The reactor pressure vessel (RPV) in nuclear power plants is the most important component for safe operation. The ability of the RPV steel to resist fracture (i.e., the fracture toughness) decreases with neutron irradiation in a process, which is known as irradiation embrittlement. Since stainless steel is weld overlaid (i.e., cladding) on the inner surface of the RPV, a heat-affected zone (HAZ) with an inhomogeneous microstructure is formed under the cladding to a depth of approximately 10 mm. The irradiation embrittlement of this HAZ region, where the irradiation dose is high due to its close proximity to the reactor core, becomes critical for a structural integrity assessment of the RPV. Nevertheless, it is difficult to investigate the fracture toughness distribution of the narrow and inhomogeneous HAZ region using a standard-size specimen. Therefore, specimens with a thickness of 4 mm (i.e., miniature compact-tension specimen (Mini-C(T)), see Fig.2-14) were employed to clarify the fracture toughness distribution of the HAZ.

One of difficulties encountered by employing such small specimens is dependency of fracture toughness on specimen size. As the fracture toughness specimen becomes smaller, the plastic deformation becomes easier due to weak plastic constraint. To prevent plastic deformation and obtain correct fracture toughness, tests must be performed at very low temperatures as possible within the ductile-brittle transition temperature region. The irradiation embrittlement of this HAZ region, where the irradiation dose is high due to its close proximity to the reactor core, becomes critical for a structural integrity assessment of the RPV. Nevertheless, it is difficult to investigate the fracture toughness distribution of the narrow and inhomogeneous HAZ region using a standard-size specimen. Therefore, specimens with a thickness of 4 mm (i.e., miniature compact-tension specimen (Mini-C(T)), see Fig.2-14) were employed to clarify the fracture toughness distribution of the HAZ.

The reactor pressure vessel (RPV) thickness of 1 inch (25.4 mm), while that of a smaller specimen such as 0.4T-C(T) and the PCCv is 10 mm; that of a Mini-C(T) is only 4 mm.

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Future work will involve evaluating the fracture toughness of HAZ in neutron-irradiated RPV steel and clarifying the sensitivity of the HAZ region to irradiation embrittlement. A part of this study was sponsored by the Secretariat of the Nuclear Regulation Authority (NRA), Japan.

Reference