UNIVERSITI PUTRA MALAYSIA

THERMAL COMFORT ANALYSIS AT UNIVERSITI PUTRA MALAYSIA HEALTH CENTRE

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THERMAL COMFORT ANALYSIS AT UNIVERSITI PUTRA MALAYSIA HEALTH CENTRE

By

ALINA BINTI AMINUDDIN

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

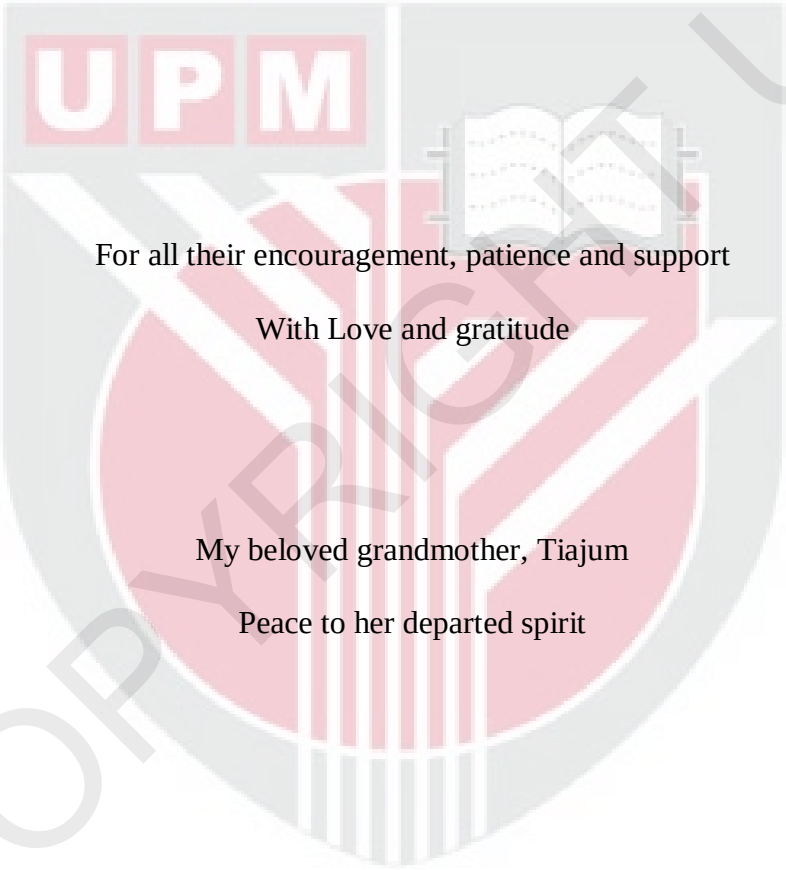
January 2013

In dedication to:

My dear, loving and supporting mother, Norhani Abdullah

My beloved father, Aminuddin Hussin

My precious husband, Muhammad Syueib



For all their encouragement, patience and support

With Love and gratitude

My beloved grandmother, Tiajum

Peace to her departed spirit

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

THERMAL COMFORT ANALYSIS AT UNIVERSITI PUTRA MALAYSIA HEALTH CENTRE

By

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January 2013

Chairman : Associate Professor Ir. Nor Mariah Adam, PhD

Faculty : Engineering

Thermal comfort analysis in any waiting areas is crucial to assess the conditions that will influence the occupants state of well being. The hot and humid environments of Malaysia can easily affect the waiting room conditions if steps are not taken to create a comfortable atmosphere. The occupants can feel aggravated and stressful while waiting for their turn to see the medical officer if the conditions at the waiting rooms are not comfortable.

The main objective of this research was to determine the thermal comfort of occupants in various waiting areas at Universiti Putra Malaysia (UPM) Health Centre seeking medical attention and to evaluate the possibility of using the Infrared Thermography for fast screening of body temperature from a distance. At the same time, a survey was performed involving the said occupants on their perception of thermal comfort.

Thermal comfort field measurements study was conducted in the Health Centre of UPM. Relative humidity, mean radiant temperature, air temperature, air velocity, clothing

insulation, metabolic rate, Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) were calculated.

The subjective survey involved questions on thermal sensation. The result yielded from subjective and objective approach was used to formulate the conclusion on thermal comfort at the Health Centre. For thermal comfort evaluation, a questionnaire according to ASHRAE Standard 55 was given to all occupants who participated in the temperature screening by the Infrared Thermography. Fanger's Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) were calculated using measurement obtained from Heat Stress Monitor.

At any given condition of a waiting room, thermal comfort may also influence body temperature of occupants. The Infrared Thermography is a potential solution to diagnose the human body temperature from a distance. The ability of this technique to differentiate different body temperatures is of practical importance in cases which require rapid screening to segregate infected occupants during mass pandemic such as HIN1 infection that occur at UPM in 2009. The study involved screening of 313 occupants at the Health Centre. Each occupant's body temperature was determined by recording the temperature profile of the face using the Infrared Thermography device Fluke Thermal Imager. The subject was seated at a distance of about 1.0 meter away from the device. The temperature profile was analyzed using the SmatView 2.0 to determine the body temperature.

The air temperature at the Health Centre measured by the Thermal Stress Monitor was between 19°C to 21°C, lower than the value given by the ANSI/ASHRAE Standard (2004) and ISO 7730 (2005) of 24°C set to be the lower limit for thermal comfort. It was observed

that 63% of occupants involved in the study were comfortable with the surrounding air temperature. PMV showed the most acceptable value was at -1.1 and PPD showed the most acceptable value at 30.5.

The results showed that a difference of about 1.1% and 5.1% was observed between the Infrared Thermography reading and the values obtained by using the Digital Clinical Thermometer and laboratory thermometer, respectively. The results were verified by a senior medical officer at the UPM Health Centre. Out of 313 occupants tested by Infrared Thermography, 38.9 % showed body temperature of 37-38ºC, 34.8% showed 38-39ºC, 14.1% showed 36-37ºC, 8.3% showed 39-40ºC and lastly, 3.5% showed 35-36ºC.

The Infrared Thermography device could be used effectively for fast screening body temperature without any personal contact with the patient, as the recordings could be done 1-2 meters away. This method could reduce 50% of screening time compared to the normal clinical method. The results from PMV and PPD study comply with the findings on the thermal sensation of occupants in the waiting area.

The study also shown that not only Infrared Thermography was applicable to measure the surface body temperature of material, but it also can be used to measure the human body temperature.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANALISIS SUHU KESELESAAN PENGUNJUNG DI PUSAT KESIHATAN UNIVERSITI PUTRA MALAYSIA

Oleh

ALINA BINTI AMINUDDIN

Januari 2013

Pengerusi : Profesor Madya Ir. Nor Mariah Adam, PhD

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Analisis keselesaan di ruang tempat menunggu adalah sangat penting kerana keadaan yang selesa mempengaruhi pengunjung . Suhu persekitaran yang panas dan lembab di Malaysia amat mudah memberi kesan di ruang menunggu jika langkah tidak diambil untuk membentuk persekitaran yang selesa. Pengunjung akan mudah merasa tidak selesa dengan suhu persekitaran yang tidak sesuai dan dalam keadaan yang tertekan semasa menunggu giliran mereka untuk berjumpa dengan pengawai kesihatan .

Objektif utama kajian ini adalah untuk menentukan suhu keselesaan pengunjung di pelbagai ruang tempat menunggu di Universiti Putra Malaysia (UPM) dan menilai kemungkinan penggunaan Termografi Inframerah untuk saringan cepat suhu badan dari jauh. Pada masa yang sama, tinjauan diadakan melibatkan pengunjung tertentu untuk menilai persepsi mereka terhadap suhu.

Fail kajian eksperimen bagi mengukur keselesaan terma telah dijalankan di Pusat Kesihatan

UPM . Kelembapan relatif, min suhu sinaran, suhu udara, halaju udara, penyalutan pakaian, kadar tenaga, *Predicted Mean Vote* (PMV) dan *Predicted Percentage of Dissatisfied* (PPD) juga dikira.

Kajian subjectif juga melibatkan soalan dari derian termal . Keputusan melibatkan kajian secara subjectif dan objektif yang digunakan untuk membentuk kesimpulan suhu keselesaan di Pusat Kesihatan. Untuk menilai keselesaan termal, soal selidik mengikut ASHRAE Piawaian 55, telah diberikan kepada semua pengunjung yang mengambil bahagian dalam saringan suhu menggunakan Termografi Inframerah. *Fanger's Predicted Mean Vote* (PMV) dan *Predicted Percentage of Dissatisfied* (PPD) dihitung menggunakan pengukuran diperolehi dari Monitor Tekanan Haba.

Dalam apa juga keadaan di ruang menunggu, suhu keselesaan juga mungkin mempengaruhi suhu badan pengunjung. Termografi Inframerah adalah penyelesaian berpotensi untuk mengdiagnosis suhu badan pengunjung dari jarak jauh. Kebolehan teknik ini untuk mengasingkan pelbagai suhu badan adalah penting di dalam kes yang memerlukan pengesanan segera dalam menyaringkan pengunjung yang dijangkiti virus seperti virus H1N1 yang melanda di UPM pada tahun 2009. Kajian melibatkan penyaringan sebanyak 313 pengunjung di Pusat Kesihatan. Setiap suhu badan pengunjung ditentukan dengan merakam profil suhu muka dengan menggunakan alat Termografi Inframerah Fluke Thermal Imager. Subjek duduk pada jarak kira-kira 1.0 meter dari alat. Profil suhu telah dianalisis dengan menggunakan SmatView 2.0 untuk menentukan suhu badan.

Suhu udara di Pusat Kesihatan yang diukur menggunakan Monitor Tekanan Haba adalah

antara 19°C hingga 21°C, lebih rendah daripada nilai yang diberikan oleh Piawaian ANSI/ASHRAE (2004) dan ISO 7730 (2005) iaitu 24°C had bawah untuk keselesaan termal. Seramai 63% dari jumlah pengunjung yang terlibat dalam ujikaji juga merasa selesa dengan suhu udara persekitaran. PMV menunjukkan nilai yang dapat diterima pada -1.1 dan PPD menunjukkan nilai yang paling diterima adalah pada 30.5.

Hasil kajian menunjukkan bahawa perbezaan kira-kira 1.1% dan 5.1% telah didapati di antara bacaan Termografi Inframerah dan nilai yang diperolehi masing-masing dengan menggunakan Termometer Klinikal Digital dan termometer makmal, masing-masing. Keputusan telah disahkan oleh pegawai kanan perubatan kanan di Pusat Kesihatan UPM. Daripada 313 pengunjung yang diuji menggunakan Termografi Inframerah, 38.9% menunjukkan suhu badan 37-38ºC, 34.8% menunjukkan 38-39ºC, 14.1% menunjukkan 36-37ºC, 8.3% menunjukkan 39-40ºC dan akhir sekali, 3.5% menunjukkan 35-36ºC.

Peranti Termografi Inframerah boleh digunakan secara berkesan untuk pemeriksaan suhu badan dengan pantas tanpa sebarang sentuhan dengan pesakit, kerana rakaman dapat dilakukan pada jarak 1-2 meter. Kaedah ini dapat mengurangkan 50% masa saringan bila dibandingkan dengan kaedah klinikal biasa. Keputusan bacaan dari PMV dan PPD juga adalah bertepatan dengan keputusan dari derian termal pengunjung di ruang menunggu.
Kajian juga menunjukkan yang Peranti Termogragfi Inframerah bukan saja berkebolehan untuk mengukur suhu permukaan sesebuah bahan, bahkan ianya juga boleh mengukur suhu badan manusia.

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Secondly, with the deepest gratitude, I wish to thank every person who has come into my life and inspired me. To abah, kak long, kak ngah, dell, bella, dafeey, I would like to express my gratitude and love for allowing me to be the person I am now.

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Finally to my husband, Muhammad Syueib Mohammed Ali, thanks for being my pillar of strength and never leaving my side. May Allah bless all of you.

I certify that a Thesis Examination Committee has met on 17 January 2013 to conduct the final examination of Alina Binti Aminuddin on her thesis entitled "THERMAL COMFORT ANALYSIS AT UNIVERSITI PUTRA MALAYSIA HEALTH CENTRE" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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_____
BUJANG BIN KIM HUAT, PhD
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Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

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ALINA BINTI AMINUDDIN

Date: 17 January 2013

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LIST OF ABBREVIATIONS

ASHRAE	The American Society of Heating, Refrigerating and Air Conditioning Engineers
clo	Clothing insulation
HSM	Heat Stress Monitor
HVAC	Heating, Ventilation, and Air Conditioning
Met	Metabolic Rate
ms^{-1}	meter per second
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
UPM	Universiti Putra Malaysia
^oC	Degree Celcius

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Comfortable condition is not only important for those who are working in the office to maintain their efficiency but also for patients in clinics, hospitals and Health Centre. As for patients, the waiting period is sometimes takes a longer duration because of needs of patients. The thermal comfort condition is important at the Health Centre in order to reduce stress and anxiety of patients. With good thermal comfort, human's mind and state of emotion express satisfaction is not aggravated.

In 2008, the emergence of a dangerous virus called H1N1 caused a fatal infection that led to the death of human beings in many countries worldwide (Mercer et al., 2009). This virus easily spread among people by personal contact, and by air. The highly risk group includes children, pregnant women and the elderly people as they are normally weak in defense and easily prone to infection. The H1N1 virus is believed to originate from pig, which have undergone mutation. However, within a period of about a year, a new vaccine against the mutated virus was developed. This vaccine is effective in preventing the endemic status of the disease (Mercer et al., 2009).

To curb the spread of the viral infection, health officials had utilized the Infrared Thermography to detect possible infected subjects at strategic locations, including airport entrance, hospitals and other public places. The Infrared Thermography device can be mounted on the wall or ceiling to record the thermograms of the face. The Infrared Thermography is widely used now to evaluate body temperature. The intention is to screen everybody to detect high body temperature (Mercer et al., 2009). Anyone with a high body temperature would be isolated for further clinical examination to confirm the condition for further action like undergoing quarantine until the body condition is normal.

Besides being essential to screen incoming subjects at airports, Infrared Thermography is also used in the hospitals and Health Centre. With this non-invasive method, this technique is highly recommended as it does not involve any physical contact with the subjects.

1.2 Problem Statement

The insufficient information on the thermal comfort at Health Centre in Malaysia led to this study as other studies emphasized investigation on thermal comfort in hospitals as reported by Hussein et al. (2009), Yau et al. (2009) and Hwang et al. (2006).

The field study on the thermal comfort at Universiti Putra Malaysia (UPM) Health Centre was different from other studies performed by authors mentioned above as this study involved determining the occupants body temperature by using the non-invasive tool (Infrared Thermography), together with subjective and physical measurements of conditions at various locations at the Health Centre. The non-invasive technique will reduce time and provide comfortable screening without any long queue and personal contact. This technique has been used widely at Malaysia's airport, and can be a potential technique to be applied at UPM Health Centre to reduce the risk of medical officer getting infected by dangerous virus such as H1N1

At the beginning of each semester, the Health Centre has to process at least 5000 students and family members who come from many countries for medical check-up. International students come from as many as 42 countries. Therefore it is crucial to segregate possible infected students or family members, for screening of incidents of H1N1.

On July 28, 2009, UPM campus in Serdang was closed for one week because of the occurrence of H1N1 case to prevent rapid spreading of the infection among students and staff at UPM. From July to December 2009, 14 confirmed cases incriminate with the virus H1N1 had been received by the Health Centre. The University management realized that this situation had to be controlled and the need to take relevant and fast action in order to reduce the possibility of epidemic among the students during the

health check as the incident to screen large number of students and family members took long period of time had cause the Health Centre officers and students to experience the stress. The usage of the Infrared Thermography is one of the best solutions to rapidly screen patients with high body temperature to prevent the spread caused by personal contact.

Procedure to measure thermal comfort follows the ISO 7730 and Fanger (1986) which involve measurements of relative humidity, air temperature, mean radiant temperature, activity level, clothing insulation and air velocity (Fanger,1986) and also calculations of Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD).

1.3 Objectives

Objectives of the study are as follows

i) To determine the thermal comforts of occupants in various waiting areas at Universiti Putra Malaysia (UPM) Health Centre.

ii) To perform the survey among the occupants of Health Centre towards their perception of thermal comfort while waiting at the Health Centre.

iii) To evaluate the possibility of using Infrared Thermography for fast screening of body temperature from a distance.

1.4 Scope and limitation

The study was limited to collecting data from more than 300 occupants at UPM Health Centre within 35 days. Studies conducted by Hussein et al. (2009), Ring et al. (2008) and Yau et al. (2009) involved a total number of 375, 191 and 114 occupants, respectively. In addition, a personal opinion from Dr Shamsul Bahari Tamrin, a lecturer from the Faculty of Medicine, UPM, stated that, a total of 315 occupants is enough for data collection and analysis. Therefore, the total number of 313 occupants investigated within a 35 days period in this study was justified.

Another limitation was the availability of rooms for conducting the investigation. The study was conducted at various locations at the Health Centre, in particular the waiting areas outside the medical officer rooms, dental clinic and near the pharmacy. The study could not be carried out in medical officer or dentists rooms, as this is forbidden by the Health Centre's authority.

1.5 Significant of the study

The quality of the indoor environment in waiting rooms is best determined by thermal comfort as it is essential to the health and comfort of those who stay in that room over an extended period of time. Besides patients and medical officer and other health care

workers are constantly exposed to indoor environments that require thermal comfort in order to carry out their duties or activities. As the condition of mind and body will be affected by thermal comfort, it is important to perform this study in order to evaluate the status of the thermal comfort of patients and health workers. The information obtained will indicate the status of thermal comfort of the subjects in these areas and form a basis for improvement.

1.6 Thesis Layout

This thesis consists of six chapters as listed below:

- Chapter 1 introduces the background, problem statement, objectives, scope and limitation and significant of the study.
- Chapter 2 elaborates the review of literature related to thermal comfort, Health Centre, Infrared Thermography and H1N1.
- Chapter 3 describes the methodology used in this research and objective approach, subjective study and survey methods that were conducted for data collection.
- Chapter 4 consists of results, analysis and discussion.
- Chapter 5 concludes the main findings in relations to the objectives of the research and recommendation for future research.

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