IMPACT TEST STUDY FOR THE FRONTAL AND SIDE OF SPACEFRAME FOR FORMULA RACING CAR

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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IMPACT TEST STUDY FOR THE FRONTAL AND SIDE OF SPACEFRAME FOR FORMULA RACING CAR

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A report submitted
In fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering (Hons)

Faculty of Mechanical Engineering

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DECLARATION

I declare that this project report entitled “Impact test study for the frontal and side of Spaceframe for Formula Racing Car” is the result of my own work except as cited in the references.

Signature : ……

Name : ……....

Date : ……

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Hons).

Signature : ……

Name : ……....

Date : ……

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DEDICATION

To my beloved mother, Kong Kim Poh

and my father, Ng Peng Khoon

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ABSTRACT

Formula Society of Automotive Engineers (FSAE) competition is a worldwide racing competition that allow the university students to develop and fabricate their own formula racing car with the practical skills and knowledge learnt throughout the academic years. Before the event started, every racing team must be confident as their racing car is well developed and well prepared. Sometimes the accident still possible to happen due to some uncontrollable factors such as weather, road condition and driver status. To prevent severe injuries to driver, the racing car must strong enough to provide a good protection. The main component that should be first to design when building a racing car is the chassis (space frame) as it plays the role as the outer shell for protection and the backbone to carry all component. Hence, the objective of this project is to design and analyze the space frame chassis for the frontal and side impact test. The design criteria for the space frame chassis is predicated to FSAE rule 2019 where the other factor like ergonomics, load analysis and safety factor are considered as well. Software used in this project for 3-Dimensional (3D) modeling and crash test simulation is Computer-Aided Three-Dimensional Interactive Application Version 5 (CATIA V5). Seven concepts had been proposed in this project by combining different component of chassis such as front bulkhead, main roll hoop, front roll hoop, side impact structure and bracing. The three best concepts were selected based on the criteria like chassis weight, material cost, manufacturability, safety and triangulation as stated in evaluation of the concept selection via weighted matrix decision method. The selected concept designs will be proceeded into the 3D modelling and Finite Element Analysis (FEA) using CATIA V5 to find out the best among three designs on protecting the driver from frontal and side impact. The value of von mises stress (N/m^2), deformation (mm) and factor of safety will be discussed and used to identify the best design.

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ABSTRAK

Pertandingan Persatuan Jurutera Automotif Formula (FSAE) adalah pertandingan perlumbaan di seluruh dunia yang membolehkan pelajar universiti untuk membangun dan membentuk kereta lumba formula mereka sendiri dengan kemahiran dan pengetahuan praktikal yang dipelajari sepanjang tahun akademik. Sebelum acara bermula, setiap pasukan perlumbaan mestilah yakin bahawa kereta lumba mereka sudah bersedia. Kadang-kadang kemalangan itu masih mungkin berlaku disebabkan beberapa faktor yang tidak dapat dikawalkan seperti cuaca, keadaan jalan raya dan status pemandu. Untuk mengelakkan kecederaan yang teruk kepada pemandu, kereta lumba mesti kuat untuk memberikan perlindungan yang terbaik. Komponen utama yang perlu dibuat pertama apabila membina sebuah kereta perlumbaan adalah casis (kerangka) kerana ia memainkan peranan sebagai perlindungan luar untuk keselamatan pemandu dan juga tulang belakang untuk menanggung semua komponen. Oleh itu, matlamat projek ini adalah untuk merekabentuk dan menganalisis casis rangka ruang untuk ujian hentaman hadapan dan sampingan. Kriteria rekabentuk untuk casis berdasarkan pada aturan FSAE 2019 di mana faktor lain seperti ergonomik, analisis beban dan faktor keselamatan juga dianggapkan. Perisian yang digunakan dalam projek ini untuk pemodelan 3-Dimensi (3D) dan simulasi ujian kemalangan adalah Aplikasi Interaktif Tiga Dimensi Interaktif Versi 5 (CATIA V5). Tujuh konsep telah dicadangkan dalam projek ini dengan menggabungkan komponen yang berbeza dari casis seperti tiang depan, gelung roll utama, gelang roll depan, struktur kesan sampingan dan pengaman. Tiga konsep terbaik dipilih berdasarkan kriteria seperti berat casis, kos bahan, "manufacturability", keselamatan dan triangulasi seperti yang dinyatakan dalam penilaian pemilihan konsep melalui kaedah "weighted decision matrix". Rekabentuk konsep yang dipilih akan diteruskan ke tahap pemodelan 3D dan Finite Element Analysis (FEA) menggunakan CATIA V5 untuk mengetahui rekabentuk yang terbaik antara tiga rekabentuk tersebut dalam melindungi pemandu dari hentaman depan dan sampingan. Nilai von mises stress (N / m2), ubah bentuk (mm) dan faktor keselamatan akan dibincangkan dan digunakan untuk mengenal pasti rekabentuk terbaik.

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Last but not least, thanks to my family for their support and my friends that helped me overcome the problems facing in this project. Thank you and hopefully this report will be useful as a guidance for other students in the future as a reference in their study.

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LIST OF ABBREVIATION

2D	**-Two-dimensional**
3D	**-Three-dimensional**
AISI	**-American Iron and Steel Institute**
AL	**-Aluminium**
ASTM	**-American Society for Testing and Materials**
ATD	**-Anthropomorphic Test Dummy**
CATIA V5	**-Computer-Aided Three-Dimensional Interactive Application Version 5**
F1	**-Formula One**
FEA	**-Finite Element Analysis**
FOS	**-Factor of Safety**
FSAE	**-Formula Society of Automotive Engineers**
IS	**-Indian Standards**
JSAE	**-Student Formula Japan**
MS	**-Mild Steel**
OD	**-Outside Diameter**
RPM	**-Revoulution per minute**
RPS	**-Rotation per second**
SI	**-Simulation**
TIG	**-Tungsten Inert Gas**
UTeM	**-Universiti Teknikal MalaysiaMelaka**

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LIST OF SYMBOLS

a	**-**	**Acceleration**
F	**-**	**Force**
m	**-**	**Mass**
r	**-**	**Radius of wheel**
t	**-**	**Time**
t	**-**	**Time of impact**
u	**-**	**Initial Velocity**
v	**-**	**Final Velocity**
x	**-**	**Chassis weight**

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LIST OF APPENDICES

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

The Formula SAE competitions is an annual event that attracts many teams from universities all over the world. It is a good platform for the undergraduate and graduate students to conceive, fabricate, develop and compete with their designed formula style vehicles. Formula SAE is a competition that strongly related to engineering education as the required performance demonstration of vehicles is the core of events. Each teams given the chance to fabricate their vehicle with creativity and engineering skills as they followed the technical requirement and FSAE rule. A high performance and durable vehicle is the key to successfully complete all the events at the Formula SAE competitions because each design will be judged and evaluated against other competing designs in a series of Static and Dynamic events. The progress of the teams to build their formula car can be assumed that they are actually work for an engineering company that focus on designing, fabricating, testing and demonstrating of vehicle. It will be a great and only chance for the student's career (Rules, 2019).

There is always a rule and regulation that every team must obeyed. The functional requirement or the criteria of the equipment must be fulfilled to ensure the safety of the driver. Tough the requirement is achieved but sometime the accident can still be happened due to some factors such as track condition, driver experience and healthy status and weather. Based on the result of Formula Student East 2017, it shows that some team had failed the dynamic event due to the accident or malfunction of the formula car (Stuttgart *et al.*, 2017). From internet resources,

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the accidents especially frontal collision had happened at the past five year events. Besides that, the side impact velocities in rally racing are sometime more dangerous than in most crash (Njuguna, 2011). Although the driver was unharmed and no any death case is recorded yet but it is frustrated as the whole team have spent their time and money on the project, just for it to be damaged on the day.

Hence, to reduce the damage from the accident, it is important to improve the structural crashworthiness of the racing car. The crashworthiness refers to the ability of vehicle on the energy absorption if a collision occurs (Wang *et al.*, 2016). The impact test of the vehicle has been important in designing and testing for the manufacturing of vehicle. Crash test dummies are one of the engineering measuring devices that used to predict the severity of potential real-world injuries to the driver and passenger during an impact. With nowadays technologies, some drawing software are improved and able to do impact test in car simulation such as CATIA and SolidWorks that can perform Finite Element Analysis (FEA) (Outline, 2016). This helped to save the budget in testing of vehicle by simulating the crash scenarios using such software. The data analyzed is also reliable as the structural frame of the vehicle and its material used is same as the one to manufacture.

1.2 Problem Statement

Formula SAE is a favor event among the university all over the world. This event has created a great chance for the students to form a team and built their racing car based on original design. They are coming to the competition with confident as the car is well established, well prepared, and safe through the event. But there are some factors that is unpredictable like weather, road condition and driver status. These factors may lead to an accident that happen during the race and injured the car driver, other racer and the audience. With such a high speed

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acts on the racing car, some common crashes may happen. For example, frontal impact can occur when the racing car is losing control and directly collide with an obstacle or another vehicle. Side impact may occur when the car is sliding, it may hit randomly with an obstacle or another vehicle. Hence, the space frame chassis of the racing car plays an important role to maximize the protection. The common types of crashes such as frontal impact and side impact must be simulated for the space frame design to make analysis and obtain the data and result. By comparing the simulated result with the result that tested with current design, we are able to improve and design a space frame for racing car based on the impact test studied and tends to provide better and safer protection to the driver.

1.3 Objectives

- To design a space frame that provide better protection when the impact happens.
- To analyze the impact test result that can be used to compare with the existed impact test result tested using the designed space frame.

1.4 Scopes

- Design a space frame for formula racing car according to product design specification using the design software, CATIA V5R19.
- Use the CATIA V5R19 to do Finite element analysis (FEA) for car simulation

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1.5 Gantt Chart

Task	Academic Week of Semester															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Introduction																
Selection of PSM Title																
Identify the Scope and Objective of the Project																
Review of Problem Statement																
Literature Review																
Explore the Information, Journals and Reference Book																
Implement Literature Review																
Conceptual Design																
Product Design Specification																
Morphological Chart																
Concept Generation																
Concept Selection																
Submit of Report																
Seminar																

Figure 1.1: Gantt chart PSM I

Task	Academic Week of Semester															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Detail Design																
Software Drawing																
Finalize the Design																
Data Analysis																
Performing FEA Simulation with Different Speed																
Result and Discussion																
Dynamic Crash Result																
Deformation																
Conclusion																
Recommendation																
Submit of Report																
Seminar																

Figure 1.2: Gantt chart PSM II

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1.6 Methodology view

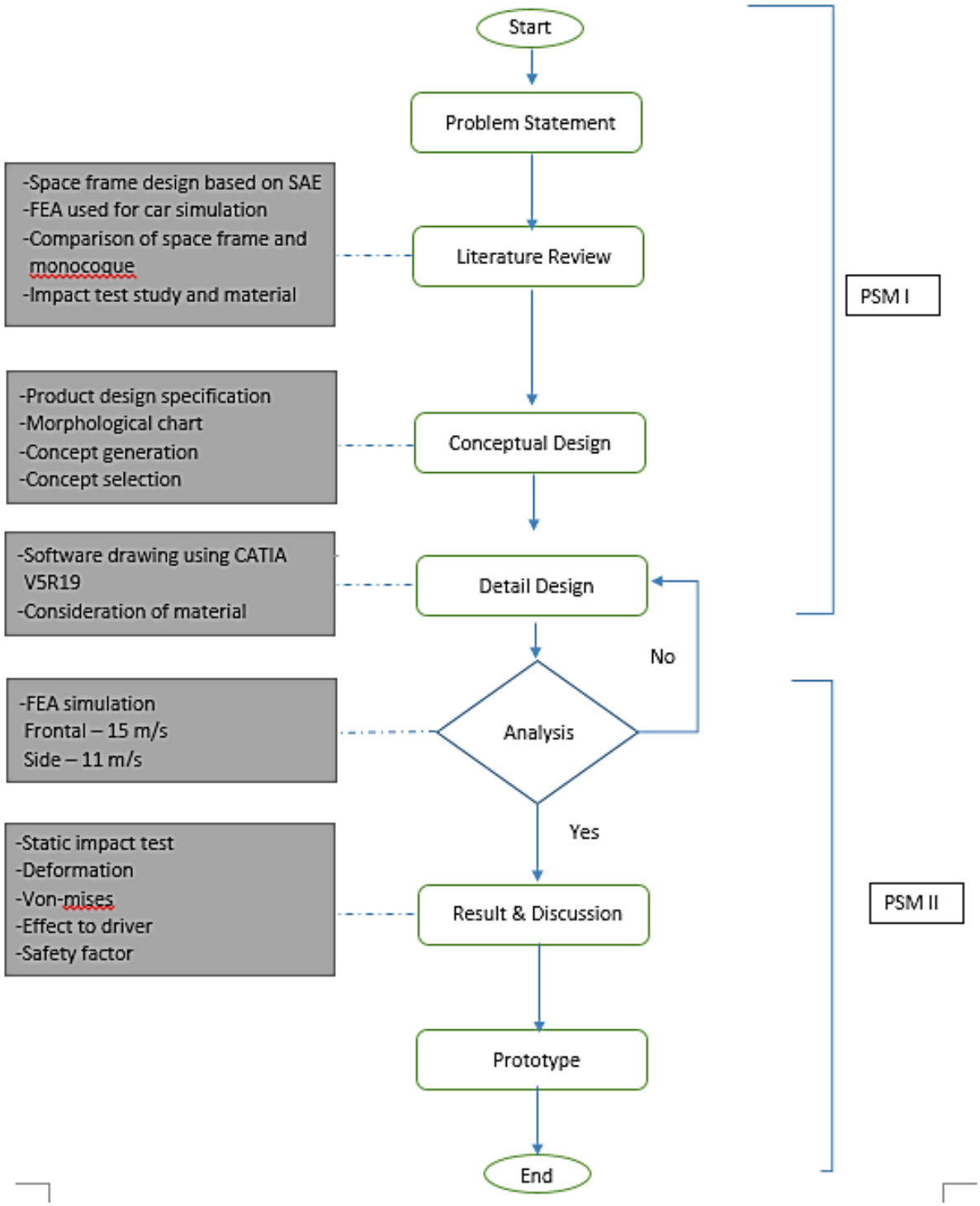

Figure 1.3: General methodology flow chart

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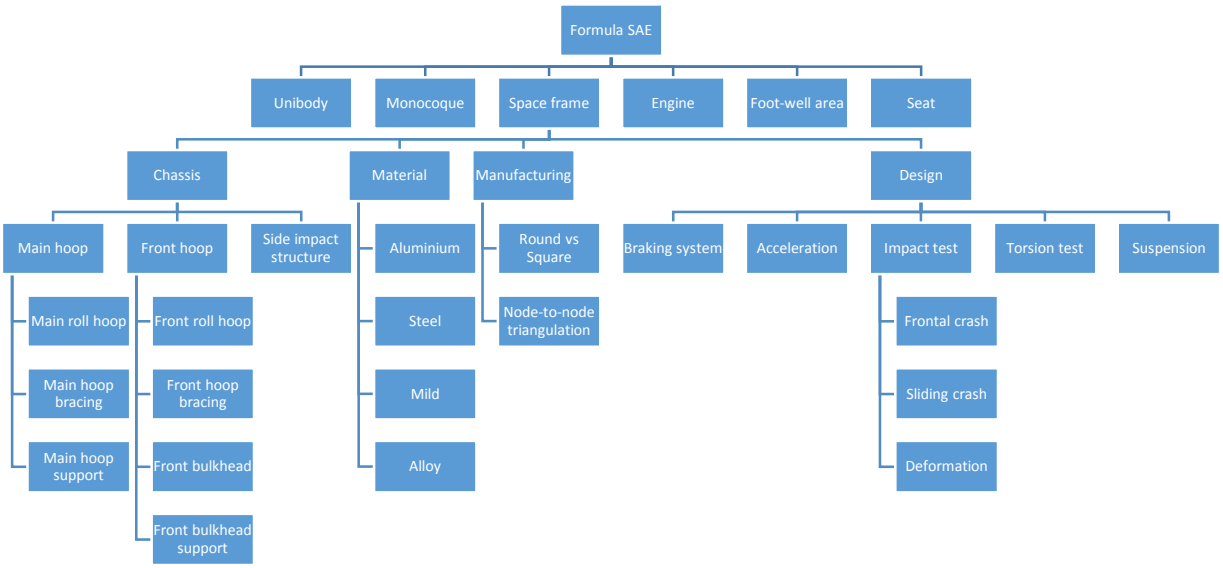

Figure 1.4: Formula SAE components

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, the data and results from the past research, experiment and reports in the form of journal will be used as a reference. All the content used and referred from the journals is related to the research on chassis, formula racing car design, structural design and analysis in Finite Element Analysis (FEA). Since the chassis is normally used for a competition, there must be standard for the dimensions and components to be followed based on the FSAE rules and regulation that updated every year (Regulations *et al.*, 2018), (Rules, 2019).Only the racing car that meets with the requirements is allowed to compete in the event.

2.2 Chassis

Chassis is the structural assembly of a system while also can be defined as the framework of a vehicle where the other components like engine and suspension mounted onto it. It can be a single fabricated structure, multiple fabricated structures or a combination of composite and welded structures. There are three different types of chassis frames are commonly used in automobile manufacturing nowadays, ladder chassis, back bone chassis and monocoque chassis (Y and S, 2013). Generally, there are two types of chassis used for the Formula SAE competition which are monocoque and space frame member (Rules, 2019). A well-designed chassis is capable to carry the total load that acted on the racing car and able to withstand the forces and

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