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Numerical Calculation of the Stress-Strain State of an Aircraft Nacelle Attachment Element

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Abstract: This paper presents the results of numerical modeling of the stress-strain state of the strut of a transport aircraft nacelle using the finite element method (FEM). The objective is to construct a computational model and analyze the stress-strain state (SSS) of the nacelle attachment element under combined loads occurring during aircraft operation.

Keywords: Stress-strain state, finite element method, nacelle, numerical modeling, strut.

Introduction:

With the development of aircraft manufacturing, the study of the strength and reliability of aircraft nacelle attachment elements has become increasingly relevant. One of the key attachment elements is the strut, which is subjected to static loads. A computational model of such a complex system should comprehensively reflect all major factors and interdependencies characterizing real operating loads.

Materials and Methods:

To analyze the stress-strain state of the nacelle attachment element, input data, including the magnitudes and nature of applied external loads, were used. The calculation was performed using FEM [1, 2], whose effectiveness has been confirmed for a wide range of solid mechanics problems [3]. The obtained results, including the distribution of stress, strain, and displacement fields in the structure, serve as a basis for assessing the static strength and service life of aviation structures throughout the entire lifecycle of an aircraft. During the calculation of the stress-strain state, an idealization of the computational model was performed: the stress-strain state was determined in the primary load-bearing elements of the structure without considering stress concentrations caused by local design and technological features (holes, notches, etc.).

Results and Discussion:

Consider the stress determination for the strut. For the analysis of the stress-strain state under tensile and bending loads, the strut was modeled as a cylindrical shell with a fixed support at one end and a hinged support at the opposite end. The cylindrical shell was subjected to axial force and bending moment. Tension or compression of the tubular specimen was induced by forces acting along its axis. Thus, in the cross-sections of the strut, only one of the six internal force factors arises—the axial force N. In the case of pure plane bending, only one of the six possible internal force factors is nonzero—the bending moment M.

Geometric characteristics of the baseline strut: the outer diameter of the tubular section of the strut was 60.5 mm, and the inner diameter was 52 mm. The strut material was Steel 30KhGSA. To study the stress-strain state, a three-dimensional geometric model of the strut was created according to the aircraft's design documentation (Fig. 1).

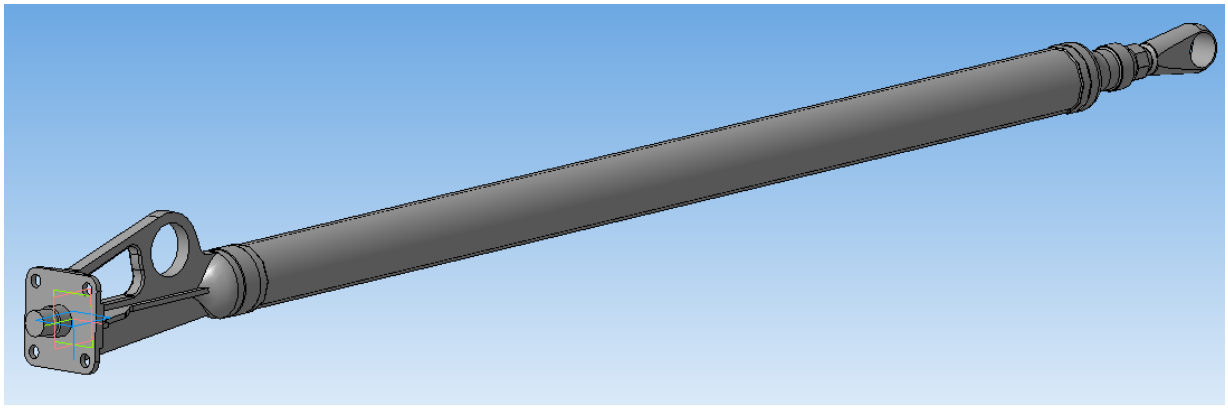

Fig. 1. 3D Model of the Aircraft Nacelle Strut

The calculations were performed using the CAE system ANSYS Workbench, which allows utilizing both solid bodies and surfaces as input geometry. For simplification, we will further use an equivalent model of the strut, specifically its tubular section (Fig. 2).

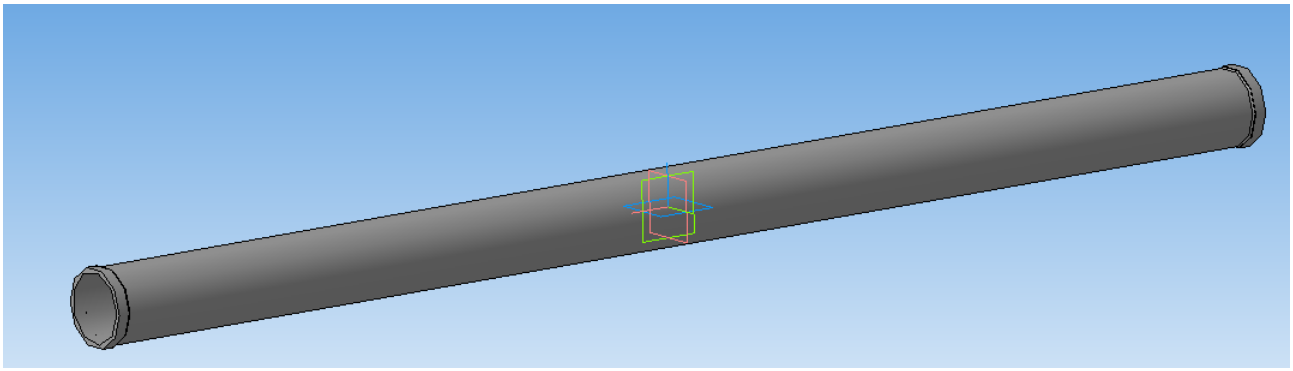

Fig. 2. Tubular Section of the Strut

The obtained three-dimensional model was exported to the finite element analysis software ANSYS for stress-strain state calculations. The computation results are presented in terms of displacement magnitudes and von Mises stress values for the tubular section of the strut under two loading conditions. In the first loading scenario, the applied force consisted of a tensile axial load $N = 26685\ kgf$ distributed along the entire edge of the tube on one side, along with a bending moment in two planes $M = \left[\frac{M_X=23000}{M_Y=15000}\right] kgf \cdot mm$. In the second loading scenario, the applied force

consisted of a compressive axial load N=-22600 kgf and a bending moment in two planes $M = \left[\frac{M_X=64600}{M_Y=10000}\right] kgf \cdot mm$. The highest stress values were obtained in the first loading scenario and are shown in Fig. 3.

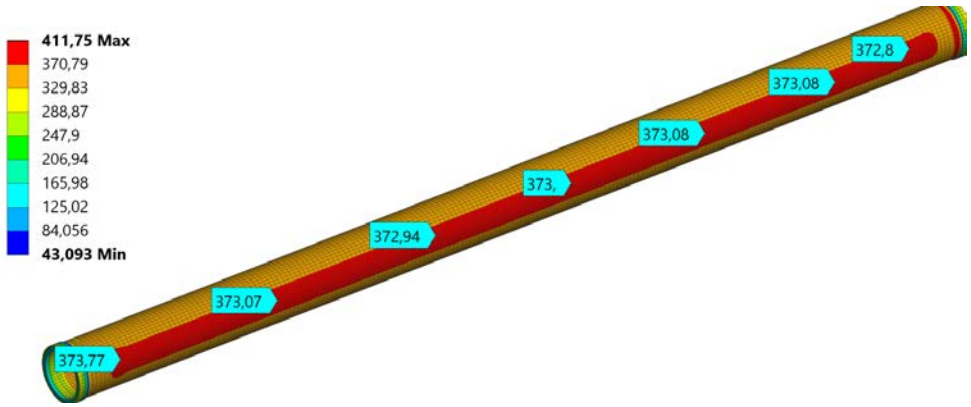

Fig. 3. Von Mises Stress (MPa) for the Tubular Section of the Strut.

Conclusions: This study presents the stress-strain state analysis of a transport aircraft nacelle strut based on the finite element method. The stress values under real operational loads were determined. The stress-strain state satisfies the strength conditions.

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