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Research Article

Design Analysis and Manufacturing Tips to Build a Compact Go-Kart

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Abstract

Go-Karting is one of the passionate competition where young Engineers Shows there Designing and manufacturing Skills by manufacturing a go-kart and making it participate in various events we as a team participated in various events by building number of Go karts and this report documents the process and methodology to produce a low cost go-kart which is compact, vulnerable, durable and complete in all aspects by modeling it with CATIA software The feasibility of the go-kart design was examined through FMEA, Cost report these design simulation helps the go kart to estimate its capability and overall performance . The team focuses on a technically sound vehicle which is backed by a profound design and good manufacturing practices. The report explains approach, reasons, selecting criteria and expected working of the vehicle parameters. This report helps you from getting a vehicle deigned to get it manufactured. The procedural way of explanation is used for different parts of the vehicle, which starts from approach with the help of known facts, then the design and calculation procedure has been explained. The best way known had been use to go on to the final result of all parameters to manufacture a perfect performed go-kart. We had developed a compact go-kart which results in robustness and increase in speed and overall performance of vehicle

Keywords: Parallel Ackerman, Compact Vehicle, Raid quality, Driver comfort, Traction force

INTRODUCTION

The go-kart will be built from the ground up to maximize the efficient use of space. We approached our design by considering all possible alternatives for a system & modeling them in CATIA software like CREO Parametric 2.0 and subjected to analysis using ANSYS 15.0 FEA software. Based on analysis result, the model was modified and retested and a final design was frozen. This started our goal and we set up some parameters for our work, distributed ourselves in groups for the technical design of our vehicle.

Table 1: Material selected and their Properties

Materials	Yield strength (MPa)	Percentage elongation at break
AISI 1026	260-440	17-27%
AISI 4130	435-979	18-26%
AISI 1020	230-370	18-28%
AISI 1018	270-400	18-29%

It is observed that material which has high machinability and inexpensive is AISI 1018, hence was a good choice but strength to weight ratio is greater for 4130.

AISI 1020 was rejected because of its high cost. AISI 4130 was rejected because of its high carbon content and lack of machinability, 4130 have the superior harden ability that other iron alloys like 4130 and 4140 possess. But 4130 is a popular steel in race car industry but is not easily available in India. Therefore, the material that the team chose to use is AISI 1018.

The benefit of using the AISI 1018 is that it can be easily welded than the 4130 material. The AISI 1018 has the same Modulus of Elasticity (E) and density as the 4130, so using it does not affect the weight or stiffness in member with same geometry.

Chemical Composition and Physical Properties of AISI 1018

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Table 2: Chemical Composition

Element	Content
Carbon (C)	0.14-0.20%
Sulphur,(S)	<=0.050%
Iron,(Fe)	98.81-99.26%
Manganese(Mn)	0.60-0.90%
Phosphorous(P)	<=0.040%

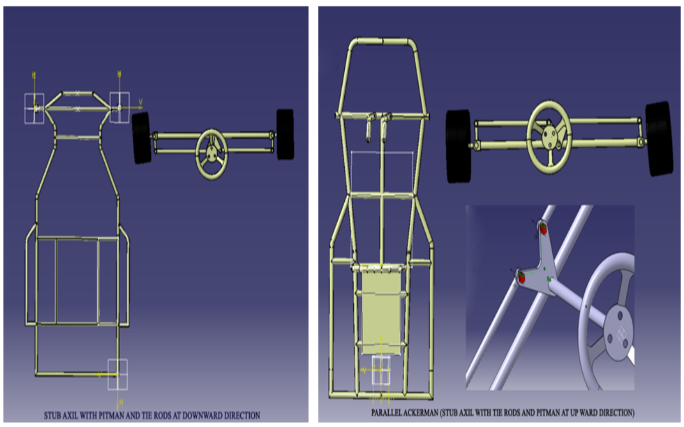
Table 3: Physical properties

Properties	Value (Metric)
Density	7.87g/Cc
Yield Tensile Strength	370 Mpa
Elongation At Break (In 50 Mm)	15%
Poisons Ratio	0.29
Modulus Of Elasticity	200Gpa

Design of Chassis

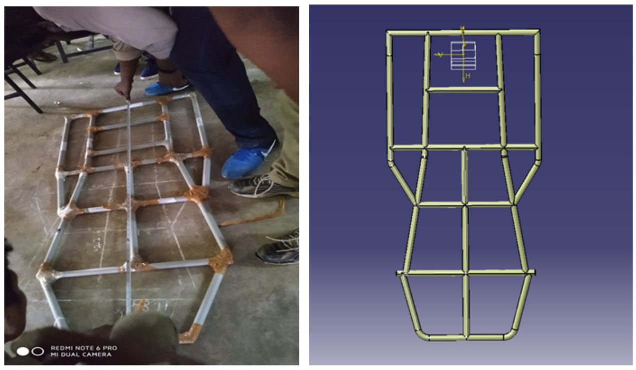
Some of the considerations are taken to design our kart such that we reduce the wheel base as small as possible by making the parallel ackermann so that the stub axel which holds the front tire gets forward direction and the whole setup takes at forward direction.

Figure1: Stub Axil Placement in General Chassis and Our Chassis (Anti Ackerman)



Analysis of go-kart chassis, especially the torsional stiffness and bending deflection, After the best possible design, is determined, the *prototype* has been built and. For who takes karting seriously, they need a chassis that are able to suit.

Figure 2: Prototype of Our Chassis



Chassis Design Specification

The chassis is design in such a way that it sustains more impact and less deformation as the primary members and secondary members of the chassis are in equal diameter and secondary members are placed in every part of the chassis where the impact occurs so that the secondary members can easily with stand the impact min every direction.

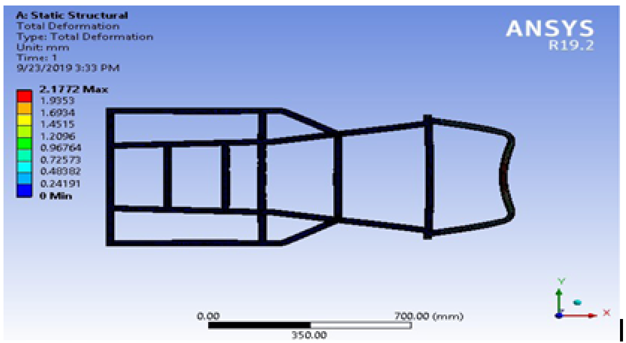
Frame Analysis

For the purpose of analysis, we have conducted Certain Tests on the Chassis, which are:-

Analysis of the Chassis Using Ansys Software

Front Impact Test

Figure 3: Front Impact Test of Chassis



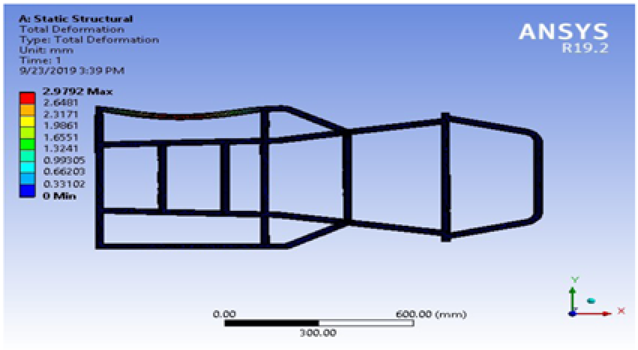
$$\frac{yield\ strength\ of\ 1018}{von\ mises\ stress} = FOS$$

$$FOS = 370/118.75 = 3.11$$

The Front Impact Analysis has been carried out on the Ansys 19.2 while constructing a perfect space frame tubular chassis on Creo 2.0 Surface module and then it was imported to Ansys 19.2. Gusset plates have been applied on the regions where the stress concentration was more. A force of 7500 N was applied to the front ends constraining the body panel rods and we had seen such results as shown above and assuming the deceleration .On applying a force of 7500N, the maximum deformation of 1.2771mm for observed in the chasses. This deformation is within the acceptable limits

Side Impact Test

Figure 4: Side Impact Test of Chassis



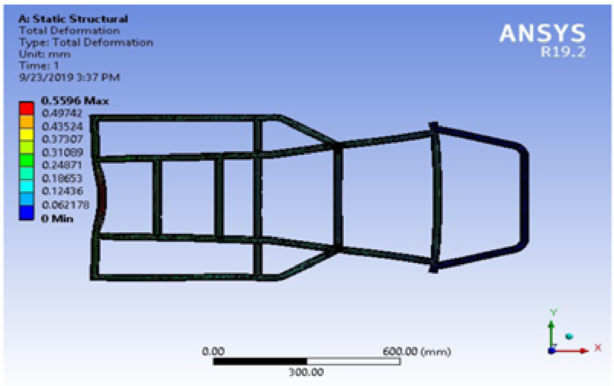
$$\frac{yield\ strength\ of\ 1018}{von\ mises\ stress} = FOS$$

$$FOS = 370/112.8 = 3.28$$

The Side Impact Analysis has been carried out on the Ansys 15.0while constructing a perfect space frame tubular chassis on Creo 2.0 Surface module and then it was imported to Ansys 15.0 with a Force with respect to the 2G criteria.

Rear Impact Test

Figure 5: Rear Impact Test of Chassis



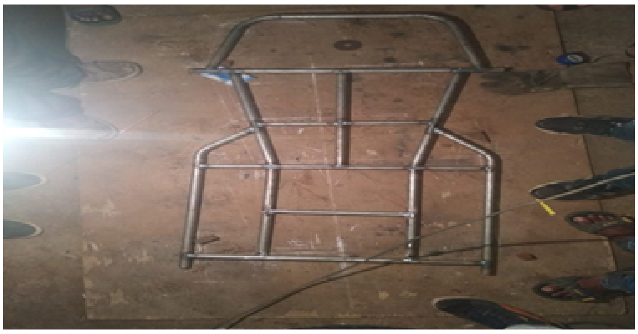
$$\frac{yield\ strength\ of\ 1018}{von\ mises\ stress} = FOS$$

$$FOS = 370/101.5 = 3.64$$

A force of 5450 N was applied to the rear ends by totally constraining the degree of freedom of the suspension points and we had seen such results as shown And assuming the deceleration of 3G .A force of 5450N has been applied and the observed deformation is 3.9mm. and is within the acceptable limit.

Welding Of Chassis

Figure 6: Chassis after Tungsten Inert Gas Welding



All welding must be carried out professionally to a high degree of accuracy by trained personnel. Avoid welding on the chassis frame as all welding increases the risk of fracture formation in the area around the weld. This applies particularly to areas on the frame with high requirements regarding strength and fatigue strength. TIG welding produces cleaner and more precise welds than MIG welding or other Arc welding methods, making it the strongest. That said, different welding jobs may require different methods, while TIG is generally stronger and higher in quality, you should use MIG or another method if the job calls for it. TIG welds are better for thinner metals and smaller projects because they produce precise and clean welds. Control. MIG is typically easier to control and is better for beginners.

We prefer TIG welding as it gets much more finish and has more material strength compare to other welding techniques and in every go-karts the primary members should be weld in a single technique and for secondary members it can be changed, compare to all other methods TIG welding is mostly considered in all automobiles.

Chapter 2

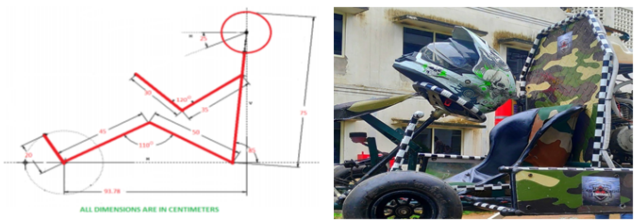
Body & Composites

The purpose of the body is to prevent debris from entering the vehicle, with the intent of protecting the driver and the vehicle's components. The seat was designed to support the driver comfortably and safely while they are operating the vehicle

Seat

The seat in this kart is also designed to be very light it is very simple made of plastic material and is attached to the chassis by four points only

Figure 7: Seat Inclination And Its Alignment



Seat fixture angle

The back rest angle of the seat is at 13 degrees which is the good position of the drivers body rest according to the ergonomics point of view and is kept almost parallel to the fire wall the seat implemented in our go kart provides a good combination of weight reduction and ergonomics.

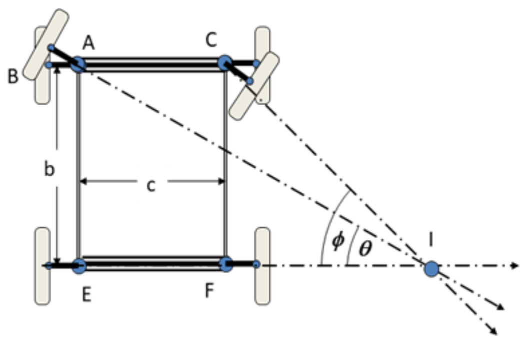
Chapter 3

Steering

The steering system is of important part of the dynamic design of any automobile to facilitate a smooth change of directions and make use of the tires ability to generate lateral forces to the highest extent. A racing driver's sensory inputs supply visual, tactile, and inertial information used in developing a "feel" for car handling and performance. This feedback is necessary in enabling the driver to extract maximum performance from the race car. Hence the steering is an important feedback mechanism giving the driver information on stability and directional control. The control of an automobile is done by means of a steering system which provides directional changes to the moving automobile.

Ackermann principle of steering to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radius, Ackermann principle of steering is used. Assumptions

Figure 8: Steering Mechanism



$$\cot \varphi - \cot \Theta = c/b$$

Θ = angle turned by inner wheel

φ = angle turned by outer wheel

b = wheel base

c = distance between pivot points

Assumptions

- 100% Ackermann steering geometry.
- Optimum kingpin inclination angle range is 4° to 8°.
- Front to rear weight ratio is 40:60.
- Taking acceleration due to gravity as 1

Steering Mechanisms

We went through "Davis" and "Ackermann" steering mechanisms.

Davis steering mechanism obtains the required steering angle using sliding pairs. Due to the presence of such sliding pairs, mechanical wear and tear increases. This increases the possibility of failure. Also due to the increase in the number of links, it increases the weight making it bulky and inefficient.

Ackermann steering mechanism is basically a 4 bar linkage mechanism. It consists of turning pairs and no sliding pairs. This helps to decrease the wear and tear of steering mechanism.

- Thus, we prefer Ackermann steering mechanism over Davis steering mechanism
- Ackermann steering mechanism is basically of 3 types -
- Ackerman steering mechanism-Angle turned by inner wheel is greater than that of outer wheel.
- Pro-Ackerman steering mechanism-Angle turned by inner wheel is less than that of outer wheel.
- Parallel (or) anti-Ackermann steering mechanism-
- Angle turned by outer wheel is equal to that of inner wheel.

In case of Ackermann, there was also a problem of interfering of tie-rod with the suspension strut. In Pro-Ackermann, wear of tires is more. Instead, Anti-Ackermann steering mechanism is used.

Wheel Alignment

Camber Angle

It is the angle made by the wheels from the true vertical when viewed from the front of the car. When camber is set chances of slipping increases. In case of positive camber outer edge of tyre wears out faster and vice versa. "Hence it was decided to set 0 camber".

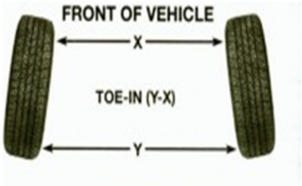
Caster Angle

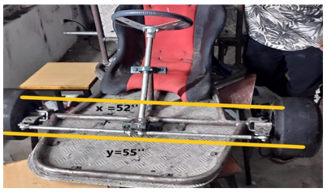
It is the angle between steering axis and the vertical, in the plane of the wheel. When the Caster Angle line hits the ground in front of where the tyre contact with the ground, this is Positive Caster. It determines the amount of self-centering the steering will have, influence the straight-line running. Also the steering axis inclination will influence the camber change when cornering as a function of the steering input. Large Caster Angles mean greater camber changes can be created and that means better negative camber when cornering and smaller camber on the straight, ideal for both performance and wear of the tyre. Unfortunately too large a caster angle can lead to poor turn-in. In our vehicle it is 5 degrees.

Toe Angle

Deviation of the wheels from straight ahead position. In case the wheels are pointing inward it is called toe in and if outward then toe out.

Figure 9: Toe Angle of Go-kart



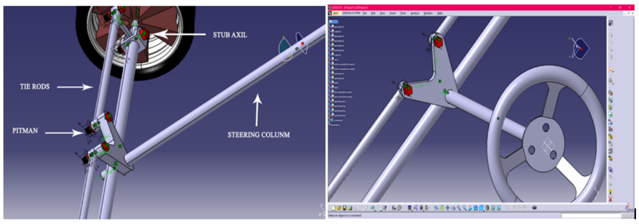


X = 52 inch, Y = 55 inch

Cad model and analysis of Steering System

A Steering System Consist of Different Moving Parts which helps the vehicle to get into its Direction Such that the torque which is applied to the Steering wheel turns the pitman and pitman helps tie rods to travel to some extent and stub axil is moved as we know the stub axil is connected to the tyre and the tyre rotates

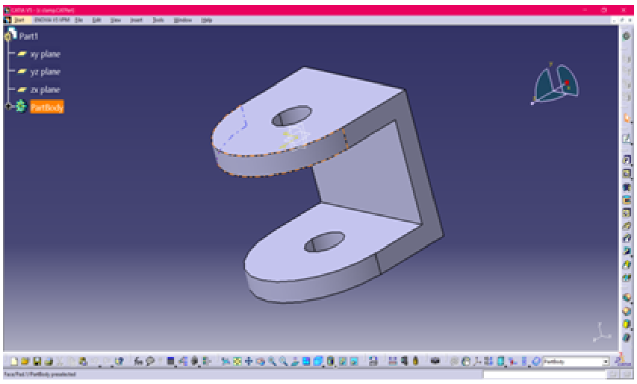
Figure 10: Steering assembly of Gokart in Catia V5



Frictin is generated from Every part of the steering syestem as they have moving parts ever link is attached it a fastner and the to and flow moment Regulates the friction So the friction losses occures and in any steering system the C clamp inclanation plays a key role to get ore turning Radius

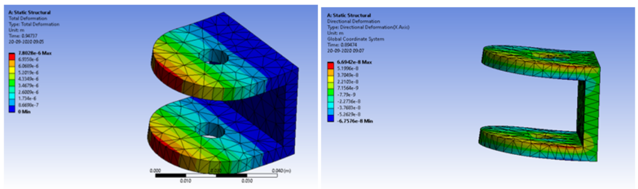
Clamp Cad madel and analysis

Figure 11: Cad model of c clamp



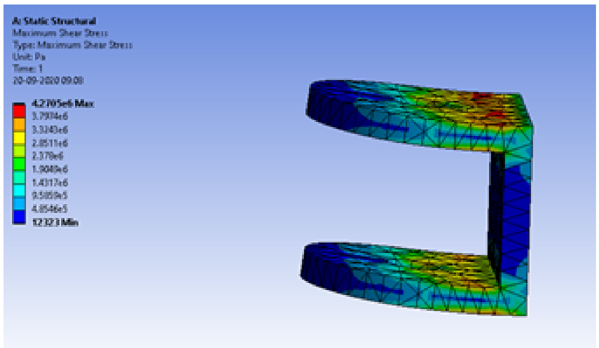
C –Clamp is One of the main Objective to built a perfect Gokart as the Camber and caster depends upon the inclination of the C Clamp . In Manufacturing process the C clamp should be Carefully placed asa misplacement of C Clamp leads to Defect of chassis and when they are not placed correctly the kart gets Bump effect when it ets turned

Figure 12: Total and Directional Deformation of C Clamp



Fixing the side of the C Clamp and applying Tensile force of 100N at the edges of Clamp Results in the image and the total deformatin is 0.0866mm and directional deformation is 0.066mm as the stub axil is attached to the c clamp and when an obstacle of 100N is imparted by tie rods to the tyre this is the result.(We cannot estimate the exact value of force of impact to the tyre during motion thus taking the driver steering effort to tie rods longitudinal force, stub axle knucking force, c-clamp force)

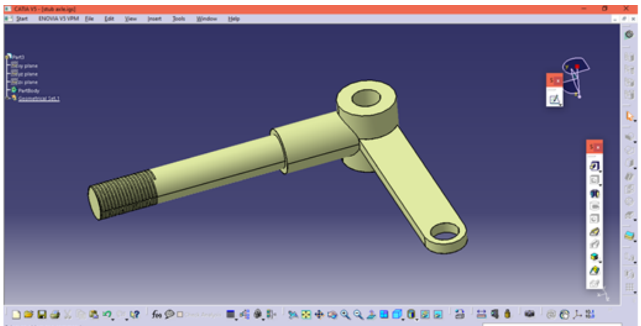
Figure 13: Shear Stress of the C Clamp



100N of Force applied to the clamp results in Shear of 4.29 mm Deflection which doesn't bother the kart

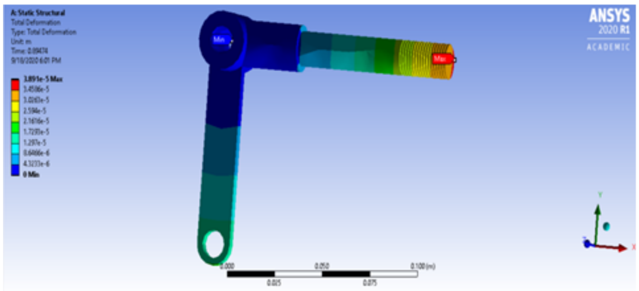
Stub axil Cad Model and Analysis

Figure 14: Cad model of Stub Axil



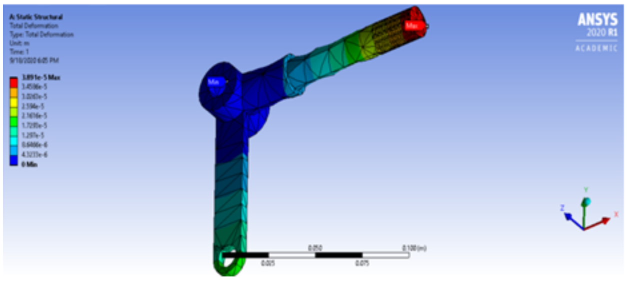
Stub axil is the one which connects the Tyre to the chassis as it is one of the most important part of the steering system as one end of the sub axil is connect to tyre and another end is connected to the tie rod and it depends upon the inclination of C Clamp the outer wheel has more turning radius compare to the inner one

Figure 15: Directional Deformation of Stub Axil



One end of the stub axil is connected to the Tie rod and other End is connected to the tyre of the Gokart so, when the Driver applies Some torque to the steering wheel the steering column rotates as the pitman is connected to it , pitman compresses the tie rod so that the tie rod travels forwards and helps stub axil to turn the tyre. Considering this mechanism to applied a total of 100 newtons of compressive force at one end and tensile force at other end .

Figure 16: Total Deformation of Stub Axil



Total deformation of the stub axil is 0.0411mm when applied with a compressive force of 100 N at one end and tensile force at another ends Results the deformation of stub axle.

Tie rods Cad model and Analysis

Figure 17: Cad Model Of Tie Rods

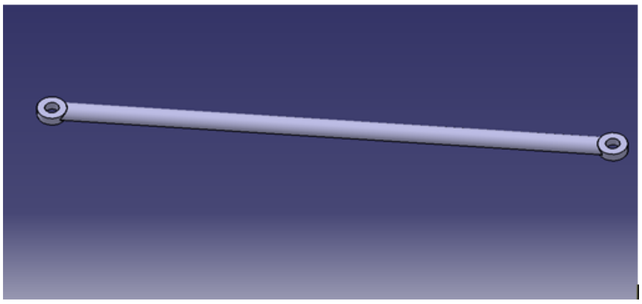
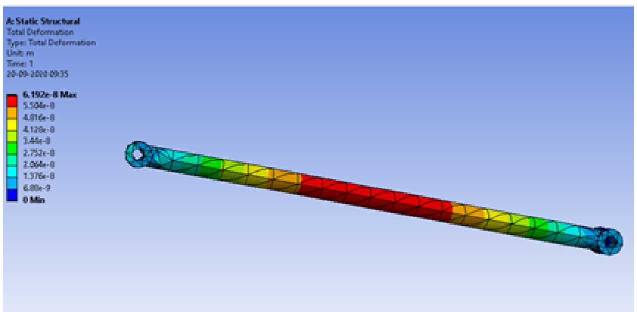
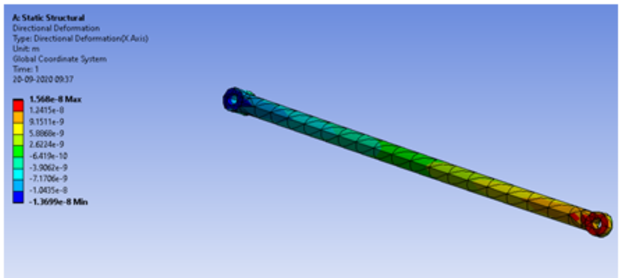


Figure 18: Directional Deformation of tie rod



More forces are acted on tie rod as the force applied by the driver and the force obtained while driving impacts the tie rod and leads to the deformation so by considering that condition we fixed on side of the tie rod and applied a force of 100N at another side and a deformation is obtained in mm, which has occurred as the red portion of the tie rod indicates the total deformation of the tie rod

Figure 19: Total Deformation of tie rod

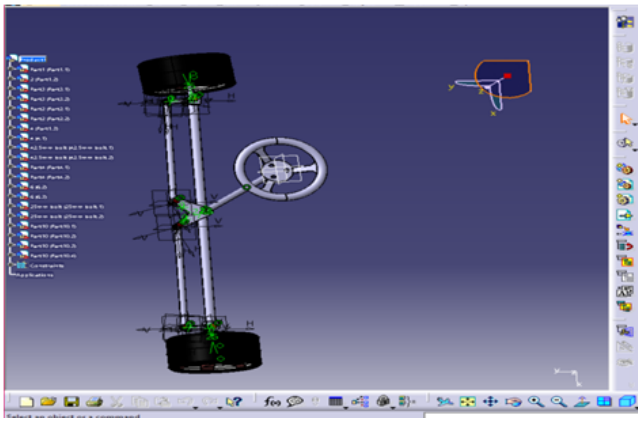


Geometry

Factors fixed before performing iterations

- Wheel track = 35.82"
- Wheel base = 37.79"
- Steering Wheel lock to center = 270 degrees
- Iterations were performed by varying length of tie-rod and steering arm and rack offset from axle in Catia

Figure 20: Catia model of Paralle or Anti Ackerman



Based on these iterations the following values were obtained:

Steering arm = 110 mm

Tie rod = 353 mm

Outer turning circle radius = 3.277 m

Initial Angle of Steering Arm = 20.9449 degrees

Ackerman Angles

Inner Wheel = 43.3291 degrees

Outer Wheel = 28.6705 degrees

Steering Ratio

The steering ratio is the amount of degrees you have to turn the steering wheel, for the wheels to turn an amount of degrees.

Steering ratio = (Lock to lock steering wheel angle)/(sum of inner and outer wheel angle)

Steering Effort

Steering Ratio of Our kart = 1: 1

Steering effort in static condition

Radius of steering wheel = 150 mm

Effort at steering wheel = Torque at pitman / Radius of steering wheel= 13.12N

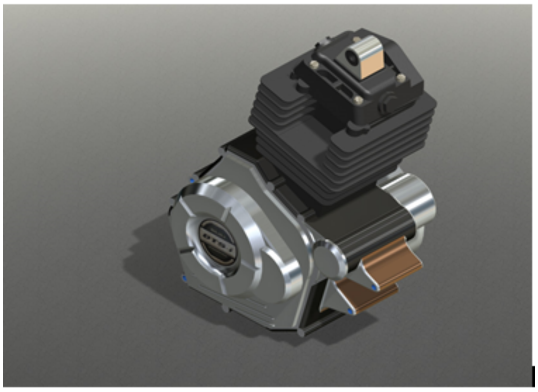
Steer Effort = 13.12N

Chapter 4

Power Transmission System

In a vehicle, the mechanism that transmits the power developed by the engine to the wheels is called the power train. In a simple application, a set of gears or a chain and sprocket could perform this task. However, automobiles are not designed for such simple operating conditions. Power train is designed to provide pulling power, to move at high speeds, to travel in reverse as well as forward, and to operate on rough terrain as well as smooth roads. To meet these varying conditions, vehicle power trains are equipped with a variety of components. Transmission system or power train is composed of clutch, gear box, propeller shaft, universal joints, rear axle, wheel and tyre. The transmission can provide torque needed to move the vehicle under a velocity of road and load condition. It does this by changing the gear ratio between the engine crankshaft and drive wheel. There are two basic types of transmission: manual and automatic, shift automatically. Basic requirements of transmission system are, it provides for disconnecting the engine from the driving wheels. When the engine is running, to enable the connection to the driving wheels to be made smoothly and without shock. It enables the leverage b/w the engine and driving wheels varied. Speed reduction b/w engine and the drive wheels. It enables power transmission at varied angles and varied lengths. Drive the driving wheel at different speeds when required.

Figure 21: Catia model of Pulser 150 cc Engine



Purpose of Transmission System

There are two reasons for having a transmission in the automotive power train or drive train. The transmission can

• Provide torque needed to move the vehicle under a velocity of road and loadcondition. It does this by changing the gear ratio between the engine and crankshaft and vehicle drive wheel

• Be shifted into neutral for starting the engine and running it without turning the drive wheels.

Specifications of Engine in Power Train

Tablel 4: Clutch

Clutch	Wet Multiplate
No. Of Cylinders	1
Valves Per Cylinder	2
No.Of Gears	5
Compression Ratio	9.5 ± 0.5 : 1
Coolant	Air Cooled

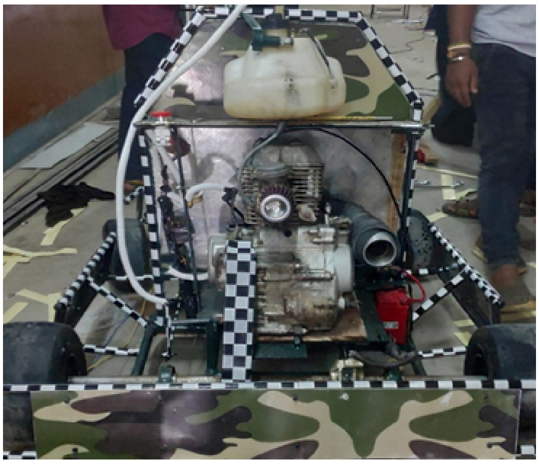
Table 5: Transmission specifications

Transmission specifications	Values
Displacement	150cc
Max. Power	14hp @ 8000 rpm
Max. Torque	13.4N-m @ 6000rpm
Bore	57mm
Stroke Length	56mm
Type Of Engine	Internal Combustion

In Go kart vehicle, the power from engine is transmitted to the sprocket using chain i.e. chain drive. Usually Go karts do not have a differential gear box so it is eliminated from vehicle. The power from the engine is transmitted to the rear two wheels using chain drive. In Present work chain drive is used because it is capable of taking shock loads.

Engine Placement in Kart`

Figure 14: Placement of Engine in Rear side of the GoKart



Power Transmission Calculation to Find the Output of the Engine

Tractive Force

μmg =0.6*160*9.81

= 941.76N

Gear Ratios	
First Gear	3.47
Second Gear	1.89
Third Gear	1.26
Fourth Gear	1.04
Fifth Gear	0.92
Total Gear Ratio	2.4

Starting Torque

FT*R =824.04*0.27

= 99.69N-m

Torque Required To Start a Vehicle

= 70N-m

Grade Ability

R GVW g sin grade □□□□

ϴ= 24 degrees

Gradability = 53%

Velocity

=Engine rpm* wheel tire perimeter/ gear ratio *axle ratio

=71Kmph

Table 6: Performance

Performance	
Torque Required	70n-M
Torque Available	100n-M
Acceleration	$3.8m/S^2$
Velocity	71kmph
Gradeability	53%

Acceleration

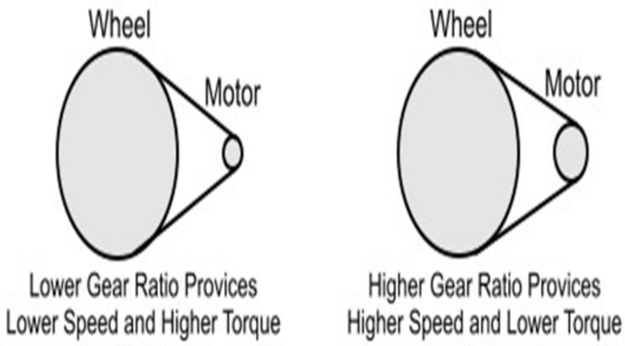
Power without loss = 142Kmph

Power with loss = 70Kmph

Ax = 10m/sec

Gear Ratio

Figure15: Types of Gear ratios and Gear ratio in our kart



Chapter 4

BRAKING

Braking system is one of the most important and fundamental system of a vehicle. They are required to stop the vehicle within smallest possible distance and this is done by converting the kinetic energy of the vehicle in to the heat energy of the vehicle which is dissipated in to the atmosphere.

The main design objectives are as follows:-

Achieving Light Braking system, focusing more at unsprung mass by incorporating inboard braking system.

To have optimum pedal ratio considering the incorporation of inboard design and also thus shifting towards lighter brake calipers(single piston)

- Good pedal placement to facilitate driver comfort and having good serviceability.
- Actuating system of brakes can be mechanical, hydraulic or pneumatic
- The modern basic types of brakes used in nowadays are
- Drum Brakes
- Disc Brakes.

Selection of Brakes

We had used a Hydraulic Disc Brake considering the following advantages, availability, and their limitations. For selection of best braking system in go-kart you have to keep some points in your mind:

- Hydraulic system
- Disc brake
- Master cylinder
- Brake lines
- Caliper double piston caliper

Master cylinder

Master cylinder with required dimensions of piston is used to generate appropriate pressure in the brake circuit. Brake pedal with optimum pedal ratio is used to apply force to the master cylinder. Pedal ratio is the mechanical advantage provided by the pedal

Brake Caliper

For achieving a better braking efficiency and to improve the vehicle braking effect we have opted to use double piston single caliper for all rear wheel drive measuring 1.25" bore diameter.

Brake Pedal

The swing pedal assembly has made the braking operations easy in terms of driver comfort while the pedal ratio of 6:1 has led to a significant pressure in the brake lines against the fixed MC of ¾ inch thereby promoting safe braking.

Brake Lines and Fluid

Brake lines and fluid lines are less concerned yet they play a major role. Pressure from master cylinder to the brake calipers. Brake lines made of carbon nickel alloy followed by flexible stainless- steel hose pipes are used. Pressure generated in master cylinder is carried to the caliper by the brake fluid confined in the fluid lines. Brake fluids generally used are glycol- based, however silicon based brake fluid can also be used. Pressure generated in the master cylinder by the force multiplied by the pedal effort is transferred to the caliper through the fluid lines. From the end of the chassis flexible steel hose pipes are engaged, as the brake lines have to be stretched when the wheel turns. Dot 3 brake fluids has been used in the circuits as it is reliable and cost efficient.

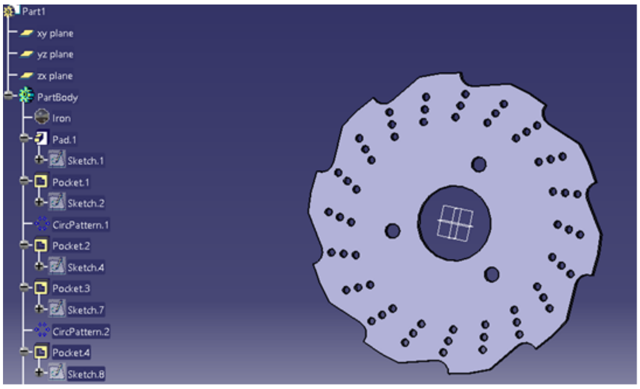
Rotor

The rear disc has been designed to integrate with the final drive, thus eliminating the requirement of a mounting hub. The rear rotor of 180 mm is enough for the required safe braking operation

Braking System Analysis Phase

The braking system is thus the foremost phase at which the efficient braking conditions is obtained at maximum speeds. It mainly depends on the type of braking and pressure limits within the cylinder and caliper setup. An assumption is taken that by neglecting fluid and contact losses in the master cylinder and caliper, the maximum fluid pressure obtained is directly transferred to the caliper without any loss in it. Thus according to the calculations, the analysis phase is performed on the disc plate (brake pad) with taking general factors such as radiation, heat flux and conduction of the material in general.

Figure 16: Catia model of Disc plate



Outer diameter= 120mm, Inner diameter=30mm

Area of the pad= (π/4)*(1202-302) =0.0106m2

Analysis

Conduction: 230W/m2. °C, Radiation =1(by assuming as black body) ,

Heat flux=Brake Power/Area of brake pad =

Kinetic energy/(time*area of pad) = [0.5*185*11.112]/[1.61*0.0106]

= 11417.46/0.017066 = 669017.93W/m2

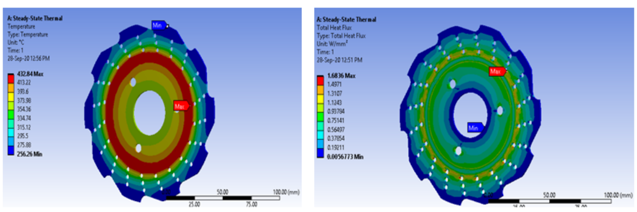
The above values are inserted in the analysis settings as input parameters.

The obtained results are:

- Thermal Analysis (A,B) & Fatigue analysis(C,D,E)
- Temperature
- Total Heat Flux
- Total Deformation
- Equivalent Stress (Von mises)
- Fatigue factors (life, damage, safety factor)

Thermal Analysis

Figure 17: Thermal analysis of disk



Obtained Temperature = 432.48°c (Max) Total heat flux = 1.6836W/mm2

Fatigue Analysis

Figure 18: Fatigue Analysis

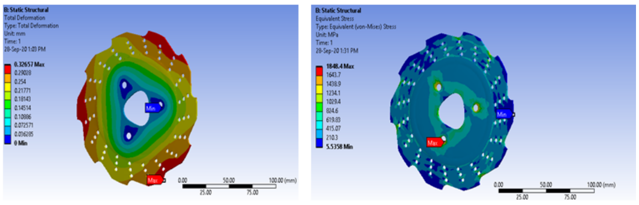
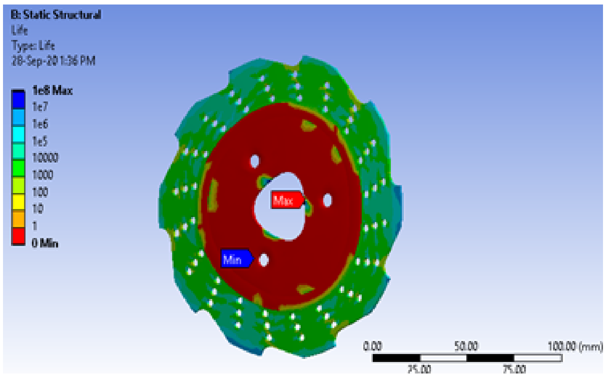


Figure 19: Life analysis



Calculations

Every racing vehicle requires good brakes to have control over the speed and stop the vehicle at any point of time within shortest time period and stopping distance. In order to achieve maximum performance from the braking system, the brakes have been designed to lock up rear wheels, while minimizing the cost and weight. To achieve best braking parameters in our Go Kart all the static and dynamic loads were calculated at the rear and front wheels.

Master Cylinder

Retardation of the body at any given time is: (co-eff of adhesion)*(acc. Due to gravity) = K*g

K: 0.7 for dry roads

Therefore retardation

(A): 0.7*9.81

= 6.686m/s

Front axle dynamic load is given as

(Wf): Wf = w1 + (a/g) ×W× (h/L)

w1 = Static load on the front wheels

= 74Kg

w2 = Static load on the rear wheels

= 111Kg

a = retardation of the vehicle

W = Weight of the vehicle

=185Kg

h = Distance of C.G from ground

= 0.29m

L = Wheel Base

=47 inch = 1014m

Braking Force

(Fb) Fb= (W*a/g) = 1269.1N

Braking efficiency

(Fb/W)*100

= 69.2%

Stopping Distance

d = v^2 /2 a v = 40 km /h = 11.1 m/s (as per rulebook)

d = 12 m (maximum)

Now the Dynamic Loads,

Wf = 105.52Kg, Wr = 79.47Kg

Braking Torque Produced:

(frictional force)*(effective disc radius) 1124.8*0.09

= 105N

Braking Torque

= 105N

Stopping Distance

= 3.3m

Stopping Time

= 1.8sec

Figure 20: Braking assembly

CONCLUSION

The 150cc, 4 stroke, 4 wheeled racing car, Go-Kart, we finally made one under 1.Lakh which is a big truth.. The materials we used are up to the mark of automotive standard. The quality of ever product is certified with Indian standard quality check and our kart is one of the best race machine which hunts opponents in races. Big companies will design one go-kart at a minimum of 2 years. But we made this within one month. We do not recommend driving this go-kart at a speed of 80 km/hour but it is best suited in 50-60 km/hour speed. The project report is prepared in such a manner that every layman can understand the details pertaining to the project. The report is prepared in simple language and described well. The report gives an adequate idea and design guide line for making suitable report is expected to prove valuable to the successor students of mechanical engineering to know the essentials of a project and project report. We have tried to cover all the aspects concerned with our project.

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