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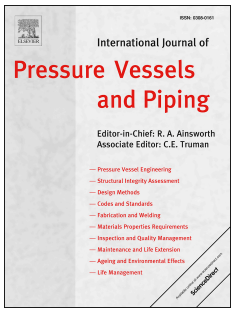

Failure probability analysis of pressure vessels that contain defects under the coupling of inertial force and internal pressure

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Failure Probability Analysis of Pressure Vessels that Contain Defects under the Coupling of Inertial Force and Internal Pressure

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Abstract: The safety and reliability of large-scale structures such as pressure vessels are related to a number of uncertain factors, including the load and the size of their initial cracks. This study carries out probabilistic fracture mechanics analyses of pressure vessels that contain defects under the coupling of inertial force and internal pressure. Based on the weight function, this paper provides an integral expression for the stress intensity factor (SIF) of the crack front and then estimates the SIF that meets the engineering accuracy requirements. Considering the fracture toughness criterion, K_{IC}, based on linear elasticity as the failure criterion, the Monte-Carlo method is used to calculate the failure probability of the pressure vessel cylinder, with the fracture toughness of materials, crack depth, and load as random variables. This method can provide a point of reference for fracture calculations and reliability analyses of pressure vessels.

Keywords: Pressure vessel; crack; probabilistic fracture; failure analysis

1 Introduction

Pressure vessels and hydrogen tanks are widely used in fields such as nuclear energy and the petrochemical industry. Because of the complex working environment, the safety of in-service pressure vessels has drawn increasing attention. Given the many uncertainties[1-2] of structural integrity, the probabilistic assessment method[3-5] for defective pressure vessels has received widespread attention.

Researchers have carried out a large number of investigations into the probabilistic assessment method for defective pressure vessels and the assessment of their structural safety and reliability, mainly focusing on the effects of changes in temperature and pressure on the reliability of pressure vessels[6-9]. Sun[10] and Kanto[11] conducted deterministic parsing and probability analyses of the pressure and temperature of reactor pressure vessels under pressurized thermal shock and discussed the differences between the results of the two types of analyses above. Qian et al.[12-13] used both the deterministic method and the probabilistic method to analyze the crack initiation and failure behavior of nuclear reactor vessels under thermal shock, finally showing that the conclusion derived from the probabilistic method was a better fit with the facts. Park et al.[14] calculated the failure probability of reactor pressure vessels under low temperature overpressure, and under cooling transient conditions, respectively, and discussed the effects of uncertain factors on sensitivity analyses. Chou[15] and Huang[16] conducted probabilistic fracture analyses of