DESIGN REPORT
NATIONAL ELECTRIC KART CHAMPIONSHIP

Team Name : FORCE RACING

College Name : KAKATIYA INSTITUTE OF TECHNOLOGY AND SCIENCE

City name : Warangal, Telangana.

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Report Co-Author : E. VAMSHIDHAR

OUR MISSION

As many say it is hard to build a team than building a car.It is difficult to build a car with multiple mindsets but our motto is to bring all of them to a common platform and build a perfect team with great co-ordination and a driver friendly car with high security.
As a part of development of team every member took part in the design and manufacturing phase with high interest and the output is clearly observed.

Our Team

A perfect car needs good skills and efforts of every individual member of a team.
Our Team

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Faculty Advisors
1.CH.Karunakar Reddy
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ABSTRACT

Our team intention is not just to build a perfect car but to build a perfect team .To improve leadership qualities and to show everyone the power of teamwork .To improve the team coordination and improve the previous year karts specifications.

In the development of the 2018-2019 competition vehicles, a strong emphasis was placed on the karts power train .Our team members took an initiative towards the development of team and finally bought lithium ion battery in order to increase the performance.

DESIGN GOALS

- To prepare a compact kart.
- Less weight
- High Reliable

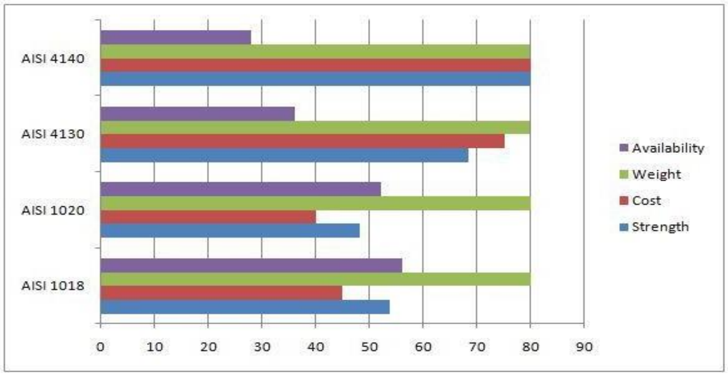
CHASSIS DESIGN

1.1. FRAME CONSIDERATIONS

- We chose a conventional frame to meet our requirements.
- Each member of the chassis is joined by TIG Welding.

1.2. MATERIAL SELECTION CRITERIA

- We selected the material which meets our requirements.
- We chose our material by performing certain tests and we observed that AISI 1018 and AISI 4130 satisfy our need and hence we selected one of them according to the test results.
- We enquired and choose AISI 1018 because of its high availability and low cost.



Comparison table between AISI 1018 and AISI 4130 material:

According to the results of tension test and Brinell Hardness Test we chose to select AISI 1018.

PROPERTIES	AISI 1018	AISI 4130
Density	7.8kg/m^3	7.8kg/m^3
Yield Stress	392.25MPa	799.803MPa
% Elongation at fracture	10.83%	10.83%
%Decrease in area	55.36%	30.57%
Breaking Strength	355.736N/mm^2	751.745N/mm^2
Elongation at break	24.130mm	28.730mm
Brinell Hardness	120	197

KART SPECIFICATIONS:

Overall Length	:67.5inches
Wheelbase	:46.5inches
Front Track Width	:34.5inches
Rear Track Width	: 33inches
Weight of chassis	: 26.06kg
Welding process	: TIG Welding
Roll Over Protection	: 37inches
Weight of driver	: 60kg
Ground (inch) Clearance	: 4inches

1.4.1. COMPARISION BETWEEN PREVIOUS AND LATEST KART

Sl. No	OLD KART	NEW KART
1	4 Lead Acid Batteries	1 Lithium ion Battery
2	Wheel Base=56 inches	Wheel Base=46.5inches
3	Front Track Width=47 inches	Front Track Width=34.5inches
4	Rear Track Width=40 inches	Rear Track Width=33 inches
5	Overall Length=72 inches	Overall Length=67.5inches

3

ANAYLSIS:

ANALYSIS CONSIDERATIONS OF KART ASSUMPTIONS

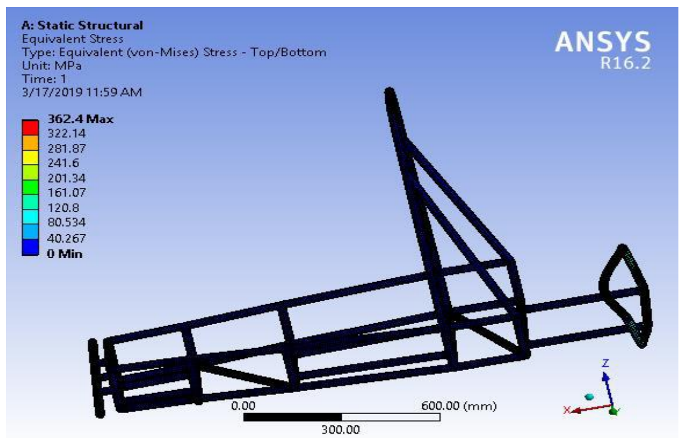
The velocity of vehicle before hitting=maximum velocity of car
The time of collision=0.4seconds
Mass of the vehicle=180kg ;
final velocity=0; a=acceleration;
Where v=final velocity=56.39kmph
=56.39×(5/18)m/s=15.6m/s

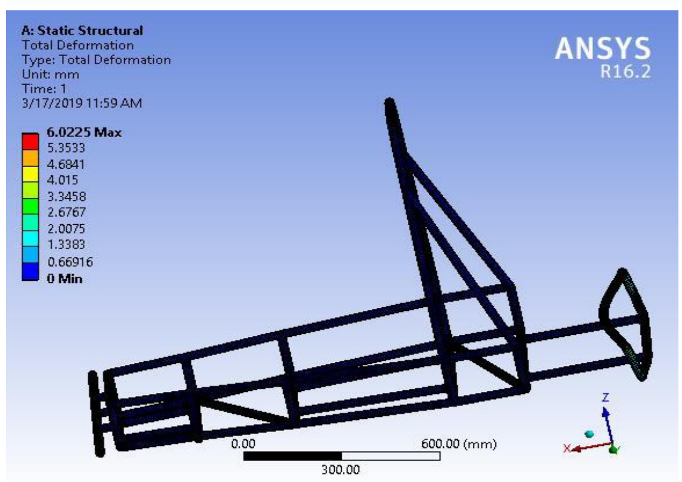
From laws of kinematics v=u+a×t
0=15.6+a×0.4
a=39m/s2 (RETARDATION)

From Newton's law
Force=Mass*Acceleration;
Force=180×39
Force=7020N
G-Force=Force/(mass×acceleration due to gravity)
G-Force=7020/(180×9.81)
G-Force=3.97 ≡4
Factor of Safety=*Yield Strength/Working load*

1.5.3. REAR IMPACT TEST

We considered the situation as in the previous case where opponent car is trying to overtake our kart and hit ours.
Force =3G
FOS=$\frac{392.25}{363.25}$
=1.05



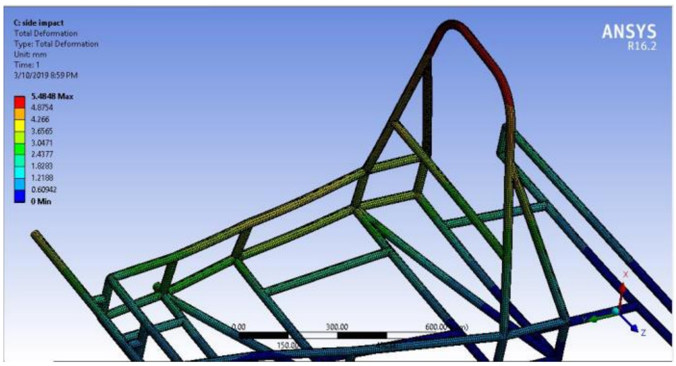


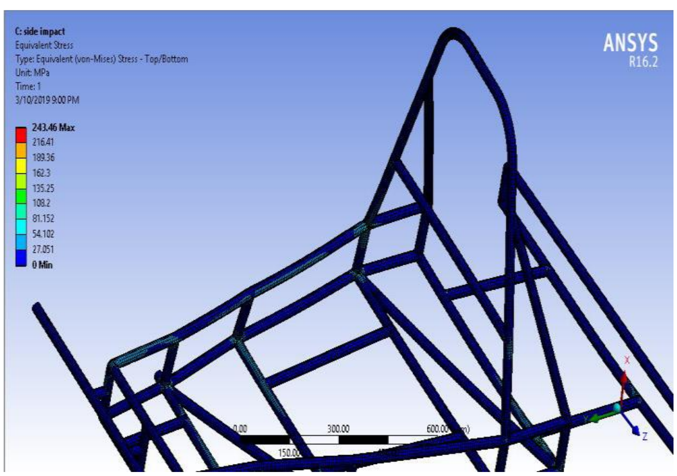
1.5.4.SIDE IMPACT TEST

We considered 2G force because before hitting the chassis, the opponent car hits tires.

Force=2G

FOS = 392.25/243.36=1.61





1.6. CENTRE OF GRAVITY CALCULATIONS

Assumptions:

The initial weight distribution of the kart is 2:3.

Calculations: Total weight of the kart (with driver) =180kg

Force=180×9.81=1765.8N.

Force acting on front tires (two tires) =1765.693 =588.6N

Force acting on single tire=294.3N

Weight acting on rear tires (two tires)

=1765.9-588.6

=1177.2N.

Force acting on rear single tire=588.6N.

Centre of gravity of kart from rear side=$Weight\ on\ front\ sidetotal\ weight\times wheelbase$

Centre of Gravity = 1181.13

=393.7mm from rear tire center .

Centre of gravity from right side of vehicle=$Weight\ on\ only\ right\ side\ tyres\ Total\ weight\times Trackwidth$

=882.9*876.3/1765.8

=438.15mm.

When the vehicle is inclined at an angle of 30 degree.

Horizontal wheel base of the kart

=1181.1×cos (30)

=1022.6mm.

Considering the bending moment of the center of gravity of the car.

Weight on front tires after inclined= $Total\ weight\ \times Cg\ from\ rearActual\ wheelbase$

So Weight on front tires=706.32N

Weight on rear tires

=1765.8-706.32

=1059.48N.

Now weight ratio = $Weight\ on\ front\ tyres/Weight\ on\ rear\ tyres\ \ =\frac{706.32}{1059.48}=\frac{2}{3}$

Centre of gravity of vehicle vertical length=$\mathit{Change\ in\ force\ on\ front\ tyres} \times \mathit{wheelbase}/\mathit{total\ weight} \times \tan(30)$
=(679.83−588.6)×1181.11765.8×.577
=105.69mm from the floor closeout
So actual center of gravity length (vertical)
=Ground clearance+105.69+pipe diameter
=25.4×4+105.69+25.4
=232.29mm=9.16 inches from ground.

2. STEERING AND WHEELS

2.1. OBJECTIVE:

The steering system must provide control over the direction of travel of the vehicle; good maneuverability for parking the vehicle; smooth recovery from turn, as the driver releases the steering wheel; and minimum transmission of road shocks from the road surface. The steering system is designed to withstand the stress of safely maneuvering the vehicle through any type of possible condition at the time of driving.
The purpose of the steering system is to provide directional control of the vehicle with minimum input.
The main goal for steering is to have 100% Ackerman steering.

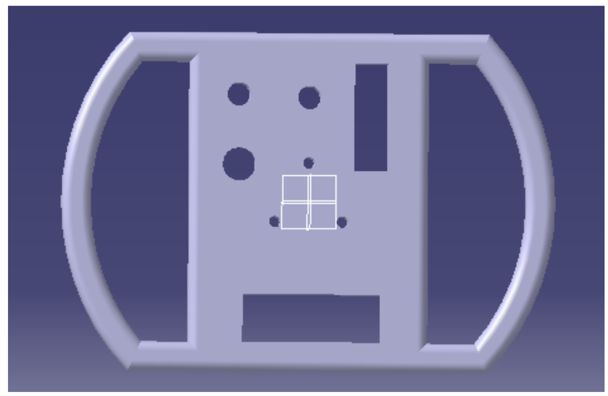
2.2. DESCRIPTION:

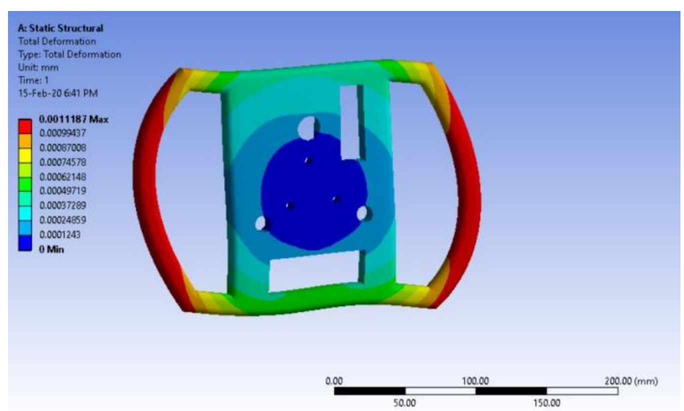
Steering is the collection of component, linkages etc. which is used to control the trajectory of the vehicle. The basic aim of steering is to ensure that the wheels are pointing in the desired direction and allow the driver to guide the vehicle.

2.2.1. STEERING:

Bell –crank actuated tie rod linkage.

We have chosen bell-crank type of steering. It changes the motion through an angle. The angle can be from 0 to 360 degrees, but 90 and 180 degrees are most common.
Self designed Steering wheel for Driver comfort and for ergonomics
Material used : Nylon
Type of machining: CNC machining

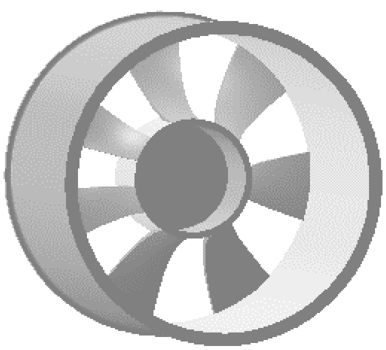




STEERING EFFORT CALCULATION :

Load on each tire = 353.16N
Ackerman angle = 15.904
Steering arm length =165.49mm
Torque at the tire = load on each tire *[Steering arm length *SIN (Ackerman angle)] = 353.16*165.49*SIN (15.905) =16016.30Nmm =16.016Nm
Steering ratio is =1:1
Steering wheel diameter = 0.26m
Torque at steering wheel = 16.016Nm
Steering effort = torque at steering wheel / steering wheel diameter
= 16.016 /0.26 = 61.6N
Steering effort = 61.6N

2.2.2. WHEELS:



Material used: Aluminum alloys.

2.2.3. HUB:

The hub is the center of the wheel, and typically houses a bearing, and is where the spokes meet.

Hubs material: Aluminium

Self-Designed Hubs

2.2.4. TYRES:

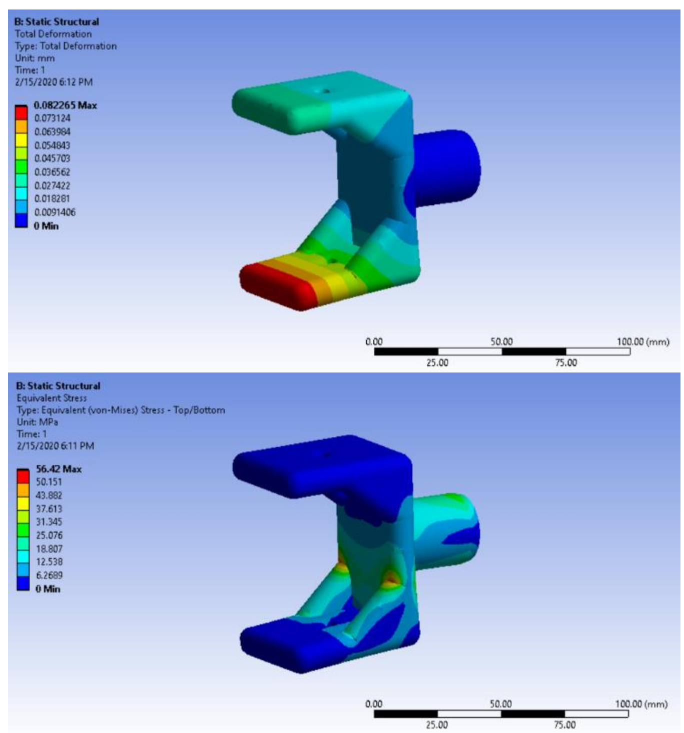
We have used standard go-karting tires.

Tire dimensions: front -10*4.5-5
Rear-11*7.1-5

2.2.5. C-Clamp Design and Analysis:

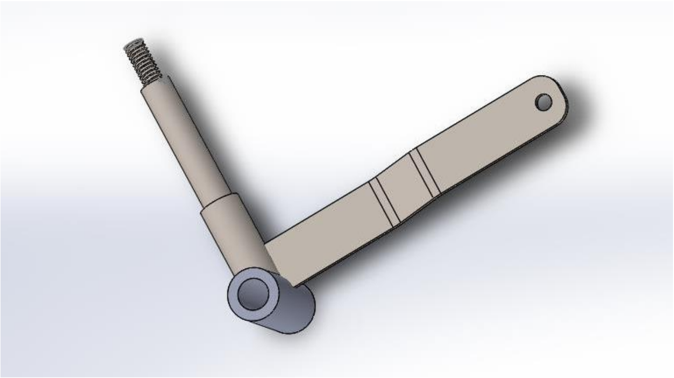
Design

Dimensions
52mm*40mm*75mm
Material used Mild Steelz

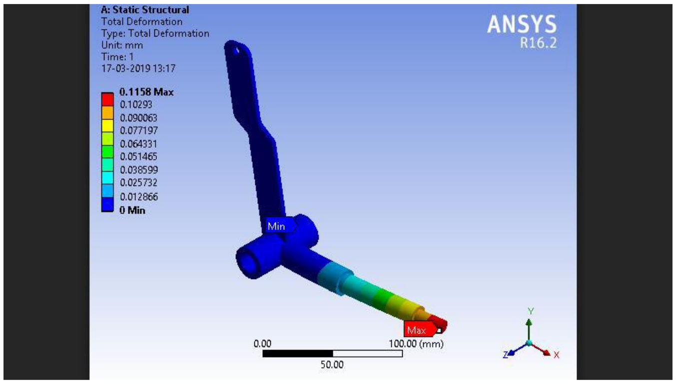


2.3. SPINDLE:

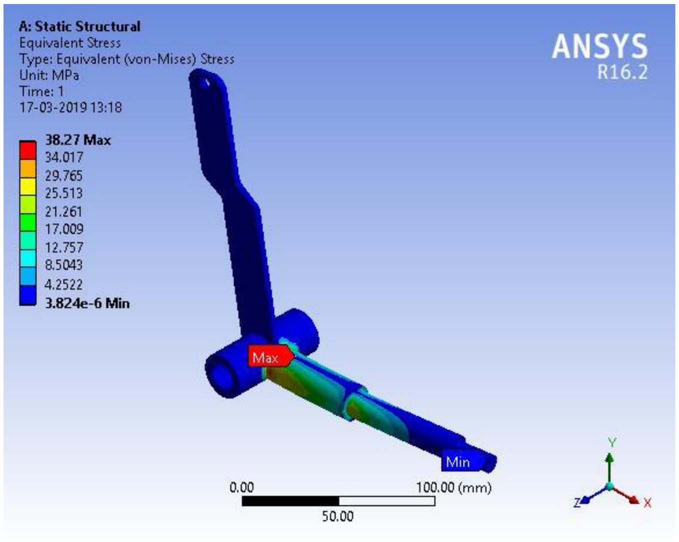
- Spindle is used to assemble the wheels and tie rods
- The material used for spindle is mild steel.



2.3.1. SPINDLE ANALYSIS:



TOTAL DEFORMATION



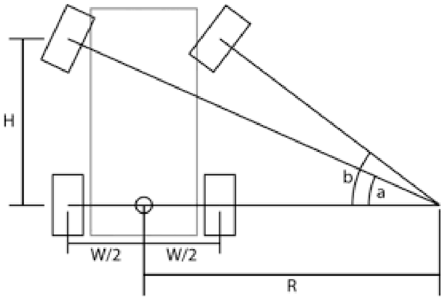
EQUIVALENT STRESS

Calculations:

Total mass =180kg
Weight=180×9.81=1765.8N
The car is divided in 2:3 ratios
It is divided into 5 parts.
Load on each tire =1765.85=353.16N
Yield load=440MPa
Factor of safety=440/146.2=3

2.4. ACKERMAN GEOMETRY:

It is the most widely used steering geometry which determines inner and outer angles of a wheel with constant turning radius



Specifications

Wheel base	46.5Inches
Track width	35 inches
Turning radius	2.5 meters
Inner wheel angle	29.88degrees
Outer wheel angle	21.85degrees
Ackerman percentage	71%

Calculations

Tan b =$wheel\ base\ (H)/turning\ radius\ (R){-}track\ width\ (W)/2$
Tan a =$wheel\ base\ (H)/turning\ radius\ (R){+}track\ width\ (W)/2$
Where a= outer wheel angle
b=inner wheel angle1
H=46.5inches
R=2.5 meters =98.42inches (as mentioned in rulebook)
W=35 inches
Tan b =46.5/98.42− 352 ;
Tan a =46.5 /98.42+352
Inner angle (b) =29.88degrees
Outer angle (a) =21.85degrees

2.5. TIE ROD CALCULATIONS:

Ackerman angle tan (Ø) = $kingpin\ center\ to\ center\ distance 2 / wheel\ base$
= 26.52⁄46.5 =15.904
Sino = YR Where Ø= Ackerman angle
R= Ackerman arm radius
Y = Sin ɵ× R
Y= sin (15.904) × 6.5
Y = 1.78 inches
Tie Rod length = Kingpin c-c distance – 2Y
= 26.5 - 2(1.78)
= 22.94 inches
Tie rod displacement =$maximum\ deflection\ of\ tyre$=360*π*2(tie rod length, inches)
Tie rod displacement=29360*π*2(11.47)
Tie rod displacement=5inches.

STEERING EFFORT CALCULATION:

Load on each tire = 353.16N
Ackerman angle = 15.904
Steering arm length =165.49mm
Torque at the tire = load on each tire * [Steering arm length *SIN (Ackerman angle)]
= 353.16*165.49*SIN (15.905)
=16016.30Nmm
=16.016Nm
Steering ratio is =1:1
Steering wheel diameter = 0.26m
Torque at steering wheel = 16.016Nm
Steering effort = torque at steering wheel / steering wheel diameter
= 16.016 /0.26
= 61.6N
Steering effort = 61.6N

3. BRAKES

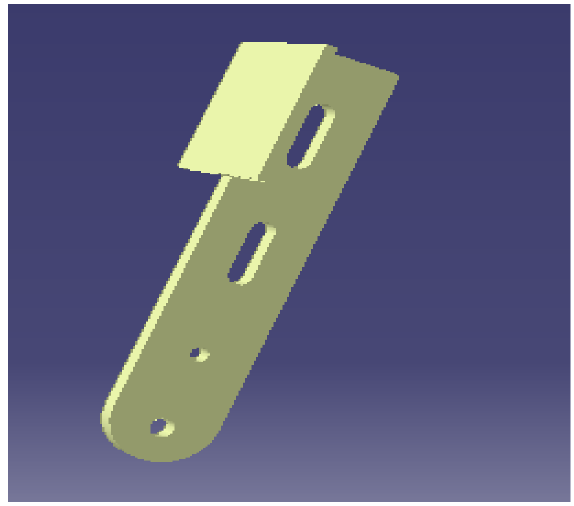
3.1. DESIGN CONSIDERATION:

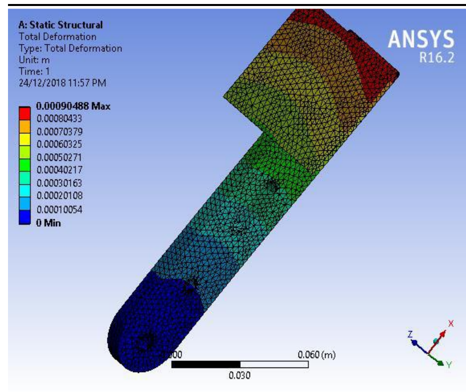
Type of brake used: Hydraulic disc brake
Type of calipers used: Dual piston fixed caliper
Type of disc used: Slotted
Material for pedal used: AL 6061 T6
Type of brake fluid reservoir used: Flexible single outlet compact reservoir
The braking system used must withstand the thermal and mechanical stresses induced during running of the kart and the components used (brake rotor and pedal have been designed and tested using design and analysis software (CATIA & ANSYS).

Design consideration for components used:

3.2. BRAKE PEDAL:

The brake pedal was designed considering the forces acting on it and considering the pedal room available. Since our design goal was focusing on compactness and light weight , we searched for viable materials available in the market and came to conclusion of AL 6061 T6, because of its light weight , easy machinability and enough strength to withstand almost 10 times the force applied on it while working.
Pedal ratio: - 5:1
Mounting: Downward





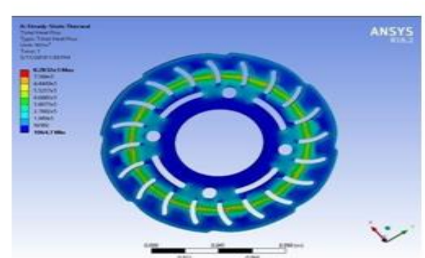
Brake rotor:

Material used – Stainless steel 314

Diameter = 165.1mm

Thickness = 3.5mm

Pitch circle diameter = 92m



3.3.1. Selection criteria:

According to wheel assembly
Area of contact
Good dissipation of heat
High Wear & Shear strength
Less weight
Less weight
Low cost
Ease of Availability

3.4. BRAKE CALIPER:

Type of calipers used: Dual piston fixed caliper

3.5. BRAKE CALCULATIONS:

Considering mass of vehicle to be 180kg's, with the vehicle moving at a speed of 40kmph, we can calculate the stopping distance and stopping time of the vehicle w.r.t the brake calipers , brake disc and the leverage ratio used.
Leverage ratio = 5:1
Diameter of master cylinder =12.6 mm.
Bore diameter of caliper =30 mm.
Consider force applied on pedal to be equal to 200N.
Master cylinder pressure = F/A = (leverage ratio*force on the pedal)/area of master cylinder.
Pressure $=\frac{5*200}{1.24*10^{-4}}$=8064516.129N/$m^2$.

Pressure (master cylinder)=pressure(caliper)
Force at caliper=pressure at master cylinder *area of caliper
Force at caliper $=\frac{\pi}{4}*0.03^2*8064516.129$ N.
Force at caliper = 5697.58N.
Frictional force at disc=force at caliper *μ*2
Frictional force at disc=4558.06N
Torque at disc= F*R(disc)
=4558.06*0.16
=729.29N-m
Torque at disc = Torque at wheel
729.29=Force(wheel)*R(wheel).
Force at wheel=5209.21N
Frictional force at wheel=μ*N.

F(wheel)$=\frac{0.8*180*9.81}{4}$ N.
=330.48 N.
Total breaking force=5209.21+330.48
=5539.69N.

We know,
F = ma
$a=\frac{F}{m}$
$a = \frac{\mu*N}{m}$
$a= \frac{\mu*m*g}{m}$
a = **μ * g**
0.9*9.81
8.829 m/s^2
∴ **Deceleration a =**8.829 m/s^2
We can calculate Stoping distance by
Stoping distance= $\frac{v^2}{2*a}$
$=\frac{11.11^2}{2*8.829}$

= 6.97m
We can calculate time to decelerate,
Time to decelerate t = $\frac{v}{a}$
$=\frac{11.11}{8.829}$
=1.25sec

∴Time taken to decelerate from 40 kmph to 0 kmph = 1.25sec

4. DRIVE TRAIN

4.1. OBJECTIVE:

Power train is a system which deals with the transmission of the power from motor to the wheels. This power train includes motor and motor controller, batteries, drive train. The purpose of power train in the electrical cars is to transmit power from the motor to the rear axle and through rear axle wheels.

4.2. BATTERY:

4.2.1. INTRODUCTION:

A battery is a device consisting of one or more electro chemical cells which transmits power to electrical devices such as motor, smart phones and electrical cars. There are many types of batteries commonly used they are LEAD ACID, LITHIUM ION, NICKEL METAL HYDRIDE and SMF BATTERY. By considering below factors LITHIUM ION battery is considered.

4.2.2. SELECTION CRIETERIA FOR LITHIUM ION:

High energy density.
Low maintenance.
Low self-discharge and light in weight.
Quick charging.
Increased life time.

4.2.3. LITHIUM ION BATTERY:

These are rechargeable type of battery in which lithium ions move from the negative electrode to the positive electrode during discharging and back when charging. Normally anode is made of lithium phosphate cathode of carbon and electrolyte varies from one type to another. These are used in smart phones, laptops, automobile etc.

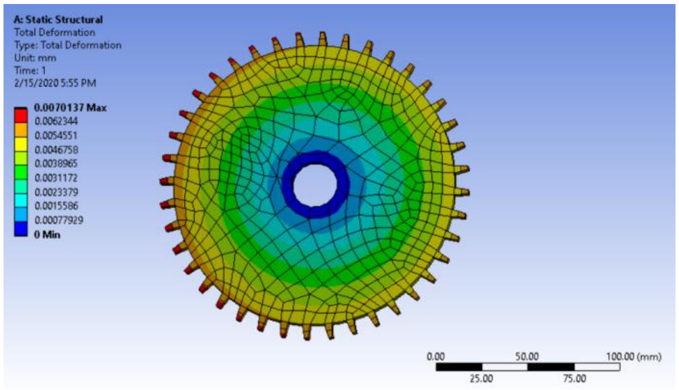
4.2.4. BATTERY AMPERE HOUR CALCULATIONS:

P=1500watt
V=48v
P=i*v
I=p/v; 1500/48=31.5amps
The calculated rated current is 31.5 amp, and max still current be approximately 50amp.

4.3. MOTOR SPROCKET:

Selection Criteria:

1.High strength
2.high resistance to breakage



We required high initial Torque so we have choosen sprocket with a gear ratio 1:2.8.

4.3.1. INTRODUCTION:

An electric motor is an electrical machine that converts electrical energy into mechanical energy. There are many types of motors that are preferred for various applications. Here we used BLDC motor by considering below factors:

4.3.2. BLDC MOTOR CONSIDERATIONS:

High efficiency due to permanent magnets.
Better speed versus torque characteristics.
Long operating life due to lack of electrical and friction losses.
High speed ranges.
Less noise.

BLDC MOTOR:

The brushes in conventional D.C motors wear out over the time and may cause sparks .as a result ,here we are using brushless D.C motor which doesn't cause sparks

4.3.3. WORKING PRINCIPLE:

BLDC motor works on the principle similar to that of a conventional D.C motor, i.e., whenever a current carrying conductor placed in a magnetic field it experiences a force. In case of BLDC motor, the current carrying conductor is stationary while the permanent magnet moves. When the stator coils are electrically switched by supply source, it becomes electromagnet and starts producing the uniform field in the air gap. Due to force of attraction between electromagnetic stator and permanent magnet rotor, the rotor continues to rotate

4.3.4. ADVANTAGES OF BLDC MOTOR:

It has no mechanical commutator and brushes.

High efficiency due to permanent magnet motor.

Long life as no maintenance is required for commutator system.

Less noise due to absence of brushes.

4.4. POWER TRANSMISSION SYSTEM:

Power transmission is the system in the electrical cars where power is transmitted from motor to rear axle. Here the type of transmission we used is chain drive.
Reasons for choosing chain drive system:
Low power losses while transmission

Less complexity

Power to be transmitted is comparatively low and chain drive would serve the need 6

4.4.1. POWER TRAIN AND DRIVE TRAIN CALCULATIONS:

P=1500watt
N=3000rpm
V=48v
Type of power transmission used : Chain Drive
Reduction Ratio :- 1:2.8
P=2*π*N1*T1/60
T_1=60*1500/2*π*3000
T_1=4.77Nm
$N_1/N_2=T_2/T_1$
T_2=3000*4.77/1071.4
T_2=41.44Nm
T_3=14.4Nm
T_4=(3000*14.4)/1500
T_4=28.8Nm
N_2=3000/2.8=1071.4rpm
V=(N2*3.14*diameter of wheel)/60
V=(1071.4*3.14*0.2794)/60
V max=56.398kmph
Here,
P=Power at motor
N_1=rpm at motor shaft =3000
N_2=rpm at wheel =1071.42
D_1=diameter of the motor shaft =23mm
D_2=diameter of wheel =279.4mm
T_1=continuous torque at motor shaft
T_2=continuous torque at wheel shaft
T_3= peak torque at motor shaft
T_4=peak torque at wheel shaft
V=velocity of the kart

4.5.. MOTOR SPECIFICATIONS:

POWER	1500watt
VOLTS	48v
PEAK TORQUE	4.77 N-m
CONTINOUS TORQUE	N-m
MOTOR SHAFT	23 mm
RPM	3000

SHAFT CALCULATIONS:

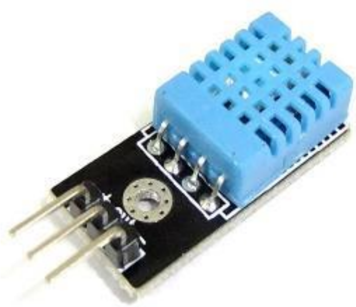
Equivalent Torque=(max.bending moment^2+max.torque^2)$^{1/2}$
$T_e=\sqrt{4.341^2+40.32^2}$=40.55301075N-m
$T_e=(\tau*\pi)/16d^3$
τ=σ*0.57=265.05N/mm^2(σ=465N/mm^2)
Therefore,
d=8.39mm
Considering F.O.S= 4.8
Diameter of shaft=25.4mm

4.6.MOTOR CONTROLLER:

A motor controller is a group of devices that serves to govern in some predetermined the performance of electric motor. A motor controller ,
manual or automatic means for starting or stopping the motor,
selecting forward or reverse rotation and protecting against overloads.

5. INNOVATION

5.1. MOTOR COOLING SYSTEM:



When motor gets over heated, temperature sensors geets activated

We passed water through the coil which acts as a coolant. The cool water absorbs the heat from the surface of the motor and reduces the heat from motor surface.

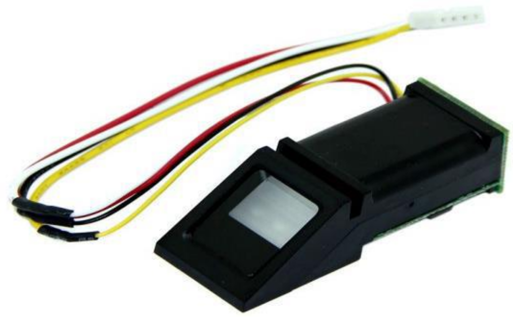
The water from the exit of the coil are collected in a container and are cooled using a Peltier module so that that coolant can be re-used.

The temperature sensor equipped automatically turns on when the motor is over heated and thus cooling system switches on.

<u>5.2. FINGER PRINT SENSOR:</u>

We used a fingerprint sensor for security purpose.

- The power train system of the vehicle only works with the registered fingerprint of drivers in other situations the vehicle does not on.



<u>5.3. GSM MODULE:</u>

A GSM-C module is a chip or circuit that will be used to establish communication between a mobile device and computing machine.

- We used a gem-c sensor which allows us to know about any accidents etc.
- This sensor helps us to send a message to our phone about the location of vehicle if any accidents occur

5.4. SMOKE SENSOR:.

We used the smoke sensor which senses the smoke, typically as an indicator of fire.

This sensor alerts and the security devices issue a signal to a fire alarm control panel as a part of a fire alarm system and prevent from accidents.