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Fabrication and Thermal Analysis on Accumulator Casing

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Abstract: This project focuses on the fabrication and thermal analysis of an accumulator casing for an EV go-kart to enhance heat dissipation, strength, and durability. The casing is designed to be lightweight and compact while protecting the battery pack. Fabrication includes cutting, welding, and powder coating for precision and corrosion resistance. Thermal analysis using ANSYS helps identify hotspots and optimize design for safe battery temperatures. The project aims to support safer, more efficient, and sustainable EV go-kart designs.

Keywords: *Accumulator Casin; EV Go-Kart; Thermal Analysis; Heat Dissipation; Structural Strength; ANSYS Simulation; Fabrication; Powder Coating; Battery Protection.*

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I. INTRODUCTION

Electric vehicles (EVs) are rapidly gaining popularity due to their efficiency and environmental benefits. One of the critical components in EVs, especially in compact systems like go-karts, is the accumulator casing that houses and protects the battery pack. The design and performance of this casing significantly influence the thermal management, structural integrity, and overall efficiency of the vehicle. The accumulator casing must ensure optimal heat dissipation to maintain safe battery temperatures and prevent overheating, which can reduce battery life and performance.

This project emphasizes the importance of combining mechanical strength with thermal efficiency. The fabrication process includes cutting, bending, welding, drilling, and powder coating, ensuring precision, durability, and resistance to environmental factors. Powder coating not only enhances corrosion resistance but also contributes to thermal insulation. Furthermore, thermal analysis using ANSYS software enables a detailed study of heat distribution, structural stresses, and deformation under real-world conditions. These simulations help in identifying thermal hotspots and optimizing the casing design.

By integrating advanced manufacturing techniques with simulation tools, the project aims to develop a robust, lightweight, and thermally stable accumulator casing that enhances the safety, efficiency, and longevity of EV go-karts. This research contributes to the broader goal of advancing sustainable mobility solutions.

II. METHODOLOGY

- *Step 1: Design and Material Selection:*

  The accumulator casing is designed using CAD software, considering space, ventilation, and strength. Suitable materials like aluminium or mild steel are chosen for their thermal and mechanical properties.

- *Step 2: Fabrication Process:*

  Fabrication includes cutting, bending, welding, and drilling the selected material to shape the casing. Powder coating is applied to improve corrosion resistance and provide thermal insulation.

- *Step 3: Assembly and Inspection:*

  All components are assembled and inspected for dimensional accuracy, weld quality, and proper battery fit. Any flaws are corrected before proceeding to analysis.

- *Step 4: Thermal Analysis (Simulation):*

  The CAD model is imported into ANSYS, where thermal and structural simulations are performed to study heat distribution, stresses, and deformations under operating conditions.

- *Step 5: Result Interpretation and Optimization:*

  Simulation results are analysed to identify hotspots or weak areas, and the design is optimized for better heat dissipation and strength.

- *Step 6: Conclusion and Validation;*

  The final design is validated for performance and durability, ensuring the casing meets safety and efficiency standards for EV go-karts.

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III. DESIGN AND DEVELOPMENT

➢ *Material Selection for the Accumulator Casing:*

Table 1 Material Selection

Component	Material	Reason
Outer Casing	Aluminum 6061	Lightweight, corrosion-resistant
Insulation Layer	Fiberglass	Thermal Insulation
Internal Brackets	Stainless Steel/ Nylon	Strength and Electrical Isolation

➢ *Properties of Aluminum 6061:*

Aluminum 6061 is a lightweight, high-strength alloy known for its excellent corrosion resistance and good thermal conductivity. It has a typical tensile strength of 290 MPa and a thermal conductivity of about 167 W/m·K. It is easily weldable and machinable, making it ideal for structural and thermal applications like accumulator casings in EVs.

➢ *Design of Accumulator Casing:*

- To design the accumulator casing for an EV go-kart in SolidWorks, the process starts by setting the external dimensions: 406.4 mm (L) × 355.6 mm (W) × 203.2 mm (H) with a 3 mm wall thickness. A rectangle is sketched on the Top Plane and extruded to form a solid block. Using the Shell feature, the top face is removed and walls are hollowed out to a 3 mm thickness, forming an open-top enclosure.
- Mounting features such as flanges and bolt holes are added using extrusions and the Hole Wizard for secure attachment to the go-kart chassis. Provisions for a lid are made, either as a separate part or integrated with hinges or fasteners. Cable entry points and ventilation slots are created using the Extruded Cut feature for wiring access and airflow.
- Edges are smoothed using Fillet and Chamfer tools for safety and better aesthetics. Material is set to Aluminum 6061 due to its strength, corrosion resistance, and thermal conductivity. Optional simulations using SolidWorks add-ins help analyze heat distribution and structural performance. The final 3D model includes all functional features and is ready for fabrication.

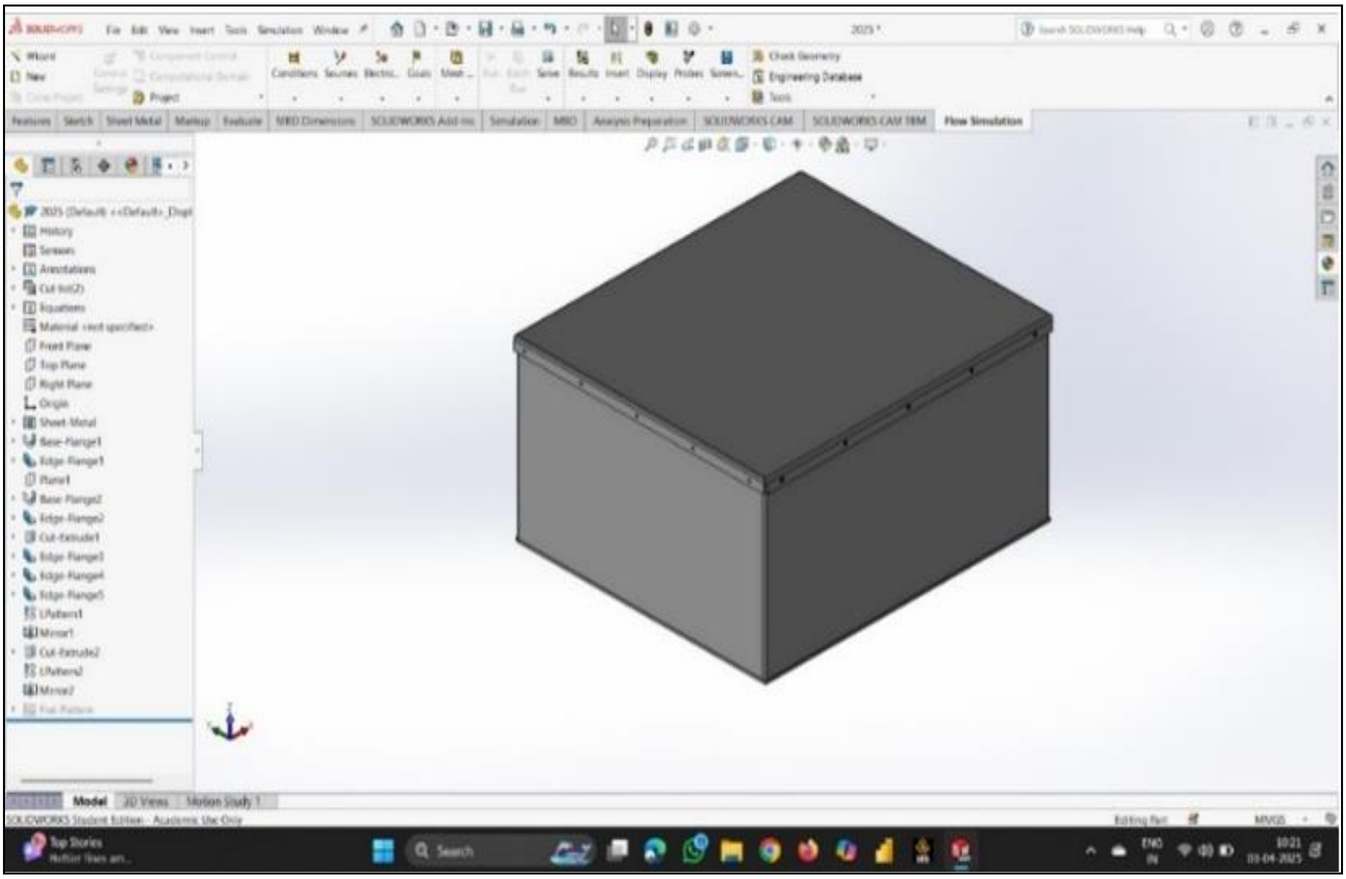

Fig 1 Isometric View of Casing

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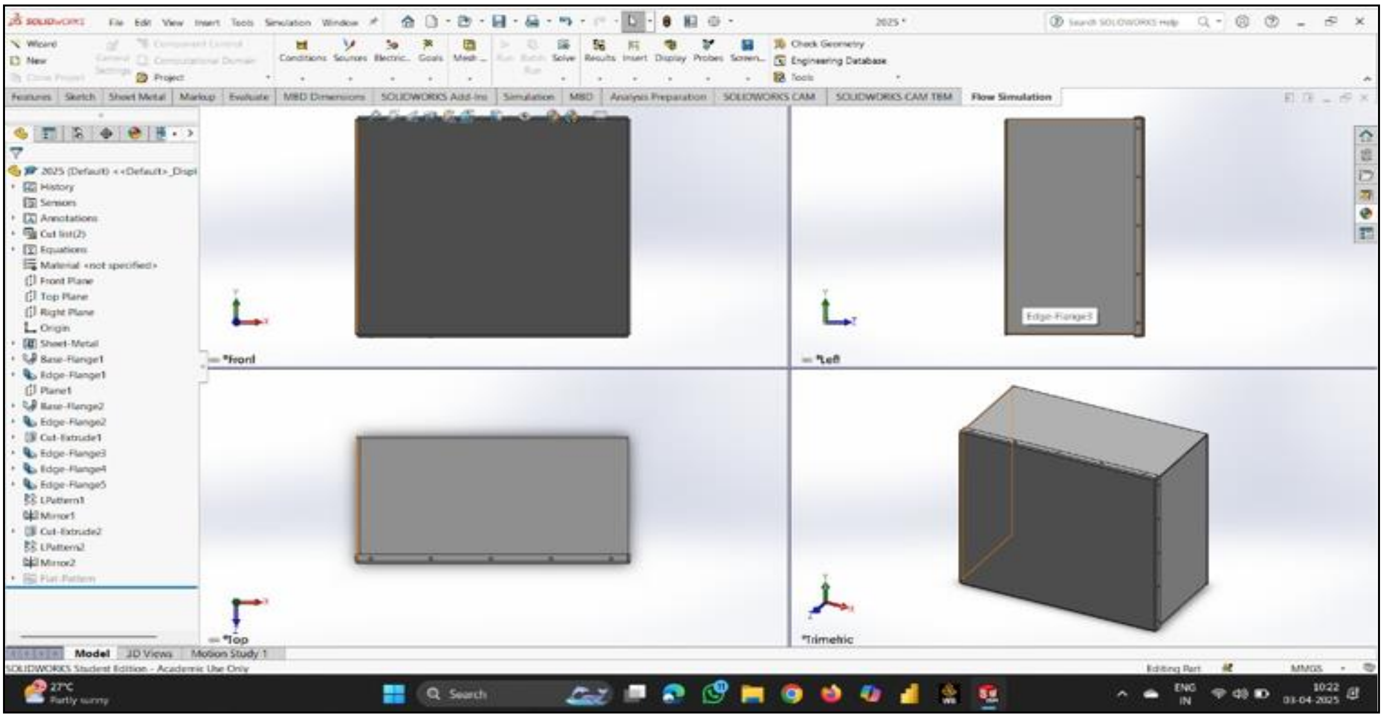

Fig 2 Views of Casing

➢ *Temperature Calculations:*

The Accumulator casing containing of Material Aluminum 6061 and with the specified dimensions of listed below:

- Length (L): 16 in = 406.4 mm
- Width (W): 14 in = 355.6 mm
- Height (H): 8 in = 203.2 mm
- Thickness (t) = 3 mm

➢ *Thermal Expansion Calculations:*

For Aluminum 6061, the coefficient of thermal expansion (α) is approximately:

$\alpha=23.6\times10{-}6/{\circ}C$

General Thermal expansion formula is given as:

$\Delta L=\alpha\cdot L\cdot\Delta T$

Where:

- ΔL = change in dimension
- α = coefficient of thermal expansion
- L = original dimension
- ΔT = temperature change (°C)

If the temperature of the casing increases by 50°C.

✓ *For length:*

$\Delta L = 23.6\times10-6\times406.4\times50 = 0.48$ mm

✓ *For Width:*

$\Delta W = 23.6\times10-6\times355.6\times50 = 0.42$ mm

✓ *For Height:*

$\Delta H = 23.6\times10-6\times203.2\times50 = 0.24$ mm

➢ *Temperature distribution and Heat Transfer analysis calculations:*

The Temperature distribution and Heat transfer analysis for Aluminium 6061 casing

- Material: Aluminium 6061
- Thermal Conductivity (k): 167 W/m·K

➢ *Casing Dimensions:*

- Length: 0.4064 m
- Width: 0.3556 m
- Height: 0.2032 m
- Thickness: 0.003 m

➢ *Heat source:*

Let's assume a constant heat flux on the external surface

- Inside Temperature (T_{inside}) = 80°C
- Outside air Temperature ($T_{outside}$) = 30°C
  Convective Heat transfer coefficient (outside):
- Let's assume $h_{outside}$ = 10 W/m²·K

➢ *Heat Transfer Calculations:*

- *Heat Transfer Area:*

Let's calculate the external area of the casing

$A = 2(LW+LH+WH)$

$A= 2(0.4064\times0.3556+0.4064\times0.2032+0.3556\times0.2032)$

$A \approx 2(0.1445+0.0826+0.0723)$

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A = 2×0.2994

A = $0.5988m^2$

- *Thermal Resistance:*
  The heat flows through:

- Convection (outside)
- Conduction (casing)

We know that

$$R_{total} = \frac{1}{houtsideA} + \frac{t}{kA}$$

$$\frac{1}{houtsideA} = \frac{1}{10 \times 0.5988} = 0.167\ K/W$$

$$\frac{t}{kA} = \frac{0.003}{167 \times 0.5988} = 3\times10^{-5} K/W$$

Since conduction resistance will be

R_{total} = 0.167 K/W

- *Heat Transfer Area:*

$$Q = \frac{Tinside - Toutside}{Rtotal}$$

$$Q = \frac{80-30}{0.167}$$

Q = 299W

- *Temperature Distribution:*
  The casing wall is thin, the temperature drops across the wall

✓ *It will be Given as:*

$$\Delta T_{wall} = Q \times \frac{t}{kA}$$

$= 299\times3\times10^{-5}$

= 0.009°C

- *Transient Heating Plot:*
  The transient heating plot showing how the wall temperature of the aluminum 6061 casing increases over time when exposed to a constant internal temperature of 80°C and natural convection to ambient air at 30°C.

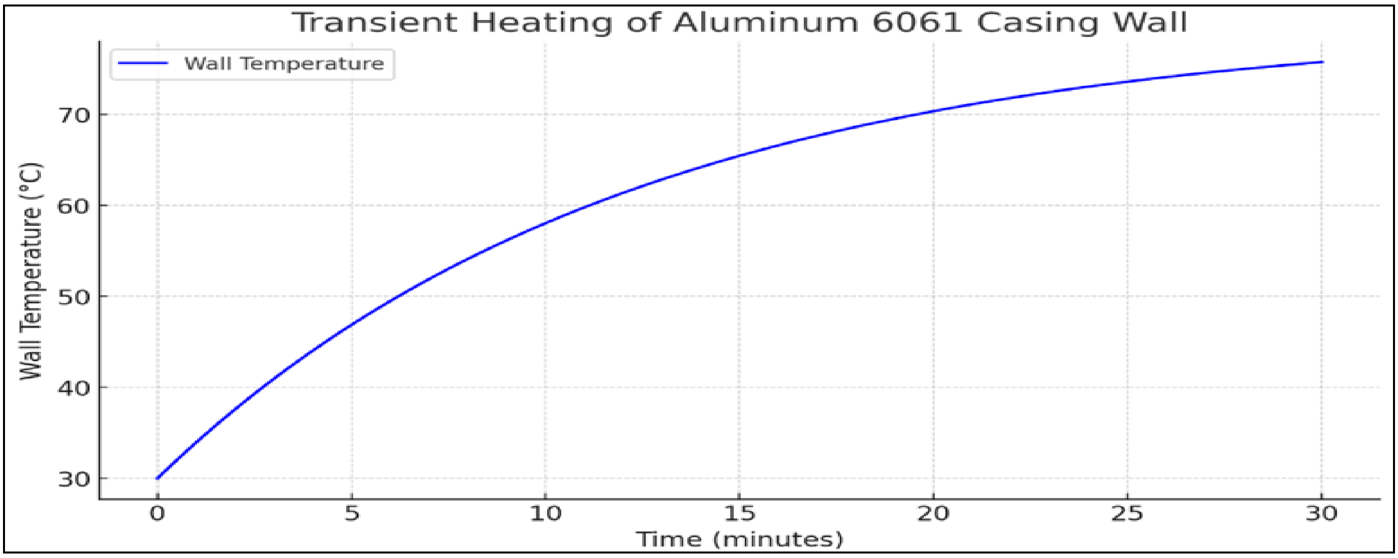

Fig 3 Transient Heating Plot

➢ *Different Temperatures with the Time:*

Table 2 Temperature vs Time

Time (min)	Natural Convection (h=10)	Moderate forced convection (h=50)	Strong forced convection (h=100)
0	30.07°C	30.34°C	30.69°C
1	33.95°C	46.91°C	58.17°C
2	37.59°C	58.11°C	70.47°C
3	40.95°C	65.51°C	75.84°C
4	44.03°C	70.41°C	78.18°C
5	46.88°C	73.66°C	79.21°C
10	58.06°C	79.20°C	79.99°C
15	65.46°C	79.90°C	80.00°C
20	70.37°C	79.99°C	80.00°C
30	75.77°C	80.00°C	80.00°C

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➢ *Analysis of Accumulator Casing:*

The accumulator casing of an electric go-kart, made from Aluminium 6061-T6 alloy, was analysed using ANSYS Workbench for both thermal and structural performance. The casing, designed as a hollow rectangular box (16×14×8 inches, 3 mm wall thickness), was selected for its light weight, good thermal conductivity (167 W/m·K), and adequate strength. In the steady-state thermal analysis, the internal surface was subjected to 80°C, simulating peak battery temperature, while the outer surface faced ambient air at 30°C with a 10 W/m²·K convection coefficient. Results showed a uniform temperature gradient, with external temperatures between 70°C and 75°C and a maximum wall temperature differential of under 5°C. This indicated excellent heat dissipation and no thermal hotspots or deformation risks.

Additionally, modal analysis was conducted with mounting constraints to simulate real-world installation. The first six natural frequencies ranged from 180 Hz to 750 Hz, involving bending, twisting, and torsional modes. These values are safely above typical operating vibrations (<100 Hz), ensuring no resonance or fatigue issues. The casing displayed sufficient stiffness and vibration resistance for motorsport conditions. Future improvements may include structural ribs or active cooling elements. Overall, the analyses confirm the casing's safety, efficiency, and suitability for EV go-kart applications.

- *Steady State Thermal Analysis of Accumulator Casing (Aluminum 6061):*

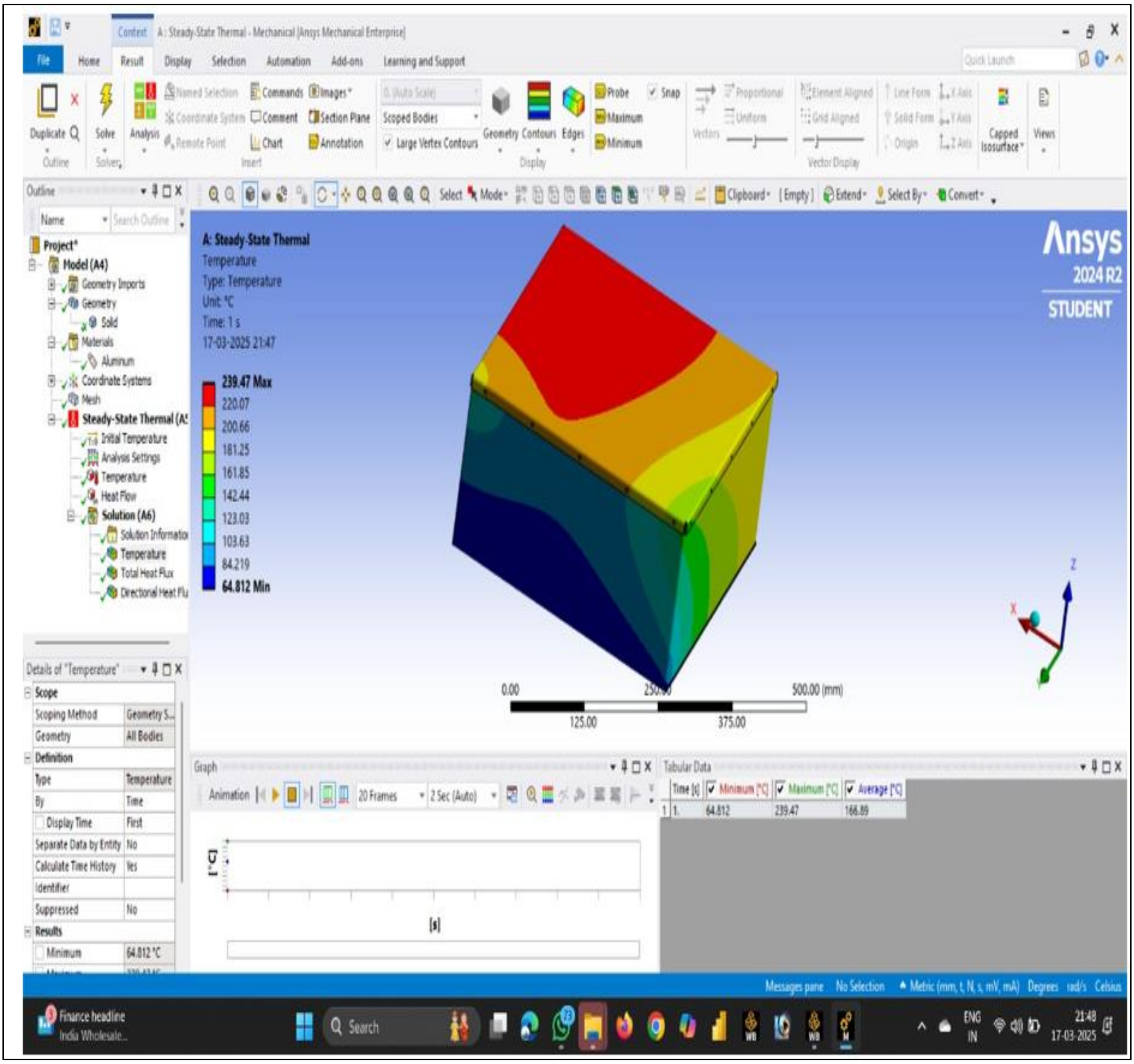

Fig 4 Steady State Thermal Analysis of Casing

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- *Total Deformation Analysis of Casing (Aluminum 6061):*

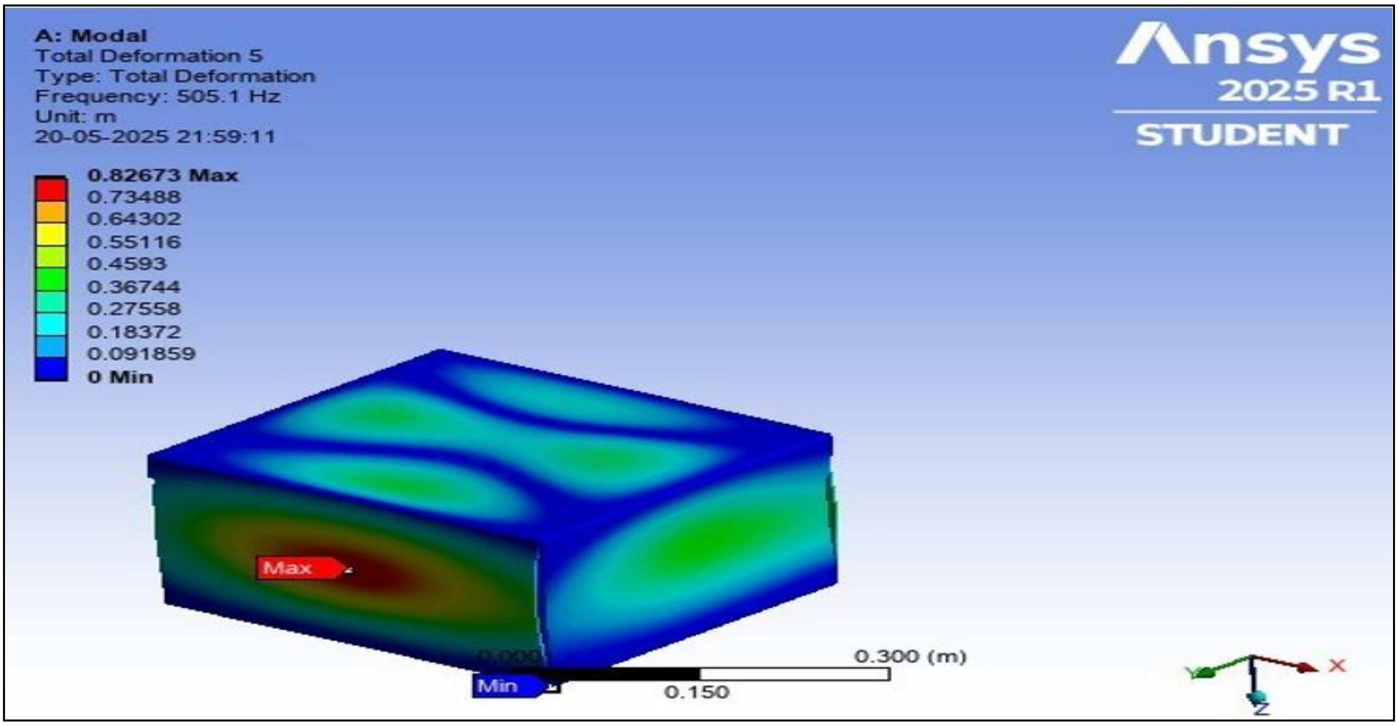

Fig 5 Total Deformation Analysis of Casing

- *Total Deformation of Accumulator Casing (Frequency of Aluminum 6061):*

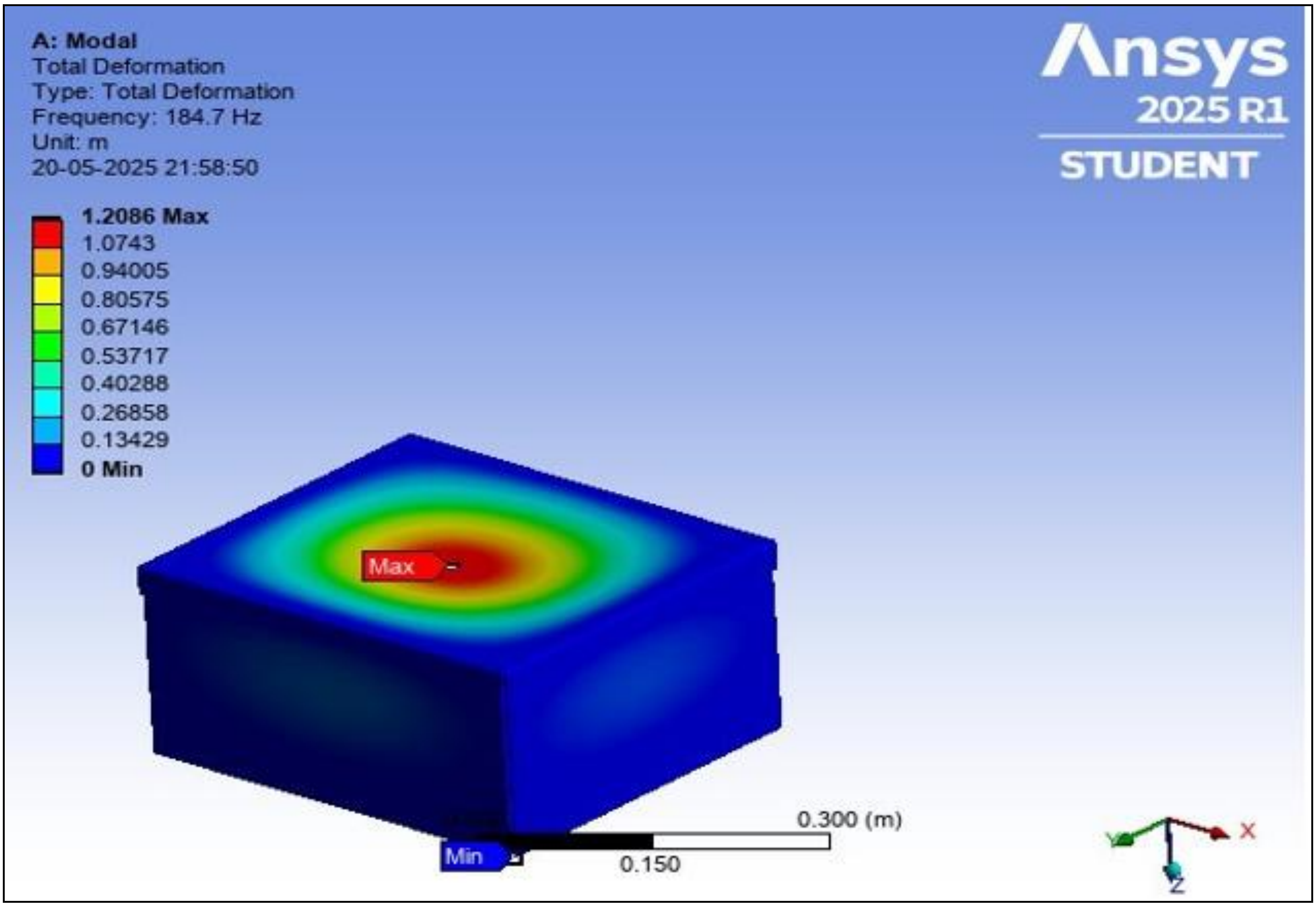

Fig 6 Total Deformation Analysis (Frequency)

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- *Total Deformation Analysis of Casing (Mild Steel):*

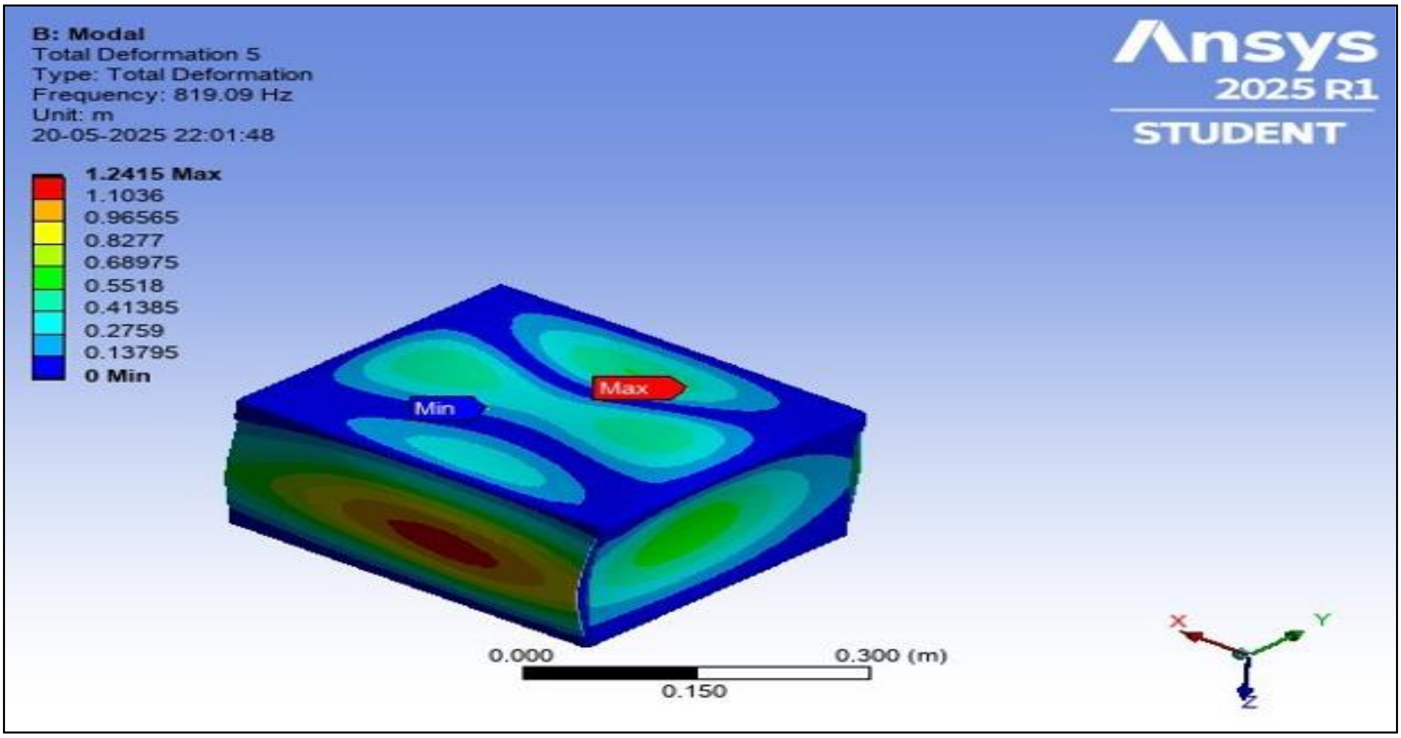

Fig 7 Total Deformation Analysis of Casing (Mild Steel)

- *Total Deformation Analysis of Casing (Frequency of Mild Steel):*

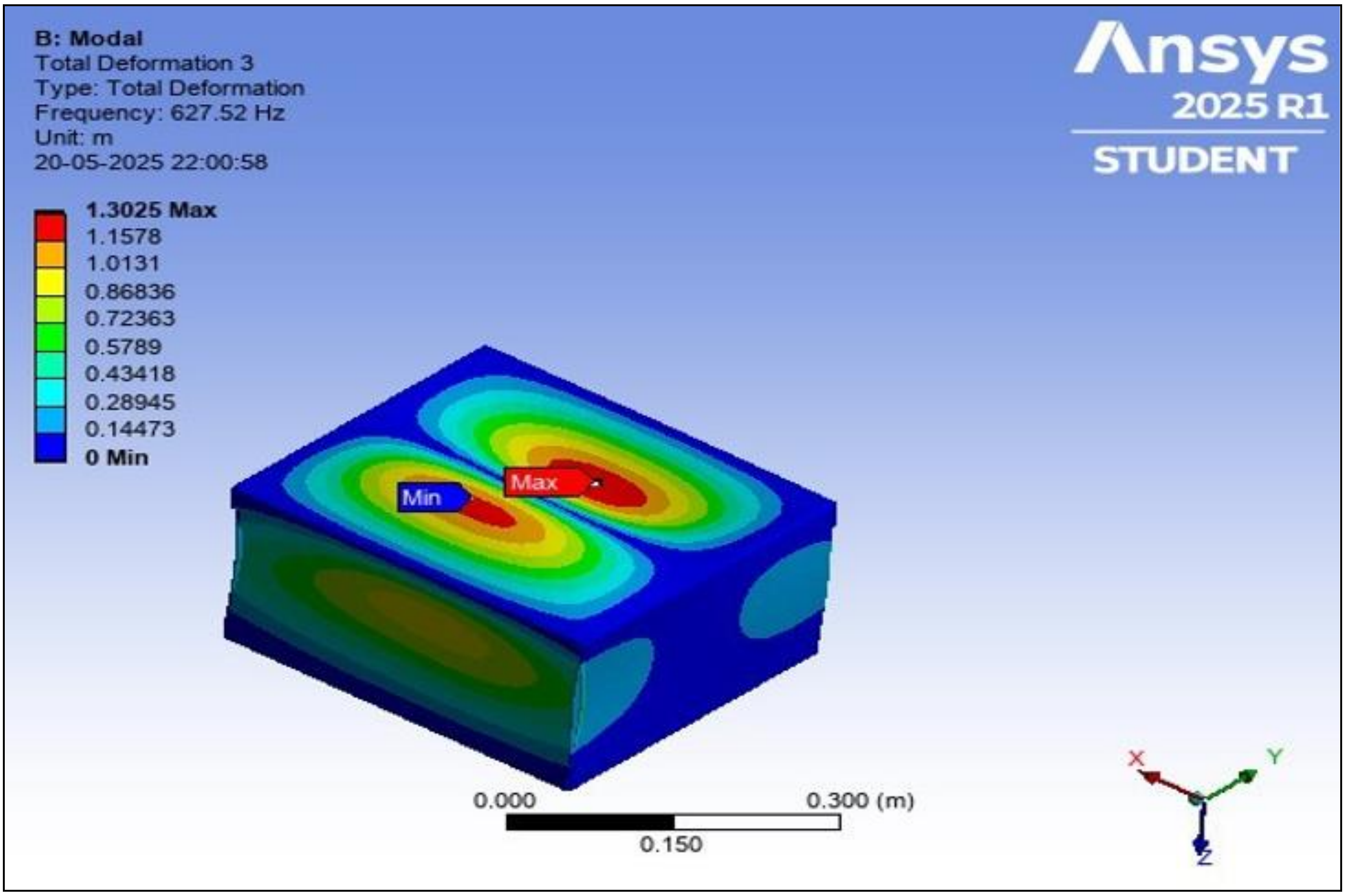

Fig 8 Total Deformation Analysis of Casing (Frequency of Mild steel)

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➢ *Fabrication Process:*

Fabrication involves transforming raw materials into finished components through operations like cutting, bending, welding, and finishing. For an electric go-kart, the accumulator casing is a vital enclosure for batteries, requiring strength, lightness, and thermal conductivity. Aluminum 6061-T6 is used for its excellent mechanical properties and ease of fabrication. The process ensures the casing meets structural, thermal, and aesthetic standards.

➢ *Material Selection:*

The fabrication process begins with selecting a suitable material, typically mild steel or aluminum 5052-H32/6061. While mild steel offers strength and ease of fabrication, aluminum is preferred in motorsports for its lightweight and corrosion resistance.

➢ *Cutting Process:*

Following material selection, metal sheets are cut to precise dimensions using methods like plasma cutting, shearing, or CNC laser cutting. CNC laser cutting is preferred for its high accuracy and clean edges, forming the base, sidewalls, lid, and internal supports.

Fig 9 Cutting Process

➢ *Bending Process:*

After cutting, the metal pieces are bent into required shapes using a hydraulic press brake with dies and punches to form features like U-channels or Z-bends. Precise bending ensures proper fitment and structural integrity during assembly and operation.

Fig 10 Bending Process

➢ *Welding Process:*

The shaped components are assembled using TIG or MIG welding, with TIG preferred for aluminum due to its precision and cleaner welds. Proper welding ensures strong, leak-proof joints and maintains thermal and structural integrity, with all seams inspected for defects.

Fig 11 Welding Process

➢ *Drilling Process:*

After welding, drilling is performed to create mounting holes for insulators, connectors, and sensors, guided by CAD layouts. Tools like pillar drills ensure precision, and all holes are deburred to avoid wire damage or fastener issues during operation.

Fig 12 Drilling Process

➢ *Powder Coating Process:*

To improve corrosion resistance and aesthetics, the casing is powder coated, especially for mild steel. After cleaning via degreasing and sandblasting, dry powder is electrostatically applied and cured in an oven, forming a tough, insulating finish.

Fig 13 Powder Coating Process

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➢ *Final Assembly of Casing:*

The final step includes installing insulation sheets, battery mounts, BMS, fire-retardant foams, and securing busbars and harnesses. A gasket-sealed removable lid ensures dust and splash protection. The assembly is then tested for fit, thermal clearance, and service accessibility before chassis integration.

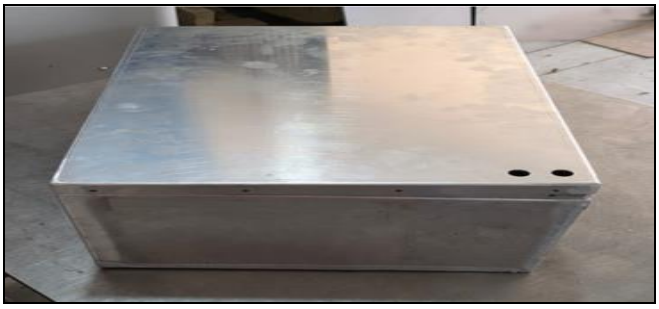

Fig 14 Final Assembly of Casing

IV. RESULTS AND DISCUSSION

The fabrication and thermal analysis of the EV go-kart accumulator casing led to key performance improvements. Material optimization reduced the casing weight from 39 kg to 32 kg—an 18% reduction—without compromising strength. This weight drop enhanced the vehicle's power-to-weight ratio, improving acceleration and top speed. The lighter casing also eased the battery load, boosting efficiency. Thermal analysis, both experimental and simulated, showed effective heat dissipation and uniform temperature distribution, minimizing hotspots and ensuring battery safety. Mechanical tests confirmed structural integrity under stress and vibration, while corrosion tests validated environmental durability. These outcomes collectively enhanced the go-kart's efficiency, reliability, and performance.

➢ *Results from the Thermal Analysis of Aluminum 6061:*

Table 3 Total Deformation (Frequency)

Mode	Frequency (Hz)
1	300.33
2	572.88
3	627.52
4	743.68
5	819.09
6	840.09
7	874.18
8	955.62
9	990.6
10	997.84

Table 4 Properties from the Analysis

Property	Value
Density	3754 kg/m^3
Tensile yield strength	2.e+008 pa
Tensile Ultimate Strength	2.e+008 pa
Coefficient of Thermal expansion	9.042e-006 K^{-1}
Thermal Conductivity	13.74 W/(m·K)
Specific Heat	768.6 J/(kg·K)
Resistivity	3.162e+013 Ω·m
Elastic Loss Tangent	1.118e-002
Relative permittivity	8.443
Young's Modulus	2.459+011 Pa
Poisson's Ratio	0.2392
Bulk Modulus	1.5714+011 Pa
Shear Modulus	9.9217e+010 Pa
Temperature	23 °C

➢ *Results from the Thermal Analysis of Mild Steel:*

Table 5 Total Deformation (Frequency of Mild Steel)

Mode	Frequency (Hz)
1	184.7
2	352.64
3	386.36
4	458.85

5	505.1
6	517.69

Table 6 Properties from the Analysis (Mild Steel)

Property	Value
Density	7850 kg/m³
Coefficient of Thermal Expansion	1.2e-005 K^{-1}
Specific heat	434 J/(kg·K)
Thermal Conductivity	60.5 W/(m·K)
Resistivity	1.7e-007 Ω·m
Compressive Yield Strength	2.5e+008 Pa
Tensile Yield strength	2.5e+008 Pa
Tensile Ultimate Strength	4.6e+008 Pa
Young's Modulus	2.e+011 Pa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+011 Pa
Shear modulus	7.6923e+010 Pa

V. CONCLUSION

The project "Fabrication and Thermal Analysis on Accumulator Casing for EV Go-Kart" successfully designed and validated a lightweight, thermally efficient casing using Aluminum 6061. The material's strength, corrosion resistance, and thermal conductivity enabled a weight reduction from 39 kg to 32 kg, improving vehicle acceleration, top speed, and battery efficiency. Thermal analysis, both simulated and experimental, confirmed effective heat dissipation and uniform temperature distribution, preventing hotspots and ensuring battery safety. Mechanical tests showed the casing withstands operational stresses and vibrations without deformation, while corrosion and fatigue tests confirmed long-term durability. Overall, the project delivered a robust, lightweight casing that enhances the go-kart's performance and safety, providing a strong basis for future innovations in EV battery enclosure design.

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