7–1 Sophisticated Structural-Integrity Assessment of Fast-Reactor Components

— A Proposal of Procedure for Assessing Leaks before Breakage of Fast-Reactor Pipes —

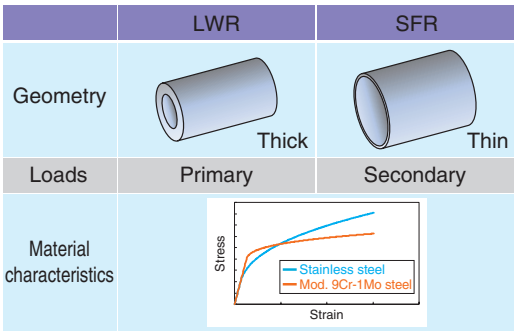

Fig.7-4 SFR-pipe features
An LBB-assessment procedure accounting for SFR-pipe features such as thin-wall geometry, material characteristics, among others, is required.

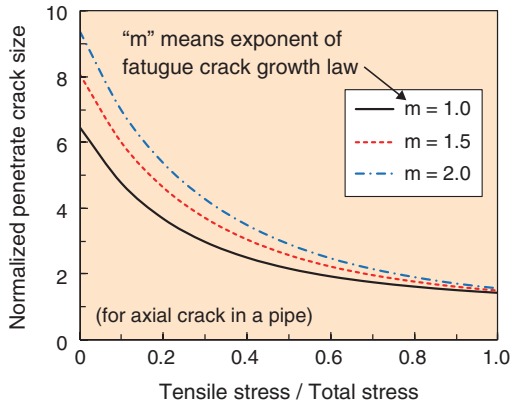

Fig.7-6 Penetrating-crack-size diagram
For users' convenience, penetrating-crack-size diagrams are prepared.

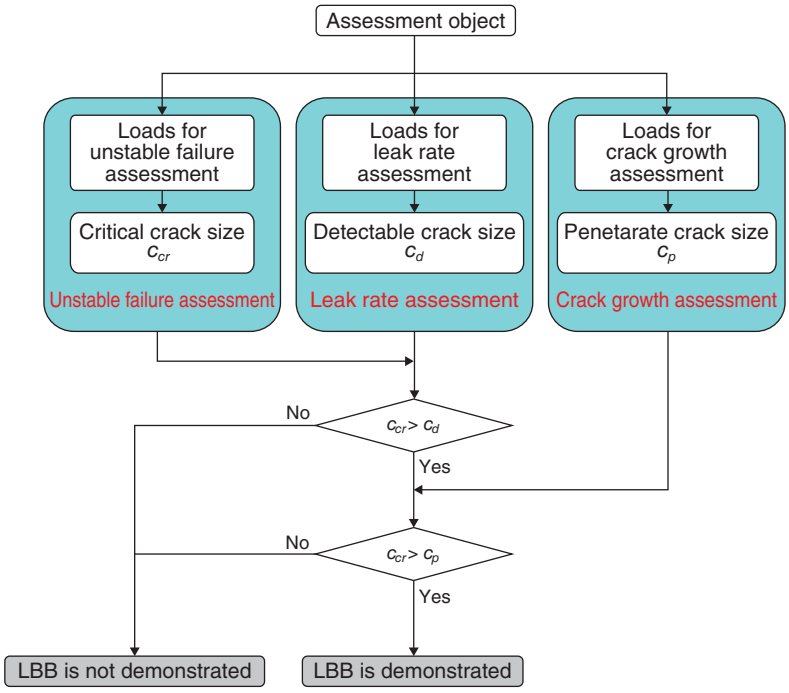

Fig.7-5 Provisional LBB-assessment flowchart
If the critical crack size is larger than the detectable or penetrating crack sizes, we conclude that LBB is demonstrated. Unstable-failure and leak-rate assessment takes SFR pipe features into account. In crack-growth assessment, a user can calculate the penetrating-crack size using the diagram, as shown in Fig.7-6.

The pipe geometry of a sodium-cooled fast reactor (SFR) has thin walls and a large diameter compared to that of a light-water reactor (LWR). The pipe material, modified 9Cr-1Mo steel, has a relatively high yield strength and low ductility compared to conventional austenitic stainless steels, as shown in Fig.7-4. In addition, the secondary stress caused by thermal expansion is predominant in SFR. Accounting for these features, a rational leak-before-break (LBB)-assessment guideline is proposed and will be published to provide a technical basis for substitution of volumetric tests by continuous leak-monitoring during in-service inspections.

LBB is based on the concept that it is possible to deal properly and safely with cracks by detecting leakage of internal fluid from a penetrating defect before catastrophic failure occurs.

First, an LBB-assessment flowchart for the SFR components was proposed, as shown in Fig.7-5. Secondly, taking the SFR-pipe features into account, evaluation methods for calculating the critical-crack size, the detectable-crack size, and the penetrating-crack size were developed and incorporated into LBB assessment. Confirming that the penetrating-crack size depends almost exclusively upon material characteristics and loading conditions, evaluation diagrams were prepared for users' convenience, as shown in Fig.7-6. Furthermore, adequate-safety margins were recommended for reasonable and conservative evaluations. As a non-mandatory appendix, some material characteristics that can be used in evaluations are also illustrated for easy use of the methods.

To publish the developed LBB-assessment procedure as a guideline officially authorized by the Japan Society of Mechanical Engineers (JSME), JAEA will make a technical contribution.

Reference

Wakai, T. et al., Demonstration of Leak-Before-Break in Japan Sodium Cooled Fast Reactor (JSFR) Pipes, Nuclear Engineering and Design, vol.269, 2014, p.88-96.