Design and Analysis of Battery Bracket for Electric Vehicle

[1] MR.NAWALE SAURABH CHANDRAKANT, [2] DR. GALHE D. S.
[1]Student, ME (Design Engineering) Dept. of Mechanical Engineering, JCOE, Kuran
2Professor, ME (Design Engineering) Dept. of Mechanical Engineering, JCOE, Kuran

Abstract: The rise of electric vehicles (EVs) necessitates novel approaches to component design to enhance their performance, safety, and efficiency. This study focuses on designing and performing finite element analysis (FEA) of a battery bracket tailored for EVs. This bracket plays a pivotal role in securing the battery pack, ensuring structural integrity, and dampening vibrations and impacts during vehicle operation. The design process incorporates meticulous material selection, weight optimization, and manufacturability considerations to develop a robust and economical solution. Utilizing advanced CAD software, a comprehensive model of the bracket is created and subjected to FEA to assess its mechanical properties under diverse load conditions. The analysis encompasses static, dynamic, and thermal simulations to gauge the bracket's performance in real-world scenarios. Results indicate that the optimized battery bracket design meets the rigorous safety and durability criteria of modern EVs while contributing to overall vehicle weight reduction. This study provides valuable insights into the engineering complexities and resolutions pertaining to EV battery support systems, thereby fostering advancements in electric vehicle technology.
Keywords: E Vehicle, Battery bracket, FEA, structural analysis

I. INTRODUCTION

Moreover, apart from technical aspects, the crashworthiness of battery brackets also undergoes scrutiny based on various regulatory standards and guidelines. Bodies such as the International Electrotechnical Commission (IEC), Society of Automotive Engineers (SAE), and National Highway Traffic Safety Administration (NHTSA) lay down specific criteria and testing methodologies to ensure the safety and reliability of battery brackets in electric vehicles. This study aims to offer an in-depth insight into crash testing methodologies, instrumentation techniques, failure analysis methods, design optimization approaches, and pertinent standards governing the assessment of battery brackets in electric vehicles.
By delving into the latest developments in this domain, researchers, engineers, and manufacturers can collaboratively strive towards crafting sturdy and effective battery bracket designs that align with rigorous safety standards, thus furthering the enhancement of electric vehicle safety.

LITERATURE REVIEW

Kennedy F. E., et al. (2021) introduce enhanced methods for finite element analysis (FEA) to accurately predict sliding surface temperatures. Addressing the challenges associated with predicting temperatures during sliding contact, the authors focus on understanding wear, friction, and thermal behavior. Their proposed techniques improve the precision and efficiency of FEA simulations, leading to more reliable predictions of sliding surface temperatures. These findings advance numerical modeling techniques for studying sliding contact phenomena across engineering applications.[1]

He et al. (2021) explore the integration of topology optimization and additive manufacturing to produce lightweight and efficient battery brackets. Leveraging modern design methodologies, they aim to reduce bracket weight while preserving structural integrity. Topology optimization optimizes material distribution within the bracket, resulting in a lightweight yet robust design. Additive manufacturing enables the creation of intricate geometries, enhancing efficiency and reducing overall vehicle weight. This study highlights the potential of these techniques to revolutionize vehicle component production, improving automotive system efficiency and performance.[2]

Burton R. A. et al. (2020) investigate thermal deformation in frictionally heated contact, examining its effects on surface deformation. Through experimental and analytical approaches, they explore thermal effects on contacting bodies and their influence on performance and reliability. This research provides insights into thermal deformation mechanisms, aiding in the development of mitigation strategies for various engineering applications.[3]

Li et al. (2020) focus on the crashworthiness of battery pack structures in electric vehicles. Employing multi-objective optimization techniques, they seek to balance weight, strength, and energy absorption capacity. Computational methods are utilized to model crash scenarios and optimize pack structural integrity. Their work contributes to safer electric vehicle designs, ensuring battery pack security and integrity during collisions. This research enhances confidence in electric vehicle safety and reliability, emphasizing the importance of robust design and computational modeling in crashworthiness assessment.[4]

II. OBJECTIVES

A. To design and develop a battery bracket that ensures the safety and protection of the battery pack.
B. To minimize the risk of battery pack failure resulting from rear, front, and side impacts during collisions.

C. To analyze the battery bracket using simulation tools like ANSYS and validate the results.
D. To compare the results from finite element analysis (FEA) with experimental data for the battery bracket.

III. EXPERIMENTATION

A. Structural Analysis of Bracket

Experimental testing of the bracket is conducted to examine the impact of composite material on its load-bearing capacity. The experimental test setup, depicted in Figure 6.1, utilizes a Universal Testing Machine with a 10-tonne capacity for this evaluation.

Figure 5.1 Test setup for battery bracket

Table 5.1: Experimental results

Sr. No.	Description	Temperature Distribution (*C)	Deformation (mm)	Von-Mises stress (MPa)
1	Battery Bracket	59	0.05112	347

B. FINITE ELEMENT ANALYSIS

Finite Element Method is a numerical procedure for solving continuum mechanics of problem with accuracy acceptable to engineers.

6.1 Post-processing of Structural Analysis

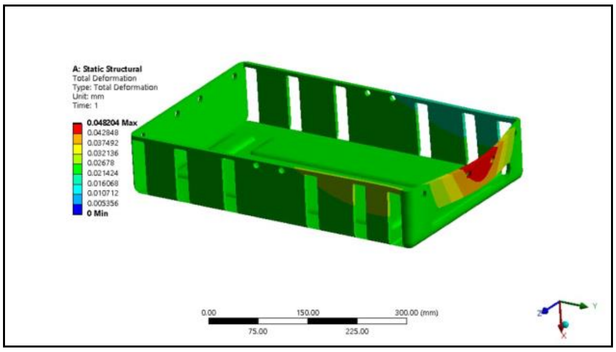

Figure 6.1: Total deformation contour plot for battery bracket

The maximum deformation shown by the battery Bracket design is 0.048204 mm.

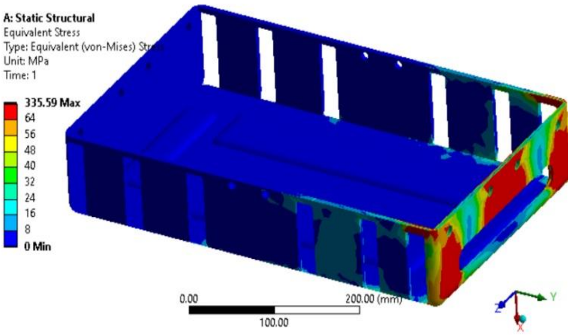

Figure 6.2: Von-Mises stress contour plot for battery bracket

The maximum equivalent stress observed in the battery bracket is 335 MPa.

The material has a yield strength of 375 MPa. The results indicate that the von-Mises stress is 335 MPa, which is slightly lower than but close to the material's yield strength.

6.2 Summary (From Finite Element Analysis)

The results reveal that the maximum stresses in the battery bracket correspond precisely with the observed field failures. A comparison has been made between the maximum total deformation and equivalent stress values for the initial battery bracket design and its subsequent modified versions. The following table presents a comparison of these different battery bracket designs using FEA.

Table 6.1: FEA Results

Sr. No.	Description	Temperature Distribution (*C)	Deformation (mm)	Von-Mises stress (MPa)
1	Battery Bracket	59	0.048204	335

The stresses in the proposed bracket are minimal. This design is deemed feasible and has been advanced to the manufacturing stage. The experimental results will be compared with the finite element analysis findings.

III. CONCLUSION

- The deformation in the modified FEA design of the bracket is minimal at 0.048 mm, while the experimental measurement is 0.05112 mm.
- The Von-Mises stress in the modified bracket design is also minimal at 335.59 MPa, compared to the experimental value of 347 MPa.
- Therefore, the modified battery bracket design is the most suitable and feasible for the current application from both design and manufacturing perspectives.

Table 7.1. FEA & Experimental Results Summary

Test	FEA For Battery Bracket	Experimental for Battery Bracket	% Error
Deformation (mm)	0.048204	0.05112	3.23%
Von Mises Stress (Mpa)	335	347	3.48%

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