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PECULIARITIES OF OPERATIONAL EMBRITTLEMENT AND FRACTURE OF STRUCTURAL STEELS UNDER HYDROGEN INFLUENCE

Nowadays, degradation of long-term operated structural steels is one of the main issues facing engineering [1–3]. The paper systematizes the structural, mechanical and electrochemical signs of operational degradation of structural steels, as well as the main stages of degradation: deformation aging and development of dissipated damaging in a metal bulk at nano- and micro-scale.

Operational degradation of steels implies changes in the microstructure, nano- and micromechanism of fracture and deterioration of their mechanical and electrochemical properties. The problem is especially important at assessing the current state of critical steel structures operated under the combined action of mechanical loading and corrosive environments, since hydrogen charging of steels under operation due to electrochemical corrosion plays an important role in their degradation.

The most important characteristic feature of the operational degradation of steels is the significant reduction of their brittle fracture resistance, namely fracture toughness and impact strength. This leads to increasing a failure risk of long-term operated steel structures. Therefore, deterioration of brittle fracture resistance under long-term operation should be considered as a particular important factor in ensuring their structural integrity. Moreover, interaction of a metal with corrosive and hydrogenating environments under operation leads to further increase failure risk not only because of acceleration of crack propagation, but also because of intensification of material degradation as a result of its hydrogen charging during long-term operation. In such circumstances, continuing damage accumulation is induced and driven by combined working loads and hydrogen, which consequently leads to deterioration of mechanical behaviour.

For assessment of in-service degradation of long-term operated steels, very important is seeking physical and mechanical parameters which are sensitive to changes in a metal, and on the basis of which it is possible to quantitatively evaluate its current state. These include, first of all, the widely used mechanical characteristics of brittle fracture resistance, namely impact toughness, fracture toughness, fatigue and corrosion fatigue crack growth resistance, and resistance to stress corrosion cracking and hydrogen embrittlement.

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