

Design and Analysis of Battery Bracket For E-Vehicle

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Abstract—The safety and durability of battery brackets in electric vehicles (EVs) are of utmost importance to ensure the reliable performance and protection of battery packs. Impact testing plays a critical role in evaluating the structural integrity and crashworthiness of battery brackets subjected to various impact scenarios. This abstract presents an overview of the research conducted on impact testing for battery brackets in EVs. Studies have focused on experimental tests, numerical simulations, and finite element analysis to assess the impact performance of battery brackets which is affected by maximum load (5000N) applied on bracket. Different impact scenarios, including frontal collisions, side impacts, and high-speed loading, have been considered to understand the response of battery brackets the von mises stress, deformation, Equivalent stress.

The research highlights the need for rigorous impact testing to ensure the safety and reliability of battery brackets in EVs. By combining experimental tests with numerical simulations, researchers have gained valuable insights into the failure modes, deformation characteristics, and energy absorption capacity and stress formations in battery brackets. These findings have led to recommendations for optimized designs, improved material selection, and enhanced crashworthiness of battery brackets. During a crash, the battery and its bracket are subjected to significant forces and accelerations. The objective of crash testing is to ensure that these components can withstand these forces and protect the battery from damage or the risk of thermal runaway. The battery bracket's role is to secure the battery in place and prevent excessive movement during an impact, thereby safeguarding both the battery and the vehicle's occupants.

I. INTRODUCTION

The crash worthiness and safety of electric vehicles (EVs) are critical considerations in their design and development. One key component that plays a crucial role in protecting the battery system during impact

events is the battery bracket. Crash testing of battery brackets is essential to evaluate their structural integrity, energy absorption capabilities, and overall performance under severe impact conditions. The battery bracket serves as a crucial structural element that secures and supports the battery pack within an electric vehicle. During a crash event, the bracket is subjected to high forces, accelerations, and deformations. The ability of the battery bracket to withstand these forces and effectively protect the battery system is of paramount importance to ensure occupant safety and prevent potential hazards, such as thermal runaway or damage to the battery cells.

Crash tests are conducted to simulate real-world crash scenarios and assess the behavior and performance of battery brackets during impact events. These tests involve subjecting the battery bracket to controlled and carefully orchestrated impacts, simulating different crash modes like frontal, side, or rear collisions. By subjecting the battery bracket to these tests, engineers can evaluate its crashworthiness, deformation characteristics, failure modes, and the level of protection it provides to the battery system. The findings from crash testing provide valuable insights into the behavior of battery brackets under high-energy impact events. This information is instrumental in guiding design improvements and optimization strategies to enhance the crashworthiness and safety of battery brackets in electric vehicles. Additionally, crash test data is used to validate and refine computer simulations and analytical models, enabling engineers to predict and optimize the performance of battery brackets during crash events.

This paper aims to provide an overview of crash testing specifically focused on battery brackets for electric vehicles. It will delve into various aspects of crash testing, including test methodologies,

instrumentation techniques, failure analysis, design optimization strategies, and the relevant standards and regulations governing this field. By comprehensively understanding the state of knowledge in crash testing of battery brackets, researchers, engineers, and manufacturers can work towards developing robust and reliable battery bracket designs that ensure the safety of electric vehicles and their occupants.

In recent years, the increasing popularity of electric vehicles (EVs) has brought a significant focus on the safety aspects associated with their design and construction. Among the critical components in an electric vehicle, the battery bracket plays a crucial role in ensuring the structural integrity and protection of the battery system during impact events. Crash testing of battery brackets is a fundamental procedure employed to assess their crashworthiness and performance under severe collision scenarios. The battery bracket serves as a primary structural element responsible for securely housing and supporting the battery pack within an electric vehicle. During a crash, the battery bracket faces immense forces and accelerations, necessitating its robust design to effectively withstand and absorb the impact energy. The primary objective of crash testing is to evaluate the ability of the battery bracket to safeguard the battery system, minimize the risk of thermal runaway, and maintain the integrity of the battery cells, ensuring the safety of both the vehicle occupants and the surrounding environment.

Crash tests are meticulously designed to replicate real-world collision scenarios, such as frontal, side, or rear impacts. By subjecting the battery bracket to controlled impact conditions, engineers can assess its performance in terms of energy absorption, deformation behavior, failure modes, and load distribution. The data obtained from these tests is crucial for understanding the structural response of the battery bracket and evaluating its overall crash worthiness. The insights gained from crash testing facilitate the optimization of battery bracket designs. Engineers can identify potential weak points, failure mechanisms, and areas for improvement through detailed analysis of the bracket's behavior during impact events. The acquired knowledge can be utilized to enhance the structural integrity, energy absorption capabilities, and protective features of the battery bracket. Moreover, crash test data serves as a

valuable resource for the validation and refinement of numerical simulation models used in virtual crash testing, enabling more accurate predictions of the bracket's performance and supporting design iterations.

In addition to the technical considerations, the crashworthiness of battery brackets is also subject to various regulatory standards and guidelines. Organizations such as the International Electrotechnical Commission (IEC), Society of Automotive Engineers (SAE), and National Highway Traffic Safety Administration (NHTSA) provide specific requirements and testing protocols that aim to ensure the safety and reliability of battery brackets in electric vehicles. This paper aims to provide a comprehensive understanding of crash testing methodologies, instrumentation techniques, failure analysis approaches, design optimization strategies, and the relevant standards governing the evaluation of battery brackets in electric vehicles. By exploring the latest advancements in this field, researchers, engineers, and manufacturers can work towards the development of robust and efficient battery bracket designs that meet stringent safety requirements and contribute to the continuous improvement of electric vehicle safety.

II. PROBLEM STATEMENT

The deployment of lithium-ion batteries (LIBs) has rapidly increased than the petrol & diesel with applications evolving from consumer electronics, to electric vehicles (EVs) and now to grid-scale balancing of renewable electricity generation.

- Battery packs in electric vehicles are susceptible to failure when subjected to sudden impacts or accidents. Rear, front, and side collisions with high impact loads pose a significant risk to the integrity of the battery packs. These impact events can lead to potential failures, compromising the safety and functionality of the batteries.
- The occurrence of jerks during accidents can induce cracks and fatigue in battery packs, making them more prone to failure. The abrupt forces and vibrations generated during these events can weaken the structural integrity of the

battery packs, increasing the likelihood of performance degradation and potential hazards. It is crucial to address these issues to ensure the reliability and safety of electric vehicle battery systems.

III. OBJECTIVES

- To design and develop battery bracket which is scalable that can meet the safety of battery pack.
- To reduce the probability of battery pack failure due to rear impact, front impact and side impact during collision.
- To analyses the tray using simulation tool like ANSYS & validate its results.
- Comparison of theoretical, FEA and experimental results for battery bracket.

IV. METHODOLOGY

- Methodology used in the failure analysis and design of the battery bracket brake is as shown in the below figure

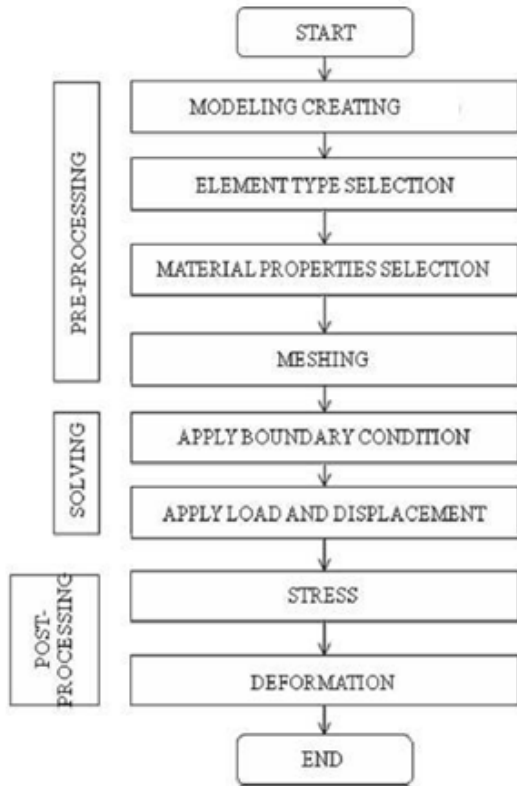


Figure: Process flow chart

V. FEA AND ANSYS

Finite Element Method is a numerical procedure for solving continuum mechanics of problem with accuracy acceptable to engineers. Finite Element Method is a mathematical modelling tool involving battery bracket retization of a continuous domain? Using building-block entities called finite elements connected to each other by nodes for once and moment transfer. This process includes Finite Element Modeling and Finite Element Analysis. In displacement-based FEM, stiffness of the entire structure (Part or assembly) is assembled from stiffness of individual elements. Loads and boundary conditions are applied at the nodes and the resulting sets of the simultaneous equations are solved using matrix methods and numerical techniques. In short, FEM is a numerical method to solve ordinary differential equations of equilibrium. Starting with simple linear static stress and heat transfer analysis, Complex simulations involving highly non-linear, fluid flow and dynamic events can be successfully analyzed on a personal computer using a host of popular software including Cosmos, NASTRAN, ANSYS and NISA among others.

Three Steps in the Finite Element Calculation

1) Pre-Processing

Create and battery bracket retize the solution domain into finite elements. This involves dividing the domain into sub-domains, called 'elements', and selecting points, called nodes, on the inter-element boundaries or in the interior of the elements.

- ✓ Assume a function to represent the behavior of the element. This function is approximate and continuous and is called the "shape function".
- ✓ Develop equations for an element.
- ✓ Assemble the elements to represent the complete problem
- ✓ Apply boundary conditions, initial conditions, and the loading.

2) Solving

Solve a set of linear or nonlinear algebraic equations simultaneously to obtain nodal results, such as displacement values or temperature values depending on the type of problem.

3) Post-Processing

This stage involves processing the nodal data to get other information such as values of principal stresses, heat fluxes etc.

A) Thermal Analysis by using ANSYS Software

ANSYS is capable of both steady state and transient analysis of any solid with thermal boundary conditions. Steady-state thermal analyses calculate the effects of steady thermal loads on a system or component. Users often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished.

ANSYS can be used to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following:

- Convection
- Radiation
- Heat flow rates
- Heat fluxes (heat flow per unit area)
- Heat generation rate (heat flow per unit volume)
- Constant temperature boundaries
- Explicit Dynamics Analysis

A steady-state thermal analysis may be either linear, with constant material properties; or nonlinear, with material properties that depend on temperature. The thermal properties of most material vary with temperature. This temperature dependency being appreciable, the analysis becomes nonlinear. Radiation boundary conditions also make the analysis nonlinear. Transient calculations are time dependent and ANSYS can both solve distributions as well as create video for time incremental displays of models.

a) Thermal Analysis Flow Chart

Flow chart for thermal analysis in ANSYS is as shown in the below figure

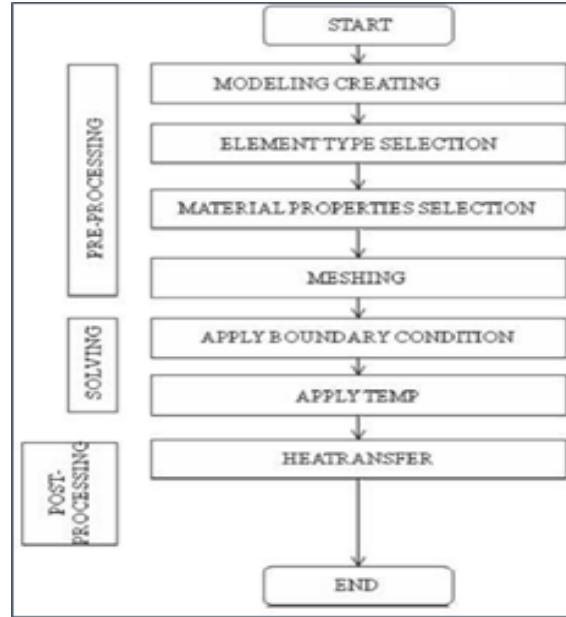


Figure: Thermal analysis flow chart

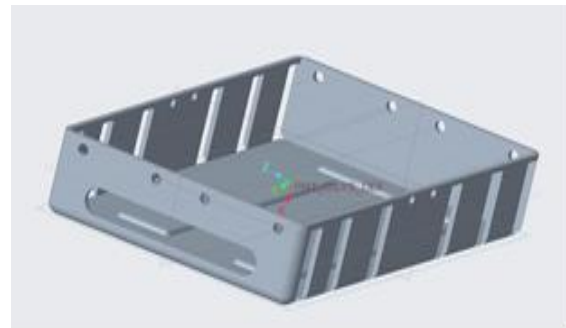


Figure: Battery Bracket CAD model in CATIA

1) Building and Importing CAD model in ANSYS

The battery Bracket () model is prepared in CATIA using Sketcher and Part Design workbench. The model prepared in CATIA is as shown in the below figure

The .CATPart file is then exported in .STEP format. The export of CAD model is done in CATIA. The same .STEP file is then imported in ANSYS workbench Design Modeler software. The STEP (Standard for the Exchange of Product model data) reader will both read and write model data to and from the STEP format. It is important to note that the STEP format does not store model data in the same way as the Design Modeler application. STEP format stores surface data, which upon import into the Design Modeler application is stitched together to form bodies. In some rare cases, the Design Modeler

application model exported to STEP format may not produce the exact same geometry when imported again into the Design Modeler application. The STEP files are transferred as full solids in the ANSYS Mechanical application. Following figure shows the imported geometry.

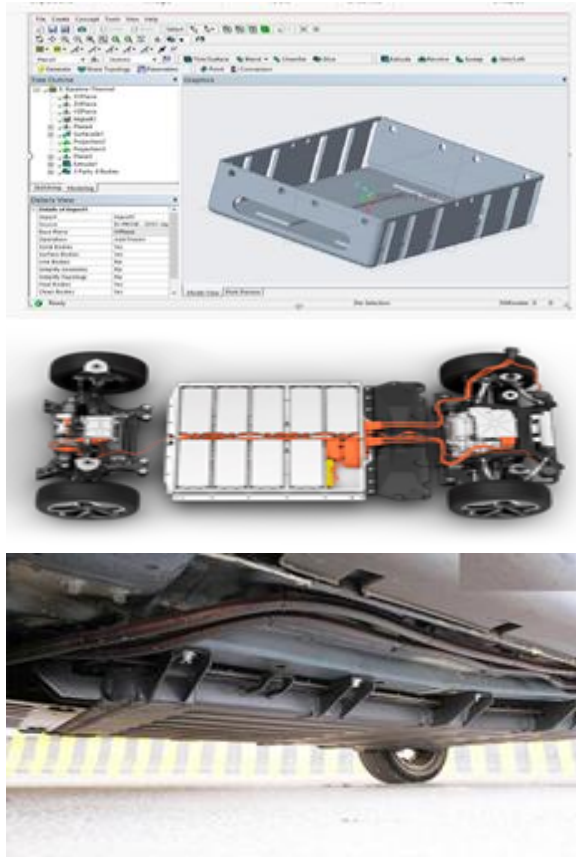


Figure CAD model imported in ANSYS & Battery Location

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