DESIGN AND ANALYSIS OF HYBRID GO-KART

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ABSTRACT

Since last 2-3 decades the average temperature of earth increased by 3-4°C because of the green house effect. Due to increase in the fuel prices and continuously depletion of natural recourses for the fuels causes fuel crises in the modern society. Due to which demand of development of newly energy efficient vehicles increases. The hybrid technology fulfils this requirement by incorporating various combinations of bio-fuels and also by combinations of highly efficient electric drive systems. Along with the same it reduces the emission and cut the fuel cost.

This project illustrates an implementation of hybrid technology on a small scale. Project aims at improving the mileage of the car using simple mild parallel hybrid technology with combination of electric motor drive and the petrol engine drive. We have used the straight open kart chassis design. The results show that alone a petrol engine gives best 25Km/lit, alone a electric motor gives 12kms on full battery charge . The combination of above two gives 40Kms.

KEY WORDS: hybrid technology, electric motor drive, petrol engine drive.

1. INTRODUCTION

A hybrid Technology is defined as a technology that uses two or more distinct power sources to move the vehicle. The term most commonly refers to hybrid electric vehicles (HEVs), which combine an internal combustion engine and one or more electric motors. A Hybrid-Electric Vehicle (HEV) combines the power of a gas engine with an electric motor. These dual engine systems can be configured for different purposes such as increasing the car's power, improving fuel economy, mileage, efficiency etc.

A HEV may include a battery, an electric motor, a generator, an internal combustion engine and a power split device. All these components make the vehicle able to run on both gas and electric power. Any vehicle that combines two or more sources of power that can directly or indirectly provide propulsion power can be called a hybrid. In fact Hybrid vehicles are all around us. For example, a moped (a motorized pedal bike) is a most common type of hybrid because it combines the power of a gasoline engine with the pedal power of its rider. Most of the locomotives we see pulling trains are diesel-electric hybrids. Cities like Seattle have diesel-electric buses these can draw electric power from overhead wires or run on diesel when they are away from the wires. Submarines are also example of hybrid vehicles using 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 Electrical Vehicles

Hybrid electric vehicles can be classified according to the way in which power is supplied to the drive train as follows:

- Classification based on degree of Hybridization:

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.

1.2.1 Working of Parallel Hybrids

1.2.1.1 Vehicle startup 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.

1.2.1.2 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.

1.2.1.3 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.

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

1.2.1.5 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.

2. Introduction to Go-Kart

Go-karts are a type of small, suspension less vehicle. They come in a variety of forms, from motorless models to high-powered, high-performance go-karts meant for competitive racing. The three main components of the go-kart are chassis, steering & transmission.

2.1 Chassis

Kart chassis are classified in as 'Open', 'Caged', 'Straight' or 'Offset'.

- Open karts have no roll cage.
- Caged karts have a roll cage surrounding the driver; they are mostly used on dirt tracks.
- In Straight chassis the driver sits in the center. Straight chassis are used for sprint racing.
- In Offset chassis the driver sits on the left side. Offset chassis are used for left-turn-only speedway racing.

We have used the straight open kart chassis design. There are no suspensions used in the kart so the chassis must be able to absorb some of the jerks and vibrations, also it must be stiff enough not to break or twist during turning. In order to reduce the weight and cost, & due to lack of space availability differentials are also not used in the kart. Most of the problem is faced during turning due to lack of differential. During turning the rear outer wheel must rotate at higher speed than the rear inner wheel. The differential allows each of the driving road wheels to rotate at different speeds; hence it allows ease of turning. In go-kart no differential is used which means power is transmitted to the rear axle through chain drive, and both wheels rotate with same speed and equal torque is transmitted to both of them. So while taking a turn the outer wheel of the kart must be able to loose traction and skid over the road surface. This is done by slightly twisting the body of the kart during turning by providing castor angle to the front steering wheels. This castor angle brings the height changes in the front wheels and the outer rear wheel looses its traction allowing it to slip.

The design of kart chassis is very complicated. The chassis are generally made of square or round steel tubing’s, or angle iron. We have built the chassis according to a standard tested design made by a leading manufacturer of go-karts STEPHEN BRUKE.

We have used 40*6 angle iron for making the frame. All the pieces are cut to required length and the being welded by MMAW (Manual Metal Arc Welding).

2.2 Steering

Steering is the term applied to the collection of components, linkages, etc. which will allow a vehicle to follow the desired course. Generally Steering used in an Go-kart is a simple linkage type Ackerman steering. Ackerman Steering Principle describes the relationship between the front wheels of a vehicle as they relate to each other when in a turn. The inner wheel will be traveling in a smaller diameter circle than the outer wheel. All the wheels should move around a common point.

![Figure-2 Steering](image)

The three main parts of the steering mechanism are Kingpins, Yoke, Stub axles.

2.2.1 Kingpins

The kingpin is the main pivot in the steering mechanism of a car. It is simply a pin made to
allow the front wheels rotate freely. It has been made from 35mm O.D MS tubing having 8mm wall thickness. Tapping of 3/8” is provided on both sides to assemble the pin with the Yoke with help of bolts.

Figure-3 kingpin

The Kingpin is directly welded to the chassis by providing some angles to it relative to the frame. These angles are important for correct steering and to reduce the tyre wear. A kart is combination of solid rear axle (no differential) and very short wheelbase, in relation to a very wide track. If a kart were to have similar geometry settings to road or racing cars, it would suffer from severe under steer at the moment of corner turn-in. This is because the combined grip of the rear tires would simply push the front wheels straight ahead. To overcome this problem, karts have steering geometry designed to lower the inside front wheel and raise the outside front wheel in relation to the chassis at corner turn-in. The chassis must be able to twist, otherwise the kart will not steer around corners correctly, and instead move in straight lines only. This change of front wheel heights causes a weight transfer from the inside rear wheel to the outside rear wheel and the inside front wheel. This mechanically lifts the inside rear wheel off, or nearly off the track surface at the moment of turn-in.

2.2.1.1 Kingpin Inclination

King-Pin Inclination (KPI) is the inward lean of the king-pins relative to the true vertical line, as viewed from the front or back of the vehicle. KPI causes some of the self centering action of the steering. This is because the straight ahead position is where the wheel is at its highest point relative to the suspended body of the vehicle - the weight of the vehicle tends to turn the kingpin to this position. A second effect of the kingpin inclination is to set the scrub radius of the steered wheel. This is the offset between the tire’s contact point with the road surface and the projected axis of the steering down through the kingpin.

Figure-4 Kingpin Inclination

2.2.1.2 Castor Angle

Castor angle is the angular displacement of the kingpin axis from the vertical axis of the vehicle measured in the longitudinal direction. It is the angle between the pivot line (in a car - an imaginary line that runs through the center of the upper ball joint to the center of the lower ball joint) and vertical.
Caster angle is responsible for most of the self-centering action of the steering and is an important factor in lowering the inside front wheel and raising the outside front wheel of the kart at corner turn-in. The greater the caster angle, the greater the height changes of the front wheels.

2.2.1.3 Camber Angle
Camber is the degree to which the front wheels lean toward or away from each other, if the tops of the tyres are closer together than the bottom, then camber is negative and positive camber is the opposite of negative camber. To maximize grip when cornering, it is highly desirable to have as much of the two outside tyre’s rubber on the track as possible. Camber is the setting mostly responsible for maintaining maximum rubber on the road in corners. If the top of the wheel is farther out than the bottom (that is, away from the axle), it is called positive camber & if the bottom of the wheel is farther out than the top, it is called negative camber. Negative camber improves grip when cornering. This is because it places the tire at a more optimal angle to the road, transmitting the forces through the vertical plane of the tire, rather than through a shear force across it. Another reason for negative camber is that a rubber tire tends to roll on itself while cornering.

2.2.1.4 Yoke
Yoke is the C-shaped link that is connected with the kingpin. It allows the wheels to turn on the pivoted end. It has been fabricated from 40*6 mm MS bar.

2.2.1.5 Stub Axles
Stub axles are small rods attached to the front steering mechanism to support the wheels. It has been made from 35 mm MS bar.

2.2.1.6 Rear Axle
Generally two types of axles are used in go-karts:
1. Live axle
2. Differential axle

2.2.1.6.1 Live Axle
A live axle on a go kart means that the engine will power both rear wheels at the same speed.
and power. This is accomplished with a single sprocket mounted to the live axle. Since both wheels are locked in to the power all the time we'll have twice the traction. This is great for sand, loose dirt, etc, where a single wheel would often spin out. It is very cheap and simple as no gears are used and also light in weight. Unfortunately for the on-road for a live axle turning is difficult. This is because both rear wheels turn at the exact same speed. When making a turn, the outside wheel must be able to spin faster than the inside wheel. If they are forced to turn at the same rate by a live axle, then the outside wheel must slip on the driving surface in order to turn as fast as needed. Wear of tires is more.

2.2.1.6.2 Differential Axle
Differential on the rear axle is just like normal car has. This allows both wheels to be powered, and allows for easy cornering. But when traction is lost on one wheel, it will spin and the other won't turn at all, effectively giving you a single-wheel drive. It has advantage of reducing tire wear during cornering by turning both wheels at different speeds. It has disadvantage that when one of the wheels struck or locked all the power is transmitted to the other wheel providing the least resistance to transmission. Its cost is higher due to various gears used and the weight of transmission also increases.

We have used a live axle to reduce the cost reduce the weight and due to its simplicity. Rear axle has been made from 25 mm bright MS bar. Pedestal bearings are used to support the axle.

2.3 Line Diagram of Parallel Hybrids
As shown in figure-8 the hybrid power train of the kart employs mainly the IC engine and electric motor connected to the rear axle via chain sprocket drive through free-wheeling hubs. The free wheel is a ratchet and pawl mechanism, which allows the outer wheel to rotate freely in one direction and locks the inner wheel with the outer in the other direction. This works on the relative motion between the two wheels hence when the inner wheel (axle) is rotating faster than the outer sprocket it rotates freely without any load on the motor, but when the motor rotates the outer sprocket it locks the inner wheel to give the drive to the axle. This mechanism is similar to that used on a bicycle, when forward motion is given to the pedal it rotates the rear wheel in the same forward direction but when going downhill or moving due to inertia of motion there is no load on the pedal.

![Figure-8 Line Diagram of Parallel Hybrids](image-url)
2.3.1 Working Modes

Engine drive: A centrifugal clutch and a 2 speed automatic transmission is used with the engine so as to facilitate idling of the engine. The driving sprocket is mounted on the clutch and the freewheeling hub on the axle giving a reduction ratio of 5:1. DC Motor drive: A same chain sprocket reduction is used between the motor and axle again to keep traction, but the sprocket on the axle uses a freewheeling hub to mechanically disconnect the electric motor from the drive when the engine is driving the axle, so as to protect the motor from any undesirable load. Electric vehicle mode: During this mode the engine is off, and the battery provides electrical energy to power the motor during starting and at lower speeds because at lower RPMs torque of IC engine is lower but starting torque of a DC motor is high. If the starting torque of the motor is less then IC engine also starts to drive the kart and after starting the electric motor takes the charge. Cruise mode: When the vehicle is cruising or accelerating and the motor cannot meet the load demand then 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. The electric motor gets disconnected due to freewheeling hub. Limit switches are provided to start the motor again when the speed of kart decreases. The selection of the power source is preset and is a function of the pedal feed provided by the driver. Initially when the pedal is pressed the DC motor brings the vehicle into motion and accelerates up to a preset pedal position after which the engine is accelerated which leads to the centrifugal clutch connecting the engine to the axle and powering the vehicle for further acceleration. This is done by leaving the engine throttle wire with slack, for it to have sufficient tension only at the desired pedal position. A foot pedal dependant system was used as it makes the driver a kind of a feedback system, as, when more power is needed such as on hill climb the driver would press the pedal further until sufficient torque is transmitted to the drive.

Figure-9a Model of gokart
3. RESULT ANALYSIS AND DISCUSSION
We have 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 our project we 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 DC brushless 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.

4. FUTURE SCOPE
By using a good battery and powerful motor we can make a typical hybrid car which drives with motor in city and on highway it uses internal combustion engine. In cities cars have speed around 40-45 k.m./ hour. And powerful motor is capable to drive car at this speed and due to this exhaust gases emissions can be reduced in cities and this is helpful for health and also for global warming. Currently, hybrid vehicles utilize Ni-MH battery technology, which needs replacements after some period, but instead of these Lithium-ion batteries which are very reliable can be used. However the initial cost increases as this is a new technology. Nowadays new bio fuels are also made to reduce the exhaust emissions and cut down the fuel prices. Also use of CVTs in hybrids has proven that they are having better transmission efficiency than normal ones. Combining CVTs with the smart computer integrated circuits and smart sensors, the efficiency can be greatly improved. New inventions of lighter but stronger materials like carbon fibers, HSP (high
strength polymers), etc. can help in reducing the overall weight of the car and thus smaller sized high efficiency engines can be used.

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