the nature of application and the value of maximum and minimum forces acting on the sucker rod string are varied, the effect of the vibrational, inertial and shock loads are reduced.

The flexibility of the elastic suspension can be easily adjusted, to change the number of working links in the elastic element, or to vary the thickness of the plate package. To extend the load range at which the device works efficiently, the working links of different thicknesses can be used, and if it is necessary for increasing the working capacity of the elastic suspension, it is a constructive possibility to include the working links in parallel operation.

Thus, presented herein work proposes a new design of the plate shock absorber of the sucker rod string. The proposed design's peculiarity is the annular thin plate package usage as the main bearing element of the device.

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EVALUATION OF STRENGTH AND STIFFNESS OF A PLATE SHOCK ABSORBER FOR A SUCKER ROD STRING

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The sucker-rod string is the most important element to transmit movement to a deep-barrel pump's plunger. Apart of regular loading, sucker-rod pump plant usage is accompanied by a wide range of oscillations, inertial and shock loadings, causing possible accidents. Therefore, sucker rod protection is an urgent problem; its solution will increase sucker-rod pump plant's efficiency and save on additional costs. To solve these, the authors propose to use shock absorbers for sucker rod strings, which designed based on packages of annular plates. Such elastic elements are technological and simple to manufacture and operate. The work presents the main concepts of mechanical and mathematical modeling of such shock absorbers and studying the most important performance – the strength and rigidity of the shock absorber.

To describe the deformation of a shock absorber we construct a mechanical and mathematical model of the plate package. We assume that in the package of two plates (Fig. 1) there are no cross-links and friction between the plates. Each of them is deformed as the separate plate, which has its own neutral surface.

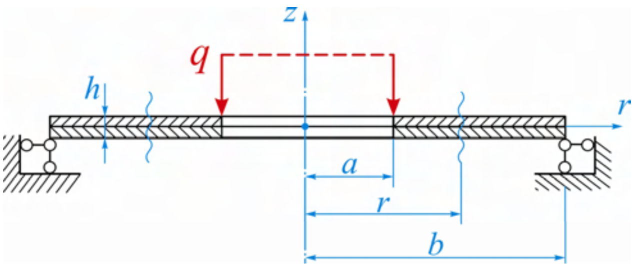

Fig. 1. The load diagram of the annular plate package for the shock absorber

The load on the package of plates is distributed between the plates in proportion to their stiffness in bending. A package of thin plates was modeled as an equivalent solid plate with a cylindrical rigidity providing equal properties of the solid model and the plate package [1, 2]. To find the submersion of the shock absorber we solve equation for the axisymmetric bend of the circular plate and obtain:

$$w^* = \frac{q \cdot n}{8\pi D}\left[\frac{1}{2} \cdot \frac{3+\mu}{1+\mu}\left(b^2 - a^2\right) + \frac{1+\mu}{1-\mu} \times \frac{2a^2b^2}{b^2 - a^2}\ln^2\frac{b}{a}\right],$$

where D is the cylindrical stiffness, μ is Poisson's coefficient. It should be noted, at time of bending the working links, it is appear the tangential stresses due to the shear strain which can be neglected for thin plates, while the accuracy of calculations is still high. The process of loading can be assumed as quasi-static and the calculation of the strength and the submersion of the device does not require the correction.

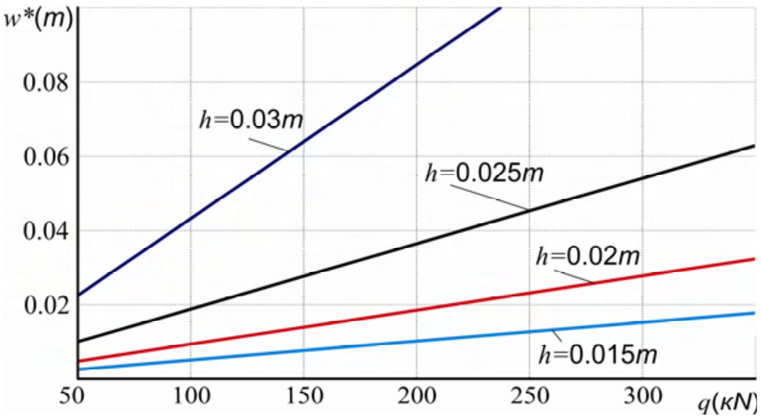

Fig. 2. Diagram of the submersion of the elastic suspension from the external load at different thicknesses of the plate package

To illustrate obtained results we choose a plate spring with parameters $a = 0{,}03m$, $b = 0{,}075m$, $n = 12$, $\mu = 0{,}3$, which correspond to the real device. There is the diagram of the submersion of the shock absorber from the external load at different thicknesses of the working plate package (Fig. 2). It should be noted that the flexibility of the elastic suspension can be easily adjusted, to change the number of working links, or to vary the thickness of the plate package. To extend the load range at which the device works efficiently, the working links of different thicknesses can be used, and if it is necessary for increasing the working capacity, it is a constructive possibility to include the working links in parallel operation.

Thus, it is proposed the new design of the plate shock absorber and studied its performance characteristics and obtained simple engineering formulas in this work.

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NEW CORROSION-RESISTANT COST-SAVING ALLOYED (NICKEL-FREE) TWO-PHASE STEELS WITH METASTABLE AUSTENITE

In the world practice, Cr-Ni steels of type 18/8 (10Cr18Ni(9…10)Ti, 08Cr22Ni6Mo2, etc.) are widely used as effective stainless (corrosion-resistant) steels. These steels are very expensive since they contain 9…11% Ni. Therefore, in many countries research and development are being carried out on low-nickel and nickel-free stainless steels capable of adequately replacing the above mentioned Cr-Ni stainless (corrosion-resistant) steels, retaining a sufficient set of mechanical properties and corrosion resistance.

With the objective of adequate replacement of expensive Fe-Cr-Ni-stainless (corrosion-resistant) steels with nickel-free steels, developed Fe-Cr-Mn steels for the ability to work in corrosive environments of low and medium aggressiveness.

To determine the optimal chemical composition of new nickel-free steels, the impact of chromium from ~14% to ~22% on the phase composition, microstructure, and mechanical properties was studied. An important feature and advantage of the developed Fe-Cr-Mn steels is the metastability of the austenitic phase, which undergoes a deformation induced martensite $\gamma \rightarrow \alpha'$ transformation that develops when testing the mechanical properties and operation DIMTT.

New nickel-free stainless steels, depending on the chromium content (from ~14 to ~22%), belong to different structural classes: austenite-martensite (10Cr14Mn6SiV), austenite-ferrite (10Cr18MnSiV), and ferrite-austenite (08Cr22Mn6SiV). After quenching at 1050 °C, the microstructure of 10Cr14Mn6SiV steel consists of austenite and martensite. With an increase in the chromium content from ~14% to ~18%, the martensite component disappears from the structure, and ferrite appears. The microstructure of 10Cr18Mn6SiV steel consists of ~46% ferrite in the form of closed regions and ~54% austenite. With an increase in chromium content to ~22%, the amount of ferrite increases to 68%, and austenite decreases to 32%. The mechanical properties of the investigated stainless steels after quenching at 1050 °C, tempering 200 °C are given in Table 1.

With an increase in the chromium content from 14 to 22%, the tensile strengths (from 1520 to 900 MPa) and the yield strength (from 920 to 500 MPa) and