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EFFECTS OF NEUTRON IRRADIATION ON RESISTIVITY OF REACTOR PRESSURE VESSEL STEEL

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HIGHLIGHTS

[1]. Commercial RPV steel is subjected to accelerated neutron irradiation.
[2]. Tests are performed at high temperature and radiation fluence up to 0.154 dpa.
[3]. Nonlinearity is observed in the resistivity of RPV steel.
[4]. Degree of nonlinearity increases with an increase in the radiation fluence.
[5]. The resistivity-radiation fluence relationship for RPV steel is a quadratic one.

ABSTRACT

The embrittlement of reactor pressure vessel (RPV) steel owing to fast-neutron irradiation is one of its primary failure mechanisms. In this work, neutron irradiation tests were performed on an RPV steel at a high temperature (565 K) using a neutron irradiation test reactor. In addition, resistivity measurements were performed on the RPV steel both before and after irradiation in a hot laboratory using the four-probe method. The results showed that the resistivity of the RPV steel exhibits nonlinear behaviour with respect to the radiation fluence and that the nonlinearity becomes more pronounced with an increase in the radiation fluence. For instance, when the radiation fluence is 0.1540 dpa and the excitation current is increased from 0.2 mA to 200 mA, the resistivity of the RPV steel decreases by as much as 67.12%. During irradiation embrittlement, the resistivity increases with the fluence. When the radiation fluence is greater than 0.116 dpa, the increase in the resistivity accelerates. When the radiation fluence is less than 0.116 dpa and when an excitation current of 2 mA or 20 mA is used, the relationship between the resistivity and the radiation fluence for the RPV steel is a quadratic one, whereas that between the rate of change in the resistivity and the radiation fluence is a linear one. Thus, the resistivity of RPV steel can be used to characterise its degree of irradiation embrittlement, and resistivity measurements can be employed as a nondestructive evaluation technique for monitoring the degree of irradiation damage experienced by in-service RPV steel.

KEYWORDS: reactor pressure vessel steel, neutron irradiation, resistivity, nonlinear effect, irradiation damage, nondestructive evaluation techniques

1. Introduction

Reactor pressure vessel (RPV) steel is the core material for pressurised water reactor nuclear power plants. The RPV is the most important safety barrier for preventing the leakage of radioactive material and is the only nonreplaceable large-scale piece of equipment in the plant. Under high-temperature and high-pressure conditions