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PERFORMANCE EVALUTION ON EV GO-KART

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Abstract - This study thoroughly evaluates the performance of an electric go-kart, covering acceleration, top speed, handling, energy efficiency, and driving experience. Real-world tests measure acceleration and top speed on a track, while expert drivers provide feedback on handling. Computational simulations analyze aerodynamics, structural integrity, and energy consumption. The study also considers subjective aspects like comfort and enjoyment through surveys and interviews. The results provide valuable insights for manufacturers, enthusiasts, and researchers, aiding the advancement of electric vehicles.

Keywords: Acceleration, Energy efficiency, Computational fluid dynamics, Finite element analysis.

1.INTRODUCTION

The transition to electric mobility is driven by environmental concerns and technological advancements, extending to various sectors including motorsport. Electric go-karts, with their instant torque and sustainability, are reshaping karting culture and racing dynamics. Evaluating their performance is crucial for optimizing design and informing stakeholders. Challenges like range limitations and regulatory compliance exist alongside opportunities for innovation. Technological advancements such as regenerative braking systems contribute to improved performance and safety. A theoretical framework guides the evaluation process, supported by literature on electric propulsion and vehicle dynamics. Methodology ensures accurate and reproducible results, with transparent experimental setups and data analysis. Overall, electric go-karts represent a promising frontier in sustainable motorsport, fostering innovation and driving conversations about environmental responsibility.

PROJECT OVERVIEW:

This project aims to assess the performance of an electric go-kart across various criteria including speed, efficiency, handling, and user experience. Through standardized tests conducted both on a track and in real-world scenarios, the objective is to gain insights into the strengths and weaknesses of electric go-karts. Ultimately, the findings will guide the development of future models towards a more sustainable and engaging future.

PROJECT OBJECTIVES:

This project aims to thoroughly evaluate electric go-karts across key areas like speed, energy efficiency, and handling. By conducting controlled track tests and real-world scenarios, we'll gauge maximum speed, acceleration, and energy consumption. We'll also delve into handling dynamics to understand agility and stability. Based on our findings, we'll provide optimization recommendations, such as enhancing aerodynamics and powertrain components. Sharing our results with the go-kart community and industry stakeholders will foster discussions on sustainable mobility. Additionally, we'll use our insights to guide the future development of electric go-kart models, collaborating with industry partners to implement improvements.

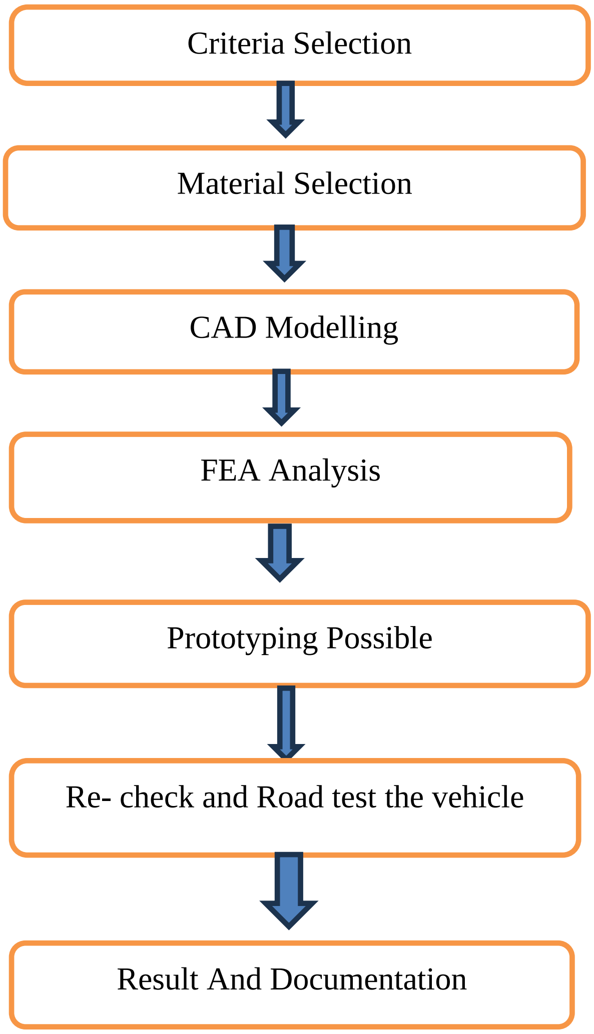
Figure 1 Acceleration Test

RESOURCES REQUIRED:

The project will require a skilled team including a project manager, researchers, technical experts, communication specialists, and education facilitators. We'll need top-notch equipment and facilities for testing, prototyping, and workshops. Key materials and components include high-performance electric motors, lithium-ion batteries, and lightweight chassis materials. Software tools such as CAD and simulation software will be crucial for design and analysis. Partnerships with industry leaders, academic institutions, and government agencies will provide valuable expertise and resources. Funding will be secured through budget allocation, grant funding, and sponsorship arrangements. Training programs and capacity-building initiatives will ensure the team is equipped with the necessary skills and knowledge for success.

Figure 2 Evaluation

2. METHODOLOGY



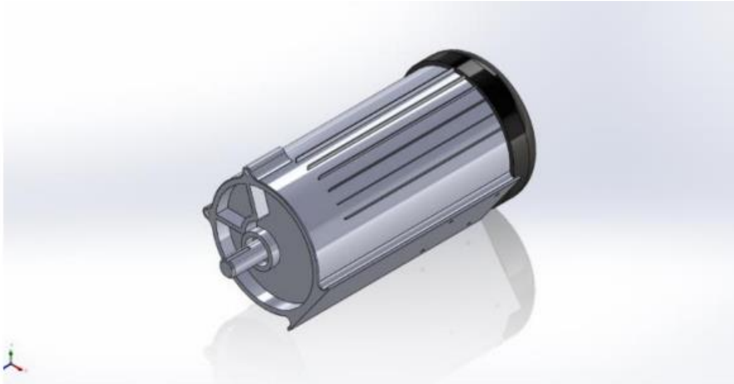


Figure 3: Motor

B) Motor Mounting and Cooling: Mounting arrangements and cooling systems are designed to optimize motor performance and prevent overheating during prolonged testing sessions.

Table 1: MOTOR SPECIFICATIONS:

Type	**Permanent Magnet Synchronous Motor**
Voltage(V)	60V
No load current (A)	7A
Rated current (A)	80A
Rated speed (RPM)	3500±100
Rated Torque(N-M)	18.9
Max Output Torque (Nm)	56
Rated power(W)	4000
Max. Power Output (W)	5000
Efficiency	>88%
Number of poles	8
Insulation class	B

c) Motor Controller:

3. EXPERIMENTAL CALCULATIONS

Design and Components of the Electric Go-Kart:

a) Design Philosophy: The design process encompasses a holistic approach focusing on performance, safety, and reliability. Considerations include aerodynamics, structural integrity, and thermal management.

b) Component Integration: Integration of components is optimized to minimize weight, reduce energy losses, and enhance overall efficiency.

c) Safety Features: Implement safety features such as roll cages, seat belts, and impact protection to ensure driver and passenger safety during testing.

Motor Specifications:

a) Motor Selection Criteria: Considerations for motor selection include power density, torque curve, thermal management capabilities, and compatibility with the control system.

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A motor controller is a device used for operating an electric motor and is coordinated in some predetermined manner. A controller can have a manual or automatic system to start and stop the motor, for changing the direction of rotation from forward to reverse, for selection and regulation of speed and for limiting the torque. It is also used to protect the motor from overloads and faults.

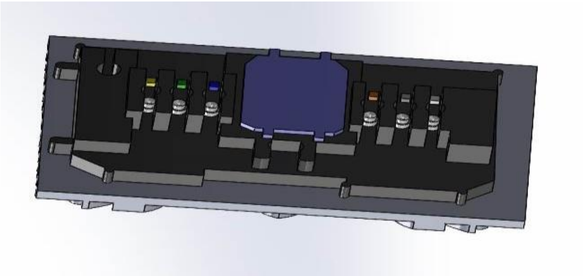

Figure 4: Motor Controller

Motor Controller Calculation:

Motor controller discharge power(peak)=Rated Voltage × Peak protection current

= 60×120

= 7.2kw

Motor controller discharge power(continuous)=Rated voltage ×Rated current

= 60×80

= 4800watts

= 4.8kw

4.3 Battery Specifications

a) Battery Chemistry and Configuration: Selection of battery chemistry (e.g., lithium-ion, lithium polymer) based on energy density, discharge characteristics, and cycle life.

Figure 5: Battery

TABLE 2: BATTERY PROPERTIES:

Rated Voltage	60V
Peak protection current	120A
Rated power	7200W
Under Voltage Protection	53V
Throttle voltage	1V to 4.5V
Phase commutation	120 degrees
Brake De-energize	High
Heat dissipation	Natural cooling
Ambient temperature	20 degrees to 60 degrees

b) Battery Management System (BMS): Implementation of a BMS to monitor cell voltages, temperatures, and state of charge, ensuring safe and efficient operation.

c) Accumulator :

An accumulator is an energy storage device that accepts, stores, and releases energy as needed.Based on our requirements, we chose a 64V And 75 amps lithium-ion phosphate battery, which consists of 5 cells connected in parallel and 20 cells connected in series, where each cell has 3.2volt.

Dimensions of the Accumulator: 810×240×175mm

Accumulator calculation:

Lithium-ion battery: Voltage:64 volts

Ampere:75 amps

Each cell voltage: 3.2volt

Number of cells :20×5=100 cells

Peak voltage:64V

Continuous rating:1.5C

Peak Rating=5C

Charge=75Ah

Accumulator Discharge Power (Peak)= (Peak Rating×Charge) ×Voltage

= (5×75) ×64

= 24000watts

= 24kw

Accumulator Discharge Power (continuous)= (Continuous rating charge) ×Voltage

= 1.5×75×64

= 7200watts

= 7.2kw

Accumulator Peak Voltage = Individual cell voltage × no. of parallel cells

= 3.2×20

= 64V

Cell type: Cylindrical cell

Because of the light weight, we are using a cylindrical cell.

Sprocket Calculation:

$$\frac{Teeth\ in}{Teeth\ out} = \frac{Torque\ in}{Torque\ out} = \frac{Rpm\ out}{Rpm\ in}$$

Assume secondary teeth=27

Torque in =126 N-m

Teeth in =12

Rpm out =3500

$$\frac{Teeth\ in}{Teeth\ out} = \frac{Torque\ in}{Torque\ out}$$

$$\frac{12}{27} = \frac{56}{X}$$

X=126 N-m

RPM calculation:

$$\frac{Teeth\ in}{Teeth\ out} = \frac{Rpm\ out}{Rpm\ in}$$

$$\frac{12}{27} = \frac{X}{3500}$$

X=1555.55 rpm

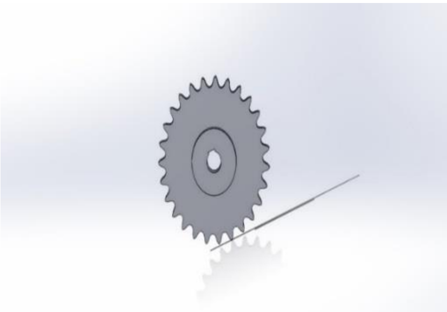

Figure 6: Sprocket

Rpm converted to speed:

Formula for finding the rpm to speed

K= D×R×0.001885

Where:

K=Speed in kmph

D=Diameter of wheel in cm

R= Revolutions per minute (RPM)

Diameter of the wheel in cm= 27.9

Rpm =1555.55

K= 27.9×1555.55×0.001885

K=81kmph

Braking System:

Considerations for the Braking System Selection:

Table 3: Selection of Braking System

Pedal Ratio	4:1
Rear Disc Diameter	200mm
Calliper Type	Fixed Calliper
No of Calliper Pistons	4
Calliper Piston Diameter	30mm
Master Cylinder Diameter	14mm
Pay Load	65kg
No Load	120kg
Tyre Diameter	140.97mm
Speed of the Vehicle	40kmph

Force acting on the brake pedal = Weight of the driver x 9.81

= 65 x 9.81

F = 637.65 N (consider 15kg force applied by the driver)

Brake line pressure:

$$P = \frac{\text{Pedal Ratio} \times \text{Force on the brake pedal}}{\text{Area of master cylinder}}$$

$$P = \frac{4\times 147.15\text{N}}{\left(\frac{\pi}{4}\right)\times(0.015)^2}$$

P = 3330794.649 Pa

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P = 3330794.649 Pa

Rotating force (RF):

$$RF = CF \times No's\ of\ caliper\ pistons \times coefficient\ friction\ of\ brake\ pads$$

$RF = 4708.8 \times 4 \times 0.3$

RF = 5650.56 N

Braking torque (BT):

$$BT = \text{Rotating force} \times \text{effective disc radius}$$

$$BT = 5650.56 \times 0.098$$

$$BT = 542.6797 \text{ N-m}$$

Braking force (BF):

$$BF = \frac{\text{Braking Torque}}{\text{Tire radius}} \times 0.8$$

$$BF = \frac{542.6797}{0.1397} \times 0.8$$

$$BF = 3107.6866\, N$$

Deacceleration:

$$F = -ma$$

$$a = -\frac{f}{m}$$

$$a = -\frac{3107.6866}{170}$$

$$a = -18.28 m/s$$

Stopping Distance:

$$V^2 - U^2 = 2as$$

$$0^2 - 11.1111^2 = 2 \times 18.28 \times s$$

$$s = 3.376m$$

4. RESULT AND DISCUSSION

Our team collaborated across disciplines to develop and evaluate an electric go-kart, showcasing remarkable performance through meticulous testing. Expertise in chassis design ensured outstanding agility and stability, while energy efficiency measurements confirmed its practicality and environmental sustainability. Safety protocols were rigorously implemented. Additionally, user experience was enhanced with optimized seating and dashboard layout for easy access to vital information. Making it suitable for recreational, commercial, and educational purposes.

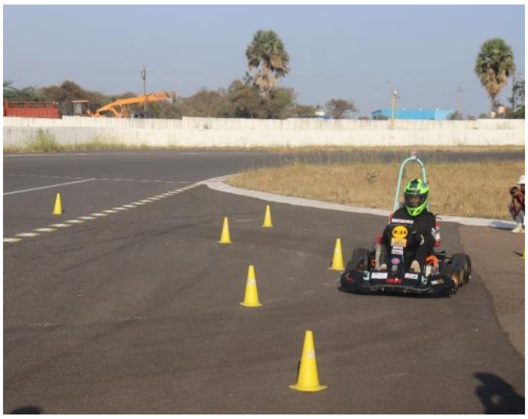


Figure 7: Skid pad

ENDURANCE ROUND -1

Table 4: Endurance Round - 1

*DNF (DID NOT FI NISH)

Kart	Registration ID	Tyours	Endurance R1
E-7	7063292	DNF	DNF
E-14	7063297	523.372	184.47
E-27	7063303	541.242	150
E-35	7063318	767.237	5
E-54	7063335	DNF	DNF
E-54	7063335	DNF	DNF
E-69	7064348	DNF	DNF
E-93	7064367	609.261	106.36
E-115	7064377	DNF	DNF
E-120	7064379	DNF	DNF
E-134	7064388	712.264	40.27
E-145	7064397	DNF	DNF
E-151	7064400	DNF	DNF
E-155	7064413	DNF	DNF

ENDURANCE ROUND -2

Table 5: Endurance Round – 2

Kart	Registration ID	Tyours	Endurance R2
E-7	7063292	DNF	DNF
E-14	7063297	DNF	DNF
E-27	7063303	DNF	DNF
E-35	7063318	DNF	DNF
E-54	7063335	DNF	DNF
E-69	7064348	857.21	5
E-93	7064367	552.292	150
E-115	7064377	DNF	DNF
E-120	7064379	DNF	DNF
E-134	7064388	DNF	DNF
E-145	7064397	DNF	DNF
E-151	7064400	DNF	DNF
E-155	7064413	DNF	DNF

Autocross:

Table 6: Autocross.

Kart	Registration ID	Autocross
E-7	7063292	DNF
E-14	7063297	91.01
E-27	7063303	100.00
E-35	7063318	79.46
E-54	7063335	DNF
E-69	7064348	97.39
E-93	7064367	86.29
E-115	7064377	DNF
E-120	7064379	DNF
E-134	7064388	5.00
E-145	7064397	DNF
E-151	7064400	DNF
E-155	7064413	DNF

SKID-PAD:

Table 7: Skid Pad.

Kart	Registration ID	Skid-Pad
E-7	7063292	DNF
E-14	7063297	68.93
E-27	7063303	80.00
E-35	7063318	55.53
E-54	7063335	DNF
E-69	7064348	75.41
E-93	7064367	71.19
E-115	7064377	4.50
E-134	7064388	52.92

Final Score:

Table 8: Final Score.

Kart	Registration ID	Final Score	Ranks
E-27	7063303	661.7	1
E-93	7064367	605.09	2
E-14	7063297	603.07	3
E-69	7064348	371.56	4
E-35	7063318	351.86	5
E-54	7063335	172.61	6
E-7	7063292	164	7
E-134	7064388	155.72	8
E-115	7064377	138.95	9
E-145	7064397	86	10
E-151	7064400	55	11
E-120	7064379	0	12
E-155	7064413	0	12

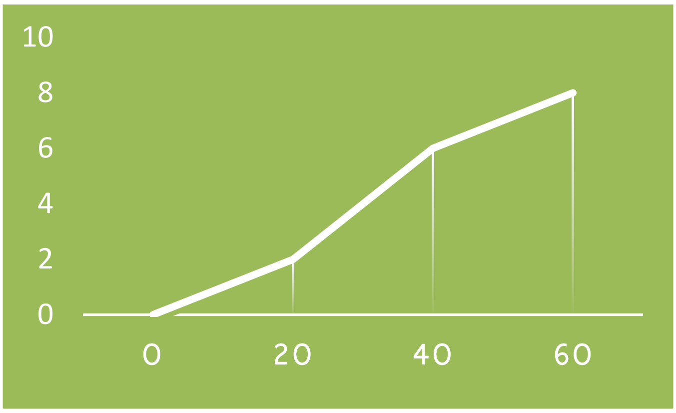
Figure 8: Vehicle Verified

GRAPHS:

Time (hr) vs Voltage(A) chart

X axis Voltage(v)

Y axis Time hr



Graph 1: Time (hr) vs Voltage (A)

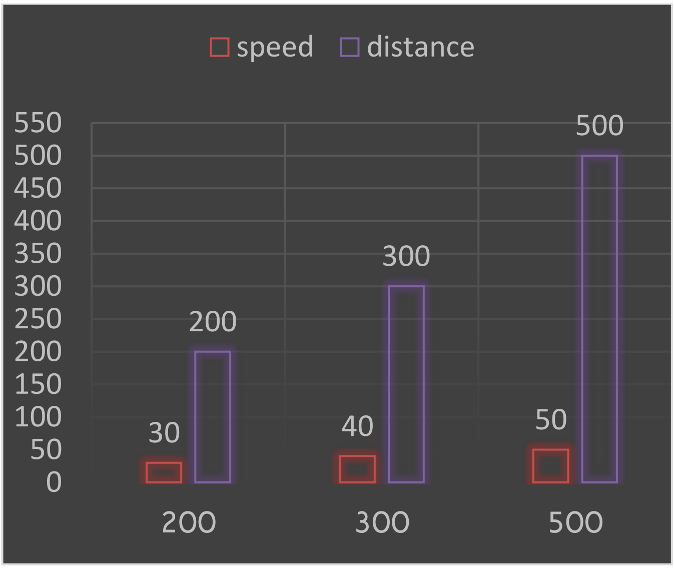
Speed vs Distance

Speed In Km/h

Distance in Meters

X Axis distance(meters)

Y Axis speed (km/h)



Graph 2: Speed vs Distance

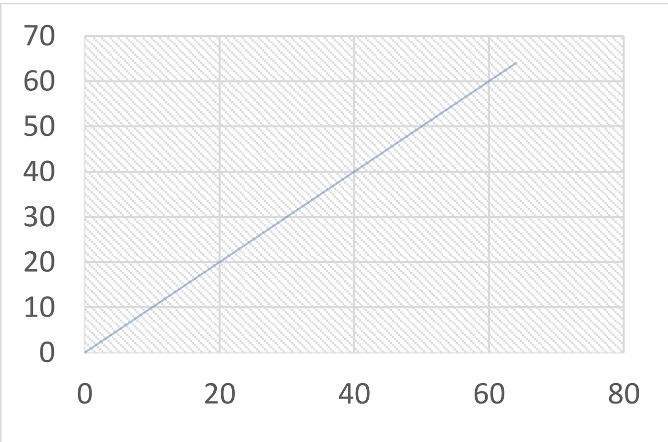
Distance Vs Time Chart

X Axis Distance (Meters)

Y axis Time (Seconds)

Graph 3: Distance Vs Time

Current vs Voltage chart
X axis voltage(V)
Y axis current(A)



Graph 4: Current vs Voltage

DISCUSSION:

To optimize vehicle performance, focus on enhancing the electric powertrain, reducing weight, and improving aerodynamics. Upgrade batteries, optimize motor efficiency, and employ advanced control algorithms. Use lightweight materials and design optimization for weight reduction without sacrificing structural integrity. Refine body shape, add aerodynamic features, and optimize airflow for drag reduction. Fine-tune suspension for better handling and ride quality. Maximize regenerative braking efficiency while minimizing wear. Select and optimize tires for grip and rolling resistance. Implement advanced vehicle dynamics control systems for stability and agility. Continuously test enhancements through rigorous procedures for real-world performance validation.

5. CONCLUSION:

An evaluation of the performance of an electric go-kart is crucial for understanding its strengths and weaknesses across various criteria such as acceleration, top speed, efficiency, handling, and range. This assessment will offer insights into the overall suitability of the go-kart for its intended purpose, whether competitive racing or recreational use. It may suggest areas for improvement or highlight notable features such as exceptional efficiency or superior handling. To gather data, advanced data logging systems will track speed, acceleration, and braking, while real-time telemetry will enable drivers to monitor their go-kart's performance while driving. Integration of artificial intelligence will provide insights and optimize race strategies. Performance metrics will be presented visually for easy analysis, fostering healthy competition among drivers. Virtual coaching programs will offer personalized feedback, and predictive analytics will help drivers anticipate issues. Specialized workshops will assist in refining driving skills, while aerodynamic enhancements, lightweight materials, efficient power management, regenerative braking, and dynamic suspension systems will enhance performance. These advancements aim to elevate electric go-kart performance to new levels of speed and excitement.

6. FUTURE SCOPE

In the future, performance evaluation of electric go-karts will see exciting advancements. Advanced data logging systems will capture detailed information about speed, acceleration, and braking, while real-time telemetry will allow drivers to monitor their go-kart's performance on the go. Artificial intelligence integration will provide valuable insights and help optimize race strategies. Performance metrics will be visualized in user-friendly graphs and charts, making it easy to identify areas for improvement. Comparative analysis will foster healthy competition among drivers. Virtual coaching programs will offer personalized feedback and tips. Predictive analytics will help drivers anticipate issues and make data-driven decisions. Specialized workshops will help fine-tune driving skills. Aerodynamic improvements and lightweight materials will enhance performance. Efficient power management and regenerative braking systems will optimize energy usage. Dynamic suspension systems will provide better handling and stability. These advancements will revolutionize the performance evaluation of electric go-karts, taking them to new heights of speed and excitement.

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