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RELIABILITY RESEARCH OF PUMP RODS UNDER WEAR-FATIGUE CONDITIONS

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Abstract*:* *The paper is dedicated to development of the experimental method for study of longevity of pump rods under influencing of wear, corrosion attack and fatigue. The construction of plant for studies is proposed. The results of experiment are displayed. It is drawn a conclusion, that in a usual terms of sucker rod string exploitation (hold-down pressure of pump rods to flow string up to 100 N) the frictional component of the process of corrosion frictional fatigue not only does not moderate, but even rises pump rods durability on curved parts of borehole.*

Key words: *pump rod, fatigue, friction, corrosion, durability*

1 Introduction

The modern tendencies of oil production consist in increasing usage of directed and horizontal drilling. Boreholes, which one are already exploited in Ukraine and Romania, also in most cases, are characterized by compound profiles. At oil production from such boreholes by plant for bottomhole pumping, which one are and remain a permanent asset of oil production, the sucker rod string (SRS) is foregone is deformed, contacts to flow string (FS), that by operation of plant results in mutual wear of SRS and FS. This phenomenon is known for a long time and is studied by many scientists, for example [1-4].

It is known, that the wear process most often takes place in bottom SRS, where through the composite mode of deformation quite often pump rods break over corrosion fatigue damages. Thus, we deal with the whole complex of the destructive factors, which one simultaneously influences a pump rod: by fatigue, corrosion attack and wear process. For a valid estimation of durability or residual operational life of pump rods it is necessary to know their parameters of fracture resistance, which one cannot be determined without conducting experimental researches. At present in a world there are no methods of applications, which one would resolve this task. Therefore purpose of article is the development of the corrosion frictional fatigue test procedure of pump rods.

2. DISCUSSION

2.1. TESTING THEORY

At first let's esteem fundamental theory, on which one such method of application should be founded [5].

The resultant process of damage and destructing at simultaneous operating of contact and not contact stresses call combined – wear-fatigue damage (WFD).

The applying of thin experimental exploratory receptions enables to learn and to understand features WFD. As an example, the fig. 1 presents the results of learning (method of an atomic-powered microscopy) processes of fracturing in samples from Steel 45 are reduced at rolling friction (left-hand column of figures) and at wear-fatigue tests (other figures) depending on a level of a contact pressure p_0 and of stress amplitude σ_a. In figures (their size 35×35 mkm^2) the typical morphology of cracks is illustrated. And on the histogram the dependence of extreme depth h of the defective blanket from the level of stress cycles (is given at an invariable contact pressure p_0 = 2130 MPa). It is possible to make the following deductions from these experimental data.

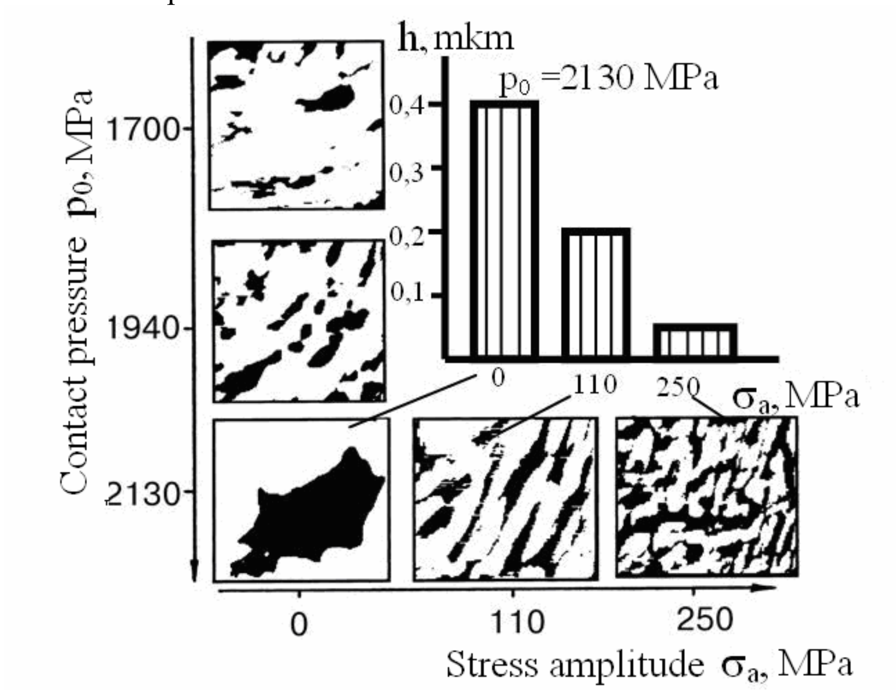


Fig. 1 Surface damage microtopography at rolling friction (vertical column of figures) and at wear-fatigue tests (other figures)

Under conditions only rolling friction the magnification of a contact pressure increases plastic strain, deformation fragmentation of grains, formation at first of discrete holes and fractures, and then and their chains. The system of the deformed grains, chains of holes and fractures is one-direction and oriented along a rolling direction. This process results in formation concerning large discrete wear pit. Two sorts of wear are main - peeling and chip (as a result of contact fatigue). And the extreme depth of an injured blanket is valued in 0.4-0.5 microns.

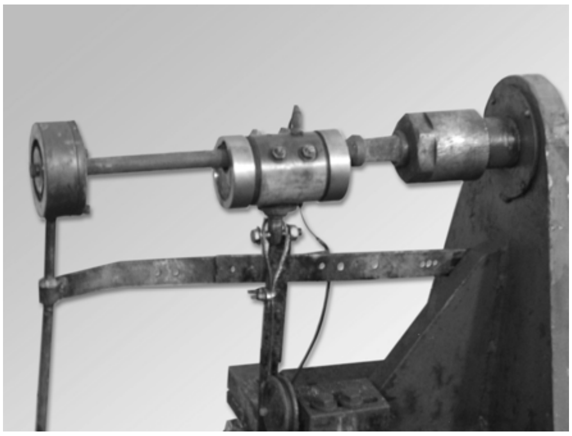
Under wear-fatigue conditions the deformation fragmentation of grains, both pore formation and cracks is similarly watched also. However form of damage essentially alters. Stress cycles magnification speeded up the process of formation of the second cracks system – cross-cut concerning the rolling direction. Therefore damage becomes dispersed, there is an almost equilibrium grid of customary cracks - holes, which one skirts finely divided fragments (pieces of grains) stuff. Than above than cyclic stresses, the more richly grid of cracks - holes, the less also is more thin separable fragments, and the extreme depth of the defective blanket is moderated up to 0.05 microns. Formation of large wear pits is not occurs in these conditions. The carrying on process of wear is surface peeling. It is characterized by compartment from a working surface of finely divided fragments of a material, which one formes as a result of a multiple micro displacement on customary plains and thin crushing of grains. Such mechanism of complex surface damage call as dispersed effect of a multiple micro displacement (DEMMD), and damage – rolling-mechanical fatigue.

From a fig. 1 follows: the tenfold recovery of a working surface is required approximately by fragmentation, shelling and compartment of fragments of metal at wear-fatigue tests before the same depth of damage will be reached, as at rolling friction, if the contact pressure in both cases is identical.

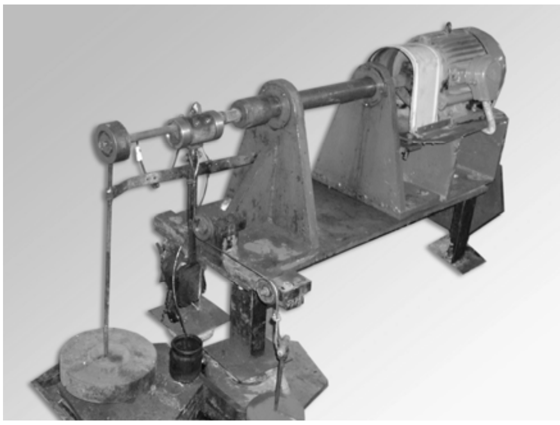
Thus, WFD is special and peculiar sort of surface damage of the power system. Its distinctive feature in such conditions: surface peeling as a result of operation DEMMD after customary slip planes. Its feature: though it is damaging process, but he can be useful, as in certain conditions results in a considerable reliability augmentation and longevity of the power system. At optimum joint of load arguments such state of the power system is reached, when bearing capacity is consensual and during continuous time is automatically maintained by thin wear and deleting from friction zone of the defective blanket. As a result, fresh surface with rather high strength to destruction is uncovered.

2.2 PLANT DESIGNING

For pump rods most actual is solutions of the forward tribo-fatigue task, i.e. definition of influencing of wear on a fatigue strength. The task becomes complicated by not forecast influencing of corrosion environment both on two main destructive factors, and on their interplay. We offer usage of plant on a circular flexure of full-scale pump rods; the general view is displayed in a fig. 2a. For implementation of the process of wear in corrosion environment in a zone of a forecast fatigue failure of a pump rod the special mounting attachment (fig. 2b) is designed, which one is installed on a body of a full-scale sample of a pump rod. A fig.3 illustrated the principal diagram of a mounting attachment.



a)



b)

Fig. 2 Plant for corrosive wear fatigue tests of pump rods:
a) – general view; b) – mounting attachment for corrosive wear.

The mounting attachment consists of bodies 1, covers 2, FS cutting 3, load screw bolt 4, choke of feeding 5 and draining 6 corrosive environments, packing rings 7. In the FS cutting the openings about a diameter of 2 mms for convenient access of driving fluid to a frictional contact part of a sample are drilled.

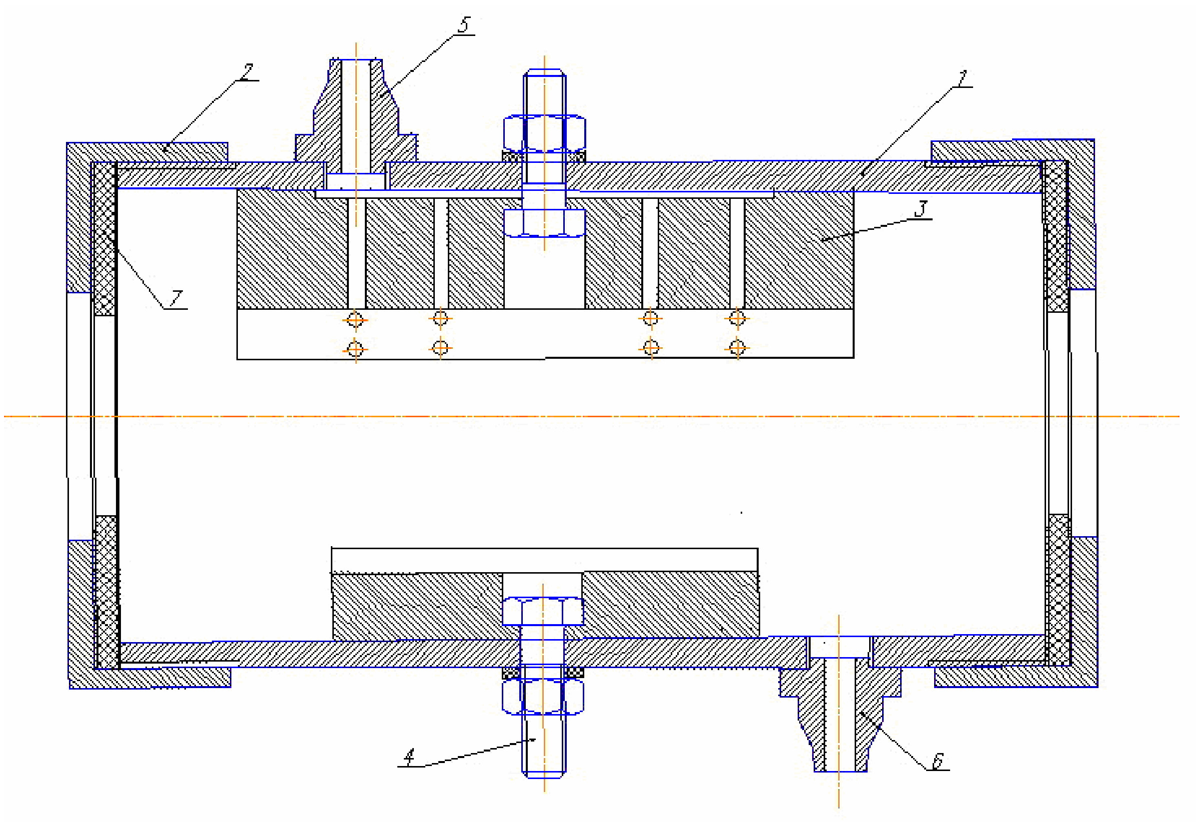


Fig. 3 Constructions of a mounting attachment

2.3 EXPERIMENTAL DATA

Allowing considerable temporary expenditures on conducting of fatigue tests, the not less relevant and actual task is the exact plan of experiment, namely choice of hold-down pressure of a pump rod to a FS. The primal problem, which one is necessary to decide first of all, is – as far as is essential influencing on resistance to corrosion fatigue renders the frictional component and or harmfully this influencing, or, to the contrary, it is useful. Therefore we have stayed on comparison testing with constructing of curves of fatigue corrosive durability without and with wear at hold-down pressure, which one is most representative of the majority of boreholes.

Studies [4, 5] demonstrate that such strain is in boundaries 30…100 N. We select smaller value (30 N) from the point of view of decrease of possible temperature rise from a zone of friction through considerable intensification of the process, which one is in a basis of experimental fatigue tests.

In total was tested 7 full-scale is model of pump rods with series decrease of a range of stress. The results of tests are showed in Table 1.

Table 1 Results of corrosive frictional fatigue tests at pump rods

Number of a	1	2	3	4	5	6	7

sample							
Stress amplitude, MPa	240.13	218.30	196.47	174.64	152.81	130.98	109.15
Life to failure, cycles	430600	762300	1693200	3587000	9519100	34283600	70000000 (Was not destructed)

With the help of the designed method of application [6] and results of experiment we determine average arguments of a curve of corrosion frictional fatigue of pump rods:

- boundary of fatigue life σ_{-1}=127.8 MPa;
- argument of slope of a curve of fatigue V_0=37.6 MPa;
- an amount of cycles to a dot of a lower bend of a curve of fatigue N_0=14790000.

A fig. 4 displayed curves of corrosion frictional fatigue, and also curve of corrosion fatigue [7].

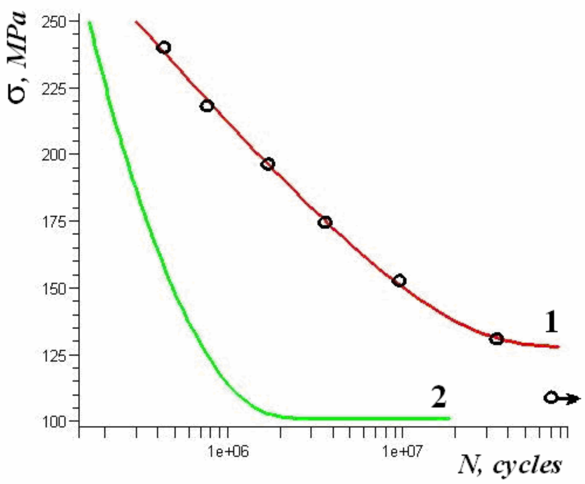


Fig. 4 Curves by corrosion frictional (1) and corrosive (2) fatigues of pump rods

3. CONCLUSIONS

As is visible, in such conditions the frictional component of the process of damage results in magnification of durability in all range of operation stresses, which one arise in a body of a drill rod. So, it is possible to draw a conclusion, that in a usual terms of exploitation SRS (hold-down pressure of pump rods to FS up to 100 N) the frictional component of the process of corrosion frictional fatigue not only does not moderate, but even rises pump rods durability on curved parts of borehole. But it is by no means decrease a complex negative role of wear process of SRS on FS, first of all, bound with wear process of rod coupling and FS.

4. BIBLIOGRAPHY

1. Протасов В.Н. Повышение надёжности оборудования скважин при насосном способе добычи нефти. – М.: ВНИИОЭНГ, 1987. – 38 с.
2. Адонин А.Н. Добыча нефти штанговыми насосами. – М.: Недра. – 1979. – 213 с.

3. Бабаев С.Г. Надёжность нефтепромыслового оборудования. – М.: Недра. – 1987. – 263 с.
4. Уразаков К.Р. Нагрузки на штанги в наклонно-направленной скважине // Эксплуатация наклонно-направленных скважин штанговыми глубинными насосами: Обз. инф. – М.: ВНИИОЭНГ, 1988. – С. 5-14.
5. Трощенко В.Т., Сосновский Л.А. Механика износоусталостного повреждения и ее применение для расчета силовых систем машин и оборудования // Праці I Міжнародної науково-технічної конференції "DSR AM - I". – Тернопіль. – 2004. – С. 61-72
6. Івасів В.М., Артим В.І., Пушкар П.В. Удосконалена методика прогнозування залишкового ресурсу деталей в типових умовах експлуатації // Тези доповідей 7 Міжнародного симпозіуму українських інженерів-механіків (МСУІМЛ-7). – Львів. – 2005. – С. 73
7. Артим В.І., Івасів В.М., Федорович Я.Т., Пушкар П.В. Визначення залишкового ресурсу насосних штанг в типових умовах експлуатації // Розвідка та розробка нафтових і газових родовищ. – 2005. – № 2. – С. 79-82