Finding Optimum Diameter and Thickness of AISI 1020 Tube for Manufacturing Go-Kart Chassis

Vishvesh L. Solanki, Rushit D. Vaishya

***Abstract*- Go kart is popular hobby sports in America and Europe, it was initially made in us in 1950 and then other country followed this carting culture. In India go kart is making huge wave, many recesses is been conducted. The important criteria to be consider while designing kart is its chassis it does not have suspension so all the load should be absorb by chassis alone without deflecting unduly, the rigidity and strength of the chassis should be consider too much of rigidity will reduce the strength of the chassis, the material used is AISI 1020. Different impact test is conducted and final optimum diameter (D) and thickness (T) is obtain using CAE toll and validate by applying formula for different values.**

***Index Terms*- go kart, AISI 1020 Tube.**

I. INTRODUCTION

There are many motor sport vehicles in the world such as bike cars and formula one the races demand professional and skillful driver, but go carting is sport in which unskilled and nonprofessional driver can take part, due to its speed limit. Go carting initially started in US in 1950's and get hug popularities in US and European country. This race is getting crazed in India as well. Many go cart races are conducted in in India by many organization. It's a great opportunity for designer and engineer to apply their innovation and creativity , it is also believed to have first step in serious racing like formula one , go kart is low cost , and have low speed hence it's a safer way for new driver to improve the driving skill .
Go cart comes in many shapes and forms , motor less model without engine and this are conducted on hills , and high power models which is used in races on long circuit , go kart is powered by 4 stroke engine and electric motors . The main part of go kart is its chassis. Go kart have no suspension. hence all the load on go kart should absorb by the chassis of the kart , without deflecting unduly, the rigidity and strength of the chassis should be such that too much of rigidity will reduce the strength of the chassis.
There are four types of go kart chassis

1. Open kart
2. Caged kart
3. Straight chassis
4. Offset chassis

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In this paper straight chassis is design and optimum diameter and thickness of the circular pipe of AISI 1020. This chassis is approved by CIK-FIA. The stiffness of the chassis provide different characteristic for different circumstances dry condition demands stiffer chassis. While wet or other poor traction condition a more flexible chassis is preferable.

The chassis of go kart is made of circular pipe using AISI 1020 material of various cross section. The chassis must have consisted of stability and torsional rigidity, as well as it should have good flexibility as there is no suspension, it should able to sustain loads of operator and other accessories.

- **Design and Analysis of Go-Kart Chassis according to fsae Constrains** [1]

Material EN22-MS (chrome steel), this material is used because following reasons good rigidity, high durability, high tensile strength; maximum resisting force is 4500N, good workability and extreme torsion resistance. Difference between fronts track and rear track width must not be less than 20% of wider track (Front or Rear). Wheel base must be at least 40 inches with smaller track width (front or rear) not less than 80% of the wheelbase.

FEA - Front impact analysis:-The vehicle was assumed to be hit by stationery object while at the speed of 65km/h i.e. 18.055m/s which would create an impact of 4514N at the four corners of the front portion of the vehicle. Assuming the construction of chassis frame to be made by being able to maintain deformation at an impact of 4514N the analysis was done and some changes were made according to it. Only the seat support was assumed to be the fixed potion of the vehicle. As the main transmission portion, fuel tank, gear box and other important equipment's of the vehicle are placed at the rear portion, the vehicle was analyzed for the impact of 4514N to be able to bear deformation during the collision. Changes were made according to the analysis of the portion.

- **Static Analysis of Go-Kart Chassis by Analytical and Solid Works Simulation** [2]

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 weld ability and comparative ease of machining

Maximum deflection value is 3.2441x10-6mm.The result shows that the location of maximum deflection goes well with theoretical location but varies in magnitude aspects, from the numerical analysis.

- **DESIGN REPORT OF A GO KART VEHICLE** [3]

This paper concentrates on explaining the design and engineering aspects of making a Go Kart for student karting championship 2015. This report explains objectives, assumptions and calculations made in designing a Go Kart. The team's primary objective is to design a safe and functional vehicle based on rigid and torsion free frame. T he design is chosen such that the Kart is easy to fabricate in every possible aspect

Paper concentrate on various design aspect, like safe Safety and Ergonomics, Market Availability, Cost of the Components, Safe Engineering Practices.

Material used in this paper is IS1161 is selected for the chassis because of following reason: Machinability, Weld ability, Availability. Round tube is used to make chassis having outer diameter 25.4mm and thickness 2mm, justification for using round tube is lightness of the tube.

Front impact analysis

- ✓ Load applied: 5000 N
- ✓ Maximum stress induced: 171.8 MPa
- ✓ Displacement: 1.9mm
- ✓ Factor of safety: 2.2

Side impact analysis

- ✓ Load applied: 3500N
- ✓ Maximum stress induced: 121.1Mpa
- ✓ Displacement: 1.14mm
- ✓ Factor of safety: 2.5

Rear impact

- ✓ Load applied: 2500N
- ✓ Maximum stress: 125.86Mpa
- ✓ Displacement: 6mm
- ✓ Factor of safety: 2.4

- **Go-Kart Injuries of the Shoulder Region** [4]

In this paper they focus on the injury due to go karting, go kart is relatively safe and wide range of stability and low center of gravity. Wide wheel base makes it safe for driver, but still one can expect an increase in injury as kart travelled faster around more ambitious circuit so in order to make go kart safe, one have to design a chassis which will absorb all the load without injury to driver.
There are case of serious injury of the shoulder region are described. Safety and measures are discussed
Case 1 ; A 42-year-old man injured his right shoulder in a karting Accident. His front wheel caught the back wheel of another, resulting in his kart flipping over. He was wearing the recommended safety equipment (crash helmet, gloves, racing suit); however the kart had no safety harness and he was thrown some distance.
Case 2 A 34-year-old men had a side on collision with another kart. He was wearing the recommended protective clothing and strapped in with a seat harness.
Case 3 A 44-year-old rolled his kart after a collision. He was wearing an open face crash helmet but no seat belt.
Many drivers are inexperienced and great care should be directed at formal instruction. The issue of seat belts has already been addressed (Miller and Procter, 1973), but until legislation exists in this respect they remain all too frequently absent. Very few go-karts have roll bars fitted. The shoulder remains dangerously exposed in the majority of cases. Finally, little attention is paid to the 'road surface'; many circuits have a painted warehouse floor. The reduced friction on such surfaces allows for skidding and a greater accident rate. The majority of go-karting centres undoubtedly have a high level of safety; it is the minority that this paper addresses. Simple safety measures will ensure low injury rates in this increasingly popular sport.

- **Design and Analysis of Go Kart Chassis** [5]

This paper deals with the Design and Analysis of Roll Cage for the Go Kart. In a Go Kart Student Car the roll cage is one of the main components. It forms the structure or the main frame of the vehicle on which other parts like Engine, Steering, and Transmission are mounted. We have made the 3D model of Go Kart and Roll Cage in Catia-V5.
The areas of max stress is find out by using the FEA analysis and Crash Analysis (Front and Side Impact), Torsional Analysis.. All these Analysis have been carried out in Hyper Works 11.0. The design procedure follows all the rules laid down by NKRC Rule Book for Go Kart Type Cars
As a part of methodology this paper have selected a material AISI-1018 which is medium carbon steel due to its good combination of weld ability , light weight high tensile strength and ductility

II. MATERIAL AND METHODOLOGY

The primary aim of chassis is to provide protection to driver. As there are injuries are due to go kart racing [(1)], its secondary objective is to reliable mounting location for component is appealing, low weight. And by changing different parameter, on selecting the appropriate dimension and material optimal design is obtain, the below flow diagram shows the methodology used in this paper.

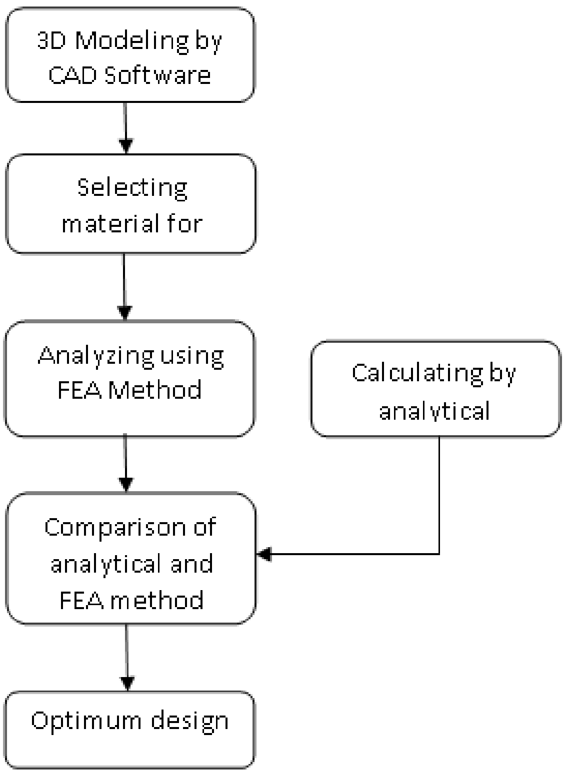

Figure 1 Flowchart for optimum Go-kart chassis design

Above block diagram shows the methodology of this this thesis, the material used is AISI1020. And various pipe thickness and outer diameter is used to make chassis of go kart minimum cross section of the pipe should be 1inch (25.4mm)(2) . For the pipe its outer diameter (OD) and for square section it's a side. By changing different design variable appropriate chassis design is suggested in the end of the thesis.

Chassis Material- The tube/rectangular pipe used in the fabrication of the chassis or the other frames/supports must be seamless. Minimum cross section must be 1 inch (25.4mm), for pipe it will be OD and for rectangular section or square section it will be its minimum height. Material certification is essentially required to be produced during the technical inspection. Material should be certified from any of the material testing laboratories for its chemical and mechanical properties, the same report should be presented at the time of inspection and throughout the event. This material is selected on the bases of rule book [6] of national go kart championship

Name:	**AISI 1020**
Model type:	**Linear Elastic Isotropic**
Yield strength:	**3.51571e+008 N/m^2**
Tensile strength:	**4.20507e+008 N/m^2**
Elastic modulus:	**2e+011 N/m^2**
Poisson's ratio:	**0.29**
Mass density:	**7900 kg/m^3**
Shear modulus:	**7.7e+010 N/m^2**
Thermal expansion coefficient:	**1.5e-005 /Kelvin**

Design of Go kart Chassis

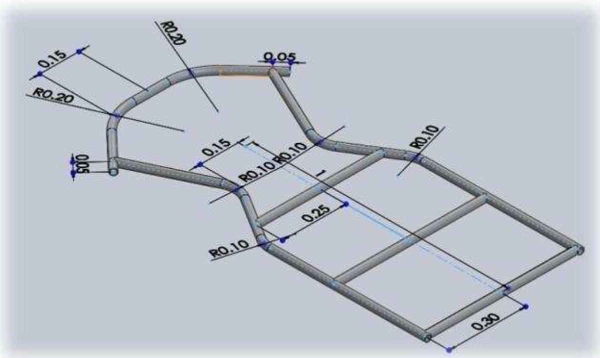

Figure 2 design of go kart chassis in cad software

Figure 2 shows the design of go kart chassis; the chassis have design in solid works software the dimension of the go kart chassis is deign by rule book [6]. The vehicle must have four (4) wheels that cannot be in a straight line in longitudinal direction. The vehicle must have a wheelbase of at least 1066.8 mm (42 inches). The wheelbase is measured from the centre of contact on ground of the front to rear tires with the wheels pointed straight ahead. The mountings and designing of chassis should be such that there should be minimum 3 inches (gap) clearances between the driver and any component of the vehicle in static and dynamic condition – hands, torso, thighs etc. Body parts making contact with the parts at normal seating position are excluded from the rule. 3D design is done using CAD software.

3.8 Finding impact force

In order to perform Front Impact Analysis, the rear bumper of the Chassis was constrained [7]. The force is applied at the front bumper which is calculated using Newton's mass moment equation,

$$F = m \times \frac{\delta v}{t} \quad (1)$$

Where,
m- Mass of the vehicle with the driver.
δv - change in velocity.
t- Time taken to decelerate.
The total mass of the vehicle is 200 kg (includes weight of the engine, drive system, brake unit, body kits and weight of the driver) and total time taken for the Go-Kart to decelerate from 60-0km/hr (16.67m/s^2) and come to rest is 0.85seconds. Therefore, the force was calculated using equation 1.
F = 165×16.67/.85
F = 3922.35 N
The above method of finding impact force is used in [7] and this impact force is used to analyse the design using FEA.

Finding Beam Deflection and Maximum Bending Stress:
Beam supported at both ends with uniform loading a simply supported beam carrying a uniformly distributed load over its length is shown in the standard formula for finding deflection y at any given point x from one end, say from lhs, is given by: where: e : young's modulus of elasticity of the material from which the beam is fabricated (N/m2)

$$\boldsymbol{Y = \frac{WX(L-X)}{24EIL}[L^2 + X(L-X)]} \quad \textbf{(2)}$$

$$Ymax = \frac{w\frac{L}{2}\left(L-\frac{L}{2}\right)}{24EIL}[L^2 + \frac{L}{2}\left(L-\frac{L}{2}\right)]$$

$$= \frac{w\frac{L^4}{2}}{24EIL}[L^2 + \frac{L^2}{4}]$$

$$= \frac{wL}{24EI \times 4}[\frac{5L^2}{4}]$$

$$\boldsymbol{Ymax = \frac{5*w*L^3}{384*E*I}} \quad \textbf{(3)}\ [8]$$

It is obvious that the deflection will be maximum at the centre, i.e. when x = L / 2. Substituting this value in equation (2), where
L: Total length of the beam measured between centers of support (m),
X = Distance from one side of the beam, say from LHS (m),
W = Load (N or kN) Since the load is uniformly distributed throughout the Span Length L.
M= Bending moment.
I = Moment of inertia of the section about the bending axis.
F = Fibre stress at a distance 'y' from the neutral axis,
E = Young's Modulus of the material of the beam.
R = radius of curvature of the bent beam.

Finding max stress in chassis

$$\frac{M}{I} = \frac{E}{R} = \frac{F}{Y} \quad (4)$$

Putting value of m and y we get max shear stress acting on it

$$F = \frac{M*Y}{I} = \frac{W*L^2*Y}{8*I}. \quad (5)\ [8]$$

FEA Simulation

Applying Load of F = 3922.35 N on the front part of the chassis obtained using equation 1.

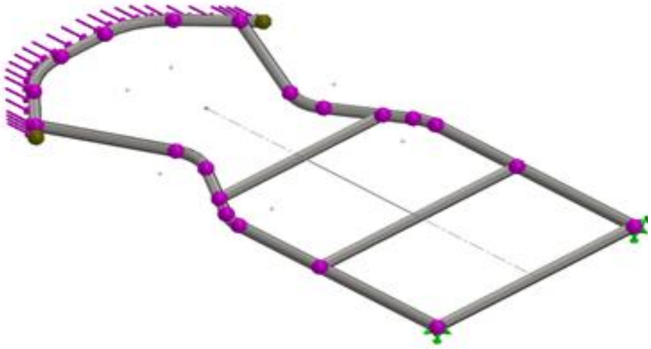

Figure 3 Front impact test for go kart chassis

Simulation of the chassis is done in solid works , for that three case is describe and stimulation is done using solid works platform this thesis also determine, defection (displacement) and maximum bending stress is find out using run

Theoretical Calculation and Analysis using cad software

CASE 1 (OD=26.9mm t=3.2mm and L=300mm E=2*10^5 N/mm^2)

Figure 4 Displacement (mm), Case 1

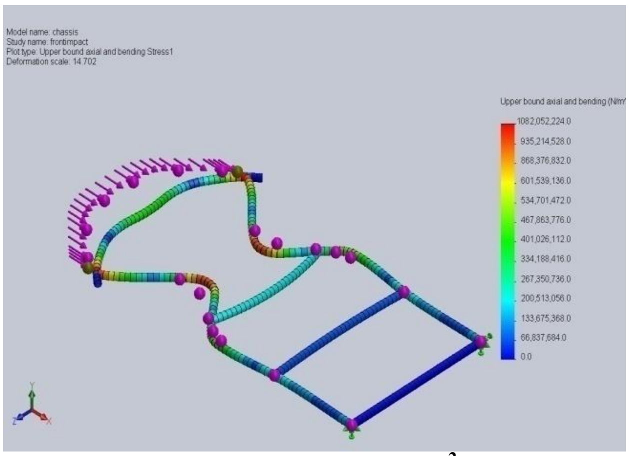

Figure 5 Bending stress (N/mm^2), Case 1

$$Y = \frac{5*w*L^3}{384*E*I} = 7.59 \text{ mm}$$

$$F = \frac{W*L^2*Y}{8*I} = 1229.87 \text{ N}/\text{mm}^2$$

CASE 2 (OD=33mm, t=3.2,L=300mm, w=3922N, E=2*10^5 N/mm^2)

Figure 6 Case 2 Bending Stress (N/mm^2)

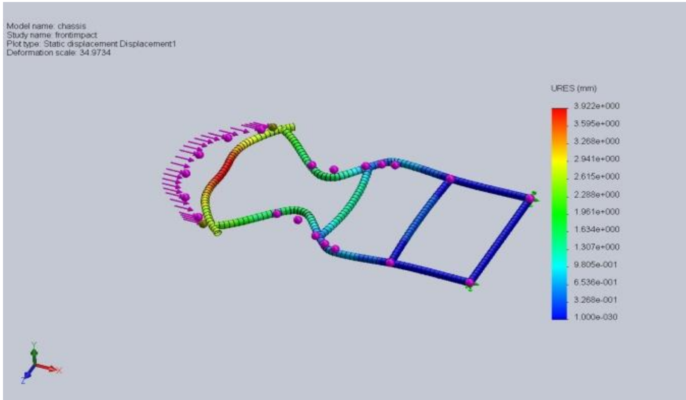

Figure 7 Displacement (mm), Case2

$$Y = \frac{5*w*L^3}{384*E*I} = 3.59\text{mm}$$

$$F = \frac{W*L^2*Y}{8*I} = 274.6 \text{ N/mm}^2$$

CASE 3 (OD=42.4mm, t=4mm, L=300mm, E=2*10^5 N/mm^2

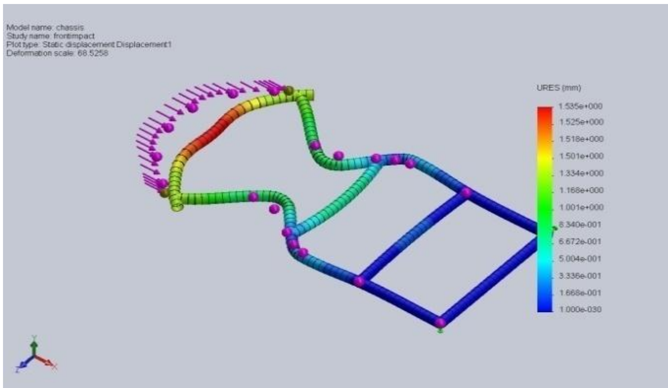

Figure 8 Displacement (mm), Case 3

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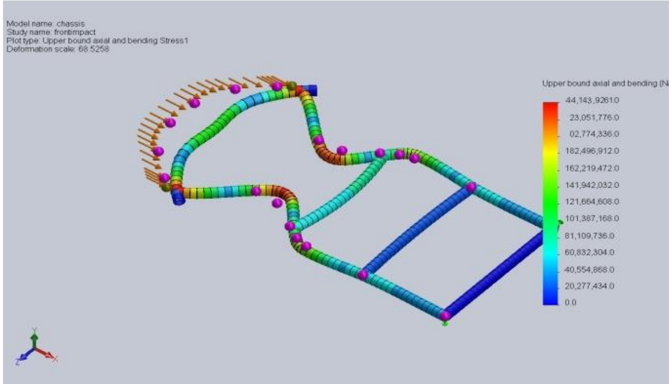

Figure 9 Bending Stress (N/mm^2), Case3

$$Y = \frac{5 * w * L^3}{384 * E * I} = 1.44mm$$

$$F = \frac{W * L^2 * Y}{8 * I} = 44.14\ N/mm^2$$

Table 1 Difference between theoretical and numerical analysis for displacement

Case	Theoretical (mm)	FEA (mm)	Difference (%)
1	7.592	8.329	-9.71
2	3.5878	3.922	-9.315
3	1.438	1.5	-4.312

Table 2 Difference between theoretical and numerical analysis for bending stress

Case	Theoretical N/mm^2	FEA N/mm^2	Difference (%)
1	1229.87	1082.052	12.02
2	274.62	250.6	8.75
3	441429061	441439261	-0.002

III. CONCLUSION

After studying above three case optimum designs to manufacture Go kart chassis is CASE 2 (OD=33mm, t=3.2,L=300mm, w=3922N, E=2*10^5 N/mm^2) . while in case 1 and case 3 is not optimum design for go kart manufacturing chassis
case 1 is not able to sustain the load. But have lesser weight, which is not preferable. Due to its less safety
In case 3 it is able to sustain the load but. the weight of chassis increase hence this design is also not preferable
In case 2 it have both the property it sustain the load and also have lesser weight then case 3.
Hence the preferable chassis design so manufacturing go kart chassis using AISI 1020 material , with OD 33mm and T=3.2mm

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