UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Finite Element Analysis Of Oblique Impact On Composite Bicycle Helmet

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

By

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APPROVAL

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

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(MR. MOHD AFDHAL BIN SHAMSUDIN)

ABSTRAK

Helmet keselamatan basikal adalah salah satu gear keselamatan untuk pelumba melindungi daripada punca kecederaan kepala akibat kejadian kemalangan. Impak adalah perlanggaran di antara dua badan dan dicirikan oleh kekuatan hubungan generasi yang relatifnya besar dan bertindak sepanjang selangan waktu yang sangat pendek. Projek ini adalah simulasi reka bentuk helmet basikal yang menganalisis kesan impak dari pelbagai sudut dan menguji penyerapan tenaga antara komposit semulajadi dan bahan komposit yang sedia ada menggunakan analisis dalam Solidwork. Pada masa ini, tiada kajian untuk membandingkan sifat mekanikal di antara helmet basikal sintetik dan helmet bukan sintetik. Selain itu, perisian Solidwork 2016 telah digunakan dalam projek ini sebagai medium simulasi kesan daripada impak oblik. Halaju impak yang digunakan adalah 19.9 meter sesaat yang digunakan dari pelumba trek kebangsaan dengan masa yang direkodkan 10.073 saat sejauh 200m. Helmet basikal dengan reka bentuk lubang mempunyai sasaran untuk mendapatkan nilai tekanan maksimum Von Mises pada 1.84E+08 Pa daripada helmet basikal dengan reka bentuk sirip pada 1.79E+08 Pa. Berdasarkan perbincangan, topi keledar basikal dengan reka bentuk lubang untuk komposit semulajadi menyediakan tenaga yang lebih baik berbanding dengan helmet dengan sirip untuk bahan yang ada. Pelumba trek boleh menyelamatkan dari kecederaan kepala kerana kesan tenaga yang diserap oleh komposit semulajadi dari simulasi hampir sama dengan bahan komposit yang sedia ada.

ABSTRACT

A safety bicycle helmet is one of the safety gears for cyclist to protect from head injury causes of impact in crash events. Impact is the collision between two bodies and is characterized by the generation relatively large contact forces that act over a very short interval of time. This project is applied for bicycle helmet design simulation to analyze the effect of impact from various angles and to test the energy absorption between existing and new natural composite using finite element analysis in Solidwork. Currently, there is no research to compare the mechanical properties in between synthetic bicycle helmet and non-synthetic bicycle helmet. Besides that, Solidwork 2016 software was used in this project as a medium for oblique impact simulation. The velocity of impact used was 19.9 meter per second used from our own national track cyclist with the recorded time of 10.073 seconds over the 200m. Bicycle helmet with hole design has an achieve target to get more maximum Von Mises stress value at 1.84E+08 Pa than the bicycle helmet with fin design at 1.79E+08 Pa. Based on the discussion, bicycle helmet with hole design for natural composite provide better energy absorb compared to helmet with fin for existing material. A track cyclist can save from head injuries as the effect of energy absorbed from the impact simulation is nearly same with the existing material.

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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%	-	Percentage
EPS	-	Expanded Polystyrene
mm	-	Millimetre
vs	-	Versus
EPP	-	Expanded Polypropylene
EPU	-	Expanded Polyurethane
PET	-	Polyethylene Terephthalate
ABS	-	Acrylonitrile Butadiene Styrene
BMX	-	Bicycle Motocross
ITW	-	Illinois Tool Works
ASTM	-	American Society for Testing and Materials
PU	-	Polyurethane
Kg	-	Kilogram
BS	-	British Standard
N	-	Newton
kn	-	Kilo newton
etc.	-	Et Cetera
cm	-	Centimetre
lm	-	Lumen
L/W	-	Weight Average Length
µm	-	Micrometer
±	-	Plus Minus
g/cm³	-	Gram per centimeter
MPa	-	Mega Pascal
GPa	-	Giga Pascal
CAD	-	Computer-aided design
°	-	Degree
m/s	-	Meter per second

N/m^2	-	Newton per square meter
W/o	-	Without
Pa	-	Pascal
m	-	Meter

CHAPTER 1

INTRODUCTION

1.0 Introduction to impact

An impact can be defined as the impact between two bodies and is described by the age moderately contact forces that demonstrate over short time. There is two type of basic impact which is very common in real life; it is normal impact and angular impact. A well-design helmet should be great at absorb as much energy and to be spread to all another helmet (Kostopoulus et al., 2002). The ability to maintain huge damage without giving in the reliability of the structure is the main feature using a composite material to produce safety helmet (Kostopoulus et al., 2002). Next, head form of the safety helmet is to be designed for head protection. Besides that, correct fitting of head form into safety helmet affects the performance of the helmet (Kostopoulus et al., 2002). Many researchers have study the impacts of helmet are oblique to helmet surface and hit the area of front and sides of the helmet (Kostopoulus et al., 2002). Helmet use by bicycle riders is considered protective because of its characteristic of function and reason (Joseph et al., 2016).

Bicycle riding has become one of the most popular of outdoor activities in the whole wide world. There are a few basic safety gears that need to be considered when riding a bicycle such as clothing, lights and reflectors, horns and bells, brakes and so on. One of the most important safety gears are the helmets. Bicycle helmets functioned as a protection to prevent a serious head and facial injury when cyclists are in crashes which may lead to death.

Eventually, two different factors, for example, thermal comfort and aerodynamic efficiency are similarly vital for any bike protective helmet outline for recreational or proficient utilize (Alam et al., 2010). Besides that, energy absorption

was one of the things that also take place in bicycle helmet crashing. The energy absorbed by a bicycle in a crash is highly changeable and the force of the impact is kinetic energy. Energy absorption depends on speed, angle collision and area contact. Basically, head injuries are the most serious wound in cycling crash. It is due to this project to overcome the energy absorption using composite material.

According to Mills et al., (2009), the oblique impact of a helmet and study with factors affected the angular acceleration of the head form. Besides that, the presence of a body with a helmet influences the head rotational acceleration components by full detail of oblique impact of helmet with finite element of human body (Ghajari et al., 2013). The main function of the outer shell is to provide reliability from multiple impacts and this makes it common in helmet design according to Kostopoulus et al., 2002. In this experiment, composite fibre will be involved as to produce a helmet with different impact angle to achieve high energy absorption. Kenaf fibre reinforced epoxy will be used in this experiment. SolidWorks software is the platform for oblique impact test for helmet in drop test simulation. Evaluating the head damage and seeing how the damage is consistent will prompt better helmet designs (Lee and Gong., 2009).

1.1 Problem Statement

Based on the world of cycling, result of the helmet need to achieve by optimizing the main objective. There are various aspects that influence when producing a helmet such as by using existing composite, bicycle helmet is not easy to dispose of compare using natural composite (Nishino T et al., 2003). The natural composite is biodegradable but not synthetic fibre. Mostly bicycle helmets are made from synthetic fibre. A safety helmet was designed as a protection to the head.

Next, synthetic helmets that already approved with standards was capable to reduce the injury of normal impact at common speed within 15 kilometres per hour (Zulkipli., 2009). Each helmet material is important with different material stiffness. Most people have applied kenaf fibre and epoxy resin as a composite to many types of product. In recent times, the usage of natural fibre has strengthened polymer composite in many sectors that have grown remarkably (Thiruchitrambalam et al., 2012).

The difficulty with using compatible impact stiffness must be carefully specified, otherwise, results from different test will not be comparable (Mills and Gilchrist., 1990). Furthermore, the kenaf fibre will not affect the human skin during normal use when exposed to sunlight, temperature extreme and rain based on American National Standard., 1984. Currently, there is no research to compare the mechanical properties in between synthetic bicycle helmet and non-synthetic bicycle helmet.

1.2 Project Objective

Apply same bicycle helmet to get the effect of oblique impact on existing synthetic composite and natural fibre composites and design fin and hole as to give effect to material stiffness in helmet. In addition, to analyse energy absorption from different angle during impact test and the helmet is using natural composite for mechanical properties and compares with the existing material of bicycle helmet in software.

The objective of this project is:

1. To compare the effect of oblique impact for bicycle helmet in between existing and new natural composite.
2. To test the energy absorption based on different angle of impact for existing and new natural composite.

1.3 Scope of Project

1. Comparing the finite element analysis technique for bicycle helmet using Solidworks software.
2. Testing new and existing composite for energy absorption of impact due to different angle using Solidwork drop test simulation.

CHAPTER 2

LITERATURE REVIEW

2.0 Bicycle Helmet

Helmets are helpful as well-being apparatus to anticipate injuries in an uncontrolled situation. A protective helmet can limit the damage to brain and head. There are many purposes behind that announcement. No head protector can secure against every single conceivable effect, and the effect may surpass the helmet's insurance. No helmet secures any part of the body that does not cover; regardless of whether the head damage is maintained at strategic distance, a cyclist may have damage on the face, broken bones or more awful. Safety always a number one priority. Moreover, the uses of helmets among the cyclists have been proved to be very helpful as a safety gear to reduce the risk of a bicycle that related to head injuries by 85% (Thompson., 1989).

Next, a helmet that could secure totally against each impact may be tremendous. A strong strap keeps the helmet set up in a crash. Protective helmets are intended to keep anticipated impacts inside the scope of human brain resilience. Existing protective helmet norms don't take this as a major issue, for example, a brain that getting more weak, less adaptable and hesitant to re-harm again on account of genetic factors, particularly for a senior citizen. Concussions are decreased, yet at the same time worthy as long as bad wounds are diminished. Lessening the crash or eliminating hard objects in the crash condition might be more compelling methods for concentrating on head damage issue than wearing a helmet. The benefits of that approach give a long-term to those different parts of the body that a head protector does not endeavour to ensure.

2.1 History

By the 1880's, riding clubs were ending up increasingly well-known and, as some people saw that head damage in riding event's crash were an issue, they started to help the utilization of protective helmets (Davison., 2013). At the beginning, they utilized substance head protectors. Pith is a plant material that is effortlessly crushable however was likely the best material accessible at the time. In spite of the fact that it would most likely separate on affect, riders just required security against a single effect to know the protective helmet spared them, and to know it was worth purchasing another head protector.

Toward the start of the twentieth century, the awful injuries and the most fatalities come from head injuries in bicyclist club race. Racers started to utilize shape of the helmet made from calfskin around the head. At that point, the style developed and it was enhanced by segments of calfskin masterminded longitudinally on the head. These offered a little-preferred insurance over the substance head protectors, yet at the same more time was required. Over the coming decades, helmets were created with hard shells and foam liners. However, they had a tendency to be either overwhelming or incapable of a crash, and some of the time both.

By the 1970's, a gathering called the Snell Foundation started to finish the testing of bicycle helmets and found that none of the helmets available was extremely compelling, so they built up some fundamental criteria for head insurance, which concurred with the bicycle blast of the 1970's, when numerous American grown-ups took up cycling as an activity and a game. At that point in 1975, Bell Auto parts built up the main genuine protective helmet for cyclists. It comprised of a hard plastic shell cushioned with foam like material. This was the start of the cutting edge protective helmet. In 1984, The American National Standards Institute presented norms for a helmet that were broadly acknowledged. This expelled inadequate protective helmet from the market and raise the nature of all caps. Before foam liner is made of extended polystyrene, by 1990's a thin hard shell was added to the polystyrene foam protective helmet for durability (Davison., 2013).

The present protective helmets are considerably lighter; more proficient, and have various vents for comfort and customizable lashes to influence them more to

secure and less demanding to wear. As insights demonstrate the lessening of head wounds with the expanding utilization of protective helmets, many states in the United States have made it mandatory to wear helmets while riding a bike. Most guardians today instruct their toddlers to never ride their bicycles without a protective helmet, putting on a head protector ought to end up as normal as wearing a safety belt only it was riding a bike.

2.2 Geometry of Bicycle Helmet

Fundamentally, geometry of bike helmet has extended shape, dependably with vents made with EPS foam secured by a thin plastic shell. Usually, bike helmets have a length, at the lower edge, of 220– 230 mm, and a width of 175– 180 mm. There is generally a 3 or 4 mm hole between the head form and the liner inside surface; the genuine helmet has pads of soft polyurethane open-cell (comfort) foam in this space (Gilchrist and Mills., 2007).

2.2.1 Effect of Geometry towards Impact

The skull goes nearly to the rigid body, with the scalp and hair going about as thin, deform-able layers on its almost circular surface. Subsequently, helmets not quite the same as hip protectors, where the head of the femur is covered in the delicate tissue of the thigh. The fit of the helmet influences to protect the head from impact. Research demonstrated that nape straps maintain at a strategic distance from forwarding protective helmet when turning, while straps running towards the front of the helmet. In the event that helmet revolutions toward the finish of experimental can be repeated, the methodologies of this and the past segment are affirmed (Gilchrist and Mills., 2007).

An analysis for the head forms linear speeding when a bike protective helmet without ventilation holes has an ordinary impact to a road surface, improved the head geometry as being locally circular and treated the head and road surfaces as being unbending (Gilchrist and Mills., 1991). It disregarded the protective helmet shell and expected the cross-sectional region of the pulverized foam region is the same as the contact zone between the head protector and the road.