EXPERIMENTAL STUDY ON THE MOTORCYCLE HELMET MICROCLIMATE HEAT DISTRIBUTION

MUHAMAD HANIF SUBHI BIN MOHD RASHID

This Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor Degree of Mechanical Engineering (Design & Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2011

SUPERVISOR DECLARATION

"I admit that I have read this report and in my opinion this report has followed the scope and quality in partial fulfillment of requirement for the degree of Bachelor of Mechanical Engineering (Design and Innovation)"

Signature   :
First Supervisor   : Dr. Abd Rahman Dullah
Date   : 27/ 5/ 11

DECLARATION

"I admit that this report is from my own work and idea except for the summary and a few sections which were extracted from other resources as being mention."

Signature   :............._____...................

Author   : Muhamad Hanif Subhi Bin Mohd Rashid

Date   :.........27 /5 /2011.....................

DEDICATION

To My Beloved Family

Mohd Rashid Bin Mat Jaki

Inon Badariah Bte Mohd Jaafar

Muhamad Adib Bin Mohd Rashid

Noradiba Hanis Binti Mohd Rashid

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

Firstly, my greatest gratitude to Allah, for His will, I managed to carry out this study. Thanks to Allah for giving me the good health and opportunity for me to completely finish this study on time. Then, for the most important person that play a big role in this study, I would like to dedicate my thousand of thanks to my supervisor Dr. Abd Rahman b. Dullah for his guidance and support while I'm doing this research besides help me to find out the information to complete this research (PSM) in the given due date. He not just guides, but also teaches those things that I do not know.

I would like to dedicate my thanks to those who are directly or indirectly involve in making this report. Thanks to all other lecturer also that give me motivation and support in order to achieved the goal of this project.

Last but not least, not forget to my beloved family, especially for my father and my mother that always supporting me from behind, all my friends, class mate, house mate, and everyone who related in process for me to complete this report. Without them all, it would be hard for me to complete this project successfully. I want to thank all of you a lot for given me support and ideas in finishing this report.

ABSTRAK

Sebahagian besar kajian telah membincangkan penyerapan tenaga impak yang disediakan oleh topi keledar ke pemakai. Selain itu aspek fisiologi topi keledar telah menjadi cabaran terpenting yang dihadapi komuniti pereka topi keledar. Tambahan lagi, kebanyakkan penunggang tidak sanggup memakai topi keledar kerana mereka merasa tidak selesa. Memakai perlindungan kepala seperti topi keledar motosikal mengurangkan aliran udara di atas kepala yang boleh mempengaruhi haba yang hilang dari kepala ke persekitaran, dan secara tidak langsung membawa peningkatan terma dalam tekanan berkaitan haba. Sifat terma topi keledar menjadi faktor yang paling penting terutama dalam iklim panas. Lantaran itu, keselesaan topi keledar dan aspek fisiologi topi keledar keselamatan telah menjadi bidang yang kian meningkat. Dalam projek ini lebih difokuskan pada kajian bereksperimen mengenai peredaran haba dari kepala ke mikroiklim topi keledar.

ABSTRACT

Most of studies have discussed the impact energy absorption provided by the helmets to the wearers. Moreover physiological aspects of helmets have become the most important challenges facing helmets design community. In addition, many riders are not willing to wear helmet because they are not comfortable. Wearing headgear properties like motorcycle helmet reduces airflow over the head which may affect heat lost from the head to the environment, and could lead numerically the thermal to an increase in heat-related stress. Helmet thermal properties become the most important factors especially in hot climate. Therefore, helmet comfort and physiological aspects of safety helmets has been a field of increasing interest. In this project it will more focused on the experimental study of the heat distribution from the head to the helmet microclimate.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF NOMENCLATURE

B.C.	=	Before century
ABS	=	Acrylonitrile-butadiene-styrene
EPS	=	Expended polystyrene
PU	=	Polyurethene
Pb	=	Polymer Blend
N_{Ra}	=	Rayleigh number

CHAPTER I

INTRODUCTION

1.1   BACKGROUND

Humans had begun protecting their heads using helmets long before injury mechanisms were studied. The way helmets were designed was, and still is, heavily dependent on the application of the helmet. In the 15th century B.C., helmets were effective means of protecting the head. Figure 1.1 shows a Roman helmet which been used to protect the head in combat.

Figure 1.1: Roman helmet

Until the end of the 19th century, it was discovered that serious head injuries may occur without having the penetration. It takes 50years later to understand that non-penetrating head injuries are caused by short-duration accelerations acting on the

head and its contents. These acceleration injuries are the most common and dangerous form of injuries for motorcyclists and are often caused by blunt impact rather than penetration [1, 2].

The early design of motorcycle helmets consist of leather covered, shock absorbing liner. In later designs, the leather cover was replaced by a stiffer, plastic outer shell. The function of this shell is not only to prevent penetration, but also to distribute the load over a larger area.

Figure 1.2 illustrates the components of a modern full-face motorcycle helmet. The modern motorcycle helmet generally consists of four main parts: the comfort padding liner, the protective padding liner, the outer shell and the retention system. The retention system/chin strap function as to keep the helmet in position prior to or during an impact.
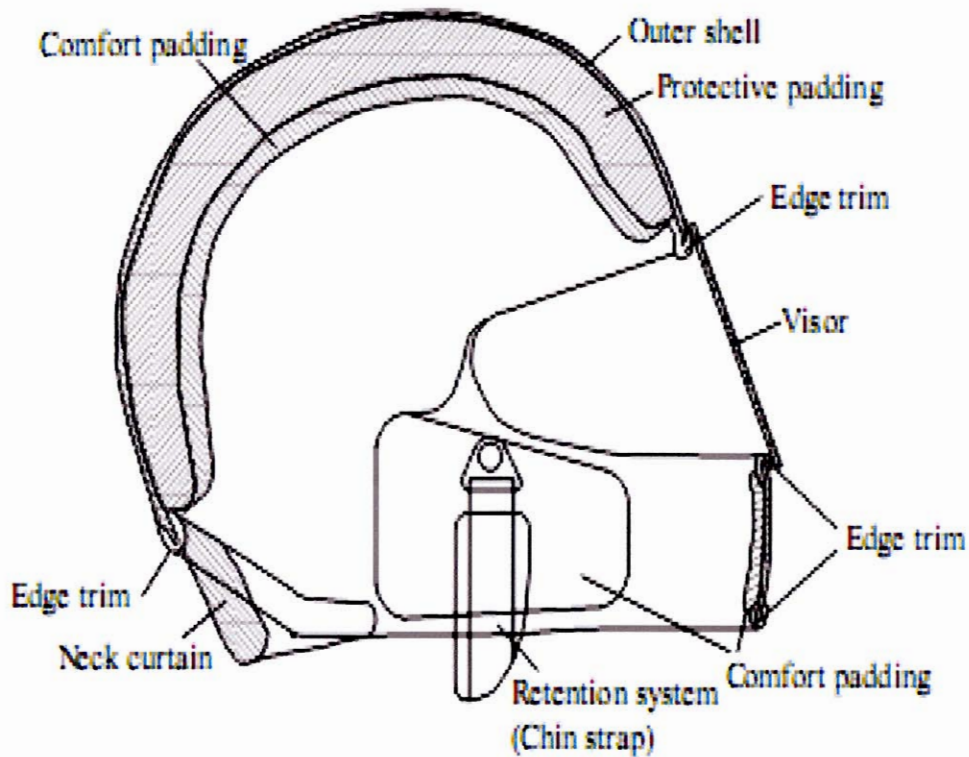
Figure 1.2: Full face helmet component

(Source: UN, 2000)

Although wearing head protection, i.e. a motorcycle helmet, motorcyclist is likely to remove the helmets during uncomfortably hot weather if they experience discomfort such as heat stress while wearing them [2]. Therefore, motorcyclist should have thermally comfortable safety helmets available to encourage them to comply with this standard.

1.2   PROBLEM STATEMENT

Today, many types and design of motorcycle helmet can be seen in markets from half helmet types to the full face helmet types. All of this helmet have one main purpose that is, to provide the head protection for human during accident or fall. However, most of the manufacturer primarily focuses on the safety features rather than thermal comfort which are a requirement for a helmet to be accepted by its

wearer. A method for testing and evaluating the thermal properties is essential to design and manufacture a thermally comfortable helmet. With the global warming condition in world today, the helmet use will be neglect.

1.3 AIMS

The purpose of this study was to optimize the helmet thermal comfort inside the motorcycle helmet. This will be achieving by developing experimental mapping of temperature/moisture and the related comprehensive computer modeling.

1.4 OBJECTIVES

Therefore, the main objectives are:

➢ To study the heat distribution inside the motorcycle helmet during static and different conditions (speeds and ambient temperatures).
➢ To propose the suitable method to improve the heat distribution.

1.5 SCOPE

In the test propose the dimensions of the head will be used, as has the heat distribution between the head and the helmet, and the feelings/opinions of the user. And the focused of the study will be:

➢ Test rig development for the study of heat distribution inside microclimate helmet.
➢ The experiment on the heat distribution by using the test rig.

CHAPTER II

LITERATURE REVIEW

This chapter will discuss of the helmet properties from the history of the first type of helmet, the function and all the major component of the helmet. The thermal properties theory of heat distribution also had been discuss in here. This is important because for any work to be done all of the element involved must be fully understand so that work can be done faster and the quality of the work is better

2.1 HELMET OVERVIEW

Motorcycle helmet primary function is helping to reduce the impact during accident or fall [3-6]. A helmet can only provide protection to the extent that the head is covered with the helmet. In order to reduce deaths and traumas of traffic accident, the helmet act for motorcyclists and bicyclists was enacted in many countries. Some countries even enforced the use of helmet to be nationwide [7].

However, for the maximum head protection, the helmet retention system must be securely fastened under the chin and be properly fit. Failure to have a proper fit and to securely fasten the helmet is dangerous as the helmet could come off in an accident resulting in severe head injury or death [8, 9]. Although the primary objective of a helmet is to provide head protection during fall or accident, thermal comfort are becoming important design criteria. Humidity and high ambient temperature make the situation worse as trapped heat causes significant discomfort [9-11].

2.2 HELMET COMPONENT

There are four basic components in every standard helmets, there are the outer shell, interior liner, comfort padding and retention system/ chin strap (Figure 1.2).

a)   Outer shell

The outer shell usually made from some family of fiber-reinforced composites or thermoplastics like polycarbonate. It is commonly accepted that industrial helmets shell can be produced using acrylonitrile-butadiene-styrene (ABS) [3].Though each type of shell has specific benefits, they all have the same basic mission, i.e. to help;

1.   Distribute the impact energy.
2.   Protect the head against penetration of sharp objects.
3.   Protect the liner from abrasions and knocks during day-to-day use.

b)   Interior liner

The inner liner is generally made from expanded polystyrene (EPS) foam liners [3]. The purpose of the liner is to help prevent or reduce brain injury by absorbing the energy of an impact through its own compression or destruction.

c)   Comfort padding

The interior pad made of soft foam and cloth layer that sits next to the head. It helps keep the head comfortable and the helmet fitting snugly.

d)   Retention system/chin strap

It is the one piece that keeps the helmet on your head in a crash. A strap is connected to each side of the shell that is designed to:

1.   Fit the helmet comfortably and securely to the wearer's head.
2.   Prevent the helmet from coming off the wearer's head during a crash.

Most helmets are made of foam that holds up heat, generated by the rider's head during riding. Humidity and high ambient temperature make the situation worse as trapped heat causes significant discomfort. Helmets with venting system can minimize this problem. However, venting generally increases aerodynamic drag. Therefore, an optimal design for helmet is very important in order to satisfy both aerodynamic and thermal efficiency [2].

The market today is large enough to run a new series of products. And the product levels should be determined. For example, it is not easy to job to get into the high performance helmet market which is shared by several specific brands. To design a functional helmet, it is important to analyze the structure of helmets.

The main helmet components in the market today are made from the foam linear (EPS, Polyurethane, Polyolefin, Polyethylene, Polymer Blend, Polyvinylidene chloride or integral skin) and the shell (thermoplastic or composite) [3]. In general, the function of the foam is to absorb most of the impact energy, while the function of the shell is to resist penetration of any foreign object from touching the head and resulting in direct skull damage, and to distribute the impact load on a wider foam area thus increasing the foam linear energy absorption capacity.

The penetration test is the main criteria for shell thickness determination and, in fact, resulting in a helmet with a thicker shell and consequently a weight of about 6-8 times as compared to the foam liner [5]. If a thicker shell is chosen, the strength will increase, unfortunately, as well as the cost and weight [5, 6]. Or an alternative material should be considered. It is very important to check out all of the local regulations of the target market. Violations of laws and standards may result in re-design and unexpected delay and cost.

2.3   HUMAN THERMOREGULATION

Humans require energy to perform work and produce heat to maintain an internal body temperature of around 37 °C. The higher their activity levels the more heat that is produced [9-11]. The body will sweat if too much heat is produced then which will cause discomfort. The core of the head consists of the brain [9]. The skin temperature of normal human is between 36.1–37.8 °C.

The rises in temperatures of the brain or head skin might reduce comfort and facilitate higher exercise intensities and body temperatures. The strong cold-afferent supply due to selective cooling of the head could also provide false representation of the body's true thermal status and will lead to an inappropriate physiological and behavior thermoregulatory response [11]. This will cause the accelerated heat storage and possibly lead to heat injury.

The heat that been generated by the head is different in a certain part. The scalp, face and a small forehead/ears zone (Figure 2.1) are the part that most of the heat lost to the surrounding [12]. The inner of the ear was the hottest part that generates the heat [11-15]. The heat from human head cans loss due to several reasons such as, radiation, convection and conduction.
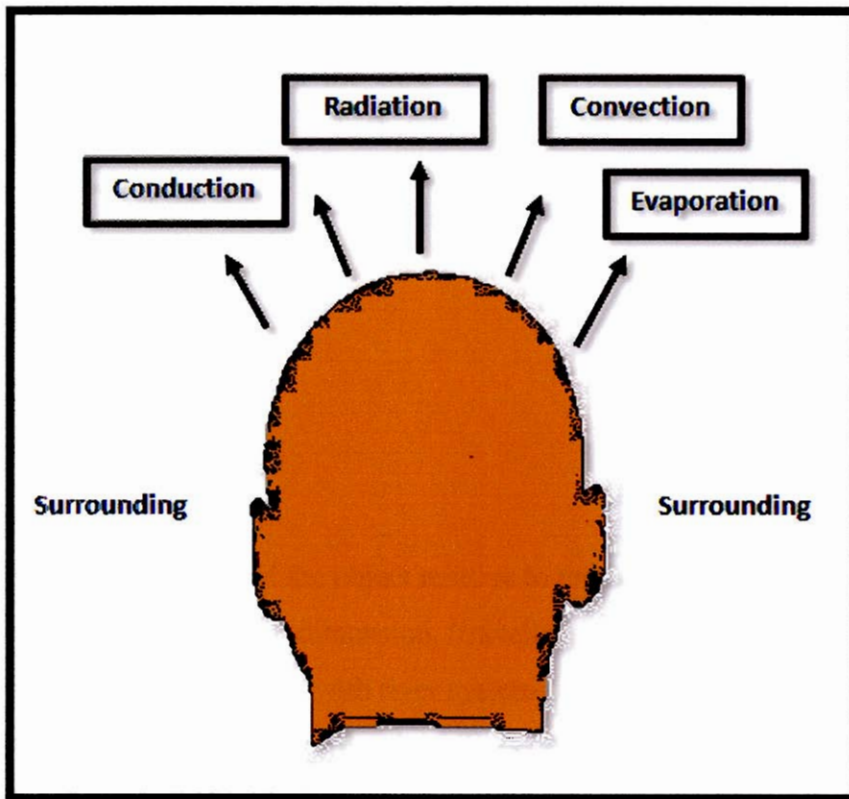

Figure 2.1: Heat loss from the head to the environment

Heat loss from the head:-

a) Radiation process happens when there are loss of heat to the environment due to the temperature gradient which may occurs if the ambient temperature is below 37 °C. Important factors in radiant heat loss are the surface area and the temperature gradient. [16]

b) Conduction is defined as heat transfer that happen due through direct contact between an objects, molecular transference of heat energy.

c) Evaporation is defined as the heat loss from converting water from a liquid to a gas. In this case the sweat.

d) Convection is a conduction process for an object in the motion. The rate of convective heat loss in water occurs more quickly than air convection. In this study it wills more focusing to the convection process.

Forced convection is a mechanism, or type of heat transport in which fluid motion is generated by an external source. It should be considered as one of the main methods of useful heat transfer as significant amounts of heat energy can be transported very efficiently. In the case of forced convection, where the body is cooled by airflow, the heat loss is dependent additionally on the non-dimensional Reynolds number, *Re* .

$$Re = \frac{\rho V L}{\mu} = \frac{VL}{v}$$

(2.1)

where:

V = the mean velocity of the object relative to the fluid (SI units: m/s)

L = a characteristic linear dimension, (travelled length of the fluid; hydraulic diameter when dealing with river systems) (m)

μ = the dynamic viscosity of the fluid (Pa·s or N·s/m² or kg/(m·s))

v = the kinematic viscosity ($v = \mu / \rho$) (m²/s)

ρ = the density of the fluid (kg/m³)

One of other formulae involve when considering the heat is Nusselt Number, Grashof number and Prandtl number. Nusselt Number (*Nu*) is the dimensionless form of convective heat transfer coefficient.

If the fluid is stationary, then

$$N_{Nu} = \frac{hD_c}{k} = a(N_{Ra})^M \tag{2.2}$$

where:

a   = constants

M   = constants

N_{Ra} = the Rayleigh number.

Grashof number and Prandtl number.

$$N_{Ra} = N_{Gr} \times N_{Pr} \tag{2.3}$$

The Grashof Number is defined as:

$$N_{Gr} = \frac{D_c^3 \rho^2 g \beta \Delta T}{\mu^2} \tag{2.4}$$

where;

D_c^3 = characteristic dimension (m);

ρ = density (kg/m^3);

g   = acceleration due to gravity (9.80665 m/s^2);

β = coefficient of volumetric expansion (K^{-1});

ΔT = temperature difference between wall and the surrounding bulk (°C);

μ = viscosity (Pa s).