

Design and Analysis of Go-Kart using Finite Element Method

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Abstract

There are many motor sports in the world. Bikes, Cars are examples of them. But there are also motor sports which do not need professional drivers and need no great speed. This paper explains the designing and fabricating a sound kart having high fuel economy and maximum driver comfort compactness. To achieve the objectives, the rulebook of NKRC 2017 is followed. Design Validation is done by conducting theoretical calculations, simulations and known facts. Analysis are conducted on all major components. The design has been modelled in SOLIDWORKS 2016, the analysis was done in ANSYS 16.0.

Keywords: Go-Kart, Design, Finite Element Analysis, Safe, Optimization

I. INTRODUCTION

Go-kart is a simple four-wheeled, small engine, single seated racing car. It is a four wheeled open car. These are mainly used for recreational purposes and sometimes for racing. These karts are powered by four stroke engines, two stroke engines or electric motors. Most of them are single seated but some recreational models can accommodate a passenger. Professional racing karts normally weigh 70-75kg. They can be used in outdoor track and indoor tracks. Outdoor track karts are low speed karts, used strictly for amusement purposes and a faster, powerful kart for racing which are normally equipped with a 4 stroke engine up to 15 HP. Indoor track karts will have a 4 stroke engine with a low power of about 4 to 13 HP. We did our design consideration by the approach of looking into all the alternatives for a system & modelling them in a CAD software like SODIWORKS and analysing it in ANSYS FEA software. Based on the result given by the analysis software, remodelling and retesting of the design was done and the final design was selected. The design process of the vehicle is iterative and is based on various engineering and reverse engineering processes depending upon the availability, cost and other such factors. The entire kart is designed by keeping in mind that it should be able to withstand the racing conditions without failure. Combining this design methodology with the standard engineering design process enabled us to achieve a perfect match of aesthetics, performance, and ease of operation.

II. OBJECTIVE

The main aim to design a Go-kart using suitable material having better performance than that of standard Go-karts but at lower cost with the results obtained from the FEA analysis.

III. METHODOLOGY

Table - 1
Specifications of Kart

<i>Roll cage</i>	
<i>Weight</i>	<i>22 kg</i>
<i>Material</i>	<i>AISI 1018</i>
<i>Outer Diameter</i>	<i>31.75 mm^{#1}, 25.4 mm^{#2}</i>
<i>Thickness</i>	<i>#2 mm</i>
<i>Engine</i>	
<i>Displacement</i>	<i>124 cc</i>
<i>Max Torque</i>	<i>9.8 Nm</i>
<i>Rated Power</i>	<i>8.6 bhp</i>
<i>Vehicle Dimensions</i>	
<i>Wheelbase</i>	<i>1181 mm</i>
<i>Trackwidth</i>	<i>1112 mm</i>
<i>Overall Length</i>	<i>1880 mm</i>
<i>Overall Width</i>	<i>1473 mm</i>
<i>Ground Clearance</i>	<i>51 mm</i>
<i>Steering</i>	

Type	Pivot Pin Steering System
Turning Radius	2.29 m
<i>Braking</i>	
Type	Rear Hydraulic
Disc diameter	200 mm
<i>Performance Target</i>	
Max. Speed	70 Kmph
Max. Acceleration	3.5 m/s ²
Max. Deceleration	30 m/s ²
Overall weight	100 kg

A. Roll Cage Design

The primary function of roll cage is to protect the driver, give a rigid support for the assembly of sub systems, engine and drive train. The roll cage is designed to meet the technical requirements of competition. The objective of the chassis is to encapsulate all components of the kart, including a driver, efficiently and safely. Proper numbers of members are used in the roll cage to ensure complete driver safety. These include the rear roll hoop, the front and rear bumpers, the side bumper, fire extinguisher, battery cover and firewall as per the specifications in the rule book. The bumpers are so designed that they will serve as protection from front and rear and will also add impressive look to the kart. All the bends are of constant radius. In this design, use variable thickness pipes in order to reduce the weight of chassis. For primary and secondary members, 2 mm thick pipes are used respectively.

Table - 2
Design Parameters

Wheelbase	1181 mm
Front Track Width	1112 mm
Rear Track Width	1371mm
Height	813 mm
Outer Diameter	31.75 mm ^{#1} , 25.4 mm ^{#2}
Thickness	#2 mm
No. of welds	41
Pipe Length	22500 mm

B. Material

The selection of material for chassis is done by detailed study of properties of material regarding strength and cost, results found that three materials AISI 1018, AISI 1020 and AISI 4130. We prefer to use AISI 1018 over AISI 1020, because of its higher yield strength and high strength to weight ratio and over AISI 4130 because of relatively lower cost.

The material AISI-1018 is used in the chassis design because of its good weld ability, relatively soft and strengthens as well as good manufacturability. A good strength material is important in a roll cage because the roll cage needs to absorb as much energy as possible to prevent the roll cage material from fracturing at the time of high impact. AISI- 1018 has chosen for the chassis because it has structural properties that provide a high strength to weight ratio.

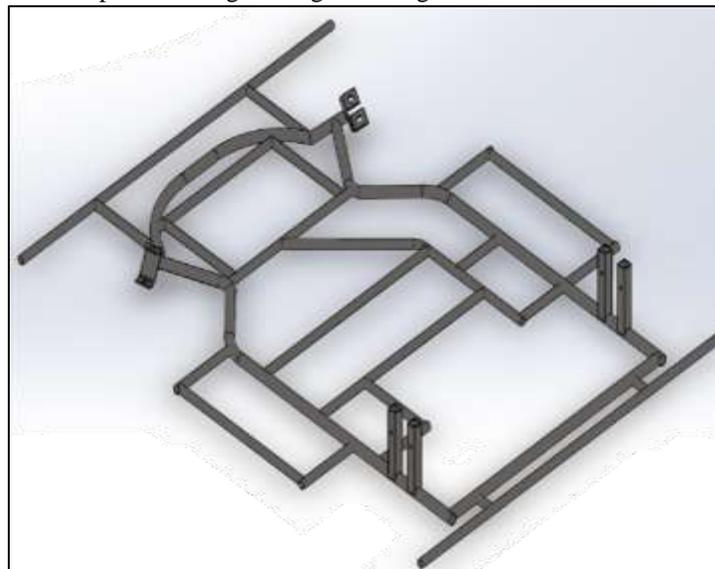


Fig. 1: Chassis CAD Model

Table - 3
Properties of Material

Ultimate Strength	420 MPa
Yield Strength	310 MPa
Density	7870 kg/m ³
Strength to Weight Ratio	60 KN-m/kg
Elongation	15%

The Chemical Composition of Material is:

Carbon C = 0.18 %
Manganese Mn = 0.73 %
Silicon Si = 0.18 %
Sulphur S = 0.017 %
Phosphorus P = 0.020 %
Iron Fe = 98.81 %

C. Welding

The material which is used AISI-1018 has good weld ability. All welds on the vehicle are made using a Electric Arc welding process. Arc welding is the process of joining metal – steel in this case – using electricity. Rather than most other formats, which generally use gas, this process uses electricity to create enough heat to melt the metal and fuse it together during cooling. Works on dirty metal. Processes can be completed during wind or rain, and spatter isn't a major concern.

IV. ANALYSIS

Structural integrity of the frame is verified by comparing the analysis result with the standard values of the material. Analysis was conducted by use of finite element analysis FEA on ANSYS software. To conduct finite element analysis of the chassis an existing design of chassis was uploaded from the computer stresses were calculated by simulating three different induced load cases. The load cases simulated were frontal impact, side impact, and rear impact. The test results showed that the deflection was within the permitted limit.

A. Meshing

Auto meshing has been done in ANSYS 16.0 software. Following data has been found after meshing of chassis –
No. of Nodes = 125008
No. of Elements = 65288

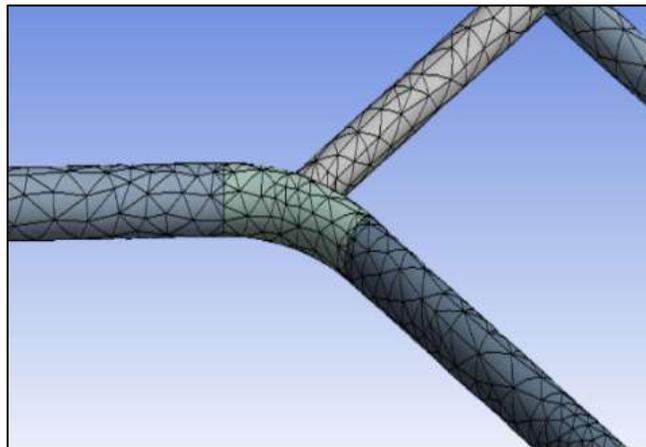


Fig. 2: Auto Meshing in ANSYS 16.0

B. Rear Impact

Considering the worst case collision for rear impact, force is calculated as similar to front impact for speed of 60 kmph. The value of 5g force has been calculated. Load was applied at rear end of the chassis while constraining front end and king pin mounting points. Time of impact considered is 0.2 seconds as per industrial standards.

$$F \times t = m \times (V_i - V_f)$$

$$F \times 0.2 = 160 \times (16.38 - 0)$$

$$F = 13.1 \text{ KN}$$

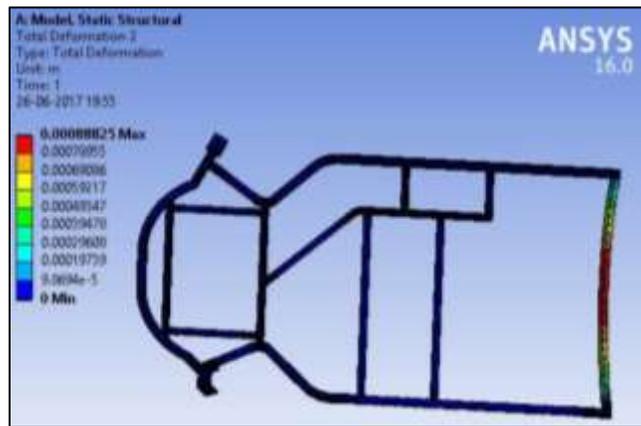


Fig. 3: Deformation

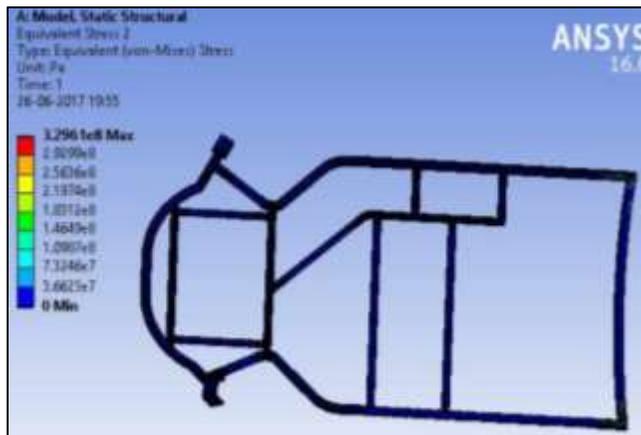


Fig. 4: Equivalent Stresses

Table - 5
Rear Impact

<i>Deformation</i>	<i>0.88 mm</i>
<i>Max. Stress</i>	<i>329.61 MPa</i>
<i>Factor of Safety</i>	<i>1.273</i>

C. Front Impact

For the front impact, engine and driver load was given at respective points. The kingpin mounting points and rear wheels position kept fixed. Front impact was calculated for an optimum speed of 60 kmph. From impulse momentum equation, 5g force has been calculated. The loads were applied only at front end of the chassis because application of forces at one end, while constraining the other, results in a more conservative approach of analysis. Time of impact considered is 0.2 seconds as per industrial standards.

$$F \times t = m \times (V_i - V_f)$$

$$F \times 0.2 = 160 \times (16.38 - 0)$$

$$F = 13.1 \text{ KN}$$

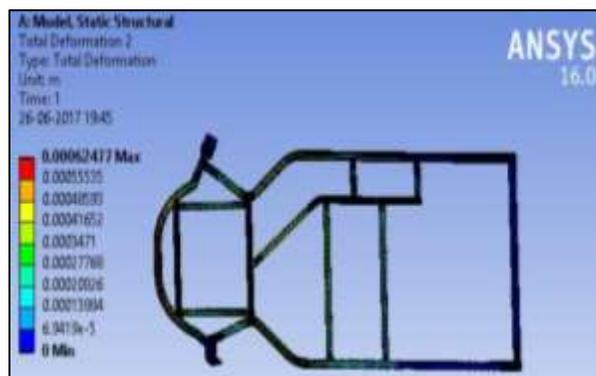


Fig. 5: Deformation

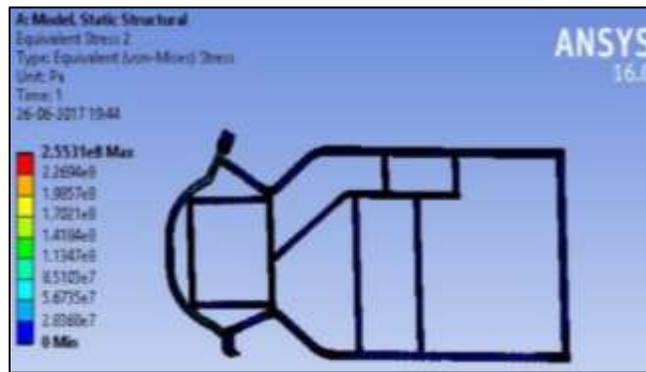


Fig. 6: Equivalent stresses

Table - 4
Frontal Impact

<i>Deformation</i>	<i>0.6 mm</i>
<i>Max. Stress</i>	<i>255.3 MPa</i>
<i>Factor of Safety</i>	<i>1.645</i>

D. Side Impact

The most probable condition of an impact from the side would be with the vehicle already in motion. So it was assumed that neither the vehicle would be a fixed object. For the side impact the velocity of vehicle is taken 30 kmph and time of impact considered is 0.2 seconds as per industrial standards. Impact force was applied by constraining left side of chassis and applying load equivalent to 2.5g force on the right side.

$$F \times t = m \times (V_i - V_f)$$

$$F \times 0.2 = 160 \times (8.19 - 0)$$

$$F = 6.5 \text{ KN}$$

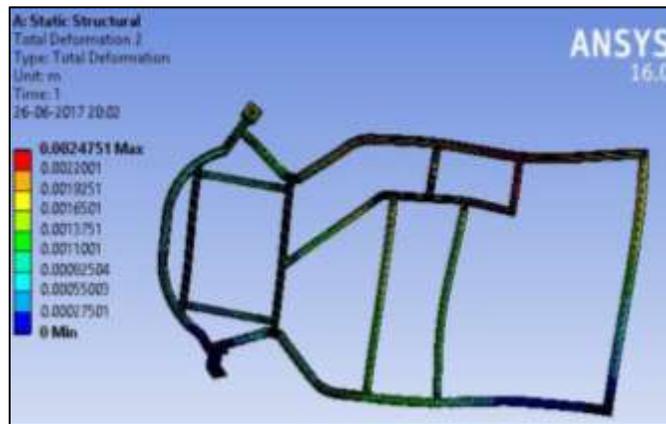


Fig. 7: Deformation

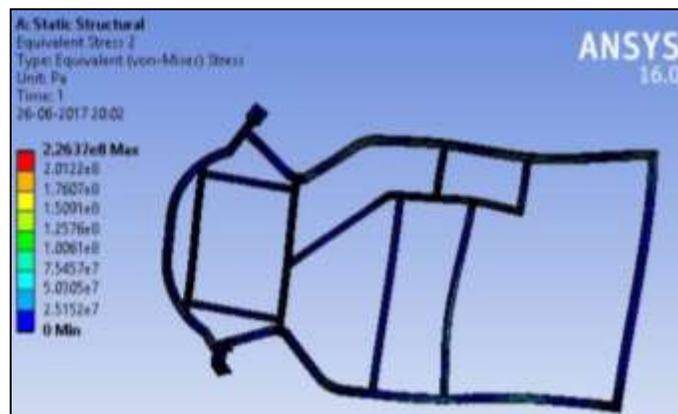


Fig. 8: Equivalent Stresses

Table – 6
Side Impact

Deformation	2.47 mm
Max. Stress	226.3 MPa
Factor of Safety	1.855

E. Modal Analysis

Modal analysis was carried out for chassis and frequency of vibration was found to be less than desired engine frequency. The maximum frequency of chassis vibration is nearly 100 Hz and the results of analysis have been shown below. The minimum frequency of vibration for engine is above 800 Hz. So the resonance will not occur. And thus design is safe.

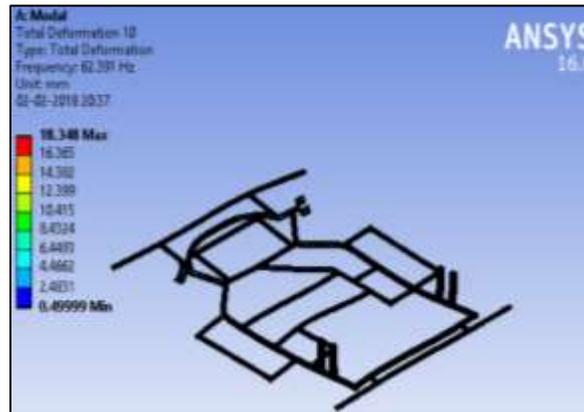


Fig. 9: Modal Analysis

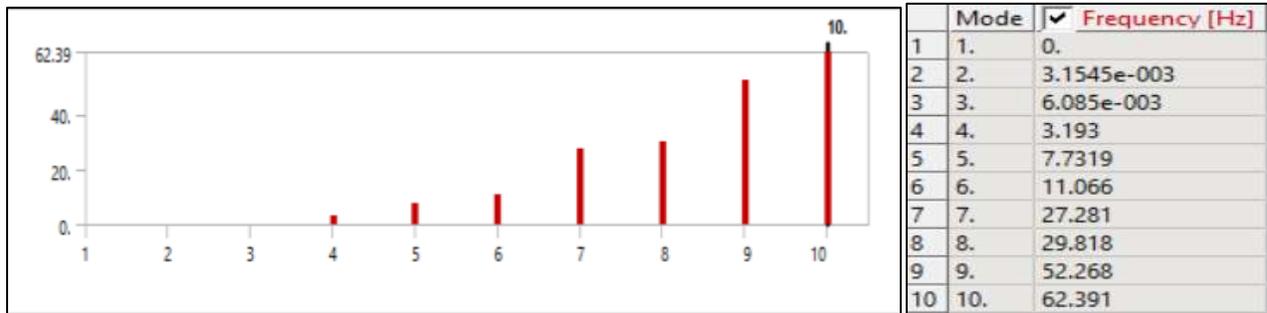


Fig. 10: Graph of Frequency

V. CONCLUSION

Result concluded that the AISI 1018 material is more economic and gives better performance. It is also suitable for large scale production. Static analysis using finite element method was successfully carried out on chassis CAD model to determine equivalent stresses, maximum deformations, Factor of Safety and its location on chassis model. The Factor of safety calculated is found to be greater than 1. Hence the chassis design is safe. This paper gives adequate idea and design guidelines about modelling of Go-Kart. Thus after all the analysis and design calculation, It concluded that our design of Go-kart is safe for fabrication using healthy manufacturing practices.

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