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Research on the On-board Battery Bracket of a Certain Heavy Haul Freight Train

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***Abstract*—For a certain type of heavy haul freight train on-board battery bracket, the software which is named Solidworks was used to build its three-dimensional model. The finite element analysis software ANSYS Workbench was used to analyze the strength of the bracket under two working conditions of parking and emergency braking. Through the finite element analysis, it can be concluded that the bracket bears the greatest stress under emergency braking conditions. The analysis results show that the design strength meets the requirements of use, and the research method can provide a calculation method for the same type of research.**

Keywords—heavy haul freight train;battery bracket;finite element analysis;ANSYS Workbench

I. INTRODUCTION

Our country has a vast land and abundant resources, but the distribution of resources is not balanced. Railway transportation is an important and efficient way to allocate resources [1]. Heavy haul transportation is an important direction for the development of railway freight transportation. Heavy haul transportation can reduce the cost of bulk material transportation and the density of trains, improve transportation efficiency, and achieve comprehensive benefits [2]. Light axle load, long marshalling group, and large annual transportation volume are the main characteristics of our country's heavy haul freight trains [3]. The performance of freight train structural parts has a significant impact on the performance of the entire vehicle. As the carrier of the battery pack, the performance of the battery bracket has a significant impact on the performance of the entire vehicle. Therefore, the battery bracket is required to always meet the requirements of strength and stability under working conditions. Taking a certain type of heavy haul freight train on-board battery bracket as the research object, it is of important engineering significance to study its strength under two working conditions: parking and emergency braking.

II. BUILDING THE MODEL

A. Structure introduction of the bracket

The total mass of the bracket is 0.83 kg, and it carries twenty kilograms of battery pack. Its material is cast aluminum alloy, and the material properties are shown in Table Ⅰ.

TABLE I. MATERIAL PROPERTIES OF THE BRACKET

Material name	Elastic modulus /Gpa	Poisson's ratio	Density /kg/mm3	Allowable stress/Mpa
Cast aluminum alloy	71	0.33	2770	215

The stress condition of the bracket changes with the change of train operation conditions. The specific working conditions are studied as follows:

(1) Working condition 1: docking status. When the vehicle is parked, it only bears gravity and the direction is vertical and downward.

(2) Working condition 2: Emergency braking state. When the vehicle is in an emergency braking state, the bracket will bear impact load in addition to its own gravity. Specifically, the impact load of 4g, 1g, and 2g is received in the front-rear direction, the left-right direction and the up-down direction.

B. Establishment of finite element model

We use Solidworks to build a three-dimensional solid model of the bracket, and appropriately simplify the model of the bracket. Then the simplified bracket model was imported into the finite element analysis software ANSYS Workbench, and added materials. Finally, the tetrahedral grid is used to divide the bracket model: The size of the global grid is 5 millimeters, however, the part where the support panel and the feet are connected has a grid size of 0.5 millimeters. The finite element mesh of the bracket is shown in Fig. 1.

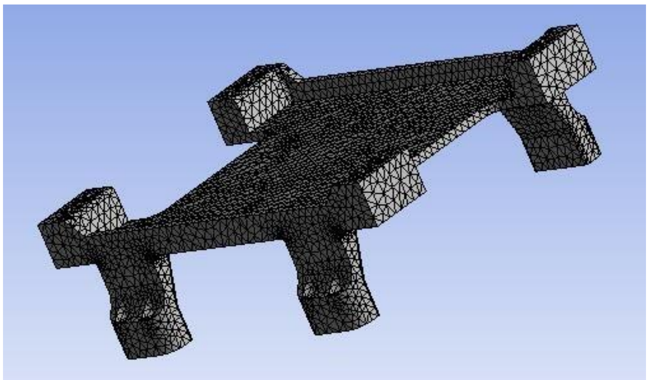

Fig. 1. *Finite element model of the bracket*

III. Strength Analysis

When the train is parked, the bottom end of the bracket is restricted by six degrees of freedom and is in a completely fixed state [4]. The bracket will withstand the pressure exerted by its own gravity and the battery pack. When the train is in an emergency braking condition, the bracket will also bear the impact load. We convert the impact load into inertial force and load it on the bracket, and keep its direction consistent with the direction of acceleration. Specifically, an acceleration of 4g is applied longitudinally, an acceleration of 2g is applied vertically, and an acceleration of 1g is applied laterally.

For the brackets under the two working conditions, the strength of the Von Mises equivalent stress is used to check the strength [5]. The results of the strength analysis of the bracket are shown in Table Ⅱ.

TABLE II. Trength Analysis Results Under Two Working Conditions

working condition	Parking	Emergency braking
Weight/kg	Maximum stress/Mpa	Maximum stress/Mpa
20	9.466	32.043

As shown in Fig. 2, when the train is in the parking state, the maximum stress on the bracket occurs at the connection between the bracket panel and the feet, and its value is 9.466Mpa; as shown in Fig.3, when the train is in an emergency braking state, the maximum stress on the bracket occurs at the connection between the bracket panel and the feet, and its value is 32.043Mpa.

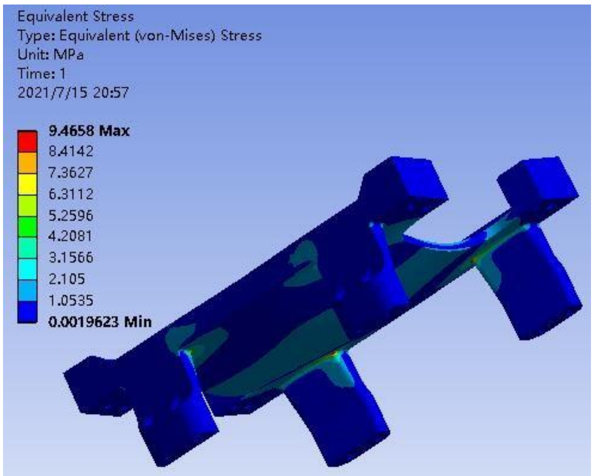

Fig. 2. *Stress analysis results in the parking state*

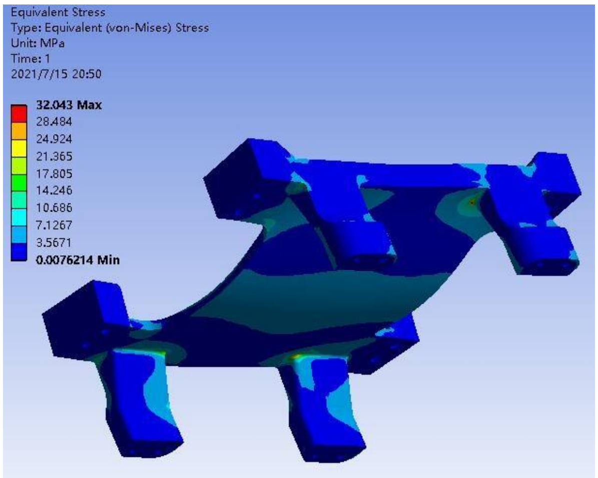

Fig. 3. *Stress analysis results in the emergency braking*

IV. Conclusion

This paper takes a certain type of heavy-duty freight train on-board battery bracket as the research object and analyzes its strength. According to the finite element analysis, the maximum stress that the bracket can withstand under emergency braking conditions is 32.043Mpa, which is mainly concentrated at the connection between the bracket panel and the foot. The actual stress does not exceed the allowable stress of the material, and the design strength meets the requirements of use. This research method can provide calculation methods for the same type of research and facilitate subsequent lightweight design.

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