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Design and Fabrication of Upgrading an Internal Combustion Engine to an Electric Motor Go-Kart

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ABSTRACT – *The transition from internal combustion engines to electric propulsion in motorsports has gained significant attention due to its potential for sustainability and performance enhancement. This study presents the development and performance evaluation of an electric go-kart, "Speed Maniac," designed to replace conventional fuel-powered systems with an electric drivetrain. The primary objectives were to optimize speed, efficiency, and control while ensuring structural integrity and energy sustainability. The research methodology involved literature review, design selection, finite element analysis (FEA), component integration, fabrication, and experimental testing. A brushless electric motor and lithium-ion battery system were selected for their efficiency and power output. Structural modifications were made to the chassis to enhance stability and weight distribution, while braking and steering systems were optimized for improved safety. Performance evaluations, including speed tests, braking efficiency analysis, and battery consumption assessments, demonstrated notable improvements in acceleration, energy efficiency, and overall handling. The results indicate that electric go-karts offer a viable alternative to traditional combustion-engine models, with enhanced environmental benefits and competitive performance. This study contributes to the growing body of research on sustainable vehicle technology and highlights the feasibility of electric propulsion in motor sports applications.*

KEYWORDS: Electric go-kart, sustainable mobility, electric propulsion, finite element analysis, performance evaluation

1. INTRODUCTION

The global automotive landscape is experiencing a transformative shift driven by technological innovation and environmental imperatives. For over a century, internal combustion engines (ICE) have powered most vehicles, converting the chemical energy of fossil fuels into mechanical motion through controlled combustion. Although ICE technology is well-established and supported by extensive infrastructure, it faces increasing criticism for its environmental impact, particularly greenhouse gas emissions, noise pollution, and fuel inefficiency (Reitz et al., 2019). As the world moves towards sustainable transportation solutions, electric vehicles (EVs) have emerged as a viable alternative. Powered by electric motors and batteries, EVs offer several advantages over ICE vehicles, including reduced tailpipe emissions, lower operating costs, and improved energy efficiency (IEA, 2023).

Electric propulsion systems are rapidly evolving, with advancements in lithium-ion battery technology, energy density, and fast-charging infrastructure making EVs more practical and accessible. Major automakers and governments worldwide are investing heavily in EV development and infrastructure to meet emissions targets and reduce dependence on fossil fuels (Bloomberg NEF, 2023). At the same time, ICE technology is also experiencing a shift towards cleaner operation through hybrid systems, engine downsizing, and alternative fuels such as biofuels and hydrogen (Liu et al., 2024). The coexistence of ICE and EV technologies during this transitional period offers valuable learning opportunities in engineering education, where students can examine both legacy and emerging propulsion systems.

In this context, project-based learning serves as an effective method to expose students to real-world engineering challenges. The “Speed Maniac” project offers a platform for students to design and build a small-scale motorized prototype, mimicking both ICE and EV principles within a controlled academic framework. Through this hands-on experience, students gain insights into vehicle dynamics, propulsion mechanisms, weight optimization, and aerodynamics-skills directly transferable to the modern automotive industry (Konak, 2025). Moreover, the integration of fundamental design and analysis with a focus on performance helps bridge theoretical knowledge with practical application.

Nevertheless, student-led design projects often encounter significant challenges, such as limited access to high-quality materials, imprecise fabrication techniques, and insufficient understanding of propulsion systems. These issues can result in unbalanced structures, excessive weight, or inefficient power transmission. Vehicles modeled after ICE systems may experience mechanical losses due to friction and vibration, while simplified electric drivetrains may face torque distribution or battery management challenges (Farfan-Cabrera, 2019; Hengst, 2022). Addressing these limitations through systematic design, careful material selection, and iterative testing is crucial to improve both performance and learning outcomes.

This study aims to design, build, and evaluate a lightweight, high-speed electric-propulsion prototype vehicle that aligns with current industry trends and environmental goals. The primary objectives include understanding key performance parameters such as power-to-weight ratio, aerodynamic design, and material efficiency. The project emphasizes the development of teamwork, critical thinking, and technical documentation skills during the design and testing processes. Additionally, the study introduces fundamental concepts of ICE and EV propulsion systems, offering students a comparative understanding of how emerging technologies influence vehicle performance and sustainability.

The scope of the project is limited to a competition-compliant prototype, focusing on chassis design, propulsion integration using small-scale electric motors, and weight reduction. Advanced features such as regenerative braking, onboard diagnostics, or full-scale battery management systems are excluded from this study. Testing is carried out in controlled indoor conditions to ensure consistency in performance evaluation.

Literature supports the significance of integrating propulsion technology, lightweight materials, and energy-efficient systems in vehicle performance improvement. ICEs remain relevant in hybrid applications and regions without EV infrastructure, but electrification is rapidly progressing due to policy incentives and technological maturity (IEA, 2023; Liu et al., 2024). Studies show that EVs are up to three times more efficient than ICE vehicles and greatly reduce urban pollution (Farfan-Cabrera, 2019; Gowda, 2025). In engineering education, design challenges and prototype competitions are known to foster innovation, technical skills, and collaboration among students, further reinforcing the value of such experiential learning initiatives (Konak, 2025).

2. METHODOLOGY

The methodology for this project is centered on developing the design concept, modelling the body and frame, integrating the electrical system, and conducting validation through testing. The aim is to ensure the final product, which is a functional electric go-kart, meets ergonomic, safety, and performance requirements.

2.1 Design Concept Preparation

The design phase involved brainstorming and sketching initial ideas using reference models from existing ICE go-kart designs. Emphasis was placed on achieving a sleek, aerodynamic body that was both ergonomic and visually attractive. Multiple iterations were considered to balance aesthetics, performance, and material feasibility.

2.1.1 Design Concept Selection

Figure 1 shows the Chassis selected for the Speed Maniac body. These chassis are all listed in Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) for ICE chassis. A design concept selection was carried out from these options to identify the most suitable chassis for modification into the EV go-kart. The criteria used for selecting the EV chassis are presented in Table 1.

(a) Chassis A

(b) Chassis B

(c) Chassis C

(d) Chassis D

FIGURE 1: Initial concept for Speed Maniac body design

TABLE 1: Explanation of go-kart chassis selection criteria

Selection Criteria	Explanation
2 Pedals	The acceleration pedal and brake pedal are crucial to accelerate or decelerate and stop or slow down the go-kart.
Frame	It is important to be able to hold all go-kart components and the driver strongly.
Rear axle	It connects the engine to the rear wheels and has a brake pad.
4 wheels and tires	Missing at least one tire or all tires not in good condition could result in an extremely unstable go-kart.
Complete steering system	The ability to steer left or right is extremely important to avoid upcoming obstacles.
Braking system	Without this system, the go-kart cannot slow down or stop when needed.
Exhaust system	The exhaust system not only helps to expel the exhaust gases but also helps to do it quietly with the use of a muffler in the system.
Seat	The driver can never drive while standing because he must control the pedals too. For that, he must sit.
Bumpers	To avoid getting hit or worse, getting injured due to mass inertia caused by collision, it is a great solution to have these fixed on all four sides of the go-kart.
Engine	Without an engine or with a failed engine, the driver must push the go-kart instead of driving it. It will take a toll on the driver even if it is a short distance because the entire go-kart is just too heavy.

2.1.2 Concept Screening

Table 2 shows the concept screening of the four go-karts identified in the auxiliary lab. The selection criteria included the presence of two pedals, a frame, rear axle, four wheels and tires, a complete steering and braking system, a seat, a full set of bumpers, and an engine in these four design concepts.

TABLE 2: Concept screening of four go-kart chassis

Selection Criteria	Concept Variants				
	Chassis A	Chassis B	Chassis C	Chassis D	REF.
2 Pedals	0	0	0	-	0
Frame	-	0	-	-	0
Rear axle	-	0	-	0	0
4 wheels and tires	-	-	-	-	0
Complete steering system	0	0	0	-	0
Braking system	-	-	-	-	0
Seat	0	+	0	0	0
Complete set of Bumpers	-	-	-	-	0
Engine	0	0	+	0	0
PLUSES	0	1	1	0	
SAMES	4	5	3	3	
MINUSES	5	3	5	6	
NET	-5	-2	-4	-6	
RANK	3	1	2	4	
CONTINUE?	NO	COMBINE	YES	COMBINE	

The ‘0’ reference is to determine whether the part exists in the reference design concept and if it is present in other design concepts, excluding the seat and engine. The ‘0’ reference for the seat and engine is to check whether these parts, which do not exist in the reference design concept, are present in other concepts.

Following the conclusion of the concept screening process, chassis B was selected due to its top ranking. Chassis D was also chosen to be paired with chassis A despite its lower ranking and rusted frame, owing to its three wheels and tires, as well as a robust left side bumper. Chassis A was rejected due to its rusted frame and weak bumpers. Chassis C was retained for further consideration despite having a rusted frame and a weak bumper, primarily because it is equipped with an engine.

2.1.3 Concept Scoring

Table 3 presents the concept scoring for chassis C and the combined evaluation of chassis B and D. The selection criteria were aligned with the concept screening table. The highest percentage weights were assigned to the frame, rear axle, four wheels and tires, and engine, as these components are essential for the mobility of the go-kart. Consequently, they represent the most critical criteria for selection. The next most important criteria include the complete steering system, braking system, and two pedals, since their absence would impair the go-kart's ability to slow down, stop, steer, or regulate speed effectively. The third tier of criteria encompasses the seat and bumpers, as their absence would significantly compromise driver comfort and safety. In particular, without these components, driving would be extremely uncomfortable, and in the event of a collision, the driver could sustain injuries due to the high inertia involved.

At the end of concept scoring, the chassis BD was selected for development because it ranked first. Chassis C was rejected despite having an engine, as chassis 3 has a rusted frame and a failed engine. Figure 2 shows the design concept of the BD chassis after combining more parts from the additional laboratory, half of which are also taken from Chassis B and D, called Chassis Combine BD. This completes the chassis by providing sufficient front and rear tires, as well as the right and left bodies and the front bumper. The chassis also features a rusty hydraulic brake wire and a 200cc engine system that complements the exhaust system.

TABLE 3: Concept scoring of Chassis C and combination of Chassis B and Chassis D

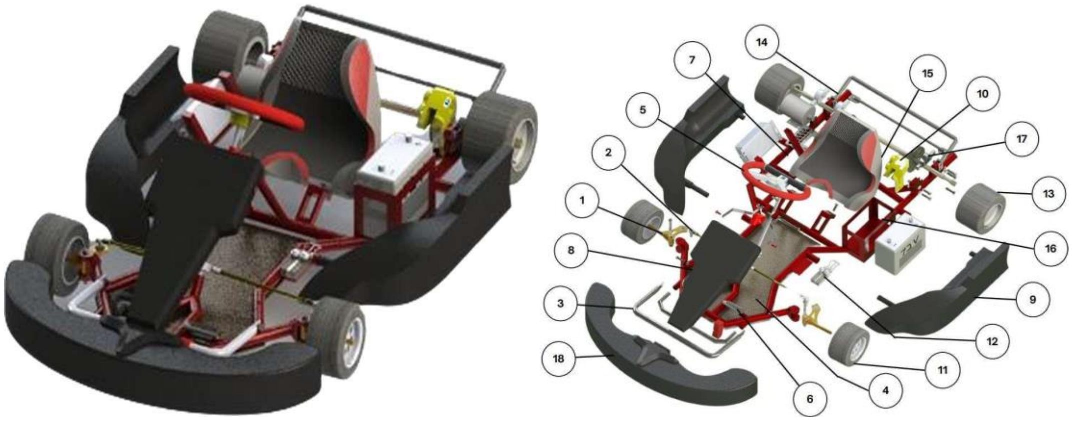
Chassis Criteria		Combination of Chassis B and Chassis D		Chassis C	
Selection Criteria	Weight (%)	Rating	Weighted Score	Rating	Weighted Score
Two Pedals	10	5	0.5	5	0.5
Frame	15	5	0.75	1	0.15
Rear Axle Shaft	15	3	0.45	0	0
Four Wheels and Tyres	15	3	0.45	0	0
Complete Steering System	10	5	0.5	5	0.5
Braking system	10	0	0	0	0
Seat	5	4	0.2	0	0
Bumpers	5	4	0.2	1	0.05
Engine	15	0	0	1	0.15
Total Score		3.05		1.35	
Rank		1		2	
Continue?		DEVELOP		NO	

FIGURE 2: Combination of Chassis B and D

2.2 Modeling

2.2.1 Full Assembly of Electric Go-Kart

Figure 3 shows the design concept and exploded view of the chassis after modifications. This concept also includes the battery, electric motor, and paddle electric. The change involves replacing the internal combustion engine with an electric motor. Consequently, there is no exhaust system. The exploded view displays the individual components of the complex assembly of the electric Go-Kart and how they fit together in various locations and orientations. The bill of materials lists all 18 major components, excluding the battery, battery bracket, body, and others. These designs pertain to the assembly required for chassis fabrication.



(a) 3D assembly electric go-kart (b) The exploded view of the 3D modelling

FIGURE 3: 3D assembly and exploded view of the go-kart

TABLE 4: Parts name and quantity for the go-kart

Part Number	Part Name	Quantity
1	Micro Stub Axle Spindle with Bearings	2
2	Steering Tie Rod with Knuckles and Joint Ball	2
3	Front Lower Bumper with Bracket Support	1
4	Aluminium Lower Front Plate	1
5	38/50 Steering Column with Steering Wheel	1
6	Chrome Brake Pedal	1
7	Body Chassis Steel AISI 4130	1
8	Front Spoiler	1
9	Side Box Bumper	2
10	Caliper and Disc Brake	1
11	Front Wheel Tyre 10x4.50-5 with Rim	2
12	Hydraulic Brake and Master Pump with Hose	1
13	Rear Wheel Tyre 11x7.10-5 with Rim	2
14	Rear Chromium-plated Bumper	1
15	Seat Plastic Cushion	1
16	Housing Placement Battery	1
17	100cm with 3 holes 5-inch Wheel Hub Rear Axle Shaft and Pillow Block	1
18	Rookie Front Fairing Bumper with Supports	1

2.2.2 The Electrical System of the Go-Kart

The electrical system of the go-kart is engineered to ensure efficient power transmission, dependable control, and fundamental safety features. Central to this system is a DC electric motor, which serves as the main propulsion device. This motor is powered by a rechargeable battery pack that supplies the requisite voltage and current to drive the go-kart. The transfer of power from the battery to the motor is regulated by a motor controller, which processes signals from the throttle pedal and modulates the motor's output accordingly.

This allows for smooth acceleration and precise speed control based on driver input. An ignition or key switch is integrated into the system to serve as master control, allowing the user to safely power the system on or off. To prevent electrical faults such as overcurrent or short circuits, fuses or circuit breakers are included in the circuit. Figure 4 shows the schematic diagram of the electrical system, and Table 5 lists the electronic components used in the go-kart.

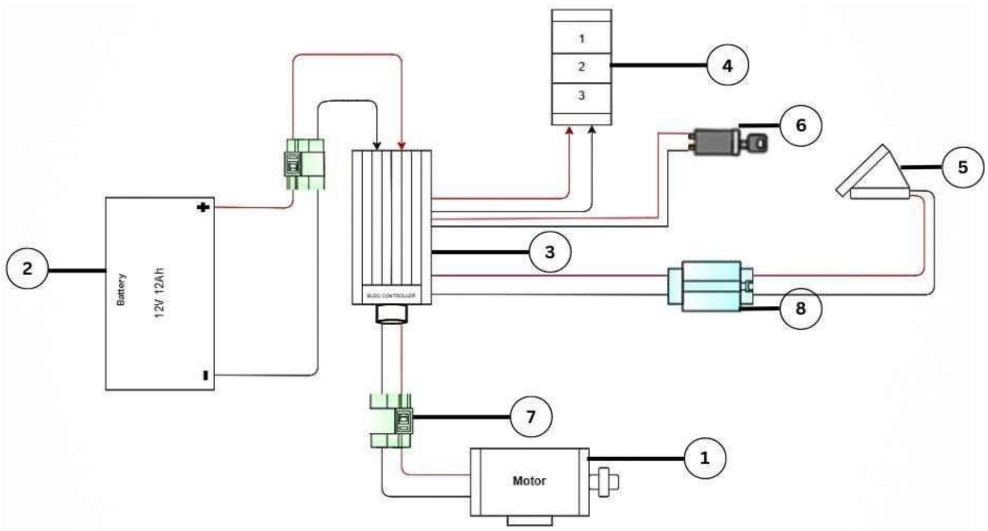


FIGURE 4: Schematic circuit diagram

TABLE 5: Electronic components

Part No.	Part Name	Quantity
1	Kunray Electric Motor 3000w 72v	1
2	Battery 72v 12Ah Lithium Ion	1
3	BLCD Controller	1
4	Speed Controller Switch	1
5	Throttle Paddle Electric	1
6	Key Switch	1
7	Connector Wire	2
8	Throttle Connector Wire	1

2.3 Fabrication Process

2.3.1 Mounting Pillow Block

Figure 5 shows the manufacturing process involves several crucial steps. To begin, the rear axle shaft housing must be entirely ground off from the chassis using a grinder, allowing for the proper installation of the rear axle shaft. Next, a hollow square metal block is welded onto the rear part of the chassis using Metal Inert Gas welding, providing a secure foundation for the placement of the pillow block bearing.

For preliminary marking, the pillow block bearing is placed directly on the hollow square metal block. In preparation for drilling, a durable mark is applied to the hollow square metal block using a dud automatic center punch. Subsequently, twist drilling is used to create larger holes in the block for screwing purposes. Ultimately, the pillow block bearing is firmly and securely attached to the hollow square metal block, establishing a strong and stable connection as shown in Figure 5.

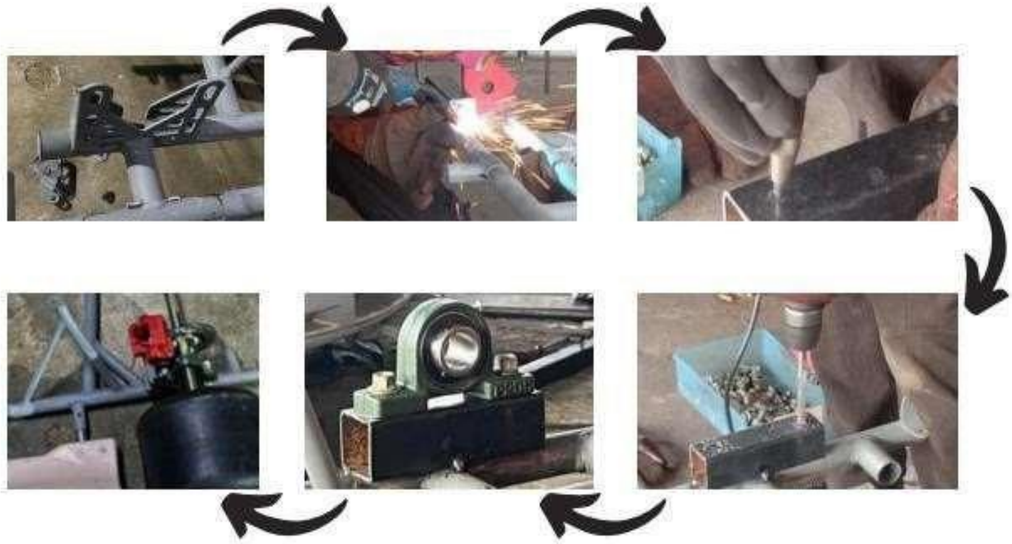


FIGURE 5: Mounting Pillow Block Fabrication

2.3.2 Battery Placement Housing

Precise measurements are obtained using the tape measure illustrated in Figure 6, which is positioned on the battery to determine the dimensions necessary for fabricating the housing or mount. Following the acquisition of these measurements, a cutting machine is used to section the iron accordingly. Once cut, an L-shaped elbow is used to ensure a 90-degree angle before proceeding to the welding stage utilizing a TIG welding apparatus. After welding, the surface is subsequently smoothed through grinding to achieve a refined finish.

FIGURE 6: Battery Placement Housing Fabrication

2.3.3 Mounting Placement Motor and BLDC Controller

Measurements of the motor and BLDC controller were taken using a measuring tape prior to cutting the iron designated for welding. Before commencing the welding process, an L-shaped elbow was utilized to ensure a 90-degree angle, thereby establishing a square-shaped motor mount. After completing the welding, a hole was punched to complete the square, as shown in Figure 7.

FIGURE 7: Mounting Placement

2.4 Battery and Motor Selection

2.4.1 Motor Selection

Figure 8 shows the motor selected using the concept score system, suitable for use with the go-kart. The specifications for this Brushless Electric Motor are 3000W, 72v, 6700 RPM, 5.4 Nm, and 45A.

FIGURE 8: Kunray-1029 Brushless electric motor

2.4.2 Battery Selection

Figure 9 shows the lithium battery selected for use with a brushless electric motor operating at a voltage of 72V. A battery with a voltage exceeding this specification may potentially damage the motor or associated components, while an underpowered battery is not advisable as it fails to deliver sufficient power for optimal motor operation.

FIGURE 9: Lithium battery 72v 50 Ah

The voltage requirement for the motor is already specified as 72 volts (72V). This indicates that the motor is designed to operate on 72 volts. Therefore, 72 volts is an appropriate battery voltage for this motor. To ensure proper and safe functioning, a battery with a voltage rating of 72V or slightly higher should be used. The electric motor, rated at 3000 watts (3 kW), operates at 72 volts, 6700 RPM, with 5.4 N · m of torque and approximately 5.05 horsepower. This horsepower should be sufficient for the construction and utilization of the chassis.

3. RESULTS AND DISCUSSION

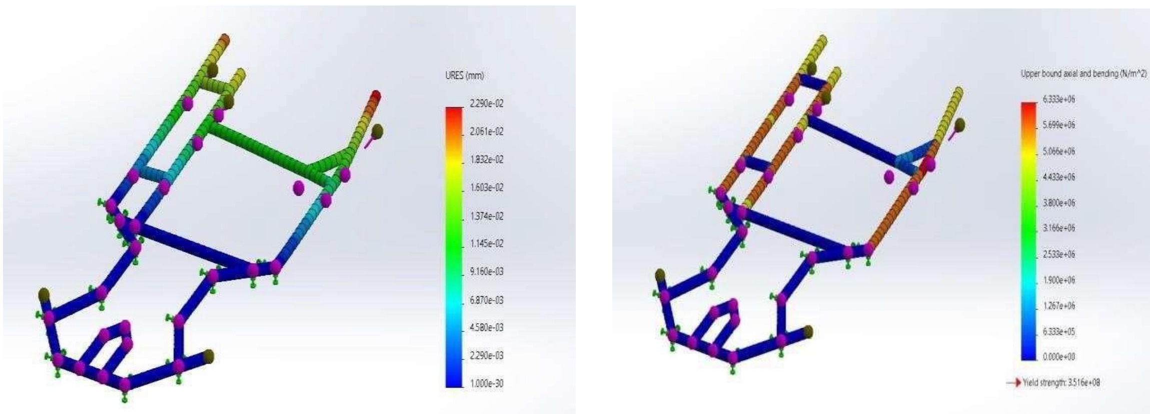
3.1 Finite Element Method

Figures 10, 11, and 12 shows the Finite Element Analysis (FEA) plays a pivotal role in the comprehensive evaluation of go-kart designs, particularly in assessing their structural integrity and safety performance under various impact scenarios, namely rear, front, and top impacts.

For the rear impact analysis, FEA enabled engineers to simulate and scrutinize the go-kart's response when struck from behind. This involves modelling the vehicle's chassis, rear components, and energy-absorbing features such as bumpers. The FEA process reveals how stress is distributed across the structure and identifies potential weaknesses that may necessitate reinforcement. It also helps assess how effectively the go-kart absorbs and dissipates energy during a rear impact, which is vital for occupant safety.

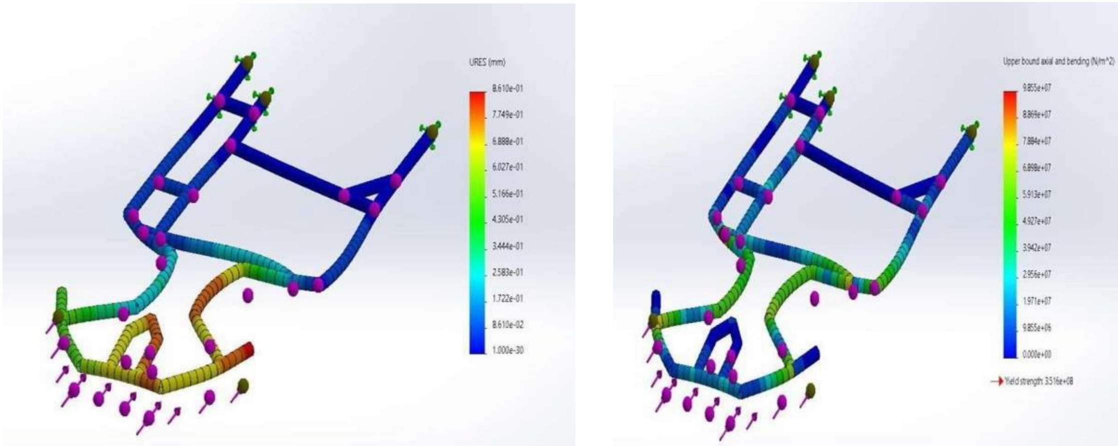
For front-impact testing, FEA is used to evaluate the vehicle's response during a head-on collision. This process entails modeling the entire go-kart structure and analyzing the forces, stresses, and deformations incurred during impact. Ensuring the structural integrity of the driver's compartment is critical for occupant safety. FEA facilitates the optimization of front-end components to effectively absorb and dissipate impact energy, thereby mitigating the severity of collision consequences.

Top impact testing examines how the go-kart responds to rollovers or overhead impacts. FEA is used to simulate rollover dynamics, evaluate the roof's structural robustness, and ensure the design effectively prevents intrusion into the passenger compartment during such incidents. Additionally, the selection of materials and the optimization of their thickness are considered critical factors in enhancing the roof's resilience and ensuring compliance with safety standards.



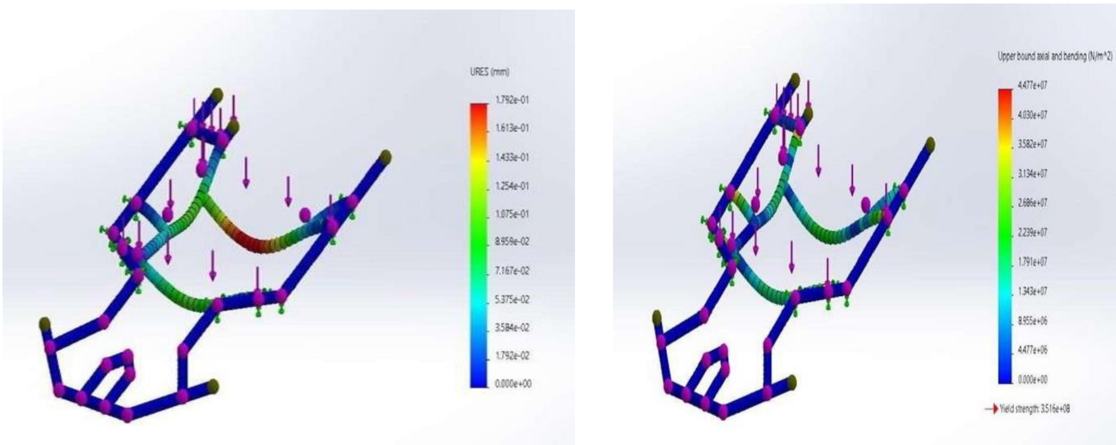
(a) Total deformation (b) Von Mises

FIGURE 10: Rear impact test



(a) Total deformation (b) Von Mises

FIGURE 11: Front impact test



(a) Total deformation (b) Von Mises

FIGURE 12: Top impact test

3.2 Braking Test

Figure 13 illustrates a clear relationship between the initial speed of the electric go-kart and the braking distance required to achieve a complete halt. Experiments were conducted at three distinct velocities - 39 km/h, 45 km/h, and 47 km/h - represented by the red, blue, and green lines, respectively. The results indicate that higher initial velocities consistently correspond to increased braking distances. Notably, the relationship between initial speed and braking distance exhibits an approximately linear trend, underscoring the significance of effective braking mechanisms at elevated velocities.

Among the three conducted trials, the go-kart traveling at 47 km/h (represented by the green line) demonstrated the greatest stopping distance, followed closely by the 45 km/h trial (blue line). In contrast, the 39 km/h test (red line) exhibited the shortest braking distance. These findings confirm the substantial impact of vehicle velocity on braking performance, emphasizing the necessity of implementing robust braking systems, particularly at elevated speeds.

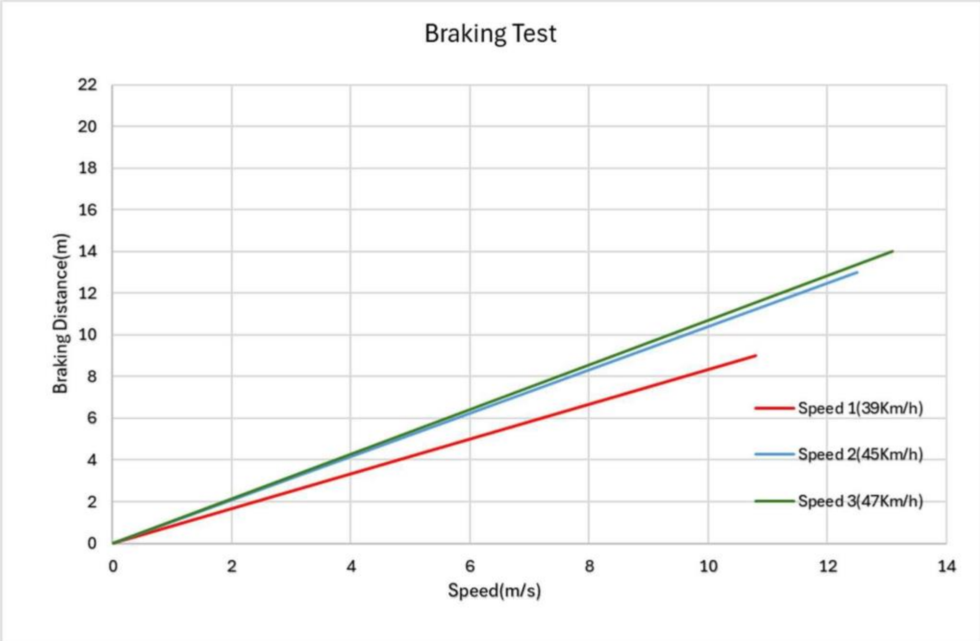


FIGURE 13: Braking distance vs. speed for braking test

3.3 Battery Consumption Test

Figure 14 shows the rate of battery consumption in the electric go-kart as a function of time across three distinct constant speeds: 39 km/h (red line), 45 km/h (blue line), and 47 km/h (green line). Additionally, an average speed driving pattern is depicted (black line). The data clearly indicate a positive correlation between increasing speed and the rate of battery consumption. Specifically, at 39 km/h, the go-kart exhibits the slowest rate of battery depletion, thereby maintaining higher residual battery capacity over time.

In contrast, driving at 47 km/h yields the steepest decline in battery percentage, indicating an accelerated rate of energy consumption attributable to increased power demands. The average driving speed falls between the constant-speed curves, reflecting a more balanced pattern of energy usage. Overall, the data highlight a direct relationship between driving speed and energy efficiency, suggesting that lower speeds are conducive to extending battery life and increasing the go-kart's operational range.

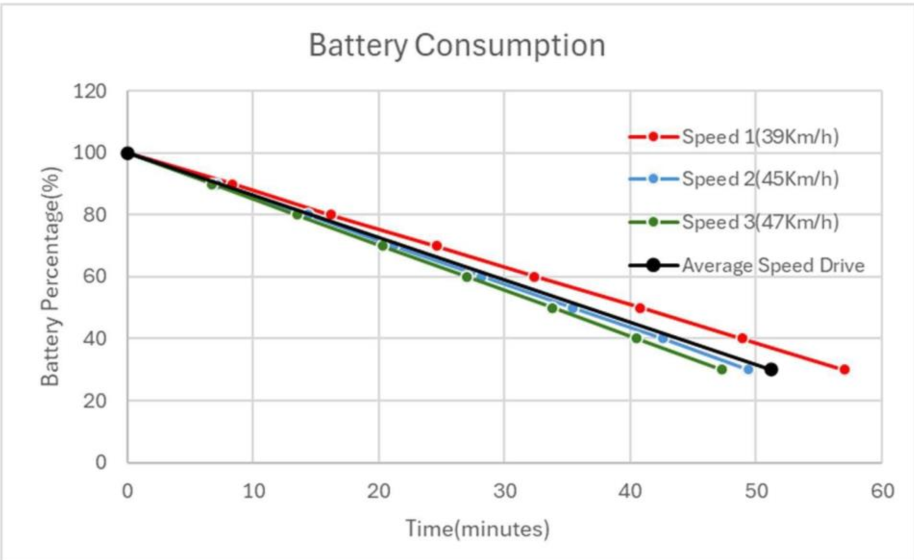


FIGURE 14: Battery percentage vs. time for battery consumption test

3.4 Speed Test

Figure 15 illustrates the relationship between travel time and distance covered by the electric go-kart at three different constant speeds: 39 km/h (red line), 45 km/h (blue line), and 47 km/h (green line). As expected, the go-kart moving at the lowest speed of 39 km/h took the longest to cover the given distances, whilst the go-kart at 47 km/h reached the same distances in the shortest time.

The lines show a linear trend, indicating a consistent velocity across the test runs. This observation confirms that each test was performed under steady-speed conditions, without instances of acceleration or deceleration. The inverse relationship between speed and time is clearly illustrated, demonstrating that higher speeds correspond to shorter travel times for an equivalent distance. This analysis substantiates the performance and velocity capabilities of the e-kart under controlled, uniform driving conditions.

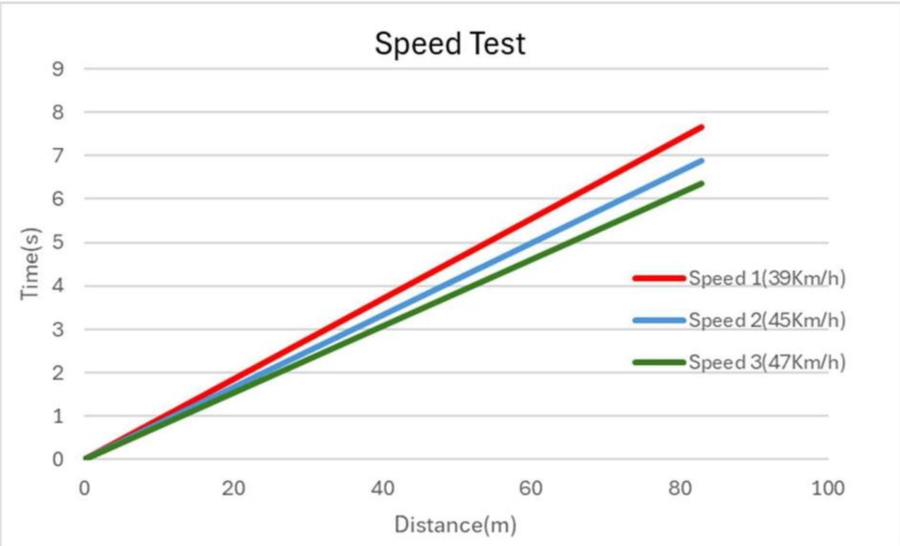


FIGURE 15: Battery percentage vs. time for battery consumption test

4. CONCLUSION

In conclusion, the project successfully achieved its objectives by designing and fabricating the “Speed Maniac” go-kart, emphasizing performance, safety, and aesthetics. The team set out to develop a high-speed go-kart prototype that not only fulfils performance expectations but also ensures driver’s safety and comfort.

Through careful selection of components, including the engine, braking system, and chassis materials, the final product demonstrated excellent maneuverability, stability, and acceleration capabilities. The test results showed that the go-kart reached a top speed of approximately 60 km/h and provided effective braking over a short distance, fulfilling the project’s primary goals.

The design was also commended for its sporty appearance and ergonomic features. Overall, the project demonstrated the feasibility of constructing a performance-oriented go-kart within a limited budget and timeframe, offering valuable insights into vehicle dynamics, fabrication methods, and teamwork.

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