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EXPERIMENTAL STUDY OF THE TENSION-DEFORMATION STATE OF THE TIGHTENING COMPONENT

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ABSTRACT

Gas lift equipment has a special place in oil extraction. This method has an important place among mechanized methods. This method is used to increase the longevity of the wells, and at the same time, when the productivity of the wells decreases, to increase the pressure at the bottom of the well by supplying gas to the space behind the well, to raise oil to the surface.

Gas lift valves are one of the main components of the equipment complex used in wells using the gas lift method. Depending on the characteristics of the wells, it is required to meet complex requirements from the gas lift valves, among which the provision of tightening is one of the important problems. In order to ensure effective tightening in gas lift valves, it is of great importance to choose the construction, dimensions of tightening elements, as well as the criteria of tightening correctly.

From this point of view, the solution of scientific-practical problems related to the design and calculation methodology of tighteners that can create reliable tightening in gas lift valves can be considered as one of the actual problems of production and exploitation of modern oil field equipment.

1. Introduction

The study of the tensıon-deformation state is one of the important problems in providing reliable hermeticity at high pressures in the gas lift equipment's tightening component. Theoretical studies lay the foundation for solving of this problem by accepting certain approximations, but in order to prove the theoretical results, there is a need to accept the results of experimental research.

A complicated tensıon-deformation state is created in the tightening component between the tightening elements, as well as in their touch with the contact surface (body).

At this stage of the research works, the tensıon-deformation state was studied by an experimental method. For this purpose, the following have been determined - variable pressure ΔP acting on the head surface of the tightener;

- axial force distributed on the tightening contact surface – Qt,

- the total tighting force applied to the tightening component.

The following approximations were accepted when solving the problem:

- the height of the tightened cylinder is the same;

- local radial and axial loads are equally distributed on the tightening surface. In this case, the axial load is replaced by its equivalent static tangential force.

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2. PROBLEM STATEMENT

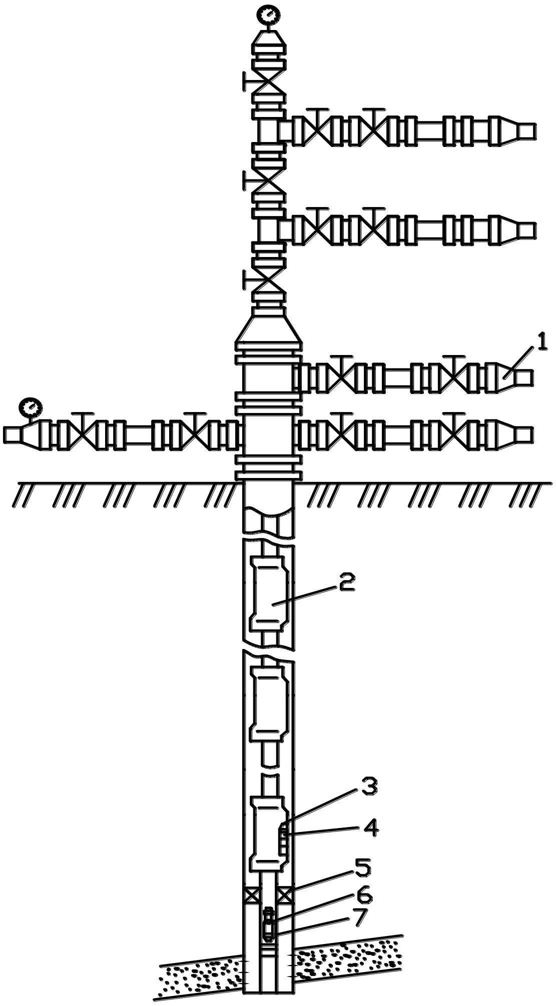

Fig. 1 1.1. General view of the gas lift well:

1- fountain armature, 2- well chamber, 3- punched fastener, 4 - gas lift valve, 5- packer, 6- intake valve, 7- nipple

Experiments were carried out on gas lift valves with both existing and offered tightening components. Constructions of tightening components are shown in Fig. 2 a and b, respectively.

The tightening component of the offered gas lift valve differs from the existing structure in that, in order to reduce relaxation tensions in the rubber cuffs, lead rings are placed in the sockets of the tightening cuffs [3].

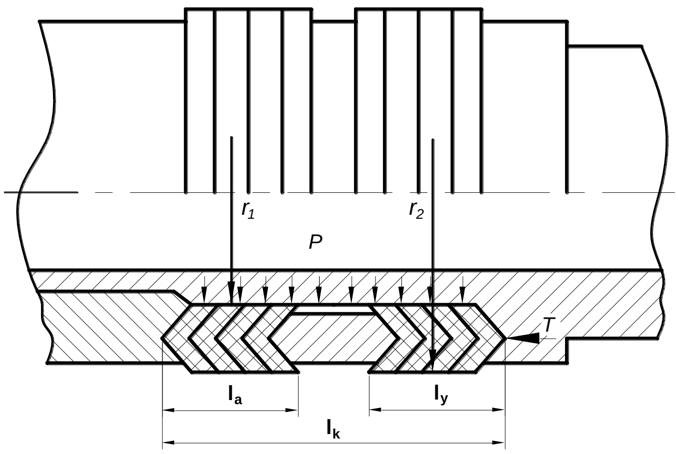

Fig. 2 a. An existing tightening component

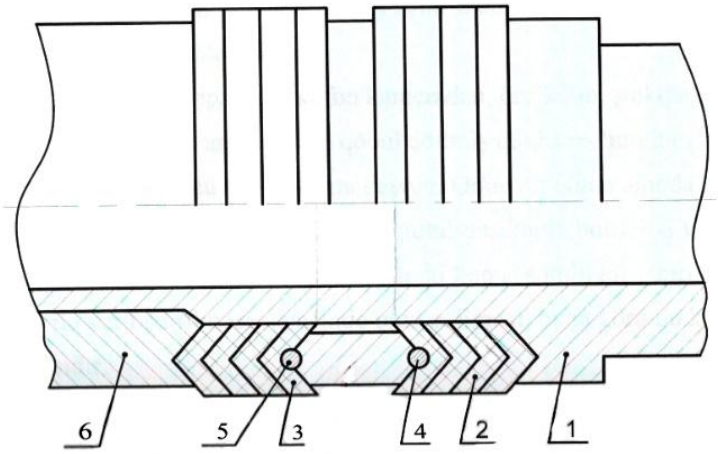

Fig. 2 b. A tightening component of the new construction

1 – a cover, 2 and 3 – rubber cuffs, 4 and 5 – lead rings, 6 – a silphon body

It is known that the tightening component of gas lift valves consists of two sets of oppositely directed tightening elements with a conical profile. For this reason, when the tighteners are placed in the chamber (cylinder) of the gas lift valve, loading of tightening has a great role.

Table 1 shows the location state and the number of the tighteners.

Table 1. The location state of the tighteners while tightening

No. of experiments	The location state of the tighteners involved in tightening	The number of the tighteners involved in the contact
1	The I set of the tightening elements meets the contact surface	3
2	The middle surface of the tightening elements is in contact	2
3	The I set and the II set of the tighteners are in contact	6

The radial deformation diagram of the displacement is given in figure 5.5. It is seen from the figure that the dependence z/r_2 of the displacement in the tighteners on dimensionless relative axial coordinate varies with the exponential law. From this one can conclude that the radial displacement is not equally distributed on the axial height in the set of tighteners.

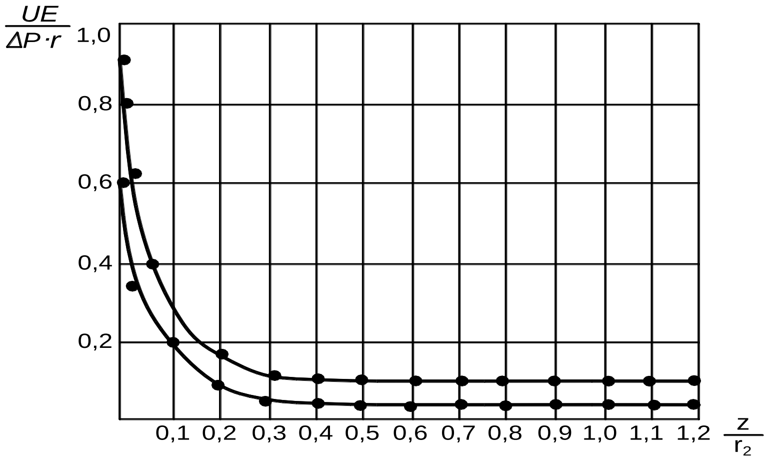

Fig. 3. The radial deformation of the displacement in the tightener.

The change diagram of pressure-dependent tensions in the tighteners is given in figure 4 and the change diagram of the force tangent to the contact line in them is given in figure 5.

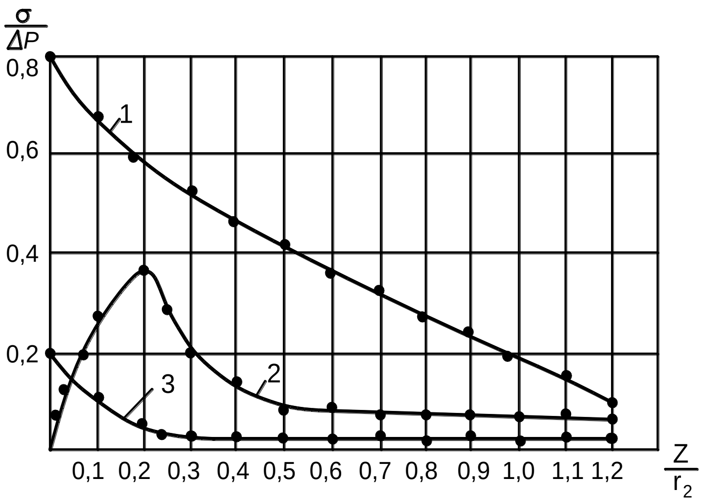

Fig. 4. The change diagram of pressure-dependent tensions in the tighteners with D=32 mm:

1- σ_z (r=r1); 2- σ_z (r=r1); 3- σ_z (r=r2)

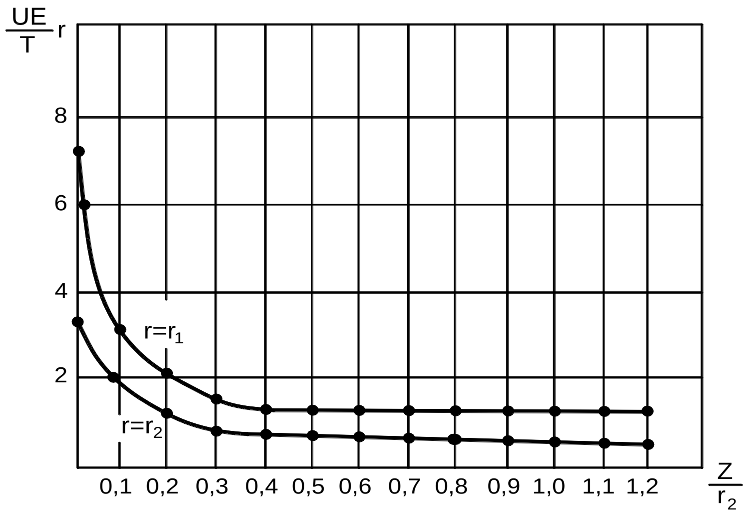

Fig. 5. The change diagram of the force tangent to the tightening contact surface

The dependence of the axial tension on dimensionless relative axial coordinates is shown in figure 5.8.

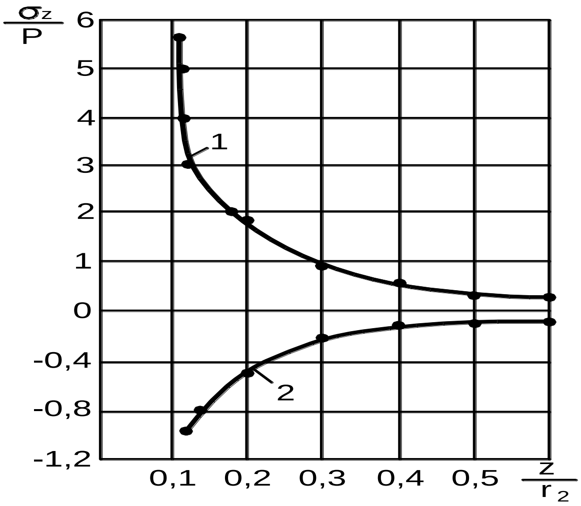

Fig. 6. The dependence of the axial tension on axial coordinate:

ly – the upper (I) set, la – the lower (II) set of tighteners.

$$1-\frac{l_y}{r_2};\ 2-\frac{l_a}{r_2}$$

3. PROBLEM SOLUTION

The II stage of the experiments is devoted to the study of the tension-deformation state created in the tighteners with a new shape due to tighting force and pressure.

In the tests, breaking the hermeticity by providing the stepwise increase of the tension on the contact surfaces and the increase of the pressure between 10-50 MPa, as well as self-tightening were performed. According to each step of tension or pressure, the tension and deformations on the inner and outer contact surfaces of the tightening element were measured.

The results of the experiments for the newly offered tighteners (with outer diameters ϕ29, ϕ32, ϕ40) are given in figure 8-14.

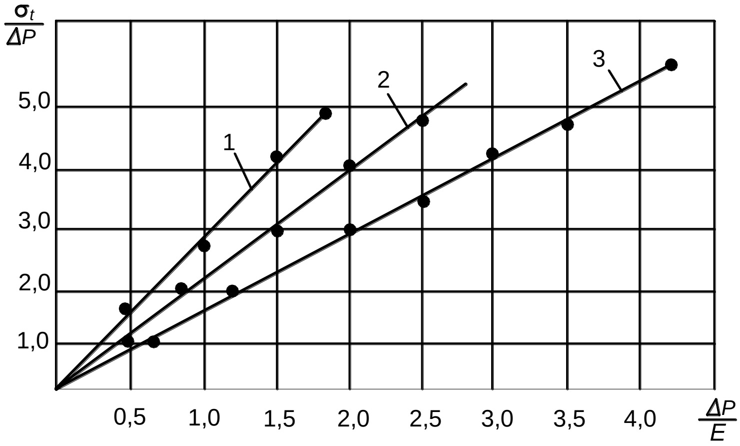

Fig. 7. The change diagram of the axial tension in the new-shaped tighteners:

1-D=29 mm; 2-D=32 mm; 3-D=40 mm

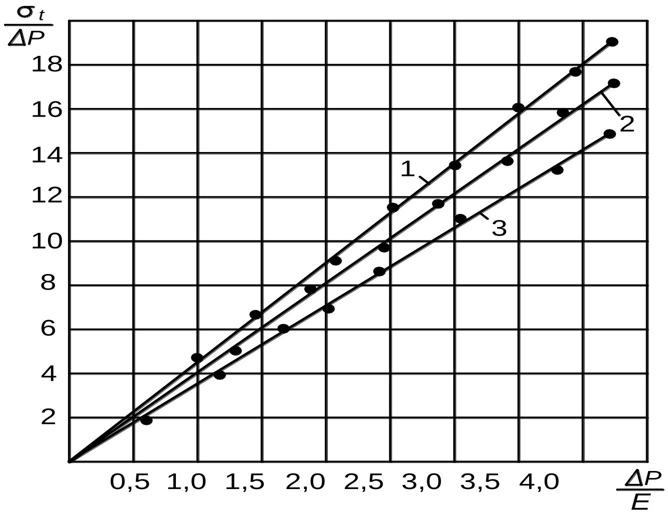

Fig. 8. The change diagram of the tangential tension in the new-shaped tighteners:

1-D=29 mm; 2-D=32 mm; 3-D=40 mm

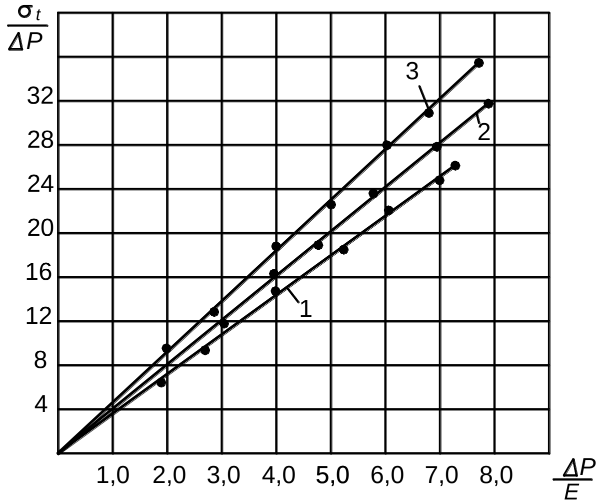

Fig. 9. The change diagram of the tangential tension in the new-shaped tighteners:

1-D=45 mm; 2-D=48 mm; 3-D=50 mm

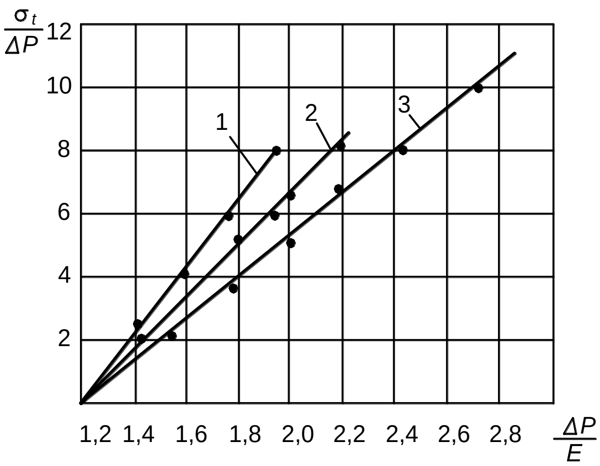

Fig. 10. The change diagram of the axial tension in the new-shaped tighteners:

1-D=45 mm; 2-D=48 mm; 3-D=50 mm;

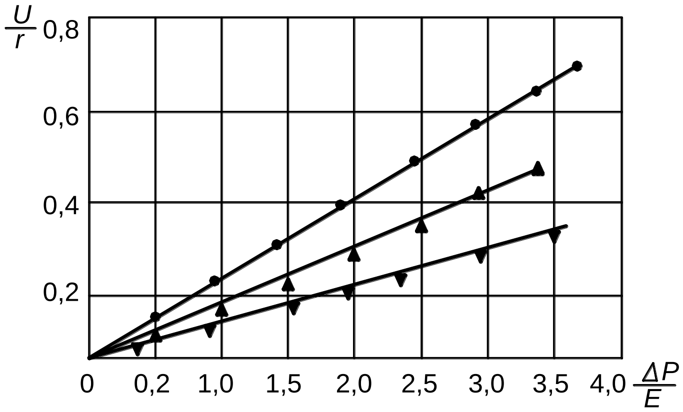

Fig. 11. The dependence of the radial displacement on the radial pressure in the new-shaped tighteners:

▼ -D= 45mm; ▲-D= 48mm; ●-D=50mm.

In existing tighteners (for loading states I and II in table 5.1), the radial displacement is obtained at a value that does not satisfy the tightening limit –U, and such an effect is typical for both tension and pressure application cases.

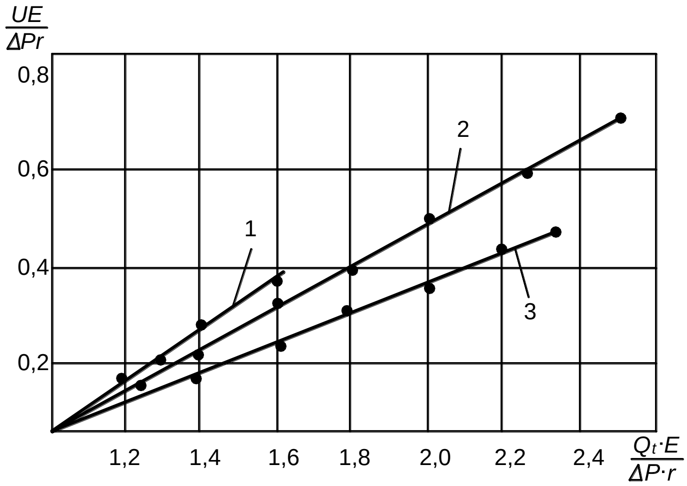

Fig. 12. The dependence of the radial tension on the total tighting force in existing tighteners:

1-D=29 mm; 2-D=32 mm; 3-D=40 mm

Characters of dependences of axial and tangential tensions on local loads Q_t for different loading regimes in the tightener with the size ϕ29 according to table 1 are given in figures 13 and 12.

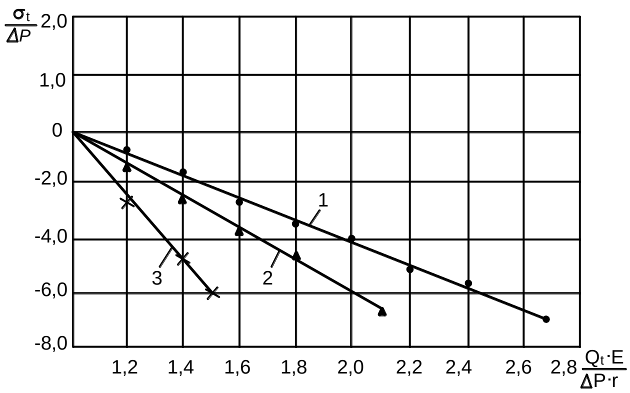

Fig. 13. The dependence of the axial tension on the tighting force: 1-✕; 2-▲; 3-●;

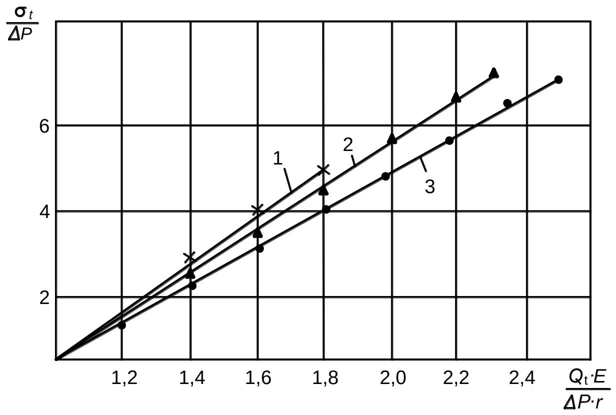

Fig. 14. The dependence of the tangential tension on the tighting force:

1-✕; 2-▲; 3-●;

It is seen from the results of the experiment that the values of the radial displacement and the tangential tension depend more on the radial load, and the axial force reduces their value.

It has been determined by the researches that depending on the loading mode of the tightening elements on the contact surface, the tensions increase with the increase of pressure, but their decrease is observed because of the influence of local loads. Also, since in the new-shaped tightening elements, tightening is obtained by a total contact, the value of the tensions is sufficient so that tightening occurs with equal contact surfaces (with tightening elements both the I set and the II set). In this case, distributions of tensions and the radial displacement satisfy Lame's law in the new-shaped tighteners.

4. CONCLUSIONS

So, an additional elastic element placed in a special slot in the tightening component reduces the effect of local loads, in this case, an equal distribution of the radial tension is observed. At the same time, the values of the radial tension are greater than the existing tightening component, and self-tightening is ensured under the direct and inverse influence of the pressure.

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