Faculty of Manufacturing Engineering

DESIGN IMPROVEMENT OF A RACE CAR CHASSIS FOR EDUCATIONAL INNOVATION IN MOTORSPORT AND AUTOMOTIVE RACING (EIMARace) EVENT

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DEDICATION

To my wife, Norfathiah binti Abd. Aziz, my beloved parents Mohd. Wazir bin Abdul Wahab and Dayang Fatimah binti Abang Aying and last but not least to my beloved daughters Nazea Farzana binti Mohd. Firdaus and Marissa Fayqa binti Mohd. Firdaus.

ABSTRACT

This study discusses the process of designing a racing frame for the 250cc race for the Educational Innovation in Motorsport and Automotive Racing (EIMARace) competition from Muadzam Shah Polytechnic. This design concept is designed to meet the EIMARace competition specifications and is a concept that has been improved from the previous design. Where the previous designs did not undergo engineering requirement process and were designed regardless of race comparison and suitability where the 250cc chassis was first designed by Muadzam Shah Polytechnic (PMS). This design and analysis of the chassis were using the CATIA V5 and ANSYS Software to design and analysis. As a result of the first chassis product, ZP Super I, there are several aspects to be taken into account to improve design and engineering features such as frame weight, main frame material size, bending load, load and shear load that can be improved to obtain racing results better. From the results of the analysis for the first frame, ZP super I and ZP Super super II, shows the weight loss, pressure. While the latest designs are designed to improve the weaknesses and the engineering design process can be applied and used so that refinement and suggestion improvements can be improved on the latest design model. Referring to the findings of the analysis, the new model certainly shows the weight enhancement, and engineering features over the ZP Super I & II model.

ABSTRAK

Kajian ini membincangkan tentang proses rekabentuk kerangka utama kereta lumba bagi 250cc untuk pertandingan Educational Innovation in Motorsport and Automotive Racing (EIMARace) daripada Politeknik Muadzam Shah. Konsep rekabentuk ini direka untuk memenuhi spesifikasi kejohanan EIMARace dan merupakan konsep yang telah ditambah baik daripada reakbentuk terdahulu. Di mana rekabentuk terdahulu tidak menjalani proses rekabetuk kejuruteraan dan direka bentuk tanpa mengambil kira perbandingan dan kesesuaian perlumbaan di mana kerangka 250cc adalah pertama kali direkabentuk oleh pasukana Politeknik Muadzam Shah (PMS). Hasil daripada produk rangka pertama, ZP Super I, terdapat beberapa aspek yang diambil kira untuk menambah baik rekaan dan ciri-ciri kejuruteraan seperti berat rangka, saiz bahan kerangka utama, beban lentur, beban kalis dan beban ricih yang boleh ditambahbaik bagi mendapatkan keputusan perlumbaan yang lebih baik. Bagi projek ini, rekabentuk dan Analisa yang dibuat menggunakan perisian CATIA V5 dan ANSYS sebagai medium rekabentuk dan Analisa. Daripada keputusan analisa bagi kerangka pertama, ZP super I dan ZP Super super II, menunjukkan penambaikan dari segi berat, tekanan. Manakala rekabentuk terbaru diwujudkan untuk memperbaiki kelemahan dan proses rekabentuk kejuruteraan dapat diaplikasikan dan digunapakai agar penialian dan cadangan penambaikkan dapat diperbaiki pada model rekabentuk terbaru. Merujuk kepada dapatan hasil analisa, model baru sememangnya menunjukkan penambaikkan dari berat, dan ciri-ciri kejuruteraan berbanding model ZP Super I & II.

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Special thanks to beloved wife, my parents and my siblings for their moral support in completing this Master of Manufacturing Engineering. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Chassis is the French word was utilized to represent the outline parts or fundamental structure of vehicle, out of these, the frame provides necessary support to the vehicle components placed on it. Chassis is one of the main key structural members of a vehicle. Every chassis design is a compromise between weight, size, performance requirements like torsional stiffness, bending stiffness. Chassis structure being one of the heavier components of an automobile has always attracted attention of the designers looking for potential weight savings. A vehicle chassis is outlined to carry the payload, weights of other auxiliary components mounted on it and instantaneous loads like large pot-holes, kerb bumps, large umps, panic braking, high 'g' cornering and high-power train torque.

The chassis has to withstand and give adequate performance under all these load conditions. They are four types of chassis Frame Ladder Chassis, Tabular Space Frame, Monocoque and Backbone. In Chassis it is possible to perform different analysis like finite element analysis, static and dynamic analysis, truss, torsional and vibration. The safety of the driver is achieved either by using high strength against the applied load. The EIMARace organization annual restricts the vehicle weight, shape, size, and dimension in their rule and regulation.

The finite element is a powerful technique for the numerical solution of wide range of engineering problems. In FEM behavior of structure is obtained by analyzing the collective behavior elements. In order to build a successful vehicles structure, we must first look at its most fundamental components, the chassis. Analysis will carry out for different possible loading conditions. This objective to make the product robust to all possible load case.

Tubular space outlines chassis utilizes dozens of circular-section tubes (some may use square section tubes for easier connection to the body panels though circular section provides the maximum strength), position in different directions to provide mechanical strength against forces from anywhere. These tubes are welded together and form a complex structure.

1.2 Problem Statement

EIMARace is an institutional program open to the Institute for Higher Learning, Private Higher Education Institutes, Colleges, Polytechnics, & Technical Institutions that highlight education through motor sports. EIMARace is a medium platform for students to apply the theory they learn and to improve their skills in the automotive field especially.

Through this challenge, educational institution will create a racing car prototype as per rules and regulation stated. This challenge will inspire students to learn about engineering automotive such as physics, aerodynamics, designs, manufacturing, branding, graphics, sponsorships, marketing, leadership, teamwork, media skills and also financial strategies, and implement practical, imaginative, and competitive ways in an engaging way. Then they can be realizing the ultimate goal of exposure to motor sports in Malaysia.

Polytechnic Muadzam Shah has participated in EIMArace competition in 2015 and 2016 that have been held in Kuantan, Pahang. In this event Polytechnic Muadzam Shah have been participated in the 250cc category. The race car named as ZP Super 1 in 2015 and ZP Super II in 2016. As a competition result, ZP Super 1's Polytechnic Muadzam Shah, has finished at number 7 out of 9 teams in the 2015 race. Meanwhile, ZP Super II has finished in 4th out of 9 team in time trial, then the race event in 2016 has been cancel due to the fatal incident.

From previous study on the ZP Super 1, there have opportunities to improve in term of weight reduction and the stiffness of the chassis to achieve a better result in fabrication the ZP Super II for EIMARace 2016. Then ,in 2016 there still have a lots of area to improve from the existing race car model in term of engineering properties and chassis structure with the proper design and analysis method for archive optimum result and better factor of safety.

In this project, will focus on design improvement for the both existing model and at the end of the project, the propose chassis design will have showed. In the existing ZP Super I & II car chassis, the chassis is too heavy due to the design structure and many unimportant structures also cause in increasing the weight. Second problem is the engine bay and cockpit is too narrow causing problem when installing engine and the narrow cockpit affecting the driver's comforts. The existing design also is inappropriate due to loads that are not properly distributed along the chassis.

Knowing the value of displacement and von misses obtained by using analyze FEA using hyperwork that would help to determine the better design improvement for the propose chassis. The result is significantly important in knowing the bending, shear and torsional improvement for the chassis able to withstand with the maximum load that have been applied which is why it use as the main respond in the study.

Figure 1.1: ZP Super I and ZP Super II

1.3 Objectives

For future research development in the idea of comparisons between ZP Super 1 and ZP Super II are finding the best design improvement in order to achieve the better result. Therefore, in order to achieve this aim, the objectives of this study are:

i. To design a 250cc race car for Polytechnic Muadzam Shah for incoming EIMARace with particular focus on the improvement on weight reduction and frame stiffness from the previous 250cc race car ZP Super I and ZP Super II.

ii. To analyze and evaluate the result using Finite Elements Analysis (FEA) to the chassis of ZP Super I and ZP Super II by utilizing the Ansys Software and comparing to the new propose design.

iii. To propose the new design that have been improve in term of weight reduction, mechanical properties and stiffness.

1.4 Scope of study

The design and improvement of a chassis for an EIMARace car must contain all necessary requirement components to support the car and the driver. It must comply with the 250 cc EIMARace Regulation rules. In order to produce a competitive vehicle with optimum chassis performance, many areas need to be studied and tested to meet the regulation given. The material would be followed the regulation which is the main frame must build from ferrous metal as the basic material. Specifically, the existing ZP Super I & II use the AISI 1040 (mild steel C40).

The analysis of the static structural analysis of the chassis cannot fail as in stated in the requirement of EIMARace regulation. So, when designing a chassis, the working stresses should be well clear of the yield strength to avoid deformation of the chassis. If the normal stress of a tension member exceeds the tensile strength of the material, a failure of the member will be occurred. As a rule, usually the tensile strength of the material is extremely high and should even be well above the stresses come into collision.

A copy of 250 cc EIMARace Regulation is presented in Appendix A.

1.5 Importance of Study

The important of this study is it would contribute to the Polytechnic Muadzam Shah, to obtain the data from the existing ZP Super I & ZP Super II race car for future research development for improvement. The significant of this study will reduce the use of high cost of money to spend in fabricate the new propose chassis, at the same time it will improve in the design process and engineering characteristic of the chassis for incoming racing event.

1.6 Research Activity

Research activity or planning cited in Gantt chart

Table 1.1: Project Gantt Chart

TASK	WEEK														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Execute Project plan															
Collecting Data for Existing Design															
Construct Design Planning process															
Construct Analysis Planning method using FEA															
Report Writing															
Submit Draft Project															
Project Report Submission, Presentation															

CHAPTER 2

LITERATURE REVIEW

In this chapter, a literature reviews are made to have a better understanding about the project. The purpose of this chapter is to give general information and create an idea about the project. This is the early step to begin he project. It begins with a briefing about formula student racing car and chassis system.

2.1 Introduction of Chassis system

Chassis is the supporting member for all the load operator, engine, brake system, fuel system and steering mechanism thus should have adequate strength to protect the driver in the event of an impact. They are four types of chassis Frame Ladder Chassis, Tabular Space Frame, Monocoque and Backbone. The material is selected according to their cost and properties required for the vehicle, the car is influential by the car weight such as carbon fiber which is light in weight. (M. Chandrasekar,2016)

The chassis are classified as:

i. **Conventional control chassis**: In these types of chassis engine is mounted in front of driver's cabin.

ii. **Semi-forward control chassis**: in these types of chassis the half engine is mounted inside the driver's cabin and other half outside driver's cabin

iii. **Full forward control chassis**: in these types of the chassis the engine is mounted completely inside driver's cabin

After second world war the major development of the chassis took place. the chassis of high complex structure and different material were developed.

Because the chassis is a one-piece rigid structure, it is unable to be adjusted for different track conditions. Therefore, all component adjustments have to be made to suit the chassis. In a professional racing teams, an adjustable anti-roll bars can be used to provide some adjustment in the racing car chassis. But, in different conditions of chassis design it required special modification which can only be applied to larger chassis. (L. D. Metz 1998)

The best position for the central gravity (CG) is to be as low as possible to the ground while central along lateral and longitudinal axes. The CG determines the wheel loads which then effects wheel traction, breaking and cornering ability. The CG can be determined in chassis design specification, by using the setup location of each of the major components. The major components are engine, driver's seat, fuel and oil tanks. (N.R.Patil, 2014) In many racing categories the vehicle must comply to a specified weight. In other word, the vehicle chassis should be make the race car underweight and use ballast to meet the requirement. This ballast can then be positioned in the car to assist in tuning for varying track conditions in race situation.

2.2 Spaceframe Technology

Spaceframes have been extensively researched in the past few years. Spaceframes technology different in style of vehicle type. If different spaceframe it requires different characteristics to design. So, it making the chassis requirements also differ for each type of vehicle such as structure, weight and geometric pattern. Spaceframe materials and fabrication techniques are generally universal across race vehicle segments and categories.