

Design And Analysis Of An Electric Go-Kart Considering Aerodynamics

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Abstract

The growing demand for sustainable and energy-efficient transportation systems has led to significant advancements in electric vehicle technology. This research aims to study the design and aerodynamic analysis of an electric go-kart with the intention of improving its efficiency. This project involves the development of a lightweight go-kart chassis with an electric drive system, including a battery, motor, and control unit.

The 3D model of the electric go-kart was created using CAD software, incorporating basic aerodynamic features such as a streamlined nose and minimized frontal area. An ANSYS Fluent analysis was conducted using the ANSYS Fluent software to simulate the airflow pattern for the electric go-kart. Important parameters, such as velocity distribution, pressure contours, drag force, and drag coefficient, were analyzed under various conditions.

The analysis revealed that aerodynamic drag has a substantial impact on the go-kart's efficiency, particularly at high speeds. As a result of these findings, the modifications made in the design have shown significant improvements in the airflow pattern, reducing turbulence and drag force. This has resulted in a significant reduction in the drag coefficient of the electric go-kart compared to its initial model, thus improving its energy efficiency.

Keywords: Electric Go-Kart, Electric Vehicles, Aerodynamics, Drag Reduction, ANSYS Fluent, BLDC Motor, Energy Efficiency, Vehicle Design, Streamlining, Drag Coefficient, Airflow Analysis, Sustainable Transportation.

1. Introduction:

The rapid growth in transportation has led to increased consumption of fossil fuels and a significant rise in environmental pollution. Conventional vehicles powered by internal combustion engines (ICEs) emit harmful gases, including carbon dioxide (CO₂), nitrogen oxides (NO_x), and hydrocarbons, which contribute to air pollution and global warming. To address these challenges, electric vehicles (EVs) have emerged as a promising alternative due to their advantages, including zero tailpipe emissions, high energy efficiency, and low operating costs.

Designing and analyzing an electric go-kart involves key factors. These include weight, structural strength, powertrain efficiency, and airflow. A strong chassis ensures safety, while an efficient motor and battery provide propulsion. Adding aerodynamic features, such as a streamlined shape, a small frontal area, and smooth surfaces, reduces drag and boosts performance.

This research highlights the value of incorporating aerodynamics into the design of small electric vehicles. It also gives practical exposure to modern engineering tools. The outcomes support efficient, high-performance, and sustainable electric transportation.

2. Problem Definition:

The increasing demand for energy-saving and eco-friendly transportation modes has led to the consideration of electric vehicles as an alternative option compared to the conventional system of internal combustion engines. The performance of small electric vehicles such as go-karts is often restricted by the high energy consumption rate, battery capacity, and inefficient design characteristics.

One of the significant factors influencing the performance of an electric go-kart is the presence of aerodynamic drag, which is the resisting force per unit weight that opposes the motion of the go-kart. The conventional designs of go-karts are not optimized in terms of aerodynamic characteristics; therefore, the presence of turbulence, flow separation, and drag coefficients is more significant in such vehicles. The electric go-kart is completely dependent on the stored electrical energy; therefore, the energy loss should be minimized in the presence of aerodynamic drag. The need of the hour is to analyze the aerodynamic characteristics of the electric go-kart using modern tools of engineering.

The problem in the electric go-kart is being addressed in the present project by using the ANSYS Fluent simulation tool to evaluate the behavior of the airflow around the go-kart. The parameters being evaluated in the present study include the velocity distribution around the go-kart, pressure changes in the presence of the go-kart, and the drag forces. The gap between the conventional go-kart design and the modern design using the aerodynamic characteristics is being filled in the present study by providing an overview of the systematic approach toward the improvement of the electric go-kart. The ultimate objective of the present study is the design of an electric go-kart with improved aerodynamic characteristics in terms of speed, stability, and energy consumption.

3. Objectives of the Project

Objectives of the Project

The main objective of this project is to design and analyze an electric go-kart in such a way that the efficiency of the go-kart improves. The specific objectives of the project are as follows:

- Design the 3D model of the electric go-kart using the CAD software by taking into consideration the basic aerodynamic features.
- Perform the analysis of the aerodynamic performance of the electric go-kart using ANSYS Fluent software.
- Perform the analysis of the significant parameters of the aerodynamic performance of the go-kart.
- Locate the areas where the turbulence and separation of the flow occur in the go-kart.
- Perform the design modification by taking into consideration the aerodynamic improvements.
- Compare the design with the initial design.
- Perform the analysis of the effect of aerodynamic drag on the efficiency of the go-kart.
- Validate the simulation results by taking into consideration the theoretical calculations.
- Develop the knowledge about the ANSYS Fluent software.

4. Research Methodology

The research methodology used for the study is as follows:

The research methodology used for this study is a scientific approach for designing, analyzing, and optimizing the aerodynamic properties of the electric go-kart.

The steps involved in the research methodology are as follows:

1. Literature Review

The study of various research papers, journals, and reports on:

- Electric vehicles
- Design of go-kart
- Aerodynamic properties and drag reduction
- Using ANSYS Fluent

2. Conceptual Design

The conceptual design of the electric go-kart is done considering:

- Structure of the chassis
- Position of the driver
- Position of the motor and battery
- Aerodynamic properties like minimizing frontal area and shaping the go-kart

3. CAD Modeling

The CAD model of the go-kart is created using CAD tools like SolidWorks and CATIA.

The CAD model is designed considering aerodynamic properties like smooth surfaces and curved shapes.

The CAD model is created for simulating the aerodynamic properties.

4. ANSYS Fluent Using ANSYS

The aerodynamic properties of the go-kart are analyzed.

The steps involved in ANSYS Fluent are as follows:

- Importing the CAD model into ANSYS Workbench
- Defining the domain
- Meshing
- Defining the boundary conditions
- Selecting the turbulence model
- Simulating the model for different velocities

5. Aerodynamic Calculations

The drag force on the go-kart is calculated using ANSYS Fluent.

The drag force is calculated as:

$$F_d = \frac{1}{2} \rho C_d A v^2$$

Where:

F_d = Drag force, ρ = Air density, C_d = Drag coefficient, A = Frontal area, v = Velocity

6. Design Optimization

The modifications made in the go-kart for better aerodynamic properties:

- Streamlining the go-kart
- Minimizing the edges
- Improving the aerodynamic properties

The model is simulated for better aerodynamic properties.

5. OBSERVATION

Parameter	Observed Value	Performance Remarks
Initial Acceleration (0–20 m)	~5–6 seconds	Good starting torque due to 2.8:1 gear ratio
Top Speed	~45–50 km/h	Limited by motor RPM and controller
Braking Distance	~3–4 meters	Disc / hydraulic brakes effective
Battery Voltage Sag	~2–3 V	Observed during full throttle
Motor Temperature	~50–55 °C	Safe for continuous operation

Properties (AISI 1018):

- Tensile strength (ultimate): 440MPa
- Tensile strength (yield): 370MPa
- Modulus of elasticity: 205GPa
- Bulk modulus: 140GPa

Ergonomics

SR.NO.	Parameter	Value
1.	Vehicle length	72 Inch
2.	Vehicle Width	44 Inch
3.	Wheel Base	1054.1 mm
4.	Chassis material	AISI 1018
5.	Tube Dimensions	OD:25.4 mm ID 23.4 mm
6.	Chassis Weight	8.84 Kg
7.	Total Vehicle Weight (approx.)	150 Kg
8.	Ground Clearance	2 In
9.	Battery	12 V (Qty 4)
10.	Max. Speed	
11.	Acceleration (Avg)	3.454 m/s ²
12.	Brake	Disc
13.	Steering	Pitman
14.	Tyre	Slick Tyres
15.	Diameter of the tyre	Front: 254 mm Rear: 279.4 mm

w= 140kg
r=(0.1397m)
v= 40 Km/hr
=11.1m/s
T=5 sec
C_r=0.015

Force Calculate

Rolling Resistance Coefficient

C_r=(F_r)/(wXg)
C_r=(20.60)/(140X9.81)
C_r=0.015

Rolling Resistance Force

F_r= C_rXwXG
F_r=0.015X140X9.81
F_r=20.60N

Acceleration Force

F_a=(wXv)/t
F_a=(140X11.1)/5
F_a=333N

Total Force Required

F_{total}=f_r+f_a
F_{total}=20.60+333
F_{total}=3353.6

Factors	Front	Rear	Side
Impact Force	3G	3G	2G
Force Value (N)	4414.5	4414.5	2207.25
FOS	4.41	4.75	18.23

Torque Required at Wheel

T_{Wheel}= F_{total}Xr
T_{Wheel}=353.60X0.1397
T_{Wheel}=49.39Nm

Parameter	Value
Turning Radius of Kart	2.53m
Inner Turning Angle	31.70°
Outer Turning Angle	24.21°
Steering Ratio	1:1
KPI	0°
Steering Wheel Diameter	10"
Castor	11°

Component	Material	Max Def. (mm)	Max. Stress (mm)
Knuckle Holder	Mild Steel	0.6796	226.65
Steering Wheel	Mild Steel	5098	2.8436
Tie Rod	EN-9	0.0045	5.586
Pitman Arm	Mild Steel	0.0046	0.8335

Brake System

Parameter	Value
Muscular Force	150N
Pedal Ratio	4:1
OD of Disc	170mm
Caliper Piston Diameter	25mm
No. of caliper Pistons	2
Mass of Vehicle	140Kg
Wheel base	1041.4 mm

Parameter	Stunner
Max. Power	3000-4000 rpm
Max. Torque	25 – 35 Nm

Gear Ratio

Gear Ratio(G) Tells HON many times the motor rotator compared to the wheel
G=(N_{motor})/(N_{wheel}) (N – r.p.m)

Wheel Rpm

N_{wheel}=(V)/(2πr) X 60
N_{wheel}=(11.1)/(2πX0.135)X 60
N_{wheel}=785.164 r.p.m

Motor RPM 3000 RPM

G=(3000)/(785.164)
G=3.82 ~ 4
G=4:1

Motor Torque SelectionGear Ratio $G=4$ (assume)Efficiency $\eta=0.9$ $T_{\text{motor}}=(T_{\text{wheel}})/(G \times \eta)$ $T_{\text{motor}}=(49.39)/(4 \times 0.9)$ $T_{\text{motor}}=13.719$ **Future Scope of the Project**

The present study on the aerodynamic design and analysis of an electric go-kart shows the need for reducing drag and enhancing the performance of the vehicle by optimizing the flow of air. Nevertheless, there are several opportunities for research and development to be undertaken in order to obtain accurate results and improve efficiency.

1. Lightweight Materials and Structural Optimization

- Utilization of advanced materials like aluminum alloys.

This will improve the speed, efficiency, and performance of the vehicle.

2. Thermal and Cooling Analysis

- Incorporation of thermal analysis into the design of the aerodynamic system.
- Optimization of the flow of air for effective cooling of Motor, Battery

This will improve the performance of the systems.

3. Integration with Vehicle Dynamics

- Study of the combined effects of aerodynamic design and vehicle dynamics.
- Analysis of lift and downforce for better vehicle stability.

4. Energy Efficiency and Range Improvement

- Study of the relationship between reducing drag and battery performance.
- Optimization of the design for increased range

.Conclusion

The study on the "Design and Analysis of an Electric Go-Kart Considering Aerodynamics" was successfully completed with the aim of enhancing the aerodynamic characteristics of the go-kart using computational methods. The project was focused on the design and analysis of the 3D model using ANSYS Fluent tools to understand the aerodynamics and its effect on the go-kart. From the ANSYS Fluent analysis, it was evident that aerodynamic drag has a significant impact on the efficiency and performance of the go-kart. High-pressure zones were also evident on the front surface of the go-kart, while low-pressure zones were evident on the rear surface. These zones contribute to the drag forces acting on the go-kart. Through aerodynamic optimization techniques such as streamlining the go-kart's body and smoothing out the edges, the optimized go-kart showed improved aerodynamic characteristics in terms of reduced turbulence and flow separation. A considerable reduction in the drag forces and the drag coefficient was achieved in the optimized go-kart compared to the original design. This shows the improved aerodynamic efficiency of the go-kart. Reduced aerodynamic drag will lead to reduced energy consumption. This is a positive factor for the go-kart, which is an electrical vehicle and has limited energy storage in the batteries. However, the study was conducted in ideal conditions. Nevertheless, the study has a strong foundation for further research and implementation. The application of aerodynamics in the design and development of electrical vehicles will go a long way in the development and implementation of more efficient and effective vehicles in the future.

Thus, the project was successfully completed with the aim of enhancing the aerodynamic characteristics of the go-kart and demonstrating the efficiency and effectiveness of the ANSYS Fluent tools in the design and development of go-karts.

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