2. R. I. Petrivskii, G. M. Krasovskaya, S. N. Alekseev, B. V. Kroshkov, and I. I. Dikii, "The influence of heat treatment and working media on the cracking of heat-treated 20GS2 reinforcing steel," Fiz.-Khim. Mekh. Mater., No. 4, 45-48 (1975).
3. R. I. Petrivskii, G. M. Krasovskaya, S. N. Alekseev, M. V. Koval', and I. I. Dikii, "Determining the resistance to brittle failure of 20GS2 reinforcing steel," Fiz.-Khim. Mekh. Mater., No. 2, 84-87 (1977).
4. S. I. Mikitishin, R. I. Petrivskii, G. M. Krasovskaya, S. N. Alekseev, I. I. Dikii, and V. A. Zozulyak, "A unit for creating and measuring an axisymmetric crack in cylindrical samples," Zavod. Lab., No. 12, 1521-1522 (1977).

INFLUENCE OF THE LEVEL OF MECHANICAL STRESSES IN PRELIMINARY CORROSION OF A LOW-CARBON STEEL ON ITS FATIGUE STRENGTH

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The ever-increasing amount of off-shore oil drilling and recovery work has made pressing the problem of increasing the supporting capacity of the design elements of off-shore oil industry equipment. Losses in the strength of the elements of equipment occur as a result of the combined action of the corrosive medium (seawater and atmosphere) and mechanical stresses occurring as a result of static and dynamic loads [1-3]. In studying such a complex process as corrosion–mechanical failure it is desirable to divide the range of problems into a series of more specific ones such as, for example, investigation of the influence of corrosion or mechanical factors of preliminary general corrosion of stressed metal on its fatigue strength.

Unnotched cylindrical samples of 20 steel with a diameter of 8 mm were tested. They were subjected to preliminary corrosion under natural seawater conditions with the use of special equipment which creates a static tensile stress in samples by the application of a constant load.

In tests in the sea the greatest difficulties are caused by the need to provide identical test conditions (the influence of the corrosive medium and the mechanical load) on each sample. The specifics of corrosion under seawater conditions require the compact placement of a significant number of samples necessary for constructing a fatigue curve at a uniform distance from sea level.

Known equipment for studying corrosion under stress at a constant load [1, 4-7] has loading of a single sample with lever or spring devices. The use of the principle of loading a single sample individually during sea experiments requires a large amount of equipment and complicates the investigation.

The method of loading a group of 25 to 30 series-connected samples directly by a weight [3] is suitable only for tests with small stresses [$(0.3-0.5)\sigma_y$] but does not provide identical conditions for all samples. In addition, the swelling and waves of the sea subject the samples to dynamic loading.

The proposed equipment lacks these disadvantages and provides identical test conditions for each of the samples investigated at a single level of stresses, constant mechanical loading with time, ease in calibration and loading, and the capacity of withstanding any swelling and waves in the sea.

The unit (Fig. 1) is a rigid $1500 \times 700 \times 240$ mm frame 12 inside which there is the system of levers 1. The samples 3 are located in three rows of four groups each, consisting of five sample each connected in series by the threaded sleeves 4. Each row is designed for a certain level of stresses. Therefore, the unit is capable of simultaneously testing 60 samples at three levels of stresses (20 at each). The amount of the load is determined by the ratio of the lever arms and is created by the spring 8. The loading force on the spring occurs as a result of rotation of the nut 9, which moves the load screw 7 along the groove 10.

From positions A–A and B–B it may be seen that the extreme groups of a single row form a statically determinate system. This provides the possibility of being limited by determination of the load in two groups of the row since the tensile forces in each group of the pairs are equal. We should also mention regulation of

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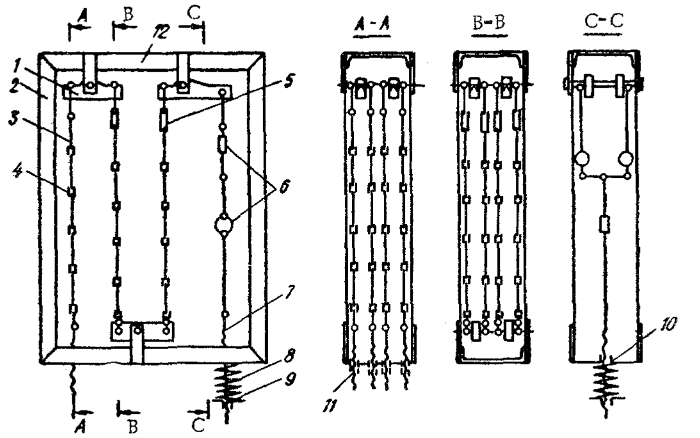
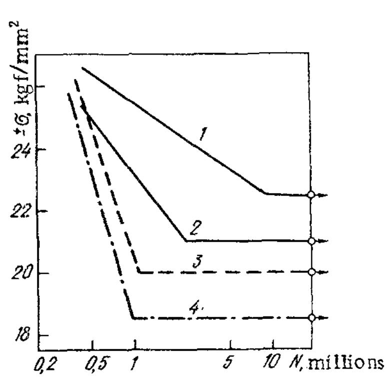


Fig. 1. The unit for corrosion testing of samples under stress.



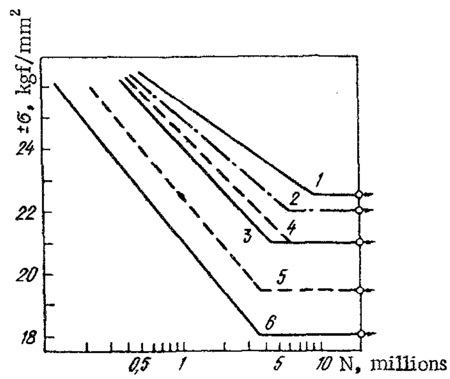


Fig. 2 Fig. 3

Fig. 2. Fatigue curves of 20 steel: 1) after normalizing; 2) after preliminary corrosion under stress for 4 months in the zone of periodic wetting with $\sigma = 0.4\sigma_y$; 3) $\sigma = 0.65\sigma_y$; 4) $\sigma = 0.9\sigma_y$.

Fig. 3. Fatigue curves of 20 steel: 1) after normalizing; 2) after preliminary corrosion under stress in the zone of atmospheric influence with $\sigma = 0.4\sigma_y$ for 3.5 and 24 months; 3, 4) with $\sigma = 0.65\sigma_y$ for 24 and 3.5 months, respectively; 5, 6) with $\sigma = 0.9\sigma_y$ for 3.5 and 24 months, respectively.

the length of the groups which is provided and which makes it possible to avoid strict control of the length of the groups and the connecting sleeves. The length of the groups of the first row is regulated with the use of the nuts 11 and of those of the second and third rows by the unit 5, which is based on the principle of the winch.

The loads on the groups are measured by wire strain gauges cemented to the elements of the groups 2, which cannot be removed from the levers and are a portion of the unit for regulating length. Each of these irremovable elements (dynamometers) has been calibrated in a certain range of loads, which makes it possible during their deformation to calculate the forces in the groups. Measurement of the deformation of the dynamometers under load may be done with any strain gauge bridge. The possible increase in tensile stresses in the samples during testing as a result of a decrease in their cross section because of corrosion may be periodically inspected for with the use of the dial dynamometers 6.

Two years of experience with the unit has shown it to be highly reliable. Subsequent fatigue testing has been done on type NU machines with a base of $10 \cdot 10^6$ cycles.

The influence of the mechanical factor was studied at three levels of stresses, $0.9\sigma_y$, $0.65\sigma_y$, and $0.4\sigma_y$, with different conditions of action of the aggressive medium (in zones of periodic wetting and of the action of the marine atmosphere) and times of preliminary corrosion under stress. Based on the data of metallographic analysis of samples which have passed the test, the depth of general corrosion was insignificant in all cases and, therefore, the decrease in cross section may be neglected in calculating the nominal stresses. However, with an increase in the level of stresses there is an increase in the number of points of local corrosion. The rate of this increase for similar times of preliminary corrosion and levels of stress is determined by the conditions of action of the aggressive medium. The greatest number of points was recorded in the zone of periodic wetting, i.e., in the areas subject to the most severe conditions.

Fatigue tests showed that preliminary corrosion under stress decreases the area of limited endurance and reduces the fatigue limit of steel (Figs. 2 and 3). The greatest reduction in limited endurance occurs under the influence of corrosion in the zone of wetting, but with high cyclic stresses the influence of the conditions of preliminary corrosion becomes weaker with an increase in the level of mechanical stresses. It is characteristic that preliminary corrosion under stress does not influence the fatigue limit.

The influence of the length of preliminary corrosion under stress on the endurance of steel was studied for the zone of action of the marine atmosphere (Fig. 3). With a stress of less than $0.65\sigma_y$ starting with some moment of time the length of the experiment is not substantially reflected in the endurance of the steel. In addition, at high levels of stresses it reduces the area of limited endurance and the fatigue limit of the steel.

LITERATURE CITED

1. N. P. Zhuk, A Course on the Theory of Corrosion and Protection of Metals [in Russian], Metallurgiya, Moscow (1976).
2. Kh. L. Logan, The Corrosion of Metals under Stress [in Russian], Metallurgiya, Moscow (1970).
3. S. A. Aleskerova, T. Yu. Agaev, Kh. D. Mustafaev, and V. A. Pakharyan, "A method of conducting corrosion-fatigue tests with preliminary static loading in an aggressive medium," in: Materials of the First All-Union Conference on the Dynamics and Strength of Oil-Industry Equipment [in Russian], Az. Inst. Neft. Khim., Baku (1974), pp. 131-135.
4. V. V. Romanov, Methods of Investigating the Corrosion of Metals [in Russian], Metallurgiya, Moscow (1965).
5. I. A. Rozenfel'd and I. A. Zhigalova, Accelerated Methods of Corrosion Testing of Metals [in Russian], Metallurgiya, Moscow (1966).
6. O. I. Steklov, The Strength of Welded Structures in Aggressive Media [in Russian], Mashinostroenie, Moscow (1976).
7. N. D. Tomashov, N. P. Zhuk, V. A. Titov, and M. A. Vedeneva, Laboratory Work on Corrosion and Protection of Metals [in Russian], Metallurgiya, Moscow (1971).