UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS OF FIN AND HOLE EFFECT TOWARDS AIR VELOCITY AND ENERGY ABSORPTION DURING IMPACT TEST FOR BICYCLE HELMET

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology
(Automotive Technology) (Hons.)

by

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I hereby, declared this report entitled "Analysis Fin and Hole Effect Towards Air Velocity and Energy Absorption During Impact Test For Bicycle Helmet" is the results of my own research except as cited in

References.

Signature:………………………

Name : MUHAMMAD AIZAT BIN BAHARI

Date : 9 DECEMBER 2016

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

………………………………

(MR. MOHD AFDHAL BIN SHAMSUDIN)

ABSTRAK

Kajian halaju air dan penyerapan tenaga adalah sangat penting dalam dunia berbasikal. halaju udara dan penyerapan tenaga adalah kawasan di mana pelumba basikal dalam keadaan selesa apabila menggunakan topi keledar basikal dan mengurangkan hentakan pada kepala apabila berlaku kemalangan berbasikal. Objektif utama kajian ini adalah untuk memahami halaju udara melalui permukaan topi keledar basikal dan penyerapan tenaga semasa ujian impak ke atas permukaan sirip dan lubang pada topi keledar basikal dengan menggunakan SolidWork flow simulation CFD dan proses FEA. Projek ini juga menyiasat cara alternatif untuk mengurangkan penurunan halaju dan penyerapan tenaga semasa ujian kesan dan juga untuk mencari tempat sirip yang paling sesuai dan lubang di permukaan untuk topi keledar basikal.

ABSTRACT

The study of air velocity and energy absorption is very important in the world of cycling. Air velocity and energy absorption is an area where cyclist in comfortable when using the bicycle helmet and reduce head impact when cyclist accident. The main objective of this research is to understand air velocity through the surface bicycle helmet and energy absorption when during impact test on fin and hole of surface bicycle helmet by using SolidWork Flow Simulation through CFD and FEA process. This project also investigates an alternative way to reduce velocity drop and energy absorption during impact test as well as finding for most suitable fin and hole on the surface for bicycle helmet.

DEDICATION

To my beloved parents, my siblings and my friends who give me support and guidance to complete my final year project work.

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Foremost, I would like to thank Mr. Mohd Afdhal Bin Shamsudin my project supervisor, for his continued support and enthusiasm regarding my work on this project and others. Also working with my co-supervisor Mr. Mohd Idain Fahmy Bin Rosley for SolidWork lectures and to my colleagues who all offered their support and guidance at one time or another. For providing the excellent foundation upon which I've built my outstanding undergraduate education I would also like to thank the Universiti Teknikal Malaysia Melaka specifically the Faculty of Technology Engineering and the Department of Mechanical Engineering. With the above resources at hand, I had the tools and support I needed to investigate and expand my engineering knowledge and to attain a higher level of technical and professional expertise than I had previously thought possible. I would like to thank my parents, Bahari Bin Marzuki and Norsiah Binti Abu Bakar, for their constant support and praise throughout my many years of education and finally, my two older siblings, Mohd Fariz and Amalina for providing me with motivation and guidance toward my schooling through their many accomplishments in life. Lastly, for encouraging and support in English education, I would like to thank all my friend BETA Kohort 3.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

2D	-	Two Dimension
3D	-	Three Dimension
CAD	-	Computer Aided Design
CFD	-	Computational Fluid Dynamic
EPS	-	Expanded Polystyrene
FEA	-	Finite Element Analysis
ICF	-	Insulated Concrete Form
m/s	-	Meter per Second
MMT	-	Montmorillonite
N	-	Newton
PU	-	Expanded Polyurethane
Cd	-	Drag Coefficient
σ	-	Stress
ϵ	-	Strain
τ	-	Torque

CHAPTER 1

INTRODUCTION

1.0 Introduction

The main target of a bicycle helmet is to give head protection from fall or accident, thermal comfort and aerodynamics are getting to be imperative design. Helmet builds the frontal zone of a rider's head that affects higher aerodynamic drag. Other than aerodynamics, energy absorption is very important for a bicycle helmet. However, generally head wounds are more serious in accidents including motor vehicles than in single-bike crashes. Data from genuine accidents demonstrate that bicycle helmets are extremely powerful in lessening head injuries. Two out of three head injuries from bike accidents could have been avoidable if the cyclist had worn a helmet (Matteo Rizzi, 2013)

Aerodynamic evaluation of bigger frameworks, from bicycle to planes, is an important theme and requires huge exertion and money related interest in today's productivity drove the world. However, the demand for growth of improvement has forced helmet producers and designers to introduce new designs regularly. Recently several helmet manufacturers (e.g., LG, Lazer and Giro) have introduced dimples on the outer shell of helmet mimicking the so called ‘Golf-ball’ dimple effects with a view to further reduce aerodynamic drag of the helmet (Firoz Alam a, 2014). Aerodynamic drag contributes most of the resistance experienced by a focused cyclist. Low aerodynamic drag is a key nature of high-performance and numerous aerodynamic helmets have been produced. Many aerodynamic helmets have been produced to reduce the aerodynamic drag experienced by cyclists (Sims and Jenkins, 2011).

Wind-tunnel (CFD) software enabled us to test the aerodynamic performances of several helmets on the market. Our evaluation determined that it was possible to create a helmet offering an exceptionally performance by optimizing its frontal surface (the surface of the helmet which faces the wind). In drafting, cyclists ride close behind each other to reduce aerodynamic drag. The helmet analysis and optimization was performed using SolidWorks Flow Simulation CFD software. Flow Simulation, like all CFD software, has distinct limitations in accuracy. This work addresses the need for development of a virtual wind tunnel, to be used as a design instrument for large-scale systems (Doval, December 2012).

The bicycle helmet was investigated by using Fenite Element analysis (FEA) in oblique impacts with a simulated road surface. The direct and rotational increasing speeds of the headform, fitted with a compliant scalp and a wig, were measured (Gilchrist, 2007). Besides that, Finite Element Analysis (FEA) was used to consider the change of bicycle helmet performance, in angled contacts with the street. The occasions, anticipated by FEA, were depicted and the peak head increasing speeds interpreted as far as an improved model.

1.1 Problem Statement

In cycling, resulting in a bicycle helmet is important for achieving the desired common goal. There are varying aspects that affect substantially in producing bicycle helmet, for example the effect of fins and hole towards air velocity. Most bicycle helmets are made of foam that holds up warmth, created by the rider's head. The total of heat transfer through the human head is below normal conditions 40–50% of the total warmth released of the body and rise with growing (W. Rasch, 1991). The gap among the head and helmet is minor, and both mass flow and air velocity in this chamber are also decrease, as a result, the sweat is not able to evaporate making the cyclist uncomfortable. The discomfort created by sweating may be reduced via increasing the air velocities inside the helmet that allows you to enhance the sweat evaporation rate (Praveen K. Pinnoji, 2008) it also the ventilation can minimize air velocity drop and maintain the mass flow rate when entering helmet. The helmet geometry can substantially decrease the linear acceleration a head undergoes in high speed (Dustin Scheer, 2015) and adding the fins on the surface might be reduce the air velocity drop.

1.2 Project Objective

Using the same helmet to find the effect of air velocity on the surface with adding a fins and holes on the bicycle helmets. Furthermore, to find energy absorption during impact test. Therefore, a study was conducted on bicycle helmets in order to improve aerodynamic performance for cyclist.

The objective of this project is:

1. To design bicycle helmet according to streamlined shape without and with hole and fin.
2. To analyze effect of air velocity and energy absorption towards without and with of fin and hole on bicycle helmet surface.
3. To compare effect of air velocity and energy absorption on bicycle helmet.

1.3 Scope of Project

1 Designing bicycle helmet according to streamlined shape without and with fin and hole using Solidwork sofware.

2 Analyzing effect of air velocity and energy absorption towards without and with of fin and hole on bicycle helmet surface by using Solidwork CFD and FEA software.

3 Comparison effect of air velocity and energy absorption on bicycle helmet.

CHAPTER 2

LITERATURE REVIEW

2.1 Bicycle Helmet

Bicycles are very famous in the Netherlands, in the middle of others for commuting, shopping, transporting children and recreation. However, cycling can also result in harm, regularly inclusive of severe head and brain damage. The bicycle helmet is supposed to reduce the risk of this type of injury. In general, cyclists do not wear helmets. If a helmet is indeed worn, this is usually done by recreational cyclists, racing cyclists, mountain bikers and young children. There is no public support in the Netherlands to make the bicycle helmet compulsory (Kemler, 2009).

2.2 History

Cycle helmets had been first brought in America in the mid 1970s. At the beginning they had promoted mainly by their manufacturers, who were often not afraid to denounce competitors' products as ineffective and bad for health (Franklin, 2000). At the beginning of bicycle helmet, they used pith helmets. Pith is a plant fabric crushable, however changed into the best high-quality material at the time. Since 1980s reports commenced to appear, especially inside the medical press, suggesting that if cyclists wore helmets, they would be less likely to suffer head damage. From that time, the advertising of helmet wearing by cyclists has been a made thrust of road safety campaigns in many countries (Franklin, 2000).

Figure 2.1: Example for existing bicycle helmet (Firoz Alam*, 2010)

2.3 Geometry of Bicycle Helmet

Bicycle helmets is difference from one model to another model, leading to considerable variations in their respective cooling efficiency as defined previously. In generally, a helmet includes an external shell of given thickness for impact safety with double openings intended for ventilation. Normally, the inner surface of a helmet includes of a series of parallel thin walls, perhaps augmented by comfort pads, in contact with the cyclist's skull (Josu´e Sznitman∗, 2005)

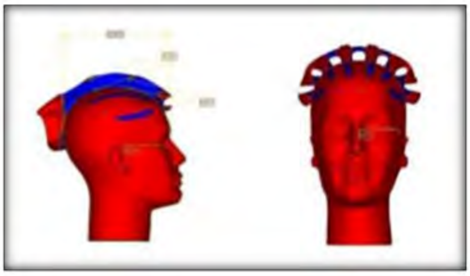

Figure 2.2: Example front and side view of helmet with ventilation channel in CAD drawing (Josu´e Sznitman∗, 2005).

2.4 Effect of Hole as Ventilation.

In professional cycling, a lot of racing cyclists complain about the truth that riding with a helmet is uncomfortable because of high temperatures and sweating under the helmet. The uncomfortable caused by sweating can be decreased by increasing the air velocities in the helmet so as to enhance the sweat evaporation rate (Praveen K. Pinnoji, 2008). In countries where the helmet is not compulsory (e.g. France), the majority of the amateur cyclists refuse to wear the helmet especially in the mountain stages during hot summer days. The discomfort of high temperatures and moisture concentrations around the head of the cyclist (A. Van Brecht, 2008).

Helmet liners are product of foam that holds heat well. Human bodies use the head to radiate extra warmth during workout. Only a flow of air over the head can bring that heat out of the helmet, so ventilation becomes critical in hot weather, and is needed even in cold weather to carry moisture away.

The combination of the excessive heat production of the head and the insufficient ventilation efficiency of the helmet result to uncomfortable gradients in temperature and moisture between head and helmet. Furthermore, the thermal balance of the head has a great influence on the complete human body. Experiments showed that cooling of the head significantly decreases the heart rate, the internal body temperature and skin temperature values on other body parts (A. Van Brecht, 2008)

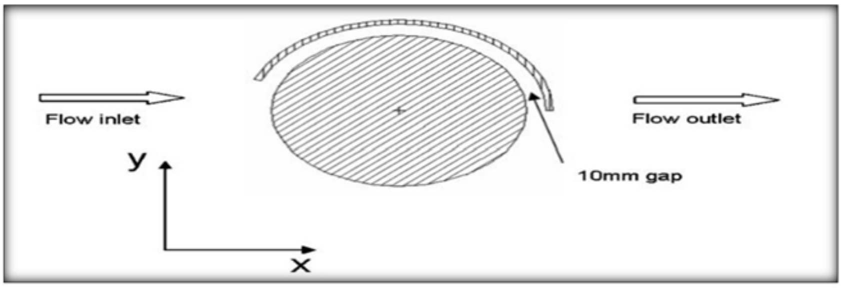

Figure 2.3: example Schematic view of air velocities through the gap of helmet (Praveen K. Pinnoji, 2008).

2.5 Material of Bicycle Helmet

Bicycle helmet liners are mainly molded in Expanded Polystyrene (EPS) foam. In the EPS world, the top-end helmets require internal reinforcement, usually to open up larger vents, and the strategies for including the reinforcements in the mold and getting them to line up correctly are critical to the manufacturing process.

By crushing and cracking, the internal EPS liner attenuates impact energy that is, it extends the hit over a longer period of time. Six milliseconds, say, instead of two. Helmet professionals call it "slowing the blow," and it can turn a lethal fall into a survivable one (Barcott, 2013).

2.6 Materials.

Today's products and their constituent components and structures have to meet increasingly stringent requirements during operation. The economic and human costs of failure during service impose a great deal of responsibility on organisations and individuals who select and integrate materials in a final engineering design. A critical feature of successful product development is the judicious selection of the best materials based on informed awareness of the capabilities and opportunities afforded by all candidates, coupled with a design that takes full advantage of their properties (Alexander M. Korsunsky, 2016). Expanded Polystyrene (EPS) material is one of the most common materials for bicycle helmet today and Acrylonitrile Butadiene Styrene (ABS) polymer is a common material for the helmet shell (O. Krupicka, 2012).

2.7 Acrylonitrile Butadiene Styrene (ABS)

ABS is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. The result is a long chain of poly butadiene criss-crossed with shorter chains of poly (styrene-co-acrylonitrile). The nitrile groups from neighboring chains, being polar, attract each other and bind the chains together, making ABS stronger than pure polystyrene. The styrene gives the plastic a shiny, impervious surface. The butadiene, a rubbery substance, provides resilience even at low temperatures (Anil Kumar. K, 2013).

2.8 Advantages of Acrylonitrile Butadiene Styrene (ABS)

Expanded polystyrene foam (EPS) is a thermoplastic polymer with a closed cellular structure. It is biologically inert and non-toxic. EPS has interesting properties such as being of low density, thermal insulation, hydrophobicity and chemical resistance when exposed to acids and alkalis (V. Ferrándiz-Mas, 2005). Polystyrene literally translated is “polymerised styrene”. That is, the single styrene molecules are chemically joined together to form a large molecule which is called the polymer. The expandable form is produced as small beads containing a blowing agent.

2.9 Expanded Polystyrene (EPS)

When the thin liquid sheet produced by both the hollow cone and flat-fan nozzles are composed of Newtonian fluids like water, the resulting fluid dynamics are controlled by a balance of inertial, gravitational and capillary stresses. At sufficiently high speed and Reynolds and Froude numbers, the effects of gravity can be neglected.(Thompson & Rothstein, 2007).

2.10 Advantages Expanded Polystyrene (EPS)

The most of modern ski helmets use Expanded Polystyrene (EPS) foam liners with a thin, hard plastic exo-skeleton to prevent sharp objects penetrating through the liner. The concept is quite simple. Upon impact the EPS foam deforms, absorbing some of the impact and reducing the energy imparted to the head. EPS foam has many advantages including light weight and low expense (Stewart, et al., 2010). The Expanded Polystyrene (EPS) is the best liner material to manage consistent amounts of impact energy. Nonetheless, EPS use has some drawbacks, such as the difficulty to optimize energy absorption in different areas of the head and the excessive insulation that prevents heat evacuation (D. Hailoua Blanco*, 2011).

2.11 Computer Aided Design (CAD)

Computer-Aided Design is a worldwide international journal that provides academia and manufacture with key papers on research and developments in the application of computers system to design. Computer-Aided Design invites papers reporting new studies, as well as novel or particularly significant applications, inside a huge range of subjects, spanning all stages of design process from concept creation to manufacture and beyond (V. Shapiro, 2016).

Today CAD systems are covering most of the activities in the design cycle, they are recording all product data, andthey are used as a platform for collaboration between remotely placed design teams. Most of its uses are for manufacturing and the usual name of the application is CAD/CAM. The areas of application of CAD related techniques, such as CAD, CAEngineering and CAManufacturing (Bilalis, 2000).

2.12 Computational Fluid Dynamics (CFD)

Computational Fluid Dynamics (CFD) is the emerging field of fluid mechanics in which fluid flow problems are solved and analysed using computational methods and numerical algorithms. In fluid mechanics, there are generally three routes of work in the field, three ways to conduct experiments. The first category is theoretical, or analytical, fluid mechanics. The first category is theoretical, or analytical, fluid mechanics. Theoretical fluid mechanics includes theorizing, manipulating and solving equations with pen and paper. The Navier-Stokes equation governing incompressible fluid flow is an example of theoretical fluid mechanics. Secondly, many engineers and physicist work in the area of experimental fluid mechanics. Experimental fluid mechanics involves conducting actual physical experiments and studying the flow and the effect of various disturbances, shapes, and stimuli on the flow. (Kumar, 2009).

Aerodynamic drag can be analyzed by field tests, wind-tunnel measurements and numerical simulation by Computational Fluid Dynamics (CFD). In recent years, several publications have reported detailed CFD simulations in cycling and other sport disciplines (Bert Blocken, 2012). While there are many unresolved fundamental issues regarding initiation, transition and propagation, for example, numerical modeling for obtaining engineering solutions are sought for the above mentioned applications. Time-accurate computational fluid dynamics (CFD) methods can be used to perform cycle analysis and performance optimization of pulse detonation engines from the simulations of the corresponding flow fields with variations in design parameters (HyungwonKIM, 2003).

The Computational Fluid Dynamics CFD simulations and the wind tunnel measurements is considered to be very good, which justifies using these simulations for further analysis of the flow field and also using the same computational method to be successful for modelling complex multiphase flow, transport bed, pneumatic and demo released (Bert Blocken, 2012).

2.13 Drag Coefficient

Aerodynamic drag contributes the majority of the resistance experienced by a competitive cyclist. Low aerodynamic drag is a key quality of high performance equipment and many aerodynamic helmets have been developed. Aerodynamic drag contributes more than 80 percent of the resistance experienced by a cyclist