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Analysis and Design of Aircraft Center Wing Structure Transfer Force

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Abstract: In the design of fuselage structure of civil aircraft, the connection of main body of wing is the most important, so it should be considered in the design to replace the central wing rear beam frame with the main body of large wing at this joint. In this paper, by comparing the design of several mature aircraft models, the view of the design of the rear beam frame of the central wing of civil aircraft is widened.

1. Introduction

In the design of civil aircraft, the design of the connection between wing and fuselage has always been one of the focuses and difficulties of aircraft structure design. The main elements of wing main body connection and force transmission are the front and rear beam frame of the central wing, spiral beam, side panel of the central fuselage, floor of the central fuselage, etc. the front and rear beam frame of the wing play an important role in the connection and force transmission of the main body of the wing. In order to avoid unreasonable design and subsequent changes or losses, this article uses mature model design to explain the design concept.

2. Force Analysis

For the purpose of using the lower single wing layout, the fuselage layout reinforcement frame corresponds to the front and rear beams of the wing, which is called the front and rear beams of the central wing. The front and rear beams are shown in Figure 1 and are integrated with the upper and lower edges of the front and rear beams of the wing and the upper and lower edges of the wing. The overall internal forces of the wing: bending, shearing and twisting are balanced by the support forces provided by the fuselage. As for the wing with swept wing, most of the symmetrical bending moment of the central wing is balanced by the wing structure itself and will not be transmitted to the fuselage[1]. The unbalanced load of the wing is transmitted to the fuselage through the wing fuselage docking fixture. As shown in Figure 2, the shear force Q, torque MT and antisymmetric bending moment of the wing are transmitted to the fuselage. Note: 1-upper panel of central wing; 2-front beam; 3-rear beam; 4-side stiffener; 5-axial force exerted by outer wing on upper panel of central wing; 6-reaction force exerted by web of central wing beam to panel; 7-reaction force exerted by joint of wing fuselage to web of central wing beam; 8-web of central wing beam. Analysis on transfer force of negative load of wing is as follows: shear force Q: shear force from front and rear beam to joint joint joint Transfer, through the joint to the front and rear beam frame of the center wing. Bending moment M: the bending moment is generated by the upper and lower plates of the central wing[2]. It is also divided into symmetrical bending moment and antisymmetric bending moment. Symmetrical bending moment: the axial force of the left and right wing panels enters the center wing panel and is balanced at the center wing. The axial force of the moment is divided into two components. The SDB code is transmitted to SDB and converted from SDB to two vertical shear forces. The axial force component is transmitted to the upper and lower wall panels of the central wing, and the nest of the span beam of the central wing is cut off. Through the ribs to the side ribs. Torque MT: part of the torque is transmitted to the kill beam and the main lift longitudinal reinforcement material through the lower panel of the center wing. The main lift vertical

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reinforcement will be transmitted to the center fuselage frame and siding, part of it through the left edge of the center wing and the other branch to the center fuselage siding. Then, through the upper wall panel on the center and the front and rear beams, the parts are transmitted to the ground beam of the main body and the front and rear docking frames.

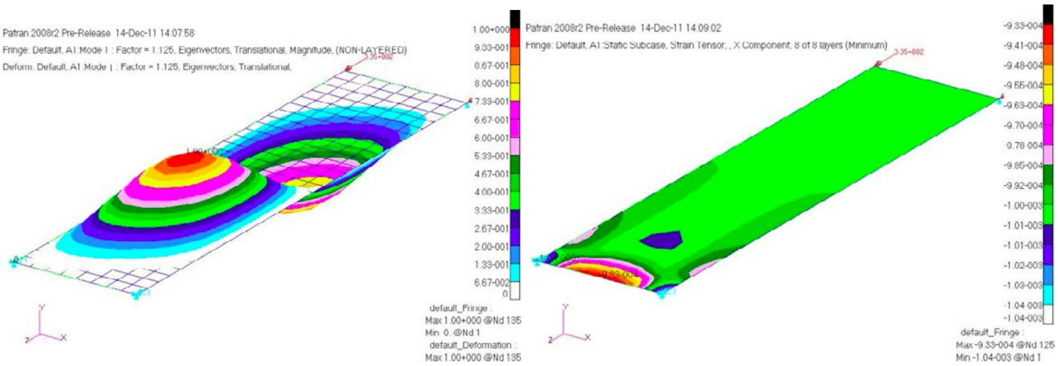

Figure 1 Analysis results of composite simply supported compression siding

3. Typical Design

According to the analysis, the front and rear beam frame of the central wing mainly transmits the shear force and part of the bending moment through the wing. Because of the circumferential area of the swept wing, the bearing capacity of the beam frame at the back of the center beam is about 3 times of that at the front of the center wing. This paper introduces the design of the center wing rear beam frame as an example. Figure 3 shows the design of the rear beam frame of the center wing of the aircraft. In addition, the rear frame of the center wing is designed to form a fork shape at the connecting part with the center wing. Because of its force transfer characteristics, the design has the following advantages. It can avoid the fatigue problem caused by too strong wing body connection[3]. That can reduce the weight of the structure. The side of the trunk skin near the ground of the upper wing of the central wing is a large area of load carrying communication. Therefore, the lower area can be appropriately reduced. Therefore, after the failure of the inner structure and outer frame of the folk song component, the way of power transmission is enhanced to reduce the risk. However, the design analysis of the center wing rear beam frame should avoid some bad design, such as cross load, as shown in Figure 4. If the rear frame of the center wing of the aircraft structure is designed to carry horizontal stripes (i.e. the span of the wing), fatigue cracks will occur in the path of the horizontal structure. And, therefore, the safety of the aircraft is in danger. The center wing rear beam frame only conveys the large concentrated shear force here.

4. Characteristics of Central Wing Structure

The center wing structure is mainly used as the connection box of left and right wings. Shows the central wing structure of a typical civil aircraft. The main functions are as follows. As the connecting box of the left and right wings, it can bear the load of lifting, bending moment, torque, etc. from the left and right wings. The connecting box part between the wing and the fuselage is balanced with the fuselage load and used as the fuel tank. The central wing tank is actually a comprehensive fuel tank which integrates the bearing function and fuel tank function. In order to meet the above functional requirements, the central wing box structure has the following characteristics. At the same time, the front and rear crossbeams are also the lower part of the central main reinforcement frame. The front and rear beams are located inside the fuselage and will not be impacted [4]. Therefore, CFRP (carbon fiber reinforced plastic / plastic) reinforcement plate can be used for rolling. The left and right side panels are relative to the surfaces of the memory components that are vulnerable to impact. There, titanium and aluminum alloy strengthened panels were used, and CFRP reinforced panels were used. Because the upper panel is on the inside of the body, CFRP reinforced rolling is used. There's a Kiel beam down there. Further intermediate zoning to prevent the use of oil lines and other components. The whole structure is designed and sealed according to the design requirements of fuel tank. In order to illustrate the structural characteristics of a typical central wing structure, a 320 central wing structure is used. The central wing box of a 320 aircraft is located between 36 and 42 frames of the aircraft fuselage. It includes top and bottom wall panels, left and right side wall panels (1 rib for outer wing), front and rear beams, and fuel tank. The same parts as the inner column. Among them, six arch aluminum alloy beams are set above the upper wall panel, which separate the central wing tank from the engine room floor and buffer the payload from the engine room floor on the upper wall of the tank. The upper and lower wall panels of the a 320's central wing box are chemically crushed variable thickness aluminum alloy plates. The main purpose is to reduce the weight of the structure. Below the upper panel and above the lower panel, horizontally in a direction perpendicular to the torso axis. On both sides of the central wing box of a 320 aircraft is a chemically mixed variable thickness sidewall panel with a thickness of 2.5-12mm[5]. And, the perimeter will be strengthened. Among them, the leading edge and the trailing edge are respectively composed of T-shaped aluminum reinforcement materials with thin section shape, the upper edge is reinforced by section aluminum profile, and the lower edge is irregular aluminum reinforcement materials. The strengthened beam is installed, and the oil hole is opened on the side wall panel to make the fuel flow between the wing tank in the center and the outer wing tank. In order to facilitate the connection with the outer wing box, a T-shaped section is also arranged under the side wall plate of the central wing box. At the edge of the sidewall panel, on both sides of the hanging wall, the central wing box is connected to the 42 frame foot fuselage 36 by a number of pieces.

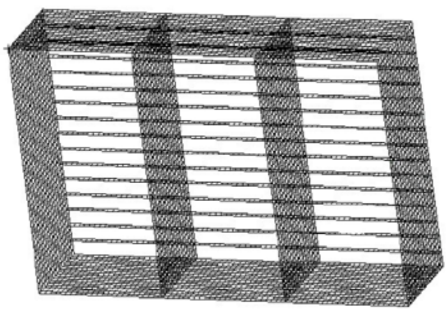

Figure 2 Single block structure model

5. Wing Structure Design and Optimization of New Regional Aircraft

High end civil aircraft is not only high-speed, safe and comfortable, but also has the characteristics of fuel saving, low environmental pollution, low operating cost, long-term free maintenance, low maintenance cost and so on. In order to achieve these goals, structural design, material and manufacturing technology innovation are needed[6]. Airbus a 380 uses 2099, 2199, 2196 and other aluminum lithium alloys. This is used in the floor structure of anti-collision beam, monorail, anti-collision beam and emergency carbine gun, electronic equipment bracket and corner. That's hundreds of kilograms less than traditional materials[7]. At the beginning of the design of A350, considering the maximum performance characteristics of different materials in material selection, it is applied to the best components. The new regional aircraft is a civil airliner for 2020. Its structural design must meet the requirements of the anti void rule, and have sufficient safety, reliability and economy in the expected service life. The structural design of aircraft in New Area will adopt advanced structural design technology and integrate advanced finite element analysis technology into structural design. It can reduce the maximum stress level of the structure, improve the fatigue characteristics of the key parts of the structure, and improve the overall damage bearing performance of the structure. The wing structure of the new regional airliner consists of main bearing support structure, wing auxiliary structure, fuselage and wing connecting parts as well as the whole fuel tank. The main bearing structure of the wing is a box section structure formed by the front wheel, rear beam, rib, long beam and the skin of the box between the front beam and rear beam between the front end of the left and right wings. The main wing is supported by the box part of the main bearing structure, which supports the bending, shearing and torsion of the wing. The front and rear beams are also the main supporting structures of the main upper and lower driving gear support grooves and each control groove. The auxiliary structure of the wing includes the wing end, leading edge and rear beam except the control surface. The front edge of the rear toe is connected with the rear toe by a detachable pull lock, and the wing piece is detachable for easy inspection and maintenance[8]. The connecting parts of fuselage and wing include the connecting parts of front and rear beams, reinforcing frames, central wings and fuselage. Fuel tank is the main place to store fuel.

6. Initial Conditions of Wing Structure Design

According to the calculation of the external load of the aircraft structure in the new area, the wing load is mainly divided into three categories: Wing balance load, wing whirlwind load and wing asymmetric load. The whirlwind load is the ultimate load of the wing[9]. After unloading the inertial load of the wing, the ultimate load of the wing is 52K, the direction is upward, and the safety rate is 1.5 times, so the final load of the wing is obtained. The air load distribution of the wing is calculated by dipole grid method, and is automatically loaded into the finite element nodes of the wing by Patran. The main bearing structure of aircraft wing in new area is carbon fiber composite prepressing tape. CCF 300 / BA 9916 is the single chip microcomputer. In order to simplify the process, the central rib of the side box is made of 7050t 7451 aluminum alloy.

7. Conclusion

The structural design of civil extension should be based on the consideration of its force transfer characteristics. The safety of damage should be considered in the area of main transmission, single transmission and large load transmission.

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