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Synergetic mechanism of high temperature radiation embrittlement of austenitic steels under long term neutron irradiation at high temperatures

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The present report represents the study results of mechanisms of fracture and embrittlement of austenitic steels of 18Cr-9Ni and 18Cr-10Ni-Ti grades after long term neutron irradiation at high temperatures. The effect of irradiation temperature, irradiation time and neutron dose is considered on the fracture strain and fracture mechanisms.

It has been found in the present research that long term neutron irradiation (near 120,000 h, neutron dose is 1dpa) at high temperature (near 500 degrees Celsius) results in significant decrease of the fracture strain for uniaxial tensile specimens tested at temperature above degrees Celsius. This decrease is accompanied by the transition from transcrystalline ductile fracture to intercrystalline quasi-brittle fracture.

Possible reasons of high temperature radiation embrittlement have been analyzed. It has been shown that the known mechanism of high temperature radiation embrittlement connected with accumulation and growth of helium bubbles on grain boundaries is not the only reason of this embrittlement for the investigated steels and irradiation condition.

It has been revealed in the present study that high temperature radiation embrittlement is caused by synergetic action of two factors - helium and thermal aging. Thermal aging results in formation of various phases on grain boundaries and, hence, in decrease of grain boundary strength. Helium diffusion at high test temperatures stimulates accumulation and growth of helium bubbles on weakened grain boundaries. Thus, thermal aging promotes the helium brittleness development. However, separately neither thermal aging nor helium bubbles results in high temperature radiation embrittlement for the investigated steels and irradiation condition.

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