FATIGUE OF HIGH-STRENGTH STEEL AT VARIOUS FREQUENCIES OF LOADING AND THE SCHEMES OF THE STRESS STATE

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As the material of the study, steel 30KHGSN2A (Table 1) was heat-treated for various categories of strength (1280 MPa, 1500 MPa, 1800 MPa) and tested at different loading frequencies (0.17 Hz, 3.33 Hz, 40 Hz, 50 Hz) under different loading schemes. Fatigue characteristics and graphical dependencies are considered in detail in [1].

Chemical composition of steel 30KHGSN2A Table 1

C	Si	Mn	Ni	S	P	Cr	Cu
0.27 - 0.34	0.9 - 1.2	1 - 1.3	1.4 - 1.8	до 0.025	до 0.025	0.9 - 1.2	до 0.3

Steel 30KHGSN2A are widely used in various industries for the manufacture of load-bearing parts due to its high strength characteristics.

The microstructure of steel at different stages of developments was examined using optical microscope MIM-7 and KEYENCE VHX-100.

Three-dimensional fractographic picture of the structures were obtained using an optical microscope KEYENCE VHX-100.

The microhardness measurements were carried out on the device PMT-3 with load on the Vickers pyramid of 0.98 N (100 g).

For quantitative estimates of indicators of fatigue resistance was taken damaging the surface (Φ) and the slope of the left branch of the curve to the axis of absorption cycles tg α_w

The tests of the samples were processed using mathematical statistics with the construction of "straightened" fatigue curves [2-4].

All the results of our tests of steel 30KHGSN2A with different types of heat treatment and the loads tested under different schemes with different frequency spectra and room temperature were reduced in Table 2.

Results of fatigue tests of steel 30KHGSN2A Table 2

Thermal Treatment Mode	ω, Hz	$\sigma_в$, MPa	Sample dimensions, mm	Equation of the fatigue curve	$K_{кор}$	tgα_w	Φ	Type of test

Y	0.17	1280	300x36x4	lgσ = 3.9821 – 0.301 lgN	-0.9795	0.301	нет данных	ORSP
Y	40	1280	300x36x4	lgσ = 3.7682 – 0.2466 lgN	-0.9834	0.2466	нет данных	ORSP
3+ NO	0.17	1800	300x36x4	lgσ = 4.0779 – 0.301 lgN	-0.989	0.301	нет данных	ORSP
3+ NO	40	1800	300x36x4	lgσ = 3.9239 – 0.2552 lgN	-0.99	0.2552	нет данных	ORSP
3+CO	3.33	1500	3x3	lgσ = 3.3432 – 0.08723 lgN	-0.8404	0.08723	$0.0126 *10^{-3}$	CPIPO
annealed	50	no data	Ø 10	lgσ = 3.3882 – 0.1299 lgN	-0.9592	0.1299	$3.86*10^{-3}$	IVTSO
3+CO	50	1500	Ø 10	lgσ = 3.3796 – 0.09257 lgN	-0.96	0.09257	0.00463	IVTSO
3+CO	50	1500	Ø 5	lgσ = 3,1308 – 0.0457 lgN	-0.9049	0.0457	$0.39 * 10^{-4}$	IVTSO

Here the conventional symbols are used: TO - heat treatment; Y - improvement, 3 - hardening; NO - low vacations; CO - average vacation; ORSP - axial extension of the pulsating cycle; CPIPO - is a cyclic transverse bending of a flat sample; IVTSO - bending of a rotating cylindrical specimen.

Analysis of experimental data presented in table 2 shows that, increasing the frequency of loading cycles and, in addition to this, mitigation of the scheme of stress state (bending deformation of the rotating cylindrical sample) lead to a noticeable decrease of the parameter (tg α_w) (slope of the left branch of the fatigue curve), i.e. to improve the characteristics of fatigue resistance. The correlation coefficient of Ccor expressing the degree of convergence of experimental test results and determining the stability behavior of steel is in all cases rather high values, with the exception of samples tested according to the scheme (CPIPO) that apparently depends on their small size and thus more sensitive to the effects of various external and internal factors. The improvement in the fatigue resistance parameter is associated with an increase in the hardening capacity of the material of the surface layers of the samples, which reduces the fatigue damage of the surface proper.

References:

1. Mylnikov VV, Shetulov DI, Pronin AI, Chernyshov EA Forecasting the strength and durability of materials of machine parts and structures, taking into account the frequency of cyclic loading // Izvestiya Vuzov. Ferrous metallurgy. 2012. No. 9. pp. 32-37.

2. Mylnikov VV, Chernyshov EA, Shetulov DI Influence of the frequency of cyclic loading on the fatigue resistance of high-strength structural materials // Procurement industries in mechanical engineering. 2009. No. 2. pp. 33-36.

3. Shetulov D.I., Myl'nikov V.V. Fatigue-induced damage of high-strength steels // Russian metallurgy (Metally). 2014. T. 2014. No. 3. C. 241-245.

4. Mylnikov V. V., Shetulov D. I., Chernyshov E. A. On evaluation of durability criteria in carbon steels // Metals Technology. 2010. No. 2. p. 19.