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Design an Exemplary Ecokart

Ankit Dubey
Dept. Mechanical Engineering
Jodhpur Institute of Engineering and Technology
Jodhpur, India

Divyanshu Vyas
Dept. Mechanical Engineering
Jodhpur Institute of Engineering and Technology
Jodhpur, India

Pallav Mathur
Dept. Mechanical Engineering
Jodhpur Institute of Engineering and Technology
Jodhpur, India

Abstract:- The paper documents the process and methodology to produce a high endurance ecokart which is comfortable, durable and complete in all aspects by a profound design chassis modeled in CAD (Computer Aided Designing) and CAE (Computer Aided Engineering) software such as SOLIDWORKS and ANSYS respectively. The team focuses on a technically sound vehicle which is backed by a profound design, high build quality yet light weight, good manufacturing practices to ensure maximum safety of driver. This paper aims to design analysis of a kart chassis as per calculations. The main intention is to provide high safety which is ensured by static analysis of chassis and CFD (Computational Fluid Dynamics) analysis of kart's aerodynamic body.

***Keywords**:- Chassis; Solidworks; ANSYS; Analysis; CFD.*

I. INTRODUCTION

Eco kart is a single seat, motor driven vehicle which is operated by a motor, where source of running the motor is a battery. In karts chassis is arguably the most important part of it. A chassis consists of an internal framework that supports a manmade object in its construction and use. It is analogous to an animal's skeleton. An example of a chassis is the underpart of a motor vehicle, consisting of the frame (on which the body is mounted).

Chassis used for designing kart is tubular space frame chassis which is a three-dimensional design employing number of circular and square section tubes. Tubes are positioned in different sections to provide mechanical strength against forces from anywhere. Tubes are welded together and form a complex structure which can withstand in adverse situations. Designing of ecokart is conducted in CAD software- SOLIDWORKS 17.0 and its analysis in CAE software- ANSYS 18.0. Force analysis is carried out on designed kart to simulate and analyses the actual accidental situations as shown in Fig.1-3. Kart's sustainability and durability have been analyzed on impact or collision with solid structure or body. To ensure the maximum safety of driver and kart, analyses have been conducted for extreme conditions by approximately 3 times the force acting on it. Surprisingly, the obtained results are in permissible limits.

II. SAFETY CONCERN

Karting is an extremely popular activity amongst people of all age groups. Like any sport which involves people travelling at speed and near each other, there is always an element of risk and danger to consider but it should be a reasonably safe sport to undertake providing that people understand the rules and their own limitations.

Types of karting can differ. In some cases, your local town may have a karting track where, although safety is still a major issue, these types of track are aimed more at people who are generally looking upon their visit as a fun day out. They do not need to have any prior experience nor need to wear any real protective clothing, apart from a helmet which is often provided anyway, and these are the types of tracks that are popular with groups like stag parties and groups of children who like to go in the school holidays etc.

Since its introduction in the 50's, karting has strongly developed itself as sports and leisure opportunity. Indoor and outdoor karting tracks accommodate thousands of people annually. Some even consider go-karting a stepping stone towards professional Formula 1 sports. [1]

While sitting in an ecokart, the trunk and extremities are relatively unprotected. The accident rate during karting is exceedingly high. Despite the substantial risk of severe injuries, the number of mandatory safety requirements for this sport remains low. Compared with other high-risk sports hardly any scientific data is available about injuries and risks concerning karting; this might explain the limited number of safety requirements.

In medical literature mainly case reports, without explicitly describing the underlying trauma mechanism are presented as described in report three categories of trauma mechanisms have been defined in Table 1.

HET (High Energetic Trauma)

A. Injuries to the extremities and trunk that are related to a direct collision at either side of the ecokart; these injuries are mainly associated with cuts, bruises, and fractures.

B. High-energetic trauma, mainly caused by frontal collision; this usually causes blunt-injury abdominal or thoracic injuries, but also compression fractures of the lower extremities can be seen.

C. Acceleration/deceleration trauma causing hyperextension injuries to the (cervical) spine. Injuries resulting from ecokart accidents are very heterogeneous.[2]

III. DESIGN

Firstly, chassis is designed for racings at descent speed and fun purpose in amusement parks as shown in Fig.6. On analyzing accidents during karting, a decision has been made to improve the safety of kart and design it for adverse situations. On analysis of different accidental situations, iteration have been carried out which is shown in Fig.5.

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IV. METHOD FOR IMPROVING SAFETY OF FRAME

A. Add additional members-

Addition of structural members increase stiffness and decrease flexural rigidity under loading conditions.

B. T joints-

These joints minimize deflection, cracking and excessive vibrations under dynamic conditions of vehicle.

C. Gussets-

Triangular gussets are used to transfer stress from small members to larger members which prevents excessive bending and breakage of members.

D. Advanced design bumpers-

Its hexagonal structure absorb the effect of impact and transmit minimum amount of force to frame.

V. FORCE CALCULATION

A. Front impact analysis-

During front impact, it is assumed that the front end of kart is colliding with the structure at maximum speed of 16.66m/s. Then force is calculated for normal and extreme condition is described in (1) and (6) respectively.

B. Side impact analysis-

On side impact analysis, it is assumed that the side faces of kart or side guard encounter with an accidental impact from another kart an average speed of 15.27m/s. Then force is calculated for normal and extreme condition is described in (3) and (8) respectively.

C. Rear impact analysis-

In rear impact analysis, kart is assumed to be stationary while another kart collides at the rear end of kart with an average speed of 16.11m/s. Then force is calculated for normal and extreme condition is described in (2) and (7) respectively.

D. Top impact analysis-

In top impact analysis, kart is assumed to be rolled in accidental case and mass of whole kart is concentrated on roll over protection. Force from top is considering to be 2 to 3 times the mass of kart. Then force is calculated for normal and extreme condition is described in (4) and (9) respectively.

E. CFD Analysis-

CFD has been carried out at the front end of kart to determine the airflow and tests the aerodynamic design of kart's body. It has been carried out on fiber body as per the calculations of fluid (air) force described in equation (5) and (10), understands the impact of air on kart's performance as shown in Fig.7. It also shows flow direction of air from body contours. Then areas facing maximum air resistance has been corrected to minimize air resistance on kart. Similar analysis is conducted for kart's speed at 50 m/s as shown in Fig.8.

VI. ITERATION

A. Side rod to plate-

Stress at ends of rod becomes high on side impact whereas plate distribute force efficiently among hexagonal structure. Welded gussets for rear safety- welded gussets efficiently manage stress due to fatigue loading at critical locations.

B. Member for side safety-

This member support seat and distribute forces and stress generate from side impact.

C. Members for top safety-

Maximum deformation in top/ roll over analysis is analysed at battery protection members, so triangulation is used to control it.

D. Members for rear safety-

Rear impact transmit from rear end of kart to diagonal member joining it with roll over. This member distributes the forces concentrate at each diagonal member. Few members are added to rear end which supports rear bumper in force absorption.

E. Members for front safety-

A diagonal member has been replaced by small members at front end of chassis to support front bumper in force distribution and weight reduction.

F. New bumpers-

In new bumpers, plate transfer force to hexagonal structure which gets deform to distribute forces equally.

VII. EQUATIONS

FORCE CALCULATION AT ONE TIME IMPACT

$$\text{Front} = mv/t = 200*16.66/0.5 = 6664\text{N} \quad (1)$$

$$\text{Rear} = mv/t = 200*16.11/0.5 = 6444\text{N} \quad (2)$$

$$\text{Side} = mv/t = 200*15.27/0.5 = 6108\text{N} \quad (3)$$

$$\text{Top} = 3mg = 3*200*9.81 = 5886\text{N} \quad (4)$$

$$\text{ADF at 1 times} = \rho * C_d * A * v^2/2 = 1.2*0.04*1.8*16.66^2/2$$

$$= 12\text{N} \quad (5)$$

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FORCE CALCULATION AT THREE TIME IMPACT

Front= mv/t= 200*50/0.5= 19992N (6)

Rear= mv/t= 200*48.33/0.5= 19332N (7)

Side= mv/t= 200*45.83/0.5= 18324N (8)

Top= 6mg= 6*200*9.81= 11772N (9)

ADF at 3 times = $\varrho * Cd * A * v^2/2 = 1.2 * 0.04 * 1.8 * 50^2/2 = 108N$ (10)

Where

$\varrho = 1.2 kg/m^3$ (Density of air)

$C_d = 0.04$ (Air drag coefficient)[3]

$A = 1.8 m^2$ (Surface area in contact with air)

V=Velocity of kart [4]

ADF = Air drag force

δ= Deformation

VIII. FIGURES AND TABLES

Trauma Mechanism	Injury Type	Specific Injury
Direct trauma	Fracture, contusion, abrasion, laceration, burn wound	Calcaneal or ankle fracture caused by pedals; humeral, shoulder, or clavicular fracture after side impact; wrist or hand fracture by steering wheel
HET deceleration trauma	Blunt abdominal or thoracic trauma, compression injury to the lower extremity	Rib fracture, lung contusion, pneumothorax, fladder thorax, cor contusion, diaphragm rupture; rupture or contusion of spleen, liver, gal bladder, pancreas, kidney, or intestines; fracture or luxation of foot, lower limb, hip, or pelvis
Acceleration/deceleration	Flexion/extension injury	Compression fracture of the spine, whiplash, injury of the carotid or vertrebral arteries

Table 1. Trauma Mechanisms and Injuries

Fig 1:- Accident type 1

Fi

Fig 2:- Accident type 2

Fi

Fig 3:- Accident type 3

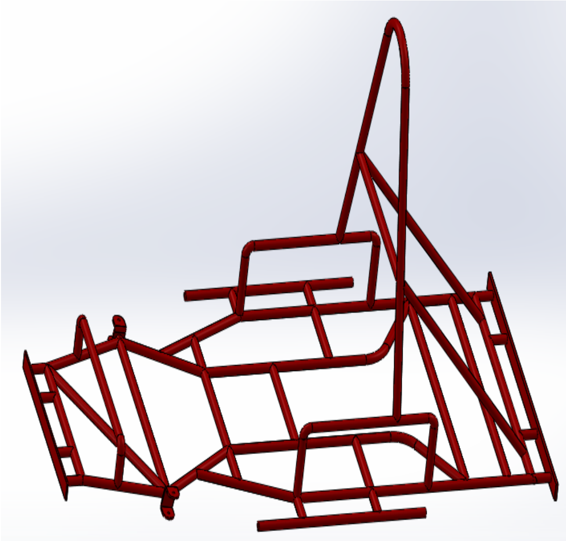

Fig 4:- Frame before iteration

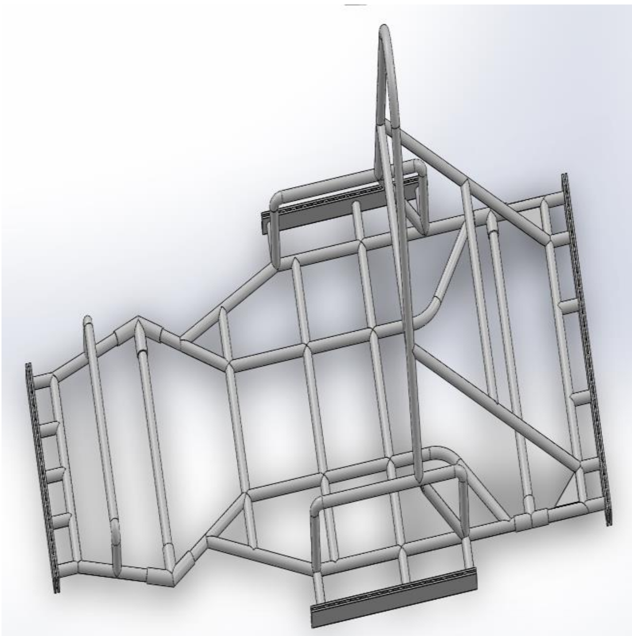

Fig 5:- Frame after iteration

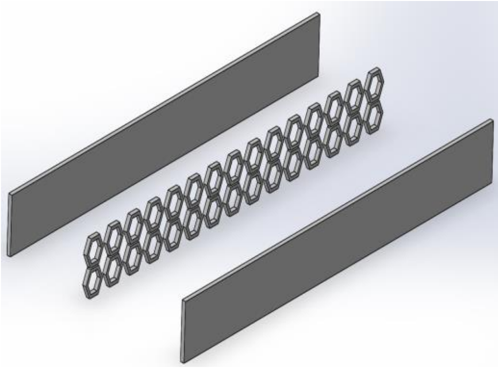

Fig 6:- Exploded view of bumper

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Table 2. Front Impact Analysis

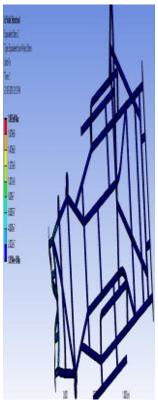
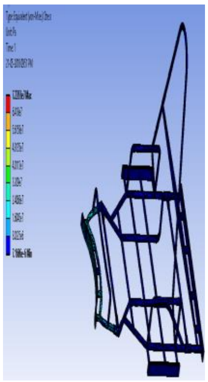
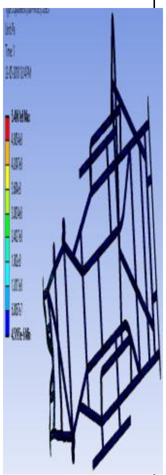
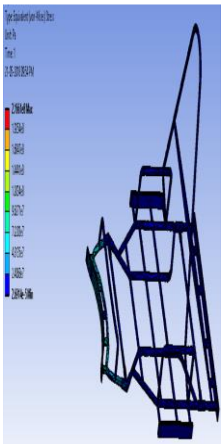
Parameter		Normal condition	Extreme condition
Before iteration			
After iteration			
Force		6664N	19992N
FOS	Before	2.05	5.13
	After	0.68	1.71
δ	Before	0.0006 m	0.0001m
	After	0.0018m	0.00043m

Table 3. Side Impact Analysis

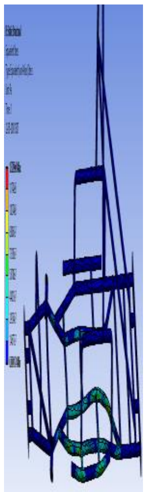
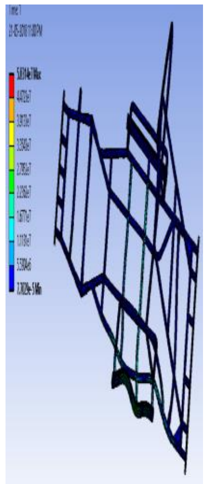
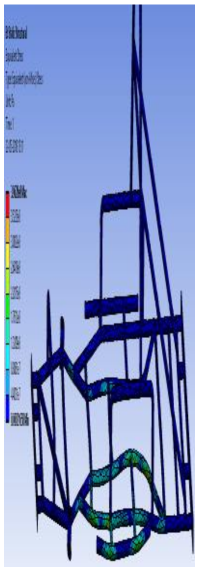
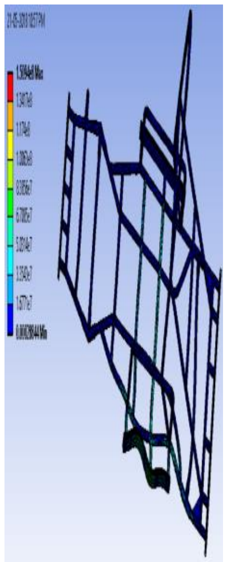
Parameter		Normal condition	Extreme condition
Before iteration			
After iteration			
Force		6108N	18324N
FOS	Before	2.80	7.3
	After	0.94	2.46
δ	BEFORE	0.0009M	0.00057M
	AFTER	0.00294M	0.00042M

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Table 4. Rear Impact Analysis

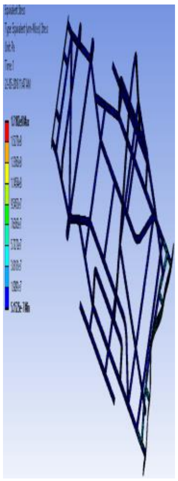
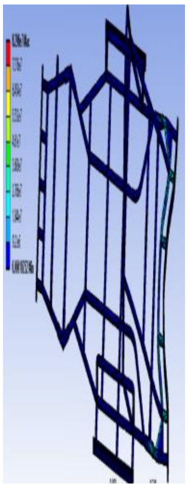
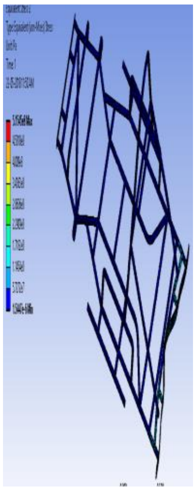
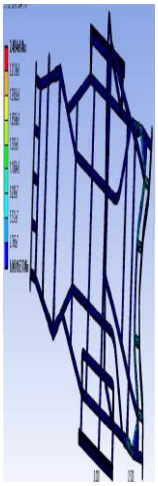
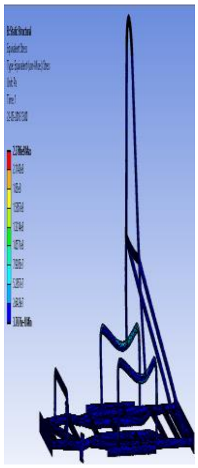
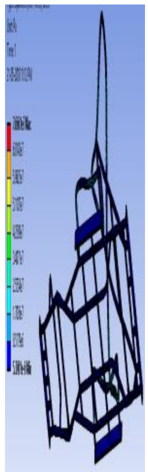
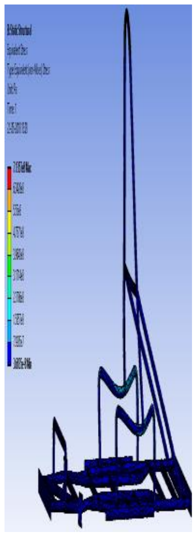
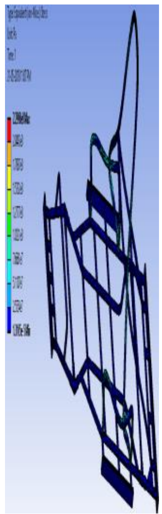
Parameter		Normal condition	Extreme condition
Before iteration			
After iteration			
Force		6444N	19332N
FOS	Before	2.16	4.46
	After	0.71	1.49
δ	Before	0.0012m	0.00022m
	After	0.0036m	0.00067m

Table 5. Top Impact Analysis

Parameter		Normal condition	Extreme condition
Before iteration			
After iteration			
Force		3924N	11772N
FOS	Before	1.54	4.8
	After	0.51	1.61
δ	Before	0.0009m	0.00028m
	After	0.0027m	0.00086m

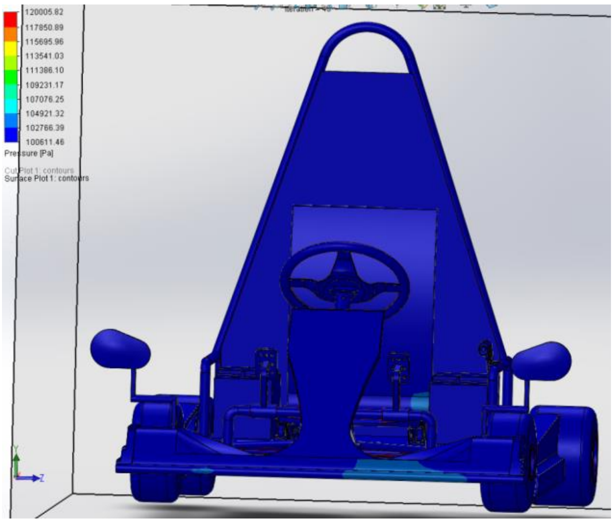


Fig 7:- CFD analysis on 1 time velocity

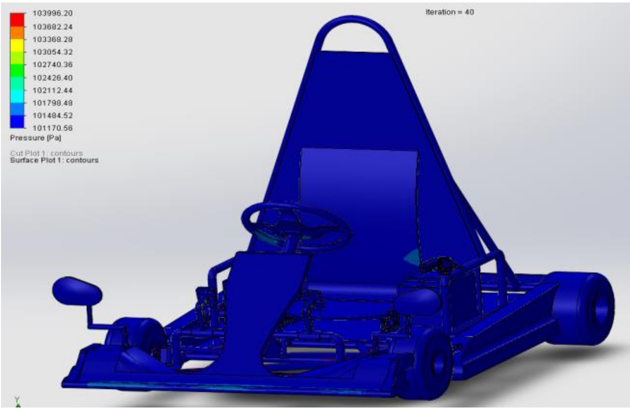


Fig 8:- CFD analysis on 3 time velocity

Fig 9:- Fire extinguisher

Fig 10:- Driver safety gears

IX. SAFETY EQUIPMENT

Irrespective of achieving the highest safety in kart, it is mandatory to wear driver's safety gears like helmet, fire resistance suit, gloves, shoes etc. as shown in Fig.10.

X. ACKNOWLEDGMENT

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