Priority Subjects — **Further Improvement of Facility Operations and Maintenance Technologies**

Integrity of Components and Piping in Nuclear Power Plants

Background and Objective

Flow Accelerated Corrosion (FAC) and Liquid Droplet Impingement Erosion (LDI) are pipe degradation phenomena managed by utilities with pipe wall thickness measurement based on JSME technical rules. There are expectations regarding optimized allocation of inspection resource for this management, with development of an accurate mechanistic prediction method for FAC and LDI as described in the revision plan of the JSME rules.

There is discussion currently underway relating to elimination of rolled steels for general structure (SS steels) from the JSME material code. Such SS steels are widely used in power plants. Rolled steels for building structures (SN steels) is a possible candidate to be included in the JSME material code as an alternative to SS steels. However, to apply SN steels to nuclear power plants, it is necessary to standardize them based on evaluation of detailed material properties.

In this project, we develop a prediction method of pipe wall thinning able to be applied to actual plants. We also evaluate mechanical properties of SN steels for standardization.

Main results

1 Verification of Pipe Wall Thinning Prediction Software, FALSET, with Water Single-Phase Flow Pipeline Data

Pipe wall thinning prediction software, FALSET, is being developed for its application to the FAC/LDI prediction methods for wall thinning management in actual power plants. FALSET was verified with FAC data in condensate and feedwater lines (water single-phase system), and its prediction accuracy was confirmed to be within about 10% of error for residual thickness (Fig. 1) (L12403). Following further verification and revision with power plant data, FALSET is expected to be introduced to wall thinning management rules and used practically as a management tool.

2 Modeling for FAC prediction in Steam-Water Two-Phase Flow

For the modeling of FAC in steam-water two-phase flow conditions, such as extraction and drain lines, an evaluation method was developed for the assumed specific hydraulic condition, i.e. annular flow. This method showed considerable accuracy for the liquid film behavior created on the inner wall of a pipe (Fig. 2) (L12008). As for water chemistry factor, a calculation method for liquid film pH was studied, including the gas-liquid distribution effect of pH agent (Fig. 3) (Q11025). Considering these differences from water single-phase flow condition, the FAC prediction method will be extended to two-phase flow condition, and applied to the FALSET software after certain verification with power plant data.

3 Evaluating Tensile Properties of 'Safety-Conscious' SN Steels at High Temperature

SN steels is expected to be used for support structures in nuclear power plants as an alternative to SS steels. Comprehensive tensile properties of SN steels were compiled at high temperature so that they can be incorporated into the JSME material code. The effect of temperature on the tensile properties was similar in spite of the different origins, material types, or plate thicknesses (Fig. 4). The effects of strain rate as well as the contents of P and S were also small (Q13009).

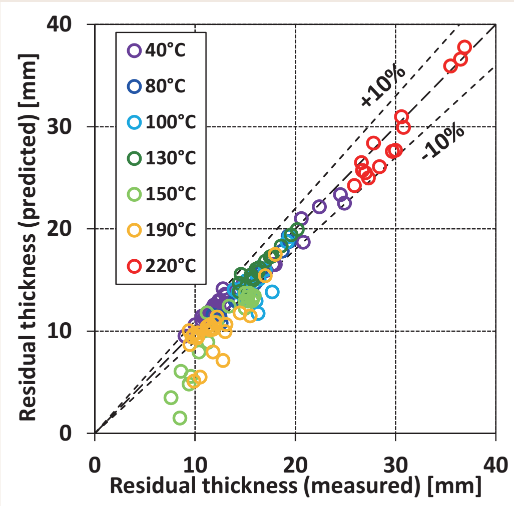

Fig. 1: Comparison of the measured residual wall thickness with that predicted by FALSET for water single-phase flow pipeline

Excluding some underestimated conservative data, FALSET demonstrated a prediction accuracy within approximately 10% of error for residual wall thickness of 160 elbows in condensate/feedwater pipelines of a PWR

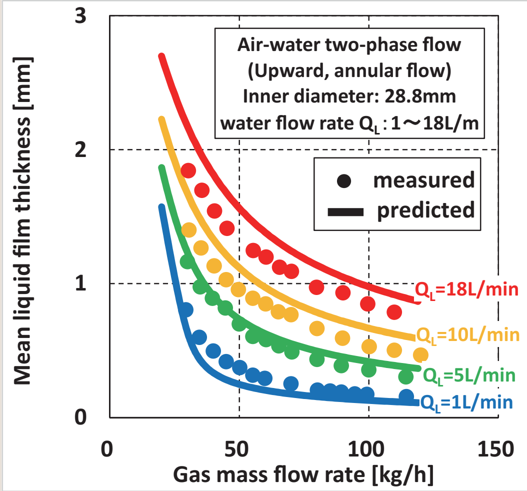

Fig. 2: Evaluation of liquid film thickness in gas-liquid two-phase annular flow

With the developed analysis method, experimental data of liquid film behavior (mean thickness) from a previous study[(1)] can be quantitatively predicted.

(1) T. Ueda, S. Nose, Trans. JSME, 39, 325 (1973)

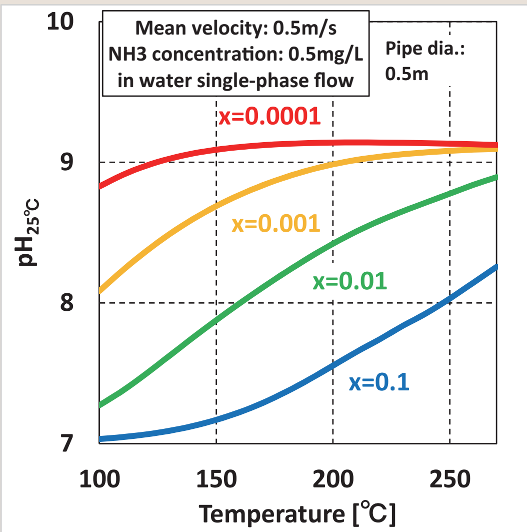

Fig. 3: pH evaluation with gas-liquid distribution of pH agent in a two-phase flow condition

Considering the distribution behavior of pH agent (ammonia: NH_3) to gas/liquid phases, pH value in the liquid film can be simply evaluated in terms of temperature and steam quality (x).

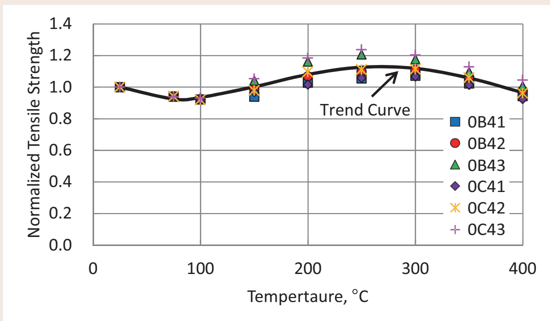

Fig. 4: Effect of temperature on tensile strength for SN steels

Tensile strengths at high temperature are normalized by those at room temperature. 0B41 to 0B43 and 0C41 to 0C43 use different steels (SN400Bs and SN400Cs) with a thickness of 40 mm, respectively. The different types of steels has different contents of P and S; nevertheless, the effect of temperature is presented by a unique line.