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Some Considerations Concerning the Overstrain of the „O" Rings Used at Bits Bearing Sealing

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Abstract

The paper presents the results of the experimental determinations concerning the "O" rings overstrain, which are used at the three-cone bit bearings sealing. The "O" rings were tested using different compression deformations, and different temperatures. There were tested rings made from three types of rubber, which were stressed in a medium constituted from the grease used for the bit bearing lubrication. The paper conclusions can be used both at the three-cone bit sealing designing and exploitation.

Key words: *bit bearing sealing, "O" rings, overstrain*

Introduction

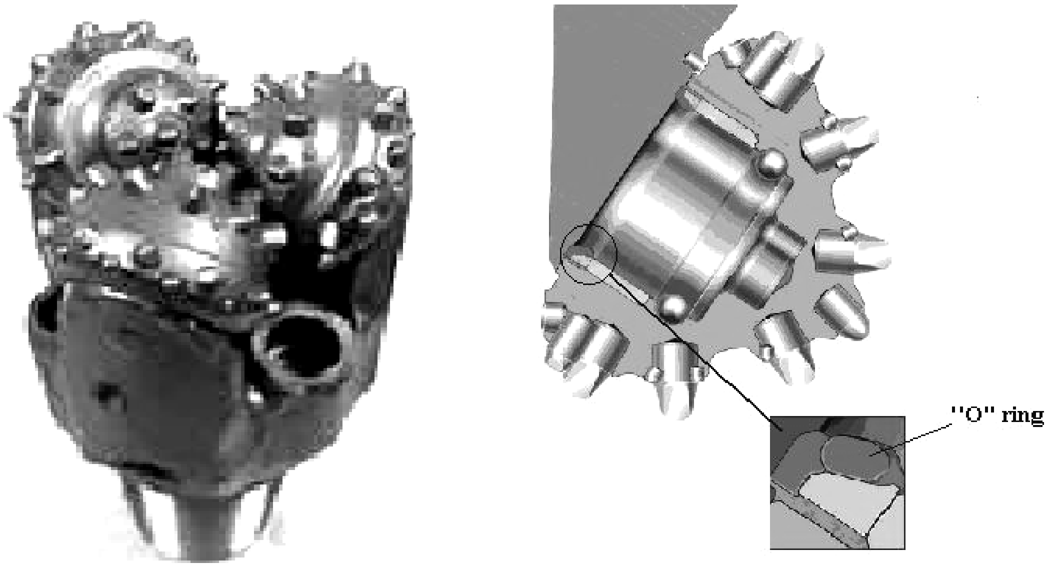
The bits are tools that are used at the drilling works. During their operating, these kinds of tools are subjected to: abrasive, erosive and corrosive working mediums; high temperatures values; high level of the mechanical stresses.

There are many types of drilling bits, which are used in drilling operations. One of the most used types is the three-cone bit that has a specific construction configuration (Fig. 1). This type of bit carries out the rock splintering using three profiled cones, which are fixed at the bit body through three journal bearings. These kinds of bearings are protected against the drilling mud penetration through sealing rings that are made from rubber [1, 2].

The sealing rings have a major role during the bit working, their behavior influencing the three-cone bit durability [3]. In Fig. 1,*b* it is presented the "O" sealing ring-bearing position. It can be observed that the ring is compressed during its function. Also, it has to be mentioned that the temperature of the bit reaches values during it working in the range of 30 … 60 ºC, and the bit bearing is lubricated with lubricating grease.

It can be concluded that the "O" sealing ring has the major role to protect the bit bearing against the drilling mud penetration and against to lubricant losses. The "O" sealing ring during its working has to maintain its elastic properties and dimensions but due to the working conditions this is almost impossible.

Taking into account the above statements, it has to conclude that for a better working behavior of the "O" sealing ring it is recommended to know the elastic and plastic ring and ring material properties. These properties have to be determined on the rings made from different rubber types and using testing conditions similar with those, which characterize the bit bearing working.



a) b)

Fig. 1. The three-cone drilling bit:
a) – general view; b) – bit bearing subassembly and the sealing “O” ring.

Experimental Details

The method principle consists in “O” ring rubber compression between two parallel plates. The distance between plates is smaller than the transversal diameter of the ring. The ring and the plates are immersed in a medium that consists in the lubricant that is used usually in the bit exploitation. The compressed ring is maintained a certain period at a given temperature value, and finally it is measured the ring overstrain (Fig. 2).

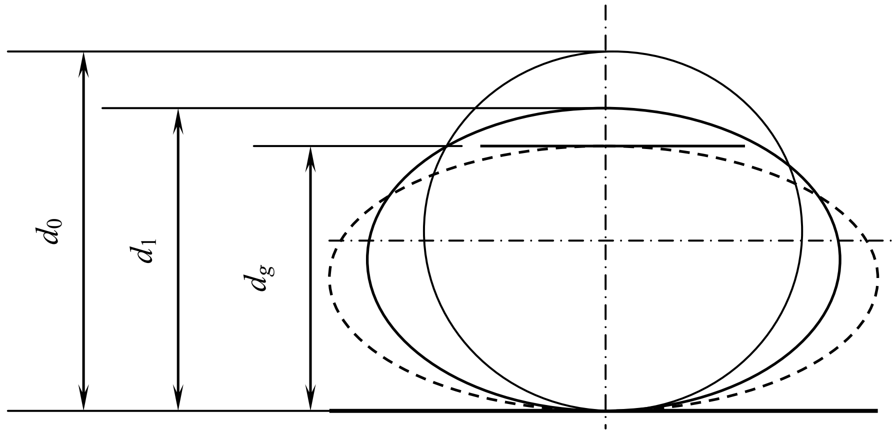


Fig. 2. The „O” rubber ring dimensions: d_0 – the diameter before deformation; d_g – the dimension during the deformation between plates; d_1 – the dimension after deformation and rest.

The rubber ring thickness after deformation (d_1) is bigger than the distance piece thickness (d_g) because of the elastic relaxation of the rubber. The relaxation depends on material quality and the time between the disassembling and the measuring of the ring thickness. The time value between the ring disassembly and the ring measuring has to be the same for all the test pieces.

The testing rings method is based on the procedure presented in standard STAS 12043/2-81, which was adapted to real working conditions of the ring. Thus the test was developed at two keeping temperature values 20 ºC and 50 ºC. The rings were deformed with three initial deformation levels 10 %, 20 % and 30 % of the initial dimension d_0. The maintaining time at fixed temperature was 22 hours, and the medium was constituted from grease used for the bits bearing lubrication, type CaEP2M. The ring measuring was performed after 30 min. of maintaining at ambient temperature. Because of the “O” rings have significant dimensional discrepancies of the cross section diameter d_0, the measuring was done in the same four diametral opposing points before and after deformation using the same measuring instrument. The device that was used for the test is presented in Fig. 3.

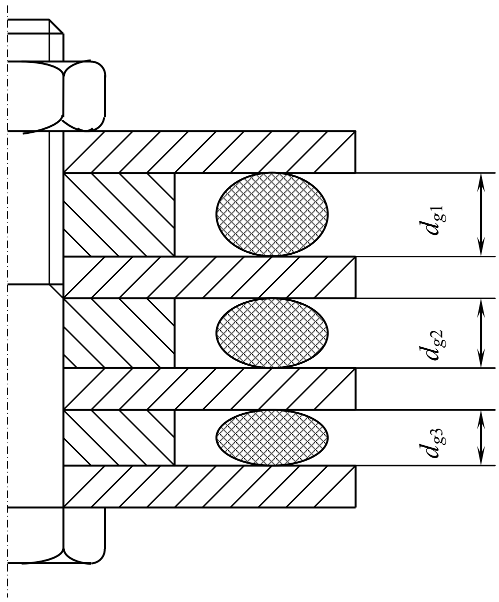


Fig. 3. The testing device

The testing device is composed from four rigid disks. Between these disks there are fixed the distance plates and the rubber rings, which are constricted with the central screw until the contact between the disks and distance plates is done. The distance plates dimensions $d_{g(1,2,3)}$ determine de initial deformation degree of the rubber rings. At the assemblage the disks surfaces and the rubber rings are lubricated with grease for a good rings sliding during the deformation and to create the same medium with those which characterizes the sealing rings work. The whole assembly is immersed in a cylindrical recipient full of with the grease, which at its side is immersed in a thermostatic bath.

The experimental determinations were done on “O” rings with the cross section diameter d_0 = 5.7 mm, and internal diameter Φ = 59.2 mm. The rings were made from three rubber types, which have the main mechanical characteristics, presented in Table 1.

Table 1. Mechanical characteristics of the “O” rings rubber

Mechanical characteristics	The type of the rubber		
	Fluorinated	Nitrile	Nitrile hydrogenated
	The commercial name		
	VITON	NBR	HNBR
Breaking strain [MPa]	12	18	20
Elongation [%]	180	250	250
Modulus of elasticity [MPa]	5	4.5	4.5
Hardness [^{o}ShA]	80	80	80
Compression overstrain [%]	70h x 200^{o}C max 20	70h x 100^{o}C max25	70h x 150^{o}C max 30

The distance plates thickness were 5.19 mm, 4.62 mm and 4.04 mm. For the tested “O” rings the distance plate’s thickness correspond to an initial deformations of 10, 20 and 30 % (considered from the initial thickness d_0 of the ring).

The “O” ring overstrain is computed with the relation:

$$O = \frac{(d_0 - d_1)}{d_0} \cdot 100 \qquad [\%] \tag{1}$$

where: d_0 is the initial diameter of ring cross-section; d_1 is the ring thickness after the disassembling.

Results and Discussions

In Fig. 4 it is presented the ring overstrain as a function of initial deformation for different testing temperatures and different rubber sorts. It can be observed, like a general tendency for all the tested rubber types, that the temperature increase implies the overstrain increase.

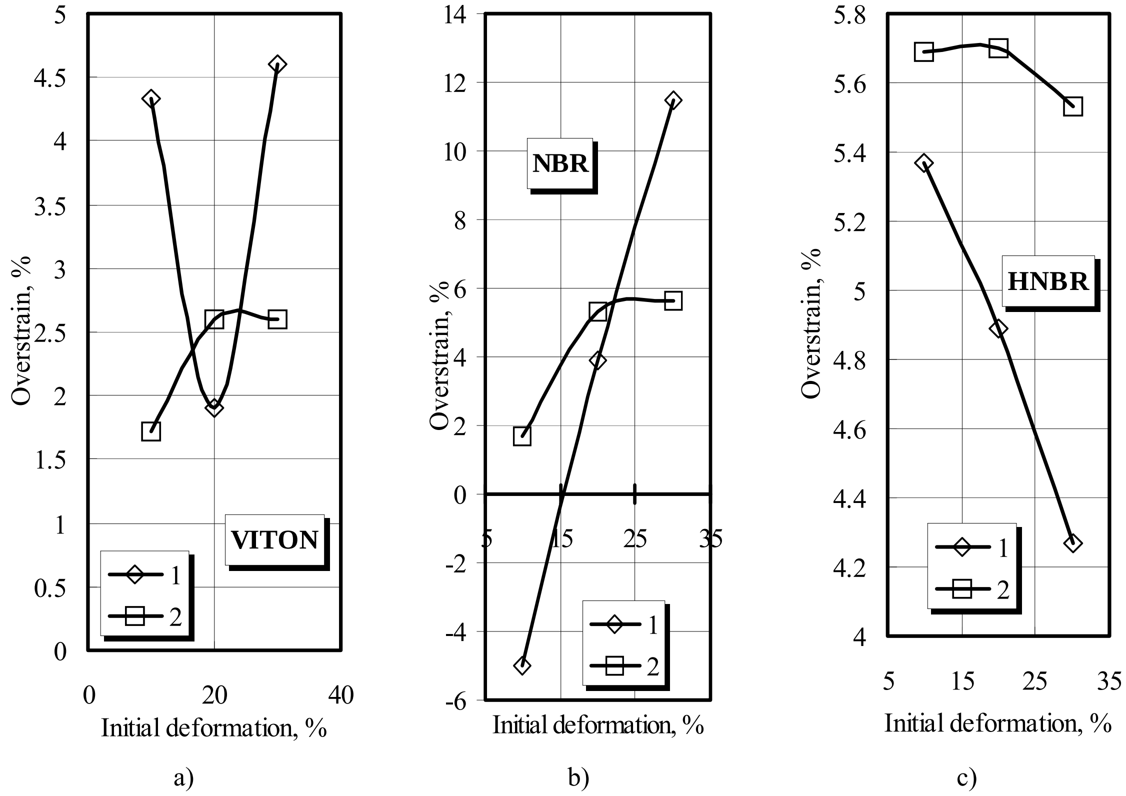
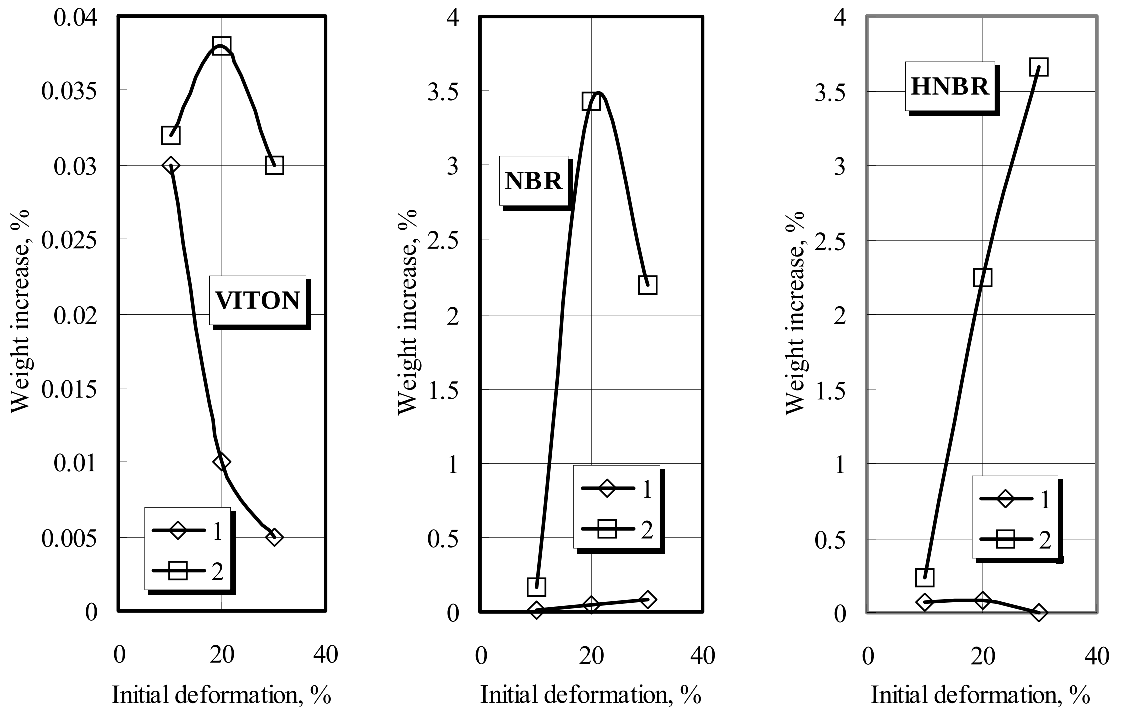


Fig. 4. The overstrain vs. initial deformation for different temperatures (1 – 50 ºC; 2 – 20 ºC), and for different rubber types: a) fluorinated ruber; b) nitrile ruber; c) nitrile hydrogenated ruber.

Between different rubber types it can be observed differences regarding overstrain evolution. Thus for the rings made from NBR rubber type it can be remarked that for 50 ºC temperature value their diameter is bigger than initial size. Also, it can be remarked that the dimensions of the rings made from HNBR rubber type were little influenced by temperature in comparison with the others rubber types. The normal evolution overstrains values exceptions, which appear for the VITON rubber (50 ºC, 20 %) and NBR rubber (50 ºC, 10 %) are justified by the material heterogeneities (chemical composition, physical properties).

An important consequence of the tests is the influence of the lubricant grease on the weight of the rings. This influence is represented, like weight increase depending on initial deformation, in Fig. 5.

Thus, for all the tested rubber types, the weight increase decreases with the temperature increase. The weight increase smallest values were registered for the rubber VITON, where for both temperature values the weight increase decreases with the initial deformation increase (excepting 20 % initial deformation value).

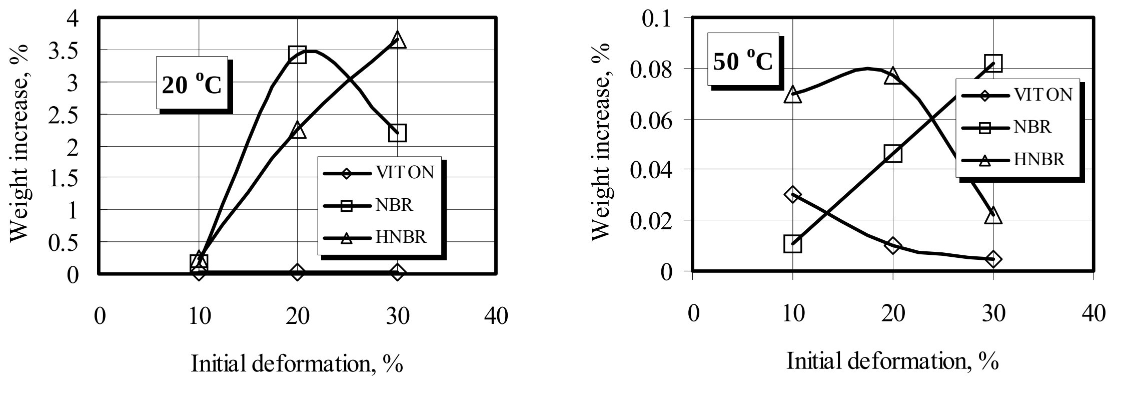


a) b) c)

Fig. 5. The weight increase vs. initial deformation for different temperatures (1 – 50 ºC; 2 – 20 ºC), and for different rubber types : a) fluorinated ruber; b) nitrile ruber; c) nitrile hydrogenated ruber.

For NBR and HNBR rubber types, tested at 20 ºC, the tendency is the weight increase with initial deformation increase. For the NBR rubber it can be observed a maximum, which corresponds to a 20 % initial deformation value. Regarding the test developed at 50 ºC temperature value, the weight increase is insignificant for al the rubber types, and the general tendency is the decrease with the initial deformation increase (excepting NBR rubber type).

The above conclusions are validated by the comparative plotting from Fig. 6, where for different temperature values are represented the weight variation depending on the initial deformation.



a) b)

Fig. 6. The influence of the initial deformation on the weight increase for different temperature values: a) 20 ºC; *b)* 50 ºC.

Conclusions

The paper general conclusions are the following:

- the test methodology which is presented by the authors permits a proper selection of the rubber type which will be used for "O" rings construction;
- the paper results can be used for the bit bearing design and exploitation;
- between the three tested rubber types the best behaviour has the HNBR type.

References

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Considerații privind deformația remanentă a inelelor „O" folosite la etanşarea lagărelor sapelor de foraj

Rezumat

Lucrarea prezintă rezultatele determinărilor experimentale privind deformația remanentă a inelelor "O" care sunt folosite la etanşările sapelor de foraj cu trei conuri. Inelele „O" au fost testate la diferite deformații de compresiune şi la diferite temperaturi. Au fost testate inele fabricate din trei tipuri de cauciuc, care au fost solicitate într-un mediu constituit din unsoarea folosită pentru ungerea lagărelor sapelor. Concluziile lucrării pot fi folosite atât la proiectarea, cât şi la exploatarea sapelor de foraj cu trei conuri.