Rapid Design of Composite Light Aircraft Wing Structure

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Abstract: The composite material ratio of aircraft structure is one of the important indexes to measure the height property of aircraft. The rigid wall structure can effectively improve the support strength and stability of the structure, reduce the weight of the structure, and is widely used in composite wing structure. The heterogeneous mechanical properties of composites greatly increase the difficulty of structural design, especially the rapid design. At present, most of the optimization design methods of the enhanced wall panel depend on the detailed model of the finite element or the agent model, thus obtaining a large number of calculations and a long design cycle. Therefore, it is an important project to study the fast design method for composite wing wall structure. A fast design method for the reinforced wall structure with different section shapes is proposed. Based on the equivalent model of the reinforcement wall, the theoretical calculation methods of the overall force, local sitting position and torsional sitting position of the reinforcement plate are put forward. In addition, the reinforced plate structure with light weight and high load efficiency is optimized. The optimization results are verified by the finite element software. In this paper, the load calculation, material selection and shape selection of the light aircraft wing structure are carried out, and the wing correction design is completed by using the high-speed design method. Based on the verification design model, firstly, the plug-in ear which has a great influence on the transfer force is designed rapidly, and then the detailed optimization design of the wing is completed by using narland, and the weight of the wing is reduced.

1. Introduction

General airplanes are widely used. Although the functions are different, the characteristics of ordinary aircraft are small flight speed, generally below 100M / s, light weight and relatively small wing load. The aspect ratio is the medium. The airfoil of the wing adopts a relatively large thickness of relatively low-speed wing, and the structural height of the wing box is relatively high.

2. The Development of Composite Structure

After the 1920s, aluminum alloy was widely used for the lightweight of aircraft structure. That's more than 90 years old. How to reduce the weight of aircraft structure is an important problem in aircraft design and manufacturing. The rapid development of information technology, material technology and manufacturing technology has brought about great changes in modern aircraft design and manufacturing technology[1]. High strength and low density composite materials can greatly reduce aircraft weight and improve performance. In the aspect of aircraft structure design and manufacturing, its appearance and extensive and successful application make composite materials gradually replace aluminum alloy as the main material of aircraft structure. Compared with traditional metal materials, composite materials have the following characteristics. Specific strength and specific stiffness are important indexes of material properties. Whether the structure can reduce weight or not depends on this property of the material. Can be specified. Composite materials have heterogeneous properties, which can be designed and cut according to the service conditions and stress conditions to improve the utilization efficiency of materials[2]. Good anti fatigue performance. Generally, metal materials have good fatigue properties, especially tensile

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fatigue properties. Large area of complex shape is easy to form and manufacture. Composite materials have a variety of process forming methods, which can be large integral parts and components with complex surface shape, can greatly reduce the number of parts and connectors, thus reducing the manufacturing cost.

2.1. Rapid Design of Composite Reinforced Structure in the Optimization Design of Composite Wing Wall Panel Layout, the Following Difficulties are Faced.

The mechanical properties of the composites are different from those of the traditional materials. In the design process, more design parameters need to be considered to make the calculation more complex. The finite element mesh is often associated with the physical topology of the model. In the aspect of layout optimization, it is necessary to reconstruct the finite element model when changing the location of the stiffener, which has an uncertain impact on the layout optimization of the wing panel structure. In the finite element analysis of flat plate structure, there are two main calculation models. One is to simulate skin through shell elements, the other is to simulate ribs through beam elements[3]. Because the one-dimensional element can not simulate the specific section shape of the rib, the calculation error is very large. Another mode is to simulate between shell and component. No matter which optimization algorithm is used, as long as it needs to be based on the actual model, it needs to establish multiple model files, so as to reduce the efficiency of optimization. The composite wing is taken as the research object. According to the simple model of the box section structure, the theoretical calculation method of the sitting position and instability of the reinforced wall is studied. In order to realize the rapid design of composite wing wall structure, the rapid design method of plate structure with section rigidity is adopted to make the structure of different rods more stable.

2.2. Strength Requirement

The strength, stiffness, stability, aeroelasticity and other design requirements should be considered in the design of composite wing structure. Among them, the strength and stiffness of the wing are the most basic and direct design requirements[4]. As the wing material of the aircraft uses fiberglass composite material, the overall strength level of the wing is controlled according to the allowable distortion from the point of view of simplified design.

2.3. Technological Requirements

The angle of the hybrid disc of the composite wing row is 45°. You need to make sure that the scale of each angle layer is greater than 10%. In general, the number of 90 degree layers must be greater than or equal to 1. For the upper and lower skin, due to the thin skin load at the front and the end of the wing is small, the impact damage performance of the structure is weak, and it is easy to peel when using. In order to improve the impact resistance of the composite structure, the minimum thickness of the hybrid optical disc material is 4 mm, and the outer layer is 90°. This ensures that the skin at the front of the wing has good impact damage performance and handling performance.

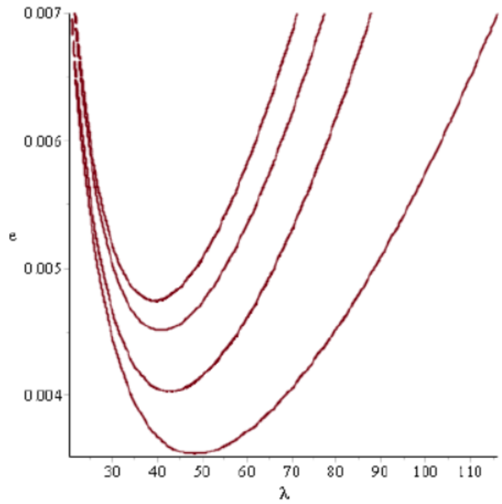

Figure 1 Relationship between skin strain and local buckling wavelength

2.4. Stability Requirements

Skin and spur are important parts of the wing to bear bending moment. Therefore, the buckling criterion of wing structure is unstable under ultimate load and will not be damaged under design load[5]. However, the post buckling analysis is more complex, and the structural details are difficult to determine temporarily. The primary instability characteristic shall be greater than 1.

3. Basic Methods of Material Selection Analysis

The bearing strength of the material reflects the ultimate stress of the test piece under tensile, compressive and bending forces. The failure of wing structure is mainly due to the decrease of structure stability. The ultimate failure stress is lower than the allowable strength of the material and can not reach the ultimate performance of the material. It is necessary to pay attention to the supporting force of the structure, which is generally determined by the stress of the structure when it is initially bent. The results show that the specific strength and stiffness of carbon fiber composite are the largest, and the mechanical properties are the best[6]. But it costs about five times as much as fiberglass. The specific rigidity of glass fiber composite is different from that of aluminum alloy. Aluminum alloy has a more mature processing technology, and the cost of glass fiber is the lowest. From the perspective of low-cost design of light aircraft, fiberglass composite material is selected as the main material of wing. The selection of high-strength fiberglass composite materials that have been manufactured in China has the advantages of low price, good process performance, wide procurement channels and mature technology.

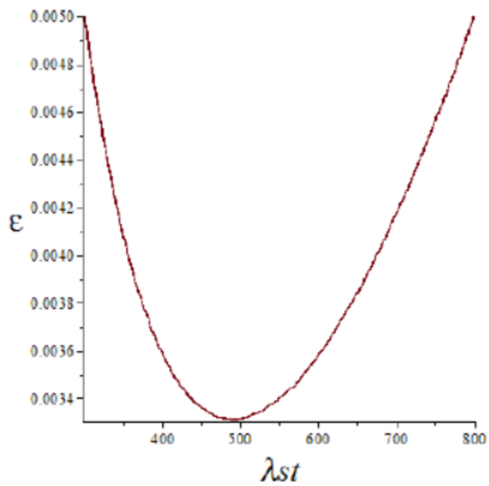

Figure 2 Relationship between axial compression strain and half wavelength of torsional buckling

3.1. Wing Configuration Selection

The single rotating wing mainly relies on the wall plate composed of skin and ribs to convey the strength and has good rigidity characteristics. At the same time, it disperses the structure force, the relative height of the wing is small, and the structure efficiency is high when the load is large. But the design separation surface of single chip microcomputer wing must adopt the form of peripheral connection. The structure of this connection is complex and it is difficult to assemble.In addition, when the thickness is 3.9 mm, if the reinforcement ratio is 1.0, the root skin thickness is 1.95 mm, and the skin thickness is smaller. The single chip microcomputer wing transmits the bending moment through the main wing wall plate. If your skin thickness is small, you need to pay a larger extra weight to ensure wing stability. The wing load is mainly transmitted at the end of the beam, the skin load is small, the stability is easy, and the structural efficiency is high[7]. Therefore, according to the aircraft type, linear wing, relatively high wing thickness, relatively small wing root bearing characteristics, easy to install and maintain the concentrated force joint, double beam wing is selected.

3.2. Arrangement of Ribs and Ribs

The stiffeners need to be placed on the wingman docking, ejection, large opening, concentrated force and flap support points. Since the trailing edge of the inner wing is flap, as the wing support body and the tail of the wing, reinforcement materials are set at the root of the wing. The ribs are fixed. At the same time, these two ribs can also be used as wall plates of the whole fuel tank. This part can be used for multiple purposes and can reduce the weight of the structure. The length of the sheet is very long. In order to improve the bending resistance of flap, more than two hinges are usually set on the flap to reduce the bending moment of flap. Generally speaking, the three-point hinge is the most suitable, the length of the aircraft flap is moderate, and no excessive hinge is required. Use a three-point hinge. Therefore, a reinforcing rib is arranged in the center of the rib at both ends of the inner wing for installing the flap hinge[8]. The outer wing is equipped with Elon. Elon is the same length as the outer wing. Therefore, the outer rib of the inner wing is also the inner rib of orlon and the hinge support rib of Elon. The end rib of the outer wing and the hinge support rib of Elon. The length of Elon is not very long, so according to the purpose of the aircraft, there is no need to over steer and Elon will not be loaded. Thus, instead of being supported by a third hinge, Elon is only used for two-point support at both ends of the outer wing[9]. As a result, the outer wing has only two stiffeners.

4. Conclusion

Select the wing of the light aircraft as the design object. Based on the design requirements, the calculation method of the wing balance load is studied, and the load at the maximum flight speed in the design envelope is selected[10]. The accuracy of the high-speed calculation method is compared and verified. Considering the efficiency coefficient of Farrar structure, the material of each part of wing is analyzed and selected. Finally, the wing structure is designed by the fast design method, and the reliability of the model calculation is verified by the finite element analysis.

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