Study on equivalent method of solder joint of BIW

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Abstract. First create a simple beam model of finite element simulation analysis, find the principle and method of equivalent ACM solder joints, then the equivalent method of ACM welds a car white body finite element model is established, by using NASTRAN analysis modal, torsional rigidity and bending rigidity, and compared with the experiment on the mark, has the very good correlation. The results show that based on the 5mm×5mm mesh size, the equivalent ACM solder joint model is reasonable and reliable for the modal and static stiffness modeling analysis of BIW.

Keywords: Nastran, ACM Weld spot, BIW model, Torsion stiffness.

1. Introduction

When the car runs on different road surfaces, it needs to bear various loads. Body stiffness is good or bad will directly affect the performance of vehicle driving performance, for example, insufficient stiffness will affect the sealing performance of the compartment, and auto harshness (NVH) performance, even affects the collision performance, because when the car collision, can cause excessive body deformation phenomenon such as the door jammed, broken glass, which threatens the safety of personnel in the cockpit. Therefore, the body structure stiffness is a very important index of the body performance evaluation. In the field of CAE, the research of one system involves many working conditions, and sometimes multiple sets of CAE grid models need to be established, which requires a lot of manpower cost and modeling cost, and the model management is not convenient. Firstly, this paper analyzes the influence of solder joint on a single part, including the study of solder joint type and solder joint equivalent method. By comparing with experiments, a reasonable solder joint simulation form is defined, and the solder joint simulation form and equivalent form are applied to the whole body in white to analyze its modal, bending stiffness and torsional stiffness.

2. Study of solder joint type

In the CAE analysis, there are many kinds of solder joint simulation methods. The commonly used solder joint simulation types include RBE2, BAR, CWELD and ACM. However, the simulation results obtained by selecting different solder joint simulation methods are different. Therefore, a simple beam model was first built, which was connected by 14 solder joints, and the mesh size was 20×20mm. The simulation model was shown in Figure 1, and the results of four solder joints were compared.
3. Study on equivalent ACM solder joints

The establishment of reasonable and accurate finite element simulation model is the precondition to ensure the correct simulation results. In the finite element mesh division of 3D geometric model, the choice of mesh size will be different according to the analysis conditions and common standards of enterprises (or individuals). The common mesh size mainly includes 4 categories: 3×3mm, 5×5mm, 10×10mm and 20×20mm. According to the previous experience, when the finite element simulation calculation of the body-in-white modal and overall stiffness is carried out, the mesh size of 20×20mm is adopted, and the simulation results are in good agreement with the experimental results. However, in the actual calculation, the grid size of 5×5mm is widely used, so the idea of ACM solder joint equivalent can be adopted to obtain the simulation results of the grid size of 20×20mm based on the grid size of 5×5mm, so as to achieve the purpose of using a set of grids to calculate multiple working conditions and reduce the workload for the subsequent grid work. For example, the solder joint of the 5×5mm mesh model is processed, and the diameter of the solder nucleus is magnified by four times to 20mm, and the elastic modulus is also scaled by a certain proportion. As shown in Figure 2, for the 20mm×20mm mesh model, the solder joint diameter is 4mm, and the affected area is a mesh cell with an area of 400mm2. 5×5mm mesh model, the same diameter solder joint influence area is 4 mesh cells, the area is only 100mm2; After the equivalent solder joint, the influence area of the 5×5mm mesh model is 16 mesh units with an area of 400mm2. The influence area of the solder joint is consistent with that of the 20mm mesh model. Table 2 shows the first five order modal simulation values of the 5×5mm equivalent solder joint, and the maximum difference from the experimental value is 4.45%, indicating the correctness of the equivalent ACM solder joint.
4. Influence of equivalent ACM solder joint on the modal and stiffness of BIW

Based on the above findings, this study adopts 5 mm x 5 mm white body grid model, using the equivalent model of the ACM solder joints, a car white body with a diameter of 4 mm and 6 mm two solder joints, the equivalent of 4 mm and 6 mm spot size and 30 mm to 20 mm, the solder joint tensile stiffness unchanged, Gpa from 210000 to 8400 Gpa elastic model, as shown in figure 3, using nastran finite element model of the white body of the car including modal, torsional stiffness and bending stiffness analysis.

4.1. Body in white modal analysis

When a car travels on different roads, it will be affected by the impact from the outside world. When the external excitation frequency approaches or reaches the natural frequency of the part or whole of the body in white, the body parts will be resonated, the noise will be generated, the comfort will be affected, and the vibration fatigue damage of the body parts will be caused in serious cases. Therefore, it is necessary to analyze the modal response of the BIW, especially the first-order torsional mode, and then evaluate the modal according to the standard requirements or experience to avoid resonance. First-order torsional mode is an important mode for BIW, and the enterprise standard requires that the first-order torsional mode is greater than 43Hz. In order to improve the calculation efficiency, the modal frequency was set within the range of 0-50Hz. Nastran linear analysis software was used to
carry out the finite element modal analysis of the body in white, and the calculated first-order torsional mode was 44.09Hz. The results are shown in Figure 4 below. In the experiment, multi-point excitation and multi-point response methods are used to extract the modes of the body in white. Suspension the body from the front suspension support area and the rear bumper beam area with soft ropes. Exciting points were selected in the Body-in-White area. Exciting points were carried out in X, Y and Z directions at the same time, and the acceleration responses in X, Y and Z directions at the excitation points were tested. The transfer function was calculated, the transfer function was averaged and the modal order was determined. The experimental value of the first-order torsional mode is 43.6Hz, and the mode is shown in Fig. 4. The simulation value of the first-order torsional mode is 44.09Hz, and the experimental value is 43.6Hz, the error is less than 2%, and the calibration is good. The equivalent ACM solder joint model based on 5×5mm mesh can be used for the modal calculation of body in white.

![Fig.4 Modal analysis and experimental results of body-in-white](image)

5. Conclusions
In this paper, the type of solder joints has been studied to find out reasonable solder joint equivalent method, and applied to the analysis of the car white body, CAE analysis values with the experimental method, comparing the experimental data obtained based on 5 x 5 mm is calculated using equivalent acm solder joint model of the grid of white body modal, torsional stiffness and bending stiffness value and experimental value between the errors are within 5%, good consistency. The research results have reference value to guide the design and development of BIW, and also help to shorten the development cycle.

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