An Innovative Energy Efficient Automobile Design

Parvez Hussain S. D, C. N. Veeramani, B. Amala Priya Shalini, R. Karthika

Abstract— The present paper deals with the innovative energy efficient automobile design is mainly focused on safety, reliability and cost effectiveness. The smart innovative design is done on safety basis. Main features of the smart vehicle design are long battery back-up and energy efficient use of drives. A back-up supply from the source is available when the vehicle is out of charge. The back-up source is combination or coupling of solar power, wind energy, and shaft coupled dynamo. The design of the motor vehicle(kart) is in accordance with the specifications laid down by the rule book given in this paper. The motor runs with a power output of 750W and 36V. The sources employed are a combination of three 12V 40Ah batteries in series. There is one more back-up battery on board, which is charged by the 2 dynamos and 1 solar panel dynamically. Efforts have been put to validate our design by theoretical calculations, simulations and known facts.

Keywords—Microcontroller, GSM module, Wind dynamo , solar panel, Finite Element Analysis(FEA) module, analysis software.

I. INTRODUCTION

National Eco kart championship is an inter-collegiate competition by SAE and Goutham Buddha University of engineering .The aim of the competition is to generate real world design projects and related challenges. An eco-kart, by definition, has no suspension and no differential. Kart racing is generally accepted as the most economic form of motor sport available. It is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people take part in the racing and this sport is getting popular. The cost of a kart starts from Rs.50, 000. The objective of the teams is to design a eco kart vehicle which is a simple four-wheeled, small motors, single sealed racing kart within budget of Rs.50, 000 to sustain a production of 3000 karts annually. The vehicle should meet the necessary requirements of performance which is manifested in terms of maneuverability, riding comfort, acceleration, braking and endurance tests. Team E^3ALPHANOIDS has decided to put utmost efforts into producing a design that promises to bring out maximum performance and at the same time abide by the indispensable rules and regulations as laid in the ECO CART rulebook.

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II. METHODOLOGY

The design is started only after a thorough study of an electric-vehicle, which was followed by system advantages and production costs. All the design issues were studied and an attempt has been made to solve them in the present design. In order to increase the ease and speed of manufacturing, great care was taken to ensure that every component of the vehicle was modeled using. The frame which has to bear various forces subject to loading conditions was tested with Finite Element Analysis (FEA) software modules. An attempt was made to do the body works in an aerodynamic shape to minimize the air resistance. It was made sure that manufacturing aspects are not neglected while designing any of the parts so that no major modifications are made while manufacturing and a technically sound kart is resulted in.

III. DESIGN O F THE DRIVING C IRCUIT

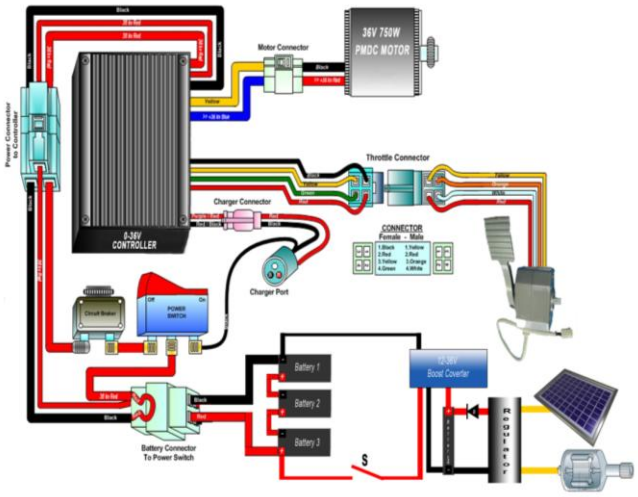

Fig. 1 Circuit Model of Smart Vehicle

IV. FEATURES OF THE MECHANICAL DESIGN:

- 1040CD seamless steel tube frame
- Motor mounted at rear.
- Pitman arm steering.
- Hydraulic disc brakes (rear).
- Smaller track width at front.
- Battery back-up of 1hr 30mins.
- Innovation is mainly concentrated on emergency period.
- Full Power Booster.

V. REQUIREMENTS

1. TYRES

Tires were strictly subjected to availability. To have larger tire at rear we procured pair of 11''x7.10'' tires with threads and a smaller pair of 10''x4.50" eco-kart tires with threads for front from MRF, Chennai. The treads ensured grip on sharp turns at high speeds. Light weight rims to decrease the mass were selected.

2. WHEEL END

The wheel end is made up of the following parts- Rim, Hub, bearing, and knuckle in sequence. Their compatibility with each other is a major design issue.

3. KNUCKLE

The steering tie rod is connected to this part. Every kart needs a separate design to have the required Caster and Kingpin angles set for the particular car. It is also to be noted that the entire load will be transferred to the tires through the knuckle only. So, this part's design is very critical for any vehicle's performance. Knuckle is mounted to the hub with a bearing with the help of a hydraulic press and bolts are screwed to keep the stud and brake disc together. The inner part of bearing is milled which acts as a spline to transmit power from the axle. Fabrication of the knuckle is done out of plates of M.S by welding and mounting it to a stud with a fabricated matching plate to fix with the rim. This would give us independence in selecting the geometry control the dimensions.

4. REAR AXLE

The rear wheels are mounted in a single axle made up of EN19 steel rod of OD 30mm. The 5'' rim is fixed in the axle with the help of three bolts. The rear axle material is selected as that it can transmit the torque during acceleration as well as braking without any losses.

5. STEERING EMPLOYED

The steering system selected for the kart was pitman arm steering. This is done in order to eliminate the steering ratio as the driver has to constantly maneuver the kart at sharp turns with little space. We started with pure Ackerman geometry and achieved close to 100% Ackerman geometry by proper arrangement of links. For better steering, a 12^{o} caster and 5^{o} camber has been given at the front wheel mounts and a final camber of 2^{o} and caster of 1^{o} has been given at the front wheels. An initial toe-in was also decided to be incorporated in the front as with the toe angle set in and more Ackerman, it will result with the outside tire being towed-in relative to the circular path and the inside tire running parallel to the circular path they are following. The consumer may be any person. The person driving the kart may be of any height and may have different driving postures. To facilitate all types of consumers, an universal coupling has been introduced in the steering shaft. This allows the angle of steering wheel to be adjusted to the driving comfort of the driver. Provisions have been made to fix the steering shaft at a particular angle even at high performance period. The design of this system is done with utmost care without compromising the safety.

6. CHASSIS DESIGN APPROACH

Chassis is being designed with due importance given to ensure its strength. Also the vision of driver was an issue, as the driver`s seat was laid quiet low to maintain the center of gravity as low as possible. We have first finalized the track width and wheel base. Then the positions of major sub-systems were decided. And then the chassis was built around these equipment's. This approach gave us a clear picture of the frame as the mounting points were known. Consequently issues related to compatibility among various subsystems are minimal.While designing the chassis, component spacing, driving comfort and high rigidity were given special considerations. The kart was designed within minimal vehicle dimensions in order to make vehicle light as well as cost effective. Chassis profile would have an effect on aerodynamics of the vehicle, though the effect is not that significant at these speeds still attempts to bring aerodynamic behavior to the kart was made.

VI. PROCEDURE : I (FOR MECHANICAL DESIGN)

The rules and regulations were carefully reviewed in order to understand the scope of designing the roll cage, and then an initial draft was drawn in order to capture all the requirements prescribed by the competition. The first stage was the tire positioning. A larger wheelbase allows more space for engine and driver but Inhibits the maneuverability, so a proper decision was taken only after fixing the track width. On the other hand larger track width adds to the stability of the vehicle, but we had to restrict it within 40 inches so as to reduce the weight of kart. Length of pitman arm and tie-rods of the steering system was also a limiting factor. Another point taken into consideration was the difference in track of front and the rear tires. It was decided to have slightly smaller track at the front which will improve the turning ability of the kart. After considering all the subsystems and other factors it was decided to have a track of 40inches at the front and 42inches at the rear, wheelbase as 50 inches and the wheelbase to track ratio of 80% as per rules. Having set the foundation, approximate spacing for driver was allotted. Then a basic frame design was drawn. After placing all the sub-systems, the final chassis design was obtained.

VII. FEATURES OF ELECTRICAL DESIGNS

PMDC Motor
Voltage: 36v
O/p Power: 750W
Speed: 2800 RPM
Rated current: 27.8 amps
Includes 11 tooth sprockets for #25 chains.18" long power leads. Shaft rotation reversible by reversing power leads. Dimensions: 4-1/2" outside diameter x 5-1/4" long excluding shaft, 6-1/4" long including shaft. Front and rear ends of motor have threaded mounting holes. Weight 9.1 lbs.

VIII. ELECTRICAL REQUIREMENTS

1. TRANSMISSION SYSTEM

The transmission system for our vehicle consists of a transmission chain and a larger sprocket fixed on the rear (live) axle. This chain is connected to the smaller sprocket of the motors from where the actual power is transmitted. BLDC MOTORS provided with a self-speed adjustment. Transmission chain is used to transfer power from motor to wheel. Control circuit is provided at the rear of the kart which will control the power transmission to the motors. The large sprocket is aligned with driving sprocket in the live axle by the aid of MIG welding. The design calculations have been given in the appendix.

2. BRAKE SYSTEM

Hydraulic disc Brakes would be the best choice for a eco kart because of its small size. It has much reduced braking distance when compared to other types of frictional brake. Rest of the frictional brakes is larger in size and also doesn't provide effective braking. Disc brakes dissipate heat quickly. While designing the brake system, simplicity was given prime importance and it was decided to use a single disc brake mounted at the rear axle which is best suited for our vehicle. The master cylinders mount directly to the custom made brake pedal and are located above the driver's feet. The design calculations for disc brakes have been given in the appendix. The caliper is mounted in the frame. Much care is to be taken when fixing the caliper any misalignment between disc and caliper will result in poor braking and quick wear of brake1 pads will occur. Nominal pedal ratio is 4:1 is kept for more ease of control.

3. AERODYANAMICS AND BODYPANELS

Though the Kart is meant for medium speeds, their aerodynamic study can reveal interesting facts which can help in reducing load on motor and it can also help in easy handling. There also remains a scope to have a powerful motor. The wheels are covered from front winds by the bumpers. The bumpers are designed in such a way that the air moves around the wheels. Apart from eliminating sharp edges in the front, the driver area over the steering will be covered by a tapered sheet to reduce air resistance. The material for paneling will be Aluminum sheets for the firewall and the base of roll cage. But for bumpers we are looking for lighter and cheaper alternatives, one of the options is the use of steel mesh coated by plastic sheets. Carbon fibers though suitable are too costly for our use.

4. FULL POWER BOOSTER

This is one of the most efficient feature of the kart. A switch is employed at the bottom of throttle arrangement such that the switch is pressed only if the throttle pedal is at maximum position. The switch is connected to a relay which is functioned to provide supply from the source directly to the battery only at full peddle of the throttle. Its advantages are No circuit loss, effective output power and high speed.

5. BATTERY

Battery used here is 12V, 42Ah, batteries 3nos. are connected in series to make 36V and amps will be 42 Ah. Chart-I and Chart-II shows detail idea about properties of batteries.

Advanced Battery Properties

CHART-I

Battery type	Specific energy (Wh/Kg)	Energy density (Wh/L)	Cycle life (80% DoD)	Relative cost per energy unit stored	Commercial Availability
Lead Acid	35	95	500	1	Good
Nickel Cadmium	50	100	1000	2 to 3	Good
Nickel Metal hydride	65	155	1500	5 to 6	>3yrs
Sodium Sulphur	100	150	1000	7 to 8	long term
Sodium Nickel Chloride	100	150	1500	7 to 8	>5yrs

CHART-II

Battery Type	Cycle Life	Deep Discharge	Environmental Care	Maintenance	Relative Cost
Automotive	H	L	H	H	30
Flat plate	L	H	H	H	100
Plante	M	H	H	H	250
Tubular	H	H	H	H	200
VRLA AGM	L	H	M	M	150
VRLA Gel	L	H	M	M	150

H-High M-Medium L-Low

6. CONTROLLER

Designed for 36 Volt motors up to 750 Watts. Maximum current 30 Amps. Under Voltage protection 31.5 Volts. Current limiting feature prevents controller and motor damage due to over-current conditions. Under voltage protection feature prevents over-discharge and extends battery life.

7. THROTTLE

Full Length Twist Throttle with 36 Volt Power Meter Twist throttle with 36 Volt power meter for Chinese-made electric: scooters, bicycles, go karts, dirt bikes, ATV's, quads, pocket bikes, and mini choppers. Three LED indicator lights: red for power-on, green, and yellow for 36 Volt batteries pack status. Red, black, green, and white wires with male connector pins for white wire connectors 50" long throttle cable.

8. CONDUCTOR AND CONNECTIVITY

The conductors are very thickly insulated and separate colures are used for positive and negative terminals .the connectivity of major connections are given using bus bar arrangements i.e., by placing thick copper plates on a insulated thick sheet, all the inter connections are made on these copper plates.

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Switches: Power switch is used for the total power ON and OFF of the entire vehicle .relay switches are used for the protection purpose .These relays are used for isolating or cutting off the connections when over voltage or any short circuit occurs in the kart.

Relays are connected to terminals of throttles, motor, and controller circuit, for safety.

Electrical Kill switch: this Switch is used to cut off the entire electrical supply from the source.These are the basic electrical required for any motor vehicle.

Wiring:2.5 sq. conductors are used with a gauge of 480

Fuses:C30 MCB is used to cut off the supply when the current drawn by the motor is more than the rated current.C 25 MCB fuse is used to limit the supply from the supply.

Charger:

I/p: 230 V 50 Hz ac.

O/P: 36 V dc. With reverse current protection diode employed for safety and a LED for Battery Charge indication.

9. SOLAR PANEL

12V 50W solar panel for backup power supply

10. DYNAMO

A 12V, 3amps dynamos for backup power supply, One is given a fan for wind power generation and the other is coupled to the rear axial. The total power O/P is together got from the combination of three back up sources and is boosted to 36V to give the supply for the motor.

11. TRANSDUCERS SPECIFICATION

The Resistance of the strain gauge (6V) is changed when any stress occurs across them. This change is amplified by an amplifier and given to the micro controller in the form of a Voltage signal and this microcontroller gives a signal to the GSM module i.e., a Mobile phone.

This Mobile phone is set for any two Phone numbers. The message is sent to those numbers stating the severity and the position of the accident.

12. BACK UP SUPPLY

There is a backup power supply employed for effective and reliable operation of the kart. the power is collected from three different renewable sources.

1. Wind dynamo: on the SIDE BUMPERS of the kart, a 12v 3 amp dynamo is employed and the Power from this is given to the Voltage regulators to get a regulated power supply O/P. and then coupled with the other two sources.
2. Dynamo coupled to the rear axial:
   A similar dynamo is coupled to the rear axle so that it gives added power to the backup source.
3. Solar panel: a solar Panel of 12V 6 amps arranged on the back of the kart and it is used to charge the Backup source.

Note: The Backup source is a 12V, 22Ah battery and this is given to a 1:3 boost converter that gives an O/P voltage of 36V to the controller.This idea of back up source is very efficient and a charging is done by renewable source of energy so it is very eco-friendly.

IX. SAFETY

The innovation Employed here is mainly concentrating on the safety aspect of the driver in any vehicle(car) if this technology is employed then immediate intimation to the Para medics will be done automatically through the micro controller and the weight distribution is given such that the impact of the crash should not be more at a single point but it gets distributed. The remaining standard safety equipment, including a 2kg fire extinguisher, chain cover, fire wall, two rear view mirrors and three kill switches were all placed for easy access and use, as well as maximum optimization of their functions during an emergency. Circuit breakers in fuses are employed to prevent damages due to short circuit and over current. Conductors used for the wiring purpose are thickly insulated and it is seen that gauge of the conductor is capable of allowing full load current. Apart from this, neck collar, motto-cross type helmet and fire proof driver suits have also been procured.

X. RESULTS

Direct Method Results:

Electricals play a predominant role in our smart vehicle. The effective use of power source is done in the smart vehicle. The entire vehicle is DC powered.

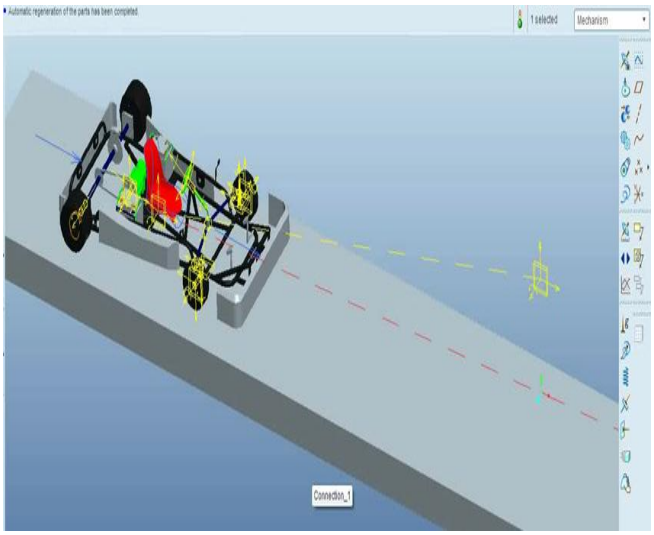

Fig. 2 Simulink Model of Kart

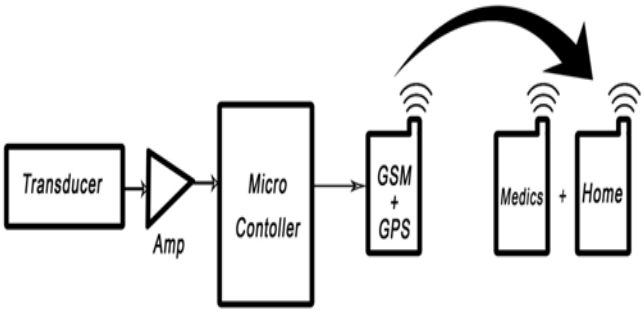

Fig. 3 Block Diagram of Innovative Smart Electronic Vehicle

The above block diagram explains the working of the system. Transducers are placed on the four corners and to the front and back of the kart they all were coupled to gather. Innovations are concentrate on two aspect one is safety and the other is durability using a micro controller the system is programmed such that there will be a message will be delivered to paramedics an simultaneously to the family members of the owner of the car.

XI. CONCLUSION

To conclude, it can be summarized that the expert system will go a long way to prove that reliable prototype design met the safety, durability, ecofriendly use of energy and maintainability as well as provide features that would have mass market appeal to the general vehicle enthusiast such as performance and comfort design decisions were made with each of these parameters in mind. The design developed on the idea of individual member's knowledge and experience with vehicle as a tool for developing many of the initial subassembly designs for the prototype. Where applicable, selection of components for each subassembly of the Pro-engineer, Computer Aided Three-Dimensional Interactive Application (CATIA) and analysis software ANSYS has been used to verify that each part of a subassembly design met or exceeded its stated objective.

XII. ACKNOWLEDGMENT

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REFERENCE AND APPROACH

1. Study of various kart designs.
2. Study of various electrical equipment specifications.
3. Gain practical knowledge by designing of different kart.
4. Investigate various reports.
5. Installation of innovative ideas

AUTHORS PROFILE

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