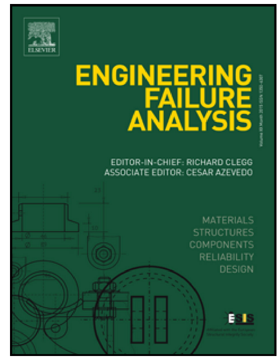

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Abstract

Under pressurized thermal shock (PTS), the structure integrity of reactor pressure vessel (RPV) meets a potential challenge. The vicinity of inlet nozzle is the weak link and hazardous area of the vessel. Once crack initiation occurs here, the stress concentration around the crack tip would lead to plastic deformation, crack propagation, and even the failure of the whole structure. Based on ABAQUS, the beltline region around the inlet nozzle was modeled to calculate the response of the transient temperature field and stress strain field. In order to demonstrate the ultimate bearing capacity of the RPV with the critical crack sizes, the dynamic process of crack propagation was simulated with the XFEM. Through the quantitative analysis of the Mises stress and circumferential stress through the wall thickness, the crack propagation paths in different directions were confirmed. The above analysis and calculation provide an important reference for the safety and reliability assessment of RPV.

Keywords: ultimate bearing capacity; RPV; pressurized thermal shock; XFEM.

1. Introduction

The most serious incident in a nuclear power plant is the catastrophic accident of reactor pressure vessel (RPV), which leads to the release and leakage of a large number of radioactive substances. The accurate and reliable design can protect the safety of RPV, but the improper design or poor operation could bring the potential threats to the safe operation of reactors, and even result in disastrous consequences. Considering, the safety testing of RPV under working conditions is very difficult and dangerous. Therefore, the integrity assessment of the RPVs in service is a very important subject [1].

In the loss of coolant accident (LOCA), the inner surface of RPV is subjected to pressurized thermal shock (PTS). Under the combined action of the internal pressure and the thermal stress produced by cooling water, a higher stress is generated around the inlet nozzle [2]. On the other hand, when the nuclear power plant runs to the end of its life, the internal neutron irradiation has a brittle effect , which leads to the decrease of the toughness of the material [3]. If there is a defect in the inner surface of the RPV, it would propagate rapidly and even through the wall thickness. So the safety of RPV would undergo a great challenge, and it is necessary to analyze the structural integrity of RPV under the PTS.

The methods for evaluating the defects of RPV include deterministic fracture mechanics analysis and probability fracture mechanics analysis [4]. In deterministic fracture mechanics