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THE DYNAMIC ANALYSIS OF ELASTIC ELEMENTS OF CONDENSING DEVICES OF PNEUMOLIFTING INSTALLATIONS AT SKIP MOVEMENT

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Modern information methods are based on the system analysis and consider peculiarities of manufacturing techniques and operation on the basis of car modelin. Their realizations are by methods of nonlinear mechanics of deformation and destruction. In this regard, application of these methods to calculation of lifting vessels (skips) of mine and opencast pneumolifting installations is an actual problem of ensuring reliability of their work, experimental check of the results obtained by theoretical way. Besides, modern theoretical methods of calculation and design of various products and constructions assume active use of the method of the final elements possessing concentrated expression that is the package of the applied ANSYS programs. In this plan the package of the applied ANSYS programs can be used at theoretical and analytical researches as well.

Keywords: mine skip, elastic, elements, pneumolifting, installations, nonlinear, deformation.

It was necessary to develop the method of calculation and modeling designs of skips of mine and opencast pneumolifting installations taking into account constructive technology factors and to create system of the automated analysis for ensuring their durability, reliability and durability. On the basis of the automated system analysis models of designs of skips of the pneumolifting installations considering constructive technology factors were developed.

Imitating modeling of dynamic processes of interaction of basic elements of skips and mine trunks (opencast overpasses) mine and opencast pneumolifting installations pursues the purpose to allow to define optimum and rational parameters of system without expensive experiments in a calculating way. Possibilities of modern computers and packages of applied programs allow to realize the system approach to the description of multiple-factor dynamic conditions of integrally interconnected links of uniform dynamic system "condensing device that is a lifting vessel (skip)".

Reliability of imitating model, so and its applied value, is defined by the following two major factors: completeness of the description of the phenomena within known physical representations and correctness of solutions of the obtained equations of interaction.

Function of a design of condensing devices of mine and opencast pneumolifting installations is maintenance of the set form. It guarantees compliance of the design of condensing devices to design parameters and, therefore, its working capacity under the influence of static and dynamic loadings. Character and volume of static and dynamic loads of an elastic element of the condensing device are various and change in very wide limits. Loading of the elastic element of the condensing device happens in the conditions of its interaction to the skip while its movement along the trunk. Therefore the value of efforts is defined not only by manifestations of external static and dynamic loadings, but also parameters of condensing devices:

- its deflection under the influence of pressure of subvessel air,
- conditions of contact with the skip

Mine and opencast lifting installations that technical condition normal functioning of technological processes depends on, belong to the class of mining cars with high intensity of use.

For increase of reliability and rational use of the construction material, special urgency is gained by creation of system methods of calculation. It demands development of the methods, allowing to investigate operability of the condensing device taking into account influences of residual tensions and deformations of designs.

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The major factors influencing bearing ability of the condensing device of mine and opencast skip pneumolifting installations are the material of an elastic element and its key parameters [1].

The main zones of destructions are the surface of the elastic element, subjected to dynamic and static loadings at the skip approaching along the trunk and while action of subvessel pressure.

It is necessary to develop the algorithms and the software for calculation spatial designs of condensing devices of the mine and opencast pneumolifting installations, considering main features of operation and manufacturing techniques.

The developed technique of the analysis and design of condensing devices of mine and opencast pneumolifting installations is based on a basis of use of rational constructive decisions and scientifically reasonable methods of calculation and design for optimum multiple calculation of condensing devices taking into account some significant factors.

For the complete analysis of condensing devices operation it is necessary to make static and dynamic imitating experiments in the ANSYS program. The static analysis of the elastic element from influence of constant subvessel pressure and the dynamic analysis from skip action while its entrance the elastic element and further movement through the elastic element.

It is obvious that at the first stage it is expedient to carry out the dynamic analysis for determination the maximum tension from skip action while the entrance and movement in an elastic element. As the internal radius of an elastic element is executed less than skip radius while the skip entrance the elastic element, the elastic element stretches and bends. There are tensions which definition without imitating modeling is quite difficult as it was told above that there is no uniform approach to the solution of problems of big deformations.

Therefore, in spite of the fact that the most used model in design calculations is the model of linear deformation of the material (Hooke's law), we need to carry out the analysis which isn't kept within a framework of this elementary case. Characteristic properties of a rubber elastic element of the condensing device of mine and opencast pneumolifting installations from the applied point of view of deformation of the material are nonlinear elasticity and plasticity.

At elastic deforming deformation is reversible, unloading in this case happens on the same curve, as loading, and after loading removal deformation completely disappears, as well as in a linear case, i.e. the body completely restores the initial form.

It should be noted that this option represents rather wide opportunities for the description of non-linearly being deformed materials. As the first approaching this option can be used for modeling of deformation of products from rubber, etc. Expression "the first approaching" for rubbers is used in the sense that for these materials there is a special option and, respectively, physical models: Mooney-Rivlin and Blatz-Ko. From the theory it is known that Mooney's material provides full incompressibility of the material, that is Poisson's coefficient is equal 0,5 while Blatz material considers small compressibility of the material [2].

After the model is constructed, the type and parameters of the necessary analysis, loading and its options are set. The specified type of the analysis shows, what equations will be used for obtaining the solution. During the phase of post-processor processing operations with the results obtained during the solution are carried out. They can include movements, temperatures, tension, deformations, speeds, etc. Results can be obtained in a graphic way or in a table form. The ANSYS program contains a powerful subsystem of geometrical modeling which creates detail or design geometry irrespective of its final element grid.

By means of this subsystem the model area is set, that is the volume which is surrounded with surfaces, lines and points. After a model task it is possible to break it by the final element grid.

Limiting conditions and loadings can be put to the solid-state model and directly to the final element grid.

The option of the most adverse condition of loading of the design of skips of mine and opencast pneumolifting installations is chosen out of all calculations. The chosen option will form

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the basis for carrying out further calculation. Further the element which is the most loaded is chosen. In our case the elastic element of pneumolifting installation is loaded.

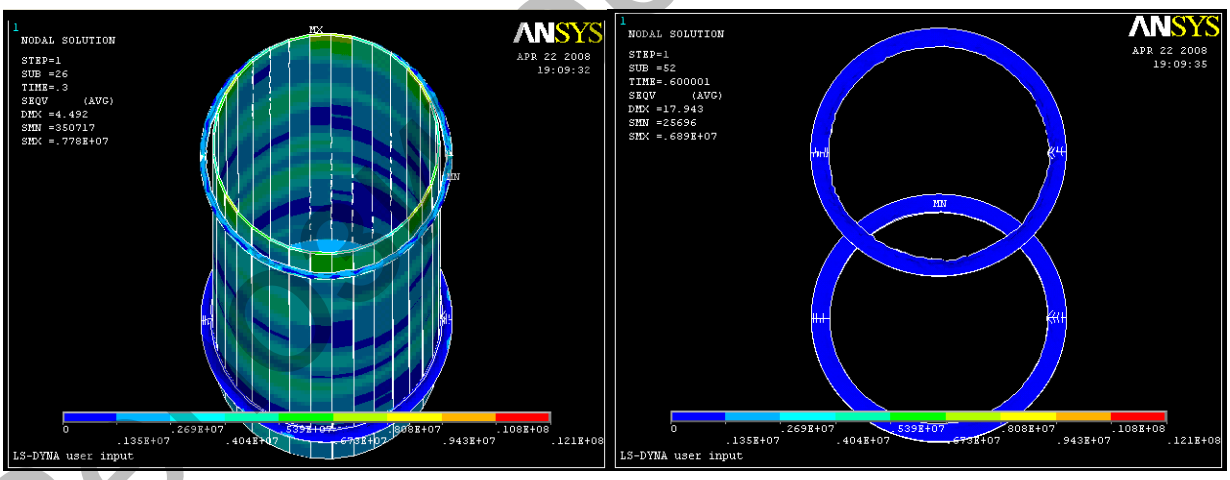
At the following stage the model is represented as a spatial roundish design. For this purpose it is offered to use the shell SHELL163 element. From this analysis we define the zone of the maximum tension and knot for which the volume model for the purpose of further research will be constructed if it is necessary. Creation of knots of the skip design on the basis of solid-state modelling gives an opportunity for the accounting of material nonlinearity, existence of the fracture similar defects and gives a picture of distribution of tension and the deformations, close to the real one. As a result of the automated analysis specification of bearing ability of skip designs of mine and opencast pneumolifting installations is carried out. One of the main objectives of mechanics of lifting installations is definition the efforts in elements of skip designs of mine and open cast pneumolifting installations in a concrete technological situation.

The main purpose at the development stage of discrete model was creation the adequate final-element model consisting of knots and elements. While creation the final-element grid the following was considered:

- in zones where it was required to determine tension or deformations, smaller grid in comparison with that which treated zones of definition of movements was used;

- at the accounting of nonlinearity, the grid was constructed in such a way that nonlinear effects could be shown, the accounting of plasticity demands reasonable increase in number of points of integration and, therefore, a frequent grid in zones with a high gradient of plastic deformations [3,4].

The shell final-element model of an elastic element of condensing devices of mine and career pneumolifting installations (metalevel), separately – discrete model of the whole pneumolifting installation (macrolevel), and also its some elements (microlevel) (fig. 1) is developed.



a) b)

a) The model TDS (tension deformed state) at an entrance of the skip to the second condensing device; b) The TDS of elastic elements of condensing devices after skip passing.

Fig.1. Dynamic model of the condensing device at skip movement.

The purpose of carrying out mathematical modelling of behavior of object under any external conditions is obtaining values of the parameters determining the value of its reaction. However, to define reaction to external influence of an object, during the solution the task at the beginning it is necessary to define type and value of the influence. Let's note that if it is absent, the solution of the task is meaningless.

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Thus, one of important stages of preparation for carrying out calculation and receiving satisfactory results is definition of external influences (mechanical, thermal, etc.) on the solid-state object concluded in volume, already broken into final elements.

External influence is usually defined on border of the created model (from it there was a term "regional condition").

The terms "limitation" and "loading" are understood as all various processes which happen both on surfaces of a solid and in separate points inside it as well. For example, "limitation" in ANSYS is understood: fixing, i.e. limitation of movements and rotations in the structural analysis, or determination temperature while the solution of problems of heat exchange; and "loading" is application of concentrated or distributed forces (the structural analysis) or thermal streams (tasks of heat exchange), etc. Simply in each type of the analysis of physical processes those types of loadings which correspond to it are available to the researcher.

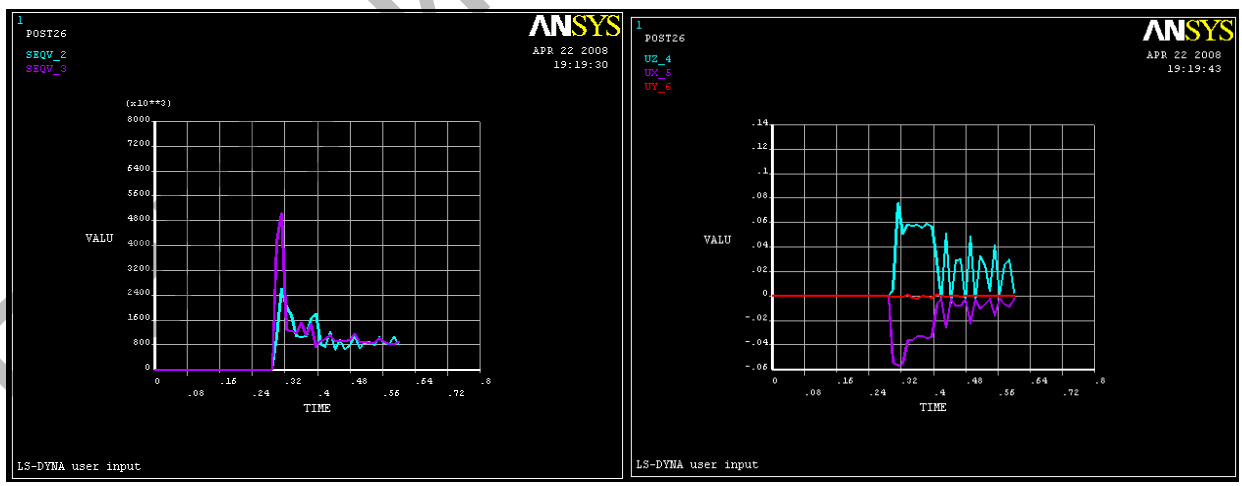
Experiments for condensing elements of skips with a diameter of 1 m were carried out. Considering the experience of researches by Nikolaev Yu.A. the dynamic analysis of elastic elements 10, 15, 20, 25, 30 mm thick was carried out (table 1) [5].

Table 1. Researched parameters of elastic element

Type of element	A	B	C	D	E	F	H	N	M
Tightness, mm	15	15	15	30	30	30	50	50	50
Departure, mm	50	70	90	50	70	90	50	70	90

When carrying out the analysis it is necessary to set not only geometrical parameters of object of experiment, but also parameters of mechanical properties of the material, one of the major one is the module of shift which is set while the solution of physical model of elasticity.

Experiment for the condensing device of the skip with the diameter of 1 m with an elastic element of D type, 0,01 m thick and the module of shift of 5 MPa which is set at the solution of the chosen physical Blatz-Ko model, yielded the following results (Figure 2)



a) b)

a) tension change on internal (SEQV_2) and external (SEQV_3) radius; b) deformation change on the XYZ axes.

Fig.2. Results of calculation of dynamic model at model shift of elastic 5 MPa.

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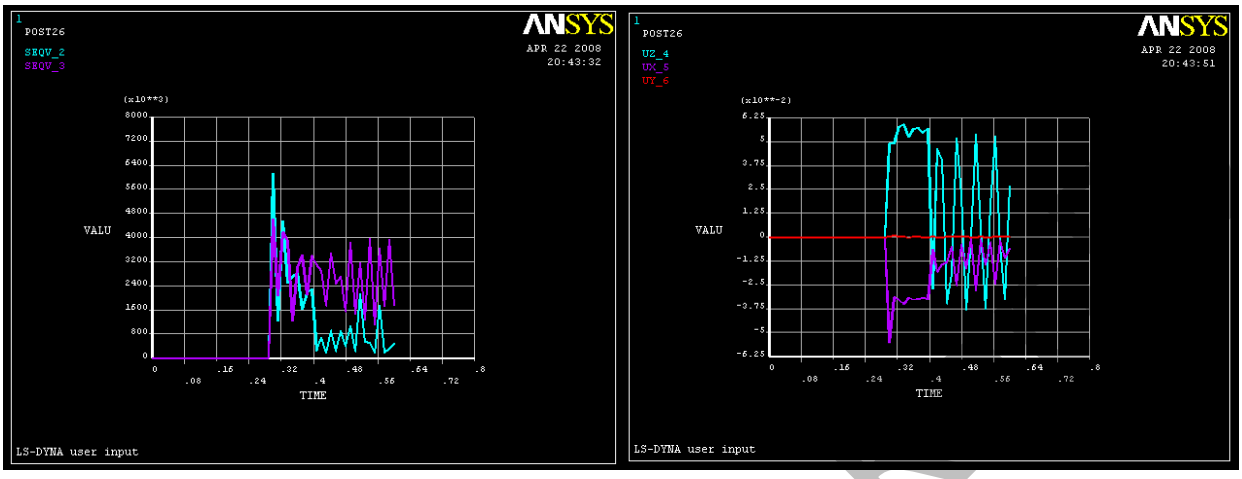
Experiment for the condensing device of the skip with a diameter of 1 m with an elastic element of D type, 0,01 m thick and the module of shift of 15 MPa which is set at the solution of the chosen physical Blatz-Ko model, yielded the following results (figure 3)



a) b)

a) tension change on internal (SEQV_2) and external (SEQV_3) radius; b) deformation change on the XYZ axes.

Fig.3. Results of calculation of dynamic model at shift module of elastic one 15 MPa.

In accordance with the obtained results it is possible to carry out the comparative analysis (fig. 4,5).

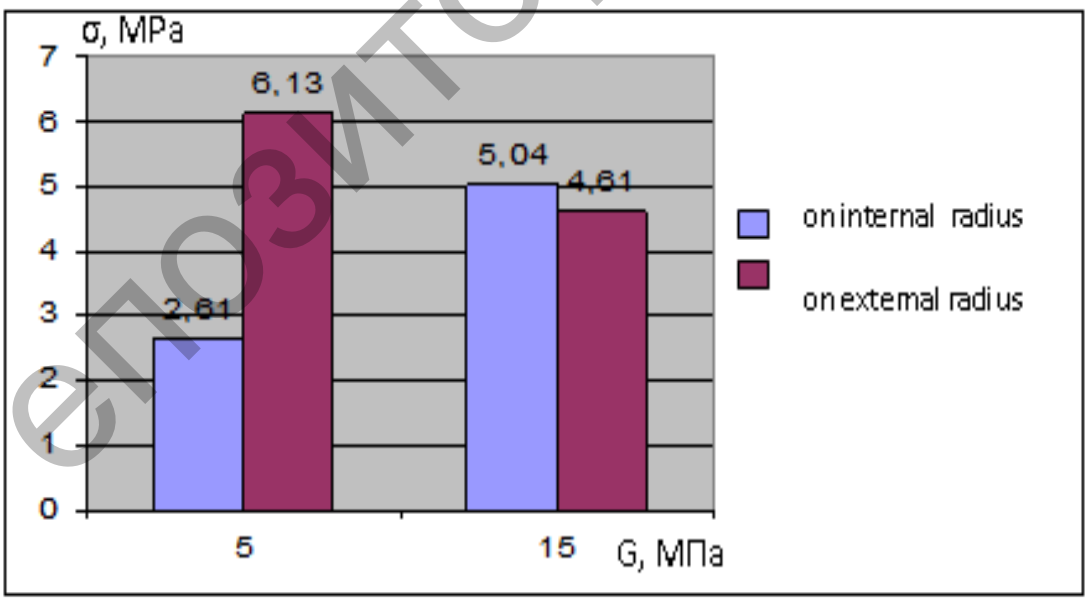


Fig.4. Comparative analysis of the maximum tension of elastic elements with the shift module of 5 MPa and 15 MPa.

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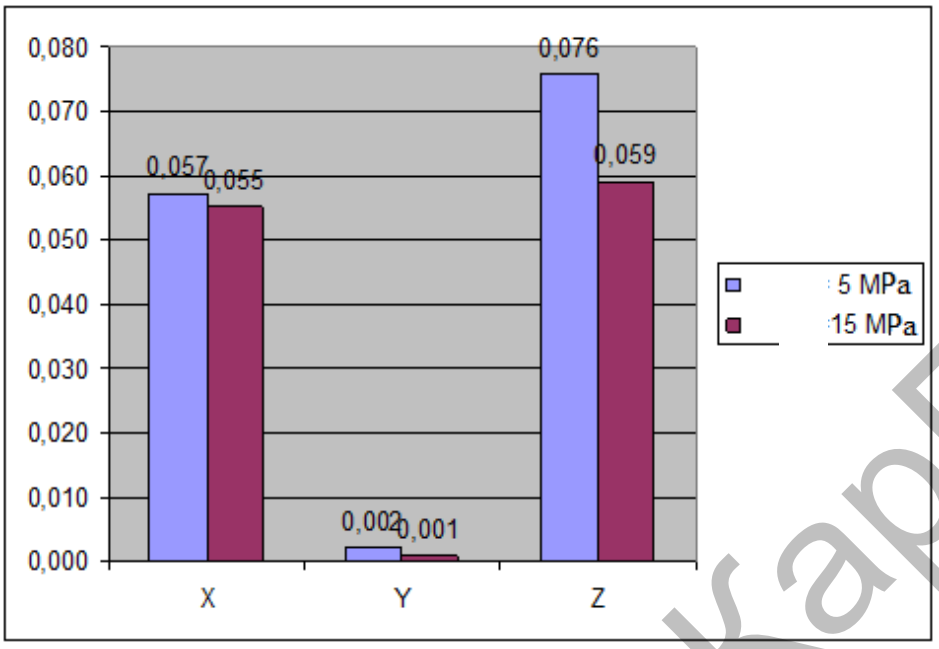

Fig.5. Comparative analysis of the maximum deformations of elastic elements with the shift module of 5 MPa and 15 MPa.

From results of the comparative analysis it is obvious that for elastic elements of condensing devices, the material with the shift module of 15 MPa is more preferable. The above described technique allows to carry out the dynamic analysis of elastic elements of condensing devices and to choose the material with the most optimum parameters.

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