



**THERMAL COMFORT OF AIR-CONDITIONED OFFICE
THROUGH DIFFERENT WINDOWS -DOOR OPENING
ARRANGEMENTS AT JTKM'S ACADEMIC STAFF AT F3,
TECHNOLOGY CAMPUS, UTEM**

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**BACHELOR OF MECHANICAL AND MANUFACTURING
ENGINEERING TECHNOLOGY (REFRIGERATION AND AIR
CONDITIONING SYSTEMS) WITH HONOURS**

2023



**Faculty of Mechanical and Manufacturing Engineering
Technology**

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A thesis submitted
in fulfillment of the requirements for the degree of
**Bachelor of Mechanical And Manufacturing Engineering Technology Engineering
Technology (Refrigeration And Air Conditioning Systems) with Honours**

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this thesis entitled Thermal Comfort Of Air-Conditioned Office Through Different Windows-Door Opening Arrangements At Jtkm's Academic Staff At F3, Teknology Campus, Utem is the result of my own research except as cited in the references. The Choose an item. 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 checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of Bachelor of Mechanical And Manufacturing Engineering Technology Engineering Technology (Refrigeration And Air Conditioning Systems) with Honours.

Signature

Supervisor Name

Date

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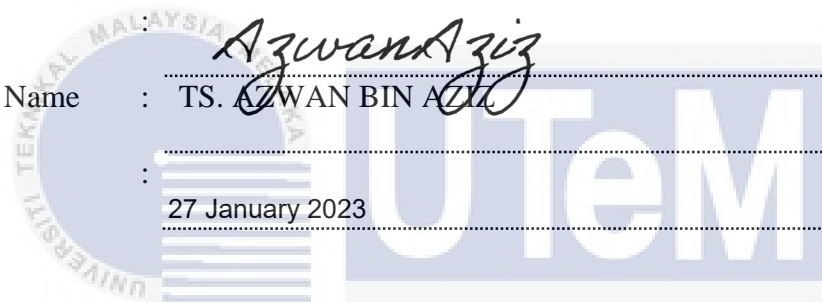
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27 January 2023



اونيورسيتي تيكنيكل مليسيا ملاك

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DEDICATION

I want to thank my loving parents, Wan Ahmad Salahuddin Bin Wan Ahmad Rafaii and Rosniza Binti Abdullah, for the study's success. I would dedicate it to them because I want to thank them for their moral support and sacrifices throughout my long academic career at this university. Lastly, I dedicate this report to my housemates, who helped me a lot in finishing it by sharing knowledge, teaching me stuff I didn't know, and many other things.



ABSTRACT

The problem of occupant window opening has been increasingly problematic. This is because, in today's world, the role of windows in controlling ventilation is important, particularly when it comes to reducing building energy consumption. Previous research has revealed a general tendency that associated window openings are substantially related to weather conditions, indoor temperature, and various non-environmental factors in different nations, climates, buildings, and room kinds, and in different observation periods. At the study of comfort levels in a place like an office in a building, the majority of researchers agree that these three characteristics are interrelated. Indoor air quality is also a significant influence in determining an individual's level of comfort. The pollutant carbon dioxide (CO₂), which is produced by occupants, has a harmful effect on them. This will make an employee unproductive and sick while on the job. As a result, it's crucial to understand how occupants interact with building controls in reaction to variations in both IAQ and temperature. Indoor air quality and thermal comfort are two important aspects of indoor environmental quality that receive considerable attention. Natural daylight that received through window in an office room also give an impact towards occupants. Windows are one of the major means by which building occupants control the indoor environment. If people are uncomfortable, they will take actions including the use of building controls which they think will improve their comfort. Most buildings are not equipped with suitable devices for natural and or mechanical ventilation. In such cases, there is no IAQ control and air changes. The main objectives of this study is to evaluate the indoor thermal comfort conditions of an air-conditioned office through different windows-door opening arrangements. The results gained, when the amount of fresh air supplied by air infiltration is not enough to assure a satisfactory indoor comfort, the occupants cannot achieve their thermal comfort sensation. According to the research, the inability of rooms to open the window in their workplace affects the relative humidity state. It may have an impact on the health of the occupants. The occupant's impression is also influenced by the distance between the office table and the window.

ABSTRAK

Masalah pembukaan tingkap penghuni semakin bermasalah. Ini kerana, dalam dunia hari ini, peranan tingkap dalam mengawal pengudaraan adalah penting, terutamanya apabila ia melibatkan pengurangan penggunaan tenaga bangunan. Penyelidikan sebelum ini telah mendedahkan kecenderungan umum bahawa bukaan tingkap yang berkaitan dengan ketara berkaitan dengan keadaan cuaca, suhu dalaman, dan pelbagai faktor bukan persekitaran di negara, iklim, bangunan dan jenis bilik yang berbeza, dan dalam tempoh pemerhatian yang berbeza. Pada kajian tahap keselesaan di tempat seperti pejabat dalam bangunan, majoriti penyelidik bersetuju bahawa ketiga-tiga ciri ini saling berkaitan. Kualiti udara dalaman juga merupakan pengaruh yang ketara dalam menentukan tahap keselesaan seseorang individu. Bahan pencemar karbon dioksida (CO₂), yang dihasilkan oleh penghuni, mempunyai kesan berbahaya kepada mereka. Ini akan menjadikan seseorang pekerja tidak produktif dan sakit semasa bekerja. Akibatnya, adalah penting untuk memahami cara penghuni berinteraksi dengan kawalan bangunan sebagai tindak balas kepada variasi dalam kedua-dua IAQ dan suhu. Kualiti udara dalaman dan keselesaan terma adalah dua aspek penting kualiti persekitaran dalaman yang mendapat perhatian yang besar. Cahaya siang semula jadi yang diterima melalui tingkap di bilik pejabat juga memberi impak kepada penghuni. Tingkap adalah salah satu cara utama yang membolehkan penghuni bangunan mengawal persekitaran dalaman. Jika orang ramai tidak selesa, mereka akan mengambil tindakan termasuk penggunaan kawalan bangunan yang mereka fikir akan meningkatkan keselesaan mereka. Kebanyakan bangunan tidak dilengkapi dengan peranti yang sesuai untuk pengudaraan semula jadi dan atau mekanikal. Dalam kes sedemikian, tiada kawalan IAQ dan perubahan udara. Objektif utama kajian ini adalah untuk menilai keadaan keselesaan terma dalaman pejabat berhawa dingin melalui susunan bukaan tingkap-pintu yang berbeza. Keputusan yang diperolehi, apabila jumlah udara segar yang dibekalkan oleh penyusupan udara tidak mencukupi untuk memastikan keselesaan dalaman yang memuaskan, penghuni tidak dapat mencapai sensasi keselesaan terma mereka. Menurut penyelidikan, ketidakupayaan bilik untuk membuka tingkap di tempat kerja mereka mempengaruhi keadaan kelembapan relatif. Ia mungkin memberi kesan kepada kesihatan penghuni. Tanggapan penghuni juga dipengaruhi oleh jarak antara meja pejabat dan tingkap.

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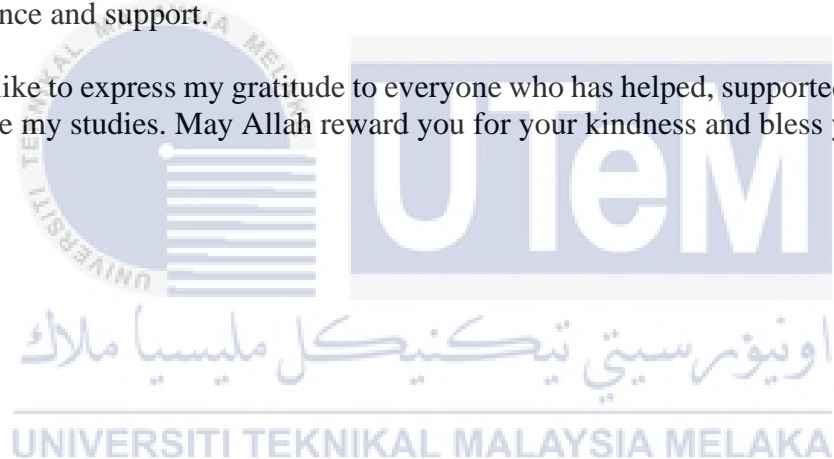


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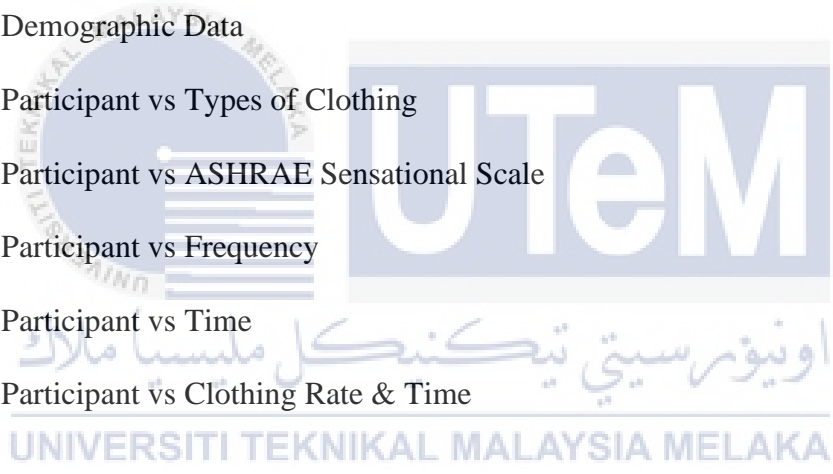
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LIST OF SYMBOLS AND ABBREVIATIONS

IAQ	-	Indoor Air Quality
CO ₂	-	Carbon Dioxide
CO	-	Carbon Monoxide
CFCs	-	Chlorofluorocarbons
USA	-	United State America
BTU	-	British thermal unit
R-values	-	thermal resistance
NFRC	-	National Fenestration Rating Council
VT	-	visible transmittance
UV	-	U-Value
NAFS	-	North American Fenestration Standard
CIMO	-	context, intervention. Mechanism, outcome
FTKMP	-	Fakulti teknologi Kejuruteraan Mekanikal Pembuatan
Am	-	ante meridiem
Pm	-	post meridiem
BP	-	Bilik Pensyarah
RH	-	Relative Humidity
ppm	-	parts per million
PMV	-	Predicted Mean Vote
PPD	-	Predicted Percentage Of Dissatisfied

%	-	Percentage
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers.
°C	-	Celcius
WHO	-	World Health Organization
JTKM'S	-	Jabatan Teknologi Kejuruteraan Melaka
UTEM	-	Universiti Teknikal Malaysia Melaka
MWh	-	megawatt-hour
kWh	-	Kilowatt hours
HVAC	-	Heating, ventilation, and air conditioning
SANS	-	SysAdmin, Audit, Network, and Security
ICI	-	Clo-Value
MS	-	Malaysia
IEQ	-	indoor environmental quality
SHGC	-	Solar Heat Gain Coefficient
m	-	Metres
m/s	-	Metres Per Second
NECB	-	Net Ecosystem Carbon Balance
BABUC/A	-	portable instrument for acquisition, display, storage and processing of environmental data

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CHAPTER 1

INTRODUCTION

1.1 Background

Every day, individuals express their dissatisfaction with global warming and hold serious discussions about it. Climate change has increased the difficulty of maintaining human thermal comfort, particularly in buildings, by raising global air temperatures and solar radiation. Every country in the world is struggling to deal with the problems and find solutions. Malaysia is no exception when it comes to dealing with the situation.

Currently, the weather in Malaysia are not easily to predictable. Unpredictable weather conditions that have seen areas that have never been flooded experience major floods and prolonged droughts are among the effects of global warming that bring changes or disruptions to climate cycles, habitats and ecosystems. Global warming is a phenomenon of gas trapping known as greenhouse gases involving a group of gases (carbon dioxide (CO₂), carbon monoxide (CO), chlorofluorocarbons (CFCs), methane, nitrogen oxides) preventing and trapping the earth's heat from being released into space.

Malaysia is a hot and humid tropical country with a yearly average temperature of 26-27°C, peak daytime temperatures of 29-34°C and relative humidity of 70-90 percent all year. As the population grows affluent, demands for air conditioning increases for both commercial and residential sectors. Most of the commercial buildings in Malaysia are equipped with mechanical cooling systems. The energy consumption of air conditioning system has become one of the major issues for these buildings.

From the latest data and observation, Malaysia's energy consumption has risen to the level of larger energy consumers across the world. In 2002, the energy consumption increased surprisingly, 2.8MWh per capita compare to 10 years ago. The latest data according to the website *worlddata.info*, Malaysia's total annual use of electric energy is 136.90 billion kWh. This equates to an average of 4,230 kWh per person. Therefore, methods of energy saving are very important and urgently needed. Figures below shows the country's population (as of 2019) has access to electricity between two country, Malaysia and USA.

Table 1.1 The Data of The Country's Population

Electricity	total	Malaysia per capita	USA per capita
Own consumption	136.90 bn kWh	4,229.75 kWh	11,842.76 kWh
Production	148.30 bn kWh	4,581.97 kWh	12,428.52 kWh
Import	33.00 m.kWh	1.02 kWh	220.71 kWh
Export	3.00 m kWh	0.09 kWh	29.42 kWh

This crisis indirectly affected people that working in building space. Because of the year-round hot and humid climate, inhabitants are unable to adequately cool their surroundings naturally. Therefore, the most obvious solution is to rely on mechanical cooling using Heating, Ventilation, and Air-Conditioning (HVAC) or in common words is by using air-conditioning. Indoor thermal environment is part of the indoor environmental quality component that close influence by the climatic condition. Indoor air quality and thermal comfort are two important aspects of indoor environmental quality that receive

considerable attention. This issues need to be conduct to study of thermal comfort more details in an office builing. This is very important because it is correlated not only with occupants' comfort, but also with energy consumption.

Buildings are designed for people, an those people are trying to accomplish a task basically. The building needs to keep people comfortable, efficient, healthy, and safe as they set about their task. Our interface to the world is through our senses, touch, sight, hearing, smell and taste. Each one of these senses can lead to a greater or lesser degree of comfort. Builing better is not only about avoiding problems, it shoul also be about creating positively pleasurable and healthy livingg places.

Comfort is about the physical environment in its totality. The issues which are most abviously associate with comfort are temperature, humidity, noise, light, smell, temperature and humidity. There are several factors that also affected the human comfort which is clothing insulation, metabolic rate and air temperature. Temperature is the most significant component to the experience of comfort in a space. Maintaining a person's thermal comfort means ensuring that they don't feel too hot or too cold. This means keeping the temperature, humiity, airflow an radiant sources within acceptable range. In the process of human bodies metabolism generates heat, which must dissipate into the surrounding air or surfaces.

The dimension of room need to calculate accurately to get the good data. The dimension of room also must be acknowledge to make sure all the process run well. The specific condition office such as consist how many windows, type of windows that used in building, the door material and dimension, all this information will be collect before conduct the experimental work. Another important information, the total of occupants in this office

building also should be take note. All this information very important to determine the accurate data while conduct this experimental work.

Other than that, the instruments that can be used for thermal comfort measurements are BABUCA and IAQ meter. There are many others type of instrument that can be used such as TSI VELOCICALC (Anemometer) and GLOBE THERMOMETER. But, based on the current situation BABUCA and IAQ meter looks very suitable. The size of this instrument also not to bigger and it can be sure it not takes up more space in the office.

Four environmental variables were measured using a measuring physical quantities instrument (BABUCA): air velocity, relative humidity, dry bulb temperature and mean radiant temperature. Physical measurements were carried out at one point in the middle of office for some conditions. The samples need to be recorded every one minute interval. Having measured the environmental parameters, the two personal parameters, metabolic rate and clothing insulation were estimated in accordance with ISO 7730.

Indoor air quality (IAQ) meter also can be used. This instrument can gauge temperature, humidity (percent RH, wet-bulb, dew point), air velocity, carbon dioxide, carbon monoxide, and airborne particles; all factors that help measure occupant thermal comfort and assure a healthy indoor environment. Why is IAQ is important? Indoor Air Quality (IAQ) is strongly connected to health and wellbeing. Humans tend to spend a large amount of time indoors. Breathable air that's free of health threatening pollutants can lead to a higher quality of life, lower risk of respiratory illnesses, and a reduced risk of various chronic conditions.

From the thermal comfort parameters, PMV and PPD for naturally and mechanically ventilated office using InfoGap and Microsoft Excel can be calculated. Based on ISO 7730,