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DESIGN AND ANALYSIS OF ELECTRIC GO-KART

Aklesh Kumar Yadav[1, a)], Ithamsetti Sai Abhishak[2, b)]

[1,2]*B. Tech Students, Department of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, India*

Abstract The Go-kart Vehicle is made with Four tires, a seat, steering, and brakes, and without suspension and differential. Racing go-karts are vehicles with very low ground clearance that can be used only on level circuits. This go-kart was designed and analysed using an electric motor. These calculations and analyses show the details of the design and analysis. We aim to reduce weight and improve performance. It was decided to use AISI 4130 for making the chassis frame. An analysis of the part was then performed with Solidworks2018 CAD software following the 3d solid modelling step. In addition, analyse the deformation of the chassis in front, side, and rear impacts. Ackerman angles are provided on all steering systems. The caster angle is 11 degrees and the kingpin inclinations are 6 degrees, respectively. Due to maximum deformation of 2.481.and the maximum factor of safety of 15 and the maximum stress 337.84.

Keywords: material used AISI4130, impact test, chassis frame, battery cell, electric motors, factor of safety.

INTRODUCTION

The Go-kart Vehicle is made with Four tires, seat, steering, brakes, and without suspension and differential. Go-kart structure refers to quadracycle vehicle that is used in sports and competition. Go-kart could also be called as the open-wheel car on land which could be made with or without the body-frame work. It has four harmonious wheels with the bottom, of which two of them assist for the turning of the vehicle with the control of steering and others would facilitate the transmit of the go-cart. Usually, the whole-body frame of the go-cart is made-up of steel pipes, apart from the other key components like engine and the wheels. There were some other parameters such as the types of materials used for the structure of the vehicle in-order to make it mechanically rugged and design of the chassis, these choices are very well concerned because they determine the safety of the vehicle and the structural analysis. now, due to the advancements in the technology and manufacturing materials go-carts are expected to be lighter, faster and should be more efficient in-terms of fuel consumption and overall performance as well. Due to road irregularities, engine loads, and other factors, lighter chassis structures can cause structural resonance as part of a rigid-body vibration. A result of this is riding discomfort and problems with ride control and safety. Finite element analysis is a proven method for designing and creating engineering products using computer-based analytical tools. Finite element modelling is already seen as a vital part of the style, as it can be used for analysing and predicting various structures with a dynamic performance within an engineering environment. Modality analysis is a common way to identify the modal parameter of a structure. After the 1950 post-war Go-kart came into existence. Go-karting was invented by the father of karting, Arts Ingles, in Southern California. In Go-kart, we divided it to four sub-divisions: (i)Chassis, (ii)Engine, (iii)Steering, (iv)Brake and Tire. For Chassis, we have to select the material like aluminum, steel. Material AISI 1018 was highly machinable and inexpensive, but AISI 4130 had a high strength-to-weight ratio. Since it is an Electric Go-kart, Battery is being used in place of conventional engine. Battery plays a crucial role in E-Kart Vehicle as it is the heart or engine of the vehicle. Battery needs to have best performance, longer life, safety, cost, energy efficiency and so on. An analysis of the part was then performed with Solidworks2018 CAD software following the 3d solid modelling step. In addition, analyse the deformation of the chassis in front, side, and rear impacts. Ackerman angles are provided on all steering systems The caster angle is 11 degrees and the kingpin inclinations are 6 degrees, respectively. Due to maximum deformation of 2.481.and the maximum factor of safety of 15 and the maximum stress 337.84.

MATERIAL SELECTION

Making a go-kart starts with the selection and analysis of materials after obtaining the required designs and modelling them in Creo or Solid Works software. The design will be analysed using Solid works 2018 CAD software. Using the analysis result, the required design will be completed.

Among all of these, Vehicles and all their components are supported by the chassis frame. As a result, it should be sturdy enough to survive the impact and weight imparted to it, resulting in a better Go Kart. Four materials were chosen for the test adapted from the previous study, and their attributes were investigated. AISI 1018 is a hard, machinable, and relatively inexpensive material. A stronger Ratio of strength to weight was achieved with AISI 4130 material.

AISI 1018: It is slightly more malleable and ductile than AISI 1018 as it contains 0.05–0.30% carbon. While these carbon steels are easy to form and cost-effective, their tensile strength is relatively low. The surface hardness of such materials may be increased by carburizing them.

Table 1: AISI 1018 Composition

Elements	**Values**
Carbon(C)	0.15-0.19%
Sulphur(S)	0.01- 0.05 %
Phosphorous(P)	0.01-0.04 %
Manganese (Mn)	0.65 – 0.85 %
Iron (Fe)	98.90-99.15%

AISI 4130: These AISI 4130 alloy steels are often called Chromoly steels because they contain molybdenum and chromium. There are exceptional strength-to-weight ratios in these steels, and they are significantly stronger and harder than other steels.

Table 2: AISI 4130 Composition

Element	**Values**
Carbon(C)	0.28 – 0.32 %
Chromium (Cr)	0.83– 1.08 %
Sulphur(S)	0.040 % Maximum
Phosphorous(P)	0.035 % Maximum
Manganese (Mn)	0.43 – 0.58 %
Silicon (Si)	0.22 – 0.33 %

Alloy steel AISI 4130

There is maximum von-misses stress of 279.24 MPA. There is a factor of safety of 15 at 460 MPA, which is below the yield strength of 460 MPA. Figure 4a shows the equivalent stress generated. Figure 4b shows the safety factor for AISI 4130.

DESIGN SPECIFICATION OF GO-KART

A detailed description of a go-kart includes its motor, the kart's performance, the chassis, the steering, and the brakes.

Table 3: Elastic Properties of Material

Property	**AISI 1018**	**AISI 1020**	**AISI 1026**	**AISI 4130**
Density (kg/m3)	7850	7870	7858	7850
Poisson's Ratio	0.29	0.29	0.3	0.3
Young's Modulus (Mpa)	200	205	200	210
Tensile Strength Yield (Mpa)	370	297.74	415	435

Table 4: Go-Kart Specifications

Motor	
Type	Direct Current Brushless Motor
Torque	4.48 Nm
Voltage	60V
Power	1500 watt
Propeller sprocket	22
Axle sprocket	54
Rotations per minute	3200
Battery	
Type	Lithium-Ion
Capacity	25Ah
Voltage	60V
Tyres	
Rear	11*7*4.8
Front	10*4*4.9
Chassis	
Ground Clearance	82mm
Tube Dimension	30*30*2.6
Tube	Circle
Material	AISI 4130

Chassis weight	25.262 kg
Length of go-kart	1135mm
Width of go-kart	1015mm
Brakes	
Brake type	Disc Brake
Brake pedal lever ratio	4:1
Disc Diameter	120mm
Calliper piston diameter	25.4mm
Disc thickness	6mm
Stopping Distance	3.23mm
Master cylinder diameter	10mm
Steering	
Caster angle	11^{o}
Minimum Turning Radius	2.307 m
Kingpin Inclination	6^{o}
Ackerman angle	0
Wheelbase	1066.8 mm
Trackwidth	889 mm

BATTERY

The most important part of an electric go-kart is the battery. A battery is a power source of the vehicle in which we should consider some parameters such as performance of the vehicle, cost of operation, lifespan of the battery, power requirements of the vehicle, energy density and charging time of the battery. For batteries, lithium or lead-acid batteries are to be considered. The Li-ion Battery is considered to be the top of the traditional lead-acid battery. Because lithium-ion based batteries are 30% more energy efficient than a lead battery and have a better life, maintain long life, prevent overheating, charge faster and low self-discharge rate. In Lithium-ion, there are two cells that meet our high safety standards LFP and LPO. The specific energy and energy density of each battery are different. There are different types of Li-ion batteries out there, of which the ones which were used in the automobile industries are NMC and NCA which have higher energy density and specific energy compared to others such as LTO and LFP. According to the battery selection parameters, it should be economical but compared to other Li-ion batteries LTO are a little bit expensive which will make them a bigger disadvantage. LTO is much more expensive than LFP by almost four times. From another point of view, there was a greater edge for LTO cells in terms of efficiency and the high currents during charging and discharging.

Table 5: Types of Li-Ion Batteries

Li-Ion Type	**Specific Energy**	**Energy density**	**Cycle life**
LTO ($Li_4Ti_5O_{12}$)	60-110	177	3000-7000
LFP (lifepo$_4$)	90-160	325	>2000
NMC	150-220	580	1000-2000
NCA	220-260	600	500

The battery cells which should be used in the go-kart must not increase the weight of the kart much higher and overall safety and efficiency should not be affected. This determines that, Since the battery capacity of the go-kart is low and which in turn should improve the safety and efficiency of the kart, we are using small cells such as LTO and LFP which has a smaller amount of energy that can be used to drive the go-kart.

Table 6: Properties of LFP(LiFepo$_4$)

Properties		
Dimensions	152 x 72x 40	mm
Weight	0.74	Kg
Voltage nominal of a battery cell	3.0	V
Battery Capacity	25	Ah
Current Discharge	0.4 C	10A
A voltage of 80% at DOD life must be maintained for at least 1500 cycles	2.8-3.65	V
Maximum Operating Temperature	60	^{o}C
Maximum Volts	3.6	V
Minimum Volts	2.6	V

DESIGN SOLID MODELLING AND ANALYSIS

For designing the chassis, the design specification was given. After selecting a motor and a steering mechanism, we will begin making the chassis design and arranging the components on the chassis as given following figures.

As shown in figure 1, the Go-kart is built on a strong chassis.

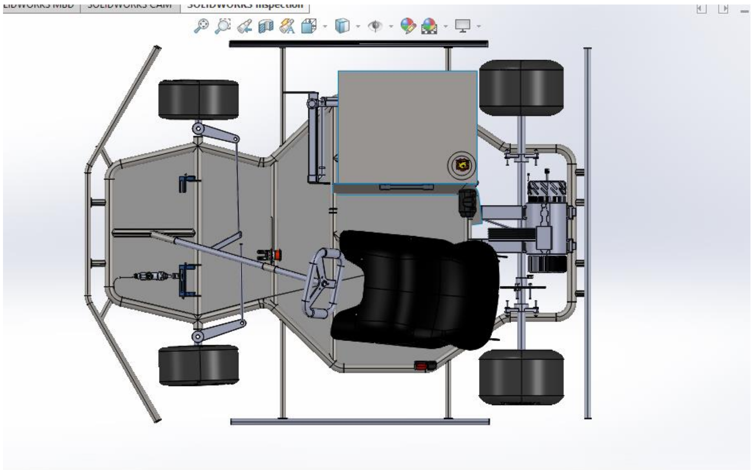

Fig 1: Top View of E-Kart

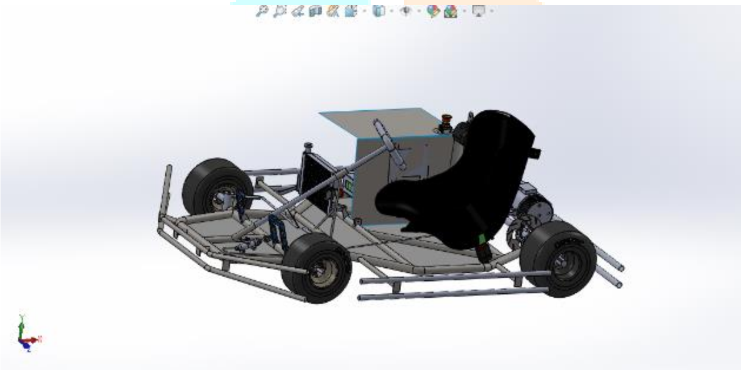

Fig 2: Isometric View of E-Kart

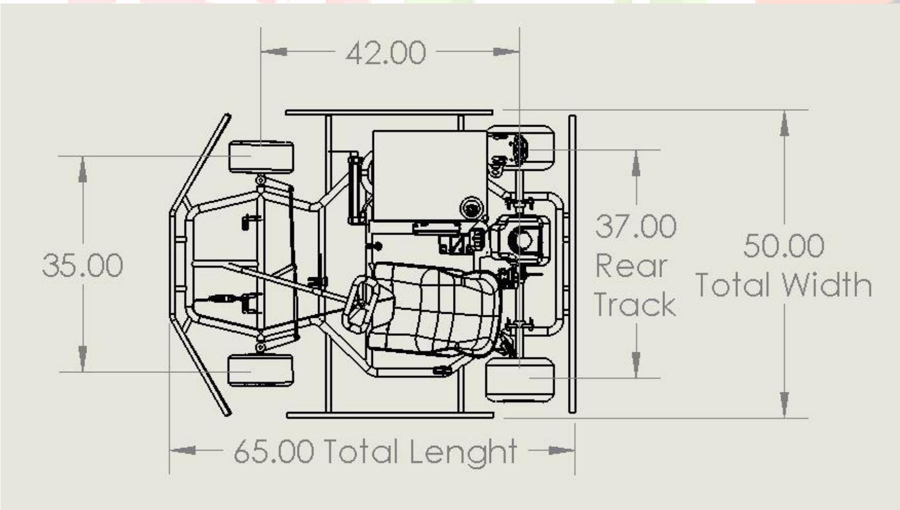

Fig 3: Sketch of E-Kart

FINITE ELEMENT ANALYSIS

FEA simulates how a chassis is affected by stresses, deformations, vibrations, and other physical effects as the chassis is subjected to force. The Solid-works is used for modelling and Solidworks2018 was used for various tests like

(i) Analysing the front-end impacts

(ii) Analysing the rear-end impacts

(iii) Analysing the side-end impacts

Analysing the front-end impacts

The analysing the front-end impacts is performed in CAD Solidworks2018 software while the chassis frame was made from solid-works software. The vehicle was simulated to hit a barrier at a speed of 60kmph. The weight of the vehicle is150kg including the driver. The outcomes are displayed in the following fig 4a, b.

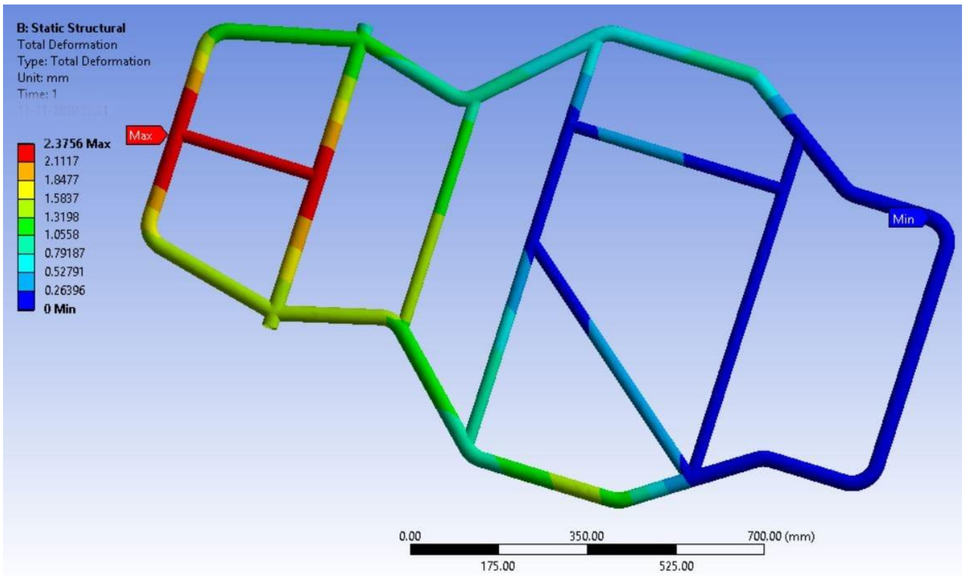

Fig 4a: Front impact analysis of chassis

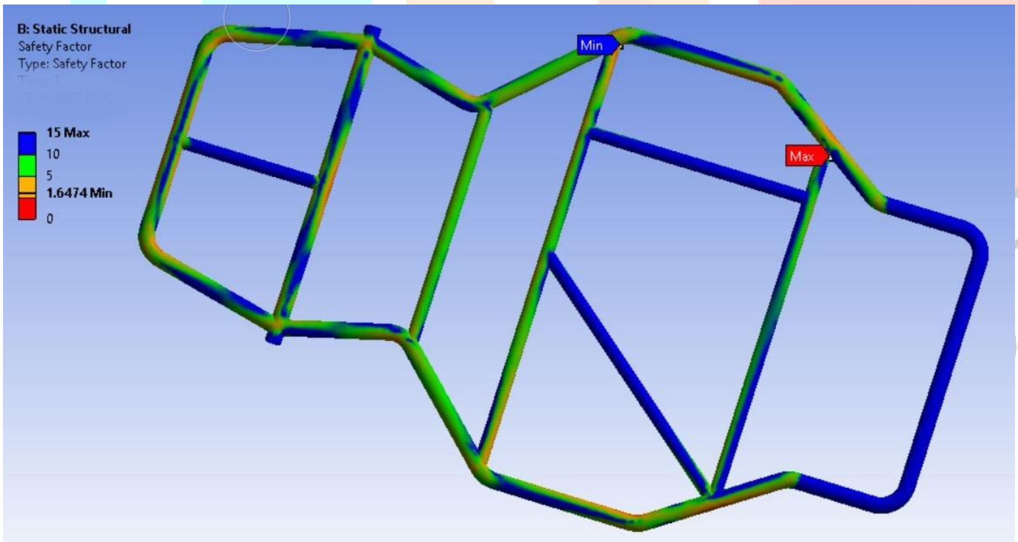

Fig 4b: Factor of Safety

Analysing the rear-end impacts

The Analysing the rear-end impacts is performed in CAD Solidworks2018 software while the chassis frame was made in Solid-works software. The vehicle was simulated to hit a barrier at a speed of 60kmph. The weight of the vehicle is 150kg including the driver. The outcomes are displayed in the following figure 5.

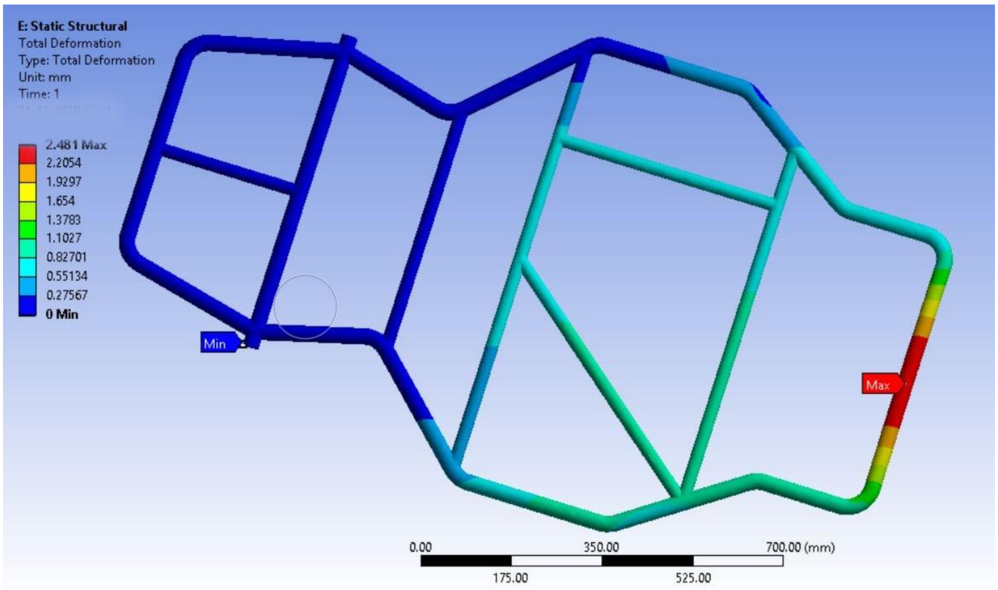

Fig 5: Rear impact analysis of chassis

Analysing the side-end impacts

The Analysing the side-end impacts is performed in CAD Solidworks2018 software while the chassis frame was made in Solid works software. The vehicle was simulated to hit a barrier at a speed of 60kmph. The weight of the vehicle is 150kg including the driver. The outcomes are displayed in the following figure 6.

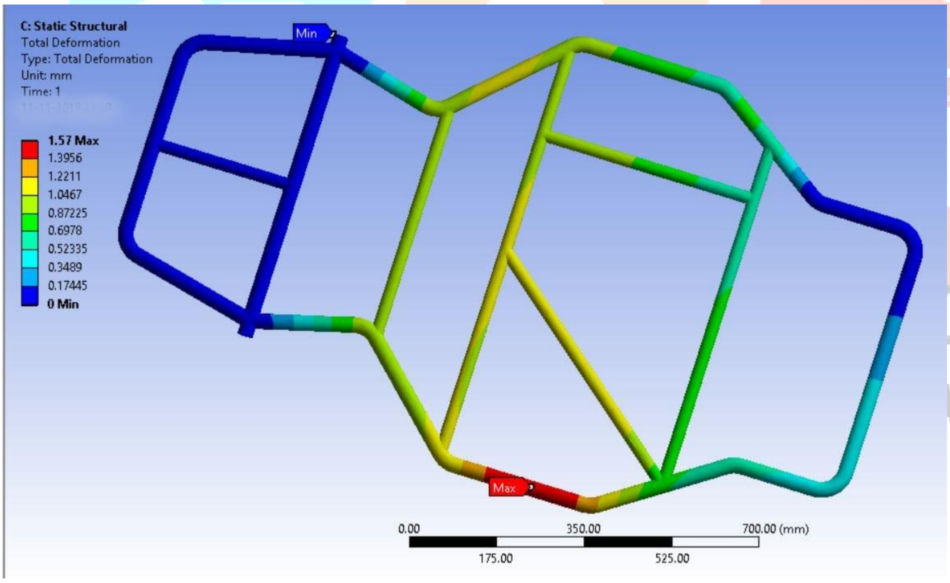

Fig 6: Side impact analysis of chassis

CONCLUSION

In this paper, our study illustrates a detailed design and analysis of the electric go-kart based on ISIE requirements. The material AISI 4130 is used for the chassis frame AISI 4130 was chosen as it has high yield strength and less weight compared to others for chassis. Battery LPO was selected from different batteries for the Electric go-kart. We optimized the chassis members by analysing frontal, side, and rear impact data. The material which was selected for the chassis has more safety factors. Electric vehicles are becoming more common these days. This design study has introduced new design concepts for a design for an electric go-kart chassis. An in-depth analysis is carried out on the design iteration and ensures that it meets industry safety standards.

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