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Development of Surface Modification Technology for Control Element Drive Mechanism Nozzle and Fatigue Enhancement of Ni-Based Alloys

Authors : Auezhan Amanov, Inho Cho, Young-Sik Pyun

Abstract : Control element drive mechanism (CEDM) nozzle is manufactured as welded on the reactor vessel and currently uses Alloy 690 material. The top of the reactor is equipped with about 100 CEDM nozzles with an internal diameter of about 70 mm. Relatively large Inlet/Outlet nozzles are equipped with two outlet nozzles and four inlet nozzles on the reactor wall. The inner diameter of the nozzle is vulnerable to stress corrosion cracking (SCC), and in order to solve this problem, an ultrasonic nanocrystal surface modification (UNSM) treatment is performed on the inner diameter of the nozzle and the weld surface. The ultimate goal is to improve the service life of parts by applying compressive residual stress and suppressing primary water stress corrosion cracking (PWSCC). The main purpose is to design and fabricate a UNSM treatment device for the internal diameter processing of CEDM nozzles and inlet/outlet nozzles. In order to develop the system, the basic technology such as the development of UNSM tooling is developed and the mechanical properties and fatigue performance of before and after UNSM treatment of reactor nozzle material made of Ni-based alloys using the specimen are compared and evaluated. The inner diameter of the nozzle was treated by a newly developed UNSM treatment under the optimized treatment parameters. It was found that the mechanical properties and fatigue performance of nozzle were improved in comparison with the untreated nozzle, which may be attributed to the increase in hardness, induced compressive residual stress.

Keywords : control element drive mechanism nozzle, fatigue, Ni-based alloy, ultrasonic nanocrystal surface modification, UNSM
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