DESIGN OF IC ENGINE GO-KART AND ANALYSIS OF ITS CHASSIS

[1]P. Krishna Kumar, [2]K. Sandeep Kumar, [3]P. Hemanth, [4]V. Sai Chandu, [5]D. Naveen Babu
[1]Assistant Professor, [2, 3, 4, 5] U.G. Students
Department of Mechanical Engineering,
Godavari Institute of Engineering and technology (Autonomous), Rajahmundry (INDIA)

ABSTRACT: The Go-kart is a four-wheeled vehicle without any suspension and differential. It is a light-weight vehicle designed for racing used for racing. Go-kart has low ground clearance in comparison to the other vehicles. The parts of go-kart are engine, wheels, steering, axle and chassis. Go-kart is powered by 125 cc engine.

We are going to use software like CATIA V5 for CAD modelling and ANSYS for analysis. In this project, we will work on the design of chassis, braking system, steering assembly and power transmission and analysis of the Chassis. For the safety point of view, analysis is carried out for a range of force values for all three impact tests like Front impact, Rear impact, Side-impact.

Keywords: Design and ANSYS, Go-Kart, IC Engine.

I. INTRODUCTION

In 1956, Art Ingels an American motorcar builder with his neighbour, Lou Borelli, created the world's first go-kart. The go-kart made its debut on 14 September 1958 when Ingels drove it round the pits in Pomona where an automobile race was taking place. McCulloch became the primary company to supply engines for karts in 1959. The original model was the McCulloch MC-10 and was adapted from a two-stroke chainsaw engine.

Go-kart could be a simple four-wheeled, lightweight, single seated vehicle. Go-kart is without suspension and differential. Go-kart is typically used for kart racing, off-road driving, desert racing, and short distance travel and fun.

Go-kart usually consists of a chassis, engine or motor, steering system, braking system. During this project, our team designed the parts of the Internal Combustion Engine Go-kart like chassis, steering wheel, steering shaft, stub axle, front axle, rear axle, sprocket wheel in CATIA Software and performing analysis of front impact load, rear impact load and side-impact load on the chassis in ANSYS Software.

TYPES OF GO-KARTS

1. Internal combustion engine Go-kart
2. Electrical go-kart
3. Hybrid go-kart

II. DESIGN PROCESS

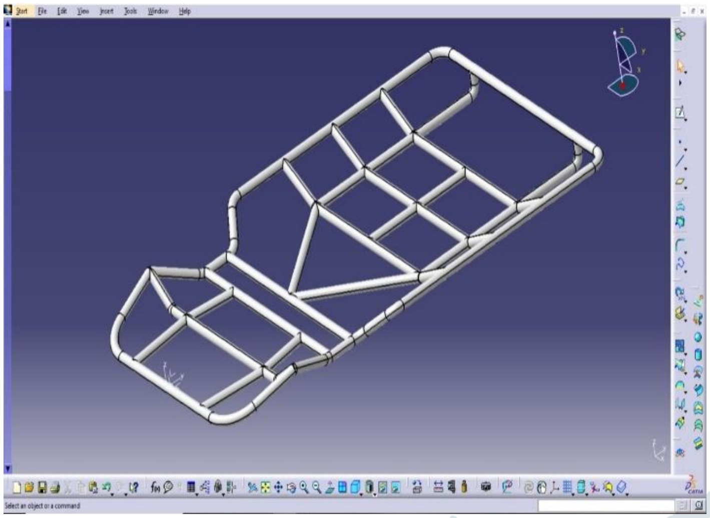
2.1 DESIGN OF CHASSIS

Chassis is the mainframe of a vehicle made of hollow pipes, where it houses the other components like engine, steering system, transmission system. This chassis has been designed with taking factors like dimension limits like width, length.

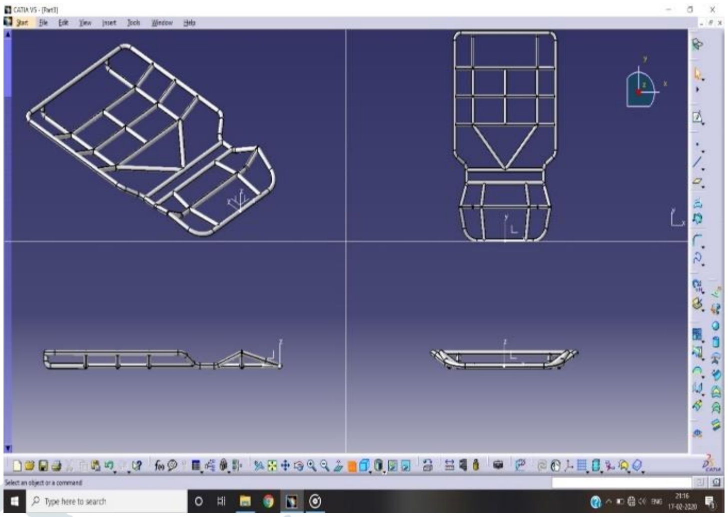
CHASSIS SPECIFICATIONS

CHASSIS	
Material	AISI 4130 (Chromoly)
Diameter	1 in
Wheel Base (L)	36 in
Front track width (B)	30 in
Rear track width (B_t)	33 in

VIEWS OF CHASSIS



Chassis



Chassis views

2.2 STEERING SYSTEM

Steering system is employed to vary the direction of the vehicle when it's in motion by slightly altering the direction of the front wheels of a vehicle. Because the mechanism changes the rotation of the steering wheel into a pivoting movement of the road wheels in such a way that the steering wheel rim moves from right to left or vice versa according to the movement given to the steering wheel.

TYPES OF STEERING MECHANISM

1. Ackermann Steering Mechanism
2. Davis Steering Mechanism

ACKERMANN STEERING MECHANISM

The Ackermann steering mechanism is a geometric arrangement of connections or linkages in the steering of a vehicle design to turn the inner and outer wheels to the acceptable angles. It is based on the principle of two front wheel steered wheels being pivoted at the ends of the axle beam.

OUR CHOICE

We choose Ackermann Steering Mechanism over the Davis Steering Mechanism because

1. This mechanism is far simple and flexible than Davis steering mechanism.
2. This mechanism only needs less power for rotating than Davis steering mechanism.
3. It takes less wear and tear to the mechanism parts.

STEERING CALCULATIONS

Assuming Turing Radius =2m

Let $\emptyset$= turn angle of the wheel on the inside of the turn

θ = turn angle of the wheel on the outside of the turn

We have:

$$\emptyset = \tan^{-1}\left(\frac{L}{R-\frac{B}{2}}\right)$$

$$\theta = \tan^{-1}\left(\frac{L}{R+\frac{B}{2}}\right)$$

$$\emptyset = \tan^{-1}\left(\frac{914.4}{2000-\frac{762}{2}}\right)$$

$$\theta = \tan^{-1}\left(\frac{914.4}{2000+\frac{762}{2}}\right)$$

$$\emptyset = 29.45° \quad \theta = 21°$$

Let β = Ackerman angle

$$\beta = \tan^{-1}\left(\frac{wheel\ base(L)}{\frac{wheel\ base\ (l)}{\tan\theta} - front\ track\ width(B)}\right)$$

$$\beta = \tan^{-1}\left(\frac{914.4}{\frac{914.4}{\tan(21)} - 762}\right)$$

$$\beta = 29.44°$$

ACKERMAN PERCENTAGE

$$\%\ ACKERMAN = \frac{\emptyset}{\beta} \times 100$$

$$\%\ ACKERMAN = \frac{29.45}{29.44} \times 100$$

$$\%\ ACKERMAN = 100\%$$

TURNING RADIUS OF DIFFERENT WHEELS

- For the inner front wheel,

$$R_{IF} = \frac{L}{\sin\theta} - \left(\frac{B-C}{2}\right)$$

Where C = Distance between pivot point

C = front track width −(2× distance between centre of front tires & king pin)

C = 762−(2× 109.22)

C = 762−218.44

C = 543.56mm

Average Turning radius = 2.15m

2.3 BRAKING SYSTEM

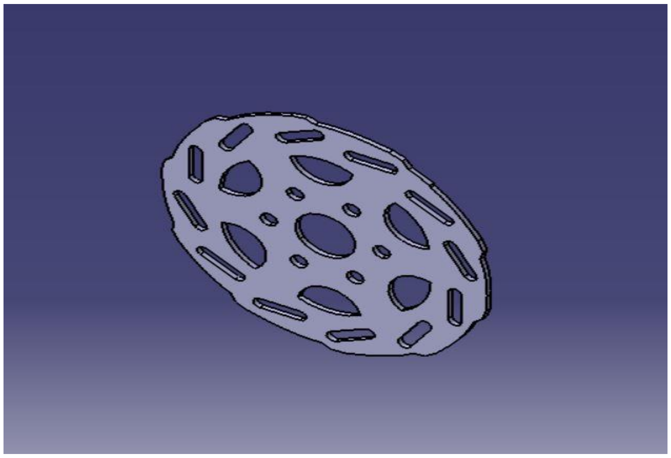
For automobiles, the braking system is of great importance, because it reduces the motion of the wheel of the vehicle by applying some external pressure on the wheel.

Braking system is classified into

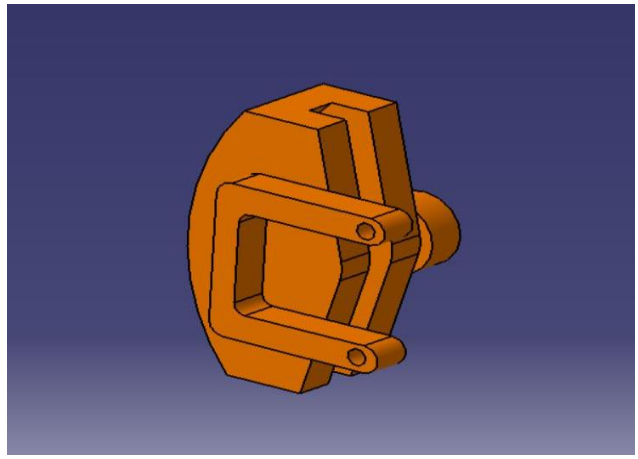
1. Hydraulic braking system
2. Electromagnetic braking system
3. Servo braking system
4. Mechanical braking system

Types of brakes

1. Disc brakes
2. Drum brakes



Disc



Brake Calliper

BRAKING CALCULATIONS

Break Force:

Total breaking force requires stopping the vehicle to rest

$$\text{B.F.} = \mu N \rightarrow \mu \times m \times g$$
$$\text{B.F.} = 0.6 \times 190 \times 9.81$$
$$\text{B.F.} = 1118.34 \text{ N}$$

Where,

m = laden mass of vehicle comes to rest
= 190kg

μ = coefficient of friction
= 0.6

Deceleration:

The rate of which the vehicle comes to rest

$$F = m \times a,$$

where,

$$F = 1118.34 \text{ Nm}$$
$$= 190 \text{ Kg}$$
$$a = \frac{F}{m}$$
$$a = 5.886 \text{ m/s}^2$$

Dynamics

Considering the car to be at rest initially,

Maximum velocity = 60km/h

V = 16.66 m/s

Front Axle Dynamic Load

$$F_f = W1 + \frac{a.W.H}{g.Wb}$$

Where,

W1 = Static front axle load
a = deceleration
W = Total weight of vehicle
H = height of centre of Gravity (C.G.)
g = acceleration due to gravity
Wb = Wheel base

Front axle dynamic load (F_f) $= 215.47 + \frac{5.886 \times 1863.9 \times 135.38}{9.81 \times 1066.8}$
= 357.39 N
= 36.43 kg

Rear dynamic axle load (Fr) $= W2 + \frac{a.W.H}{g.Wb}$
$= 811.91 + \frac{5.886 \times 1863.9 \times 133.382}{9.81 \times 1066.8}$
= 953 .83 N
= 97.23 Kg

Breaking Torque

$T = \frac{\text{Dynamic braking force} \times \text{Radius of Tyre}}{\text{Speed Ratio of disc of tyre}}$

$\mu = 0.6$, Radius of rear tyre = 0.139m

$$T = \mu \times Fr \times r$$

$$T = 0.6 \times 953.83 \times 0.139$$

$$T = 79.55\ N.m$$

Clamp Load

The load with which the Calliper acts on the disc,

$\text{Clamp Load} = \frac{\text{breaking torque}}{R_{eff} \times \mu \times n}$

Where,

R_{eff}(Disc effective Radius) $= \frac{\text{disc useable outside diameter(m)+disc useable inside diameter(m)}}{4}$

$R_{eff} = \frac{D+d}{4}$

D = 17cm = 6.7inches = 170mm = 0.17m

D = 9.5cm= 3.74 inches = 95mm = 0.095m

$$R_{eff} = \frac{0.17 + 0.095}{4}$$

R_{eff} = 0.06625 m

μ = coeeficient of friction = 0.6

n = Number of friction forces = 2

Clamp load = 1000.63N

Line Pressure

The pressure which is developed inside the calliper with which the brake pads are pressed towards the disc

Line Pressure $= \frac{\text{Clamp load}}{\text{Piston area}}$

Calliper piston diameter = 3.8cm

d = 0.038m

A $= \frac{\pi}{4} d^2$

$= \frac{\pi}{4} (0.038^2)$

Line Pressure $= \frac{1000.63}{1.13}$

Line Pressure $= 885.51\ N/m^2$

Calliper Force

The force provided by the calliper with which it presses the brake pad to disc is called as calliper force.

Calliper Force = Line Pressure × Piston area × Number of pistons

= Clamp load × Number of pistons

Calliper force = 1000.63 × 2

Calliper force = 2001.26 N

Stopping Distance

The appropriate distance required by the vehicle to stop from a certain velocity to zero.

V = Speed at which brake is applied

$= 16.66\ m/s$

d = deceleration rate

$= 5.886\ m/s^2$

Average deceleration $= \frac{V}{\frac{V}{d} + 0.3 \times g}$

$$= \frac{16.66}{\frac{16.66}{5.886} + 0.3 \times 9.81}$$

$a_d = 2.886\ {}^{m}/{}_{s^2}$

Stopping distance $= \frac{V^2}{(2 \times g \times \text{average deceleration})}$

$$= \frac{16.66^2}{(2 \times 9.81 \times 2.886)}$$

Stopping distance = 4.52 m

Breaking Power

The power required to stop the vehicle to rest position is denoted asB_p.

Where,

$$Bp = \frac{E}{t}$$

t = breaking time $\rightarrow \frac{V}{d} = \frac{16.66}{5.886}$

t = 2.83 s

E = Kinetic Energy

$= \frac{1}{2} m.v^2$

E $= \frac{1}{2} 190.(16.66)^2$

E = 26367.782 J

Breaking Power $= \frac{26367.782}{2.83}$

Breaking Power = 9317.24 W

= 9.3 KW

<u>Wheel Lock</u>

The force with which the brake locks the wheel, it happens in case of skidding.

Wheel lock = Dynamic × g × μ

<u>Wheel lock front:</u>

g = 9.81

μ = 0.6

Wheel lock = 36.43 × 9.81 × 0.6

Wheel lock = 214.43 N

<u>Rear wheel lock:</u>

= 97.23 × 9.81 × 0.6

= 572.3 N

<u>Breaking Efficiency (ƞ)</u>

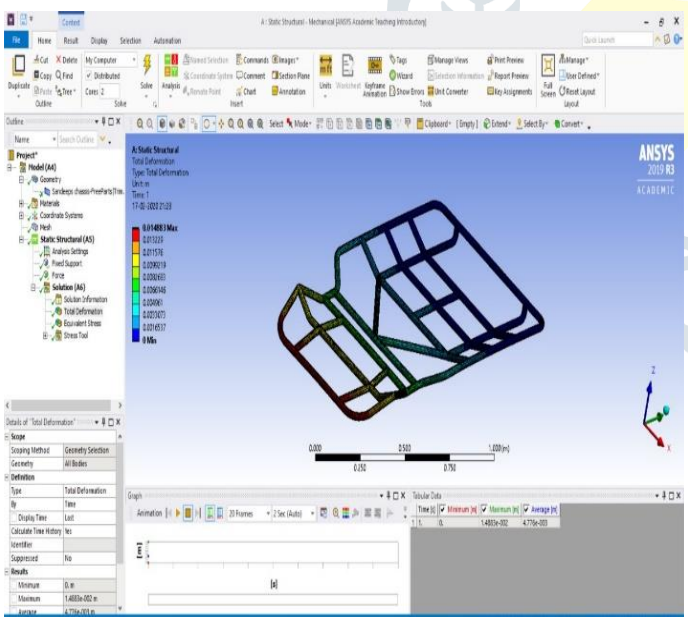
$\eta = \frac{\text{breaking force}}{\text{weight of kart}} \times 100$

$\eta = \frac{1118.34}{190 \times 9.81} \times 100$

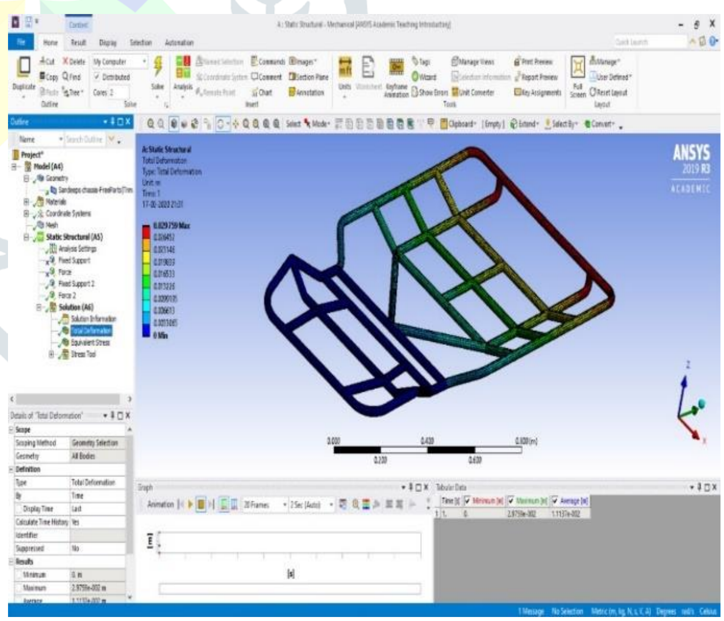
η = 60%

3. ANALYSIS OF CHASSIS

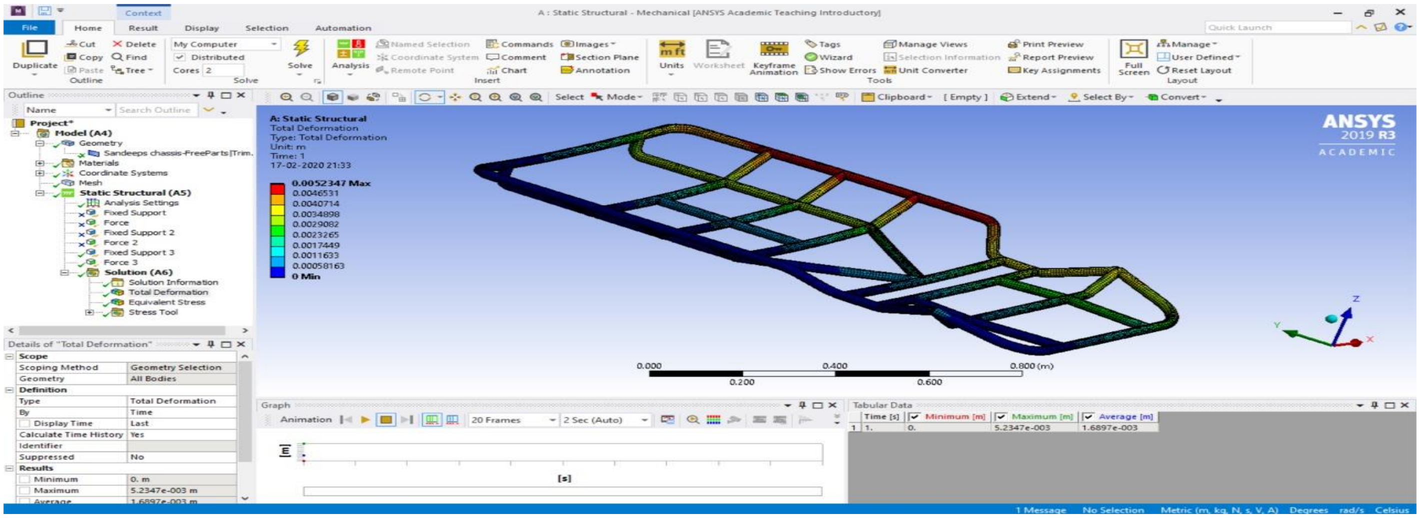
Analysis is the process of dividing a convoluted component into minute parts to obtain superior results. This approach has been applied in the research.



Front impact



Rear Impact



Side-impact

Force Calculations

Front impact

Considering the kart moving with the highest velocity of 60 km/hr, the time taken for the impact is 0.2 second.

Force exerted by the kart is:

$$F = \frac{1}{2} \times \frac{mv}{t}$$

Where,

$$V = 60 \text{ km/hr} = 0.01666 \text{ km/s} = 16.66 \text{ m/s}$$

Hence,

$$F = \frac{1}{2} \times \frac{130 \times 16.66}{0.2}$$

$$F = 5414.5 \text{ N}$$

Where 130 → Maximum approximate weight of the go-kart.

G-Force

The force exerted by a mass due to acceleration due to gravity

Hence, 130×9.81 = 1275.3 = 1 G-Force

Value of G-Force in case of the front impact

$$\text{G-Force} = \frac{5414.5}{1275.3} = 4.245$$

Value of G-Force = 4 G-Force

Energy Released

$$E = \frac{1}{2} \times m\, v^2$$

$$E = \frac{1}{2} \times 130 \times 16.66^2$$

$$E = 18041.144 \text{ J}$$

$$E = 18.04 \text{ KJ}$$

Side Impact

Considering the kart moving with the highest velocity and it is called from the side by a moving object, creating side impact and the go-kart deviated at an angle of 25°. So the speed of the kart will be

$$v= \frac{60 \cos 25}{Time\ impact\ is\ 0.3s}$$

v = 60 cos25

v = 54.38 km/hr

v = 0.0151 km/s

v = 15.1 m/s

Force exerted by the kart

$$F = \frac{1}{2} \times \frac{130 \times 15.1}{0.3}$$

F = 3271.66 N

G-Force

130 × 9.81 = 1275.3 = 1 G-Force

$$\text{Value of G-Force} = \frac{3271.66}{1275.3}$$

= 2.56

Value of G-Force = 3 G-Force

Energy Released

$$E = \frac{1}{2} \times m\, v^2$$

$$E = \frac{1}{2} \times 130 \times 15.1^2$$

E = 14820.65 J

E = 14.82 KJ

Back Impact

Consider the kart in a stationary position and is collided from the rear by any moving object.

Considering the velocity of the moving object is 18 m/s. The impact time is 0.3s.

So the force exerted is

$$F = \frac{1}{2} \times \frac{mv}{0.3}$$

$$F = \frac{1}{2} \times \frac{130 \times 18}{0.3}$$

F = 3900 N

G-Force

1 G-Force = 1275.3

$$\text{Value of G-Force} = \frac{3900}{1275.3}$$

= 3.05

Value of G-Force = 3 G-Force

Energy Released

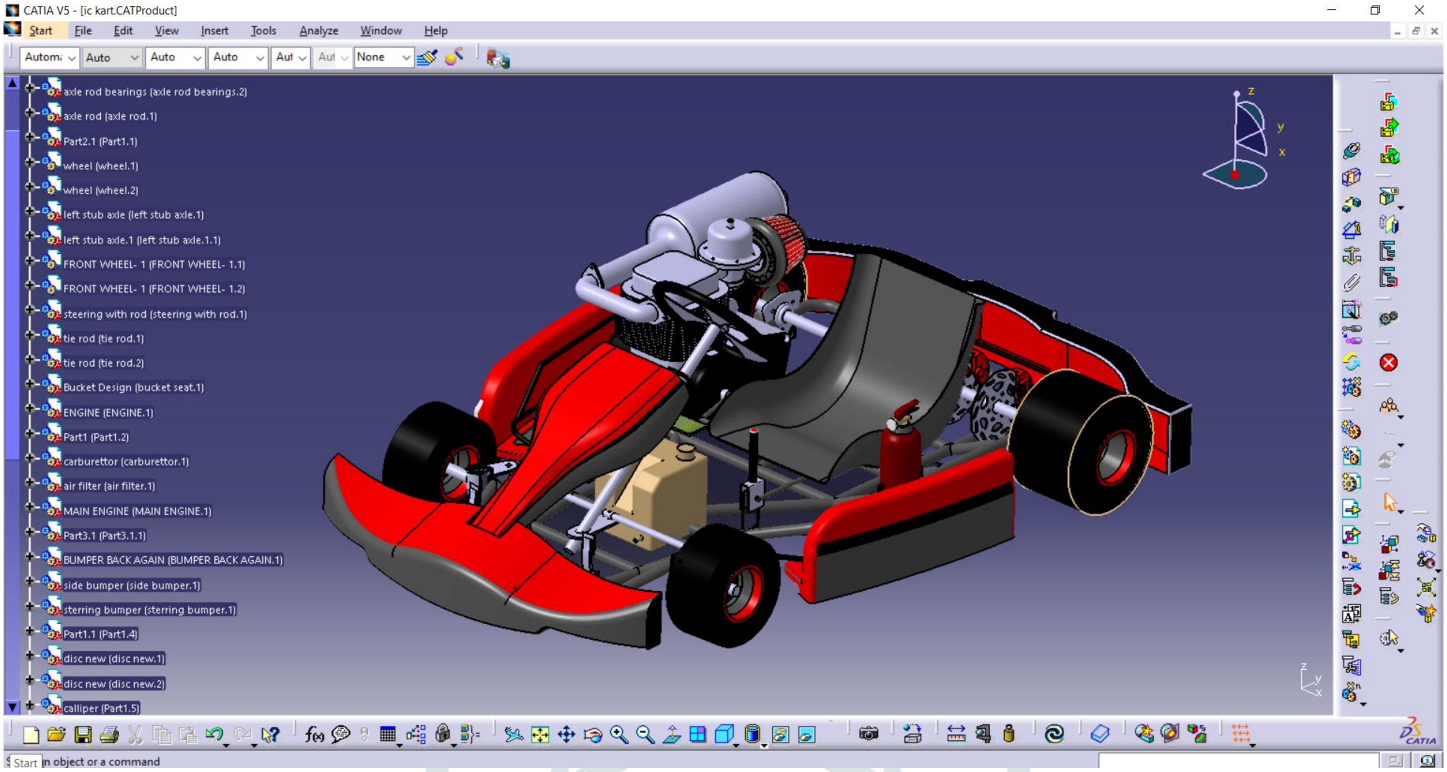
$$E = \frac{1}{2} \times m\, v^2$$

$$E = \frac{1}{2} \times 130 \times 18^2$$

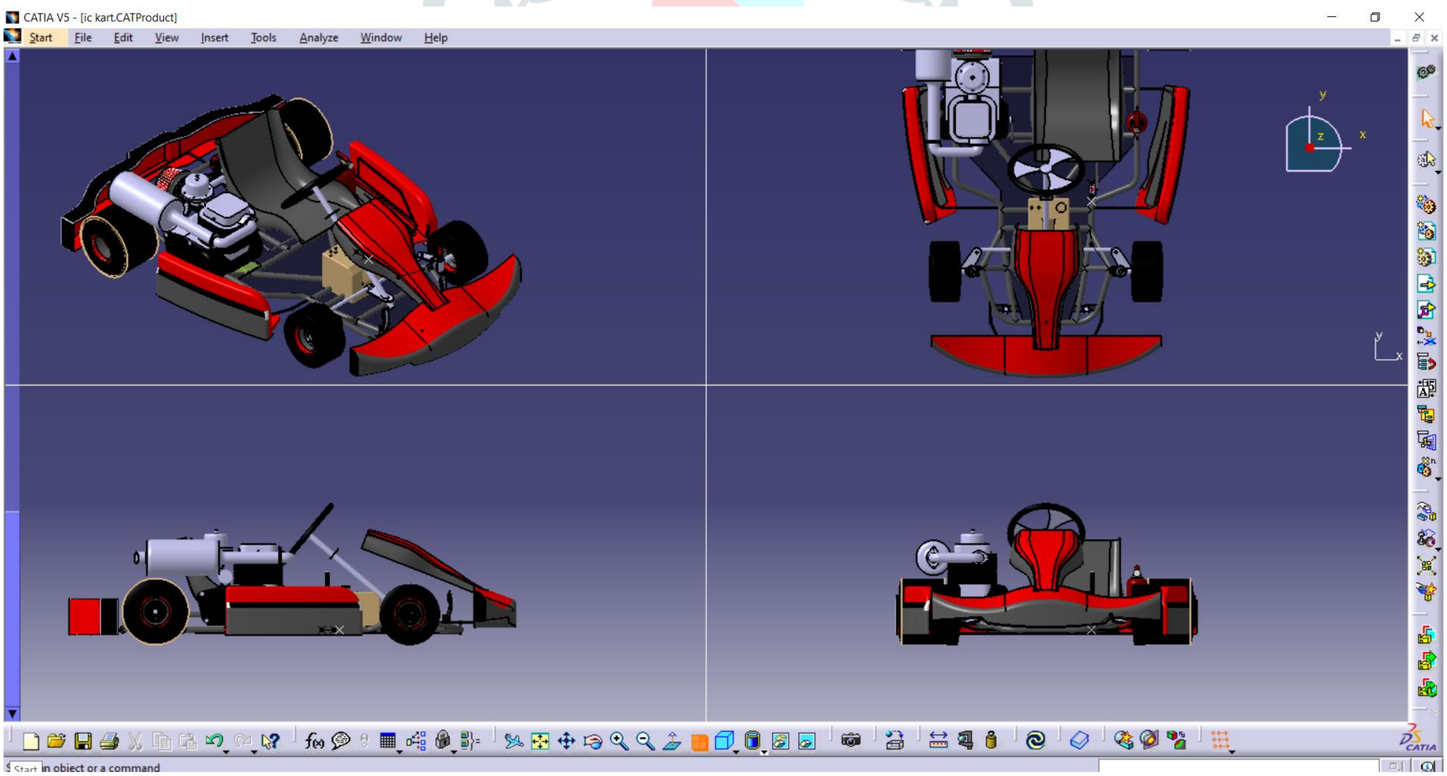
E = 21060 J

E = 21.06 KJ

4. ASSEMBLY



Go-kart Assembly



Assembly views

5. CONCLUSION

In this project, we designed the parts of Go-Kart like chassis, steering wheel, steering shaft, stub axle, front axle, rear axle, sprocket wheel.

Our team designed go-kart chassis by considering the various factors like strength, durability and toughness, it is designed to withstand the overall load of 190kg. It was designed in the cradle frame structure and completely designed in CATIA software.

We have considered AISI 4130 Chromoly material for the chassis by keeping the fabrication of the kart in mind and finite element analysis of the chassis is carried out in the ANSYS software then by considering above calculations the front impact is 5414N and side-impact is 3271N and rear impact is 3900N and the maximum deformation found is 4.5mm.

6. REFERENCE

1. D. Raghunandan, A. Pandiyan, Shajin Majeed, (Design and Analysis of Go-Kart Chassis), IJESRT-Journal, 2016.
2. Thomas A Gillespie (Fundamentals of Vehicle Dynamics).
3. Kirpal Singh - Automobile Engineering, 2015.
4. Dr D. Ravikanth, Dr K. Rajagopal, Dr V.S.S. Murty, A. Harikrishna, International Journal of Science, Engineering And Technology Research (Ijsetr) Volume 6, Issue 3, Issn: 2278 -7798, March 2017.
5. Dr D. Ravikanth, Dr K. Rajagopal, Dr V.S.S. Murty, A. Harikrishna, International Journal of Science, Engineering And Technology Research (Ijsetr) Volume 6, Issue-3, Issn: 2278 -7798,March 2017.
6. Sannake Aniket S, Shaikh Sameer R, Khandare Shubham A, Prof. S.A. Nehatrao, Design and Analysis Of Go-Kart Chassis" Ijariie-Issn(O)-2395-4396, Volume 3, Issue 2, 2017
7. Koustubh Hajare, Yuvraj Shet, Ankush Khot, "A Review Paper on Design And Analysis Of A Go-Kart Chassis" International Journal Of Engineering Technology, Management and Applied Sciences, Issn 2349-4476, Volume 4, Issue 2, Feb 2016