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Bench tests SHESTERENZI AND STEEL 12HN3A 15HHNBTCH

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Investigated performance properties of steels and 12HN3A 15HHNBTCH during bench testing gears.

Gears, steel, pitynh, closed loop torque load.

Problem. To ensure the required service life of toothing, necessary to study conditions, causes and nature of deterioration and destruction. Just knowing beforehand the mechanism of destruction of steel, can adequately adapt its structure to counteract this destruction.

The reasons decrease the performance of cylindrical gears. On the basis of literary analysis studied the problem of contact endurance cylindrical gears associated with the choice of materials and manufacturing technology.

Analysis of recent research. One way to improve the performance of gears found an increase in actual contact area [1] by increasing the precision manufacturing gear pairs, which reduces contact stress, and increases endurance contact gears.

The main criterion for the performance of the material gears and contact fatigue strength, determined by the size and hardness of martensite packet, shape and dispersion carbide phase and nonmetallic inclusions, and that the surface layer of the optimum amount of residual austenite. Also, you should take into account the fact that the core material tooth gear should provide sufficient rigidity of the substrate, depending on load conditions. I have an adequate supply of specific destruction.

Based on the fact that the mechanical properties of steels with a martensitic structure not directly related to the strength austenitic grain boundaries, they are determined mainly martensite morphology and size of the package, the presence in the other phases (residual austenite, ferrite) [2]. Thus, the strength and fracture toughness martensite is controlled by various structural factors, so that it is possible to separate and deliberate action on the structure to enhance structural strength steels. Given that the level of liquid limit 1200-2000 MPa, it is sufficient for most structural materials [3], the main problem here is to consider the need to address Intergrain crack growth.

In addition to strength characteristics of the contact fatigue strength must have a significant impact and the specific work of fracture of steel.

Because, based on the theory considered the contact fatigue strength of materials, 80% of the time accounted for crack propagation. The simultaneous increase in viscosity and plasticity possible by reducing the grain size.

In martensite and carbide phase in cemented layer structure always exists a significant amount of residual austenite, although earlier and it was believed that the presence of residual austenite is unacceptable in cemented layer [4], in later works convincingly proved that the structural component may favorably influence contact fatigue strength of the surface layer [5]. However, in most cases find that the surface layer of cemented gears retained austenite content should not exceed 25 ... 30%. However, one should take into account the factor that changing the content of the residual austenite content changes in steel and other structural components. Most authors nevertheless agree that the optimal content of residual austenite within 30 ... 50%, depending on the value of specific pressure [6].

The purpose of research. Based on the analysis literature on the impact of structural components in contact fatigue strength steels for cementing, for solving problems in the optimized selection for cementing steel gears and a comparative bench tests gears of recommended materials and continuous steel 12HN3A.

Because only bench tests make it possible to evaluate the real performance materials for gears and provide identification of the impact of possible extreme loads in the process of meshing gear on its workability.

Results. Bench tests conducted most heavy gear parts GMP-2, which is the reverse gear and the first gear. Also, because the manufacture of gears blocks first transmission used electron-beam welding, then to evaluate its quality was also tested weld.

During the test tasks were as follows:

- Compare the durability of gears made of serial and experimental steels;
- Determination of noise characteristics when running gear transmissions;
- Investigate the nature of the destruction of the working surface of the teeth of gears;
- Determine the reliability of the weld first transmission gears.

Comparative tests were conducted on gears SOSH.1.0.0.000SB stand with adjustable mechanical load in a closed loop. The kinematics of the stand shown in Fig. 1.

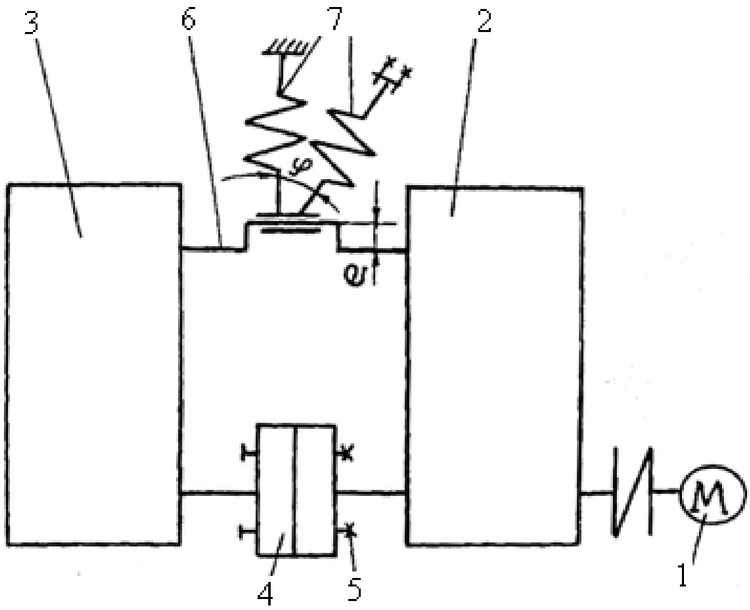

Fig. 1. Scheme of the stand with varying load:
1 - electric motor; 2 - reduction of the experimental gear; 3 - reduction gear with serial; 4 - torsion loader;
5 - latches; 6 - eccentric shaft; 7 - elastic elements.

Stand for testing consisted of two gears with the same gear ratio that allows a comparative test series and experimental details in absolutely identical load conditions.

Gear reducers are interconnected directly through the mechanisms of stress, it ensures the stability of the load, which does not depend on external factors.

To create a variable load with varying amplitude used special loader that allows you to play loads of elements with different coefficients of asymmetry. In low-speed link is set eccentric shaft to which are attached two elastic elements when necessary angles, with alternating load created by the efforts of stretching elastic elements on the value of eccentricity.

To determine the in demand during accelerated tests to calculate the rate of acceleration zadavshys forced equivalent amplitude at a constant frequency, or frequency - at a constant amplitude, based on the fact that the predominant type of abnormal function of gear transmissions are fatigue fracture surfaces of the teeth (pitynh).

Increased frequency implies conformity to the following conditions:

- Study unit approaches the resonance;
- The impact of re-frequency alternating load on the destruction of small.

With increasing load amplitudes necessary to stress the design did not exceed permissible.

Compliance with the assumed conditions allows to reduce the test on the stand comparison with the performance:

$$K_y = \frac{\tau_н}{\tau_c} = \frac{w_y}{w} \cdot \left(\frac{q_y}{q} \right)^m ,$$

where $\tau_{Categories}$ - The duration of the performance test;

τ_{with} - Duration of the test on the stand;

ω_y, *Qy*- The frequency and amplitude of the load at bench trials;

ω, *Q*- The frequency and amplitude of load performance testing;

m- Exponent curve of fatigue;

Ky acceleration coefficient.

Based on the fact that nominal modes gear GMP-2 replied: T = torque 1000 Nm·m, At speed n = 1000 rev / min and average transmit power N = 100 kW, was defined test mode Ty = 2000 N·m, Ny = 750 rev / min, Ny == 150 kW. In this case, the acceleration factor of power is:

$$K_y = \frac{N_y}{N} = \frac{150}{100} = 1{,}5 .$$

Torque mounted torsion truck (Tmah = 1500N·m). The required eccentricity crankshaft provided by alternating loader (Emax = = 30 mm). The required angle between the elastic elements made: φ = = 0 ... 90o. At all stages of testing the measurement of sound pressure device YSHV-1 for additional status monitoring gear transmission.

When tested on a break load gears gears carried on the following timeline: 10% - T = 0.2 M; 20% - T == 0.4 M; 50% - T = 0.75 M; 20% - T = M, where: T - torque loading time; M - equivalent amplitude periodic load was determined by the formula:

$$M = \sqrt[m]{\frac{K_y}{w_ш}} \cdot \sqrt{\sum_{i=0}^{k} T_i^2 \cdot w_i^{\frac{2}{m}}} ;$$

where Ky - accelerating factor;

Wsh - Rotational speed gears on the stand;

Ti - Torque;

Wi- Rotational speed gears in the wild;

m - Indicators of the degree of material fatigue curve gears.

Thus, regimes of bench testing gear reducer GMP-2 were fully comply modes of toothing in operating conditions. To ensure the probability of the results of comparative tests on the stand with closed loop simultaneously set two gears. (Fig. 2). In one of the gears were installed serial 12HNZA steel, and another - a comprehensive introduction to the made-alloy steel 15HHNBTCH. Production of chemical and heat treatment details held simultaneously by the same modes. Installing the stand motor nominal capacity of 30 kW and the rotation speed of 750 rev / min, allowed a torque to 2000 Nm, ensuring dual exceeding the nominal operating modes toothing in operating conditions.

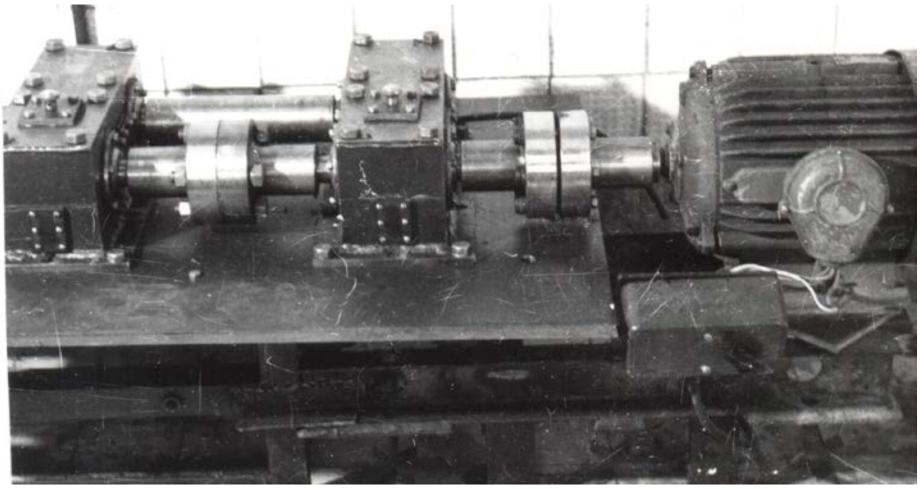

Fig. 2. Appearance stand with closed loop.

To control the magnitude of torque during testing, the measurements were run out of time at the beginning of the experiment and after the period of time of 30 min.

With increasing run-time load carried again to the value of maximum torque.

Control of the state gears carried through inspection openings gear intervals of time equal to one hour of pure time trial. The results of the comparative tests are summarized in Table. 1.

1. Results of bench tests.

	I transmission gears		Pinion reverse gear	
	15HHNBTCH	12HNZA	15HHNBTCH	12HNZA
The number of cycles before the appearance pitynhu	2.9·106	2.1·106	6.0·106	3.1·106
The overall sound pressure level, dB	98	103	108	112
The distribution of the frequencies				
500 Hz	90	92	94	96
250 Hz	85	89	90	91
125 Hz	82	85	86	87
63 Hz	73	75	76	76

Test first transmission gears carried at a value of torque - 1250 Nm and speed of rotation of 750 rev / min.

Under these conditions, the load on the serial pitynh gear formed after 48 hours, corresponding to 2.1 · 106 cycles. Sinks formed had dimensions of 2.5 mm in diameter, with a depth of 0.5 mm. Damage concentrated in the area of greatest stress - in extreme gearing. Average number of bowls on one tooth gear with serial steel was - 10 ... 15.

The origin of fatigue damage on gears of steel was recommended after 64 hours of stand corresponding to - 2.9·106 cycles. Thus, the life of toothing of the developed steel than 15HHNBTCH life of toothing serial steel 12HNZA 1.33 times. Thus, we see a qualitatively different nature and origin of fatigue damage in experimental gears. Dimensions shells do not exceed 0.4 mm, with a depth of 0.01 mm. The average number of shells in the tooth does not exceed 3-5. In addition, the contact zone serial gears after one hour test appears plastic deformation of the surface of the pole engagement. Plastic deformation of the surface layer of the teeth of gears experimental appears only after ten hours. The challenge test was part of the first transmission gears research on the strength of the weld pinion gear couplings made from steel 15HHNBTCH. Visual inspection of the weld four gears at rated load waste to Mn = 1500 N·mrevealed no defects.

When loading gear to load - 2000 N·m, Which is 1.7 times the value of the maximum torque that arise in operating conditions is premature fracture of tooth wheels through 2.9·102 cycles changes in stress (Fig. 3), while the weld gears left no trace of damage.

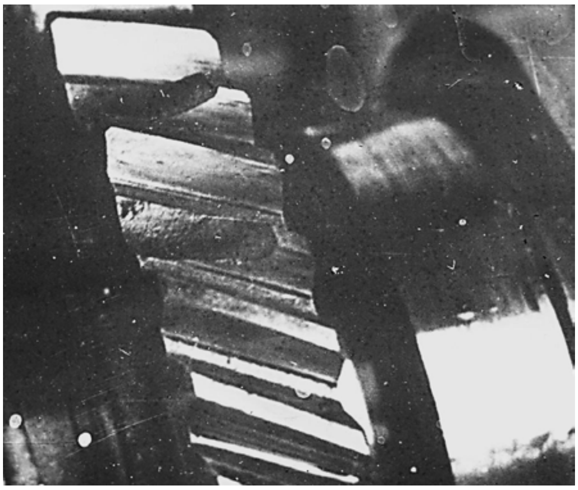

Fig. 3. Breaking teeth during testing of the weld.

These observations suggest that the margin weld strength is much higher than most of the teeth.

Test gears with reverse gear gears carried out at torque - 500 N·mand the speed of rotation of 2940 rev / min. Pitynh on serial gears formed after 16 hours, ie 3.1·106 cycles. In serial gear sink with dimensions: diameter to - 3 mm, depth of - 0.5 mm. Damage concentrated in the area of greatest stress - Pole engagement. The origin of fatigue damage gear tooth surface of the material is recommended after 30 hours, ie 6·106changes in stress cycles. Dimensions shells on these gears was: diameter 0.5 mm, depth 0.1 mm. The average number of shells in one experimental tooth gears - 3 ... 4, and the batch - 14 ... 16.

Periodically, with an interval of 30 minutes time control conducted sound pressure level, which created a working stand. The measurement of sound pressure was carried out to further monitor the state of gears. The value of sound pressure level are shown in Table. 1. Analysis of the results of bench tests show that the details of our recommended service life of steel have at different load modes in 1,3-1,9 times higher than the details of the serial 12HNZA steel, due to a higher level of physical and mechanical properties of steel 15HHNBTCH .

During the studies found that parts of the developed steel 15HHNBTCH have not only a higher resource work, compared with the details of the serial 12HNZA steel, but qualitatively different fracture.

Considering the structure of the boundary layer 12HNZA in the contact zone (Fig. 4), we see that the first metal is deformed, as if floating structure under contact loads.

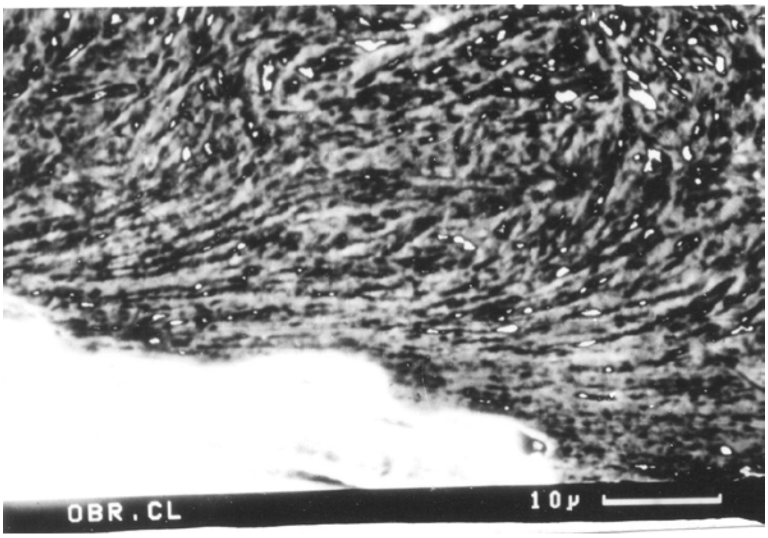

Fig. 4. Deformation structure of the surface layer (steel 12HNZA detail).

Then, at a certain stage, the nucleation of microcracks, and the cracks are emerging in the area major or plastic deformation, and this area is on the surface or below the surface in areas of structural imperfections that as stress concentrators lead to premature formation of microcracks.

Conclusions

Analyzing the results of comparative bench testing gear with the details of the serial 12HNZA steel and steel 15HHNBTCH research and the results of research into the causes and nature of the destruction of contacting, the following conclusions:

1. Details of the experimental steels have a life of 1,3-1,9 times higher than the details of the serial steel.

2. In parts of serial steel surface deformation observed in the contact zone, due to poor dispersion and microhardness structure. The destruction of the steel surface burst is fragile nature, there is a high speed, which increases the likelihood of accidental breakage.

3. The surface of the parts of the developed steel 15HHNBTCH destroyed much slower due to the viscous nature of the damage.

4. The reason for the formation of sub-surface cracks are superficial layer structure deformation resulting from insufficient physical and mechanical properties of a material that can not withstand the impact of external contact loads.

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Yssledovanы эkspluatatsyonnыe properties of steels and 12HN3A 15HHNBTCH while conducting tests of stendovыh zubchatыh gear.

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