasaan termal adalah gabungan empat parameter alam sekitar, contohnya ialah suhu udara, kelembapan relatif, halaju udara, dan bermakna suhu berseri, dan digabungkan dengan dua faktor tamabahan iaitu cara pemakaian individu semasa eksperimen dijalankan dan jumlah aktiviti yang dilakukan semasa eksperimen dijalankan. Kajian ini bertujuan untuk mengukur tahap keselesaan termal di Makmal Fakulti Kejuruteraan Mekanikal. Dua makmal telah dipilh sebagai kes kajian untuk projek ini. Satu menggunakan sistem penyejukan udara manakala makmal yang satu lagi tidak mengunakan sistem penyejukan. Kaedah untuk menentukan jawapan penilai ke arah keselesaan termal dalam makmal pelajar adalah melalui kaedah pemerhatian dibantu dengan kaji selidik. Pengukuran keselesaan sebenar haba dalam makmal pelajar dicapai melalui pengukuran lurus teknikal berkaitan dengan monitor keselesaan terma dan analisis sebagai Undian Anggaran Termal (PTVc), Aliran Udara Aggaran (PAF), Aliran Udara Pilihan (PRAF), Kekeringan Kulit (SD) dan sebagainya. Makmal ujikaji menggunakan sistem penyejukan udara mencatatkan suhu pada 23.4^{o}C sehingga 23.9^{o}C, kelembapan udara 58.2% sehingga 60.1%, kelajuan udara 0.01 m/s sehingga 0.08 m/s. manakala untuk makmal fabrikasi tidak menggunakan sistem penyejukan udara mencatatkan suhu 31.3^{o}C sehingga 32.9^{o}C, kelembapan udara 63.6% sehingga 68.7% dan kelajuan udara 0.13 m/s sehingga 0.34 m/s

DEDICATION

For my beloved mother and father.

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I sincerely like to express my gratitude to those who have helped me during my final year project in some ways or another. I owe the accomplishment in this project to them. First and foremost, my deep appreciation to my supervisor, Engr. Dr. Tee Boon Tuan for his excellent supervision, invaluable guidance, trust, advice and constant help, support, encouragement, and assistance towards me throughout this project.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
CATI	-	Computer-Assisted Telephone Interview
DB	-	Dry Bulb Temperature
HI	-	Heat Index
HVAC	-	Heating, Ventilating, and Air Conditioning
IPTA	-	Institusi Pengajian Tinggi Awam
ISO	-	International Organization for Standardization
NIOSH	-	National Institute for Occupational Safety and Health
No.	-	Number
NWBT	-	Natural Wet Bulb Temperature
PD	-	Percentage Dissatisfied
PhD	-	Doctor of Philosophy
PMV	-	Predicted Mean Vote
PPD	-	Predicted Percentage Dissatisfied
RH	-	Relative Humidity
UTeM	-	Universiti Teknikal Malaysia Melaka
WB	-	Wet Bulb Temperature
m	-	Meter
lbs	-	Pounds
°C	-	Degree Celsius
e.g.	-	Exempli Gratia (Latin), means “For Example”

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

This chapter provides background information of the study. Generally it covers background of study, problem statements, objectives, scope and limitation of project, potential benefits of study, project outline, and structure of the report.

1.1 Background of Study

The study is concerning the quantification of thermal comfort at laboratory in Universiti Teknikal Malaysia Melaka (UTeM). The study will be carried-out within the Complex Mechanical Engineering Laboratory or can be called FASA B at Taman Tasik Utama.

1.1.1 Relationship between Student Laboratory and Thermal Comfort

ISO 7730 and ASHRAE 55-92 state that thermal comfort can be defined as a condition of mind which expresses satisfaction with the surrounding thermal environment. While Karimipanah, T. (2007) state that good thermal comfort and indoor air quality can actually have a positive impact not just on students' health but can also improve learning.

Thermal comfort for a student's is affected by several parameter such as air movement or velocity in the laboratory, humidity in laboratory, air temperature in laboratory, the clothing they worn to lecture, the average temperature of the walls, amount of physical work activity done in laboratory, mean radiant temperature, floor windows, and some other factors.

However, the high occupant density and machine in the laboratory has to be considered seriously to achieve a thermal comfort in laboratory. Students learning and performance will be affected greatly if they feel thermal discomfort with the environmental throughout the lab session.

A fresh and uncontaminated environment in a laboratory can make the lecturer and students to feel comfortable, energetic and active. Therefore reduce their physical stress, hence the students and lecturer can be improving their learning and teaching skills to present a good performance.

1.2 Problem Statements

From the related sources, some of the problem statements had found which relevant to the effects of the thermal comfort or discomfort in the environment of classrooms. People working in uncomfortably hot and cold environments are more likely to behave unsafely. This is because their ability to make decisions or perform manual tasks deteriorates as mentioned in previous research by Paulo (2004). A long side these Budaiwi (2007) state that undesirable thermal conditions can lead to occupant dissatisfaction, which in turn has an adverse effect on their health, productivity, and performance By implementing this case study in UTeM's laboratories, thermal discomfort can be prevent therefore students can performed at their best level. Orosa (2010) found that, in order to conduct a research in the field of thermal comfort, there are six most important thermal variables such as the human activity level, clothing insulation, mean radiant temperature, humidity, temperature and velocity of the indoor air. Those thermal variables will be the main parameters to assess the thermal comfort level in student laboratories for this project.

1.3 Objectives

Within acknowledgement the importance regarding thermal comfort inside the laboratory, the study was carried out to achieve the following objectives:

(1) To explore the indoor climate in mechanically ventilated student laboratories. Laboratory session usually is being spent at indoor environment. Therefore ventilated is one of parameter that should be considered to get a good thermal comfort in the laboratory.

(2) To investigate occupants perception of the accepted level of indoor thermal comfort in a tropical region.

In this objective the occupant response will be noted during the learning and teaching process in the laboratory. Each occupant has their own opinion about the classroom environment.

1.4 Scope and Limitation of Project

The scope of the project is mainly focus on the thermal comfort at FASA B laboratory. Two laboratories had been chose to carry out the thermal comfort measurement, which are the welding workshop for the non-air conditioning type and the other one is computer aided room for the air conditioning type.

The report will evaluates the current thermal comfort conditions by using objective measurement, computational fluid dynamic (CFD) modeling and subjective assessment.

1.5 Potential Benefits of Study

From the determination and measurement of thermal comfort in classroom, the study was carried out to achieve the potential benefits to the following parties:

(1) University

The University laboratory can maintain the satisfied thermal comfort and make an improvement to the unsatisfied laboratory, which is thermal discomfort such as overheated or too cold classrooms. Furthermore, there are many types of machine that can release heat. as a result the thermal comfort for a laboratory become more difficult to achieve.

(2) Students

The study can be a guideline for the students' future studies that concerned in thermal comfort. It is also revealed the students responses due to thermal comfort in the laboratory. The students would know the thermal comfort in some of the laboratory that provided a fresh and clean environment.

(3) Author

The study was carried out to show the thermal comfort knowledge, which including the Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD), the personal factors and environmental parameters which affect the thermal comfort in laboratory. The author also had learned to use the equipment for measuring the thermal comfort in laboratory. Through the study, author can improve his knowledge on thermal comfort and gain an experience on how to conduct measurement of thermal comfort. From the knowledge experience, it is very useful when working in factory environments for author future career.

1.6 Project Outline

1.6.1 Determination of the Occupants' Responses regarding to Thermal Comfort at Classroom.

The students will be asked to complete a questionnaire during the measurement data been taken. It is consists of general personal information included classroom number, the date and time during completing the questionnaire, students' gender, age, height and weight and six factors of thermal comfort such as air temperature, mean radiant temperature, air velocity, humidity, metabolic rates for work activity, clothing insulation, and final synthesis information.

The thermal comfort was only divided into two levels, which were comfortable and uncomfortable. Furthermore, the thermal sensation was tested by using 7-point ASHRAE scale in the air temperature section. At the last section of the questionnaire, the final synthesis judgement about the perception of the thermal environments in classroom was asked to the students.

1.6.2 Measurement of Actual Thermal Comfort at Laboratory.

Four basic environmental parameters, which are air temperature, mean radiant temperature, air velocity, and relative humidity, were measured while the students and lecturers were completing their questionnaire. The measurement apparatus for the study is VelociCalc plus Anemometer (Model 8347A).

The VelociCalc plus Anemometer measures four parameters, which are ambient or dry bulb temperature (DB), natural wet bulb temperature (WB), globe temperature (G), and relative humidity (RH). It allow the user to log 1394 samples with a time and date stamp, the data can be recorded simultaneously, it can reviewed the data on screen or downloaded to a computer spreadsheet program, with a wide velocity range of 0 to 50m/s depend on the study that will be performed. It also have statistics function displays average, minimum and maximum values, and the number of recorded samples

1.7 Structure of the Report

There are seven chapters in this report. Chapter one will be discussing on the introduction of this study such as background of study, problem statements, objectives of the study, scope and limitation of the study and potential benefit of study.

In chapter two, there it will discuss on the literature review on the study which involve theoretical of thermal comfort, equation of PMV and PPD, methods and tools used from journals, important of thermal comfort, and summaries of journals. From this chapter, we can know more details about thermal comfort and methods and tools have been used in thermal experimental.

Chapter three will specially deliberate the methodology of the thermal comfort study. According to methods and tools section, there are two methods have been used in this study such as survey and measurement experimental. In survey method, the tool would be selected is questionnaire where that can be obtained the response of students about thermal comfort at workshop areas. Additionally, the second method that used the direct measurement that is VelociCalc plus Anemometer.

In chapter four, there are two methods of determination on thermal comfort where will show out the results from response students and actual environment condition. After the collection data have be taken from Questionnaire and measurement of thermal comfort around workshop, there are difference results at each section among thermal environment.

Chapter five is the results analysis. Here student will be using the data that have been taken that is by surveying and direct measurement and use mathematically solution to get the end results.

In chapter six, that is discussion parts of the study which is explanation and distribution about the reasons of difference thermal comfort and environment condition based on the results obtained. By the ways, the improvement of thermal comfort will be discussed so that the temperature and heat generated around workshop will be decreased and maintained thermal environment along working time.