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Probabilistic Fracture Evaluation of Reactor Pressure Vessel Subjected to Pressurized Thermal Shock

Authors : Jianguo Chen, Fenggang Zang, Yu Yang, Liangang Zheng

Abstract : Reactor Pressure Vessel (RPV) is an important security barrier in nuclear power plant. Crack like defects may be produced on RPV during the whole operation lifetime due to the harsh operation condition and irradiation embrittlement. During the severe loss of coolant accident, thermal shock happened as the injection of emergency cooling water into RPV, which results in re-pressurization of the vessel and very high tension stress on the vessel wall, this event called Pressurized Thermal Shock (PTS). Crack on the vessel wall may propagate even penetrate the vessel, so the safety of the RPV would undergo great challenge. Many assumptions in structure integrity evaluation make the result of deterministic fracture mechanics very conservative, which affect the operation lifetime of the plant. Actually, many parameters in the evaluation process, such as fracture toughness and nil-ductility transition temperature, have statistical distribution characteristics. So it is necessary to assess the structural integrity of RPV subjected to PTS event by means of Probabilistic Fracture Mechanics (PFM). Structure integrity evaluation methods of RPV subjected to PTS event are summarized firstly, then evaluation method based on probabilistic fracture mechanics are presented by considering the probabilistic characteristics of material and structure parameters. A comprehensive analysis example is carried out at last. The results show that the probability of crack penetrates through wall increases gradually with the growth of fast neutron irradiation flux. The results give advice for reactor life extension.

Keywords : fracture toughness, integrity evaluation, pressurized thermal shock, probabilistic fracture mechanics, reactor pressure vessel
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