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#00657Low and high cycle fatigue of heat resistant steels and nickel based alloys in hydrogen for gas, steam turbines and generators applications

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Abstract

The production of turbine and generator equipment requires a wide usage of dispersive hardened heat-resistant Ni-Co alloys and high nitrogen steels. Elevated temperature steels and alloys are exploited at high temperatures steam (up to 700 °C), hydrogen containing gas mixtures (up to 900 °C). Therefore one of the most important requirements for such steels and alloys is their resistance to hydrogen degradation at very high temperatures. In other words their ability to keep high level of mechanical and fatigue properties under the action of hydrogen in wide range of exploitation parameters. At the same time, age-hardening alloys are known to be rather sensitive to hydrogen embrittlement.

The serviceability of structures in hydrogen is, as a rule, estimated according to the results of testing at room temperature and life extension procedures has base on such approaches. However, the operating conditions of the equipment for hydrogen power engineering include cyclic loading of the products in hydrogen in fairly broad temperature ranges. In most cases, the influence of gaseous hydrogen on mechanical properties weakens as temperature increases and, according to the presented in, the upper temperature of embrittlement under the analyzed conditions was equal to 300 °C. At the same time, we reveal a significant decrease in the plasticity of heat-resistant nickel alloys in hydrogen under a pressure of 35 MPa at temperature 700 °C.

It has been established that, at some region of hydrogen pressure and strain rate exists a maximum influence of hydrogen on the plasticity, low cycle fatigue and cyclic crack resistance of Ni-Co alloys and high nitrogen steels. The drop of plasticity of the dispersion-hardening materials within the temperature range of intense phase transformations is caused by the localization of strains on the grain boundaries due to the intense redistribution of alloying elements in the boundary regions. Moreover, the increase in plasticity observed at higher temperatures is caused both by partial coagulation of hardening phases and possible dissolution of small amounts of finely divided precipitations.