Finite Element Analysis of Power Battery Box Chassis of Electric Bus

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Abstract. Power battery is an important part of electric bus. With the standardization of electric bus manufacturing, a standardized power battery has been formed. In this paper, the standardized power battery box chassis of electric bus is taken as the research object, and the finite element analysis method is used to simulate its mechanical characteristics. The results show that the maximum equivalent stress of the battery box chassis is 50.7 mpa, which is far less than the allowable stress value of the material. The first six modes have a vibration frequency range of 36.76-246.12 Hz, and the frequency distribution of the modes is relatively scattered.

Keywords: Power Battery, Finite Element Analysis; Electric Bus

1. Introduction
With the enhancement of human society's awareness of environmental protection and the continuous consumption of fossil fuels, electric vehicles have developed rapidly, especially in the field of public transport, more and more electric vehicles have replaced fuel vehicles [1, 2]. Bus is one of the most common means of public transportation. Power battery is an important part of electric bus [3, 4]. With the standardization of electric bus manufacturing, standardized power battery has been formed.

In this paper, the chassis of the standardized power battery box of electric bus is taken as the research object, and the mechanical characteristics are simulated by the method of finite element analysis. Through the simulation analysis, the stress-strain and modal conditions of the battery box under the working state are obtained, which provides the data basis for the optimization of the subsequent standardized battery box.

2. Model Analysis
The standardized power battery box chassis used in this analysis is made of aluminum alloy, and its material parameters are shown in Table 1. The power battery chassis is a casting, and its structure is shown in Figure 1.
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            |

Figure 1. Standardized power battery box chassis

3. Static Analysis
When the mechanical structure is in steady state, the static analysis is a common analysis method, which can effectively analyze the mechanical characteristics of mechanical structure under the static action [5].

3.1. Statics Pretreatment
The three-dimensional model of the chassis of the power battery box is established by using Creo, and then the three-dimensional model is imported into ANSYS Workbench. In order to reduce the calculation of the analysis process, the non key features of the model are simplified. A fixed constraint is applied on the mounting hole of the chassis to simulate the constraint of the battery box under real working conditions [6, 7]. A vertical pressure of 1620n is applied on the bottom surface of the inner cavity of the chassis to simulate the pressure of the battery module on the chassis.

3.2. Static Analysis Results
According to the structural characteristics of the battery box chassis, the hexahedron is used as the leading way to mesh. After getting a reasonable grid, the static analysis of the battery box chassis is carried out.

Figure 2 is the equivalent stress cloud chart of the battery box chassis. From the figure, it can be seen that the stress mainly occurs in two positions, the first position is the joint of the chassis side and the bottom, the second position is the center of the tray bottom; the maximum equivalent stress is 50.7mpa, which is far less than the allowable stress value of the material.
Figure 2. Cloud chart of equivalent force

Figure 3 is the total deformation cloud diagram of the battery box chassis. It can be seen from the figure that the maximum deformation of the tray occurs in the center of the tray bottom, and the maximum deformation is 0.5mm.

Figure 3. Total deformation cloud

4. Modal Analysis

Modal analysis is one of the common methods to study the vibration characteristics of mechanical structure [8]. In this paper, the first six modes of the power battery chassis are analyzed.

4.1. Pretreatment of Modal Analysis

In order to get the mode of chassis in working state accurately, the results of statics analysis are taken as the simulation conditions of modal analysis[9,10], and the mesh division of modal analysis is consistent with that of statics analysis.

4.2. Modal Analysis Results

Through modal analysis, the first six modes of the 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 36.76-246.12Hz, and the frequency distribution of the modes is relatively scattered.

| Table 2. First six modal frequencies |
|-----------------|-----------------|
| Step | Frequency/Hz     |
| 1    | 36.76            |
| 2    | 98.58            |
| 3    | 165.28           |
| 4    | 166.66           |
| 5    | 171.22           |
| 6    | 246.12           |
Figure 4 is a cloud chart of the first-order modal vibration of the chassis. It can be seen from the figure that the chassis as a whole has a large deformation. The maximum deformation occurs on the four upper feet on the side of the chassis, and the deformation in the middle of the chassis bottom is small.

![Figure 4. First mode cloud](image)

Figure 5 is a cloud chart of the second-order modal vibration of the chassis. It can be seen from the figure that the overall deformation of the chassis is small, the deformation in the middle of the chassis bottom surface is the largest, and the long side of the chassis also has some deformation.

![Figure 5. Second mode cloud](image)

Figure 6 cloud chart of the third-order modal vibration of the chassis. It can be seen from the figure that the overall deformation of the chassis is small, the deformation of the chassis bottom is the largest, and the side of the chassis also has some deformation.

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

Figure 7 cloud chart of the fourth-order modal vibration of the chassis. It can be seen from the figure that the overall deformation of the chassis is large, the deformation of the side position of the chassis is the largest, and the bottom surface of the chassis also has some deformation.
Figure 7. Fourth modal cloud

Figure 8 cloud chart of the fifth mode vibration of the chassis. It can be seen from the figure that the overall deformation of the chassis is large, and the side and bottom of the chassis have large deformation, and the maximum deformation appears on the side of the chassis.

Figure 8. Fifth mode cloud

Figure 9 cloud chart of the sixth mode vibration of the chassis. It can be seen from the figure that the overall deformation of the chassis is large, and the side and bottom surface of the chassis have large deformation, and the deformation of the bottom surface is symmetrical about the center.

Figure 9. Sixth mode cloud

5. Conclusion

The chassis of the bus power battery box is the main part to ensure the safety of the power battery. Through the static analysis and modal analysis of the standardized chassis of the power battery box, the following conclusions are obtained.

(1) At present, the chassis structure of the battery box can bear the gravity of the battery module and provide effective support for the battery module.
(2) From the vibration characteristics of the battery box chassis, when the external interference frequency of the battery box chassis is 36.76-246.12Hz, attention should be paid to the resonance phenomenon.

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