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DESIGNING COMPOSITE HORIZONTAL STABILIZER

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The task to make structure as light as possible with sufficient strength is a fundamental task of aircraft engineering. In recent years, engineers have been directed at the extensive use of composite materials in heavy-loaded primary structures such as wing, fuselage and empennage components. The object of the paper is to develop a structure of Airbus A320 horizontal stabilizer considering the use of traditional metal and composite materials.

A horizontal stabilizer is an aerodynamic surface, that provides the longitudinal stability and control of the aircraft. It bears weight and aerodynamic loads and transfers them to the fuselage structure [1]. A horizontal stabilizer is loaded by weight and aerodynamic loads. The weight load was neglected from consideration because it is much smaller than the aerodynamic load. In turn, the aerodynamic load includes balancing, maneuver loads and loads during the flight in turbulent air. The action of 2nd maneuver load is the most dangerous loading case. Thus, it was selected to be the design loads for further calculations.

The paper considers two principal load-carrying schemes. The metal version of the A320 horizontal stabilizer represents thin-metal solid skins over a substructure with two spars, 14 normal and 4 strong ribs. The ribs are vertical to the most loaded second spar. Metal spars are in the area of maximum structural heights of the airfoil. The design calculations of the principal cross-sections of the main structural elements were carried out considering that the allowable stresses for selected aluminum and steel alloys are respectively equal to 300 MPa and 710 MPa.

In case of composite version, the A-320 horizontal stabilizer is a two-spar, four rib-stiffened structure with sandwich skin construction. The skin bears some torsion and shear force from spars that allows to eliminate normal ribs and simplify the structure. Composite skin panel is to be made using vacuum infusion technology. Sandwich panel consists of several layers of carbon fabric at the top and bottom face sheet and a foam plastic between them [2], the laminate lay-up can be presented [45/0/45/f/45/0/45]. A symmetric lay-up was selected to receive better bending properties of the laminate. It should be also mentioned, that sandwich construction needs to be designed from orientation, thickness and number of layers and the sequence of their layout [3]. According to the loads distribution, sandwich construction with countless number of fabric layers and thickness of foam plastic was arranged at different areas of skin to provide sufficient strength. It also reduces unnecessary weight. The thickness of bearing layers of the laminate was calculated considering the shear strength condition under the action of tangential forces. The thickness of foam plastic was determined from the condition of maintaining the shape of airfoil, considering the condition of sufficient bending stiffness.

The geometric models of two versions of A320 stabilizer were generated by means of ANSYS software. ACP modular of ANSYS was used for modelling composite skin. The static structural analysis of both models shows that the equivalent stress and strain of the main metal structural elements are less that the allowable values. The analysis of load-carrying work of a composite skin was carried out using criterion of maximum stresses. The distribution of the special criterion over the sandwich thickness is not critical.

The weight of conventional stabilizer structure is 336 kg, meanwhile the composite version is 12% lighter. In this way, structural weight reduction is the key advantage in using composite materials without sacrificing strength and stiffness of airframe structures.

References

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