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THE AIRCRAFT NACELLE BRACE STRENGTH UNDER SOME STATIC TYPES OF LOADS

Ua У зв'язку із розвитком авіабудування актуальною являється задача розрахунку напружено-деформованого стану та розв'язок задачі вагової оптимізації елементів кріплення мотогондоли одномоторного транспортного літака. Одним із елементів кріплення є підкіс, який знаходиться під дією статичних навантажень. У роботі розглянута методика розрахунку підкоса мотогондоли транспортного літака, яка базується на методі скінченних елементів. У якості елемента вибирався тетраедричній скінченний елемент. Були визначені напруження та деформації підкосу, проаналізовано напружено-деформований стан та були дані рекомендації по оптимізації конструктивних елементів.

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En The problem of calculating the stress-strain state and solving the problem of weight optimization of a single-engine transport aircraft nacelle fasteners is relevant In connection with the development of aircraft construction. One of the fastening elements is the brace, which is under the action of static loads.. The method of calculation of the transport aircraft nacelle brace, which is based on the finite element method, is considered in the work. A tetrahedral finite element was chosen as the element. The stresses and strains of the brace were determined, the stress-strain state was analyzed and recommendations for optimization of structural elements were given.

Introduction

Currently, the aircraft industry occupies a significant place in mechanical engineering and every year this part increases. Therefore, there is a problem in improving the parts and structures of the aircraft, in order to reduce the weight of the structure for increasing of the useful weight of the aircraft. Let's look design elements of the aircraft nacelle. The power truss used to attach the engine frame and power frame to the centerplane spar consists of eight braces and attaches it to the centerplane spar brackets and the nodes for attaching the power frame of the brace frame. Braces are made of steel pipes with diameters of 60, 50 and 45 mm with a wall thickness of 2,5 and 3 mm for the convenience of assembling the truss on the plane are connected by bolts with a diameter of 12 and 14 mm. The brace is a diagonal power element of the truss structure that serves to reinforce and stiffen the nacelle.

The brace of the aircraft nacelle (Fig. 1) consists of such main parts as the bracket, the tubular part and the fork. The brace is a diagonal power element of the truss structure, which serves to reinforce and stiffen the nacelle.

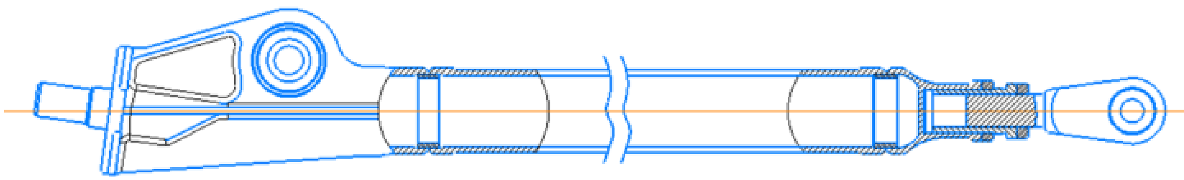

Fig. 1. Brace of the nacelle

Statement and solution of the problem

We consider the brace as a beam on one side is rigidly fixed and hinged on the other, it is acted upon by the longitudinal force and the bending moment in the eyelet. The stretching or compression of the tubular specimen is caused by forces acting along its axis. That is, in the cross sections of the brace sample of the six internal force factors there is only one: the longitudinal force *N*. In the case of pure plane bending of the six internal force factors that can act in its cross sections is not equal to zero only one – the bending moment M. The six components of internal forces will operate at the combined loading, that is at a tension (compression) with a bend, but for the given loading in cross section of a tubular part of a brace only three components of internal forces N, M_X, M_Y will operate [2].

The first load mode

For the first case when stretching with bending the transport aircraft nacelle brace with cantilevered one edge and the other hinged and loaded with longitudinal force $N = 266{,}85 kN$, and the moment in the clamp

$$M = \left[\frac{M_X = 230}{M_Y = 150}\right] kN \cdot mm.$$

The length of the brace is $L = 1526\,mm$, and the size of its tubular part $l = 1120\,mm$.

The second load mode

For the second case, when compressing with a bend of the transport aircraft nacelle brace with cantilevered one edge and the other hinged and loaded with longitudinal force $N = -226 kN$, and the moment in the clamp

$$M = \left[\frac{M_X = 646}{M_Y = 100}\right] kN \cdot mm.$$

The danger of the beginning of destruction is characterized not so much by the values of internal forces and moments in the section, but by the values of the greatest normal and tangential stresses. Therefore, the highest stresses from the condition of reliable operation of the part must be limited to some permissible values. In this case, the strength calculation will be performed with a safety factor of at least *n*=2,4 [3].

To study the stress deformed state, a three-dimensional geometric model of the brace (Fig. 2) was built in accordance with the design documentation of the aircraft in the system.

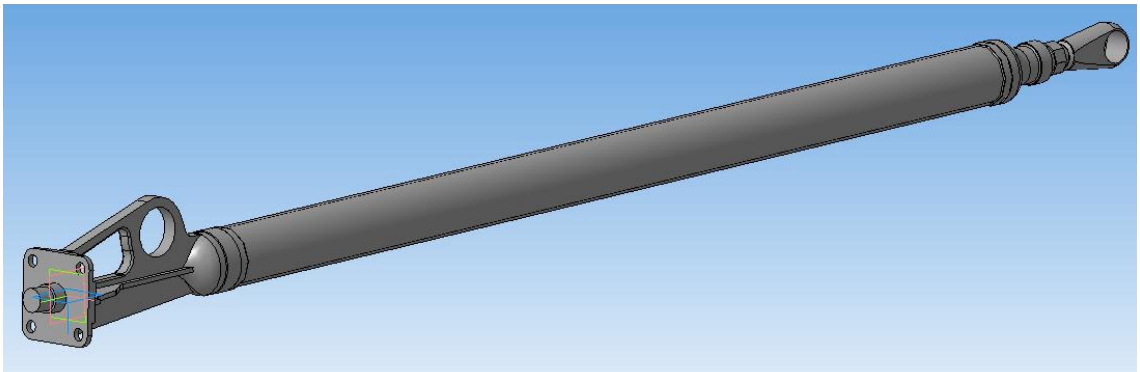

Fig. 2. 3D model of the aircraft nacelle brace

The CAE ANSYS Workbench system was used in the calculations, which allows us to use as the original geometry of both solids and surfaces.

For simplification in the future we will use an equivalent model of the brace, or rather its tubular part (Fig. 3).

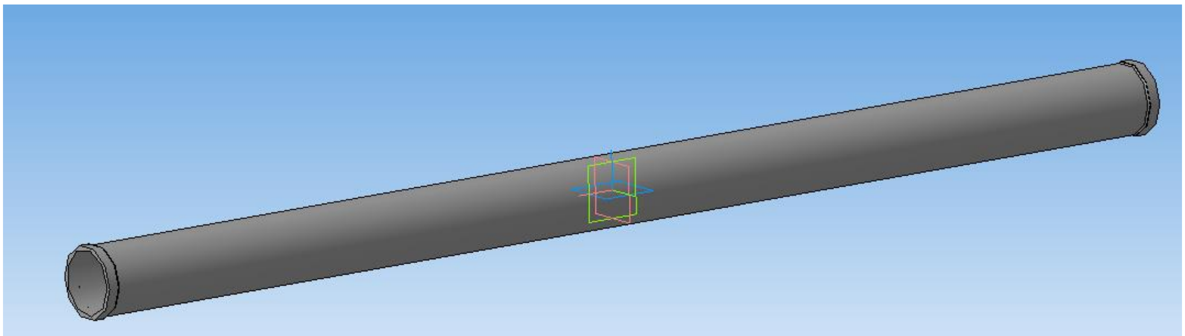

Fig. 3. Tubular part of the brace

Simplification of geometry is carried out by the following sequential methods:

– combining parts that perform one function;
– removal of rounding's and chamfers;
– removal of holes, ledges, grooves;
– creation of a solid surface of the middle body.

The obtained three-dimensional model was exported to the software package of completed elemental analysis ANSIS for the stress deformed state calculation. A tetrahedral finite element was used for the calculation [1 - 3]. As a result of the calculation, the equivalent Mises stresses and displacements were determined.

Determination of stresses for the brace of the base brace. The calculation was performed to determine the Mises stresses and displacements of the tubular part of the brace for the two load modes.

For the first load mode under the following load conditions: longitudinal force is applied along the entire edge of the pipe $N = 266{,}85 kN$ from one part and the bending moment in two planes $M = \begin{bmatrix} M_X = 230 \\ M_Y = 150 \end{bmatrix} kN \cdot mm.$

For the first case at tension with a bend we define durability of a tubular core $l = 1432\, mm$ with cantilever fastening of one edge and with the other hinged fastening and loaded with longitudinal force $N = 266{,}85 kN$, and the moment in the clamp $M = \begin{bmatrix} M_X = 230 \\ M_Y = 150 \end{bmatrix} kN \cdot mm.$ Material of a brace is a steel St30HGSA.

The geometrical characteristics of the base brace were adopted as follows: the outer diameter of the tubular part of the brace was equal to 60,5 mm, and the inner diameter was equal to 52 mm.

The stress distribution for the tubular part of the brace for the first and second load modes is shown in Fig. 4, Fig. 5, respectively

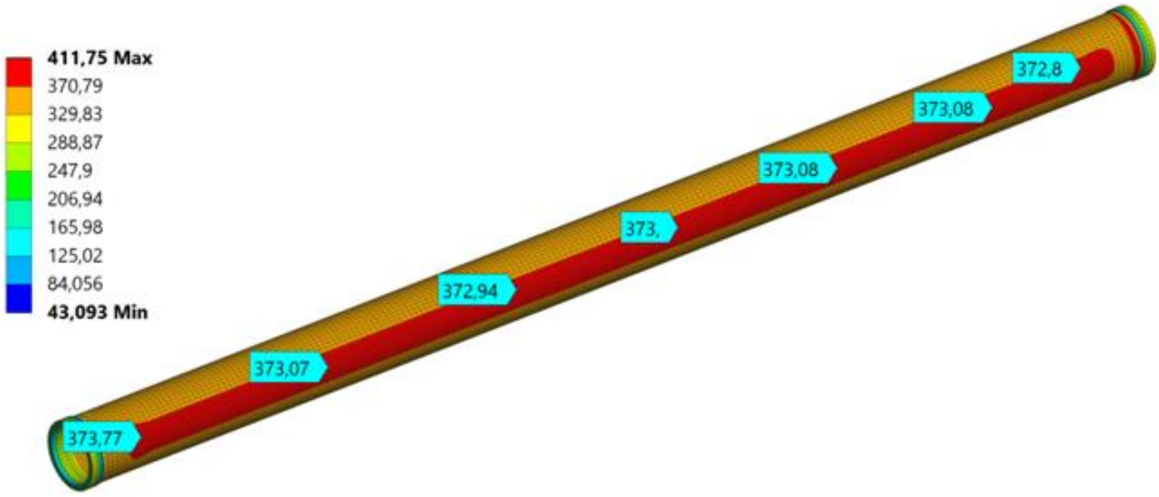

Fig. 4. Mises stress (MPa) for the tubular part of the brace for the first load mode

For the second load mode under the following load conditions:

Longitudinal compressive force is applied along the entire edge of the pipe from one part and the bending moment in two planes $M = \begin{bmatrix} M_X = 646 \\ \hline M_Y = 100 \end{bmatrix} kN \cdot mm.$

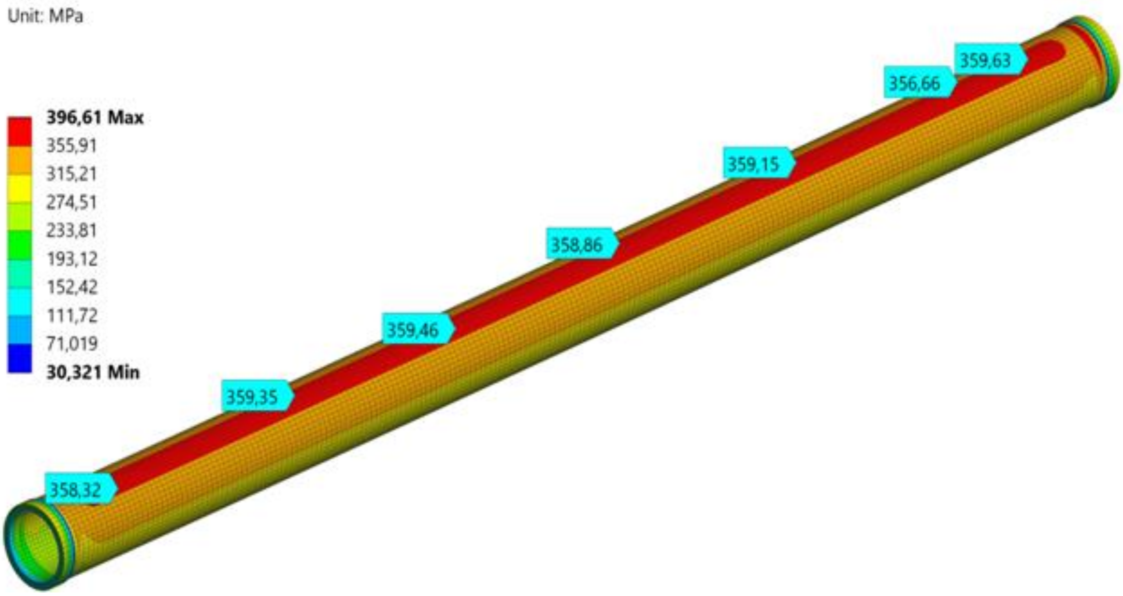

Fig. 5. Mises stress (MPa) for the tubular part of the brace for the second load mode

The purpose of this work was to optimize the brace and calculate the strength with a safety factor of at least n=2,4. Optimization was performed by changing its geometric characteristics, i.e. the outer and inner diameters of the tubular part were selected for a given load. The selection of diameters took place in such a way that at the smallest cross-sectional area was the largest moment of inertia and the strength conditions were met. The geometrical characteristics of the optimized brace were adopted as follows: the outer diameter of the tubular part of the brace was 60 mm, and the inner diameter was 53,5 mm. To calculate the elements of the nacelle for stability, the recommended method is recommended, which is thoroughly presented in the work [4]. Table 1 shows the data for comparative analysis of the stress deformed state of the original and optimized design of the brace tubular part after the calculations by finite element method

***Table* 1.**

Criteria	Initial model		Optimized model	
Load mode	First	Second	First	Second
Displacement, mm	3,32	7,001	4,586	9,123
Equivalent Mises stresses, MPa	373,77	359,63	489,2	471,84
Estimated stresses, MPa	375,6	353,95	486,08	464,6

Conclusions

The paper presents a method for calculating the stress-strain state and weight optimization of the transport aircraft nacelle brace. Stresses were determined at real operating loads. As a result of finite element calculations, it was recognized that it is possible to reduce the weight of the aircraft brace by 20 percent.

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