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STRUCTURAL PHASE STATES AND PROPERTIES OF 100-M RAILS AFTER LONG-TERM OPERATION

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The purpose of the research is to study the structural phase states and properties being formed on the tread surface and fillet in the head of 100-m differentiatedly quenched rails after passed tonnage of 1411 mln. t. brutto and the comparative analysis with volume parameters of rail steel.

The microhardness profiles testify that rail operation is accompanied by the essential strengthening of the near-surface steel layer up to 80-100 μm thick independent of the rail area under study (zone of tread surface or working fillet). In this case the steel hardness is 1.5-2 – fold higher at rail surface as compared with the volume and it decreases with a greater distance from the working surface.

The strengthening of steel surface layer is accompanied by the increase in material wear resistance. The results testify that wear resistance of tread surface increased ≈ 7 – fold in relation to volume.

The increase in steel wear resistance is accompanied by the friction coefficient growth (by ≈1.3 times). The character of friction coefficient dependence on test time is different for steel volume located at 15 mm depth from tread surface and the one forming the tread surface. In the first case the change in friction coefficient returns to the standard level after 100 s running-in; in the second case - after 400 s. The latter evidently is indicative of the change in structural phase of steel in the surface layer in the process of rails' operation. The friction track obtained in tribological tests of rail tread surface has a smoother profile that is indicative of a more equistrength state of surface layer of friction track as compared with the rail volume material.

In rail head the steel microstructure is formed by lamellar pearlite with average grain size of 29.8 μm (the size of real grains varies within the limits from 15.0 μm to 51.2 μm). Along the pearlite grain boundaries the comparatively fine grains of excess ferrite are detected, they are estimated by 1.5 number of scale № 7 of Russian State Standard 8233. Bainite in the sample metal microstructure is not revealed by the metallography methods.

By the methods of scanning electron microscopy of the etched metallographic sections of fillet and head tread surface at 0.5-1.0 mm depth it has been stated that steel structure is presented by fine-grained pearlite of lamellar morphology. In the pearlite structure in addition to the regular colonies with cementite plates located in parallel the colonies in which the cementite plates are failed or located in random fashion are detected.

Analysis of the revealed structure has shown that the value of steel pearlite colonies varies in thelimits from 2.7 μm to 12.2 μ mat average value of 6.2 μm. The distance between plates (the distance between the boundaries of neighboring plates of cementite) varies in thelimits from 73 nm to 256 nm atthe average value of 132 nm and practically is independent of the location of area under analysis relative to fillet and tread surface.

By the methods of X-ray structural analysis it has been determined that the main phases of steel under study are the solid solution based on α-iron (bcc crystal lattice) and carbide of iron (Fe_3C, cementite). Examination of X-ray structural analysis results shows that the cementite located in steel volume forming the tread surface is in the essentially higher stress state in comparisonwith volume cementite.

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