PERCEPTION OF THE THERMAL ENVIRONMENT IN LIBRARY CENTRE AT UTeM: SUBJECTIVE PREFERENCES AND THERMAL COMFORT DUE TO AIR CONDITIONING SYSTEM

NADIAH ZAFIRAH BINTI AL-AZMI
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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Refrigeration & Air-Conditioning Systems) (Hons.)

by

NADIAH ZAFIRAH BINTI AL-AZMI

B071110328

920722-14-6522

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ABSTRAK

Keselesaan terma merupakan adaptasi daripada tubuh badan manusia cenderung untuk menerima keadaan persekitaran. Persepsi seseorang terhadap keselesaan terma adalah dipengaruhi oleh suhu udara, kelembapan relatif, halaju udara, suhu pancaran persekitaran, kadar metabolisme bagi aktiviti-aktiviti kerja dan penebat pakaian. Sistem penyaman udara bangunan yang cekap dan kondusif akan memberi impak persekitaran yang baik bagi keselesaan penghuni dan menigkatkan prestasi produktiviti kerja serta mengurangkan kadar tidak puas hati pengguna. Setelah mengenalpasti akan kepentingan keselesaan terma kepada penghuni, objektif utama kajian adalah untuk mengenalpasti persepi staf perpustakaan UTeM terhadap haba persekitaran di tempat kerja mereka kepada sistem penyaman udara yang sedia ada dengan menggunakan pendekatan kualitatif dan kuantitatif. Penentuan persepsi penghuni terhadap keselesaan terma telah diperolehi melalui kaedah pemerhatian dan analisis yang berkaitan dengan soal selidik keselesaan terma serta hubungkait dengan hasil daripada pengukuran objektif. Pengukuran sebenar keselesaan terma dalam unit-unit kerja telah dilaksanakan menggunakan pengukuran pemantauan bacaan terusan oleh instrumen keselesaan terma bagi menentukan nilai-nilai PMV dan PPD. Lanjutan daripada kajian ini menunjukkan persepsi kakitangan perpustakaan terhadap persekitan haba di ruang kerja mereka adalah pada tahap sederhana (melebihi 60%). Selain daripada faktor persekitaran, penyesuaian terma dan psikologi penghuni kuat mempengaruhi keselesaan terma manusia. Penyelenggaraan pada sistem penyaman udara bangunan perlu diambil kira bagi menghasilkan persekitaran haba yang baik.

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ABSTRACT

Thermal comfort is an adaptation of the human body, tends to accept environmental conditions. A person's perception of thermal comfort is affected by air temperature, relative humidity, air velocity, mean radiant temperature, metabolic rate for work activities and clothing insulation. The demand for conducive high efficient air conditioned office building provides a thermally acceptable environment for human comfort and work that would in order to enable better work productivity performance and less occupant's thermal dissatisfaction. In recognizing the significance of thermal comfort level to occupants, the main objective of the study is to determine the thermal environment perception among UTeM's library staffs to the existing air conditioning system in their workplace by means of both qualitative and quantitative approaches. Determination of occupants' perception on thermal comfort was obtained through observation and analysis method associated with a questionnaire on thermal comfort with respect to findings of objective measurement. Measurement of actual thermal comfort in work units was conducted by direct reading monitoring linked with thermal comfort instruments to determine the PMV and PPD values. Further to this study, it shown that the perception of library staffs on thermal environment in their workspace is at moderate level (more than 60%). The result indicated besides the substantial role of environmental factors, thermal adaptation and psychological parameters strongly affect human thermal comfort. Maintaining on AC system of the research building should be taken into consideration to produce good thermal environment.

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DEDICATION

I would like to express my deepest appreciation and special thanks to everyone, especially to both of my beloved parents and family who have given their support, encouragement and good advice to me. Not forgotten, to my project supervisor, panel, lecturer and friends that were helped directly or indirectly in this study.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Air Conditioning
ANOVA	-	Analysis of Variance
F	-	F Test (ANOVA)
HVAC	-	Heating, Ventilating, and Air Conditioning
IAQ	-	Indoor Air Quality
PMV	-	Predicted Mean Vote
PPD	-	Predicted Percentage of Dissatisfied
SBS	-	Sick Building Syndrome
℃	-	Degree Celsius
%	-	Percent
m/s	-	Meter per second
n	-	Number of sample
p	-	Significant value
r	-	Correlation Value
sd	-	Standard Deviations

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CHAPTER 1
INTRODUCTION

This chapter is intended to provide background information of the study conducted. It covers the background of study, problem statements, research objectives and limitations of the study.

1.1 Background Of Study

Fanger (1986) defined "Thermal comfort is the condition of mind which expresses satisfaction and comfortable international human body with complex thermal factors. Thermal comfort is affected by the environmental parameters or personal factors and the combination both of them. Hussin *et al.* (2013) studies highlighted that there are four primary factors that can affect human comfort, which should be considered by the HVAC design engineers before designing air conditioning systems are effective air temperature, relative humidity, air velocity and mean radiant temperature. Havenith *et al.* (2002) also added about the personal factors include clothing properties and metabolic heat production that will contribute to achieve human comfort. Kosonen and Tan (2004) claimed that high efficient air conditioned office buildings provide a thermally acceptable environment for human comfort and work that would in order to enable better work productivity and less thermal dissatisfaction. Zailani *et al.* (2012) continued saying that occupant's attention, concentration, learning, hearing, and performances will be improved by high environmental quality.

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Thermal comfort is difficult to define because it is needed to take into account a range of environmental parameters and personal factors when deciding on the temperatures and ventilation that will make occupants feel comfortable. It is a psychological where it may affect our overall emotional. For example, in industrial field, the employee complaints may increase when they work in uncomfortable conditions. Some parameters of the thermal environment such as bad air temperature, poor relative humidity, worse mean radiant temperature and uncontrolling air movement (velocity) may contribute human discomfort which can lead to the symptoms of sick building syndrome (SBS). Then, their productivity in an organization may fall down and maybe in some cases, they refuse to work in a particular environment if they are still working under dissatisfied environment.

1.2 Problem Statements

Thermal comfort is an adaptation of the human body, tends to accept the environment conditions. Thermal indoor environment is essential not only because of the amount of time spent in the building, but because there are indoor sources of contaminants (Aziah *et al.*, 2010). Even in optimal conditions, some individuals may experience discomfort. Budaiwi (2007) revealed that undesirable thermal comfort conditions may lead to occupant dissatisfaction which will directly affect their health, productivity, and efficiency. Ismail *et al.* (2009) also stated that high level of thermal comfort will meet the needs of occupational health, safety concern and environmental impact.

Individual thermal comfort can be affected by environmental and personal factors. Crowded working areas, the job being undertaken, physical exertion, radiant temperatures and penetration also may cause people to feel discomfort. In a research carried out by Wagner (2007), in the workplace which have different capacities, it was reported that the level of thermal comfort conditions during high occupant density periods were very poor. Staff with existing medical problems such as bad respiratory conditions can be more susceptible to adverse health effects from working in conditions that are not ideal. Thermal discomfort such as temperature in

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the workplace is too hot or too cold can be related to physical stress, which be responsible for poor health and bad productivity of the occupants (Wong and Khoo, 2003). Good indoor environment quality will encompass high quality in the dimensions of thermal comfort, indoor air quality, acoustical comfort, visual comfort. Last, this study will undergoes further detailed about the parameters that can impart to high level of thermal comfort environment. This study is conducted due to less information and statistics on thermal comfort level in UTeM's Library Centre among staffs.

1.3 Research Objectives

The aim of the research is to determine the thermal environment perception among staffs in Library Centre, University Teknikal Malaysia Melaka (UTeM) to the existing air conditioning (AC) system in their workplace by means of both a qualitative and a quantitative approach. The specific objectives of the research are listed below:

(a) To measure the thermal comfort environmental parameters by field measurement.
(b) To determine the status of thermal comfort perception among library staffs by subjective approach.
(c) To analyze the result of experimental and subjective approach.
(d) To associate the relationship between results from field measurement and subjective approach to be thermally acceptable by the staffs.

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1.4 Limitations Of Study

A cross-sectional study was carried out among UTeM's library staffs from October 2014 to November 2014. In this study, 54 staffs (28 male and 26 female) were selected as the respondents by using the universal sampling. They are permanent employees who work for a minimum of three months. The respondents were selected is from their work unit. There are six units were selected purposively based on the Library Staff Directory. There are two types of measurement method that the data were collected; 1. By field measurement, and 2. By subjective assessment. The specific thermal comfort parameters were measured continuously for 8-hours Time Weighted Average (TWA) which 40-hours per week.

The background study and introduction of thermal comfort, previous research and observation of thermal comfort, secondary factors affecting comfort, predictions thermal comfort, are just an additional knowledge for the readers. However, this study was conducted in order to determine the thermal comfort status of the building occupants with the correct setting of an existing air conditioning system based on primary thermal comfort parameters in UTeM library centre.

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CHAPTER 2
LITERATURE REVIEW

While the first chapter clarified the background of the study, this chapter proceeds with a fully-referenced review from the relevant literature. It covers introduction to thermal comfort, research and observation of thermal comfort, factors affecting thermal comfort, secondary factor affecting comfort, prediction thermal comfort and general thermal comfort conditions for determining comfort zone.

2.1 Introduction To Thermal Comfort

Human has always striven to create a thermally acceptable environment. Thermal comfort becomes a worldwide attention due to its relevance with all life fields. The development of human civilization in creating comfort environment in doing a daily work has evolved. From ancient history until today, man has created a lot of facilities in creating and achieving comfort, especially in technology thermal comfort to their environment. Nowadays, in the process of designing buildings, one of the important parameters that need to be considered is creating a thermally acceptable environment by occupants.

Comfort is feeling of human body that tends to accept the thermal of surroundings. According to ASHRAE (1992), thermal comfort is described as a condition of mind which expresses satisfaction with the surrounding thermal environment. Fanger (1986) also defined that "Thermal comfort is the condition of mind which expresses satisfaction and comfortable international human body with their thermal

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environment which is influenced by environmental or personal factors, or the combination both of them. Kilic *et al.* (2006) also revealed environmental parameters that affecting thermal environment are air temperature, relative humidity, air velocity and radiant conditions such as mean temperature or solar intensity in their studies. The personal factors such as clothing properties and activity level (Candido *et al.,* 2010). Furthermore, there are some secondary factors affecting comfort such as human factors of different stage or ages among children, adults, and elderly. Gender factor is also calculated for the type of skin between male and female in terms of skin temperature, evaporation loss, metabolic rate and type of clothing worn. Then, human adaptation to the environment, for example, the ability of people from warm climates may adapt to the hot environment. This explanation in terms of thermal comfort basically describes a person's psychological state of mind where a person feels too hot or too cold.

Modern technology in achieving thermal comfort in buildings has been made to provide comfort to all occupants and maintaining health and improving the productivity of occupants. Heating, ventilating and air conditioning (HVAC) is sometimes referred as climate control and is particularly important for the design of industrial buildings and large office buildings, which the conditions inside the buildings are safe and healthy where it is arranged with reference to relative humidity and air temperature of the building using the fresh air of nature, both factors should be closely regulated while maintaining the comfort environment. ASHRAE (2009) stated the main purpose of HVAC system is to provide conditions for human thermal comfort. Indoor air should minimize the occupant discomfort, irritation, and illness. Sick building syndrome symptoms, discomfort and irritation can result from poor indoor air quality, bad environmental factors such as noise, poor quality or inadequate lighting, and also the other environmental factors.

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2.2 Research And Observations Of Thermal Comfort

Thermal comfort is a complex phenomenon which is subjective by several thermal comfort parameters: environmental parameters, personal factors and psychological. Parson (2002) highlighted the two common methods to quantitatively expressing thermal comfort and thermal sensation is Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) after Fanger (1970) studies.

Corgnati (2007) claimed in his studies that in the middle of 1950, the first scientific studies about the effect of the thermal environmental quality in classrooms on the students' performances were conducted by Pepler and Warner. An interesting analysis of the results of the first studies, lots of them performed as field studies. After this period, the Fanger theory was developed about thermal comfort based on the results from a fully controlled climate chamber, which broke the developing of new field researches on thermal comfort. Then, Corgnati (2009) stated that the growing interest in the last years about adaptive theory of thermal comfort has again stimulated researches by field studies aimed at qualifying the thermal environment, both objectively (by measurements) and subjectively (by occupants judgements) must be done.

De Dear and Brager (1998) summarized that the PMV model works best only in buildings that have HVAC systems. The studies also described that in naturally ventilated buildings (no mechanical systems), people seem can adapt and accept higher indoor temperature than the predicted temperature by the PMV model calculation. They discourage the use of naturally ventilated passive solar building because of the narrow band of comfort limits. Occupants in this type of buildings have more relaxed expectations and can tolerate with a wider temperature change. Furthermore, occupants in air conditioned buildings have a narrow rigid thermal environment and are more sensitive to thermal surroundings (ASHRAE, 2009).

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