UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

THERMAL COMFORT AND ENERGY CONSUMPTION ANALYSIS FOR ENGINEERING LABORATORY BUILDINGS IN UTeM

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Master of Mechanical Engineering
(Energy Engineering)

2017

THERMAL COMFORT AND ENERGY CONSUMPTION ANALYSIS FOR ENGINEERING LABORATORY BUILDINGS IN UTeM

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Energy
in Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this thesis entitle "Thermal Comfort and Energy Consumption Analysis for Engineering Laboratory Buildings in UTeM" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Mechanical Engineering (Energy Engineering).

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DEDICATION

I dedicate my project work to our heroic Iraqi Army, Popular Mobilization Forces, our martyrs (may Allah have mercy on them), my family and my friends. A special feeling of gratitude to my father, and to my beloved mother, who encouraged me and a push for tenacity to improve myself throughout all my walks of life and who has always been with me in overcoming difficult times in my life. His patience is the meaning of love, kindness and gentle soul. Thank you for giving me a chance and I love them.

I also dedicate this project to my brothers, my sisters, my wife, and my wonderful child (Mohammed Ali and Zainab) who have supported me through my life. I always miss and I cherish the memories that we had. I love all of you.

ABSTRACT

This study aims to conduct thermal comfort and energy consumption analysis at Mechanical Engineering Laboratories Complex (KMKM). A few laboratories have been selected as the case study for sample measurement with an air-conditioning system and without air-conditioning system. Measurement of thermal comfort level in student laboratories is accomplished by using thermal microclimate and indoor air quality meter. In addition, the Building Energy Index (BEI) was also being determined for each block of the building. Based on the calculation, the overall BEI from March 2015 to February 2016 is 86.5634 kWh/m^2/year. Meanwhile, the BEI for March 2016 to February 2017 is 73.456 kWh/m^2/year. The calculation shows that the KMKM building energy index for (March 2015 to February 2016) and (March 2016 to February 2017) is lower than the maximum range of the Malaysia Standard 1525:2014. The measurement data is then compared with the current Malaysia Standard 1525:2014 and ASHRAE:-55 Standard. The results of this study shows that overall average air velocity is 0.116 m/s, less than Malaysian Standard 1525:2014. The overall average operative temperature is 25.88°C, the overall average relative humidity is 60.15% and the overall average CO_2 is 511.28 ppm were within the range of Malaysian Standard 1525:2014.

ABSTRAK

Kajian ini bertujuan untuk menjalankan analisis keselesaan termal dan penggunaan tenaga pada Kompleks Makmal Kejuruteraan Mekanikal (KMKM). Beberapa bilik makmal telah dipilih sebagai kajian kes untuk pengukuran sampel yang mempunyai sistem penyaman udara dan tanpa sistem penyaman udara. Pengukuran kadar keselesaan termal dalam makmal pelajar dilaksanakan dengan menggunakan peralatan thermal microclimate dan meter kualiti udara dalaman. Selain itu, indeks tenaga bangunan (BEI) juga ditentukan untuk setiap blok bangunan. Berdasarkan kepada pengiraan, BEI keseluruhan daripada Mac 2015 hingga Februari 2016 ialah 86.5634 kWh/m^2/tahun. Sementara BEI untuk Mac 2016 hingga Februari 2017 ialah 73.456 kWh/m^2/tahun. Data pengukuran kemudiannya dibandingkan dengan Piawaian Malaysia 1525:2014 dan Piawaian ASHRAE:-55. Hasil keputusan kajian menunjukkan halaju udara purata keseluruhan ialah 0.116 m/s, kurang daripada Piawaian Malaysia 1525:2014. Suhu operatif purata keseluruhan ialah 25.88°C, kelembapan relatif purata keseluruhan ialah 60.15% dan kadar purata CO_2 keseluruhan ialah 511.28 ppm, yang masih berada dalam julat Piawaian Malaysia 1525:2014.

ACKNOWLEDGEMENT

Thanks, all thanks to my God. I would like to extend my gratitude to my supervisor, Dr. Tee Boon Tuan, for his invaluable advice, assistance, and guidance. Without his continued support, this thesis would not have been the same as presented here. My appreciation and gratitude to each and every staff of Faculty of Mechanical Engineering (FKM) and Universiti Teknikal Malaysia Melaka (UTeM) for their generous helping in completing my thesis. My heartfelt gratitude also goes to my beloved family, thank you for the encouragements, supports, and prayers, for being my inspiration, for your understanding and most importantly, for your endless love. Finally, I thank my country (IRAQ).

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LIST OF SYMBOLS

SYMBOL	DESCRIPTION
m/s	Meter per second
°C	Degrees Celsius
hr	hour
BTU	British Thermal Unit
m	Meter
kW	kilowatt
kWh / m^2 /yr	kilowatt hours per meter square year
lb	pound
W/ m^2	Watt per meter square
%	Percentage
RH	Relative Humidity
TR	Tones Refrigerant
CO_2	Carbon Dioxide
ppm	Parts-per Million

LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
2015/2016	March 2015 to febraury 2016
2016/2017	March 2016 to febraury 2017
PMV	Predicted Mean Vote
PPD	Predicted Percentage Dissatisfied
ACMV	Air-conditioning & Mechanical Ventilation
KMKM	Kompleks Makmal Kejuruteraan Mekanikal
IEQ	Indoor Environmental Quality
BEI	Building Energy Index
TNB	Tenaga Nasional Berhad
GWh	Giga watts
USGBC	Building Council of the United States of America
BRE	Building Research Establishment
BREEAM	BRE Environmental Assessment Method
MRT	Mean Radiant Temperature

UTCI	Universal Thermal Climate Index
IAQ	Indoor Air Quality
CO	Carbon Monoxide
Rn	Radon
VOC	Volatile Organic Compounds
HVAC	Heating, Ventilation and Air-Conditioning
GHG	Greenhouse Gas
TAC	Task/Ambient Conditioning Systems
RH	Relative Humidity
NO_2	Nitrogen Dioxide
VOC	Volatile Organic Compound
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
UTeM	Universiti Teknikal Malaysia Melaka
UTHM	Universiti Tun Hussein Onn Malaysia
MS	Malaysian Standard
ISO	International Organization for Standardization
EN	European Sandard

CHAPTER 1

INTRODUCTION

1.1 Introduction:

The ultimate aim of conditioning the interior environment of buildings is to provide a comfortable and healthy indoor environment for the occupants. Research on the relationships of indoor environment quality and its effects on the health, comfort and performance of occupants is becoming increasingly essential. Although it is difficult to satisfy everyone in a space due to physiological and psychological variations from person to person, thermal comfort is still one of the most significant factors affecting environmental satisfaction (Nasrollahi et. al., 2008). Furthermore, 'feeling comfortable' is very subjective in nature and cannot be defined objectively. The environmental parameters that constitute the thermal environment are: temperature (air, radiant, surface), humidity, air velocity, and personal parameters (clothing together with activity level). The rising interest in this field has placed additional pressure on the research community to provide practical guidelines on creating a safe, healthy and comfortable indoor environment (Kumar et. al., 2002).

Nowadays, people spend more than 90% of their lives in the building (Klepeis et.al. 2001). Interior dividing of building is an act of demarcating spaces into several volumes for variety uses. It's challenging for architects and engineers design for quantitatively allow decision making process of the installation or removal of partition in an environment of air-conditioned rooms closed it because there are many restrictions on the comfort of heat effect on occupants interact and building energy use. In general, the achievement of simultaneous internal environment comfortable and efficient use of energy is not a simple task (De Dear et. al. 2015, Yahya et. al. 2014).

In the partitioning scenario, without conditioned space interior design should pose a threat is great not only for the comfort of the occupants but also to energy use in the building. Therefore, it is important to study qualitatively impact restrictions in place of interaction of the air-conditioned comfort of heat, and energy consumption when restrictions are installed in or removed from the air conditioned space (Azar et. al., 2014, Li, Z., et. al.2014).

One of the prime goals concerning building energy consumption is to ensure thermal comfort conditions with respect to energy consumption and carbon emissions. Different strategies are researched to achieve these goals. In different cooling technologies have been evaluated as for both thermal comfort and energy savings. Low-energy technologies prove to be an efficient solution to keep indoor thermal comfort and to reduce energy consumptions.

1.2 Research Background

Industrial developments, the growth rate of world population and the increasing of global social welfare has controlled to an ascent in the global request for energy in recent years. In this regards, building sector is the largest energy consumers across other sectors, accounting for around 40% of the aggregate energy use and 36% of the carbon dioxide emission in the world(Hasan et. al.,2014), and is estimated to quickly augment with future building development. However, a large ratio of the energy consumed in buildings is to improve the indoor environment wellbeing. Thermal comfort is the status of awareness so as to describes contentment with the thermal ambience "ASHRAE Standard:-55–2013", and is so important for health and well-being as well as productivity.

Generally, there are two prime models to assess the condition of thermal comfort including the static paradigm (PMV- PPD) and the adaptive paradigm. Fanger (Fanger, 1970) developed the PMV-PPD model by means of the heat balance equations and empirical studies on the human body. The Predicted Mean Vote (PMV) indicator forecasts the average comfort restraint of a larger set of human on a (7) points ASHRAE thermal sensibility measure, including -3 as cold -2 as cool -1 as somewhat cool 0 as neuter $+1$ as somewhat warm $+2$ as warm and $+3$ as hot (Yang et. al., 2014).

In addition, Fanger presented another thermal comfort index called Predicted Percentage Dissatisfied (PPD) to predict the rate of occupants who are thermally disgruntled with the environmental status and, feel excessively cool or too warm (Fanger, 1972). The thermal acceptability of indoor environments is taken into account in ASHRAE Standard 55 (ASHRAE Standard:-55–2013) so that at least more than 80% of the occupants need to be satisfied.

However, the recommended accepted (PPD) for thermal comfort of occupants is 10% (i.e. $0.5 < PMV < 0.5$). The second thermal comfort model known as the adaptive paradigm is on the assumption that the outdoor environments affects the indoor thermal comfort since people can adjust to the environment and accept various temperatures during various times of the year (Brager et. al.,1998).

The total energy consumption and the thermal comfort are two important conflicting criteria in the building design process. Decreasing the building energy consumption as well as increasing the indoor thermal comfort not just makes the environmental quality better because of the pollution reduction from the fossil fuels yet, likewise keeps individuals more productive at work and far from building health related issues (Chen et. al.,2015). Thus, in order to obtain comfort-energy improvements of buildings, executive decisions for optimization of the building energy consumption, at the same time, indoor thermal comfort are highly required. Moreover, the energy efficient facilities are just beneficial when the occupants of the buildings are restful with the environmental conditions.

1.3 Problem Statement

In order to achieve thermal comfort inside an academic building in the university and to choose the best design ventilation strategies for that building, it is very important to know the actual situation of the indoor environment concerning temperature and relative humidity. Buildings consume large amounts of energy for its operation. Air-conditioning & Mechanical Ventilation (ACMV) systems are accountable for around half of the energy used in buildings. This project examines indoor environmental quality IEQ field measurement for an academic building in the Kompleks Makmal Kejuruteraan Mekanikal (KMKM), UTeM. The project is aimed to answer the following question:

i- What is the current status for the indoor environment (air temperature, relative humidity, air velocity, CO_2) conditions in the building compare with the recommended standard MS1525:2014?

ii- How is the relation of thermal comfort factors with respect to energy consumption?

1.4 Objective of study

The effectiveness of the same method used in the different building types will be affected by variables such as climate, habits of residents, HVAC system, enclosure properties, geometric properties, etc., and therefore, the final decision varies greatly. Researchers need to invest time and money with the thoroughness of the properties for building and different methods. There is no quick way to policy makers and engineers to make broad judgments about the appropriate energy-saving methods. These specific study objectives below:

i- To assess the indoor environment quality within the evaluation of the energy consumption.

ii- To conduct a comparative analysis between the measurement parameters with the available standard such as ASHRAE:-55 and MS1525:2014.

1.5 Significance of Study

Study on building energy demand has become a very important topic, because the significant increase in interest in sustainable energy. In the circumstances it may be possible to determine energy performance in buildings through model calculations start from build characteristics of known (front approach) or to evaluate energy consumption of energy meter (inverse approach).

The purpose of this study is to illustrate how the result of thermal comfort changes under various conditions and how susceptible is the thermal comfort as to the progressions in various parameters. Also to characterize the thermal comfort and to investigate a thermal comfort factors in a Mechanical Engineering Laboratory Complex and to reduce consumption of the electrical energy which is used for air conditioning of each block in the facility. Therefore, there are two points to illustrate this Significance,

i- This project can provide data for physical Parameter measurements consist of air temperature, relative humidity, air velocity, and CO_2 which can assist in thermal comfort study.

ii- The energy consumption analysis can give an overview of energy usage in Mechanical Engineering Laboratory Complex.

1.6 Scope of work

The study involves gathering of data and to measure indoor air physical parameters, like relative humidity, temperature, and CO_2 and air velocity in the selected location is UTeM's Kompleks Makmal Kejuruteraan Mekanikal (KMKM) located at Taman Tasik Utama, Melaka. It define the current indoor air circumstance of non-equipped buildings to assess prerequisites to reach the comfortable and agreeable indoor circumstance of every kind of rooms, since, this building have been utilized as educational intended functionally and classified as offices, lecture rooms and laboratories.

i- Reviewing and evaluating the present energy consumption.

ii- Obtain the physical characteristics of the facility and collect aggregate blocks area of the facility.

iii- Determination important physical parameters that may impact the system performance.

iv- Determine the relationship between energy consumption with the indoor condition.

1.7 Report Outline

The increasing demand for energy consumption and indoor environmental quality better motivated in seeking solution efficiency, electricity consumption and energy saving in modern buildings. This study aimed to analyze the energy usage of mechanical engineering complex, through physical parameters and then compared with the current standards Malaysian (MS 1525:2014).

Chapter 1 shows the introduction, background, objectives, significant and problem related to this study discussed in details. Chapter 2 shows and discussed the history issue of the study. However, this chapter will deal with the previous studies that is related to this