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Abstract

In this paper thermal stability and radiation resistance of VVER-type RPV steels for pressure vessels of advanced reactors with different nickel content were studied. A complex of microstructural studies and mechanical tests of the steels in different states (after long thermal exposures, provoking embrittling heat treatment and accelerated neutron irradiation) was carried out. It is shown that nickel content (other things being equal) determines the extent of materials degradation under influence of operational factors: steels with a lower nickel concentration demonstrate a higher thermal stability and radiation resistance.

Keywords: reactor pressure vessel steel, thermal stability, radiation resistance, phase composition, microstructural studies, embrittlement heat treatment, neutron irradiation,

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1 Introduction

Bcc-lattice steels used for manufacture of water-moderated reactor pressure vessels are characterized by the phenomena of ductile-to-brittle transition, which is expressed in a sharp change of the fracture energy, reduction of plastic properties and a change of fracture mode from ductile to brittle within a narrow temperature range. The quantity that characterizes ductile-to brittle transition is traditionally a critical brittleness temperature (T_K), that corresponds to the temperature when tension strength of the material is equal to its yield strength ($\sigma_{0.2}$).

Operation of reactor pressure vessel (RPV) steels leads to their embrittlement – the shift of the critical brittleness temperature to higher temperatures, which may result in a serious accident due to RPV brittle fracture. Numerous studies [1-8] showed that mechanisms of RPV steel embrittlement can be divided into the hardening and non-hardening ones.

The hardening mechanism is related to a change of strength characteristics due to formation of radiation defects (dislocation loops) and radiation-induced precipitates. In this the rate of precipitates formation is determined mainly by irradiation conditions and chemical composition of the steel. This primarily relates to the nickel content and copper and phosphorus