STUDY OF ENERGY ABSORPTION OF MOTORCYCLE SAFETY HELMET

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"It is hereby certified that I have read this project paper entitled "Study of Energy Absorption of Motorcycle Safety Helmet" by Ahmad Faiz Fikri B. Hj Ghazali and in our opinion it is satisfactory in terms of scope, quality and presentation as a fulfillment of the requirements for the course Degree of The Bachelor of Mechanical Engineering (Automotive)".

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THIS THESIS IS SUBMITTED AS PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE DEGREE OF THE BACHELOR OF MECHANICAL ENGINEERING

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"I admit that the *Study of Energy Absorption of Motorcycle Safety Helmet* is my own work except every statement and passage that I have already mention its source"

Signature : .....

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DEDICATION

My special dedication towards my beloved parents, family, Mrs. Zakiah bt Abd Halim; my supervisor and all friends. May Allah bless them for all the help to complete this thesis.

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I am really sorry for all the mistakes that happened and I hope that this report could contribute something meaningful in the future of times for other students. Thank You.

CONTENT

ABSTRACT

This project is carried out to study the energy absorption of a motorcycle helmet during an impact with a rigid wall surface using simulation software. In this study, there are several impact positions being considered that are frontal, side and top impact. The different impact positions will gave a different value of energy absorption due to the material used, the area of contact and force on loading. This study is carried out with simulation software called the ABAQUS/ Explicit 6.8. The motorcycle helmet is modelled in CATIA V5R10 software and then being imported to the ABAQUS/Explicit 6.8 through the IGES file consists of CAD data. To find the energy absorption of the motorcycle helmet during impact with the flat rigid wall surface, the impact simulation of the motorcycle helmet is simulated and analysed in ABAQUS/Explicit 6.8. The result of the simulation is then compared with the existing research data and it is found that the top impact gave higher energy absorption compared to the side and front impact.

ABSTRAK

Projek ini di jalankan dengan tujuan untuk mengkaji tenaga penyerapan oleh topi keledar motorsikal apabila menghentam permukaan dinding tegar menggunakan perisian simulasi. Dalam kajian ini, terdapat beberapa posisi hentaman yang dipertimbangkan iaitu hentaman dari depan, tepi dan juga hentaman dari atas. Posisi hentaman yang berbeza akan memberikan nilai tenaga penyerapan yang berbeza mengambil kira bahan yang digunakan, luas permukaan sentuhan dan daya yang bertindak pada perlanggaran. Projek ini di jalankan dengan menggunakan perisian yang dipanggil ABAQUS/Explicit 6.8. Model topi keledar motorsikal dilukis dengan menggunakan perisian CATIA V5R10 dan kemudian model ini di serasikan ke dalam perisian ABAQUS/Explicit 6.8 menerusi fail IGES yang mengandungi data CAD. Untuk mencari tenaga penyerapan oleh topi keledar motorsikal ketika hentaman pada permukaan dinding tegar, simulasi hentaman akan di analisa menggunakan perisian ABAQUS/Explicit 6.8. Keputusan yang didapati dari hasil simulasi akan dibandingkan dengan hasil kajian yang terdahulu dan didapati bahawa hentaman dari bahagian atas memberi nilai tenaga penyerapan yang lebih tinggi berbanding hentaman dari bahagian sisi dan depan.

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A	=	Area of surface contact, mm^2
V	=	Velocity, m/s
F	=	Force, kN
υ	=	Poisson Ratio
ρ	=	Density, kg/m^3
E	=	Modulus Elasticity, MPa
t	=	Thickness of shell, mm
R	=	Radius of Curvature, mm
m_{total}	=	Mass of helmet and head, kg
σ_y	=	Yield Stress, MPa
E_a	=	Energy Absorption, J
E_k	=	Kinetic Energy, J
E_d	=	Plastic Dissipation, J
T	=	Time, s

LIST OF ABBREVIATION

PDRM	=	Polis Di Raja Malaysia
JPJ	=	Road and Transport Department of Malaysia
JKJR	=	Jabatan Keselamatan Jalan Raya
CAP	=	Consumer Association of Penang
SIRIM	=	Standards and Industrial Research Institute of Malaysia
FE	=	Finite Element
PSM	=	Projek Sarjana Muda
MIROS	=	Malaysian Institute of Road Safety Research
RSRC	=	Road Safety Research Center
UPM	=	University Putra Malaysia
ISO	=	International Organization for Standardization
USA	=	Unites States of America
NHTSA	=	National Highway Traffic Safety Administration
FMVSS	=	Federal Motor Vehicle Safety Standards
DOT	=	Department of Transportation
NCSA	=	National Center for Statistics and Analysis
FARS	=	Fatality Analysis Report System
UK	=	United Kingdom
RIT	=	Royal Institute of Technology
TRL	=	Transport Research Laboratory
ULP	=	Universitè Louis Pasteur
HIC	=	Head Injury Criterion
ABS	=	Acrylonitrile butadiene styrene
EPS	=	Expanded Polystyrene
MIROS	=	Malaysian Institute of Road Safety Research

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Fundamentally, the usages of motorcycle become extremely common for those who live in a well developed country which most of the residents obtain average household income level. Not only that, because of its simplicity to moved without being stuck in the traffic and can be used in small road at the rural area, people prefer to choose motorcycle as their means of transportation. Furthermore, by the increasing of petrol price in Jun 2008 recently, many people had changed their lifestyle from driving a car to riding a motorcycle.

However, motorcyclists and pillion riders had the greatest number of death in road accidents in Malaysia. According to Polis Di Raja Malaysia (PDRM) website, the death toll of motorcycles accidents had increased almost every year [2]. From January to July 2008, motorcyclists and pillion riders had contributed about 58.7% of death in road accidents, far exceeded other vehicles such as cars and buses [2]. The recorded statistic also stated that there are 9.2% increased in death for motorcycle's rider between January to July 2007 and January to July 2008 [2]. The motorcycle's drivers have a bigger chance of death in road accident compared to the pillion riders. In 2007, there are 3197 motorcycle's drivers who died in road accidents compared 447 pillion riders died in the same events [2]. The main cause of death for motorcycle's riders in road accidents is serious head injury and other causes are injuries on the body [3].

The data obtained from Road and Transport Department of Malaysia (JPJ) revealed that 68% of 3963 people who died while riding a motorcycle in year 2007 did not wore any helmets or whore a sub-standard helmets[4].

Table 1.1 shows the road fatality statistic from June until July 2008. It is clearly that motorcyclist and pillion rider still have the highest death toll in a road accident in Malaysia.

Table 1.1: Road fatality statistic from July until Jun 2008
(Source: Jabatan Keselamatan Jalan Raya (JKJR), 2008)

Consumer Category	**2008 JUNE**	**2008 JULY**	**Difference**	**%**
Passenger/Driver car	143	102	-41	-28.7
Motorcycle pillion/rider	304	300	-4	-1.3
Pedestrian	47	47	0	0.0
Pillion/Rider Bicycle	13	21	8	61.5
Bus passenger/Driver	10	1	-9	-90.0
Driver/lorry attendant	13	14	1	7.7
Driver/Attendant van	5	12	7	140.0
Driver/Attendant race 4 wheel	11	11	0	0.0
Others vehicle	9	1	-8	-88.9
Total	555	509	-46	-8.3

One of the most effective ways of solving this problem is wearing a safety helmet while riding a motorcycle. In Malaysia, the legislation for wearing a motorcycle helmets was introduced in year 1980. After the law had been enforced, the injuries caused by accidents for motorcyclists had been reduced.

In S.M Mohamed Idris speech, the president of Consumer Association of Penang (CAP) said that wearing a helmet while crashing accident could reduce the risk of head injury up to 85% [4]. He also added that safety helmets are specially designed for motorcycle used and it cannot be interchange with other safety helmet [4]. So, while choosing a motorcycle helmet, it is crucial to choose a standard helmet that had been approved by Standards and Industrial Research Institute of Malaysia (SIRIM).

A standard motorcycle helmets are made of a combination of fibers, glass and carbon on the outer shell and special polystyrene foam with fire retardant lining on the inside. This is the composite that help to absorb impact and prevent burn if the rider involved in an accident. There is one more important matter when wearing a safety helmet that is to fasten the strap of the helmet.

1.2 Problem Statement

Motorcycle riders and pillion riders are the most vulnerable people when it comes to death in crash accidents. From the data collected in PDRM and JKJR websites, it has clearly stated that almost every year the death toll of motorcyclists and pillion riders increased [2]. The most common cause of these deaths is head injury. The most effective way of reducing these death tolls is for motorcyclists and pillion riders to wear motorcycle safety helmet. The problem with Malaysian specifically and other peoples around the world generally is that they do no realise the importance of wearing a motorcycle helmets while riding motorcycle.

Even if they wear them, they usually don't fasten the chin strap properly because lack of knowledge about the importance of doing so. Other problem is Malaysian who rides motorcycles do not know how to choose a proper motorcycle safety helmets that follow the SIRIM standards. It is important to choose helmets that are specifically design for motorcyclist. Although they are many motorcycle helmets sold in the markets, but not all of them pass the SIRIM standards. So, this study is conducted to analyse the motorcycle safety helmets performance and how this safety helmets works when it is subjected to impact.

1.3 Objective

The objectives of this research are to study the energy absorption of motorcycle safety helmet and analyse its impact performance when subjected to different impact position. Also, the project includes how the helmet works when it is subjected to impact.

1.4 Scope

The scope of this study are measuring the helmet that had been choose, Apollo MS 88, then hand drawing the initial sketch to put all the dimension in its place. Then, using CATIA V5R10 software, the helmet is drawn. After that, the data drawing is imported to ABAQUS/ Explicit 6.8 to develop Finite Element (FE) model. The model is analysed using an explicit finite analysis. From the analysis, the energy absorption of the motorcycle helmet is analysed.

1.5 Project Synopsis

This project is conducted under the Projek Sarjana Muda (PSM) for the final year student. The purpose of this project is to study the energy absorption of the motorcycle helmet. As we all know, most fatal accident involve the motorcyclists and its pillion riders and head injuries are the common reason for it. This is because people don't seem to care about wearing a safety helmet while riding a motorcycle.

To fulfil the task given in this project, the model of the motorcycle helmet is first choose and then been drawn by using CATIA V5R10 software. After that, to obtain the value of energy absorption by the motorcycle helmet, the model is being simulated by using to ABAQUS/ Explicit 6.8 software. All the data is collected and analyse. FE Analysis is being used to determine the energy absorb by the helmet. Finally, the result is validated with an establish journal.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Literature review is an academic study that is being done to previous research that relates to the topic. This chapter show a concise summary of the journal or report, providing an overview of what the researcher actually done, the methods that had been used and the results obtained.

2.2 Data and Statistic in Malaysia

In Malaysia, using a motorcycle as a primary transport is quite common. Statistic shows that motorcyclists have the highest death toll compared to others vehicle's users and hence many researches had been conducted regarding motorcycle helmets since head injury is the main cause of death for motorcycles crash accidents. Table 2.1 has proven that motorcyclists and pillion riders are still at the top of the chart when it comes to death toll in crash accidents.

Table 2.1: Road fatality statistic for 2007 and 2008 (Jan until March)

(Source: JKJR, 2008)

Consumer Category	**2007**	**%**	**2007 JAN-MARCH**	**2008 JAN-MARCH**	**DIFFERENT**	**%**
Passenger/Driver car	1228	19.5	287	308	21	7.3
Motorcycle Pillion/Rider	3646	58.0	866	992	126	14.5
Pedestrian	636	10.1	157	187	30	19.1
Pillion/Rider Bicycle	190	3.0	47	45	-2	-4.3
Bus Passenger/Driver	75	1.2	16	6	-10	-37.0
Driver/Lorry Attendant	204	3.2	51	52	1	2.0
Driver/Attendant Van	133	2.1	27	17	-10	-37.0
Driver/Attendant Race 4 Wheel	99	1.6	14	21	7	50.0
Others vehicle	71	1.1	17	15	-2	-11.8
TOTAL	**6282**	**100**	**1482**	**1643**	**161**	**10.9**