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FEATURES OF FORMATION OF THE STRUCTURE AND PROPERTIES OF LOW-CARBON STEEL AFTER WARM TWIST EXTRUSION

The new developing technologies of metal formation based on simple shear are called severe plastic deformation (SPD). Their advantage is that they allow obtaining materials with unique complex properties combining high strength and plasticity as distinct from classical methods of metal forming. Numerous structural studies have been carried out for SPD-processed materials, such as Al, Ti, Cu and their alloys. Such complex systems as steels have not been adequately investigated because of labor intensive deformation processes. However, the studies are in progress. Due to insufficient knowledge of the structural changes occurring in low-carbon steels during SPD, there is a need for a more detailed consideration by modern methods. Thus, electron backscattered diffraction is a relatively new method, which allows a detailed study of the structure of metals. The paper discusses the characteristics of the formation of structure and texture of low-carbon steel subjected to warm twist extrusion (TE).

As the SPD, warm TE was applied at the temperature of 400°C. It should be noted that after warm deformation of low carbon steel, recrystallized ferrite grains are observed in the material. Qualitative and quantitative analysis of statistics shows effective influence of the twist extrusion on the structure of steel. Electron backscattering diffraction demonstrates that the warm TE increases the structure isotropy, results in significant fragmentation and activation of the mechanisms of dynamic polygonisation and recrystallization, grain boundary sliding. These structural features have led to hardening of the material in 1.5 times, with maintaining a high level of plasticity.

Keywords: electron backscattering diffraction, structure, texture, high angle boundaries, twist extrusion, dynamical recrystallization, mechanical properties.

Fig. 1. Microstructure of low-carbon steel 20G2S: *а*, *в*, *д* – EBSD maps of band contrast; *б*, *г*, *е* – TEM, ×5000; *а*, *б* – the initial state; *в*, *г* – warm TE, cross section; *д*, *е* – warm TE, longitudinal section

Fig. 2. Data of the structure analysis of low-carbon steel 20G2S: *а* – size distribution of grains: ■ – initial state, ○ – TE, cross section, △ – TE, longitudinal section; *б* – aspect ratio of grains: ▧ – initial state, ■ – TE, cross section, ▤ – TE, longitudinal section; *в* – size distribution of grains in normalized coordinates: ■, □ – initial state, big and small grains accordingly; ●, ○ – TE, big and small grains, respectively; *г* – misorientation angle distribution of grain boundaries: □ – initial state, ● – TE, cross section, △ – TE, longitudinal section

Fig. 3. Stress-strain curve for low-carbon steel 20G2S, upsetting tests: *1* – initial state; *2*, *3* – TE axis is perpendicular and parallel to the axis of upsetting, respectively