Numerical Simulation Analysis of Power Battery Chassis of Electric Car

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Abstract. The power battery is not only the power source of the electric car, but also one of the important factors affecting the safety of the electric vehicle. The structural mechanical characteristics of the power battery chassis is the primary condition to ensure the normal operation and safety of the battery. In this paper, the chassis of the power battery of the car is taken as the research object, and the static analysis and modal analysis are carried out by using the method of finite simulation. The results show that: under the influence of the weight of the battery module, the battery chassis will be deformed by 0.2mm, which will not have a great impact on the production of the power battery; when the external interference frequency is between 30.61-137.24Hz, attention should be paid to avoid the resonance phenomenon of the power battery structure.

Keywords: Power Battery, Static Analysis, Mode Analysis, Electric Car

1. Introduction

With the increasing lack of energy in the world, electric vehicles have developed rapidly. The power source of electric vehicles is the power battery [1,2]. The performance of the power battery has become an important indicator of the performance of cross beam electric vehicles. Because the power battery stores a lot of energy, when the power battery is damaged [3], it is easy to cause safety problems in electric vehicles [4,5]. The power battery is an important factor affecting the safety of electric vehicles, and the power battery chassis is an important carrier to ensure the function and safety of the power battery.

In this paper, the static and modal analysis of the power battery chassis of electric vehicle is carried out by using the method of finite element simulation analysis, and the static and modal characteristics of the power battery chassis under the working state are obtained, and the structural mechanical characteristics of the power battery chassis are analyzed according to the simulation analysis results, so as to optimize the following power battery chassis. The theoretical basis of chemical design is provided.

2. Model Analysis
The structure of the power battery is mainly composed of chassis, battery module and upper cover. The battery module is placed on the chassis, the upper cover is on the chassis, and the chassis of the power battery is shown in Figure 1. The battery chassis is mainly made of aluminum alloy, and its characteristic parameters are shown in Table 1.

![Power battery chassis](image)

**Figure 1. Power battery chassis**

**Table 1. Characteristic parameters of aluminum alloy**

| Material Name | Modulus of Elasticity/GPa | Poisson Ratio | Tensile Yield Strength/MPa | Density/kg·m⁻³ |
|---------------|---------------------------|---------------|-----------------------------|---------------|
| Aluminum Alloy | 71                        | 0.33          | 280                         | 2770          |

3. **Static Analysis**

The battery module is composed of single battery, and the single battery contains a lot of aluminum foil and copper foil. The density of the single battery is large, so the density of the battery module is also large [6]. When the battery module is placed in the bottom plate, the chassis will bear the greater pressure brought by the battery module [7,8]. This paper uses the method of static analysis to analyze this problem.

3.1. **Static Analysis Pretreatment**

According to the geometric parameters of the battery chassis, the three-dimensional parametric model is established by using SolidWords, and the model is saved as a general three-dimensional format and imported into ANSYS Workbench. A fixed constraint is added to the 12 lifting lugs of the battery chassis, and a positive pressure simulation module is applied to the bottom surface.

3.2. **Static Analysis Results**

The tetrahedron dominated method is used to divide the mesh, and then the solution is calculated. Figure 2 is the total deformation cloud diagram of battery tray. It can be seen from the figure that the maximum deformation position of chassis appears in the center of the bottom surface, and the maximum deformation value is 0.2mm. The deformation around the chassis is small.
Figure 2. Total deformation cloud

Figure 3 is the equivalent stress cloud picture of battery tray. From the diagram, we can see that the maximum equivalent stress appears on the lifting lug of the battery chassis, the maximum equivalent stress is 11.86 MPa, and the larger stress appears on the bottom surface.

Figure 3. Cloud chart of equivalent force

4. Modal Analysis

Resonance is a common hazard of mechanical structure. Modal analysis is a common method to solve the problem of resonance [9]. In this paper, the first six modes of battery tray are analyzed by finite element software.

4.1. Pretreatment of Modal Analysis

In order to analyze the vibration of the battery tray in the actual working condition, the external constraints and loads of the modal analysis are consistent with the static analysis [10].

4.2. Modal Analysis Results

By solving the calculation, the first six modes of the battery chassis are obtained. The vibration frequency of the first six modes is shown in Table 2. It can be seen from the table that the vibration frequency range of the first six modes is 30.61-137.24 Hz. When the frequency of external interference vibration is within this range, the main resonance problem occurs.
Table 2. Vibration frequency of the first six modes

| Step | Frequency/Hz |
|------|--------------|
| 1    | 30.61        |
| 2    | 51.53        |
| 3    | 86.1         |
| 4    | 90.73        |
| 5    | 122.19       |
| 6    | 137.24       |

Figure 4 is the first-order modal cloud diagram of the battery chassis. It can be seen from the figure that a large amount of deformation occurs on the four feet of the chassis. The deformation in the middle of the tray is small, and the deformation of the whole chassis has a certain symmetry relationship.

Figure 5 is the second-order modal cloud diagram of the battery chassis. It can be seen from the figure that the whole battery chassis has been greatly deformed. The middle part of the battery chassis bends downward, and both ends of the battery chassis are completely upward. The maximum deformation appears at both ends of the battery chassis.

Figure 6 is the third-order modal cloud diagram of the battery chassis. It can be seen from the figure that the battery chassis is deformed symmetrically left and right, the two long sides are
deformed upward, the center position is deformed downward, and the maximum deformation appears at the lifting lug position.

![Figure 6. Third modal cloud](image)

**Figure 6. Third modal cloud**

Figure 7 is the fourth-order modal cloud diagram of the battery chassis. It can be seen from the figure that the whole battery chassis has large deformation and serious distortion. The maximum deformation occurs at four corners.

![Figure 7. Fourth modal cloud](image)

**Figure 7. Fourth modal cloud**

Figure 8 the fifth mode cloud diagram of the battery chassis. It can be seen from the figure that the whole battery chassis has serious deformation. The maximum deformation position is at both ends of the chassis, one end protrudes upward and the other end protrudes downward.
5. Conclusion
The battery chassis is an important support and protection component of the power battery safety of electric bus. The structural stability of the battery chassis is an important factor affecting the normal operation and safety of the power battery. In this paper, the static analysis and modal analysis of the battery chassis are carried out, and the following conclusions are obtained.

(1) Under the rated working condition, under the influence of the weight of the battery module, the battery chassis will have a deformation of 0.2mm, with a small amount of deformation, which will not have a greater impact on the production of the power battery.

(2) According to the results of modal analysis, when the external interference frequency is between 30.61-137.24Hz, attention should be paid to avoid the resonance of the power battery structure.

References
[1] Wenwei Wang, Fengling Gao, Yuting Cheng. Multidisciplinary design optimization for front structure of an electric car body-in-white based on improved Collaborative Optimization method [J]. International Journal of Automotive Technology, 2017, Vol.18 (6), pp.1007-1015 Springer.
[2] Xinchun Liu, Maoyan Liang, Qiang Luo. Innovative Electric Vehicle Body Design Based on Insurance Institute for Highway Safety Side Impact Conditions [J]. Automotive Innovation, 2019, Vol.2 (3), pp.201-211 Springer.
[3] Ge Dongdong, Zhu Liangrong, Xuan Dongji. Topology Optimization in Electric Car Body Frame Based on Optistruct [J]. MATEC Web of Conferences, 2017, Vol.100 DOAJ.
[4] Jiuyu Du, Xiangfeng Meng, Jianqiu Li. Insights into the characteristics of technologies and industrialization for plug-in electric cars in China [J]. Energy, 2018, Vol.164, pp.910-924Elsevier.
[5] Tabb Wilberforce, Zaki El-Hassan, F.N. Khatib. Developments of electric cars and fuel cell hydrogen electric cars [J]. International Journal of Hydrogen Energy, 2017 Elsevier.
[6] Yongxin Lai, Weixiong Wu, Kai Chen. A compact and lightweight liquid-cooled thermal management solution for cylindrical lithium-ion power battery pack [J]. International Journal of Heat and Mass Transfer, 2019, Vol.144.
[7] Shouguang Yao, Yunhui Zhao, Xiaofei Sun et al.. Numerical Studies of Cell Stack for Zinc-Nickel Single Flow Battery [J]. International Journal of Electrochemical Science, 2019, 14(3).
[8] Sanghamitra Debta, Kaushik Kumar. Static Structural Analysis of a Powered Ankle Foot Prosthesis Mechanism [J]. Materials Today: Proceedings, 2018, Vol.5 (5), pp.11616-
M. L. Chandravanshi, A. K. Mukhopadhyay. Analysis of variations in vibration behavior of vibratory feeder due to change in stiffness of helical springs using FEM and EMA methods [J]. Journal of the Brazilian Society of Mechanical Sciences and Engineering, 2017, Vol.39 (9), pp.3343-3362 Springer.

Aishwary Singh Rajawat, Avadesh K. Sharma. Free vibration analysis of Stiffened Laminated Plate using FEM [J]. Materials Today: Proceedings, 2018, Vol.5 (2), pp.5313-5321 Elsevier.