

Hybrid Go Kart Using Single Cylinder Engine

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Abstract: This project report describes the design, fabrication, and testing of a hybrid go kart using a single cylinder engine and a Lead acid battery pack. The go kart uses a chain drive system to transmit power from the engine and electric motor to the rear wheels. The go kart also has a braking system, steering system, and seat. The go kart is designed to be lightweight and strong, and to provide a good balance between handling and stability. It is decided to use AISI 1018 for making the chassis frame. The engine, electric motor, battery pack, and chain drive system were then installed in the chassis. The hybrid go kart is a viable alternative to traditional go karts. It offers a number of advantages, including improved fuel efficiency, lower emissions, and increased performance.

Key words: Hybrid Go-kart, Increased Performance, Lower Emission

1. Introduction

A hybrid technology is a technology that utilizes two or more different power sources to move a vehicle. The most common type of hybrid technology is a hybrid electric vehicle (HEV), which combines an internal combustion engine with one or several electric motors. A gas engine is combined with an electric motor in a hybrid-electric vehicle (HEV). A dual engine system can be configured to increase the power of the car, improve fuel economy, mileage, and efficiency.

A Hybrid Electric Vehicle (HEV) may have a battery, electric motor, generator, internal combustion engine and power split device. These components allow the vehicle to run on both gas and electricity. Any vehicle that combines two or more power sources that can be used directly or indirectly to provide propulsion power

can be considered a hybrid. Hybrid vehicles are actually all around us. A moped is a very common type of hybrid vehicle because it combines the power of a gasoline motor with the power of the rider's pedal. Most of the diesel-powered locomotives that we see pulling trains today are diesel-electric hybrid vehicles. In cities like Seattle, diesel-electric buses can be used to run on electric power from overhead wires or run on diesel power when they are away from the wires. Hybrid underwater vehicles are also examples of hybrid vehicles using a nuclear-electric or diesel-electric system.

Electric motors use no energy during idle or during turn off and use less energy than IC engines at low speeds. IC-engines do better at high speeds and can deliver more power for a given motor weight. That means during rush hour to stop and to go, the electric motor works great and, as an added benefit, does not produce any exhaust thus reducing smog levels. At higher speeds, the IC-engines kicks in and gives that power feeling that many car owners look for when driving on the highway. Another benefit is to charge the batteries while it's running.

Much of the fuel efficiency comes from improvements in aero dynamics behaviors of vehicles, weight reduction and, the biggest change: a smaller, less powerful gas engine. In fact, any vehicle will get substantially better mileage just by reducing the engine size. Even a small increase in fuel economy makes a large difference in emissions over the life of the vehicle. Also, in large cities where pollution is at its worst, they make an even larger difference since they produce very little emissions during low speed city driving and the inevitable traffic jams. Because hybrids use

regenerative braking, brake pads may even last longer than those in normal vehicles. A hybrid vehicle cuts emissions by 25% to 35% over even the most fuel efficient gas powered models.

1.1 CLASSIFICATION OF HYBRID VEHICLES

1. Depending on Drive Train Structure.
2. Depending on degree of Hybridization.
3. Depending on nature of Power Source.

1.1.1 Depending on Drive Train Structure.

1. Parallel Hybrids
2. Series Hybrids
3. Series-Parallel Hybrids

1.1.2 Depending on degree of Hybridization

1. Full Hybrids
2. Mild Hybrids
3. Power Assisted Hybrids

1.2. Parallel Hybrid Technology

In parallel hybrids, the engine and the electric motor are both connected to the mechanical transmission in parallel and can simultaneously transmit power to drive the wheels. Engine can also act a generator for recharging of the battery with help of a generator. Parallel hybrids are more efficient for highway driving than in urban stop-and-go conditions.

Generally in parallel hybrid vehicles both the power sources IC-engine & the electric motor are connected to same transmission via torque convertor so that at any time only one of them is in action. Regenerative braking is also used to convert the vehicles kinetic energy into electrical energy which is stored in batteries

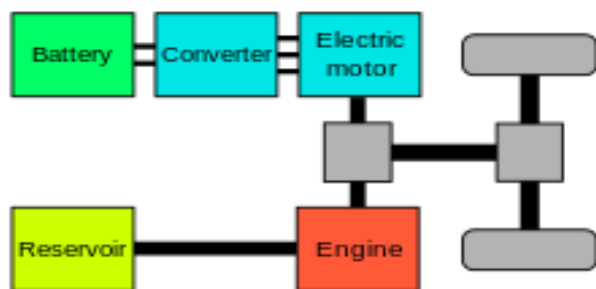


Figure 1 Parallel Hybrid Technology

1.2.1 Working of Parallel Hybrids

Vehicle start up and low speeds: As the internal combustion engine is inefficient in this range due to low torque at lower RPMs, acceleration with electrical motor with higher starting torque is suitable.

Normal working: To avoid the battery flat-outs and excessive performance losses in this range, vehicle is driven by both internal combustion engine and electrical motor.

Sudden acceleration: In this mode, full throttle acceleration of the vehicle is considered. With the help of the extra energy from the generator, electrical motor runs in its full performance. So, internal combustion engine and electric motor together produce the maximum available power.

Regenerative braking: During deceleration, vehicle generates energy from its kinetic energy by running the electric motor in generator mode.

Battery recharge at rest: When the state of charge is below certain levels, it is possible to run the internal combustion engine in its efficient ranges and recharge the batteries with the help of the generator

1.3 Objectives Of The Project

Objectives of the project are given as follow

- Study of the principles and working of Hybrid Electric Go-kart in working parameters and performance parameters
- Design the structural Frame and components for the Go-kart
- Static Structural analysis on the Go-kart frame.
- Implementation of combined drive train for Electric and Ic engine
- Large flexibility to switch between electric and IC Engine power
- To investigate methods to increase the efficiency in order to conserve power and the money

2. Literature review

Shubham Sanjay Thorat et al. studied design and fabrication of hybrid go-kart in which they have tested e tested the kart for its fuel economy under three conditions.

1. Running on I.C. engine on petrol they got the efficiency of 35 kmpl,
2. Running on electric motor on battery they got efficiency of 15 kms on full charge,
3. Running on combination of both electric motor and I.C. engine on petrol and battery (hybrid mode) they got the efficiency of 50 Kms.

They have used BLDC motor of 48 Volts and 1500 Watts with high torque during start up. They stated that use of Brushed DC motor drains out battery quickly reducing the overall efficiency. Instead of this to improve the performance high efficiency DC brushless motor is used which have low current consumption. The IC-engine used is an old 98 CC, 2 stroke single cylinder having very less efficiency which reduces the overall efficiency.[1] **K. GOWTHAMI et al.** studied design of hybrid electric go-kart and done analysis of the chassis using CATIA software for design and Ansys for analysis. They developed a design and made an analysis. AISI 4130 is the material we have selected for the chassis and the finite element analysis of the chassis was carried out in the Ansys software and the factor safety was found more than 1 and the Front impact was 9163N and Side impact was 5536N and Rear Impact was 6600N and max deformation found is 4.0mm Their results showed that the chassis had enough strength and stability and it can withstand stresses and impact loads[2]

Mr. Virendra.S. Pattanshetti This paper deals with the Design and Analysis of Roll Cage for the Go Kart. In a Go Kart Student Car, the roll cage is one of the main components. It forms the structure or the main frame of the vehicle on which other parts like Engine, Steering, and Transmission are mounted. We have made the 3D model of Go Kart and Roll Cage in Catia-V5. Roll Cage comes under the sprung mass of the Vehicle. There are a lot of forces acting on vehicle in the running condition. These forces are responsible for causing crack initiation and deformation in the vehicle. Deformation results in Stress Generation in the Roll Cage. Hence it is important to find out these areas of maximum Stresses. In this paper an attempt is made to find out these areas by carrying out FEA of the Roll Cage. We have carried out Crash Analysis (Front and Side Impact), Torsion Analysis. All these Analysis have been carried out in Hyper Works 11.0. The design procedure follows all the rules laid down by NKRC Rule Book for Go Kart Type Cars.[3] **P. Brabec** studied conceptual design of two-cylinder spark-ignition internal combustion engine for a hybrid car with power requirement at least 45 kW at 6000 rpm intended for use in HEV and PHEV vehicles. In the first part of the paper is presented the design of the engine and 3D CAD model, created with support of 3D CAD software. The main part shows the thermodynamic calculation of the main parameters of the combustion engine by means of special software[4] **Prof. Alpesh V.**

Mehta et al tested the kart for its fuel economy under three conditions running fully on IC engine, running fully on electric motor, & running on combination of both electric and IC-engine (hybrid). In this project they have used an old DC starter motor of a car which has very high current consumption of the rate of 25 amperes at start-up because of high torque requirements during start up, but it gradually decreases to 10-12 amperes as it gains speed. So the battery drains out quickly reducing the overall efficiency. Instead of this to improve the performance high efficiency BLDC motor can be used which have low current consumption. The IC-engine used is also an old 75CC, 3.5 h.p. having very less efficiency reducing the overall efficiency.[5]

2. Methodology:

In this project A single cylinder 156.8 CC engine with the 5 speed manual transmission is used to power the go kart. The driving sprocket is modified in such a way that two chains can be fit together at the same time on the output shaft of the gearbox. The first chain is connected between 14T engine sprocket and 43T Rear driven sprocket. This results in gear ratio of 3:1, Simultaneously a 750watt BLDC motor having 19T sprocket at the output shaft is connected with the engine sprocket at the same time having gear ratio of 1:1. The go kart can switch the drive line with the help of one single switch. Through this hybrid switch the go kart can switch into IC engine or pure electric mode within few seconds. As the initial torque of the BLDC motor is more and linear compare to IC engines, this hybrid go kart can run on the electric mode in initial stage during the race and can switch to the IC engine to go further. This combination of electric mode and IC engine mode provide high performance, better efficiency compared to traditional go karts.

In pure electric mode all the connections from battery to ignition of the IC engine is completely cut-off. At the a 48V and 45Amp battery pack made up of combination of series and parallel connections of six lead acid batteries of 12V 7.5Amp. This is providing continuous input to the motor controller Which further provides input signals to the 750watt BLDC motor. This BLDC motor has 19T sprocket which rotates the engine sprocket through a chain drive similarly another chain

on the engine sprocket is connected to the rear driven sprocket with the chain drive itself. As there is no ignition to the IC engine only the gear box of the IC engine works with the motor.

In pure IC engine mode all the electrical power supply to the motor controller is cut-off. A dc to dc converter is connected to the 48v battery pack of the hybrid go kart. This dc to dc converter converts 48v to 12v instantly. As the operating voltage of all electrical components of IC engine is 12v which is compensated by this dc to dc converter. In this mode the hybrid go kart uses fuel from the fuel-tank to start and run the IC engine.

In hybrid mode the go-kart accelerating the point where electric motor reaches its peak torque the hybrid go kart switch to the IC engine. The engine takes over and the motor switches off. The power from the engine is transmitted through the chain sprocket drive to the rear axle. When the electric motor is disconnected an alternator is connected to the rear axle with the pulley and belt. Whenever the go kart is in running state the pulley on the axle rotates the alternator pulley due to which emf is generated. This output signal are passed through dc to dc boost converter which converts 12v from alternator to 48 v. This 48v output are sent to charge the 48 volt battery pack. There is an plug in charge facility in this hybrid go-kart. This help to charge the 48v battery pack of the hybrid go kart externally through a 48v charger.

2.1 Material Selection

Mild Carbon Steel AISI 1018 material has been taken for the overall fabrication of Chassis and for manufacturing of Shaft and Rear wheel hub whose ultimate Strength is 440 MPa

2.2 Components Of Hybrid Go-Kart

Hybrid Go-kart consists of following components:

- Chassis
- Engine and Transmission
- Steering
- BLDC Motor
- Battery
- Controller

2.2.1 Chassis

Chassis is a primary component of Go-kart which is rigid in structure and it is made up of hollow tubes that are in circular or rectangular cross-section. The auxiliaries and driver bed were mounted on the chassis. In our project, we have adopted closed frame chassis to withstand the loads and weight which acts on it and it doesn't have the roll cage. This chassis which we have designed can absorb some jerks, vibrations and it is also strong enough to break. The wheels were attached to chassis on either side.

Parameters	Values
Vehicle length	63inches(1646.2mm)
Vehicle wheel base	42inches(1066.8mm)
Vehicle Front Track width	34inches(863.6mm)
Vehicle Back Track Width	40inches(1016mm)
Chassis material	AISI 1018
Pipe Thickness	2.0mm

Table 1 : Chassis Parameters

The assortment of frame material while designing any chassis, strength, and lightweight is the basic consideration. So material used in chassis is one of its important criteria. AISI 1018 is one of the suitable materials for a go-kart frame. AISI 1018 mild/low carbon steel offers a good balance of toughness, strength and ductility. Provided with higher mechanical properties, AISI 1018 hot rolled steel also includes improved machining characteristics and Brinell hardness. The frame material used for this go-kart was mild/low carbon steel which was technically named as AISI 1018. They include chemical compositions of C, Fe, Mn, P, S.

Table 2 Chemical compositionTable 3:- Physical Properties

Table 4:- Mechanical Propertie

Figure 2 Chassis Layout



Figure 3: 3-D View of Chassis

Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. Here

we divide the chassis into small sizes known as element and collective elements on the model form a mesh. The computer analyses the elements and shows us a collective result. The computer solves by the computational method provided. The material and structure of chassis was finalized and then FEA was performed on it. It is tested whether the chassis will be able to withstand torsion, impact.

2.2.2.1 Meshing

Meshing is probably the most important part in any of the computer simulations, because it can show drastic changes in results.

Meshing has been done in Ansys 2023 R2 Software. Following data has been found after meshing of chassis –

No. of Nodes = 117180

No. of Elements = 59958

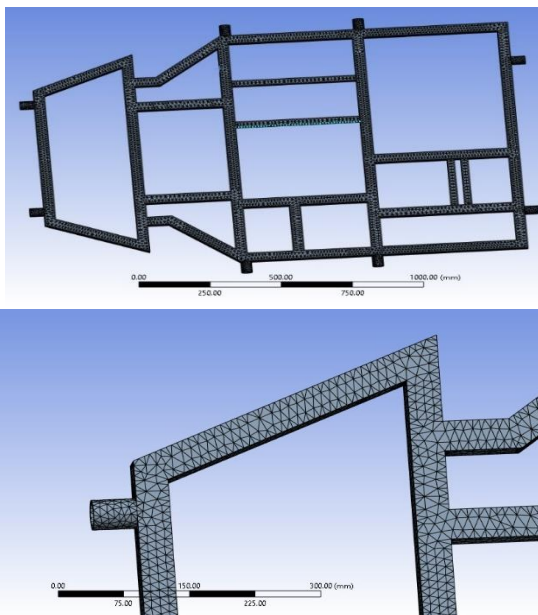


Figure 4 Meshing in Ansys

2.2.2.2 Front Impact Analysis

IMPACT LOAD CALCULATION: In front collision test, the go-kart collides with a stationary rigid wall and comes to rest. Using the projected vehicle/driver mass of 180 kg, the impact force was calculated based on a G-load of 4.

According to second law of motion

Force = Mass * Acceleration

But in case of free falling body the force is equal to the product of the body and acceleration due to gravity.

Hence,

$$F = mg \dots\dots (1)$$

$$= 180 \times 4 \times 9.81$$

$$F = 7063.2 \text{ N}$$

We apply 7063.2 N from the front for the test of front impact of the chassis structure of the vehicle for determining strength at the time of front collision.

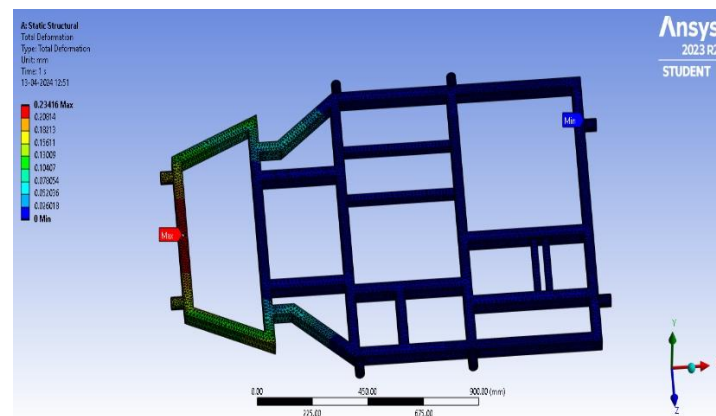


Figure 5 Total Deformation for front impact

Maximum Deformation : 0.234 mm

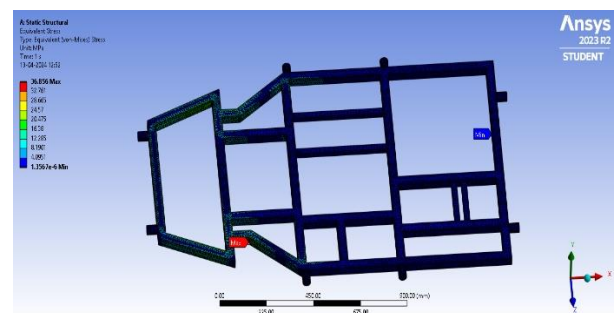


Figure 6: Equivalent Stress for front impact

Maximum Stress : 36.856 MPa

RESULT

Maximum Stress = 36.856 MPa

Incorporated Factor of Safety = $\sigma_{yt} / \sigma_{max} \dots (3)$

$$= 370 / 36.856$$

$$= 10.03$$

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

2.2.2.3 Rear Impact Analysis IMPACT LOAD CALCULATION

Using the projected vehicle/driver mass of 180 kg, the impact force was calculated based on a G-load of 4.

According to second law of motion

Force = Mass * Acceleration

But in case of free falling body the force is equal to the product of the body and acceleration due to gravity.

Hence,

$$F = mg \dots\dots (1)$$

$$= 180 * 4 * 9.81$$

$$F = 7063.2 \text{ N}$$

We apply 7063.2 N from the Rear for the test of rear impact of the chassis structure of the vehicle for determining strength at the time of rear collision

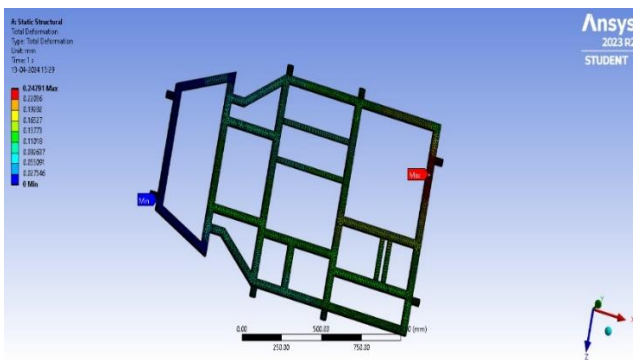


Figure 7: Total Deformation for Rear impact

Maximum Deformation : 0.247 mm

Maximum deformation for the rear impact is also under the safe limit & not affects the safety of driver

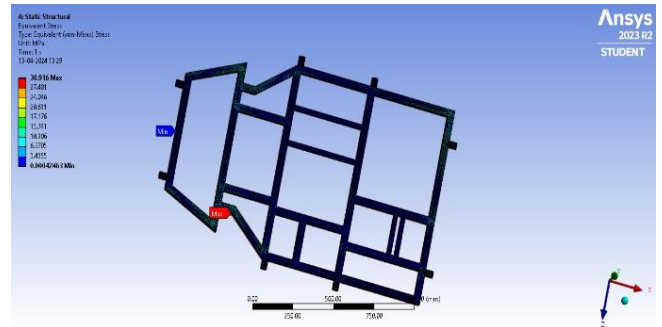


Figure 8 Equivalent Stress for Rear impact

Maximum Stress : 30.916 MPa

RESULT

Maximum Stress = 30.916 MPa

Incorporated Factor of Safety = $\sigma_{yt}/\sigma_{max} \dots (3)$

$$= 370 / 30.916$$

$$= 11.96$$

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

2.2.2.4 Side Impact Analysis

Using the projected vehicle/driver mass of 400 kg, the impact force was calculated based on a G-load of 2.

$$F = ma$$

$$= 180 * 2 * 9.81$$

$$= 3531.6 \text{ N}$$

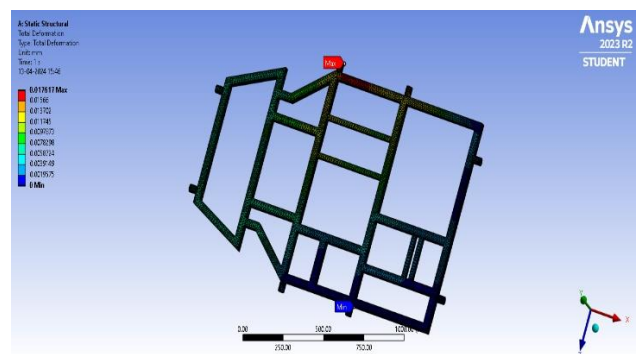


Figure 9 Total Deformation for Side impact

Maximum Deformation : 0.0176 mm

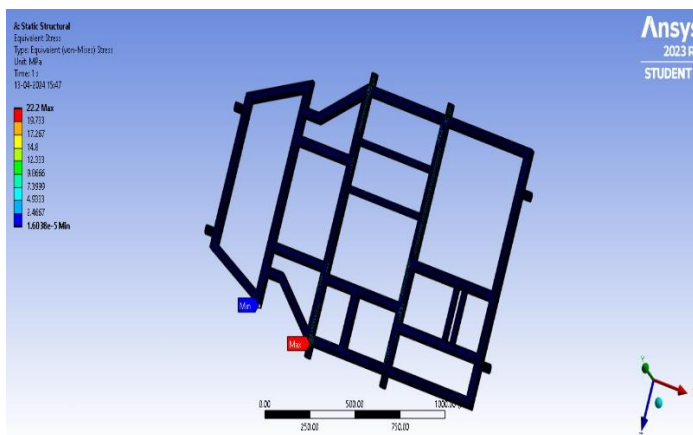


Figure 10 : Equivalent Stress for front impact

Maximum Stress : 22.2 MPa

RESULT

Maximum Stress = 22.2 MPa

Incorporated Factor of Safety = $\sigma_{yt}/\sigma_{max} \dots (3)$

$$= 370 / 22.2$$

$$= 16.6$$

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

2.2.3 Engine and Transmission

The Go-Karts moves with the Internal Combustion engine which used in smaller ratios about 100-200 CC. In this, we are using the Honda CBZ engine which had a 156.8CC a Four-valve single-cylinder engine that produces about 12.8 bhp @ 8000 rpm and highest torque of 12.45Nm @ 6500 rpm We have used four-stroke single-cylinder engine for this kart.

Transmission is a fundamental aspect of any vehicle which the entire mechanism of transmission of energy from the engine to the transaxle, it is connected to the wheels utilizing sprocket which is having 43 teeth on driver and 14 teeth on the driven gear allows the sprocket ratio of 3 and these sprockets connected using the chain drive for transmission.

Model	Honda CBZ
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Makers name	Honda
No of strokes	4 stroke Si engine
Maximum power	12.8 bhp @ 8000 rpm
Maximum torque	12.45 Nm @ 6500 rpm
No cylinders	1

Table 5: Engine Parameter

2.2.4 BLDC Motor

The electric motors were generally classified based on the electric power supplied to it they are Ac, Dc, and induction motor, the brushless dc motor consists of permanent magnet stator and the rotor placed inside it. Brushless dc motor most widely used for commercial purposes because of its extraordinary performance in the commercial region the BLDC motor used in this project.

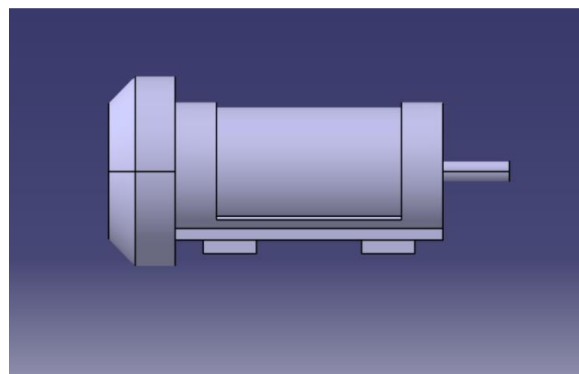


Figure11:BLDC Motor

Table 6:BLDC Motor Specifications

Commutation	Brushless
No of poles	8
Phase	3-phase
Speed	3000rpm
Torque	7.16 N-m peak torque

H.P	1
Power	2646watts

2.2.5 Battery

The battery used for the primary purpose of energy storage the battery used in this project was lead-acid battery the battery containing the lead and acids inside it the battery has a rating of 12V and 24 Ah used in this project We configured a pack of six 12V 7.5 Amp lead acid batteries together. In which four 12V 7.5 Amp batteries are connected in series, to get the power of 48V 30Amp. Additional 1 pair of 12V lead acid batteries are connected in parallel with the above four 12V batteries. This will Increase the ampere capacity of 48V 30Amp battery pack to 48V 45Amp

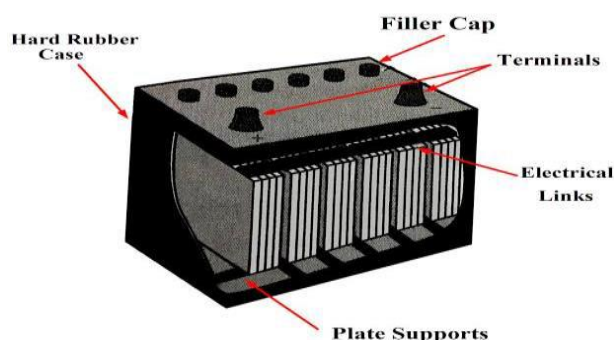


Figure12 : Lead Acid Battery

2.2.6 Design of rear axel

Material	Mild/Low Carbon Steel
Diameter	25mm
Length	1270

Table 7: Specification of rear axel

2.2.7 Design of rear wheel hub

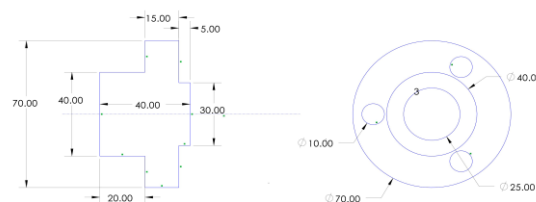


Figure 11 : Front view and side view of hub

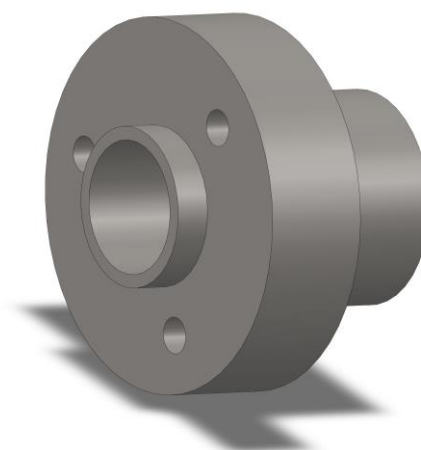


Figure 12: 3D View of hub

Material	Mild/Low Carbon Steel
Outer Radius	70mm
Through Hole	25mm
Tapping	M10

Table 8 : Specification of hub

3. Fabrication and Assemblage

All the parts were fabricated according to the design dimensions discussed earlier. Materials were purchased from the local markets. Firstly, the body of the vehicle (Chassis) was fabricated. After this, some of the parts were purchased from the local markets and some were machined on lathe machine according to the need of the project. These parts included bearings, seats, engine, brakes, and steering system. These parts were fitted in the chassis of in the desired place. The college workshop was used to assemble this go-kart. The pictures of the product during manufacturing is given in the following pictures.



Impact was 7063.2N and max deformation found is 0.247mm Max stress found was 36.846MPa

5. Reference:

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4. Conclusion:

We have successfully configured a single cylinder IC engine into high performance hybrid engine. The linear acceleration of go-kart has been increased with the help of BLDC motor. The over all range (in kms) of kart has been increased. We have determined the basic need of the hybrid kart than the conventional and electric drives for the efficient fuel saving and reducing the global warming effect caused by the conventional drive vehicles and we have designed the chassis was successfully completed using SOLIDWORKS software.

AISI 1018 is the material we have selected for the chassis and the finite element analysis of the chassis was carried out in the Ansys software and the factor safety was found more than 1 and the Front impact was 7063.2N and Side impact was 3531.6N and Rear