STUDY ON THERMAL DISCOMFORT OF MOTORCYCLE HELMET USER

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DECLARATION

I declare that this thesis entitled " Study On Thermal Discomfort Of Motorcycle Helmet User " 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.

Signature : .....

Name : Aravinthaan a/l Ravichandran

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality as a partial fulfilment of Bachelor in Mechanical Engineering (with Honours).

Signature : .....

Supervisor Name : Dr. Abd Rahman Bin Dullah

Date : .....

DEDICATION

Highest gratitude to Dr. Abd Rahman bin Dullah from Faculty of Mechanical Engineering for his encouragements and guidance towards me to complete this thesis. Also, to my beloved family members and friends whom helped me in completing this thesis.

ABSTRACT

Thermal comfort is a state of mind that represents fulfillment with the environment. Thermal comfort varies from one person to another. To maintain thermal equilibrium it is necessary that the heat generated as a result of human activities is made to dissipate at a rate to maintain equilibrium within the body. Discomfort occurs when the heat gain or heat is beyond this result. Climate change is becoming undeniably significant every day which is beneficial neither for human population nor the planet. This directly affect thermal comfort level in our surroundings. However, it is difficult to curb it all at once. It is necessary to look into possible aspects that can be explored and studied that may contribute towards the betterment of the environment. It is important to measure microclimate parameters quantitatively within the helmet and link to the human perception. The importance of the parameters influencing the thermal comfort varies with the climate of the countries. In many cases, the air temperature has been considered the major influencing factor to the thermal comfort and many of the indexes produced are mainly focusing to the determination of the comfort temperature. The purpose of this study is to measure multi-point temperature and relative humidity inside a helmet while human subject wearing it on head using micro sensors. Test rig was developed using three types of the motorcycle helmets which is with full face helmet, open face helmet and half face helmet. The exercise bicycle used for the human subject to sit on it and run it in order for them to out the heat and sweat from their head and body. The micro sensors measure the both temperature and relative humidity which is from the heat transfer from the subject's head to the helmets. This depends on subject's body type and head size. There is up to five subjects were tested for each type of helmets. Results give the original measurements of the in-helmet micro climate. Results also show some interested interaction between the in-helmet temperature and relative humidity.

ABSTRAK

Keselesaan terma adalah keadaan minda yang mewakili pemenuhan dengan alam sekitar. Keselesaan terma berbeza dari satu orang ke satu sama lain. Untuk mengekalkan keseimbangan termal, perlunya haba yang dijana akibat aktiviti manusia dibuat untuk menghilangkan kadar untuk mengekalkan keseimbangan dalam tubuh. Ketidakselesaan berlaku apabila mendapatkan haba atau haba melebihi peringkat ini. Perubahan iklim menjadi tidak dapat dinafikan setiap hari yang tidak memberi manfaat kepada penduduk manusia mahupun planet. Ini secara langsung mempengaruhi paras keselesaan terma di persekitaran kita. Bagaimanapun, sukar untuk membendung semua sekaligus. Ini adalah perlu untuk melihat aspek-aspek yang mungkin dapat diterokai dan dikaji yang boleh menyumbang kepada peningkatan alam sekitar. Ini penting untuk mengukur parameter mikroklimat secara kuantitatif dalam helmet dan menghubungkannya dengan persepsi manusia. Kepentingan parameter mempengaruhi keselesaan termal berbeza dengan iklim negara-negara. Dalam banyak kes, suhu udara telah dianggap sebagai faktor utama yang mempengaruhi keselesaan termal dan banyak indeks yang dihasilkan terutamanya memberi tumpuan kepada penentuan suhu keselesaan. Tujuan kajian ini adalah untuk mengukur suhu pelbagai titik dan kelembapan relatif di dalam topi keledar manakala subjek manusia memakainya di kepala menggunakan sensor mikro. Peralatan eksperimen dibentuk dengan menggunakan tiga jenis topi keledar motosikal iaitu topi keledar muka penuh, topi keledar muka terbuka dan topi keledar separuh muka. Basikal senaman yang digunakan untuk mata pelajaran itu untuk duduk di atasnya dan jalankan agar mereka keluar dari panas dan peluh dari kepala dan badan mereka. Sensor mikro mengukur kedua-dua suhu dan kelembapan relatif yang berasal dari pemindahan haba dari kepala subjek ke helm. Ini bergantung pada jenis badan dan saiz kepala subjek. Terdapat sehingga lima subjek manusia yang diuji untuk setiap jenis topi keledar. Hasilnya memberikan pengukuran asal mikroklimat dalam helmet. Keputusan ini juga menunjukkan beberapa hubungan antara suhu helmet dan kelembapan relatif.

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CHAPTER 1

INTRODUCTION

1.1 Background of the project

Lately, the residents of Malaysia really depend on motorcycles for their daily mobility. Traveling on motorcycles has its own flexibility compare to other transportation because it has its own advantages like low-cost maintenance, easy to travel in congested roads, able to ride in narrow and broken roads and the prices are affordable too. The most number of people in Malaysia using motorcycles as the main option of transport on their everyday routine for business, work and school-related travels. Helmets are of important personal protective equipment (PPE) that each person needs to wear when they ride their motorcycles to protect their head against impact during any accidents. The helmet helps to prevent the severity and frequencies of head and brain injuries resulting from motorcycle accidents. A helmet is also largely important in preventing motorcyclists from serious neck and head injuries when a crash occurs. Motorcyclists will be having great challenges when riding their bike on the road whereas involving in the road crashes mostly in the rural areas where the road and the traffic networks are busy and complex. The National Highway Traffic Safety Administration, NHTSA (2007) has been revealed that the injury rate for motorcyclists is about eight times more likely to exist than the injury rate that involves car users. Therefore, wearing a helmet is compulsory for a motorcyclist to prevent their deadly head and neck injuries and enhance the safety measure within the motorcyclists. Indoor comfort for the occupants can be classified into three such as thermal comfort, visual comfort and indoor air quality. Comfort is defined as the sensation of complete physical and mental well-being. Thermal neutrality, where an individual desires neither a warmer nor a colder environment, is a necessary condition for thermal comfort. The factors affecting comfort are divided into personal variables such as activity, clothing and environmental variables will be air temperature, mean radiant temperature, air velocity and air humidity. Besides that, thermal comfort is one the common factor when wearing a helmet.

Thermal comfort describes a condition of mind of a human that satisfies the thermal environment, Toh Yen Pang, A. S,(2011). The strongest thermal comfort sensors of a human body are their heads. This is where the thermal comfort comes into a question. There is a complaint among people about the headgear in warm environments related to thermal comfort. The helmet enhances heat loss and enlarges thermal comfort in a warm environment with the appearance of wind. The helmets can cause problems for the user of the motorcyclist by factors such as CO_2 and O_2 concentrations. The airflow around the head of the helmet user will decrease and it leads to an increase in heat-related stress in leisure, play and recreation activities. Moreover, the helmets can cause thermal discomfort when the user wears it during warmer days or the under hot sunny day when riding on the motorcycle. Heat stress can cause discomfort due to the heat generated within the helmets and it leads to damage the performance of the daily activities such as correct and rapid decision making and focused attention. Heat transfer approach from the head will take as a medium in this study without considering other parts of the human body. This study will focus on the heat transfer and the convective heat loss of a motorcycle helmet user.

1.2 Problem statement

In this era of globalization, one of the world's main concerns is thermal comfort. Nowadays, thermal comfort is being considered by humans for their daily needs and also to run their daily lives. On the other hand, thermal comfort is based on the surrounding environment. Therefore, the surrounding environment must satisfy the perception and condition of the mind of a human in order for them to feel comfortable. This is because every human in the world wants to live a comfy and luxury life and it does depend on the surrounding environment. These do apply to a motorcyclist who is wearing a helmet during his traveling on his bike for his daily activities. Hence, a safer option of a helmet to protect the motorcyclist user should be considered.

The helmet of a motorcyclist must be taking into account benchmarks such as must depends on the head size, the temperature of the body and the types of the helmet in order to have a better thermal comfort. Furthermore, the heat transfer of a human's head to the helmet needs to be tested using the sensors and thermocouples. This will give the results depends on each of the individual body temperatures. This approach also could further satisfy the benchmarks mentioned before which were the head size, body temperature and the types of helmet.

1.3 Objectives

The objective of this project is as follows:

1. To determine and analyze the temperature and relative humidity inside different helmets by human testing.
2. To investigate the effect of different head size and the heat transfer on the thermal comfort of a helmet user.

1.4 Scope of project

The scopes of this project are:

1. The test rig of the helmet setup will be built based on the ventilation holes on the each type of the helmet.
2. The experiments will carry out for testing the parameters such as minutes, level of humidity, human perceptions and the surrounding temperature changes and will be taken down and tabulated based on the subject being tested.
3. There are 3 types of the helmet will be tested using 5 subjects for each of the helmet.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A human being in this world able to focus and be effective in whatever activity they intend to do in a comfortable and pleasant environment. Thermal comfort is defined as a matter of comfort of a person's surrounding environment. Thermal comfort is one of the important aspects which plays a role in human life to bring out an amazing environment. Nonetheless, materials and substances occurring in nature are being exploited in a larger volume in order to achieve a high level of thermal comfort. This will influence and devastate the environment as well as the unhealthy activities that will turn result in bad effects on climate. Hence, it is important to study about thermal discomfort of motorcycle helmet user and perform a better purpose of achieving the desired level of human comfort. This particular chapter will review studies and researches carried out about the thermal discomfort on different types of motorcycle helmet and body temperature of the user.

Based on the research paper (Havenith.K, 2010), humans head can produce up to 50% of the produced latent and sensible heat loss when insulating with any types of item such helmets or any clothes worn on it. Large sweat production on the human head in order to maintain thermal neutrality in warm environments. Different body parts produced to vary the quantity of sweat and distribution changes with changing non-thermal (work rate) and thermal conditions showed spatial differences in sweat production on the human skull. The spatial and temporal gradients in latent heat loss of the human head allow optimization of headgear for thermal comfort if these measures are validated by thermal comfort studies. Furthermore, a head and a headgear could be optimized by using thermal manikins in Figure 2.1 to evaluate heat accumulation in a realistic way. The thermal manikins been used and do not consider the dynamics of (latent) heat loss.

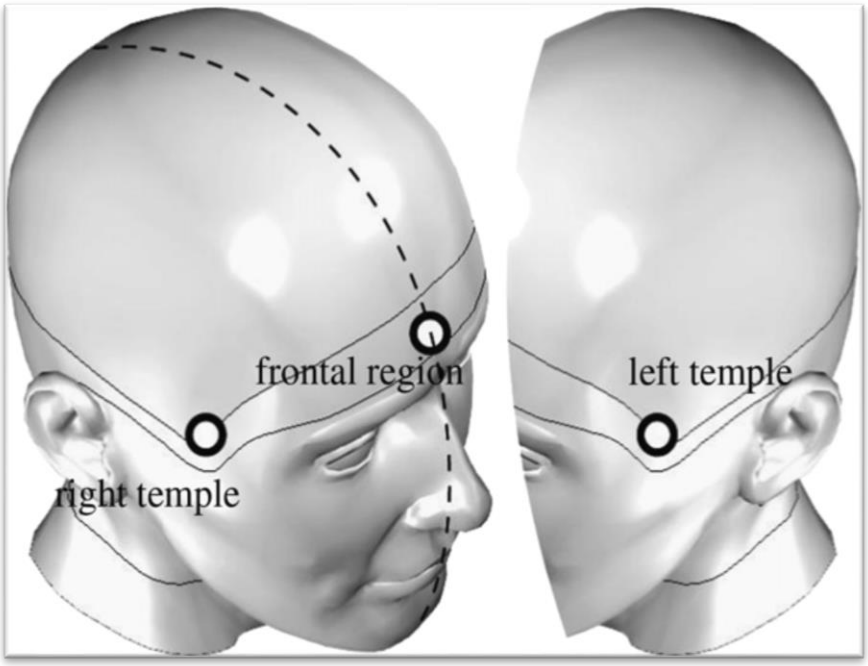

Figure 2.1 View of the three sites of the head where sweat production measured

Source: Havenith.K,(2010)

2.2 Simplified thermoregulation model of the human body

According to (Chelliah, B. K., 2015), the thermal connection of the human body with the environment includes two procedures which are the heat exchange between the human body and the thermal environment, at the same time including radiation, convection, conduction, respiration and evaporation; and the self-control function of the human body which reacts to fluctuated thermal environments, for example, vasoconstriction, vasodilation, sweating and shivering. According to (Parsons.K,2014), thermoregulation models of the human body are grown to reenact these two procedures of interaction and foresee the human thermal reaction under various thermal conditions and have been generally utilized in the field of physiology or thermal comfort studies. Furthermore, precise thermoregulation model will help enhance the exactness of the present thermal comfort forecast models, and give an essential hypothetical examination of the precision of the different models in the application.

There are various types of models used in thermoregulation. One of the most famous used in thermal comfort study is the simplified Gagge's 2-node model, (Gagge.A.J,1971). Moreover, there are many types of complex thermoregulation models which have been grown by enhancing the modelling of body segmentation, especially for heat insulation, thermoregulatory systems and heat exchange,. The mean skin temperature was utilized for the approval of the developed model. In the current research, skin temperature has been exhibited to be emphatically identified with the thermal interaction between the human body and the thermal environment, which is likewise an imperative pointer of thermal comfort. It has been effectively used to approve progressively complex and modern prescient models for thermoregulatory reactions, and to assemble thermal sensation models. Furthermore, based on (Yang, Y. Y.,2015) there are some characteristics which caused by individual differences in human thermal responses which are gender, age, height, weight and there are also consists of some major differences between human which are the skin composition, fat composition and muscle composition as different human body has their different composition. In Figure 2.2 shows the thermoregulation model of a human body that heat flows showing the interrelationship of the physiological and external factors that influence thermoregulation.

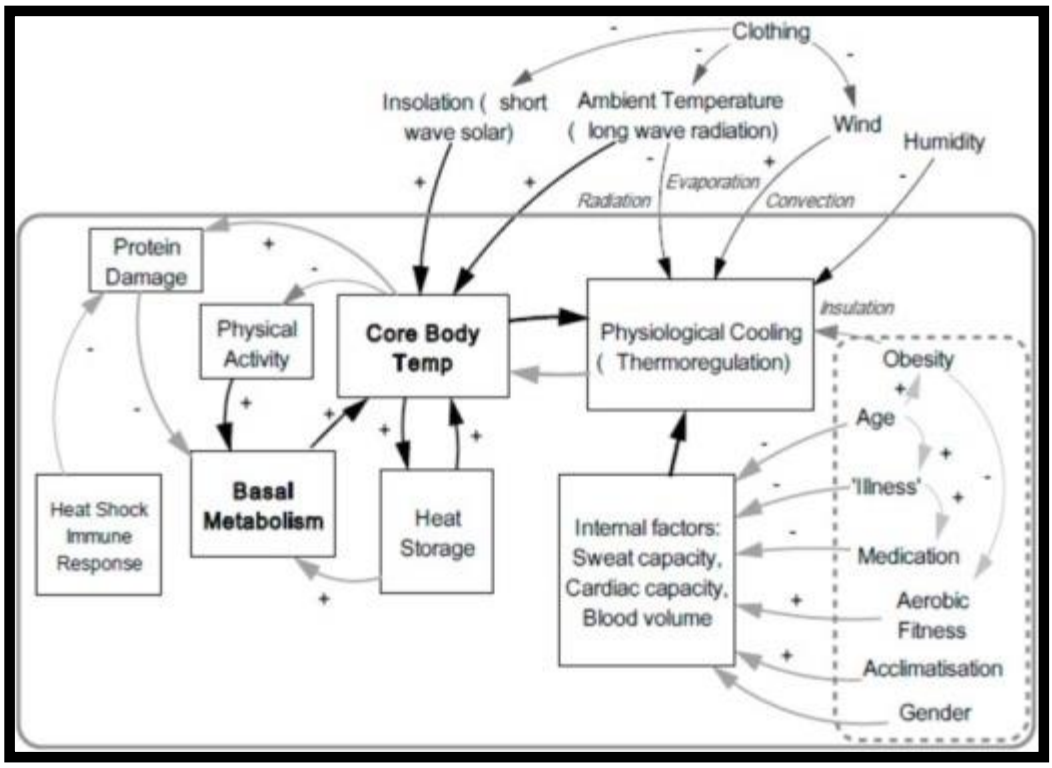

Figure 2.2 Thermoregulation model

Source: Gagge.A.J,(1971)

2.3 Thermal and moisture test on industrial safety helmet

According to (Mills.N.,2008), construction or collecting of a manufacturing line is generally a physically requesting movement with specialists working for times of up to 8 hours in multi-day. By and large, such movement could be much additionally requested by the way that labors are required to wear defensive hardware so as to avert genuine damage that may come about because of being hit by falling nuts or potentially screws. Joined with the way that development or gathering are regularly done in the heat of summer, this may offer ascent to physiological and mental strains for specialists who need to wear helmets to shield their heads from damage by law. It is hence crucial to limit any uneasiness that may result from this equipment, so as to guarantee the ideal conditions are accessible for the users. This uneasiness might be either, thermal discomfort as far as heat and sweat, or mechanical because of friction or aggravation.

Different designs and material choices were had to augment effect opposition of the helmet. A general survey of research on modern protective helmet configuration was given by Proctor in mid-1980s. The review secured insights on the occurrence and seriousness of head injuries in accidents where protective helmets were being worn, as contrasted and those where helmets were not being worn. Be that as it may, according to (Davies.C.,1979), the comfort which managed by the review was for contact mechanical pressures, despite the fact that the review called attention to inconvenience could likewise be caused by a high temperature inside the helmets. Subsequently, thermal comfort was not a noteworthy issue around then for modern protective helmets, in spite of the fact that researches on how skin temperature influence on sweating and oxygen-consuming activities amid extreme work was done.

Thermal comfort has drawn consideration and pulled in some studies since the 1970s. Early research was embraced by utilizing secluded fluid cooled protective helmets liner in space explorer helmets to enhance thermal comfort, (Williams and Shitzer,1974). There are three types of industrial safety helmets have been tested as shown in Figure 2.3.