Finite element optimization design of aircraft equipment installation structure

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Abstract. In this paper, the crack of the saggar was solved by finite element method, and the reason of the crack was found out through calculation and analysis. Then, the optimized design of the saggar was carried out, and the longitudinal stiffness of the saggar was strengthened, and the connection mode between the saggar and the saggar was changed. After calculating the optimized equipment support and saggar, it is found that the maximum stress of saggar is reduced by about 95% compared with that before optimization, which meets the requirements of strength design, indicating that the optimized scheme is very effective.

Keywords: Equipment rack, Finite element, Strength, Stiffness

1. Introduction
A crack was found in the protective saggar on the mounting bracket of an airborne equipment in the process of using in the field. In order to ensure the flight safety and the normal operation of the equipment, it is necessary to conduct a detailed study on the problem and find the root of the problem and solve it. In view of this problem, this paper will use the finite element method to calculate and analyze it, through the structural strength check of the saggar and the mounting bracket, to find out the reason for the crack of the saggar, and according to the analysis results of the original structure optimization, finally verify the structural strength of the optimized protective saggar.

2. Equipment installation structure
The equipment is installed in the rear cabin of the aircraft and arranged symmetrically on the left and right sides of the fuselage. The mounting bracket is composed of ear piece, beam, longitudinal beam and bottom plate. One end of the eight triangular ear pieces is connected with the frame section of the fuselage, and the other end is connected with the beam of the bracket. The bottom plate is connected with the beam and longitudinal beam, as shown in Fig. 1.
The device is fitted with saggers and structural supports. The device is connected with the bracket bottom plate by bolts, and the device is protected by the sagger outside, but the sagger does not contact the device. The protective sagger is shown in Figure 2, with a rectangular section. The outer side of the protective sagger is riveted with the frame of the fuselage beam by flanging, and the inner side is riveted with the mounting bracket by Angle material. According to the user's feedback, it was found that cracks occurred in the sagger of the equipment installation during the ground inspection of several aircraft with fewer flight take-off and landing times, and the cracks appeared at the corners of the sagger. See Figure 3 for the crack photos.
3. Finite element modeling analysis

3.1. Finite element analysis of equipment support

In this paper, the finite element software Patran of MSC Company was used to establish the finite element model with reference to the actual structure of the equipment bracket as shown in Figure 1, as shown in Figure 4. One-dimensional beam element is used for beam and longitudinal beam, and two-dimensional plate element is used for base plate and ear plate. A 0-dimensional mass element is established at the center of gravity of the equipment. According to the actual installation method, multi-point constraint (MPC) is used to connect the base plate of the mounting bracket, and Bush element is used to connect the components of the bracket. The scaffold is made of aluminum alloy [1], and its strength limit is 405 MPa. According to the established finite element model, the bracket was fixed on the fuselage in the analysis, and the flight parameters in the military aircraft structural strength specification [2] were referred to. The maximum overload condition of the position was selected as the load condition of the bracket, which was submitted to MSC.NASTRAN software for calculation. The deformation cloud diagram is shown in Figure 5.

Figure 4. Finite element model of equipment support

Figure 5. Finite element model of equipment support
The calculation results show that the maximum stress of the support structure is 152MPa, which is less than the ultimate strength of the material. The maximum displacement is 1.61mm (absolute value, the same below), in which the maximum longitudinal displacement is 1.56mm, the maximum vertical displacement is 0.743mm, and the maximum lateral displacement is 0.656mm. It can be seen from the results that the equipment support meets the strength design requirements, but the longitudinal displacement is significantly greater than the other two directions, and the longitudinal stiffness of the structure is small.

3.2. Finite element analysis of protective saggar
One end of the equipment protection saggar is connected with the frame of the fuselage beam and the other end is connected with the bottom plate of the mounting bracket. Due to the deformation of the mounting bracket in the flight process, the saggar will have forced displacement through the connecting angle material. Referring to the actual aggar structure, a two-dimensional plate element is used to build a finite element model. As shown in Figure 2, the saggar material is the same as the bracket material. According to the established model, the saggar is fixed with the connecting end of the fuselage and free with the connecting end of the bracket bottom plate. The forced displacement caused by the equipment bracket is applied at the free end. Considering the actual connecting mode, the displacement is only applied on the left and right sides of the saggar.

![Figure 6. Protection saggar stress nebula](image)

4. Optimize the design scheme

4.1. Optimization scheme
It is necessary to consider strengthening the device support to reduce the forced displacement of the saggar. According to the calculation results, the longitudinal stiffness of the equipment support is relatively small, so it is strengthened in this direction, and the left and right ends of the support as well as the upper and lower sides are added with oblique bracing bars. Calculate the equipment support after strengthening, and the results are shown in Figure 7. It can be seen that the stiffness of the equipment support is significantly enhanced after strengthening, and the maximum displacement is 0.667mm, which is 58% less than before strengthening. The maximum longitudinal displacement is 0.265mm, the maximum vertical displacement is 0.528mm, and the maximum lateral displacement is 0.460mm. The maximum stress is 8.93MPa.
5. Conclusions
In this paper, through the use of MSC company finite element software, the equipment installation structure modeling analysis and put forward the structure optimization scheme, and the optimization scheme was verified and checked, proved that the optimization scheme is reasonable and effective. Through the strength analysis of the structure and puts forward the design principle, structural stiffness in the early part of the structure design, structure should be considered in each stiffness distribution of the stress direction, depending on the different direction of the load, design the structure of the different stiffness in all directions, such not only can satisfy the demands of structure strength, still can make the lightest structure do quality. Can be seen from the finite element analysis results, equipment support to strengthen, the maximum stress of only 8.93 MPa, relative to the material limit strength is small, the structure of the material is underutilized, therefore, can be in the subsequent models to further optimization of the equipment rack, considering the structural strength and stiffness of the coordination, improve material utilization, reduce the equipment quality.

Acknowledgements
The research was financially supported by the National Natural Science Foundation of China (51275541).

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