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FINITE ELEMENT ANALYSIS OF GO-KART CHASSIS

Mohamad Azri Haziq Mohd Jafri, Shahrul Hisyam Marwan, Muhammad Khairudin Mohd Lazim, Nurul Damia Mohd Anuar

Faculty of Mechanical Engineering, Universiti Teknologi MARA, Kampus Bukit Besi
23200 Dungun, Terengganu, MALAYSIA

Corresponding author email: shahrulhisyam@tganu.uitm.edu.my

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Abstract

This paper aims to model, simulate and perform the static analysis of a go-kart chassis consisting of circular beams. Modelling, simulations and analysis are performed using modelling software i.e. SolidWorks for Go Kart Challenges 2017 (GKC-17). The maximum stress and displacement is determined by performing static analysis. The result of maximum stress is compared to maximum yield strength of maximum stress whether the maximum stress is exceeding the maximum yield strength or not. It can also show the displacement where it shows the deformation of the chassis part when the load applied to the chassis.

Keywords: chassis; Go kart; FEA; SolidWorks

1.0 INTRODUCTION / BACKGROUND OF THE STUDY

The structure of chassis consists of the tubing thickness and various cross section tubes which to protect the driver and to support the various vehicle components (Thakare et al., 2016). Most important parts on the go-kart is chassis, it is like the human skeleton where it holds all the parts together. Without it, the go-kart will not complete and will not moving. In order to choose the chassis design, every aspect of the mechanical element must be considered. The inspiration behind this design came from various types of chassis frame, body kit and seat. Thus, it only makes sense that there should be a way to create any type of chassis frame to support the go kart so that the go kart can move freely without any problem and the aesthetics and functionality were bring by the seat and body kit to attract the customers.

Two type of load acting on chassis that are external and internal load. The external loads come from the wheel-ground interface, moving through the suspension mechanism and its elastic elements, and from the aerodynamic field around the car body and the internal load are caused by the mass of the vehicle and payloads (such as driver and engine). The reaction forces of the powertrain suspension produce significant internal loads. The chassis takes a load of the operator, engine, brake system, fuel system and steering mechanism (Machado et al., 2015).

The chassis should have adequate strength to protect the operator in the event of an impact. The driver cabin must have the all the capacity to resist the forces that has been exerted upon it. This can be achieved by either using high strength material or better cross sections against the applied load. However, the most feasible way to balance the dry mass of chassis with the optimum number of longitudinal and lateral members. The chassis is constructed of steel tubing with minimum dimensional and strength requirements. Circular cross-section is used for the chassis development as it helps to overcome difficulties as increment in dimension, rise in the overall weight and decrease in performance due to reduction in acceleration (Abhishek, Pradeep & Apoorv, 2016).

Circular section is always a preferred over other cross section become it resist the twisting effects. Circular section is selected for torsional rigidity. Design objectives of chassis are divide into four category which are the first one is provide full protection of the driver, by obtaining required strength and torsional rigidity, while reducing weight through diligent tubing selection. The round cross sectional tube also has greater energy absorption than the square cross section tube. This higher energy absorption will absorb more energy when the go-cart crash and it will be safer for the consumer. Crush force efficiencies (CFE) result also higher for round cross sectional tube rather than the square cross sectional tube and its makes the round cross sectional tube is more efficient (Jin, Shun & William, 2007).

To compare between round, square and ellipse cross sectional shape for energy absorption per weight of steel tube, the ellipse shape tube is lower in energy absorption per weight compare to other shape makes it not suitable for go kart chassis as it will increase weight and cost to build the chassis. Therefore, the round cross sectional tube is the best material to use in this design (Jin, Shun, & William, 2007). Next is design for manufacturability, as well as cost reduction, to ensure both material and manufacturing costs are competitive with other Go Karts. After that is to improve driver comfort by providing more lateral space in the driver compartment. Lastly is to maintain ease of serviceability by ensuring that chassis members do not interfere with other subsystems. This study attempted to analyse stress on the chassis design using finite element analysis. This is important because the simulation data are useful for further design improvement and subsequently leads to cost effectiveness.

2.0 METHODOLOGY

2.1 Material Selection

The chassis is made up of AISI-1018 (mild steel).This material was selected due to great weld ability, toughness, high strength, ductile and ease of machining (Padhi, 2016). The properties of the material presented in Table 1.

Table 1 Mechanical Properties

Mechanical Properties	Value
Modulus of elasticity (GPa)	200
Density (Kg/m^3)	7850
Poisson ratio	0.29

2.2 Modelling

3-D modelling is constructed using SolidWorks software as shown in Figure 1. The purpose is to show the early design in a visual presentation as the actual product need to be understood first. The idea of the design need to be expressed in the form of technical drawing. The design need to have functionality and aesthetically pleasure to the eyes of the customers. Without the function, the design is useless. Simple is better when designing go-kart to ease the work when manufacture the chassis.

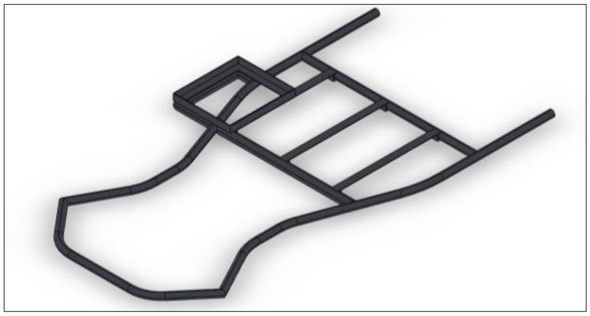

Figure 1 CAD model of chassis

2.3 Finite element analysis

Structure of the chassis need to be high strength and can withstand the forces applied to it to ensure the safety when operate the go-kart. Performing static analysis is essential to make sure the chassis met the requirements. Static analysis is done using finite element method, as it is an effective and efficient approach. SolidWorks simulation software is used for finite element analysis.

2.4 Meshing

In order to make sure the result of the chassis is constant every time the chassis is mesh, the meshing is done by standard mesh setting and automatic transition parameters in SolidWorks simulation as shown in Figure 2.

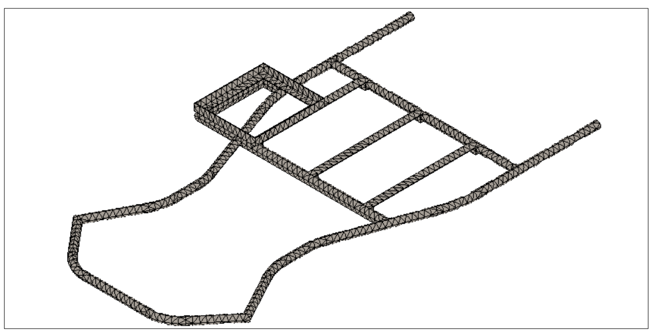

Figure 2 Meshing of Chassis

2.5 Boundary conditions

Four area of fixed points were selected for boundary condition, it indicates where the front and rear axle will be placed as shown on the Figure 3.

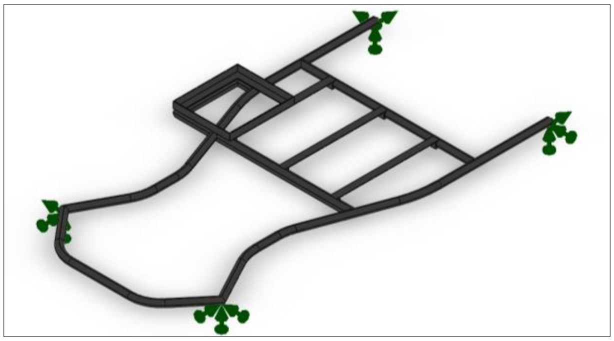

Figure 3 Boundary conditions

2.6 Loading

Figure 4 indicates the forces applied by the drivers load for average male weight in Malaysia (Azmi et al., 2009). The average weight of male Malaysian is 67 kg. In this paper, male average weight was used because compare to female average weight at 59 kg, higher weight need to consider for the strength study of a chassis to ensure its safety. When getting the result, if it safe for 67 kg person, it will be surely safe for the lower weight person to operate the go kart, that is why the male Malaysian weight is used for the study. Figure 5 indicate the load applied at the engine mounting cause by the engine weight at 30 kg.

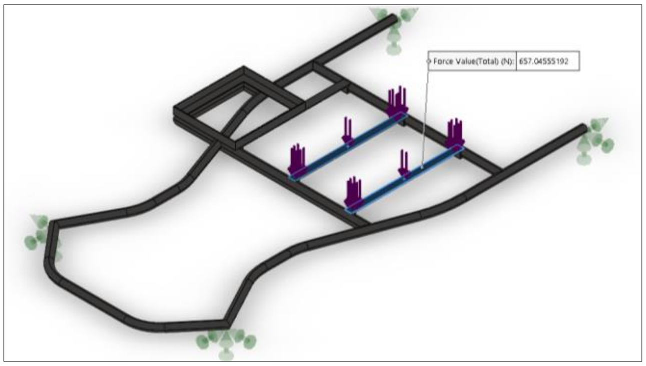

Figure 4 Driver Load

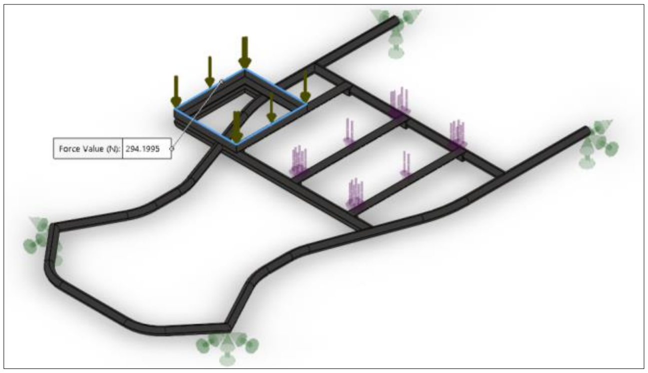

Figure 5 Engine Load

3.0 RESULT AND DISCUSSION

From the simulation, the maximum stress result on the chassis is 118.4 MPa. When compare to the material yield strength of 310 MPa (Lienert et al., 2013), it can conclude, the chassis is able to withstand currently applied load due to the maximum stress is not exceed the material yield strength value. It shows the chassis provide high strength criteria. Figure 6 indicates the stress result on the chassis at 1:1 deformation scale.

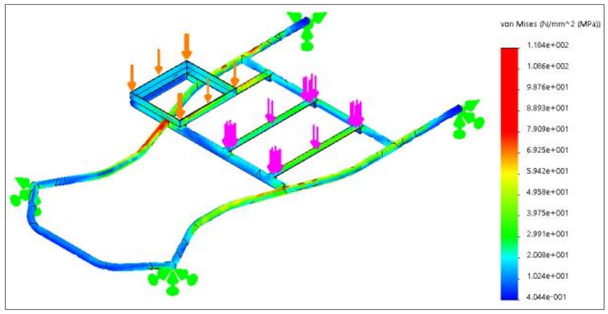

Figure 6 Stress result

The simulation results of displacement occur on the chassis where the middle area will have a lot of displacement compare to other area. The fixed point and location of load is the cause the chassis to bend in the middle. From the result, the maximum displacement using 1:1 scale deformation is 6.904 mm and it can be considered small and did not make large impact to the chassis performance. The use of 1:1 scale deformation is to synchronize it to the real life application when the result will be the around the same as the simulation calculation. Figure 7 shows the displacement of the chassis when load applied.

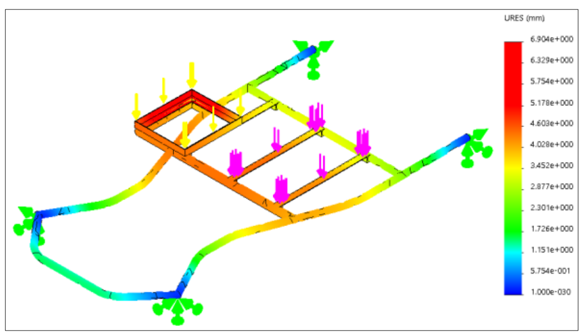

Figure 7 Displacement result

4.0 CONCLUSION AND FUTURE WORKS

Static analysis using finite element method is successfully done to determine the maximum stress and maximum displacement that affect the chassis and where it occurs. The result of stress and displacement indicates that the chassis have a good strength and rigidity to operate safely without compromising the performance of the chassis. By increasing the thickness of the round tube or use the solid round tube, the chassis will be more increase in strength, but it will also increase the weight, cost and harder to manufacture the chassis. The dimension, thickness and size of the rounded hollow tube used for the chassis is already enough to safely operate for the weight of average Malaysian. The minimization of the material and the cost will help to optimize the performance and prevent from use the material as it will be wasted and it will reduce the performance.

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