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Design and Simulation of an ECO-Friendly kart

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ABSTRACT

In this paper, design and fabrication of an eco-friendly, battery powered, single passenger E-GO KART is discussed.

An Electric Go-kart is a small four wheeled vehicle without suspension and differential. E-Go kart is designed and meant for racing only (though in some countries it is used for fun and personal transportation).

It is a miniature of a racing car. This E-Go kart is designed and fabricated for participation at the E-NKRC {Electric National Kart Racing Championship}.

Modeling of chassis is performed in solid works. Kart chassis is different from Car chassis. Kart chassis is made from hollow circular pipes/rods. Strength and Light weight are the basic consideration for choosing the chassis material. AISI1018 is the suitable material to be used for E-GO kart chassis which is medium carbon steel having high tensile strength and offers good balance of toughness and ductility.[1]

I.INTRODUCTION

There is a growing demand for fossil fuel like diesel and petrol to power the automotives and cater other needs of human. Fossil fuels are being deflected because of their excessive use limited stocks. Further the use of fossil fuels is polluting the environment. Because of this people are fragile to wear mask for filtering the polluted air for respiration.

To minimize all these problems and to keep our earth free from pollution, there is an urgent need to explore alternative in place of fossil fuel powered vehicles. Efforts are being out to develop vehicle powered by solar energy, hydrogen, biodiesel and batteries.

Battery powered vehicle are not so popular in India because they need frequent charging. In order to overcome above mentioned problems an attempt has been made to design and fabricate environment friendly, battery powered, single passenger E-GO kart. [2]

II.DESIGN OF VEHICLE

The design section of this report is divided into three major topics-

- The design objective
- The design calculation and analysis

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- Consideration

Based on overall design objectives of durability, performance, light weight etc.

FRAME DESIGN

The frame is designed to meet the technical requirements of competition

According to rulebook .the objective of the chassis is to encapsulate all components of the kart, including a driver, efficently and safely. Principal aspects of chassis focused on the design and implementation included driver safety and structual weight and ergonomics.

MATERIAL-

We are using material AISI-1018 for frame design because of its good weld ability, strength as well as good manufacturability. A good strength material is important in roll cage because the roll cage needs to absorb as much energy as possible to prevent the roll cage material from fracturing at the time of high impact.

The various mechanical, physical properties, chemical of the material are as follows-

Mechanical properties	Metric
Ultimate tensile strength	440MPa
Yield tensile strength	370MPa
Poisons ratio	0.290
Bulk modulus	140GPa
Reduction of area	40.0%
Shear modulus	80GPa
Brinell hardness	126

Physical properties	Metric
Density	7.87g/cc

Chemical composition of element	content
Carbon, C	0.14-0.20%
Iron, Fe	98.81-99.26%
Manganese , Mn	0.60-0.90%
Phosphorous , P	<0.040%
Sulfur,S	<0.050%

The above mentioned properties satisfy the technical requirement of material which is to be used in frame.

FRONT IMAPCT ALALYSIS-

Generally in the case of pure elastic collision in front impact the linear velocity remains at 53 km/h according to ENCAP (the european new car assesment program)

Hence the value of force is calculated by mass moment equation that is-

F= P×T

Where

T= short duration of time because collision occurs for short interval of time (1.10 sec).

M=200 kg (weight of kart +driver)

P = moment

Hence the moment of kart at 53 km/h or 14.72 m/s that is-

P=M×V

P=200×14.72

P=2944.44 kg-m/s

Front impact force

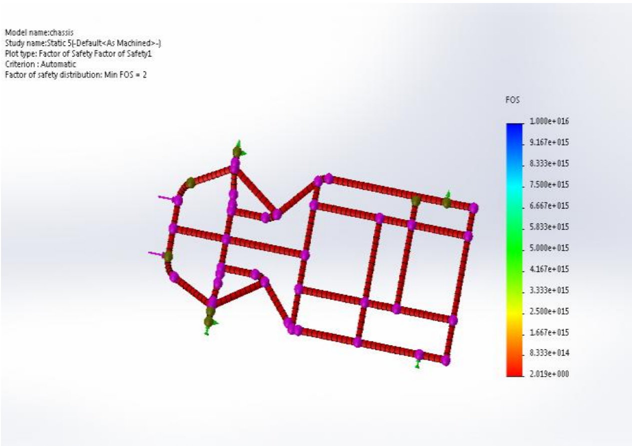
F=P×T

F=2944.44×1.10

F=3238.884N

Now the calculated force were placed on the front part of chassis by keeping the rear part fix on solidworks the result along with the image as-

III.REAR IMPACT ANALYSIS-



FRONT IMPACT– F.O.S. SIMULATION

Fig. 1

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SIDE IMPACT ANALYSIS-

In case of collision by side impact the value of the impact force generated is calculated in the same way as in front impact.

For the side impact the velocity of kart is taken as 45 km/h or12.5m/s according to ENCAP standard and then force is calculated i.e.

$F = P \times T$

$P = M \times V$

$P = 200 \times 12.5$

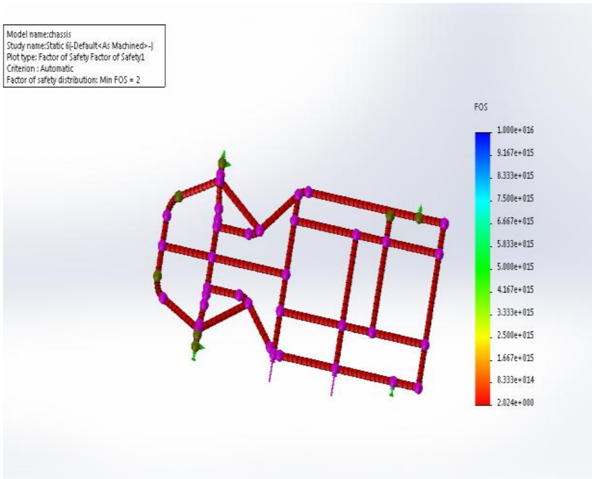
P=2500 kg-m/s

The side impact force is-

$F = 2500 \times 1.10$

F=2750N

Hence the calculated force were placed on one side of the chassis while keeping another side fixed and simulated image as shown in fig-



SIDE IMPACT - F.O.S. SIMULATION

Fig.2

The rear impact force is also calculated in the same way as above two. In this case the velocity of collision is taken as 50 km/h or 13.88 m/s by the calculation and also according to the ENCAP standards the calculations are as-

$$P = M \times V$$

$P = 200 \times 13.88$

P= 2760kg-m/s

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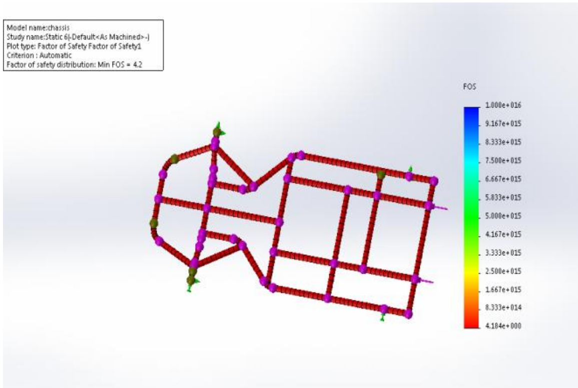
Rear impact force

F=P×T

F=2760×1.10

F=3036N

Hence the calculated value of the rear impact force was placed on the rear part of the chassis while keeping the front part fixed. The analysis result is shown in fig-



REAR IMPACT- F.O.S. SIMULATION

Fig.3

Factor of safety is determined by using the following formula i.e.-

F.O.S.=DESIGN STRESS/YIELD STRESS

WEIGHT

Keeping the frame as light as possible is a main priority when power is limited, vehicle weight is a larger factor in vehicle performance. The frame is one of the largest and heavy component of the vehicle. the strategy utilized to minimize weight consisted of determining defined goals for the chassis and employing the correct material in the best places to **STEERING SYSTEM DESIGN**

Accomplish those goals, FEA aided the material decision making process. FEA specifically helped to determined whether a member was under high or low stress, we are using AISI-1018 for frame and its thickness 1.5mm,outer diameter 1.5 inch. The final weight of the chassis is measured on software is 15 kg. the final weight of the vehicle along with driver is estimated to be 200kg.

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WELDING

The material which is used AISI-1018 has good weldability. All weld on the kart will make using a electric arc welding.

BODY AND COMPOSITES-

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

BODY PANELS-

The body panels we are using is made of FRP(fiber reinforced plastic).FRP is a composite material made of a matrix reinforced with fibers the polymer is usually epoxy , polyster thermosetting plastic are used in FRP. It is very light material that has desirable properties for a body panels.

SEAT-

We are using bucket type standard go-kart/e-kart seat which is made of FRP and is attached to chassis by four points only.

The purpose of steering system is to provide directional stability of vehicle with minimum input. we are using pitman arm steering system.

The main goal for steering is to have steering radius of 4m or less.(our steering wheel radius 3.048m) to have 100% ackerman steering.

DESIGN-

Simplicity and safety is the main design specification for vehicle steering system . we are drawing steering geometry in solid works and calculate following points-

Inner turning angle	32.4 deg
Outer turning angle	24.1 deg
Turning radius	2.74 m
Caster angle	25 deg
Camber angle	1 deg
Steering wheel diameter	3.04 m
King pin inclination	11 deg
Tie rod length	260&32mm

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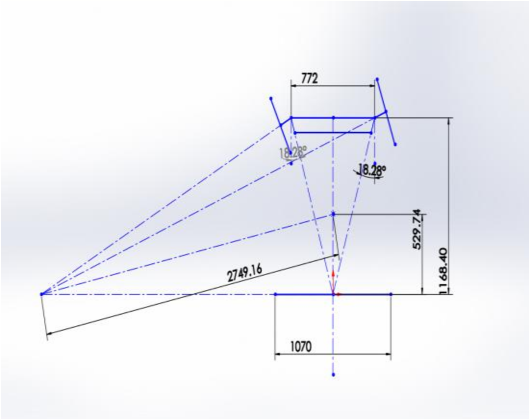
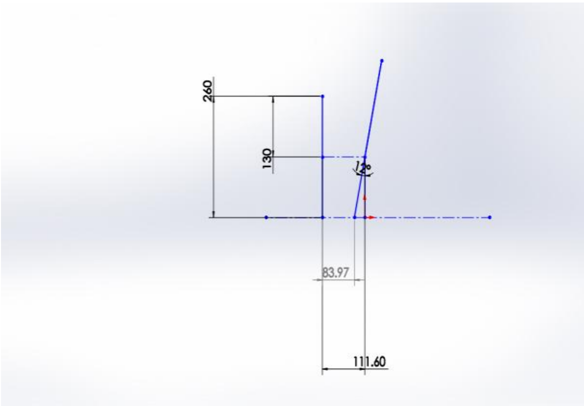


STEERING GEOMETRY

Fig.4



KING PIN INCLINATION

Fig.5

IV.CALCULATION-

From rulebook we select following data-

- wheel base(b)=1168.4mm
- front wheel track(a)=996 mm
- stubaxlelength(x)=111.76mm (from manufacturer)

distance between stub axle (c)=A-2X

c=996-2×111.76

c=772.48mm

ackerman equation &ratio

cot(ϕ) – cot(Θ) = c/b = [772.48/1168.4] = 0.6611

From design

Θ=32.4 degree

Φ=24.1106 degree

To satisfy ackerman equation put value of Θ & Φ in ackerman equation we get result 0.6611.

Now we calculate ackerman angle(α)

$\alpha = \tan^{-1}\left(\frac{c}{2b}\right)$

$\alpha = \tan^{-1}\left(\frac{772.48}{2\times1168.4}\right)$

α=18.2924°

now R(i)= inner turning radius

R(o)= outer turning radius

R(i)=b/sin $\theta - x$

R(i)=1168.4/ sin32.4 – 111.76

R(i)=2068.90mm

R(o)=b/sin $\emptyset - x$

R(o)=1168.4/sin 24.1106 −111.76

R(o)=2749.1606mm

If we are taking left turn the turning radius is 2.74m

1.Steering effort-

Maximum normal reaction at front wheels =mg× weight transfer ratio at front wheels

= 200×9.81×0.45

=882.9 N

Force on steering arm=μ × normal reaction force

F=0.6 ×882.9

F=529.74 N

2. Force on tie road-

Force on steering arm × scrub radius=f ×88.09

529.74×84.04=f×88.09 (from stub axle)

F=505.38 N

3. Torque on steering shaft=force on tie road×0.0889

T=47.07 N-m

4.Force on steering wheel=torque/steering wheel dia.

=47.7/0.3048

=154.49 N

5. Steering effort=154.49/9.81

6. Steering effort=15.7487 kg

BRAKE SYSTEM-

The purpose of the brakes is to stop the vehicle safely and effectively. In order to achieve maximum performance from the braking system the brake have been designed to lock up rear wheels, while minimizing the cost and weight. We are using hydraulic braking system.

DESIGN-

The brake system design includes the single disc at rear axle to stop the vehicle. It is mounted in one third part of rear axle with opposite position of drive train sprocket hence also enables the good balancing requirement.

Master cylinder is used at the front near the brake pedal providing the occupant to easily accessible space.

CALCULATIONS-

Brake pedal force

(1.) Brake pedal force

F= force applied by driver on pedal× levarage ratio

F= 150×7/1

F= 1050 N

(2.) Pressure on master cylinder

P= brake pedal force/area of master cylinder

P=1050/254.46

P=4.1263 N/mm square

Pressure on caliper = pressure on master cylinder

(3.) Caliper force

F= pressure on caliper× area of caliper

F= 4.12×706.8583

F= 2916.66N

Total caliper force=2×2916.66

Total caliper force=5833.33 N

(4.) Friction force

F= force on caliper× μ

F= 5833.33×0.4

F=2333.33 N

(5.) Rotor torque

T= friction force×effective radius

T =2333.33×0.090

T = 209.99

(6.) Brake force on tire

F= rotor torque/radius of tire

F =209.99/.1395

F= 1503.1496 N

(7.) Deaccleration of vehicle in motion

A= brake force/ total mass of vehicle & driver

A=1503.1496/200

A=7.51 meter/ second square

(8.) Stopping distance of vehicle

From newton law of motion

S= 13.88×13.88/7.51×2

S= 12.82 m

(9.) Time travel to achieve stopping distance

T=v/a

T=13.88/7.51

T=1.85 sec

TRANSMISSION

Power developed by the engine/motor is transferred to the wheels by transmission system. The main function of transmission system are-

- it must provide varying gear ratios.
- It must provide a reverse gear for moving vehicle in reverse direction.

We are using BLDC motor of 1000 watt. It is better compare to PMDC& AC motor.

TRANSMISSION CALCULATION-

Motor rpm= 3000

Motor power=1000 watt

- Kart speed=wheel speed× π ×D/60

D= diameter of rear wheel

Wheel speed= motor rpm/gear ratio

Wheel speed=3000/3

Wheel speed =1000rpm

Kart speed =1000× π ×.279/60

Kart speed= 14.6084 meter/ second

- Rolling resistance on rear tire-

R =μmg × weight transfer ratio on rear

R= 0.040×200×9.81×0.55

R=43.164 N

- Rolling resistance on front tire-

=0.040×200×9.81×0.45

=35.316 N

4. Total rolling force-

= rolling force on front tire+ rolling force on rear tire

=35.316+43.164

=78.48 N

5. Drag force-

= 0.5× ρ ×v×v× a × $c$oefficient of discharge

$$\rho = 1.4$$

Coefficient of discharge=0.3

=17.32 N

6. Total force-

= drag force+ rolling force

=17.32+78.48

=95.8 N

7. Maximum input torque-

=3.18×19.55×3

=186.50 Nm

8. Force on tire through motor-

F = maximum input torque/radius of tire

F=186.50/.1397

F =1335.0035 N

9. Total force on tire-

=1335.0035-95.8

=1239.2035 N

10. Accleration-

F = ma

A=f/m

A=1239.2035/200

A =6.1960 meter/ second square

11. Time to achieve-

T=v/a

T=14.60/6.1960

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T=2.3563 sec.

12. Distance to achieve speed-

From newton second law of displacement

S=0.5×6.1960×2.3563×2.3563

S= 17.2014 m

S= 18m

13. Tractive force-

$= \mu m g$

=0.5×200×9.81

=981 N

For each wheel=981/4

=245.25 N

14. Maximum acceleration=490.5/200

=2.4525 meter/ second square

15. Distance to achieve speed-

S= 0.5×2.4525×5.95×5.95

S= 43.75 m

KILL SWITCH-

Kill switch is provided in our vehicle as a safety to our driver in case of emergency. If driver wants to stop the vehicle in any critical situation so he pushes the kill switch gently and stop the rotation of motor.

Vehicle specification-

Vehicle parameters	dimension
Wheel base	1168.4mm
Front Wheel track	992mm
Overall length	1780mm
Overall width	1320mm

Ground clearance	2 inch
Overall weight	200 kg
Material	AISI-1018
Motor type	B.L.D.C.
Maximum speed	53 Km/hr
Steering	Pitman arm
Turning radius	2.7 m
Brake	Hydraulic

V.CONCLUSION

1. The 1250 watt, 48 volt, 4 wheeled racing car, E- Go Kart, is designed and fabricated within RS.80000 using the automotive standard materials.
2. The E-Go Kart designed and fabricated is recommended for a speed of 60km/hr. An old men aged about 50+ and women can also drive this E-Go kart.
3. FEA analysis of chassis loading is performed to evaluate the maximum stresses that the member can bear.

VI.FUTURE SCOPE

- E-karting is a growing business with the increasing interest of the youth in driving sporty rides without any pollution and noise.
- Now a days trend is emerging in Automobile sector, Mostly students are enthusiastic in racing cars.
- Students and youngsters are the hot cake for this business to grow.
- This E-kart is a low price & safe product equipped with eye catching graphics and a ride full of fun.
- It is a complete package for competitions.

Our idea is to provide an experience feild with the rush to our audience which they are looking for with the safety and enjoyment.

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