International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Design and Analysis of Light Weight Glass Fiber Composite Suspension Housing

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1. ABSTRACT

In the pursuit of efficient power generation systems, the thermal management of electromagnet housings plays a critical role in ensuring operational stability and longevity. This study investigates the performance of composite glass fiber housing compared to conventional metallic housing for electromagnets used in power generation applications. Finite Element Analysis (FEA) was conducted using ANSYS software to evaluate structural integrity and thermal behavior under operating conditions. The results demonstrate that glass fiber housing exhibits superior thermal control, maintaining lower surface temperatures and reducing heat transfer compared to metal housing. This enhanced thermal resistance minimizes thermal stresses, thereby improving reliability and extending service life. Additionally, the lightweight nature of glass fiber composites contributes to reduced overall system weight without compromising mechanical strength. The findings highlight the potential of composite materials as a viable alternative to metals in electromagnet housing, offering improved thermal management, durability, and efficiency in modern power generation systems.

2. OVERVIEW OF PROJECT:

Electromagnetic coils are vital in power generation systems, and their housing material significantly affects performance, durability, and thermal management. Metals, though strong and easy to fabricate, suffer from high thermal conductivity, leading to rapid heat transfer and increased thermal stresses. Glass fiber composites, with low thermal conductivity, lightweight properties, and good strength-to-weight ratio, present a promising alternative. This study compares metal and glass fiber housings using ANSYS simulations under operating temperatures of 30 °C, 40 °C, and 50 °C. The analysis focuses on temperature distribution, total and directional heat flux, and volumetric response to determine the most suitable material for improved efficiency, thermal control, and reliability in power generation applications.

3. GLASS FIBER SUSPENSION HOUSING:

Glass fiber-reinforced polymer (GFRP) offers a lightweight, corrosion-resistant alternative to traditional metal components, making it highly suitable for electric vehicle (EV) suspension systems where weight reduction and thermal stability are critical. With its high strength-to-weight ratio, fatigue resistance, and design flexibility, GFRP is increasingly applied to shock absorber casings, piston rod housings, and control arm enclosures. Its key properties— lightweight construction that reduces unsprung mass, high tensile strength to withstand dynamic loads, corrosion resistance against moisture and road salts, thermal insulation for managing heat from damping fluids, and moldability for complex geometries with integrated cooling channels or sensor mounts—collectively enhance ride quality, energy efficiency, and long-term durability in EV applications.

Fig 1: Glass fiber

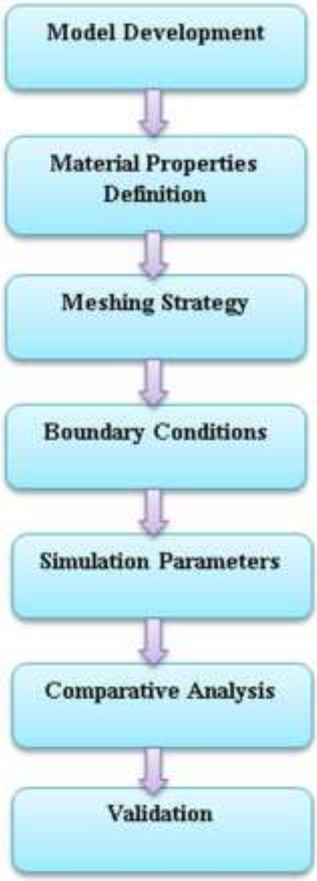
4. OBJECTIVES

The primary objective of this study is to evaluate and compare the structural and thermal performance of metal and glass fiber composite housings for an electromagnetic coil used in power generation systems. Specifically, the work focuses on analyzing temperature distribution at different operating conditions, assessing total and directional heat flux to understand insulation and conductivity behavior, and studying the volumetric response of both materials under thermal loading to ensure structural stability. By benchmarking these parameters, the study aims to identify the most suitable housing material that offers improved thermal management and operational efficiency in power generation applications.

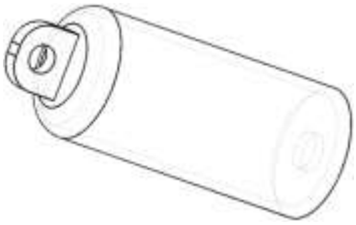
5. PROBLEM STATEMENT

Electromagnetic coils in power generation systems experience significant thermal and structural stresses, and the housing material directly affects their performance, durability, and efficiency. While metallic housings provide mechanical strength, their high thermal conductivity leads to rapid heat transfer, elevated temperatures, and reduced service life. In contrast, glass fiber composites offer lower thermal conductivity, lightweight properties, and good strength, making them potential alternatives. However, their behavior under varying operating temperatures must be quantitatively assessed. The core problem is the lack of comparative data on metal versus glass fiber housings in terms of temperature distribution, heat flux, and volumetric response. This study addresses that gap using ANSYS simulations to identify the material that ensures better thermal control, structural stability, and overall efficiency in power generation applications.

6. METHODOLOGY



7. DESIGN OF THE PROJECT GLASS FIBER HOUSING:



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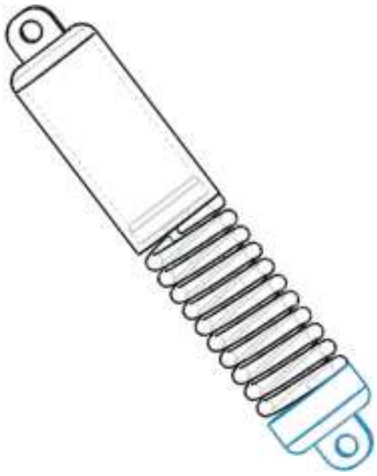
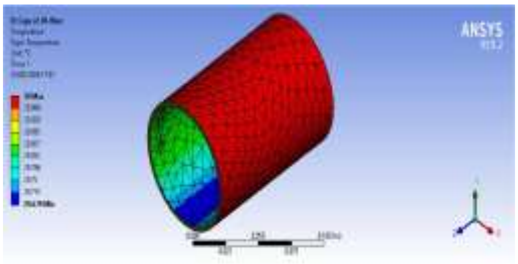
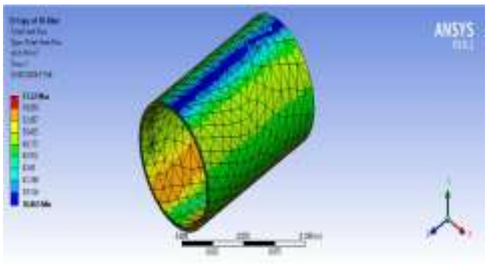
COMPOSITE SUSPENSION:

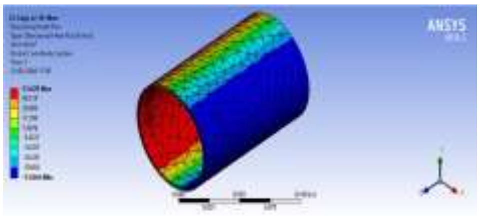


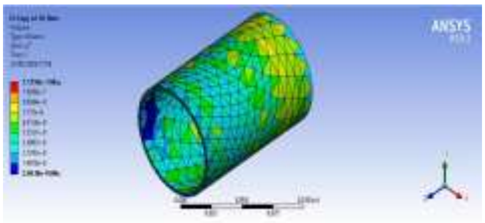
8. ANALYSIS WORK & RESULT

Analysis on Glass fiber housing at 30°



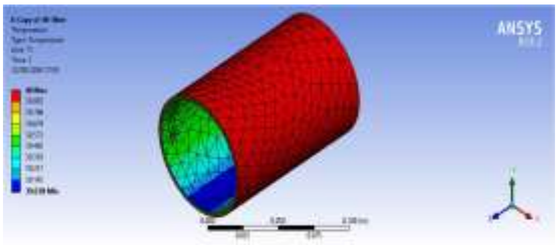


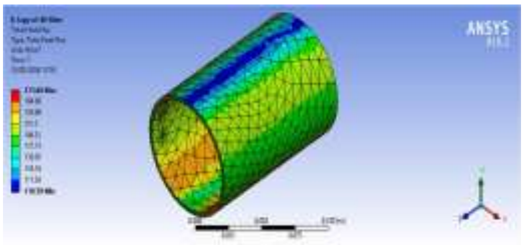


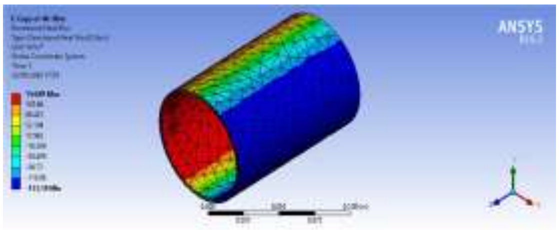


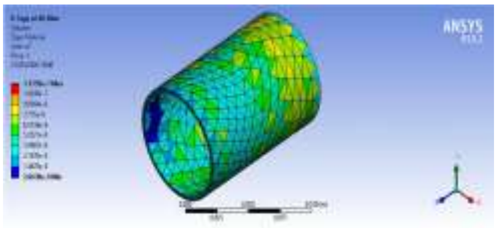
Parameter	Minimum Value	Maximum Value	Observations
Temperature (°C)	29.679	29.964	Surface region shows higher temperatures (red), inner core cooler (blue–green).
Total Heat Flux (W/m²)	36.865	57.220	Heat flux concentrated at outer surface, indicating controlled transfer through composite.
Directional Heat Flux (X-axis, W/m²)	-51.064	51.629	Heat flow balanced in positive and negative directions, showing anisotropic behavior of composite.
Volume (m³)	2.0638e-9	1.1559e-7	Stable volumetric response, minimal expansion under thermal load.

Analysis on Glass fiber housing at 40°





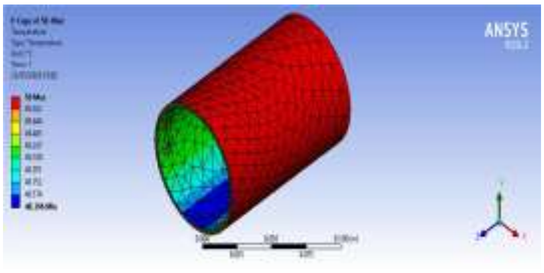


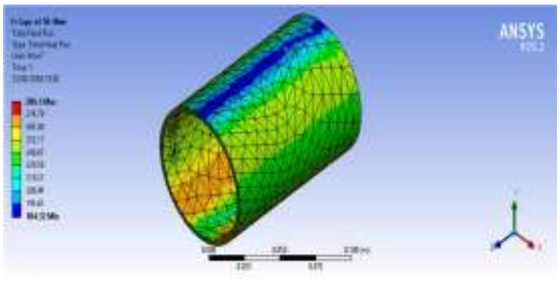


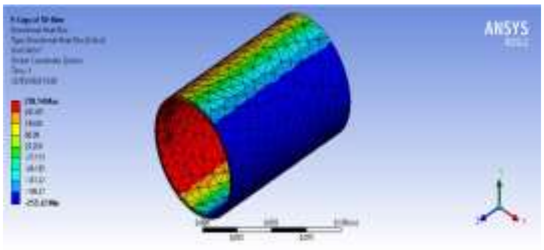
Results at 40 °C (Glass Fiber Housing)

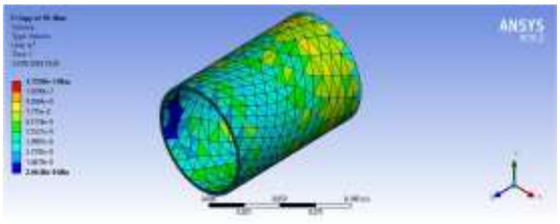
Parameter	Minimum Value	Maximum Value	Observations
Temperature (°C)	39.080	39.893	Narrow temperature band; composite housing maintains controlled thermal distribution with reduced hot spots.
Total Heat Flux (W/m²)	110.59	171.66	Heat flux increases compared to 30 °C, but remains lower than expected for metals, confirming insulation effect.
Directional Heat Flux (X-axis, W/m²)	-153.19	154.89	Balanced positive and negative flux values; anisotropic nature of composite reduces concentrated heat transfer.
Volume (m³)	2.0638e-9	1.1559e-7	Stable volumetric response, similar to 30 °C, showing minimal expansion under thermal load.

Analysis on Glass fiber housing at 50°







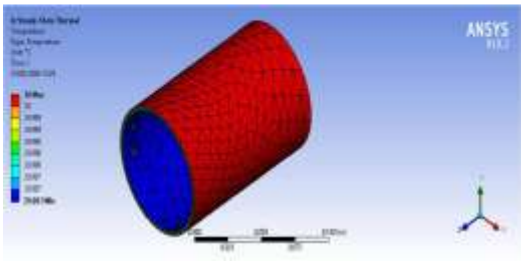


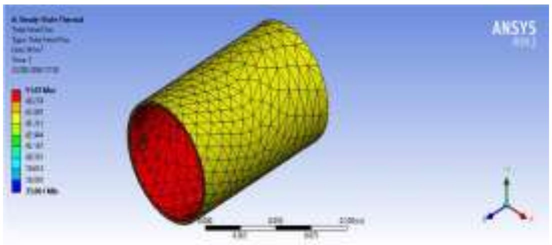
Results at 50 °C (Glass Fiber Housing)

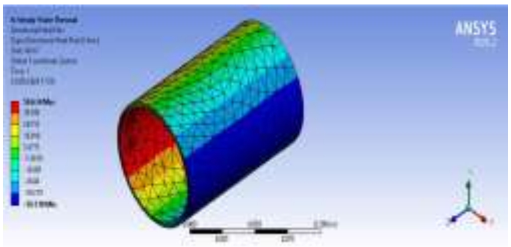
Parameter	**Minimum Value**	**Maximum Value**	**Observations**
Temperature (°C)	48.396	49.822	Composite housing maintains a narrow temperature band, preventing excessive heating despite higher input temperature.
Total Heat Flux (W/m²)	184.32	286.10	Heat flux rises significantly compared to 30 °C and 40 °C, but remains lower than expected for metals, confirming insulation effect.
Directional Heat Flux **(X-axis, W/m²)**	-255.32	258.14	Balanced distribution of positive and negative flux values; anisotropic composite reduces concentrated heat transfer.
Volume (m³)	2.0638e-9	1.1559e-7	Stable volumetric response, similar to lower temperatures, showing minimal expansion under thermal load.

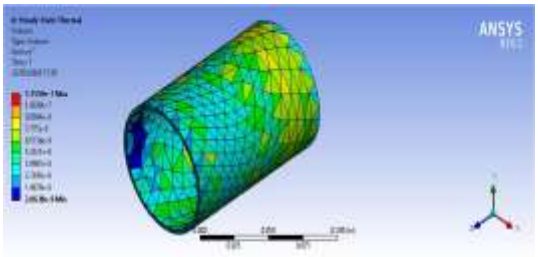
9. ANALYSIS AT METAL HOUSING

Analysis on Metal housing at 30°





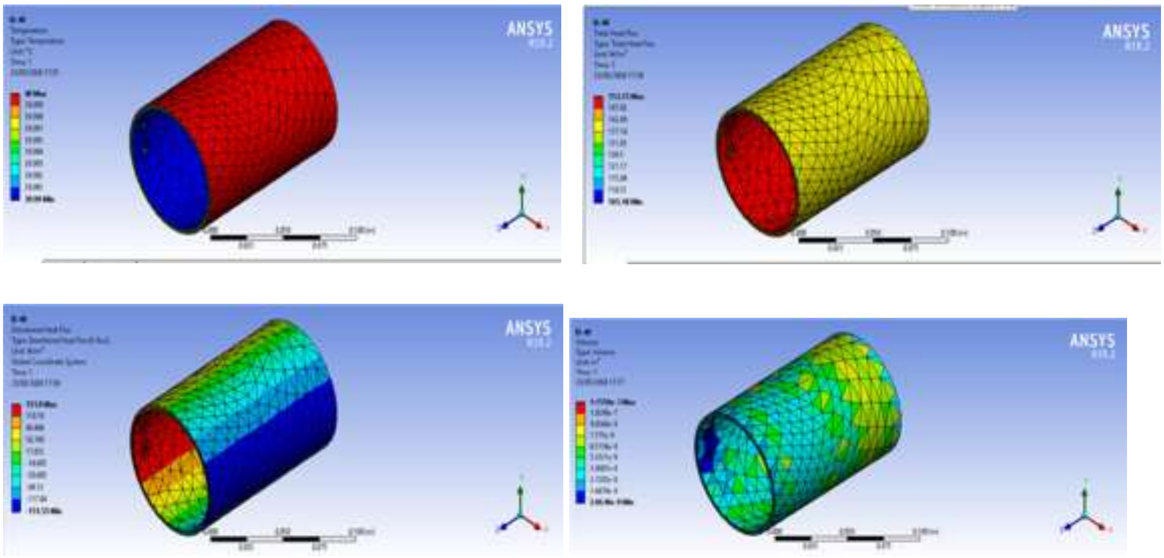




Results at 30 °C (Metal Housing)

Parameter	**Minimum Value**	**Maximum Value**	**Observations**
Temperature (°C)	29.997	30.000	Very narrow band, but surface quickly reaches maximum due to high conductivity of metal.
Total Heat Flux (W/m²)	35.061	51.050	Higher flux compared to composite at the same
			temperature, showing rapid heat transfer through metal.
Directional Heat Flux **(X-axis, W/m²)**	-50.518	50.634	Strong bidirectional flux; isotropic nature of metal results in uniform but intense heat flow.
Volume (m³)	2.0638e-9	1.1559e-7	Stable volumetric response, but higher thermal expansion stresses expected compared to composite.

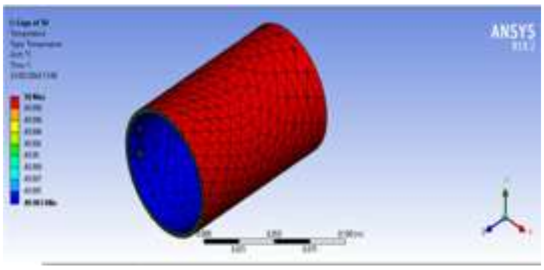
Analysis on Metal housing at 40°

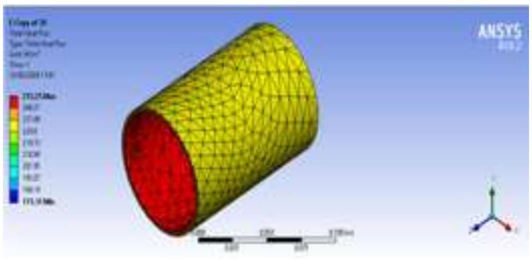


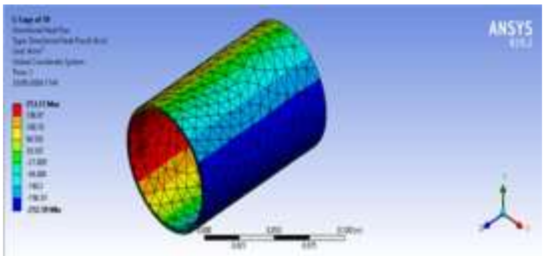
Results at 40 °C (Metal Housing)

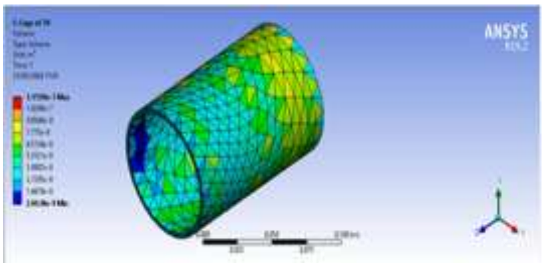
Parameter	Minimum Value	Maximum Value	Observations
Temperature (°C)	39.99	40.00	Very narrow band; surface quickly reaches maximum due to high conductivity of metal.
Total Heat Flux (W/m²)	105.18	153.15	Heat flux rises significantly compared to 30 °C, showing rapid heat transfer through metal.
Directional Heat Flux **(X-axis, W/m²)**	-151.55	151.19	Strong bidirectional flux; isotropic nature of metal results in uniform but intense heat flow.
Volume (m³)	2.0638e-9	1.1559e-7	Stable volumetric response, but higher thermal expansion stresses compared to composite housing.

Analysis on Metal housing at 50°









Results at 50 °C (Metal Housing)

Parameter	Minimum Value	Maximum Value	Observations
Temperature (°C)	49.983	50.000	Very narrow band; surface rapidly reaches maximum due to high conductivity of metal.
Total Heat Flux (W/m²)	175.31	255.25	Heat flux rises sharply compared to 40 °C, showing

			rapid heat transfer through metal housing.
Directional Heat Flux (X-axis, W/m^2)	-252.59	253.17	Strong bidirectional flux; isotropic nature of metal results in uniform but intense heat flow.
Volume (m^3)	2.6038e-9	1.1559e-7	Stable volumetric response, but higher thermal expansion stresses compared to composite housing.

10. COMPARATIVE RESULTS OF GLASS FIBER VS. METAL HOUSING

Parameter	**Temp (°C)**	**Glass Fiber Housing**	**Metal Housing**	**Key Comparison**
Temperature (°C)	30	29.679 – 29.964	29.997 – 30.000	Metal reaches max faster; composite maintains controlled gradient.
	40	39.080 – 39.893	39.99 – 40.00	Composite shows widerbetter gradient, insulation.
	50	48.396 – 49.822	49.983 – 50.00	Composite prevents sharp rise; metal surface saturates quickly.
Total Heat Flux (W/m^2)	30	36.865 – 57.220	35.061 – 51.050	Composite lower flux, better insulation.
	40	110.59 – 171.66	105.18 – 153.15	Composite higher but more slightly controlled distribution.
	50	184.32 – 286.10	175.31 – 255.25	Composite shows higher range but still better thermal control.
Directional Heat Flux (X-axis, W/m^2)	30	-51.064 – 51.629	-50.518 – 50.634	Both composite anisotropic, balanced; metal isotropic.
	40	-153.19 – 154.89	-151.55 – 151.19	Composite reduces concentrated stress; metal uniform but intense.
	50	-255.32 – 258.14	-252.59 – 253.17	Composite shows controlled anisotropy; metal shows strong uniform flux.
Volume (m^3)	30	2.0638e-9 –	2.0638e-9 –	Both stable; composite less prone to

		1.1559e-7	1.1559e-7	expansion stress.
	40	2.0638e-9 – 1.1559e-7	2.0638e-9 – 1.1559e-7	Similar stability; composite better dimensional reliability.
	50	2.0638e-9 – 1.1559e-7	2.6038e-9 – 1.1559e-7	Composite maintains stability; metal shows slightly higher expansion tendency.

11. CONCLUSION

The comparative study shows that glass fiber composite housings outperform metals in thermal management and structural stability for electromagnetic coils. Composites maintain lower temperatures, restrict heat flux, and exhibit excellent volumetric stability, while metals, though strong, suffer from high thermal conductivity and greater thermal stresses. Overall, glass fiber composites prove to be a more efficient, durable, and reliable alternative for coil housings in modern power generation systems.

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