Manufacturing and Validation of Go Kart

Sudhanshu Shende[1], Viplav Barai[2], Sahil Gulhane[3], Alok Raipure[4]

[1,2,3,4]*Students, Dept. Mechanical Engineering G.H. Raisoni College Of Engineering, Nagpur Maharashtra, India*

Abstract - *Team barriers breakers Moto is to design and fabricate the sophisticated and simple kart design with factor of high fuel economy as well as with more suitable driver comfort without reconciliation the kart performance.*

This paper aims to increase thefactor of safety of go kart chassis which is designed keeping in mind the rules imposedby INDKC 2019. This paper tends to design all the convenient features established inthe go kart vehicle. There is involvement of many systems in manufacturing of go kart such as steering, braking, transmission, chassis etc. We have extensively designed and carried out the design analysis regarding separate parameters of all the systems involved in the kart. The designhas been modeled in Catia V5 and Solidworks while the analysis was done in Ansys R1 and same rendering was done using Solidworks.

1. INTRODUCTION

The go kart has been designed by team barrier breakers consisting of under graduated students from G.H.Raisoni College Of Engineering affiliated to R.T.M.N.U University, Nagpur.

We approach our design by considering all alternatives for a system and molding them inCAD software; Solidworks and Catia subjected to analysis using Ansys. Based on analysis result the specimen was modified and retested and final designed was fixed.The primary objective of work is to design and develop a safer and functional vehicle based on a torsional free and rigid frame, well mounted power train and to understand the finer aspects of vehicle design with an in tension of working it easy to manufacture for consumer sale, while strictly following the rulebook.

The second objective is to make a kart with driver comfort to increase the performance maneuverability of the vehicle to achieve our goal the team is divided into core groups which are responsible for design and optimization of major sub systems which were later integrated into the final kart. The design has been approached in view of all possible substitutions for a system.

2. TECHNICAL SPECIFICATION OF KART

2.1 CHASSIS

The material used for the chassis is AISI 4130 normalized mild steel. The pipe is of D31 mm having 1.8 mm thickness.

The physical properties of pipe as follows:-

Table-1: Physical properties of material

SR.NO	PROPERTIES	VALUES
1.	Tensile strength	560 Mpa
2.	Yield strength	460 Mpa
3.	Bulk modulus	140 Gpa
4.	Hardness, Brinell	217
5.	Young's modulus	210 Gpa
6.	Poisson's ratio	0.3
7.	Elongation at break	21.50%

The chemical composition of the pipe is as follows:-

Table -2: Chemical properties of material

MATERIAL	PERCENTAGE
Iron(Fe)	97.03-98.22%
Chromium(Cr)	0.80-1.10%
Manganese(Mn)	0.40-0.60%
Carbon(C)	0.280-0.330%
Silicon(Si)	0.15-0.30%
Molybdenum(Mo)	0.15-0.25%
Sulfur(S)	0.040%
Phosphorous(K)	0.035%

By surveying the various materials, we havestudied and as per our requirement we haveselected material AISI 4130, as it provides stability, torsional rigidity and high degree of flexibility as there is no suspension in go kart. As, we want a strong and light frame so, we had taken 2 mm thick tubing which is suitable to sustain different loads acting on the vehicle and other accessories. Same, we have preferred circular section over cross section as it provides enough torsional rigidity and resists the twisting effects.

2.2 ENGINE

The engine used in the kart is BAJAJ Discover 125 ST twin spark.

Engine specifications are as follows:-

Table-3: Engine specification

SPECIFICATIONS	VALUES
Displacement	124.6 CC
Maximum Power	12.8 HP@9000 rpm
Maximum torque	11 Nm@7000 rpm
No of cylinders	1
No of gears	5
Top speed	105 Kmph

Clutch	Wet multi-plate type
Cooling	Air cooled

As, engine of a go kart is usually a small one. About 100-200cc so this kart we use a BAJAJ Discover single cylinder 125 cc four- stroke petrol engine which produces 12 BHP of power at 9000 rpm. Used four- stroke engine because this used for racing and good mileage also.

2.3 STEERING

The steering system used in the kart is Ackerman steering system. The specifications are as follows:-

Table-4: Steering Parameters

PARAMETERS	VALUES
Type of tripod mechanism	Ackerman's steering
Steering ratio	1:1
Maximum turning radius	2.96 m
Camber	0 Deg
Castor	5 Deg
Kin pin inclination	15 Deg
Inside steering angle	30 Deg
Outside steering angle	20.43 Deg
Steering effort	25.67 N-m
Ackerman steering angle	29.9 Deg
Ackerman percentage	100%

Knuckle Specifications are as follows:-

Table-5: Knuckle specification

PARAMETERS	VALUES
Material	AISI 1040
Maximum stress	47.101 Mpa
Factor of safety	8.8
Deformation	0.349 mm

Mechanical arrangement is planned to be used this type of steering system was selected because of its simple working mechanism and steering ratio of 1:1, so simply we have preferred mechanical type of linkage.

Our steering geometry having 100% Ackerman and gives 60 Degree lock to lock turn of steering wheel which is very suitable for our race track as it allows quick turn witha small input and being more precise at the same time. We also attains a perspective turning radius of 2.96 m

2.4 TRANSIMISSION

As per our above selected engine, there is a geared transmission in which the driver sprocket has 14 teeth and driven sprocket has 30 teeth. The parameters of the transmission are given as per the table below:-

Table-6: Transmission parameter

PARAMETERS	VALUES
Engine weight	32 kg
Maximum torque of shaft	11 N-m @7000 RPM
Shaft material	AISI 1040
Shaft diameter	40 mm
Top speed	75 Kmph
Tractive force	1000.62 N
Front weight	68 kg
Rear weight	102 kg
No of teeth on sprocket	30

Additionally, we used hollow shaft which arehaving more polar moment of inertia, thus they can transmit more torque compared to solid shaft. We have preferred gear transmission instead of automatic transmission because it gives more torque and speed at different gear reductions. Gear reductions are given in table below:-

Table-7: Gear reduction

Primary gear reduction	3.08
1st gear reduction	2.38
2nd gear reduction	1.71
3rd gear reduction	1.33
4th gear reduction	1.08
5th gear reduction	0.91
Maximum engine rpm	9000

Table-8: Speed

No of gear	Speed(kmph)
1st gear	24.10 kmph
2nd gear	39.49 kmph
3rd gear	51.29 kmph
4th gear	63.16 kmph
5th gear	74.97 kmph

For our Go kart, chain drive type transmission is most preferable as it is easy to install, simple in design and cost effective. As we have taken the teeth of the driven sprocket 30, as it gives more speed at low rpm at higher gear.

2.5 BRAKING

As, we know that braking is the main part in go kart, so as per our analysis we have came to a conclusion that the caliper of the Apache RTR 160 is best for our customized disc of material stainless steel (ferrite).

Table-9 : Brake disc parameter

PARAMETERS	VALUES
OD of disc	200 mm
ID of disc	105 mm
Thickness of disc	4mm

Material	Stainless steel (ferrite).

Specifications of caliper as given below:-

Table-10: Caliper specification

PARAMETERS	VALUES
Master cylinder diameter	10mm
Caliper piston diameter	25.4 mm
Brake pedal lever ratio	3:1

As per our synopsis and overall analysis, our calculated values are given in the tablementioned below:-

Table-11: Braking parameter

PARAMETERS	VALUES
Front axle static load	68 kg
Rear axle static load	102 kg
Gross weight	170 kg
Stopping distance	5.14 m
Leverage	4:1
Load applied by driver	250 N
Braking force	4590 N
Braking torque	643.005 N.m
Stopping time	0.617 sec

We are using a disc brake for rear wheel considering the abilities and their limitations,so we use a disc brake which contributes forreduction in the overall weight of vehicleand for more braking torque even after weight transfer because the single brake has to manage the braking torque requirement of entire rear drive shaft.

For achieving a better braking efficiency and to improve the vehicle braking efforts we have opted to use single piston single caliper for all rear wheels.

2.6 KART DIMENSIONS

Table-11: Kart Dimensions

PARAMETERS	VALUES
Total length	1900 mm
Total width	1200 mm
Rear track width	1080 mm
Front track width	1000 mm
Wheel base	1050 mm
Total height	650 mm
Total weight	170 kg
Ground clearance	38 mm

2.6 **KART PERFORMANCE**

Table-12: Kart Performance

PARAMETERS	VALUES
Top speed	75 kmph
Maximum torque	11 N-m

Braking force	4560 N
Ackerman's Percentage	100%
Ackerman's Angle	29.99^0
Steering effort	25.67 N-m

3.3D VIEWS OF GO KART

3.1 ISOMATRIC VIEW

Fig-1

3.2 FRONT VIEW

Fig-2

3.3 SIDE VIEW

Fig-3

3.4 REAR VIEW

Fig-4

3.5 ISOMATRIC WITH BODYWORK

Fig-5

4. DESIGN METHODOLOGY

4.1 Ergonomics Consideration

We have designed our posture of driver in such a way to keep driver in a comfortable zone and ability to perform a quick escape (within 5 sec) from the kart during fire accidents. The ergonomics of the driver a shown below:-

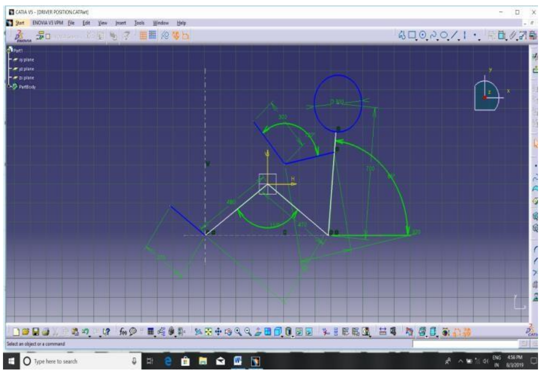

Fig-6

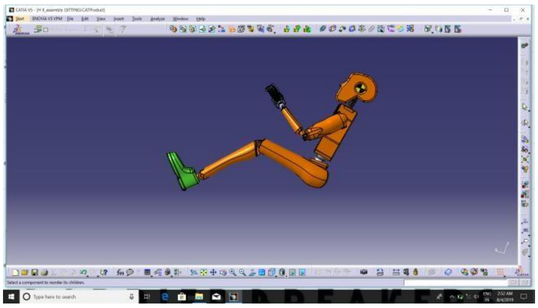

Fig-7

Considering ergonomics, driver was made to sit in the actual scale model of the kart frame.

4.2 FLOOR PLANNING

Fig-8

- As the floor was considered as thebase floor of kart.
- Driver's seating angle measured for a 5ft11" person. The driver remained in the position for 20 min therebysimulating driving conditions
- An optimum seat position was fixed considering their reviews and all other member's various body parts angles measured and clearance were measured.

4.3 FRAME AND PROTOTYPE

Fig-9

Ergonomic Measurements:

Knee angle for 5ft11" driver: 152 Deg

Thigh angle for 5ft11" driver: 115 Deg

Elbow angle for 5ft11" driver: 142 Deg

Fig-10

4.4 MATERIAL SELECTION

The chassis material is considereddepending upon various factors such as

Table-12: Chemical properties of material

SR.NO	PROPERTIES	VALUES
1.	Tensile strength	560 Mpa
2.	Yield strength	460 Mpa
3.	Bulk modulus	140 Gpa
4.	Hardness, Brinell	217
5.	Young's modulus	210 Gpa
6.	Poisson's ratio	0.3
7.	Elongation at break	21.50%

maximum load capacity, absorption force capacity, strength, rigidity. The material selected for the chassis building is AISI 4130 i.e. normalized mild steel.

Table-13: Physical properties of material

MATERIAL	PERCENTAGE
Iron(Fe)	97.03-98.22%
Chromium(Cr)	0.80-1.10%
Manganese(Mn)	0.40-0.60%
Carbon(C)	0.280-0.330%
Silicon(Si)	0.15-0.30%
Molybdenum(Mo)	0.15-0.25%
Sulfur(S)	0.040%
Phosphorous(K)	0.035%

4.5 DESIGN DECISIONS

Table-14: Physical properties of material

SR.N	SUB-SYSTEMS	REASONS
1.	Chassis (a) Type-Roll cage (b) Material-AISI 4130 (c) Thickness 2mm (d) Provide inclination in frame	(a) Due to driver safety (b) High flexibility and torsional rigidity (c) For strong andlight frame (d) For loweringthe C.G. of kart
2.	Transmission (a) Engine-Bajaj125 ST (b) Sprocket-30 teeth's (c) Shaft-hollow	(a) For more torque at low RPM (b) For more speed (c)Power to weight ratio is more
3.	Brake (a) Caliper- Apache RTR (b) Disc- Stainless	(a) Moderate weight and simpler mechanism. (b) Creates more frictional effect.
	steel material (c) Brake fluid-DOT 4	(c) For low moisture activity.
4.	Steering (a) Type- Ackerman steering (b) Scrub radius-low (c) Track width- small	(a) Better turning result (b) Effort of driveron kart is low (c) Fast cornering

5. FINITE ELEMENTANALYSIS

In this type of analysis, we predict that whether a product will break, wear out, or work the way it was designed. Here we divide the roll cage into small sizes known as element and collective elements on the model form a mesh.

The analysis was done in ANSYS R1 software:

5.1 CHASSIS

5.1.1 Front impact analysis

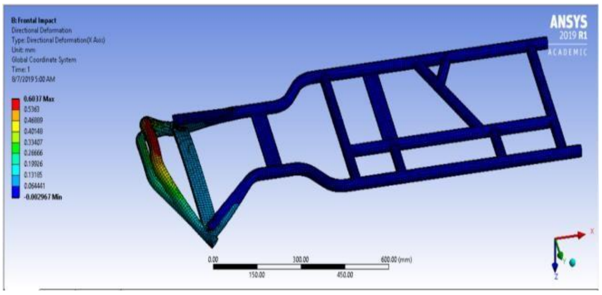

Fig-11

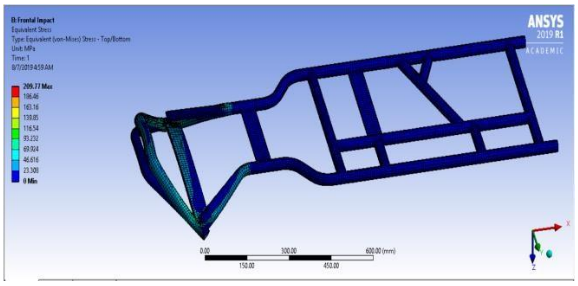

Fig-12

5.1.2 Rear impact analysis

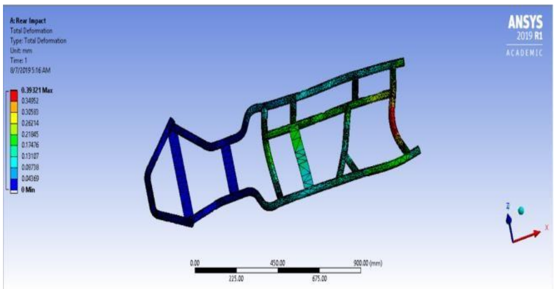

Fig-13

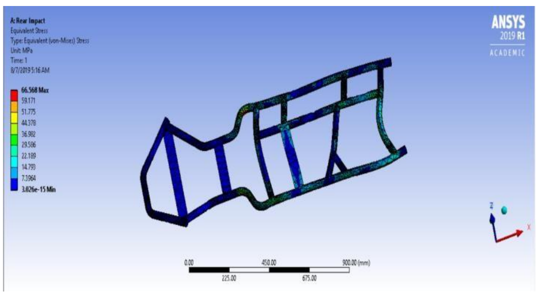

Fig-14

5.1.3 Side impact analysis

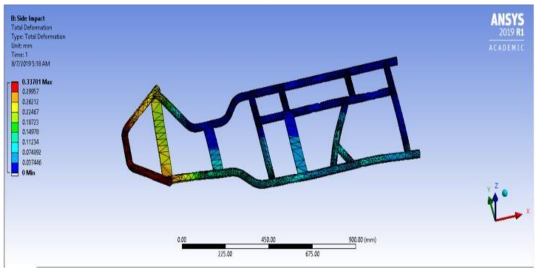

Fig-15

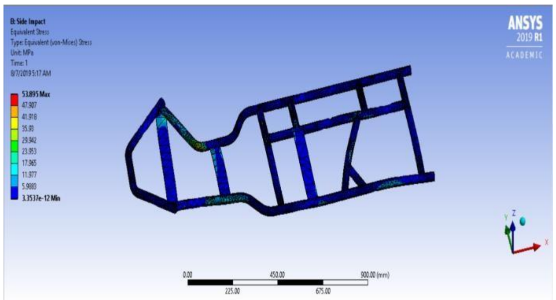

Fig-16

6. CONSIDERATIONS OF SUB-SYSTEM

Table-15 : Consideration of sub-system

ENGINE	
Displacement	124.6 cc
Maximum torque	11 N-m
Maximum power	12.8 bhp
CHASSIS	
Type	Roll cage
Weight	9.8 kg
Material	AISI 4130
VEHICLE DIMENSION	
Wheel base	1050 mm
Front track width	1000 mm
Rear track width	1080 mm
Initial weight	100 kg
Ground clearance	38 mm
STEERING	
Type	Ackerman
Turning radius	2.96 m
Articulation angle	
TRANSMISSION	
Gear box	Constant mesh
Type	Chain Drive

Top speed	75 kmph
Acceleration	27 m/s²
BRAKING	
Braking force	4600
Braking torque	643.005 N-m
Stopping time	0.617 Sec
Gross weight	100 kg

6.1 TRANSMISSION

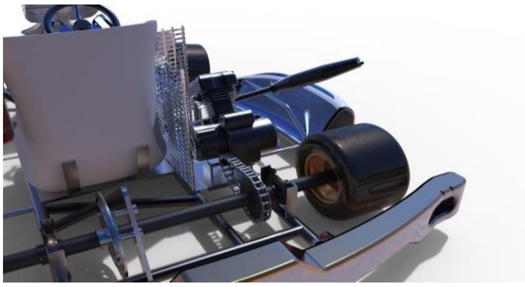

Fig-17

6.2 BRAKING

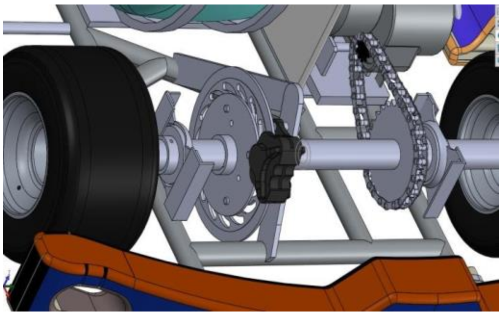

Fig-18

6.3 STEERING

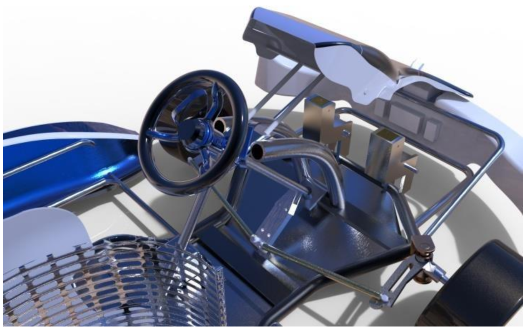

Fig-19

6.4 SAFETY EQUIPMENTS

6.4.1 FIRE EXTINGUISHER-

Fig-20

6.4.2 BODYWORKS-

Fig-21

6.5 DYNAMICS & HANDLIN

- In our kart, we have taken the articulation angle is maintained low (35 Deg), so due to that reason there will be equal distribution of weight all over four wheels and due to low articulation angle the C.G. of kart is maintained low.
- Due to low articulation angle the stresses on our roll cage chassis gets minimized and due to that the chassis FOS increases.

7. INNOVATIONS

PORTABLE ENGINE MOUNTING:

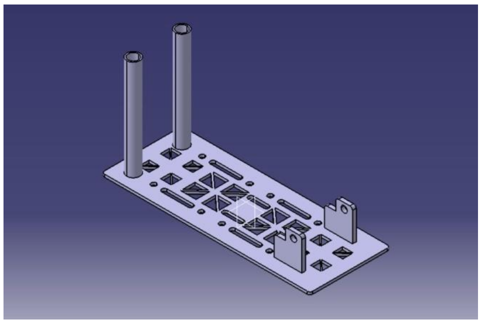

Fig-22

ADVANTAGES:

(i) The main mounting can be easily fabricated as per the enginedimensions.

(ii) Due, to its portability it can be fitted on all designed chassis.

(iii) The mounting can be easily disassembled for engine maintenance.

(iv) Due to its low weight it easy to replace & easy to handle.

8. FABRICATED AND PRE- FABRICATED PARTS

Table-16: Fabricated and pre-fabricatedparts

	FABRICATED PARTS	OUTSOURCED PARTS
1	Rear wheel hub	Castor & Camber
2	Engine mounting	Sprocket
3	Steering column	Caliper
4	Steering wheel hub	Master cylinder
5	Pedals	Steering wheel
6	Pedal Gear shifter	Wheels &Rims
7	Clutch	Knuckle
8	Disc	
9	Disc hub	

9. WEIGHT OPTIMIZATION

Table-17: Weight optimization

SR NO.	PART NAME	WEIGHT OPTIMIZED
1.	Axle	Hollow-For more torque
2.	Wheel Hub	Aluminum-For more strength
3.	Gear shifter	Pedal type-More compact and easy to use
4.	Clutch	Hand clutch-Easyto operate
5.	Engine mounting	Portable-Easily movable
6.	Knuckles	Slots-To reduce its weight
7.	Exhaust	Light in weight

10. WEIGHT OF SUB-SYSTEM

Table-18: Weight of sub-system

SR NO	SUB-SYSTEMS	WEIGHT
1.	CHASSIS	9.8 kg
2.	TRANSMISSION	62 kg
3.	STEERING	20 kg
4.	BRAKING	8.2 kg

11. REFERENCES

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BIOGRAPHIES

Sudhanshu Ravi Shende, Student at G.H.Raisoni College of Engineering. Mechanical Department Nagpur, Maharashtra

Viplav Anil Barai, Student at G.H.Raisoni College of Engineering. Mechanical Department Nagpur, Maharashtra

Sahil Ashok Gulhane, Student at G.H.Raisoni College of Engineering. Mechanical Department Nagpur, Maharashtra

Alok Atul Raipure, Student at G.H.Raisoni College of Engineering. Mechanical Department Nagpur, Maharashtra