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Performance Oriented High Speed Go-Kart

Abhay S. Nilawar
Associate Professors:
Department of Mechanical Engineering,
Rajiv Gandhi College of Engineering,
Research & Technology,
Chandrapur, Maharashtra, India

Sudhakar D. Khamankar
Associate Professors:
Department of Mechanical Engineering,
Rajiv Gandhi College of Engineering,
Research & Technology,
Chandrapur, Maharashtra, India

Shashikant Parsutkar, Mohit Yadav, Ravi Kushwaha, Vaibhao Wagh, Rakesh Yadav, Pranay Sathe, Rohit Zurmure & Bhushan Nikode
BE Students: Department of Mechanical Engineering,
Rajiv Gandhi College of Engineering, Research & Technology,
Chandrapur, Maharashtra, India

***Abstract*— Go-kart is a small, light in weight and four wheeled vehicle which is mainly used for racing purpose and grasp lots of popularity among young generation. Such type of vehicle doesn't require any professional driver it is much easy and controllable that common people can enjoy it. Various events are also organized for students upliftment through Go-kart like Supra, Baja, GKDC etc. The entire paper focus on Go-kart development like Material Selection, Methodology, Design and Analysis, Fabrication etc. We have modeled our Go-kart in 3D software CATIA and also used Ansys R15.0 Workbench for Analysis purpose.**

Keywords- Popularity; Modeled; 3D Software; CATIA; Workbench

I. INTRODUCTION

Over the past few decades, a lot of interests have been given in this simple, four-wheeled, small engine, single seated, light weighed racing car popularly known as GO-KART. It was initially created by Art Ingles during post war period in the year 1950_s but lately gained its popularity all over the world.

The main part of go-kart is engine, steering, axle, tyre, chassis and bumpers. The engine used in go-kart is either two stroke engine or four stroke engine. Go-kart are designed for flat track racing only as it has very less ground clearance compared to any other four wheeled vehicles hence it doesn't have any suspension. We approached our design by considering all possible alternatives for a system and modeling them in CAD software like CATIA and subjected to analysis using ANSYS and FEA software. Based on analysis result, the model was modified and retested and a final design was finalized. The design and fabrication of our Go-kart is done keeping in mind the rules and regulation of popular event named Go-Kart Design Challenge (GKDC) which have restricted our self on Go-kart shape, its overall weight, shape, size, dimensions and various other factors.

Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of sports because of its simplicity, cost, ease and safer way to race. The track of go-kart is similar to F1 racing track. Go-kart is generally raced on downsized tracks but as usually sometimes non-professionals drive it for their entertainment.

II. METHODOLOGY

Methodology is general research strategy that outlines the way in which research is to be under taken. The following flow chart shows the methodology we adopted during our Go-kart manufacturing.

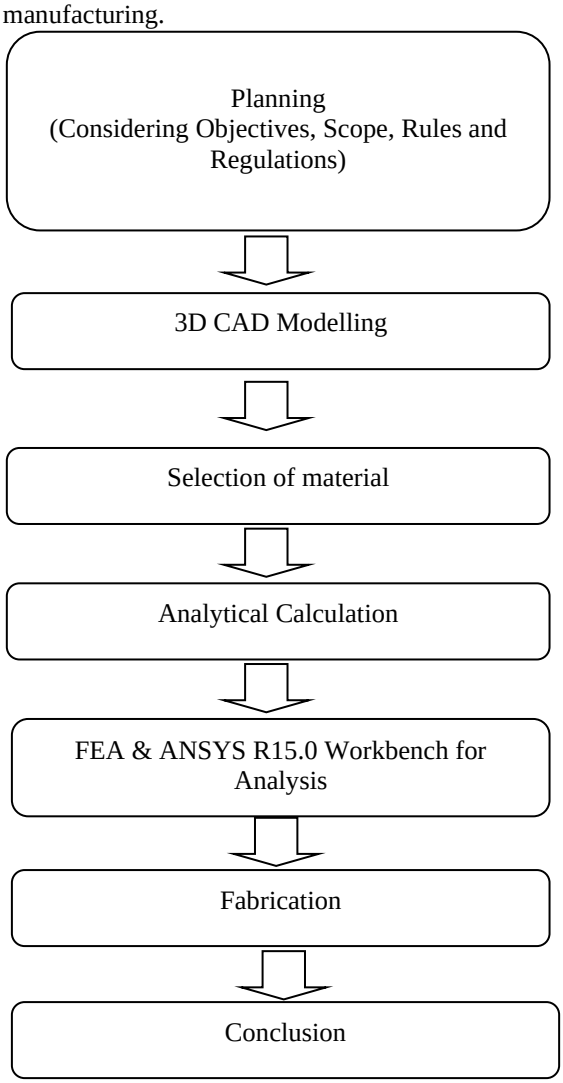

Fig. 1. Methodology

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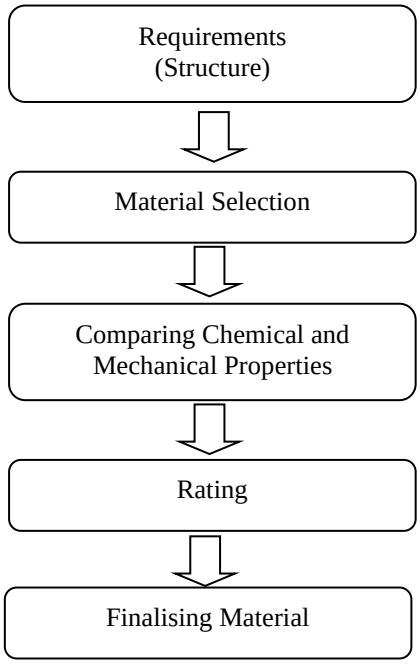
III. MATERIAL SELECTION

Selection of material makes a significant contribution in Design and Fabrication of Go Kart as it undergoes many stresses and Deformation during the fabrication process. During selecting any material, it is important to know what type of material is needed and what type & amount of forces are going to act on it. We should also note the Chemical and Mechanical properties as they are important aspects in determination of strength of material. The overall phenomenon of material selection is to select an optimum material through a scientific selection process as shown in the flowchart.



A. Chassis

Chassis is the main base of Go Kart therefore its material should contain high strength and cost should be low. Keeping in mind all the factors and the forces acting on the chassis we have we have selected three materials SAE 1018, AISI 1212 & AISI4130 and compared their mechanical and chemical properties. After comparing we found that SAE 1018 and AISI 1212 where heavy in weight and comparatively lower in strength than AISI 4130.

AISI 4130 also clear the factor of safety when normalized at 870

TABLE I. PROPERTIES OF CHASSIS MATERIAL

Ultimate strength	420 MPa
Yield strength	310 MPa
Density	7870 kg/m3
Strength to Weight Ratio	60 KN-m/kg

B. Stub Axle

Stub axle mainly consists of two types of load vertical and breaking road and vertical and cornering load. Keeping the two loading condition in mind we have selected AISI 4130 material for stub axle as it can with stand the maximum stress level for each case

C. Shaft design

Here the shaft used is hollow pipe. The shaft is the rear axle of kart on which disc & sprocket wheel are mounted. With the help of chain drive rear axle will transmit the generated power to rear or back tires. The material used for shaft is mild steel. External diameter of the shaft is 32mm and internal is 30mm. Mild steel will improve strength over carbon steel and it is easy to machine at supplied condition. The machining work of the shaft is done on lathe machine. On the shaft 4 keyways was done by machining, i.e. of 6*3 so that we can transmit the rotation motion to the wheels.

TABLE II. SHAFT PROPERTIES

Ultimate tensile strength	620 MPa
Yield strength	415 MPa
Hardness	58 Rockwell
Density	7.8452 g/cc
Young's modulus	210 a

D. Hub

The hubs are usually made from material aluminum OR mild steel. In this kart we have prepared the hub by using the lathe machine and material used is mild steel. It contains three holes of diameter 8mm through which we can fix the hub to the rim.

HUB DIMENSIONS:

Length = 80mm

Internal Keyway = 6*3

Diameter =76mm

The Chemical Composition used in our Go-kart for material AISI 4130 is stated below:

TABLE III. CHEMICAL COMPOSITION

Element	Content (%)
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
Sulphur, S	0.040

CHEMICAL PROPERTIES OF MATERIAL:

AISI 4130 Steel, normalized at 870°C (1600°F)

TABLE IV. CHEMICAL PROPERTIES

Component	Wt. %
C	0.28-0.33
Cr	0.8-1.1
Fe	97.3-98.22
Mn	0.4-0.6
Mo	0.15-0.25
P	Max 0.035
S	Max 0.04
Si	0.15-0.35

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MECHANICAL PROPERTIES OF MATERIAL:

AISI 4130 Steel, normalized at 870°C (1600°F)

TABLE V. MECHANICAL PROPERTIES

Physical Properties	Metric	English
Density	7.85 g/cc	0.284 lb/in
Mechanical Properties		
Hardness, Brinell	197	197
Hardness, Knoop	219	219
Hardness, Rockwell B	92	92
Hardness, Rockwell c	13	13
Hardness, Vickers	207	207
Tensile Strength, Ultimate	670MPa	97200 psi
Tensile Strength, Yield	435 MPa	63100 psi
Elongation at Break	25.5%	25.5%
Reduction of Area	60%	60%
Modulus of Elasticity	205GPa	29700ksi
Bulk Modulus	140GPa	20300kis
Poisson`s Ratio	0.29	0.29
Izod Impact	87J	64.2 ft-lb
Machinability	70%	70%
Shear Modulus	80GPa	11600ksi

IV. SYSTEMS OF GO-KART AND THEIR OPERATION

Few of Systems of our Go-Kart are discussed below:

A. Steering System

Steering system in our Go-Kart provides complete control to driver for better experience. The most ideal Steering system for Go-kart has found to be “Ackerman steering system” as it provides control of the vehicle and also it is easy to operate. This system provides steering radius of 4m or less, which helps in turning the kart to take a round on the same spot and also enhances turning propensity at the corners. The Mechanism of this System lies in its Geometry which makes the inner wheel steer to an extended projection as compared to the outer wheel. The primary goal of this system is to avoid the requirement for tyres to slip sideways, when it comes to curved path. Along with its simplicity, the system also comes with other major advantage of safety by decreasing the chances of accidents.

TABLE VI. STEERING SPECIFICATIONS

Sr. no.	Steering system	Ackerman steering
1	Caster angle	12 Degrees
2	Camber angle	0 Degrees
3	Kin-pin Inclination angle	7 degrees
4	Steering – wheel diameter	280mm
5	Combine angle	10 degrees
6	Scrub radius	9mm
7	Turning radius	3.5m
8	Tie rod	14 inch
9	Steering angle (inside)	30 degrees
10	Steering angle (outside)	25.52 degrees
11	Diameter of spindle	20mm

B. Breaking system

Breaking system is very crucial part for go-kart to decelerate or decrease the speed of the vehicle. With hydraulic disc brake it is possible to stop kart within 4 meters when rushing in full force. The master cylinder is provided at the front around the brake pedal which helps the driver to easily accessible space. By pressing the brake pedal, the vehicle stops or slows due to friction as the brake pedal compress against the rotor linked to the wheel. Hence, the car stops safely and efficiently. The lock-up rear wheels also enhance the functioning of the braking system with minimal cost and weight.

We have used YAMAHA RAY-ZR disc plate, which was preferred to gain sufficient ground clearance and better heat dissipation.

TABLE VII. BREAKING PARAMETERS

1	Inner radius of disc	130mm
2	Outer radius of disc	200mm
3	Thickness of disc plate (Double plated)	10mm
4	Pedal ratio	4:1
5	Coefficient of friction (Between pads & disc)	0.4
6	Brake pressure (Brake force/Area of Brake)	6.1M
7	Breaking torque	3137.63 N-mm
8	Breaking Force	3260.84 N

C. Transmission System

Transmission system is a device which provides motion to the wheels with the aid of motor. This system operates as a connecting link between engine and shaft by transmitting the power from the engine to the shaft using chain drive. Generally, this system does not contain differential gear box. The primary objective of this system is to eliminate all the major and minor power losses efficiently to acquire maximum speed using gears. The combination of CVT + belt drive provides high flexibility along with efficiency (approx. 88%) which consequently enables the input shaft to retain a steady angular velocity.

Gear ratio (overall):

First: 27.64 Second: 16.07

Third: 11.68 Fourth: 9.58

Primary reduction: 3.41

TABLE VIII. TRANSMISSION SPECIFICATIONS

1	Rear axel (EN8 Carbon steel Diameter)	30mm
2	Young’s Modulus	210Gpa
3	Poisson’s Ratio	0.29
4	Specific heat	450J/Kg-K
5	Density	7.8gm/cu.cm
6	Torque	19Nm
7	CVT to Chain Drive	For transmission
8	Sprocket teeth	41

D. Engine

The Engine employed in Go-kart is HONDA CB SHINE 125CC. We have bored the Engine to 129CC. The dimension

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of the Engine is 27 cm in length, 25 cm in width and 48 cm in height and it needs 59535 cubic square cm on and above chassis along with 30 kg dry weight. The maximum net power and maximum net torque has been found to be 7.58Kw@7500rpm & 10.30Nm@5500rpm respectively. Also, it has been established that the top speed with all the weight of go-kart will ground to 75km/hr and fuel economy will be 55km/lit. We have fulfilled all the required dimensions so as to achieve maximum power and torque.

TABLE IX. ENGINE SPECIFICATIONS

Specification	Value
Engine type	Air cooled, 4 stroke, SI Engine
Engine Displacement(cc)	124.73cc
Power (PS@rpm)	7.58 PS@7500rpm
Torque (Nm@rpm)	10.30 Nm@5500rpm
Bore	52.4mm
Stroke	57.8mm
Drive type	Chain drive
No. of Cylinder	1
Valves (per cylinder)	2
Fuel system	Carburettor
Fuel type	Petrol
Ignition	Digital CDI (multi mapping)
No. of gears	4

V. DESIGN

Designing is mother of inventions in any automotive industry or automotive sector because with the help of designing & newly developed designing software's the fabrication portion has got lot of ease also the scrap reduced which reduces in manufacturing cost hence the product cost reduced and common people as consumer got benefitted. The main target is to design a protected and operative vehicle which gives complete authority to driver to drive it. We have designed our Go-kart based on a unbending and torsion less chassis frame with an all-around mounted power train which help all of us to understand every tiny aspects of our vehicle structure design while doing this all we were carefully and strictly keeping the event rules and regulation in ours mind. We have designed our Go-kart model in CATIA V5R19. The design procedure of the vehicle depends on different engineering aspects such as:

(1) Safety and Ergonomics
(2) Availability
(3) Components overall Cost
(4) Safe Engineering Practice

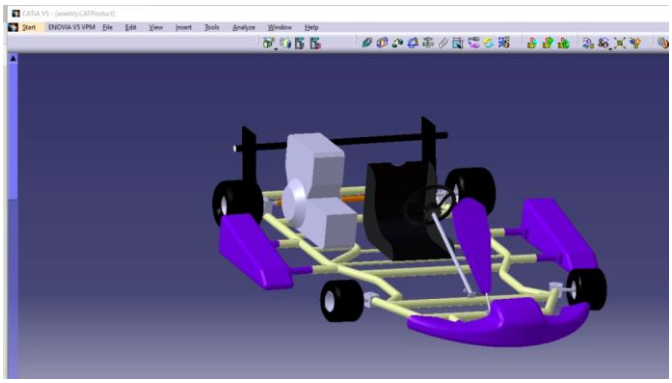

Fig. 3. Go-kart Model in CATIA V5R19

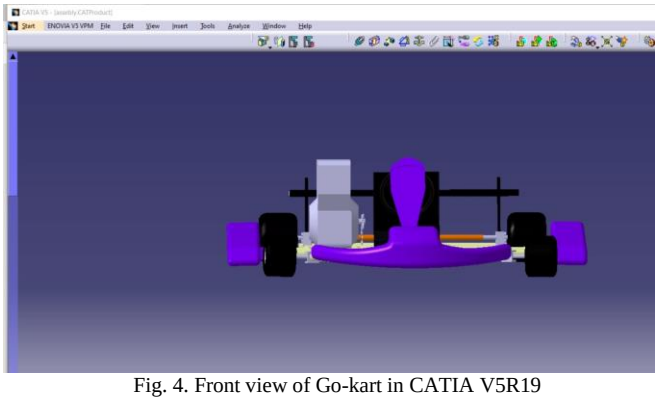

Fig. 4. Front view of Go-kart in CATIA V5R19

VI. ANALYSIS

We made our analysis on software named Ansys R15.0 analysis for few of Go-kart parts are shown below:

A. Stub Axle

We have chosen AISI 1040 steel as a material for the designing ours stub axle. The Force is equal to entire load of front tyres, cornering the magnitude of force which is 1.2g and kingpin movement were utilized to respective points while obliging the stud around all the directions. The deformation and equivalent stresses are stated below:

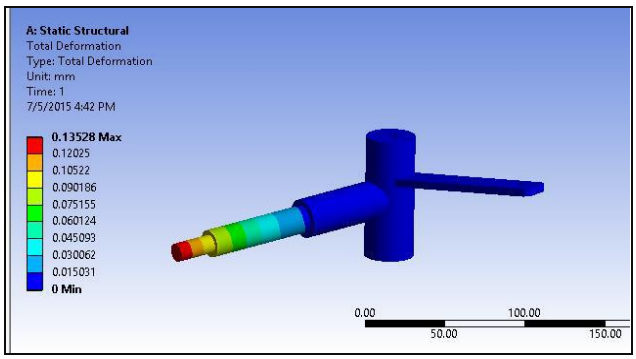

Fig. 5. Deformation

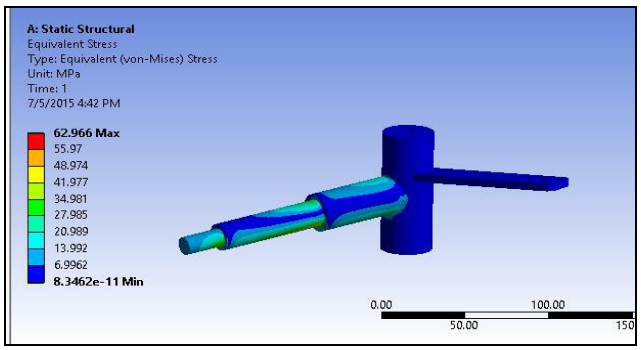

Fig. 6. Equivalent stresses

B. Frame Safety Analysis

We had chosen ANSYS R15.0 as a software workbench for analysis of chassis with the help of finite element analysis. To do the analysis of the chassis we used 3D CAD software CATIA V5R19. Stresses were calculated by simulating three different cases as front impact, side impact, and rear impact.

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Different cases of impacts are calculated by the procedure as follows:
As the mass of our Go-kart is 118 kg
And gravitational acceleration g = 9.81m/s^2. We assume it approximately as 10 m/s^2.
Calculations:
F = m x g
F = 118 x 10 = 1180N

1) Front Impact Analysis

As per standards we use 4G for front impact analysis.
Therefore,
Total force = 4 x F
= 4 x 1180 = 4720 N
Now this force was placed on the frontal part of frame by fixing the rear part in ANSYS R15.0. And the stimulated result in ANSYS R15.0 found is shown below

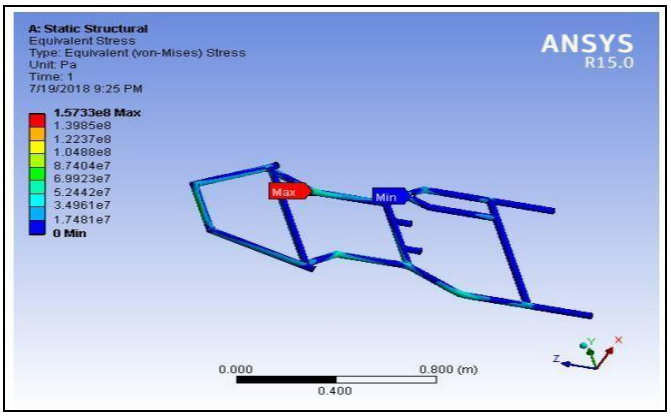

Fig. 7. Front Impact Analysis

2) Side Impact Analysis

As per standards we use 2G for side impact analysis.
Therefore,
Total force = 2 x F
= 2 x 1180
= 2360 N
Now this force was placed on one side of the frame by keeping the other side fixed in ANSYS R15.0. And the stimulated result found was shown in below

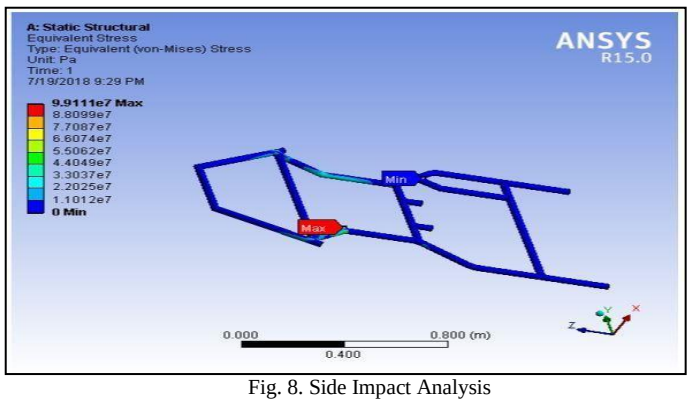

Fig. 8. Side Impact Analysis

3) Rear Impact Analysis

As per standards we use 4G for rear impact analysis.
Therefore,
Total force = 4 x F
= 4 x 1180= 4720 N
Now this force was placed on rear part of the frame by keeping the frontal part fixed in ANSYS R15.0. And the result found was shown in below

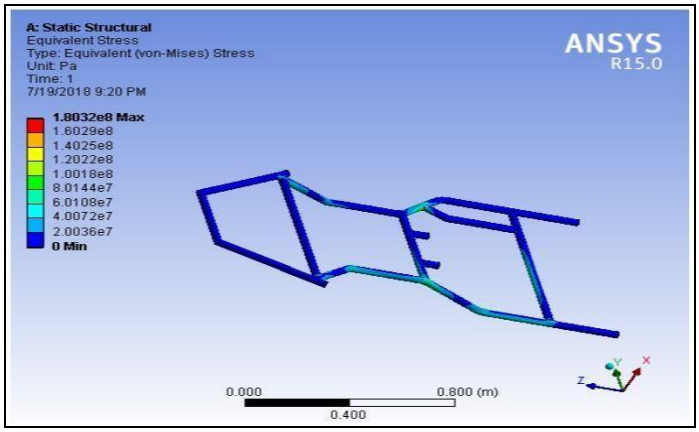

Fig. 9. Rear Impact Analysis

Conclusions of the analysis

TABLE X. CONCLUSION OF ANALYSIS

FACTORS	FRONT IMPACT	SIDE IMPACT	REAR IMPACT
Impact Force	4720 N	2360 N	4720 N
Stress Generated	157 Mpa	99 Mpa	180 Mpa
Total Deformation	0.005 m	0.0006 m	0.0022 m
F.O.S	3.56	5.67	3.11

VII. PERFORMANCE ENHANCEMENT IN GO-KART

A. Aerodynamics

Aerodynamics plays important role factorizing in improving speed, traction, efficiency & reduction in drag force. 'Basically it is study contributing the analysis of air motion through in interaction with various parts exposed air drag reducing sudden obstructions in air flow. It is the only science which gives us overall efficiency without sparing any external energy for it, just by improving aerodynamic shapes and air movements for the part.

Thus aerodynamic factor adds competitive value for the vehicle reducing significant lap time & increase in speed.

1) Front Bumper

The streamline shape of front bumper gives smooth flow of air throughout the bumper So Kart has no sudden drag and current has no interaction with the front wheel giving the free movement of air through the front wheel minimizing eddies formation.

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Fig. 10. Front Bumper

2) Side Bumper

The front end of the side bumper is narrow so that the incoming air can move smoothly without any sudden air impact as happens in flat box barriers; the rear end of bumper is extended through giving the free movement of air through the wheel and minimizing eddies impact.

Fig. 11. Side Bumper

3) Front Nose

The front nose is maintained at an angle more than 45 degrees giving air crossover above drivers helmet. Giving no direct air impact on driver at high speed.

4) Flat Bottom

A flat sheet is introduced in the chassis frame same as that of chassis shape giving a flat base to the kart improving the aerodynamics

5) Rear spoiler & bumper

Rear bumper introduced is a round bar instead of a flat sheet/plate giving free flow of air current through the round bar. As the base of go-kart is introduced with the flat sheet so there are necessary chances of uplift of vehicle at high speed hence rear spoiler helps us to provide necessary downward force giving good track grip.

B. Steering Geometry

1) Castor Angle

Angle introduced between vertical and pivot line, we have given 12 degrees of castor angle to the wheel. It is been given to provide the directional stability & ease of steering at high speed.

2) King pin inclination

The inward tilt at an angle from vertical plane determines the K.P. inclination. We have provided 10 degrees of K.P. Inclination to the wheels. The K.P. inclination It helps to keep vehicle straight ahead & being a vehicle without power steering it helps us automatic return of wheel after completion of turn and giving good steering control.

C. Managing Center of Gravity and Weight distribution

The most weighed components of vehicles are managed & placed at centralized position without hampering performance and safety/ Example/ The placement of fuel tank, centrally behind the seat, the centralized position of driver's seat & steering system.
Being a vehicle with low ground clearance and even mass distribution Center of gravity is being managed to be extremely low Thus giving good road grip, better turning ability and less tilt chances at high speed.

Fig. 12. Fuel Tank

VIII. CONCLUSION

As we know for making any Go-Kart the foremost important point is the design of Go-kart. Then come the material selection which we use for making the base of a Go-Kart i.e. Chassis on which all the parts of the Go-Kart are mounted. The material which we have used is AISI 4130 which is free from failure and safe for the rider.

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The engine which has been used according to the requirement of the GKDC GO-Kart book is 135 cc. of Honda shine.
The steering of the kart is made in wide angle Ackerman's geometry.
The braking system of our Go-Kart gives more confidence in riding the kart. It has a disc brake mounted on the rear shaft which brings our Go-Kart to halt within 4 meters when running on top speed.
Following are the results of the performance of the go kart:-
Fuel economy – 55kmpl
Wheel base - 107 cm
Braking - stops within 4 meters when running on top speed
Reach 0-70 - within 4 sec.
Top speed - 75 kmph.

Fig. 13. Completely Fabricated Go-Kart

IX. FUTURE SCOPE

People are always in search of a new source of entertainment and racing is one of them. Go kart is gradually becoming one of the most important components of racing industry.
As we know every automobile industry is going electric, Go-kart is also moving from 2-stroke and 4-stroke engine to electric engine. It is more efficient. It is also eco-friendly as it doesn't emit any smoke. Electrical engines are low maintenance; just require the lead-acid or lithium-polymer batteries to charge after every run. Some karts are even fit with hydrogen fuel cells.
Over the last five years, we have seen a great market spike in business of go kart. The industry is flourishing. Many big companies are willing to invest in this sector as its popularity is growing immensely.
Even in India, we have seen the same growth as worldwide. Many small industries are trying to make their presence in this industry. They are making small spare parts and contributing the industry.

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