THE EFFECT OF HYDROGENATION ON MECHANICAL PROPERTIES AND DEFORMATION MECHANISM IN <144> SINGLE CRYSTALS OF HADFIELD STEEL

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The influence of hydrogenation on microstructure and mechanical properties of <144> single crystals of Hadfield steel (Fe–13Mn–1.3C, wt. %) was investigated using transmission electron microscopy, optical metallography, tensile testing at room temperature. Electrochemical hydrogen charging was performed for 0.5–15 hours at room temperature in 3% water solution of NaCl containing 3g l^{-1} of NH_4SCN as recombination poison at current density of 10 mA/cm^2.

Electron microscopic examinations of specimens deformed at room temperature showed that the main mechanism of deformation of the <144>-oriented single crystals in the initial state (without hydrogenation) is mechanical twinning. Single twinning starts from the very beginning of plastic flow, after yield point and determines the first stage of plastic curve with low strain hardening coefficient $\theta = d\sigma/d\varepsilon \approx 0$ MPa. The second stage of plastic flow with $\theta \approx 1000$ MPa corresponds to multiple twinning, and starts after 30–45% of plastic strain.

Hydrogenation for 0.5 and 1 hour provides a decrease in value of σ_0 from 396 MPa in initial state (without hydrogen saturation) down to 300 MPa after charging for 1 hour. Increase in duration of hydrogen saturation up to 2–15 hours leads to increase in value of σ_0 up to 310-320MPa compared to states after hydrogen charging for 0.5 and 1 hour. But independently on duration of hydrogenation, the yield stresses of hydrogen saturated specimens are lower than in hydrogen-free ones. The total elongation of specimens hydrogenated for 0.5 and 1 hour is higher than that for specimens without hydrogen alloying – $\varepsilon\approx70\%$ for hydrogen-free and $\varepsilon\approx80\%$ for hydrogen-charged specimens. With following increase in hydrogenation duration up to 15 hours, the elongation of specimens decreases and gets similar to initial state.

The stages of plastic flow and deformation mechanisms for hydrogen-charged specimens are similar to one in initial state, but the strain-hardening coefficient on the second stage (associated with multiple twinning) tends to be lower for hydrogenated specimens $\theta\approx700$MPa compared to hydrogen-free one. These features arise from the prevalent role of the twinning in one system during deformation of hydrogen-saturated specimens, even in second stage corresponded to multiple shear.

The study on <144>-oriented single crystals of hydrogen-free and hydrogen-charged Hadfield steel has experimentally demonstrated a substantial activation of mechanical twinning in the hydrogen-charged specimens, which in turn caused a decrease in yield stresses and an increase in ductility (for hydrogenation duration of 0.5 – 5 hours).

This research was supported by the Russian Foundation for Basic Researches (project No. 15-38-20056). The authors are grateful to Professor Yu.I. Chumlyakov for steel single crystals.