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CALCULATION THE COMPENSATORS STRESS-DEFORMED STATE OF IN THE AIR SUPPLY SYSTEM

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Abstract. *The paper presents the numerical simulation of the stress-strain state of the bellows compensator in the air intake system of the aircraft. Bellows expansion joints are an integral part of many air or fluid supply systems in many installations and vehicles. To solve the problem of determining the stress-strain state of the bellows compensator in the air intake system of the aircraft, analytical methods are ineffective due to the complex geometry, so it is advisable to use numerical methods of calculation. To build a finite-dimensional model, three-dimensional finite elements in the form of a tetrahedron were used. An analysis of the stress-strain state of the bellows compensator and its main components: cardan ring, crosspiece, inner ring of the hinge, outer ring of the hinge was carried out.*

Key words: *stress-strain state, air intake system*

Introduction.

The development of aircraft construction involves the creation of reliable structural elements in the air intake system of modern transport aircraft, so the urgent task is to determine the stress-strain state of the bellows compensation of the aircraft. Bellows expansion joints are an integral part of many air or fluid supply systems in many installations and vehicles. Due to the presence of com-pensators, the breakage from multi-cycle stresses is prevented. Bellows compen-sator is used to compensate for the thermal expansion of pipelines, as well as to compensate for the lack of coherence in pipeline systems appeared after installa-tion work.

In a critical situation, when the auxiliary power plant (APP) is run, a rapid supply of air is produced, which causes the pipes to heat up. Temperature causes the pipes to lengthen, and it is at this time that the presence of a compensator in the system of the APP plays an important role. The bellows allow them to move without damage to the pipes.

Problem setting and problem solving

Analytical methods are ineffective due to complex geometry in solving the problem of determining the stress-strain state of the bellows compensator in the air intake system, so it is advisable to use numerical calculation methods [1, 2]. Three-dimensional finite elements in the form of a tetrahedron were used to construct a finite-dimensional model , within which a linear field of displacements is specified:

$$u_x = f_1 + f_2 x + f_3 y + f_4 z\,;$$

$$u_y = f_5 + f_6 x + f_7 y + f_8 z\,;$$

$$u_z = f_9 + f_{10} x + f_{11} y + f_{12} z\,.$$

where $f_1 ... f_{12}$ are the arbitrary steels. By equatingat nodal points u_x, u_y, u_z to the corresponding nodal displacements, it is possible to express constants through nodal displacements v^e and to obtain the dependence in the form $u = \alpha v^e$.

Using of the usual procedure allows us to find the stiffness matrix of such an element.

In the three-dimensional case, all six components of deformation are taken into account. We can write the matrix – column of deformations using geometric equations in the form:

$$\{\varepsilon\} = \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \\ \gamma_{xy} \\ \gamma_{yz} \\ \gamma_{zx} \end{Bmatrix} = \begin{Bmatrix} \dfrac{\partial u}{\partial x} \\ \dfrac{\partial v}{\partial y} \\ \dfrac{\partial w}{\partial z} \\ \dfrac{\partial u}{\partial y} + \dfrac{\partial v}{\partial x} \\ \dfrac{\partial v}{\partial z} + \dfrac{\partial w}{\partial x} \\ \dfrac{\partial w}{\partial x} + \dfrac{\partial u}{\partial z} \end{Bmatrix}$$

Stress matrix column is written as in the form in the general case:

$$\{\sigma\} = \begin{Bmatrix} \sigma_x \\ \sigma_y \\ \sigma_z \\ \tau_{xy} \\ \tau_{yz} \\ \tau_{zx} \end{Bmatrix} = [D]\left(\{\varepsilon\} - \{\varepsilon_0\}\right).$$

$$\{\sigma\} = \begin{Bmatrix} \sigma_x \\ \sigma_y \\ \sigma_z \\ \tau_{xy} \\ \tau_{yz} \\ \tau_{zx} \end{Bmatrix} = [D]\left(\{\varepsilon\} - \{\varepsilon_0\}\right).$$

$\{\varepsilon_0\}$ – is the temperature deformation.

The elasticity matrix for the isotropic material has the form:

$$[D] = \frac{E(1-v)}{(1+v)(1-2v)} \begin{bmatrix} 1 & \frac{v}{1-v} & \frac{v}{1-v} & 0 & 0 & 0 \\ \frac{v}{1-v} & 1 & \frac{v}{1-v} & 0 & 0 & 0 \\ \frac{v}{1-v} & \frac{v}{1-v} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1-2v}{2(1-v)} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1-2v}{2(1-v)} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1-2v}{2(1-v)} \end{bmatrix}.$$

This work deals with the bellows compensator in the air intake system of modern transport aircraft, and it determines its stress-strain state with a maxi-mum design pressure of 4,8 MPa.

The stress-strain state of the bellows compensator and its main compo-nents such as cardan ring, crosspiece, inner hingering, outer hingering were ana-lyzed on the basis of modern numerical methods. The calculation was carried out by finite element in ANSYS software package [2].Tetrahedral linear ele-ments were used. The number of elements was 98450.

Equivalent voltages were determined by Mises' criterion.

Conclusion

This approach allows to determine the location of possible destruction of the structure, and to optimize the geometry, which should increase the life of the bellows compensator.

Reference

1. *Trubachev S. I., Alekseychuk O. N.* The calculation of the stress-strain state of the front landing gear transport aircraft. Інформаційні системи, механіка та керування – №11, 2014 р., – с. 88-92.

2. *Trubachev S. I., Alekseychuk O. N.* The strength calculation of energy system pipelines with bends by finite element method. Інформаційні системи, ме-ханіка та керування.– №12, 2015р. – с. 94-99.

3. *Каплун А. Б.* ANSYS в руках инженера : практическое руководство. – М.:УРСС, 2003. –275 с.

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