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"I hereby declared that I have read through this thesis entitle "Energy and Thermal Comfort Analysis for ACMV System in Academic Building" in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluid)."

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ENERGY AND THERMAL COMFORT ANALYSIS FOR ACMV SYSTEM IN ACADEMIC BUILDING

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This thesis submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering (Thermal-Fluid) with Honours.

Faculty of Mechanical Engineering

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DECLARATION

"I hereby declared that this thesis entitle "Energy and Thermal Comfort Analysis for ACMV System in Academic Building" is the result of my own work except for summaries and quotations which have been duly acknowledged."

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Specially dedicated to my beloved Father, Mother and Family

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ABSTRACT

The main objective of this project is to identify area where energy is being used efficiently or being wasted in the current air-conditioning and ventilation system. The project is also aim to analyze the thermal comfort level based on the Air Conditioning and Mechanical Ventilation (ACMV) system in the building. The case study area for this project is FTK's building. The building can be divided into three sections: Lobby 1, Lobby 2 and Classrooms. The measurement of thermal comfort around FTK building is taken using Thermal Microclimate in two conditions: with the presence of occupants and without the presence of occupants. The physical measurement parameters include air temperature, radiant temperature, air speed/velocity and relative humidity. The analysis consists of building cooling loads, energy saving estimates and costing for the building. Improvement methods in ACMV system is later being proposed to reduce energy consumption. Based on the result, the thermal comfort level of the building is warm. The average energy consumption of the building is 692 485.20 kW/year.

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ABSTRAK

Objektif utama projek ini adalah untuk mengenal pasti kawasan di mana tenaga yang digunakan berkesan atau yang sia-sia di udara dingin dan pengudaraan sistem semasa. Projek ini juga bertujuan untuk menganalisis tahap keselesaan termal berdasarkan pendingin hawa dan Pengudaraan Mekanikal (ACMV) sistem di dalam bangunan. Kawasan kajian kes untuk projek ini ialah bangunan FTK. Bangunan ini boleh dibahagikan kepada tiga bahagian: Lobi 1, Lobi 2 dan Bilik Darjah. Pengukuran keselesaan termal di sekitar bangunan FTK diambil menggunakan Microclimate Thermal dalam dua keadaan: dengan kehadiran penghuni dan tanpa kehadiran penghuni. Parameter pengukuran fizikal termasuk suhu udara, suhu sinaran, kelajuan udara / halaju dan kelembapan relatif. Analisis ini terdiri daripada bangunan penyejukan beban, anggaran penjimatan tenaga dan kos untuk bangunan. Kaedah penambahbaikan dalam sistem ACMV kemudiannya dicadangkan untuk mengurangkan penggunaan tenaga. Berdasarkan keputusan, tahap keselesaan haba bangunan itu panas. Penggunaan tenaga purata bangunan itu 692 485.20 kW / tahun.

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TABLE OF CONTENT

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LIST OF TABLES

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LIST OF FIGURES

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ABBREVIATION

ACMV	Air Conditioning and Mechanical Ventilation
UTeM	Universiti Teknikal Malaysia Melaka
FTK	Faculty of Technology Engineering
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers

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CHAPTER 1

INTRODUCTION

In this chapter, the purpose of the project will be described generally. Start with a brief explanation about the background of the project. Then, the problem statement that lead to the idea for this project and several objectives that aimed to achieve are established in order to overcome the problem statement. This chapter also explains the scope that will be discussed in the project.

1.1 BACKGROUND STUDY

Thermal comfort is one of the important parameter in evaluating the indoor comfort level. It is known that thermal environmental affecting the performance of human being. Thermal comfort in academic building has a great influence on the productivity and satisfaction of student, lecturer and staff inside it. The thermal sensation for every person is not the same. There are six basic factors that affect thermal comfort: air temperature, air velocity, radiant temperature, humidity, metabolic heat and clothing insulation. It may influence the Air Conditioning and Mechanical Ventilation

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(ACMV) performance. Energy consumption and thermal comfort is contributed with each other to analyze student's comfort level in the building. The study is about the quantification of thermal comfort based on ACMV system inside academic building in Universiti Teknikal Malaysia Melaka (UTeM). The study is carried-out in the Industrial Campus of UTeM, inside the Faculty of Technology Engineering (FTK) Academic Building.

1.2 PROBLEM STATEMENT

Building energy analysis examines the ways actual energy consumption is currently used in the facility, in the case of a completed and occupied building and identifies some alternatives to reduce current energy usage. Implementation of energy analysis are practically used to analyze energy consumption pattern, monitoring on how the energy used varies with time in the building, how the system element interrelate, and study the effect of external environment towards building. It is also the main system that provides comfortable and healthy environment for the occupants. The main purpose of this study is to evaluate the current ACMV system performance, energy optimization and identifying the energy waste on UTeM's academic building. Besides that, the project will also investigate the thermal comfort level for the respective building.

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1.3 OBJECTIVES

The main objective of this project:

- To identify areas where energy is being used efficiently or being wasted in the current air-conditioning and ventilation system.
- To analyze the thermal comfort level based on the ACMV system in the building.

1.4 SCOPES

The main tasks of the project are:

a) Reviewing and evaluating of current energy consumption.
b) Evaluating the human thermal comfort level in the building.
c) Identify important physical parameters that may influence the system performance.
d) Finding relationship between energy optimization with human comfort.
e) Propose cost saving methods for the audited building.

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CHAPTER 2

LITERATURE REVIEW

This chapter will cover the literature review of the previous research in thermal comfort analysis in a building. Literature review is a part where the critical study and evaluation of the previous research is done. It is a synopsis of the particular area or correlated topic of the previous research and will be summarize in this chapter. The summarize topic include the entire important subject regarding the project that leads to the development and improvement of the project. Review had been made through the journals, articles and also some books to study the theory, basic concept and method of the related aspect. Based on the previous research, the comparison and improvement can be made for this project.

2.1 INTRODUCTION TO THERMAL COMFORT AND ACMV SYSTEM

Thermal comfort is recognized as an important parameter for a healthy and productive workplace (Ismail, 2010) and studies environment. The human thermal

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comfort can be defined as the state of mind which expresses satisfaction with the thermal environment, according to the published standard such as ASHRAE STANDARD-55 and ISO 7730 (Ari et al, 2007). The reference to "mind" is a subjective matter. It is difficult to please everyone because the environment conditions for everyone are not the same. Primary concern should be given to making sure the people inside are pleased and comfortable to stay – the environment inside not too cold or too hot (Daghigh, 2012). ACMV is an initials that stands for "Air Conditioning and Mechanical Ventilation" system. The air-conditioning and mechanical ventilation (ACMV) systems in the Malaysia (tropic) can be very different from those of the temperate environment (Yau, 2011). Chen, 2012 stated that poorly operated air conditioning and mechanical ventilation (ACMV) system might cause Sick Building Syndrome (SBS) symptoms and thermal discomfort in the hot and humid atmosphere.

2.2 AIR-CONDITIONING AND MECHANICAL VENTILATION

ACMV stands for "Air Conditioning and Mechanical Ventilation" system. The Air-Conditioning and Mechanical Ventilation (ACMV) system provides conditioned air into the building to keep occupants inside the building comfortable. According to MALAYSIAN STANDARD-1525 (2007), ACMV systems have three basic types:

a) Central Air-distribution System

For this type, ACMV system equipment receives recirculated air (whether room air or outside air) from a central duct system. After that the system perform the necessary ventilating or air-conditioning functions, and delivers the conditioned air to the central duct system and finally deliver the conditioned air into the conditioned space of the building.

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b) Central Circulating Water Systems

In this type, components like centrifugal, rotary, screw, scroll or reciprocating, compression refrigeration or absorption refrigeration type water-chilling package provides chilled water to a central piping system. Then, the chilled water was supplies using piping system to water-air heat exchangers (terminal units) serving the conditioned space of the building.

c) Multiple Units Systems

In this case, units of ACMV equipment will receiving a supply of electric energy and then it will perform the functions of cooling air for distribution to a space or zone of the building.

2.3 FACTORS AFFECTING THERMAL COMFORT

According to ASHRAE STANDARD-55 (2004), there are six primary factors or that must be followed when addressed about thermal comfort. Four of them are environmental parameters. The four environmental parameters are air temperature, radiant temperature, air speed/velocity and relative humidity. It is a well known fact, that the environmental factors manipulate the performance of an individual (Ismail, 2010). In more detail, the effects of four environment parameters had been described as following:

a) Air Temperature

Air temperature is the average temperature of the air surrounding of an occupant. Air temperature is the most important aspect contributing to thermal comfort. There is no precisely correct “best” temperature. The best temperature is the temperature that most people find comfortable. To create a comfortable environment, temperature must be must be maintained between 20-26°C (Shaharon, 2012).

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b) Radiant Temperature

Mean radiant temperature is the average temperature of surfaces that surround a person. Radiant temperature has a bigger influence than air temperature on how people lose or gain heat to the environment. Radiant heat will manipulate people anywhere there is direct sunlight. Sunlight coming throughout a window will have effect to mean radiant temperature. This may be decreased by simple actions such as the closing of blinds and curtains or the installation of solar film.

c) Air Velocity

Air velocity is an important factor in thermal comfort because people are sensitive to it. Air velocity is the average speed of the air to which the body is exposed. Effect of air velocity affects human comfort. Air velocity will provide relief to people in a hot situation, but the higher air velocity will give additional chill to people in a cold situation.

d) Relative Humidity

Humidity is reference to the moisture content of the air. It can be expressed in terms of several thermodynamic variables, including vapor pressure, dew-point temperature, and humidity ratio. Relative humidity is the ratio between the actual amount of water vapour in the air to the maximum amount of water vapour that the air can hold at the similar temperature and similar pressure. High humidity makes people feel hotter than low humidity. To create comfortable surroundings, relative humidity must be maintained between 40-60% (Shaharon, 2012). Generally, people are much more sensitive to higher temperature than high humidity.

Besides the environmental parameters, there are two other factors which can determine the levels of thermal comfort are metabolic rate and clothing insulation. The effects of these two factors are described as follows:

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e) Metabolic Rate

Metabolic rate was defined as the rate of change of chemical energy into heat and mechanical work by metabolic activities. Metabolic rate is usually expressed in terms of unit area of the total body surface. Our bodies generate heat. The more physical work being done, the more heat that being formed by the bodies (HSE). The more heat being formed, the more heat needs to be lost so the body does not overheat. Based on ASHRAE STANDARD-55 (2004), metabolic rate is expressed in met units.

$$1\ met = 58.2\ W/m^2 \qquad (2.1)$$

Where W is the unit watt and m is the unit meter.

Values of the metabolic rates for various typical tasks are shown in Table 2.1 below:

Table 2.1: Metabolic Rates for Typical Tasks

Activity	Heat generation, W/m2
Resting	
Sleeping	40
Reclining	45
Seated, quiet	60
Standing, relaxed	70
Walking (on the level)	
0.89 m/s	115
1.34 m/s	150
1.79 m/s	220
Office activities	
Reading	55
Writing	60
Typing	65
Filing, seated	70

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