A Review Paper on the Influence of Various Parameters on the Performance of the E-Kart

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***Abstract* - Designing and Analysing an Electric Kart is a huge platform for the students. So many competitions are used to organize for the students on this platform. This review paper is for the study of different research papers for a better understanding of the problems and to get better solutions to them. The study will inspire us to work with the researcher's ideas and the student's ideas for innovations and techniques.**

The paper is intended to help undergraduates by giving a neat overview in terms of the design and simulation of E-kart to participate in national competitions. This research aims to point out the findings and studying the results of the researchers.

***Index Terms* - E-Kart, Designing, Analysis, Finite Element Analysis (FEA), Steering System, Transmission System.**

INTRODUCTION

Electric Go-Kart, (E-Kart) is the eco-friendly kart which was firstly introduced in Los Angeles by Art Ingels and his neighbour Lou Borelli in 1956.

In today’s world, non-renewable resources are being used on a huge scale which includes the fuel on which vehicle operates. Looking at the world energy outlook perspective, year by year the energy conservation of non-renewable sources is decreasing. With the increase in the usage of these resources there is also increase in greenhouse gases, damage to the environment, potential threat to human health, acid rain, etc. An IC engine emits pollutants such as Carbon Monoxide, Nitrogen Oxides, and Hydrocarbons.

Energy build Systems such as Electrical energy is more compatible, clean and more sustainable, that is why E-Kart is a good alternative. It is an electrical four-wheel vehicle, basically a type of mini car. It contains various systems such as Designing, Steering System, Power Transmission System, Braking System; it is used for student kart championships. Karting is commonly discerned as the preliminary step to F1 car. E-kart is a rear-wheel motor-driven automobile without any suspension and differential. The main objective of the design is to make a kart that is light in weight and performance centrepiece. As it is a four-wheeled vehicle without suspensions the major problem such as vibration study and the design safety is the must parameter to focus on. Hence simulation process is the best method to get the outputs on the considered design. The important factors such as transmissions, chassis design, steering system, and drive types, of the kart are needed to study. Analysis & Simulation is the best way to find out the optimum results of the parameters. In practice if we have to do the changes in the structure of the components of Kart it will consume time as well as the capital, hence simulation on the software is the best way to perform trials and get the output. The reviewed researches will help to point out the areas on which we have to focus on, and also for better improvements.

STUDYS AND FINDINGS

Mukesh Kumar Jha et al. have studied and examined the basic components and simulation results of electric-go-kart. The Author has selected Roll Cage as the design for the chassis. The material used for the chassis is AISI1018 since it is carbon steel is a free-machining grade that is the most commonly available grade around the world. The simulation was done on the solid work software. For front impact, the linear velocity kept at 53 km/h according to ENCAP (The European New Car Assessment Program) and the force estimated was 3238.884N. The side impact velocity of kart was taken as 45 km/h or 12.5m/s according to ENCAP standard and then force calculated was 2750N. The rear impact force is calculated by taking velocity of collision as 50 km/h or 13.88 m/s by the calculation and also according to the ENCAP standards and the force calculated as 3036N. In this research, the author has selected the Ackermann geometry steering system for the kart. Using Calculations the turning radius of 2.74m was obtained. Force calculated on the tie rod was 505.38 N. Torque on steering shaft was calculated as 47.07Nm. Force on Steering wheel obtained as 154.49N and Steering Effort obtained as 15.7487 kg. The brake system design includes a single disc at the rear axle to stop the vehicle. Using Calculations following results were obtained. Brake pedal force - 1050 N, Pressure on master cylinder — 4.1263 N/mm square, Calliper force — 5833.33 N, Friction force — 2333.33 N, Rotor torque — 209.99 Nm, Stopping distance of vehicle — 12.82 m, Time travel to achieve stopping distance — 1.85 sec. For the transmission system, the BLDC motor of 1,000 watts 3000 rpm is used. Using Calculations following values were obtained, Rolling resistance on rear tire obtained as 43.164 N, Rolling resistance on front tire 35.316 N, Drag force 1.4, Maximum input torque 186.50 Nm, Force on the tire through motor 1335.0035 N, Distance to achieve speed-18m.u. [1]

Harshal D. Patil et al. The Author selected Roll Cage design for the chassis. The material used for the chassis is AISI1018. The MIG welding is used for joining the members of chassis.

Analysis of Chassis: Analysis is done by using the finite element method. The impact was tested on the three sides i.e., front impact, rear impact and side impact. The forces are calculated by taking the optimum speed of 60kmph with 5g force (Acceleration force) and 0.2 sec time of impact consideration. Force on the front impact is found 14.7KN where deformation is of 1.47mm. Force on the rear impact is found 14.7KN where deformation is 2.74 mm. Force on side impact is found 7.35KN where deformation is 1.46mm. Modal analysis is done for the frequency of vibration, the result found is the vibrations of chassis and the engine doesn't match, there is no condition for resonance.

Steering System: Ackerman steering system is selected for the kart. The mechanical steering linkages system is selected to ease for the manufacturing. The aim was to get the turning radius less than 4m. The material used to design the stub axel is AISI 1040. The analysis done on the stub axel by taking the force of 1.2g, the deformation of 0.14mm and maximum stress of 62.97MPa is found. By using the calculations the turning radius of 2.29m is obtained.

Transmission System: Although the Author manufactured Go-Kart vehicle, the Engine is used for transmission system. They have selected Bajaj Discover 125cc engine which have inbuilt gear box of manual 5 speed constant mesh gear box, with the multi plate wet clutch.

Shaft Design: The rear axle is used to transmit the power from engine to the rear tire through chain drive. It is the solid shaft of diameter 30 mm and length of 42" according to design calculations. The material used is EN8 which is also known as AISI 1040. It is the medium carbon steel with improve strength over mild steel and it is easy to machine at supplied condition. Using the values of forces and bending moment diagram the diameter of shaft is found to be 28.01mm hence the shaft of standard diameter i.e., 30mm is used. [2]

Sathish Kumar N. and Vignesh A., et al. Author had decided to go with aluminium alloy for the chassis. Their aim behind selecting the material was to achieve maximum welding area, good bending stiffness, minimum weight and maximum strength for the pipes.

Analysis of Chassis: Analysis is done by using the finite element method. Mesh was generated in ANSYS 14.5. The impacts were taken according to the European New Car Assessment Program. The forces are calculated by taking the ENCAP velocity for front impact, side impact and rear impact test was 64 km/hr. The equivalent stress was found in front impact was 103.15 MPA, with applied load of 2667.67 N and a factor of safety of 2.07 is achieved. The equivalent stress was found in side impact was 96.885 MPA, with applied load of 2083.33 N and a factor of safety of 2.20 is achieved. The equivalent stress was found in rear impact was 54.99 MPA, with applied load of 2666.67 N and a factor of safety of 3.80 is achieved. All the equivalent stresses were found to be under yield stresses hence the design was safe.

Steering System: The author selected linkage type steering system. Reverse engineering process is carried out to find the turning radius of the kart by using the simple Ackerman principle. The turning radius of the kart was found 1.65m where the Inner wheel angle & Outer wheel angle was 41 degrees and 28.53 degrees resp.

Braking System: A hydraulic brake circuit was designed (Apache RTR 180-disc brake) in accordance with the vehicle weight, length and top speed. Brake pedal force calculated 500 N, Fluid pressure was 0.98 MPA, Pedal ratio was 5: 1, Braking torque 119.7 Nm, Braking force 785.3 N, Temperature 1800 C, Work done by braking 3619.9 N, stopping distance 4.6 m, Braking distance 4.1 m, Deceleration 5.83 m/s2, Stopping time 1.2 sec, Frictional force 1333.04 N, Calliper force (normal) 1110.87 N, Human perception time/reaction time 0.5 s.

Transmission System: The PMDC motor was implemented in kart which was 2.5 kW powered 48 V motor. An equivalent of 48V, 42A-hr lead acid battery was used to quench its thirst. Four secondary rechargeable 12V Sealed Lead Acid batteries in series connection were used. A 5A battery charger was fixed in the kart to charge the batteries. Calculations were carried out on the motor with chosen gear ratio 2:1 to find the speed, design torque, velocity of the vehicle. Motor speed and torque relation was described using the above graph as the speed is increasing the torque of the motor is decreasing. [3]

Aditya Pawar et al. have carried out an experimental study on steering system as it is a very important parameter for the vehicle. Its improvement could give proper turning while racing events so that lap time could reduce and help the driver to reach beyond the finish line and win the race. To avoid skidding, two front wheels should turn about the same instantaneous centre and it also avoids the wear of tires. And this is achieved by using the Ackerman steering Geometry method. Components used for steering system are 1) knuckle 2) Kingpin 3) Tie Rod 4) Pitman Arm Tripod 5) Steering column 6) Steering wheel.

Following are the parameters which influence the function of the steering system.

1) Ackerman steering Geometry
2) Minimum Turning Radius
3) Camber
4) Caster angle
5) Kingpin inclination

The minimum turning radius of the vehicle should not be more than 2.5 m. It plays a crucial role in racing events for proper and sharp turning of the vehicle. According to this paper, we have not to focus more on the camber and keep the camber value zero. In the steering system, the caster angle is set for the jacking effect. If we increase the caster angle, the jacking effect also increases which makes turn in a sharper manner. Also, he has done the simulation on components of steering system like C type bracket, knuckle, ties rod, etc. This paper focused on improving a steering system of a kart. We have to understand the parameters which influence the function of the steering system. [4]

Gurunath C. Kudari et al. carried out research and discussed the design of transmission systems by considering different factors and methods to enhance reliability, and maximum torque. Different factors are depending on the design transmission systems are as below.

A) Design of chain drive and sprocket: a)The driving sprocket teeth by considering the practice limitations like a minimum number of on pinion, noise, moderate shock condition & moderate wear is 13 Z1= 13.the selected 08A type of chain.

b) Number of teeth on Driven Sprocket selected by using the condition of the maximum speed of 45km/hr. For gear ratio 3.25, providing maximum torque for better acceleration and better power for top speed.

G=Z2/Z1; Z2= 13*3.25;

Z2 = 39.

B) Resistances to the vehicle: As the track is without any gradient the gradient resistance will be considered negligible. While wind resistance is calculated using co-efficient of air resistance 0.02, and rolling resistance using the coefficient of rolling resistance 0.03. The author discussed various graphs by considering required power, available power, and maximum valued Vehicle speed for a maximum speed of the engine. [5]

Hemant Pratap Singh and Pulkit Sagar et al. manufactured an electric kart in which they have used SS304 material. The steering mechanism was designed in such a way that it can provide a larger rotation angle to wheels with lower force on steering. They used Ackerman Geometry in electric kart; it is just like a simple 4 bar mechanism. With Ackerman at a lower force, a larger rotation angle can be obtainable. A lesser force good turning radius can obtain. 1:1.5 ratio of the angle of steering to an angle of a wheel is obtained, with the gear system. For power transmission, they used a gear chain mechanism. In the gear chain mechanism, they used 42 teeth gear on shaft or rear sprocket and 10 teeth gear on motor or diver sprocket. For battery, they selected a 48v/90AH lithium-Ion Phosphate battery whose cut-off voltage was 48V. It requires 2-3hrs to charge, with a weight of 31kg. They have used 2000W BLDC motor type ISO O8B-2 DR1278. Hydraulics brakes were used in the braking system. [6]

Mr. Girish Mekalke et al. carried out the research on static Analysis of a Go-kart Chassis, they aimed to simulate and perform the static analysis on a go-kart chassis consisting of Circular beams. Modelling, simulations, and analysis were performed using modelling software. Aspects of ergonomics, safety, ease of manufacture, and reliability were incorporated into the design specifications. 3D models have been made for analysis purposes in SOLIDWORKS and analysis has been made in hyper mesh. To test how the chassis deforms on direct collision into a wall or other body, the analysis was done in Hyper mesh assuming an impact force of 4*g N in the front direction and rear direction, and 2*g in the right-hand side and left-hand side impact test. [7]

Muhammad Ikhwan Bin Razak et al. carried out an experimental investigation on basic knowledge of steering system for designing steering system based on different components, mechanism, and its force transmission.

Basic components of steering system for electric go-kart.

Steering column: - A shaft that connects the steering wheel of a vehicle to the rest of the steering mechanism. The primary function, of steering column is to transmit the turning moment of the steering wheel to the tie rods. So that, steering column converts the rotary movement of the steering wheel into the angular turn of the front wheels on track.

Track Rods and Ball Joint:-A hallow cylindrical rack-rod spans the wheel track and pivots together with the two stub axles. Ball joints are the type of ball-and-socket joint that helps to connect a vehicle's control arms to the steering knuckles and also behave like the pivot point for generating the steering geometry. Ball-joints are required to move only in the horizontal plane to carry out the pushing and pulling mechanism and rotate one of the stub-axles. It can make tension and compression in the component. This motion is transferred to the other stub-axle through the track-rod and tie rod. The function of the ball joint allows precisely the wheels to move so that driver can smoothly steer. It is used to connect the steering knuckle.

Stub Axle:-The stub-axle is a short length axle-shaft to which one steered road-wheel is mounted. It carries two extended horizontal prongs that fit over the ends of the axle beam. The king-pin and short-length circular bar pass vertically through both prongs and the eye of the axle-beam to frame the hinge pivot. The stub-axle behaves like the wheel axle as well as the pivot support member in the steering system.

Steering Wheel:-The steering wheel helps to control the steering system and maintain the direction of the vehicle and involves a linkage system to directly respond to the vehicle, through the front wheels. [8]

Koustubh Hajare et al. carried out research and discussed the chassis design for improved strength and reliability using various tools i.e. Solid-works, FEA, Meshing, and Boundary Condition to obtain a safe ride. They select 3.125mm thick tubing, either square or round (or both) depending on preference so, the bending operation of the material which users should be easier and by adding a filler material to the notched area during welding operation strength of frame can be increased. Chassis is designed in view of the factors like factor of safety maximum load-carrying capacity, force absorption capacity, required space for accessories and driver, and specific dimensions. The analysis of the chassis performed under various impact forces. The chassis experience loads such as cornering force, torsional rigidity, and overall dynamic loads applied during the race. [9]

Srinivasa Reddy et al. carried out research in which their main motive was to fabricate a new go-kart. There are three basic designs used in chassis design frame, unit body, and space frame construction. The author used space frame construction type to fabricate the chassis for this project. The chassis was made up of pipes and other materials of various cross-sections. Following are the materials which were included by the author in this research paper, Galvanized steel, high strength steel, and Grey Cast Iron. Tools used in modelling go-kart chassis are Sketch, Line, Constrain toolbar, Sweep, Split, Joint, Trim. The analysis was done by the finite element method. For the analysis, the data set prepared by pre-processor is used as an input to the finite element analysis. Also, the engineering analysis such as structural, vibrational, fatigue, and heat transfer was performed. [10]

Mihir M. Pewekar et al. experimentally investigated and used ladder frame structure for fabricating frame in a go-kart. The material AISI 4130 is used in frame design.

The author has considered Ackermann geometry to design the steering system for go-kart and worked on steering geometry parts such as caster angle, camber angle, turning radius and Ackerman Angele, etc. Although the author has also considered the transmission system of go-kart, design of shaft and braking system of a go-kart in this paper. [11]

Mohd Anwar et al. have carried out an experimental study on the transmission system of an electric go-kart. In this paper, the author aims to achieve maximum possible speed using suitable gear ratio, maximum torque at the starting and continues, reduce the major and minor power losses, and also achieve high efficiency. The author has used a brushless DC electric motor. The brushless DC motor was used in this experiment. Brushless DC electric motors are the electronically commutated motors. These are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. This paper concludes that selecting an appropriate transmission for electric go-kart and also helps to enhance the stability of the vehicle. The idea behind this transmission system is that to get a maximum speed with minimum load on the motor as the design component of the paper, various, mathematical formula was derived from the fundamental to calculate the various parameters needed under the assumption of some basic values of the vehicle. [12]

Muhammad Khristamto et al. carried out an experimental investigation on the steering system of the electric golf kart in which they have discussed that, in the four-wheel steering system, there is a condition when the front wheels turn left or to right condition in which the right and left wheels forming the same angel or both wheels to form a different angle from the corner of the wheel only. They found out the best R (turning radius) of the electric golf car was 372cm, and a turning angle diameter of 30°. [13]

Tanumoy Mukherjee et al. experimentally presented the roll cage design for the chassis, and the material used for the chassis is AISI 4130.

They have used a CAD model of the chassis for simulations, in which they have experimented with Front-impact analysis, Rear Impact Analysis, Side Impact Analysis, and Torsional Impact Analysis. [14]

Karan Parihar et al. carried out research on the working mechanism of go-kart according to the author go-kart consists of four major components Engine, Chassis, Steering System, and Braking system. All of the components impart on the chassis that's why it should be designed for safety purposes without compromising the structure strength. They also mentioned that a long-wheelbase vehicle is much smoother and stronger than a short wheelbase vehicle and it increases the stability of the vehicle from the cornering. [15]

Jing-Shan Zhao et al. experimentally studied that the steering mechanism for four wheels are four-bar linkages which called Ackerman Steering Mechanism. The author deeply studied synthesis of the Ackerman-type steering mechanism. The author worked on kinematics simulation that could be completely reached by the incomplete- noncircular gear coupled five link mechanisms. The mechanism of steering system should improve the vehicle steering performance. [16]

Alnaqi, Abdulwahab et al. experimentally presented a theoretical and experimental basis for representing the thermal performance of automotive brake discs at a reduced scale. Experimental data from the reduced scale disc was compared with the corresponding full-scale disc obtained from a laboratory brake dynamometer. Overall, the results demonstrated that the scaling mythology can be used with confidence for the design and development of the automotive disc brakes system.

To produce the temperature distribution of the disc brake, the heat flux generated by friction between the pad and disc is required according to their respective thermal properties methodology. The scaling factor is the fundamental relation used in the scaling methodology. The physical specifications of the small-scale test brake were developed by applying the scaling factor to the full-scale disc as explained. Rotation Speed is the relation used to evaluate the relation between the full- and small-scale rotational speed by utilities.

Experimental validation of scaling methodology, in this section a comparison between the experimental results from the small scale and full-scale brake was presented. The surface temperature of the small-scale disc showed good agreement with that of the full-scale disc which a maximum difference of the order of 10° c.

Abaqus FEA software was used to further investigate the scaling methodology and thermal performance of the small and full-scale solid brakes two-dimensional axisymmetric transient heat transfer models of the discs were developed in standard. [17]

Nipun Jalhotra et al. have carried out an experimental study on the design and fabrication of chassis to make it light-weighted to maximize power to weight ratio. He made a compact and durable vehicle with a low center of gravity which gives better stability to the vehicle. Ladder frame type chassis was used by him. Material selection for chassis plays an important role to make desired weight, strength, and stability of the vehicle. He was selected stainless steel as chassis material that does not corrode and rust with water as compared to steel. Pipe size plays a crucial role in strength and load-carrying capacity. So, he selected a circular cross-section pipe of outer diameter 25.4mm and thickness is 2mm. He was done a simulation of load analysis using the Finite Element Method (FEM) and he was found that chassis design was able to sustain vertical load and impact load. He has used Ackermann steering geometry with minimum turning radius, less steering effort, and optimum steering response. He has used a Detachable steering wheel which allows the driver of any height to sit comfortably and then fit the steering wheel.

Conclusion: Aim of this paper is to make the design of the vehicle aesthetically and ergonomically strong. He focused on the weight, strength, and stability of the vehicle. [18]

CONCLUSION

In this review paper an exhaustive review is carried out to find out the effect of various parameters on the performance of

E-Kart. Parameters such as Steering system, braking system, transmission system, chassis and their analysis was considered in many literature reviews, but in the analysis section it was not more explored. In analysis section most of the authors have analyzed the chassis of the vehicle, others parameters needs to be consider in analysis such as –

- Analysis of Fundamental Steering Equation.
- Satisfying Fundamental Steering Equation.
- Equating Optimum Turning Radius.
- Calculation of forces on Stub Axel.
- Inner Wheel angle and Outer Wheel angle.
- Implementation of Convergence tool in FEA.

FUTURE SCOPE

- E-Kart has many systems such as Steering system, Braking system, Transmission, Ergonomics, Designing, Analysis.
- It is a vast topic to study whole system at once.
- This review will helpful to study various systems of the E-Kart.
- This work will also motivate future batch to work more thoroughly on the other systems of the Kart.
- In future modification in the Electric -go-kart will provide a major role in increasing the power transmission efficiency, stable steering geometry, compact chassis design, and effective cooling of the controller.
- The researcher has opportunity to differ in the dimensions in order to increase the kart efficiency, reduction in the cost and standardization.
- It can become the best package for national and international competition.
- Up comers have chance to improve ergonomics of kart for reaching more comfortable drive.
- In future researchers can improve aesthetics of kart so that it can make positive effect on aerodynamics drag forces, pleasure view and gives chance to reduce fabrication cost.
- Students can investigate and design the steering system with sensors which can help for effective steering system. Such as torque, position sensor and steering wheel sensors.
- In future student have scope to apply modern technology like artificial intelligence, machine learning, embedded systems, etc.

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