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INFLUENCE OF THE SHOCK WAVE OF ELECTRIC DISCHARGE ON THE FATIGUE CHARACTERISTICS OF THERMALLY HARDENED STEEL

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The procedure of treatment of thermally hardened steel by pulses of shock waves from electric discharges in water increases its hardness and the limited fatigue strength. As a result of the action of shock-wave pulses, the number of dislocations increases. This guarantees the propagation of deformation in a cycle, which promotes the increase in cyclic fatigue strength

Keywords: fatigue strength, dislocation, pulse, shock wave, cyclic amplitude.

As compared with thermal technologies, the application of the pulses of electric current [1] or the stresses caused by shock wave [2] may change the structural states of metallic materials. The complexity of control over a single high-power pulse of shock wave can be removed by its replacement by numerous low-power pulses caused by the electric discharges in liquids. The analysis of the accumulated results shows that the changes in the power and number of pulses from the electric discharge in water [3] enable us to exert a strong influence on the complex of properties of metals and alloys. At the same time, this influence is ambiguous [4]. According to the results presented in [3, 4], the increase in the amplitude of the pulse promotes the accumulation of dislocations and the duration of its action determines the conditions of their motion. The available investigations are, for the most part, devoted to the analysis of the effect of treatment by electric discharges in the liquid on the properties of metallic materials under the conditions of static loading [2–5].

In what follows, we analyze the influence of shock-wave pulses on the limited fatigue strength of thermally hardened carbon steel under the conditions of fatigue.

Material and Method

The investigated material is carbon steel of the railroad wheelset axle with the following chemical composition (%): 0.45 C, 0.85 Mn, 0.50 Si, 0.022 S, and 0.017 P. The amount of other chemical elements lies within the limits of the grade composition of 45 steel. After manufacturing, the specimens for fatigue tests were thermally hardened: hardening from the temperature higher than Ac_3 followed by tempering at a temperature of 300°C. The fatigue tests were carried out by bending in a "Saturn-10" machine under symmetric loading cycles. The strength was evaluated according to the Rockwell hardness. The specimens were treated by shock-wave pulses in water with the use of an "Iskra-23" industrial bath-type installation. The electric discharge with a voltage 15–18 kV was used to form pulses with an energy of 10–12 kJ and a stress amplitude of 1–2 GPa. The number of treating pulses with a frequency of 2–3 Hz was as large as 15,000. The density of dislocations was evaluated by the X-ray phase diffraction analysis in a DRON-3 installation.

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thermal hardening. The increased number of dislocations in various crystallographic sliding systems after the action of shock-wave pulses reveals the development of complex reactions with participation of dislocations guaranteeing the increment of the cyclic fatigue strength of carbon steel.

CONCLUSIONS

The procedure of treatment of thermally hardened carbon steel by shock-wave pulses from electric discharges in water is accompanied by the increase in the density of dislocations, which favors the increase in the limited fatigue strength. The comparative analysis of a section of the curve of limited fatigue strength demonstrate that, for the same number of cycles ($0.4 \cdot 10^6$), the procedure of treatment by shock-wave pulses leads to an increase in the fatigue limit of steel from 540 up to 900 MPa (i.e., more than 1.5-fold). The practical application of this kind of treatment can be useful for the analysis of proposals concerning the increase in the lifetime of elements of rolling stock suffering numerous repeated cyclic loads.

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