Structure Analysis of the Airborne Optoelectronic Stabilized Pod Systems for Power Line Inspection

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Abstract: The airborne pod system can reduce the difficulty of power line inspection and enhance the degree of automation for inspection tasks. At the same time it also has a higher requirement of the structure performance of the airborne pod system. Therefore the finite element statics analysis and modal analysis for the structure of the airborne pod system was carried by using ANSYS WORKBENCH software. From the analysis result, the maximum stress of the airborne pod system structure is 16.561MPa， the maximum deformation is 0.14705 mm and the first three order natural frequencies are 19.258 Hz, 21.187 Hz and 63.44 Hz. And the weak links relatively of the structure were found out. Analysis results show that the structure of the airborne pod system has a good performance and can meet the requirement of airborne conditions.

Introduction

In recent years, with China's energy development center gradually moving to the West and North, ultra high voltage transmission line distribution became more and more broad, the regional topography became more and more complex and natural environment became worse and worse. High voltage transmission wire and tower attachment have long been under the effect of mechanical tension and electrical flashover, circuit aging, freezing and so on, which would lead to the phenomenon like broken strands, wear and corrosion. Therefore, it is very necessary that carrying the inspection for transmission line at regular intervals, grasping and understanding the operational aspect of transmission line, the environment around the line and the change of the line protection area at any time and timely detection and elimination of hidden dangers to prevent accidents and ensure the safety of power supply. And the difficulty of the inspection in the complex environment makes the automation and modernization of the inspection increasingly urgent [1].

For the reason above the Air-borne pod system was designed, which installed in the flying platforms including the fixed wing aircraft, helicopters, unmanned aircraft, airship. Through the optical system of the gyro stabilized platform closely inspect high voltage overhead transmission line and monitor the operating condition of high voltage overhead transmission line. The stable image information can be obtained [2]. So, this paper uses the finite element software to analysis the structure of the pod system, find out the weak links of the system and provide suggestions to optimize the structure. It has an important significance for the stable operation of the airborne pod system.

Pod system structure finite element analysis

For making finite element analysis, first of all, modeling in 3d software according to the actual model. The holes, chamfering and some other local parts that will not affect the analysis should be simplified. And then it should be converted into universal file format like STEP, IGES and Parasolid and so on. Next, it was imported into the finite element software to make pre-processing of the analysis and submit analysis.

The 3d model was built according to the pod system entity by using the Solidworks . After completing the various parts of the assembly, they were assembled into a whole part as shown in figure 1. And then it was converted to the parasolid format and imported to the Ansys workbench environment to make finite element statics analysis and modal analysis respectively.

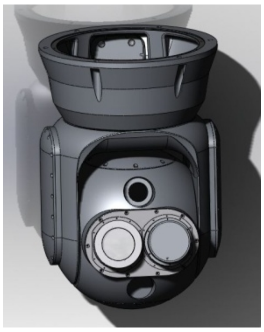


Fig.1 3d assembly model for the structure of the pod system

According to the pod system entity model select four kinds of materials: glass, rubber, aluminum alloy and structural steel. Different parts of the pod system model use different materials respectively.

Pod system integral structure is connected to the aircraft through the top of the base. So the constraint should be add on the top face of base and all constraints for the six degrees of freedom should be defined. They are mainly rigid connections between various components, so they were set as bonded. The mesh was divided by using automatic mesh generation function [3]. There are a total of 537179 elements and 1016250 nodes. The effect of mesh is shown in Fig 2.

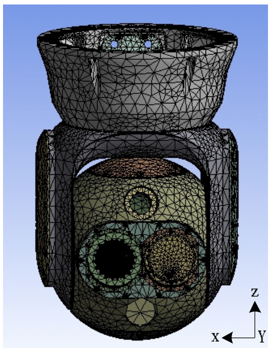
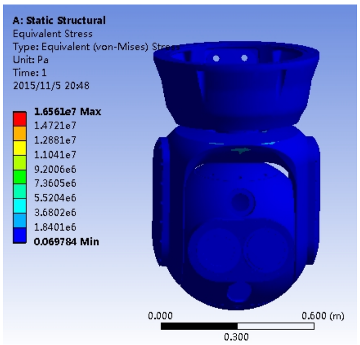
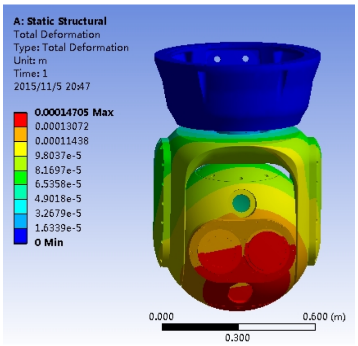


Fig.2. The finite element mesh of the pod system structure

The static analysis of airborne pod system

The airborne pod system is suffered acceleration load of different situations in the process of the aircraft flying. According to the numerical statistics of acceleration sensor in the aircraft flight control system, the acceleration is less than 10 m/s2 generally. So in addition to the gravity load, the acceleration loads of 10 m/s2 in the x, y, z directions were added in the statics analysis [4]. The rationality of the design of its structure was verified through the stress and strain distribution of the airborne pod system in the finite element statics analysis. The stress and deformation distribution of the airborne pod system structure are shown in figure 3a and b respectively.





(a) The stress distribution (b) The deformation distribution

Fig.3. The stress and deformation distributions of airborne pod system structure

The maximum stress is 16.561MPa, mainly in the joint of the base and the following parts. The maximum deformation is 0.14705mm, located in the lower part of the entire pod system. Static stress and the deformation data verified the rationality of the structure design of airborne pod system.

Modal analysis of airborne Pod System

Basic theory of finite element modal analysis. Modal analysis is the most basic content of all the types of dynamic analysis. It is very important to understand the dynamic characteristic and the structure optimization through carrying on modal analysis of the structure. Modal analysis can identify the inherent characteristics of the structure (natural frequency, damping ratio, mode shape, etc.) that are not related to the excitation [5].

The mode of airborne pod system. Modal analysis is to examine the inherent characteristics of the structure. So simply set the constraints without the need to add other loads. And generally only the first few natural frequencies and the corresponding vibration modes are concerned about, so set extracting the first 6 order modes [6]. The first six of the natural frequencies are shown in Table 2, the corresponding modes are shown in Figure 4.

Table 1 The first six natural frequency of the pod structure

order	1	2	3	4	5	6
Frequency（Hz）	19.258	21.187	63.44	92.818	126.71	147.64

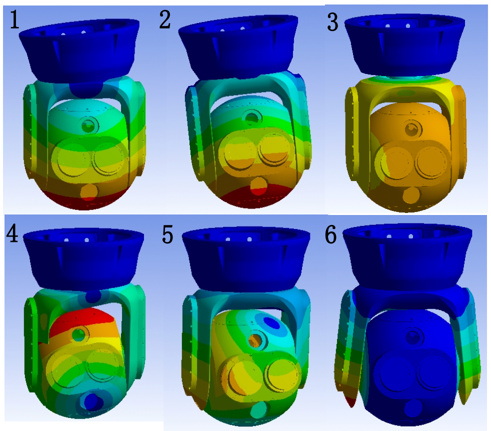


Fig.4. The first 6 modes graph of the pod system structure

Among them, the first vibration mode is the assembly under pod base swing along the X direction, the second vibration mode is the assembly under pod base swing along the Y direction, the third vibration mode is the assembly under pod base swing along the Z direction, the fourth is the twist of the assembly under pod base in the Z direction, the fifth is the twist of the assembly under pod base in the Y direction, the sixth is the swing of the two frameworks from opening to closing and from closing to opening.

Conclusion

The character of airborne pod system's structure has significant impact on the work of inspection. The airborne pod system's static character including stress and deformation with the gravity load and inertial load and the dynamic characteristic are understood through the system's static analysis and modal analysis by using finite element software. The maximum stress is 16.561MPa. The maximum deformation is 0.14705mm. The first three natural frequencies are 19.258Hz, 21.187 Hz and 63.44Hz. The analysis shows that the airborne pod system's structure has an excellent performance which satisfies require of this system's work environment basically and makes sure that optical system could capture the target image smoothly. Structural optimization Based on the results of the analysis can improve the performance of the system structure further and provide higher assurance for inspection work.

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