Design and Analysis of Tubular Chassis for Professional Racing Go-Kart to Withstand High Speed Impact

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Abstract - Go-karting is a constantly growing concept all over the world. A go-kart is a four wheeled vehicle designed for racing purpose and sometimes for entertainment purposes. It is neither a factory-made product nor a professional engineer made product. Karting is commonly perceived as the steppingstone for the higher ranked motorsports like formula racing. Karting is accepted as the most economic form of motorsport available. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. The main aim of this work is to model and perform dynamic analysis of the professional go-kart chassis for a maximum speed of 160 kmph. Modelling and Analysis of the chassis were performed in SOLIDWORKS and ANSYS respectively. The go-kart chassis is different from ordinary car chassis. The chassis is designed in such a way that it requires less material and has the ability to withstand the loads applied. Strength and light weight are the basic considerations for choosing the chassis material. AISI 1018 is the suitable material to be used for the go-kart chassis which is a medium carbon steel having high tensile strength, high machinability and offers good balance of toughness and ductility.

Keywords: Go-kart, Tubular chassis, Material, CAD model, Solidworks, Ansys, FEA Analysis, Impact test.

1. INTRODUCTION

Go-kart is a simple four-wheeled, single seated racing car used mainly in United States. They were initially created in the 1950s, Post-war period by airmen as a way to pass spare time. Art Ingles is generally accepted to be the father of karting. He built the first kart in Southern California in 1956. From then, it is being popular all over America and in Europe. A Gokart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks but are sometimes driven as entertainment or as a hobby by non-professionals. Karting is commonly perceived as the steppingstone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivers, but adults are also very active in karting. Karting is considered as the first step in any serious racer's career. It can prepare the driver for high-speed wheel-to-wheel racing by helping to develop guide reflexes, precision car control and decision-making skills. In addition, it brings an awareness of the various parameters that can be altered to try to improve the competitiveness of the kart that also exist in other forms of motor racing.

We approached our design by considering all possible alternatives for a system and modeling them in SOLIDWORKS software subjected to analysis using ANSYS. Based on analysis result, the model was modified and re-tested and a final design was fixed. The design process of the vehicle is based on various engineering aspects depending upon Safety and Ergonomics, Market Availability, Cost of the Components and Safe Engineering Practices.

1.1 PARTS OF GO-KART

The Go-kart consists of various parts such as

1. Chassis
2. Engine and Transmission System
3. Steering Assembly
4. Braking system
5. Electrical and Engine Wiring
6. Body Panels

1.2 GO-KART CHASSIS

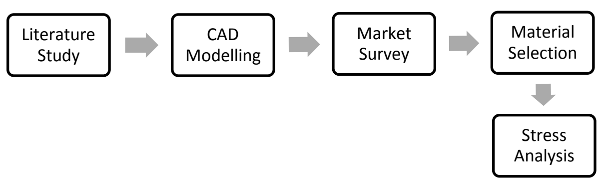
The chassis of go-kart is a skeleton frame made up of hollow pipes and other materials of different cross sections. The chassis of go-kart must be stable with high torsional rigidity, as well as it should have relatively high degree of flexibility as there is no suspension. So that it can give enough strength to withstand with grub load as well as with other accessories. The chassis is designed by taking ergonomics as main factor. The chassis is designed in such a way that it should ride safe and the load that applies does not change the structural strength of the chassis. The chassis is the backbone of the kart as it must be flexible so that it must be equal enough to the suspension. High strength and light weight are the two main parameters to be considered on selection of chassis material.

2. DESIGN OBJECTIVE

The Design Objective of the work is to

1. To select suitable chassis material
2. To design appropriate professional go-kart chassis for 160 kmph
3. To analyze the stress impacts on the designed chassis

3. DESIGN METHODOLOGY



4. MODELLING OF CHASSIS

The 3D CAD modelling of tubular chassis for professional go-kart was done using SOLIDWORKS software as shown in the figure below.

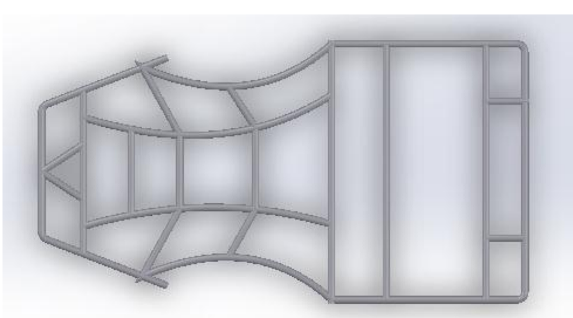


Fig1 - CAD Model – Go-kart Chassis

5. MATERIAL SELECTION

The selection of material was a tedious task as it had many constraints of weight, structural resilience towards various types of forces, torsional rigidity, factor of safety under application of various loads and also market availability with cost constraints.

The amount of carbon in steel is important to determine the strength, hardness, and providing desired strength, endurance, safety and reliability of the vehicle. The material used for chassis are various grades of steel or aluminum alloys. The main component of steel is carbon which increases the hardness of material of chassis. Aluminum alloy is expensive than steel so mainly steel is used to constructs the chassis. The chassis is made up of AISI-1018 which is a medium carbon steel. This material was selected due to its good Combination of all of the typical traits of Steel – high tensile strength, ductility, light weight, better weldability and comparative ease of machining.

The properties of the material are presented in ***Table 1***

PROPERTIES	**AISI 1010**	**AISI 1015**	**AISI 1018**	**AISI 1020**
Density (gm/cc)	7.87	7.87	7.87	7.87
Tensile Strength (Mpa)	365	385	440	420
Yield Strength (Mpa)	305	325	370	350
Modulus of Elasticity (Gpa)	190-210	190-210	205	205
Shear Modulus (Gpa)	80	80	80	80
Poisson Ratio	0.27-0.3	0.27-0.3	0.29	0.29
Elongation in Break (50mm)	20%	18%	15%	15%
BHN	105	111	126	121
Rockwell Hardness	60	64	71	68
Thermal Conductivity (W/mK)	49.8	51.9	51.9	51.9

Table 1 Mechanical Properties of Chassis Materials

6. CHASSIS ANALYSIS

The modelled chassis was analysed for stress impacts on front impact, rear impact and side impact using ANSYS 14.5 software.

6.1 Front Impact Analysis

The force of the impact is calculated using the formula,

Force = mv/t

where,

m – mass

v – Velocity of the vehicle

t – impact duration

The mass is considered to be 120kg with a desirable factor of safety and the velocity is considered to be 45 m/s (or) 160 kmph.

$$Front\ Impact\ Force = \frac{120 * 45}{0.1}$$

= 54000 N

For the front impact test, the front nodes are applied with the load calculated. The rear is completely constrained and the allowing displacement to occur only in direction of the load applied. The stress and displacement values are within the permissible values.

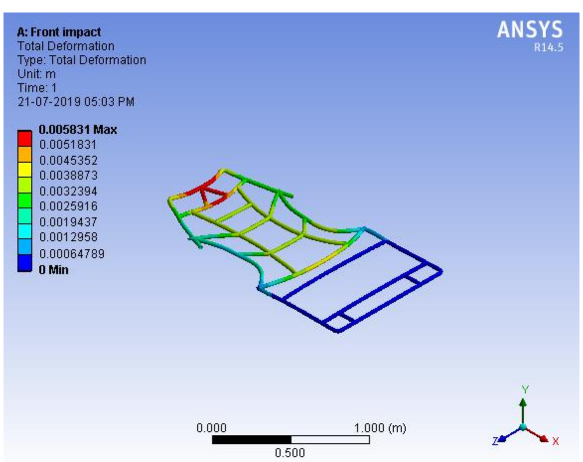


Fig 2 – Front Impact Analysis

6.2 Rear Impact Analysis

Rear impact test is very similar to the front impact analysis but in this case, vehicle is considered to be movable so during impact the vehicle experience less Gravitational Force than front impact test.

Torsional rigidity:

Torsional stiffness is the ratio of torque applied to angular deformation. It is very important to calculate the torsional stiffness of the chassis. Torsional stiffness directly affects the stability of the vehicle. If the torsional stiffness is too small, then the vehicle will be more comfortable but will be very unstable but if it is very large then it will be very stable and under control, but it will be very uncomfortable to the driver. For this analysis we got around 1.2 FOS which means the vehicle can survive the impact with little deformation.

The mass is considered to be 150 Kg with a desirable factor of safety and the velocity is considered to be 45 m/s (or) 160kmph.

$$Rear\ Impact\ Force = \frac{120 * 45}{0.1}$$

= 54000 N

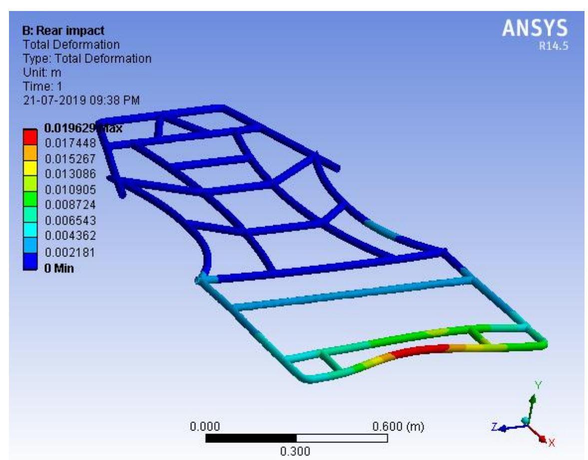


Fig 3 – Rear Impact Analysis

6.3 Side Impact Analysis

During a side impact the vehicle experience approximately half of the force that it experiences during front impact so, we assume half the force that is used in the front impact and the rear impact.

The mass is considered to be 150 Kg with a desirable factor of safety and the velocity is considered to be 22.5 m/s (or) 80 kmph

$$Side\ Impact\ Force = \frac{120 * 22.5}{0.1}$$

$$= 27000\ N$$

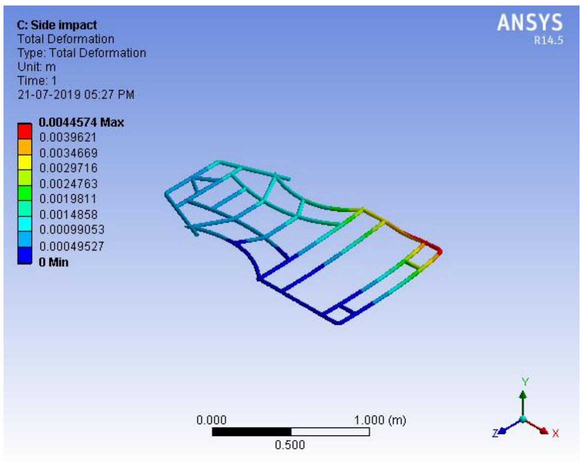


Fig 4 – Side Impact Analysis

7. CONCLUSION

The FEA Analysis shown that the vehicle can sustain maximum force for 160kmph from front as well as rear & half the force from side and that the deformation & stresses are within the permissible limits. The basic need of a Go-kart, which is lower weight to strength is also satisfied. Keeping the manufacturing in mind, We have tried to make the design optimum and simple. Thus, it can be concluded that this chassis demonstrates good strengths against the collision from front, rear, as well as side. Factor of safety is under the safe limit and can be used to make a professional go-kart for 160kmph application.

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