DESIGN AND ANALYSIS OF CHASSIS FRAME FOR EDUCATIONAL RACING VEHICLE

AHMAD AFIFI BIN MOHD NOOR

This report is submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Automotive)

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DECLARATION

I declare that this project report entitled “Design And Analysis Of Chassis Frame For Educational Racing Vehicle” is the result of my own work except as cited in the references

Signature : .....

Name : AHMAD AFIFI BIN MOHD NOOR

Date : .....

SUPERVISOR'S DECLARATION

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 (Automotive).

Signature : .....

Name of Supervisor : DR. FUDHAIL BIN ABDUL MUNIR

Date : .....

DEDICATION

To my beloved mother Rohana Binti Mat Yusoff and
my father Mohd Noor Bin Haron.

ACKNOWLEDGEMENT

In this great opportunity, I would like to thank Allah S.W.T for giving me strength and good health to finish up this final year project. I would like to express my gratitude to all those who gave me the possibility to complete this project.

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ABSRACT

Chassis frame is one of the important part for every vehicle. To build an educational racing vehicle, it is started with designing and analysing the chassis frame. Therefore, this project was carried out to design and analyse a chassis frame for educational racing vehicle. It is desirable for a racing car to be light in weight. The reduction in terms of weight allows the maximum speed of the vehicle to be improved. The designing and analysing the chassis frame were conducted in this project to obtain a simple design with lighter chassis frame but strength enough for the safety of the driver. The chassis frame is designed with the aid of CATIA V5 software. For the analysis work, ANSYS-Mechanical module software was utilized to conduct analysis of the chassis frame. Different types of materials are chosen for the chassis frame in order to get a lightweight and strong chassis frame structure. The bending and torsional stiffness value is determined to know the stiffness of this chassis. The chassis was later analysed for its structural performance using Finite Element Analysis method (FEA) to determine the critical path and to predict any possible failure effect on the part. From the analysis, the value of bending stiffness, torsional stiffness, total deformation and also Von Mises stress for the chassis frame will gathered for choosing the chassis design.

ABSTRAK

Kerangka casis adalah salah satu bahagian yang penting bagi setiap kenderaan. Untuk membina sebuah kenderaan lumba pendidikan, ianya bermula dengan mereka bentuk dan menganalisis rangka casis. Oleh itu, projek ini telah dijalankan untuk mereka bentuk dan menganalisis rangka casis untuk kenderaan perlumbaan pendidikan. Adalah penting untuk sesebuah kereta lumba memiliki berat casis yang ringan. Pengurangan dari segi berat membolehkan kelajuan maksimum kenderaan diperbaiki. Mereka bentuk dan menganalisis rangka casis telah dijalankan dalam projek ini untuk mendapatkan reka bentuk yang ringkas beserta kerangka casis yang ringan tetapi mempunyai kekuatan yang cukup untuk keselamatan pemandu. Kerangka casis direka dengan bantuan perisian CATIA V5. Untuk kerja-kerja analisis, perisian modul ANSYS mekanikal telah digunakan untuk menjalankan analisis kerangka casis. jenis bahan yang dipilih untuk rangka casis untuk mendapatkan struktur kerangka casis ringan dan kuat. Nilai kekukuhan lenturan dan kilasan ini telah dipilih untuk mengetahui kekukuhan casis ini. casis kemudiannya dianalisis untuk prestasi struktur menggunakan kaedah Finite Element Analysis (FEA) untuk menentukan laluan kritikal dan untuk meramalkan sebarang kemungkinan kesan kegagalan di bahagian. Daripada analisis, nilai kekukuhan lenturan, kekerasan torsi, jumlah ubah bentuk dan juga tekanan Von Mises untuk rangka casis akan berkumpul untuk memilih reka bentuk casis.

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LIST OF ABBREVIATIONS

FSAE	Formula Society of Automotive Engineers
CATIA	Computer Aided Three-dimensional Interactive Application
SAE	Society of Automotive Engineers

LIST OF SYMBOLS

N	Newton
m	Meter
mm	Millimetre
kg	Kilogram
Pa	Pascal
W	Watt
J	Joule
%	Percent
g	Gram

CHAPTER 1

INTRODUCTION

1.1 Background

Spaceframe chassis have been in use since the start of the motor sport event. A spaceframe is consist of steel or aluminium tubular pipes placed in a triangulated format to support the loads from the vehicle caused by; suspension, engine, driver and aerodynamics.

There are two main types of chassis used in race cars, steel spaceframes and composite monocoque. Although spaceframes can be considered as conventional style, they are still very popular today in amateur motorsport. Their popularity maintains because of their simplicity, the only tools required to construct a spaceframe is a saw, measuring device and welder.

The spaceframe still has advantages over a monocoque as it can easily be repaired and inspected for damage after a collision. The chassis must contain the various components required for the race car as the safety of the driver in the cockpit is the major aspect in the design. The design is based on the requirements and regulations set by the FSAE which all the requirements will be references for designing. Due to limited budgets and time constraints the design of the chassis will need to be geared towards simplicity and strength.

1.2 Problem Statement

The design of a chassis for a formula style race car contains all the necessary components to support the car and the driver. It must comply with the Formula Varsity rules and regulation. In order to produce a competitive vehicle with optimum chassis performance, many areas need to be studied and tested.

Weight is the main point that affected the performance of the car. Therefore, the main purpose of this project is to design and develop a lightweight chassis. The new chassis is must be lighter than the past year chassis but must maintain the strength of the chassis when load is applied on it.

Some factors that can affect the weight of a vehicle are the types of material used, the diameter or dimension of tubes use to build space frame chassis, and the design geometry of chassis.

This project was started by performing background research required to sustain an accurate database of design criteria. Design criteria is allowed the design process and methodology to be derived as well as and to allow for smooth construction of an efficient and effective space frame chassis. Once construction of the chassis was completed, analyses were conducted to investigate the effects of working loads on the chassis. Finite element analysis was used to simulate the conditions of various load combinations.

1.3 Project Objectives

The main objectives of this project are to design and analyse a chassis frame for educational racing vehicle. The design chassis must be simple so that it will lighter but strength enough for the safety.

1.4 Scope of the Project

The scopes of this project are:

i. To produce three-dimensional (3-D) design and the detail design of the chassis using CATIA.
ii. To perform the static Finite Element Analysis to the chassis.
iii. To make an analysis and calculate the load acting on chassis during operation.
iv. To select suitable material for the chassis.
v. To evaluate the torsional stiffness for the chassis based on the load analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Chassis

"Chassis" a French term, which is means the complete automobiles without body (N.R.Hema Kumar., 2009). It is a fabricated structural assembly that supports all functional vehicle systems. It includes all the systems related to automobile like engine, transmission, steering, suspension, wheels tyres, auto electric system and braking system which are attached to chassis without body (N.R.Hema Kumar., 2009).

Apart from supporting all the car components, the propose of automotive chassis is to take care of the form of the vehicle and to support the varied loads applied to the chassis that act like the protection as a major aspect. Chassis is the most important component among the many structures of associate automobile. It is fabricated from a steel frame that holds the body of an automotive vehicle. To be exact, the automobile chassis could be a frame that bolts numerous mechanical elements like engine, tires, brakes, steering and shaft assemblies (Chandan, S. N. et al., 2016).

For a normal car, the chassis has to last for a pretty long period of time. Also, the chassis has to designed in a manner to fulfil the passenger comfort when they are driving and as such, various vehicle components have to be mounted in a different manner. However, it is different for the race car chassis structure because the driver comfort will

not be the main focus on the designing. It has to be stiff and lightweight, plus has to be durable enough to last for the entire duration of a race or series of races, which have various of high forces.

The chassis frame in an automobile such as racing car is important as it holds different mechanical parts like engine, tires, axle assemblies, brake, steering, suspension systems, and so on. The chassis also provides flexibility, strength, and stability to the car under many circumstances. Other than that, chassis frame minimizes vibration, noise, and harshness of the vehicle (Shreepathi et. al., 2015).

According to Dardinski and Norcross (n.d.), the chassis of any automobile is the main structure of the vehicle. The chassis is responsible for resisting breaking or deforming excessively under the loads experienced by the car during acceleration, braking, cornering, and combinations thereof. To properly manage these loads, a chassis must be a rigid structure. A chassis must be stiff when in torsion, a twisting force applied on the chassis. Having a chassis that is very high in torsional rigidity, meaning very resistant to flexing when a torsional load is applied, is important to a controllable car (Aird, F.,2008).

As a car travel along the road, the car chassis is excited by forces induced by the road roughness, engine, transmission and more. Under such various forces, the car chassis tends to vibrate. Whenever the natural frequency of vibration of a machine or structure coincides with the frequency of the external excitation, there occurs a phenomenon known as resonance, which leads to excessive deflections and failure. The literature is full of accounts of system failures brought about by resonance and excessive vibration of components and systems.

2.1.1 Passenger Car Chassis

For a passenger car, the main function of the chassis is to support the car components and payload mounted upon it including engine, body, passengers and also luggage. Chassis function's also to maintain the relationship between the suspension and steering mechanism mounting points.

2.1.2 Racing Car Chassis

Generally, a racing car chassis design is not being focus on the comfort of the driver itself. The design of the chassis actually should help the racing car going faster without ignore the safety as the main priority. Racing vehicles are usually required to be as light as possible but must be able to survive the immense forces that could be created in the unlikely event of a crash.

In the present, the highlight for the racing vehicle design is generally considered to be the Formula 1 motor racing series. These cars are built with the highest budgets and can achieve the fastest speeds of up to 220 mph yet are strong and safe enough to survive crashes above speeds of 100 mph (Wright, P., 2001).

Figure 2.1: Example of the Formula 1 race car (Wright, P., 2001).

2.1.3 Educational Racing Vehicle

For an educational racing vehicle, the chassis design often is single seater chassis. It is actually based on the regulation for the chassis specifications. The educational racing vehicle normally design and fabricate focus on to has lightweight and strong chassis structural.

Among the well-known university level, the race car competitions are Formula SAE, organised by the Society of Automotive Engineers and Formula Student, organised by the Institute of Mechanical Engineers UK. Locally, the competitions like Formula Varsity and EIMA RACE usually organised by a university and supported by Malaysian car manufacturers, i.e. PROTON and PERODUA. The structure of the chassis specifications is based on regulation of UniMAP-MODENAS Racing Challenge specification which only

allowed the participant to construct a space frame race car platform (Marzuki, M., et al, 2015).

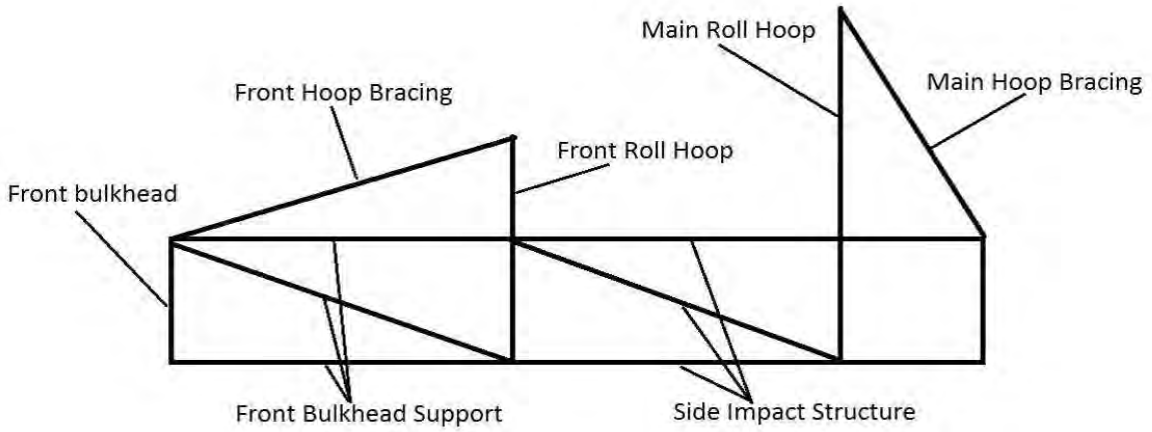

Figure 2.2: Drawing representation of the members required by the FSAE rules (Lavanya, D., 2014).

2.2 Role of Chassis in Automotive

Every vehicle body include of two parts chassis and bodywork or superstructure. The chassis is the framework of any vehicle that are manufacture. Its function is to safely carry the maximum load for all designed operating conditions. It also has to absorb engine and driveline torque, endure shock loading and accommodate twisting on uneven road surfaces. The chassis receives the reaction forces of the wheels during acceleration and braking and absorbs aerodynamic wind forces and road shocks through the suspension. So, the chassis should be engineered and built to maximize payload capability and to provide versatility, durability as well as adequate performance. To achieve a satisfactory performance, the construction of a heavy vehicle chassis is the result of careful design and rigorous testing.

It should be noted that the ‘ladder’ type of frame construction is designed to offer good downward support for the body and payload and at the same time provide torsional

flexibility, mainly in the region between the gearbox cross member and the cross member ahead of the rear suspension. This chassis flexing is necessary because a rigid frame is more likely to fail than a flexible one that can 'weave' when the vehicle is exposed to arduous conditions. A torsional flexible frame also has the advantage of decreasing the suspension loading when the vehicle is on uneven surfaces.

The chassis which made by pressed steel members can be considered structurally as grillages. It acts as a skeleton on which, the engine, wheels, axle assemblies, brakes, suspensions etc. are mounted. The frame and cross members form an important part of the chassis. The frame supports the cab, engine transmission, axles and various other components. Cross members are also used for vehicle component mounting, and protecting the wires and tubing that are routed from one side of the vehicle to the other. The cross members control axial rotation and longitudinal motion of the main frame, and reduce torsion stress transmitted from one rail to the other.

2.3 Type of Chassis Frame

There are many different styles of frames that being used for race car frames, for example space frame, monocoque, and ladder. Space frame chassis will be more focused because this type of chassis is typically used on educational racing cars based on the FSAE specification.

2.3.1 Space Frame Chassis

Space Frame chassis consist of combination of metal tubes, usually steel, that is joined together by welding work to form the whole chassis (Dardinski and Norcross, n.d.). This type of chassis may consist of various shapes of metal combination according to the desired design. Dardinski and Norcross (n.d) also stated that this kind of chassis apply the "triangulation" method which strong triangles are created in the Space Frame structure. Figure 2.3 shows the concept of the "triangulation" method.