Topological Optimization of Fan Blade of Ultra-High Bypass Ratio Turbofan Engine

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Abstract

For aircraft components, particularly power plants, minimizing weight is a key criterion. One of the trends in modern engine manufacturing is the development of engines with high and ultra-high bypass ratios. A distinctive feature of such engines is the fan, the diameter of which can reach 2–4.5 m. Consequently, the weight of the fan assembly is quite significant. Reducing fan weight is an important and pressing issue for ensuring high-efficiency next-generation engines. This work addresses the problem of minimizing the weight of fan blades for a high-bypass ratio turbofan engine. The fan diameter is 2.94 m, and the fan blade height is 1.17 m. This paper presents a topological optimization of a fan blade. Several variants of the objective function are considered. The initial data for the topology optimization include a geometric model of the blade and inter-blade channel, and an aerodynamic calculation performed in Ansys CFX. The Ansys Mechanical module was used for topology optimization, taking into account the distributed aerodynamic load, fan speed, and blade material. To minimize the weight of the inner blade, it was divided into a 2 mm-thick shell and an inner section, which was then topologically optimized. As a result of the research, the weight of the blade under study was reduced by 30% to 60%, depending on the objective function. The next stage of the research is to create a new geometric model of the fan blade based on the topology optimization results and conduct a strength test.

Keywords

Topological optimization, fan, blade, turbofan engine, weight, CFD, ultra-high bypass ratio.