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Design and Manufacturing of Go-Kart

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Abstract: *This paper concentrate on explaining the design and engineering aspects of making a Go Kart for student karting championship. This report explains the objectives, assumptions and calculations made in designing a Go Kart. The team's primary objective is that to design a safe and functional vehicle based on rigid and torsion free frame. The design is chosen such that the Kart is easy to fabricate in every possible aspect. Go-Kart is small four-wheeled vehicle. The design report focuses on briefing the sole ideology behind the development of lightweight, compact, economical, durable and easy to manufacture GO-KART. The team's primary objective is to design safe and functional vehicle based on rigid and torsional free frame. Even in their most primitive form, go-karts may be adapted as transportation technology in developing countries to leverage economic growth and poverty alleviation. Go karts offer a simple and inexpensive technology that meet many rural transportation needs. The technology is a bridge between simple pushcarts and rickshaws on one hand and the automobile and truck technology designed to western specifications on the other. The relative inefficiency of the former technology is the very cause of poverty in many areas while the cost and technology burden of the latter makes them inaccessible to the poor.*

Keywords: *Ergonomics, Design of chassis, Static analysis, Analysis of Go-Kart components,Selection of engine, Design of shaft , Brake system.*

I. Introduction

In the 1950, a group of tinkerers and thrill seekers in Southern California welded together a crude frame from steel tubing. Mounted it on wheel intended for wheelbarrows, powered the contraption with a spall 3 HP engine intended for lawn mowers and raced it around the parking lot of the Rose Bowl in Pasadena. These vehicles, now called as "Go-karts" have grown into a multi-billion dollar industry in the USA and throughout the developed world. They are made, sold, and weld exclusively as recreational racers. They are not designed for transportation as well as illegal in most places to drive them on the road. These vehicles are typically 30 inches wide, 4 to 5 feet bong. In addition, weigh between 50 and 70 pounds. They are simple and inexpensive to build as well as operate and they can travel on rough terrain and roads at speeds exceeding 20 miles per hour. It is estimated that large volume export in OEM contracts could be negotiated somewhere near half this amount. Alternate Asian sources particularly China or S. Korea might yield lower cost designs. Chinese-made 4-cycle irrigation pump engines are widely available in Asia for around $100 and these may be substituted for lawn mower engines in Asian designs. An additional consideration in favor of the irrigation pump engines is 4- cycle engines are less polluting and many countries in Asia are phasing out the use of 2-cycle engines for that reason. Normally a 30-inch wheelbase is used with 1" by 36" threaded axles and 3 to 6 inches of ground clearance depending on the type of terrain the vehicle and expected to traverse. A very elementary steering system of the tie-and-rod variety sufficient. Brakes may be 4-1/2 inch band or drum design 8-inch to 14-inch standard wheels from the garden supply industry may be utilized. The other significant components are clutch, sprocket assembly, bearings, and a throttle control assembly. Even in their most primitive forms, go-karts may be adapted as transportation technology in developing countries to leverage economic growth as well as poverty alleviation. Go karts offer a simple and expensive technology that meets many rural transportation needs. The technology is a bridge between simple pushcarts and rickshaws on one hand and the automobile and truck technology designed to western specifications on the other. The relative inefficiency of the former technology's the very cause of poverty in many areas while the cost and technology. The design process of the vehicle is iterative as well as it is based on various engineering and reverse engineering processes depending upon the availability, cost and other such factors like-Safety, Serviceability, cost, Strength, ruggedness, Standardization, Driving feel and ergonomics, Aesthetics. In CAE Analysis, we have done both Static as well as Dynamic analysis. We approached our design by considering all possible alternatives for a system & modeling them in CAD software like CATIA, Pro-E etc. and subjected to analysis using ANSYS FEA software.

II. Design of chassis

II. 1 Objective

The frame is designed to meet the technical requirement of competition. Frame design is first implemented by considering the safety. The first primary safety focused on maintaining the proper clearance *between driver's body and other rigid parts such as engine compartments. The chassis is designed by considering the comfort of the driver. All the parts must be solidly attached to the chassis for safety while performing in the event. Keeping the frame as light as possible was top priority because when power is limited weight play an important role in vehicle performance. The main component of the frame are divided into two major parts first the front block (cockpit) for steering and seat positions etc. and second rear block (engine compartment) which is for transmission and brake assembly. Chassis construction is of a tubular construction, typically mild steel with different grades. In this kart, we had used AISI-4130 having low weight and high strength having same dimensions*

Composition- (AISI-4130)

Iron, Fe	*97.03-98.22*
Chromium, Cr	*0.80-1.10*
Manganese, Mn	*0.40-0.60*
Carbon, C	*0.28-0.33*
Silicon, Si	*0.15-0.30*
Molybdenum, Mo	*0.15-0.25*
Sulphur, S	*0.040*
Phosphorus, P	*0.035*

Properties

Tensile strength (ultimate)-560Mpa
Tensile strength (yield)-460MPa
Modulus of elasticity-190-210 GPa
Bulk modulus -140 GPa

II.2 Ergonomics:

Figure 1

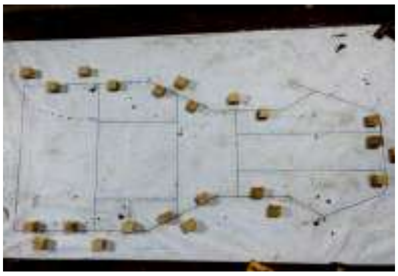

Figure 2

II.3 Static analysis

Assume
u= 40kmph = 11.11 m/s ,t = 0.4 sec ,v = 0 (final velocity after collision) ,
v= u+at
0 = 11.11 + a (0.4)
-11.11 = 0.4a
a= 27.77 m/s2
Where,
u = Initial velocity , v = Final velocity
Force = m × a
= 155 × 27.77
= 4304.35 N
Gforce = F / (mg)
= 4304.35 / (155 × 9.81)
=2.83 = 3
For Front Impact,
=3×155×9.81 = 4561.65 N
Rear Impact,
=3×155×9.81 = 4561.65 N
Side Impact,
=2×155×9.81 = 3041.1 N

II.4 Front impact analysis

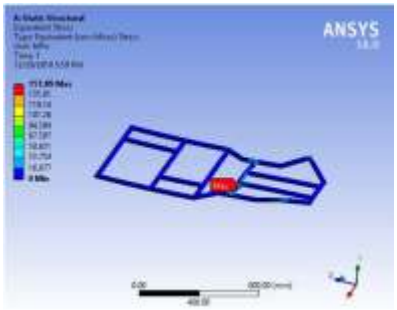

Figure 3*- Equivalent stress*

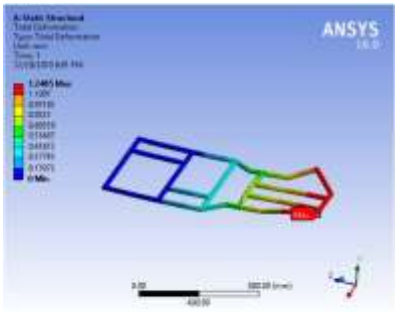

Figure 4*- Total Deformation*

II.5 Side impact analysis

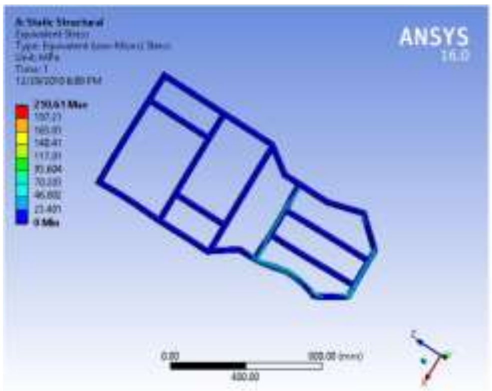

Figure5*- Equivalent stress*

II.6 Rear impact analysis

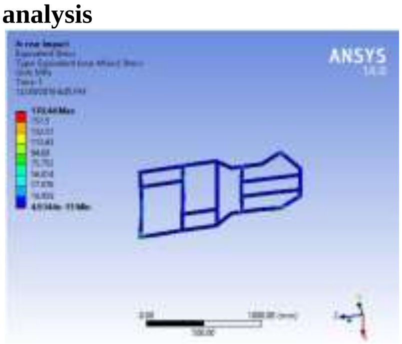

Figure6*- Equivalent stress*

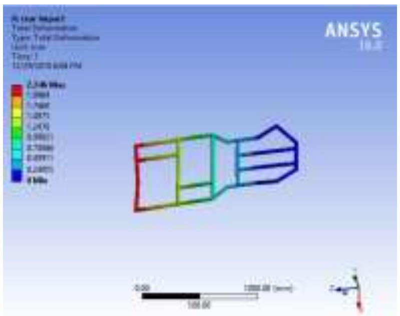

Figure7*- Total deformation*

Factor	Front	Rear	Side
Impact Forces	4561.6	4561.6	3041.1
Stresses	151.89	170.44	210
Total deformation	1.2485	2.24	0.93
FOS	3.02	2.69	2.18

Table for safety analysis

III. Analysis Of Components

III.1 Disc Hub analysis :-

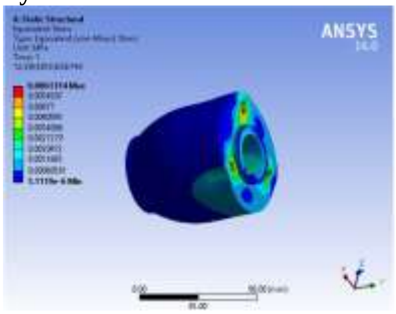

Figure 8*- Equivalent stress*

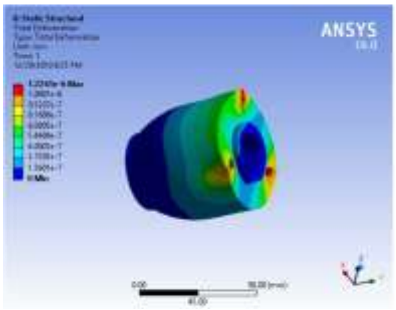

Figure 9*- Total deformation*

III. 2 Wheel hub analysis :-

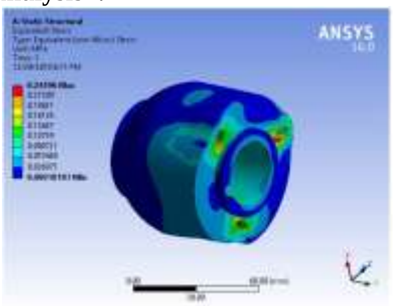

Figure 10*- Equivalent stress*

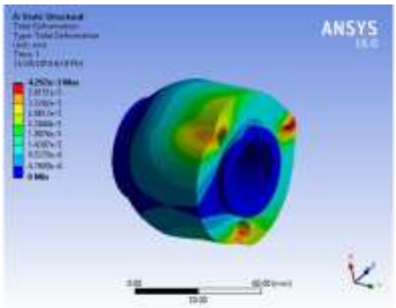

Figure 11*- Total deformation*

III. 3 Sprocket hub analysis

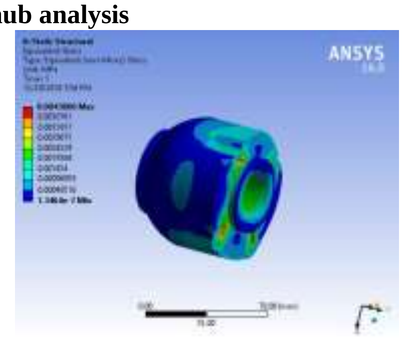

Figure 12*- Equivalent stress*

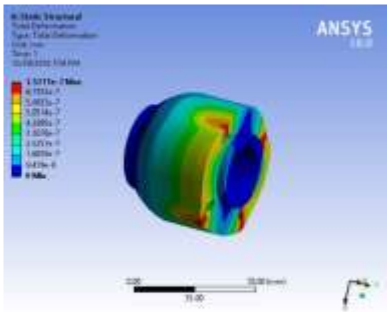

Figure 13*- Total deformation*

III. 4 Shaft analysis

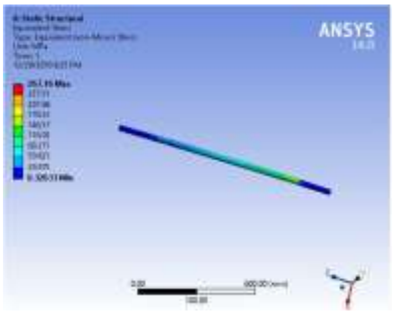

Figure 14- *Equivalent stress*

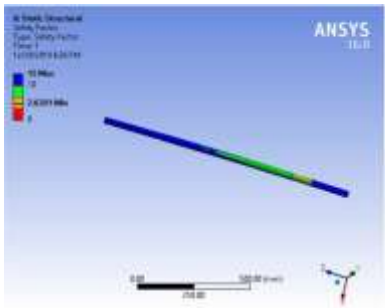

Figure 15*- Safety Factor*

III. 4 Pedal analysis

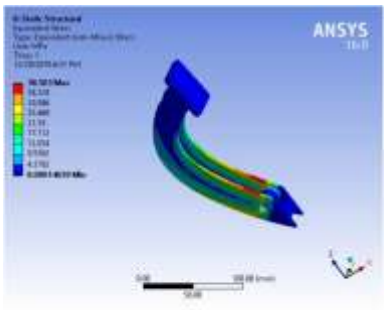

Figure 16- *Equivalent stress*

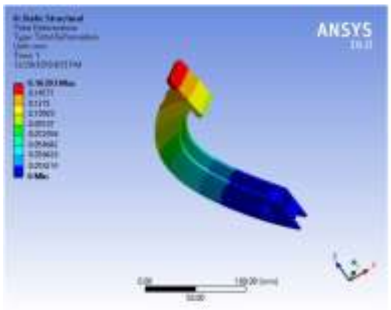

Figure 17- *Total deformation*

IV. Selection of engine

Considering vehicle at an angle of 5°on the road.
Mass of Vehicle = 155 kg
Velocity of Vehicle = 20.83 m/s
μ*(coefficient of friction) of road = 0.6*
MgsinƟ = 155 x 9.81 x sin5 = 132.52 N
Neglecting air resistance
Rolling Friction = Coeff. of Rolling Resistance xMg=0.025x155x9.81= 38.01N
*Total resistance****(Tr)*** *=132.52+38.01=170.53N*
Torque required at the wheels = Tr x Tire radius=170.53 x 0.1397=23.82 N-m
This torque must be overcome by tire. Vehicle power required= Tr x V = 170.53x20.83=3.52 KW
This much amount of power is required to vehicle at 5º.
Required Engine power
=vehicle power/transmission efficiency =3.52/0.8=4.4 kw
This amount of power is required to engine.
Specification of Engine Honda CBF Stunner 125cc
*Engine power (****PE****) = 11 BHP (brake horse power) at 8000 rpm*
= 8.20 kw
*Max. Engine Torque(****TE****) =11N-m at*
6500 rpm = 95km/hr
5 speed Engine: 1-N-2-3-4-5
*Gear ratio (****G****) = 1st-3.076, 2nd-1.944, 3rd-1.473, 4th-1.19, 5th- 1.038*
Wheel Torque = G x Transmission efficiency x Engine Torque x2
=11x3.076 x 0 .80x2=54.13Nm
This torque greater than the torque required at wheel. Hence Vehicle will move forward.
Tractive Effort (Te)=Torque at Wheel / Radius of tyre= 54.13/0.1397 = 387.47 N
Also engine overcoming resistance force coming at wheel. Hence this vehicle is perfect for vehicle.

Final Speed Calculation :-
Hence this vehicle is perfect for vehicle.
Acceleration=F/M =387.47/155=2.49m/ s2
Net force (F) = Te - Tr
=387.47– 170.53=216.94N
Torque = Net force x tire radius
=216.94×0.1397=30.30Nm
P=2ΠNT/60000
N=8.20 ×60000/2Π×30.30
N=2584.29 rpm
N/V=2.65Gr/r
V=2584.29×0.1397/(2.65×1.744)=78.09 km/hr
V=78.09×5/18=21.69 m/s
As per terms given in rulebook, we must select engine which is equal to or less than 125cc. Thus, we selected the engines which will fulfill the criterion.

Selection of manual transmission system

Manual transmission drivers prefer a manual transmission because it gives the driver a feeling of being in control of the vehicle. In the automatic transmission vehicle, the torque converter pushes the vehicle forward. Manual transmission vehicles did not have a torque converter. For this reason, manual transmission drivers are able to use the momentum of the engine to slow down the vehicle and brake more easily.

Selection of appropriate engine

We have selected Honda Stunner engine due to its technical specifications, availability, performance maximum power transmission.

We rejected Discover 125 because it does not transmit power more than Stunner 125.Simultaneously we selected two engines Yamaha gladiator and Bajaj Discover 125 but when we compared the torque of these engines with the torque of other engines, it was less than the rest so we rejected it.

V. Design of shaft

While designing a shaft, following parameters are necessary.

As per the rule of GOKART, the shaft material is magnetic steel. By considering the factors like availability, Property, Cost, etc. we selected the material EN19 (709M40).

Chemical composition (en-19)

- • Carbon = 0.36-0.44%
- Silicon =0.10- 0.40%
- • Manganese= 0.70-1.00%
- • Sulphur=0.040% (maximum)
- • Phosphorus=0.030%(maximum)
- • Chromium=0.90-1.20%
- • Molybdenum=0.25-0.35%

Mechanical properties

- • Ultimate stress=850-1000 N/mm2
- • Yield stress=700 N/mm2
- • 0.2% Proof Stress=680 N/mm2
- • Elongation=9% (minimum)
- • Hardness=248-302 BHN

Material selected is Mild steel:-

Yield stress=700 N/mm2
Ultimate Stress=1000 N/mm2
Taking Factor of safety as 3
Permissible shear stress acting on shaft
Tmax =0.75(0.18Sut)
=0.75(0.18×1000)
=135 N/mm2

Total weight of the vehicle=155×9.81=1520.55N
Weight distribution on rear wheel is 60%
Weight distribution over rear wheel=0.60×1520.55=912.33N
Taking independent distribution over both wheels=912.332=456.165 N
Sprocket Wt. = 1.5×9.81 = 14.71N
Disc Wt. =1.5×9.81 = 14.71N

VI. Design of brake system

Objective

The purpose of the brakes is to stop the car safely as well as effectively. In order to achieve maximum performance in the braking system, the brakes has designed to lock up rear wheels, while minimizing the cost and weight

Design

The brake system design included the single disc at the rear axle for stop the vehicle. It is mounted in the one third part position of the axle with opposing the position of drive train sprocket hence it enables the good balancing requirement.

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Pedal ratio = 4:1
Manual force applied=300N Mass of vehicle = 155 Kg
*Velocity (**v**) = 75 km/h =20.83 m/s*
Weight distribution: 40% for front and 60%for rear.
Double piston calliper calculation:-
• Gross weight of vehicle(w)=155×9.81=1520.55N
Pedal ratio=4:1
• Brake line pressure:
Bp=(pedal ratio×force on pedal/area of master cylinder)

$=4\times 300\pi 4\times 0.012$
$=15.27mpa$
Clamping force (F)=brake line pressure ×piston area
= Bp×(π4×d2)
= 15.27×(π4×25.42)=15474.84N
Rotating force(Rf)= F× No. of piston× μ(μ=coefficient of friction between disc and pad)
=15474.84×2×0.5=15474.84N
Braking Torque(Tb)= Rf×disc radius
=15474.84×0.053=820.16N/m
Braking Force(Fb)=$Tbtire\ radius$
=820.160.1397=5870.91N
Deacceleration(a)= -Fb/m= -5870.91/155= -37.87m/s2
Stopping distance(S)=$v2-U22a$=02−20.8322(37.87)=5.72m
Stopping time(t)= V/g
= 20.83/9.81=2.12s
We have also calculated stopping distance for single piston calliper so its stopping distance is 11.9m. Thus, we have selected double piston calliper.

VII. Conclusion

The Team Blackspanners 2.0 used the finite element analysis system to evaluate, create and modify the best vehicle design to achieve set goals. The main goal was to simplify the overall design for making it more light-weight without sacrificing performance and durability. The result is a lighter, faster, and more agile vehicle which improves go kart design. The designed chassis falls within the dimensional constraints of a standard go-kart chassis. The deformation of the chassis & the stresses induced in the chassis during static loading are within permissible limits. The chassis has sufficient strength to withstand front impact, rear impact, side impact & minor road bumps The model analysis was carried out to find out the natural frequencies of the chassis.

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