UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPACT ANALYSIS OF MOTORCYCLE HELMET USING FINITE ELEMENT METHOD

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2022

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 Engineering Technology (Automotive Technology) with Honours**

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project entitled "Impact Analysis of Motorcycle Helmet Using Finite Element Method" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 28 January 2022

APPROVAL

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Signature : ....

Supervisor Name : Professor Madya Ts. Dr. Muhammad Zahir Bin Hassan

Date : 28 January 2022

DEDICATION

To my beloved mother, Dayang Mazlina Binti Datu Omar Hatta and
my beloved father, Encik Zusdi bin Othman

ABSTRACT

Motorcycle accidents are well-known for causing serious injuries and even death. Wearing the right motorcycle helmet can save lives and lessen the risk of traumatic brain injuries, concussions, and other ailments. Because a motorbike does not have the protection of an enclosed car, it is more likely that the rider may suffer serious, life-threatening injuries or death. As a result, numerous nations have passed regulations requiring all motorcycle riders to wear authorised helmets. Therefore, the primary goal of this research was to use a widely available motorcycle helmet to replicate numerical impact testing. Existing material data from an open literature study was used to determine the mechanical characteristics of the helmet's shell. The material data were modified to meet the conditioning of each rigidity test, drop test, and the kind of motorcycle helmet utilized in this research was selected. All computational impact testing was carried out with the help of the Simsolid and Solidworks finite element software and suitable helmet's shell material models. The findings show that virtual testing methods may correctly simulate the top, side and rear motorcycle drop test for the impact analysis, indicating that virtual testing methods may be used in the helmet design process for motorcycle helmets and other helmet configurations.

ABSTRAK

Kemalangan motosikal motosikal terkenal kerana menyebabkan kecederaan parah dan juga kematian. Memakai topi keledar motosikal yang betul dapat menyelamatkan nyawa dan mengurangkan risiko kecederaan otak traumatik, gegaran, dan penyakit lain. Oleh kerana motosikal tidak mempunyai perlindungan kereta tertutup, kemungkinan besar penunggang mungkin mengalami kecederaan serius, mengancam nyawa atau kematian adalah tinggi. Akibatnya, banyak negara telah meluluskan peraturan yang memerlukan semua penunggang motosikal memakai topi keledar yang sah. Oleh sebab itu, Matlamat utama penyelidikan ini adalah untuk menggunakan topi keledar motosikal yang tersedia secara meluas untuk meniru ujian kesan berangka. Data bahan sedia ada daripada kajian literatur terbuka digunakan untuk menentukan ciri mekanikal cangkerang topi keledar. Data bahan telah diubah suai untuk memenuhi pengkondisian setiap ujian ketegaran, ujian jatuh, dan jenis topi keledar motosikal yang digunakan dalam penyelidikan ini dipilih. Semua ujian impak pengiraan telah dijalankan dengan bantuan perisian unsur terhingga Simsolid dan Solidworks dan model bahan cangkerang topi keledar yang sesuai. Penemuan menunjukkan bahawa kaedah ujian maya boleh mensimulasikan ujian jatuh motosikal atas, sisi dan belakang dengan betul untuk analisis impak, menunjukkan bahawa kaedah ujian maya boleh digunakan dalam proses reka bentuk topi keledar untuk topi keledar motosikal dan konfigurasi topi keledar lain.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to use this opportunity to offer my heartfelt appreciation to everyone who assisted and guided me through the process of completing my research. My sincere gratitude to my supervisor, Associate Professor Ts. Dr. Muhammad Zahir Bin Hassan, who has provided me with unwavering support and advice for me to finish my final year project successfully. I've acquired a lot of information and experience working under her guidance, which has helped me finish my final year project.

I'm also thankful to both of my parents, Zusdi bin Othman and Dayang Mazlina Binti Datu Omar Hatta, for their continuous emotional and physical support while I worked on my final year project.

Last but not least, I'd want to express my gratitude to everyone who helped me finish my final year project, whether directly or indirectly. I am grateful for all of the help provided to me in completing my final year assignment.

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		i
ABSTRAK		ii
ACKNOWLEDGMENTS		iii
TABLE OF CONTENTS		iv
LIST OF TABLES		vii
LIST OF FIGURES		ix
LIST OF SYMBOLS AND ABBREVIATIONS		xii
CHAPTER 1	**INTRODUCTION**	
1.1	Overview Introduction of Motorcycle Impact	1
1.2	Analysis Background	2
1.3	Objective	2
1.4	Aim	3
1.5	Scope	3
CHAPTER 2	**LITERATURE REVIEW**	
2.1	Introduction	4
2.2	Origins of protective helmet	4
2.3	Types of helmet	9
	2.3.1 Full face helmet	9
	2.3.2 Modular / flip up helmet	11

2.3.3 Open face helmet 12
2.3.4 Half helmet 13
2.4 Important Components of Helmet 14
2.4.1 External shell 15
2.5 Types of Material used for External Shell 16
2.5.1 Acrylonite Butadiene Styrene (ABS) 16
2.5.2 Polycarbonate (PC) 17
2.5.3 Polyvinyl Chloride (PVC) 19

2.6 Experimental Test of Motorcycle Helmet Impact 21
2.7 Numerical Modelling Motorcycle Helmet Impact Test 28
2.7.1 Finite Element Modelling 28
2.7.2 Modelling of ABS 29
2.7.3 Boundary Conditions 30
2.8 Past Finite Element Analysis Results 32

CHAPTER 3 METHODOLODGY
3.1 Overview Impact Analysis of Motorcycle Helmet 39
3.2 Geometrical Development 41
3.2.1 Open face helmet model 41
3.2.2 Open face helmet geometry 42
3.3 Material Analysis 43
3.4 Finite Element Method Setup 43
3.4.1 Meshing 43
3.4.2 Boundary conditions 45
3.4.2.1 Boundary condition for rigidity test 45
3.4.2.2 Boundary condition for drop test 46
3.4.3 Load and velocities 47
3.4.3.1 Load Applied in Rigidity Test 47
3.4.3.2 Velocities Applied in Drop Test 47
3.4.4 Finite Element Solution Strategy: Simple Load Analysis 48
3.4.4.1 Finite Element Solution Strategy: Rigidity Test 48
3.4.4.2 Finite Element Solution Strategy: Drop Test 48

3.5 Summary 49

CHAPTER 4 RIGIDITY TEST RESULTS

4.1 Introduction 50
4.2 Finite Element Analysis 51
4.2.1 Results of Finite Element Method : Rigidity Test of Exterior Shell 53
4.3 Summary of Rigidity test 56

CHAPTER 5 DROP TEST RESULTS

5.1 Introduction 57
5.2 Results of Finite Element Method: Drop Test of Exterior Shell 58
5.2.1 Results of Top Direction Drop Test 58
5.2.2 Results of Side Direction Drop Test 62
5.2.3 Results of Rear Direction Drop Test 66
5.3 Helmet Materials results for Finite Element Analysis for Drop test 71
5.4 Comparison of current Finite Element Results with Past Journal results 71

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion 72
6.2 Recommendations 74

REFERENCES 75

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1:	Summary of the dummy test program (Hering and Derler, 2000)	26
Table 2.2:	Summary of head-form test program (Hering and Derler, 2000)	27
Table 2.3:	Mechanical Properties of ABS (Fernandes *et al*., 2013)	29
Table 2.4:	Material properties for ABS shell (P.K. Pinnoji *et al*., 2010)	30
Table 2.5:	Mass properties of helmet (Sadaq et al., 2014)	32
Table 2.6:	Consolidate result of ABS helmet in all the direction (Sadaq et al., 2014)	34
Table 2.7:	Consolidate result of PVC helmet in all the direction (Sadaq et al., 2014)	34
Table 3.1:	Mass properties of open face helmet exterior shell	41
Table 3.2:	Material Properties for helmet outer shell provided in software	42
Table 3.3:	Automeshing Properties of Exterior Shell	43
Table 4.1:	Results of rigidity test for different materials of helmet	54
Table 4.2:	The exterior open face helmet with different material shell test results	54
Table 5.1:	Result of ABS material Helmet for different speeds in from top direction	59
Table 5.2:	Result of PC material Helmet for different speeds in from top direction	59
Table 5.3:	Result of PVC material Helmet for different speeds in from top direction	60
Table 5.4:	Result of ABS material Helmet for different speeds in from side direction	63
Table 5.5:	Result of PC material Helmet for different speeds in from side direction	64
Table 5.6:	Result of PVC material Helmet for different speeds in from side direction	65
Table 5.7:	Result of ABS material Helmet for different speeds in from rear direction	68

Table 5.8: Result of PC material Helmet for different speeds in from rear direction 69

Table 5.9: Result of PVC material Helmet for different speeds in from rear direction 70

LIST OF FIGURES

FIGURES **TITLE** **PAGE**

Figure 1-1: Grabfood rider died due to motorcycle accidents in Selangor (MYKMU.NET, 2021) 2

Figure 2-1: Ancient Corinthian bronze helmet – 5th century B.C. 5

Figure 2-2: Leather bonnet (Fernandes and Alves de Sousa, 2013) 6

Figure 2-3: Roth's and Lombard's helmet (Fernandes and Alves de Sousa, 2013) 8

Figure 2-4: Open face helmets, 500-TX (Bell, 2021) 9

Figure 2-5: GT-Air 2 Full face helmet (Shoei, 2021) 10

Figure 2-6: Neotec 2 Splicer Flip-Up Helmet (Shoei, 2021) 12

Figure 2-7: J.O Carburettor TC-6 Open Face Helmet (Shoei, 2021) 13

Figure 2-8: Half Helmet with visor (Bell, 2021) 14

Figure 2-9: Anatomy of a motorcycle helmet (Motorcycle Legal Foundation, 2021) 15

Figure 2-10: Relative impact strength of plastics 18

Figure 2-11: PVC Heapro Industrial Safety Helmet Model Ventra Rs 100 (Indiamart, accessed 2021) 20

Figure 2-12: Oblique abrasive anvil and helmet positioning (Hering and Derler, 2000) 23

Figure 2-13: European drop test equipment for motorcycle helmet (Kim et al., 1997) 24

Figure 2-14: Schematic diagram of helmet test equipment (P.K. Pinnoji et al., 2010) 25

Figure 2-15: Configuration for R/0°-impacts (Hering and Derler, 2000) 26

Figure 2-16: Components of the helmet and the head form (Aiello et al., 2010) 29

Figure 2-17: The ECE R22.05 impact configurations 31

Figure 2-18: Anvil Geometries (M Aiello et al., 2010) 31

Figure 2-19: Surface model of helmet (Sadaq et al., 2014) 33

Figure 2-20: Solid model of helmet (Sadaq et al., 2014) 33

Figure 2-21: Graph of ABS and PVC material Von Mises Stresses at Different Speed from side direction (Sadaq et al., 2014) 35

Figure 2-22: Graph of ABS and PVC material Von Mises Stresses at Different Speed from rear direction (Sadaq et al., 2014) 36

Figure 2-23: Graph of ABS and PVC material Von Mises Stresses at Different Speed from front direction (Sadaq et al., 2014) 36

Figure 3-1: Flowchart of methodology 39

Figure 3-2: Open face helmet 40

Figure 3-3: Open face helmet model via Solidworks 40

Figure 3-4: Open face helmet geometry 41

Figure 3-5: Constraints at the open face helmet model 44

Figure 3-6: Load point applied on top of helmet model 44

Figure 3-7: Top-impact configuration 45

Figure 3-8: Side-impact configuration 45

Figure 3-9: Rear-impact configuration 46

Figure 4-1: Overview of Rigidity Test Analysis and Drop Test Analysis 49

Figure 4-2: Von Misses Stress of ABS helmet 50

Figure 4-3: Displacement of ABS helmet 51

Figure 4-4: Strain of ABS helmet 51

Figure 4-5: Graph displacements of helmet with different materials 53

Figure 5-1: FEA for Top direction drop test 57

Figure 5-2: Von Misses Stress for Different Material helmets for top direction 61

Figure 5-3: Strain for Different Material helmets for top direction 61

Figure 5-4: FEA for Side direction drop test 62

Figure 5-5: Von Misses Stress for Different Material helmets for side direction 64

Figure 5-6: Strain for Different Material helmets for side direction 65

Figure 5-7: FEA for rear direction drop test 66

Figure 5-8: Von Misses Stress for Different Material helmets for rear direction 67

Figure 5-9: Strain for Different Material helmets for rear direction 68

LIST OF SYMBOLS AND ABBREVIATIONS

E	-	Young's modulus
g	-	Gravity = 9.81 m/s
mm	-	Milimeter
m	-	Mass
N	-	Newton
P	-	Pressure
R	-	Relative density
σ	-	Stress
ε	-	Engineering strain
V	-	Velocity
$\boldsymbol{\sigma_{c^0}/P_{c^0}}$	-	Ratios of the beginning yield pressures hydrostatic tension
$\boldsymbol{P_t/P_{c^0}}$	-	Ratios of the beginning yield pressures hydrostatic compression
FEM	-	Finite Element Method
SIRIM	-	Standard and Industrial Research Institute of Malaysia
ECE R	-	Economic Commission for Europe Regulation
ABS	-	Acrylonitrile Butadiene Styrene
EPS	-	Expanded Polystyrene
PU	-	Polyurethane

ISO	**-**	International Standard Organisation
DOT	**-**	Department of Transportation
PC	**-**	Polycarbonate
CRP	**-**	Carbon Reinforced Plastic
FRP	**-**	Fiber Reinforced Plastic
GRP	**-**	Glass Reinforced Plastic
BSI	**-**	British Standards Institution
HIC	**-**	Head Injury Criteria
CAD	**-**	Computer-aided Design
3D	**-**	3-Dimensioning

CHAPTER 1

INTRODUCTION

1.1 Overview introduction of Impact Analysis of Motorcycle Helmet using Finite Element Method

Generally, a helmet is used by people to decrease the chance of serious head trauma or even death by reducing the impact of a force and hard collision to the head during unwanted accidents occur. Nearly 900 people die each year from head injuries, and more than 50,000 more are seriously wounded as a result of not wearing a helmet. In the year 2020 alone, motorcycle usage in Malaysia has been drastically increased due to the Movement Control Order (MCO) where the movement of citizens around Malaysia is restricted because of the pandemic of Covid-19 and the increases in delivery services around the country (Nawawi M. H., 2021). As stated by the Director of Traffic Investigation and Enforcement Department, Datuk Azisman Alias, 3118 people died due to motorcycle accidents, and 67.3 percent of the total death accidents in Malaysia are caused by motorcycle accidents (Nawawi M. H., 2021). Therefore, this analysis is to investigate whether affordable open face helmet available in the market will perform much better if different material is applied to it. **Figure 1-1** below shows the severity of motorcycle crashes.

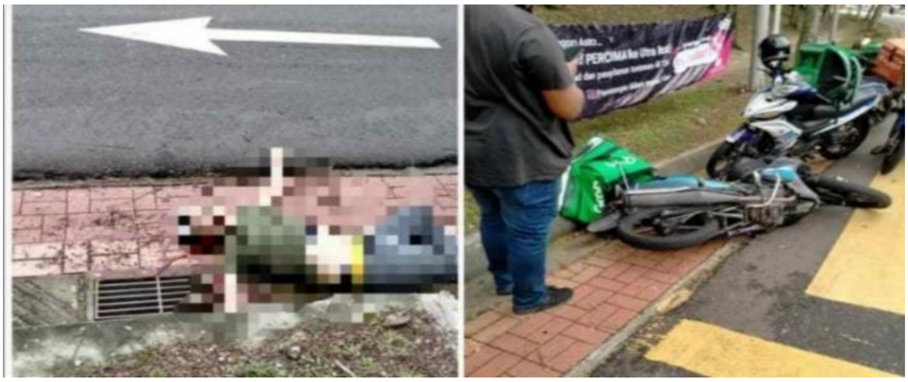

Figure 1-1: Grabfood rider died due to motorcycle accidents in Selangor (MYKMU.NET, 2021)

1.2 Analysis Background for Motorcycle Helmets

This finite element analysis is about to determine the strength and stability of the motorcycle helmets using the Finite Element Method via Simsolid and Solidworks. The type of helmet is picked by finding the most sought-after helmets which are accessible in the market in Malaysia. Then, different types of material used to fabricate a motorcycle helmet is applied to it. A velocity impact simulating impact force is applied to the helmet on each of its sides to simulate actual accidents and their effect on the helmet with different types of material. Then, the desired data will be collected and determine whether the material helmet used during this analysis is suitable or not.

1.3 Objective

The objectives of the analysis are as follows:

i. To set up an open face helmet CAD model as a standard for the present finite element modelling.

ii. To apply velocity impact at a different angle of the motorcycle helmet to simulate its effect on an actual accidents.

iii. To assess the structural of the motorcycle helmet shell with different material applied to it to predict which material is more suitable in making a helmet.

1.4 Aim

The aims of the analysis are as follows:

i. To apply different material with different properties to the motorcycle helmet.

ii. To compare the selected material applied to the motorcycle helmet to assess which material is more adequate in fabricating a strong helmet.

1.5 Scope

The scope of the analysis are as follows:

i. The motorcycle helmet chosen in this analysis is the MS88 open-face helmet which is available in the Malaysian market.

ii. Testing the top, side, and rear of the motorcycle helmet by applying force to simulate a force and drop test that could be generated during the accidents.

iii. Investigate the structural analysis and compare each of motorcycle helmet data with the different material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The subject of motorcycle helmets has spawned a substantial quantity of literature, which includes a variety of studies and experiments designed to explain the functioning and efficacy of motorcycle helmets in dissipating impact energy and reducing head damage during an accident. Analysis of motorcycle helmet during an impact mostly involves around the study of motorcycle helmet which is available in the market to withstand impact due to crash.

This chapter begins with the introduction of a protective helmet, to give an overview of the structure, design, and materials of the motorcycle helmet. The distinct categories of a motorcycle helmet are presented in order to justify which type of helmet to be analyzed. A review of the helmet literature and material is then presented to explain how the helmet effectively protects the users. The scientific findings are categorized into numerical modelling and experimental approaches to tackle and analyze the motorcycle helmet effectiveness.

2.2 Origins of protective helmet

Helmets have been used to shield the wearer's head from assault rifles and other piercing weapons since ancient times. The major role of helmets, however, was to decrease the number of brain injuries, particularly during conflict or conflict. For example, the helmet illustrated in **Figure 2-1** is known as the Ancient Greek Corinthian bronze helmet. By following the growth of civilization, we can see how the materials and construction methods of the helmets have improved throughout time. Following the changing demands for head protection, various types of helmets were invented and varied to defend against a variety of head injuries and impacts.

Figure 2-1: Ancient Corinthian bronze helmet – 5^{th} century B.C.

(Fernandes and Alves de Sousa, 2013)

In the early 19^{th} century amid the widespread conception and design of the motorcycle, the necessity of protection for motorcycle helmets during accidents or collisions arose. Motorcycle helmets are initially little more than leather bonnets worn with goggles and first used in racing. These hats were evolved from older aviators, with the primary purpose of providing some kind of comfort and practically little kind of protection for the wearer's head. As a result, the issue of not having a crash helmet remained, as seen in **Figure 2-2**.