Pipe Wall Thinning Evaluation & Seismic Evaluation of Thinned Pipeline

Background and Objective

Pipe wall thinning due to flow accelerated corrosion (FAC) and liquid droplet impingement erosion (LDI) is one of the important subjects which should be taken into consideration for aging light-water reactors. Pipe wall thinning rate and remaining period for fitness-for-service of thinned pipes are managed based on wall thickness measurement. The number of wall thickness measurements is several hundred for each plant in every regular inspection.

In this project, evaluation methods for FAC and LDI which can evaluate local thinning distribution were developed for the purpose of rationalizing measuring points. It is also necessary to develop the seismic evaluation method for wall thinned piping systems, comparing the current evaluation method applied to the overall thinning with the local wall thinning which existed in the actual piping systems.

Main results

1. Performance improvement of FAC prediction model

Effects of geometric and hydraulic parameters on thinning profile of piping elements, such as elbows and orifices, were studied, qualitatively, by combining CFD calculation of plant pipings and FAC prediction model being developed in CRIEPI. In T-junction piping, susceptible areas to FAC were revealed to spread axisymmetrically in junctions downstream. It was also found that FAC rate and profiles depend on diameter and velocity ratio of main pipe and branch pipe (Fig. 1).

2. Performance improvement of LDI evaluation system

Thinning rate and shape evaluation on LDI at elbow in a plant have been conducted by CRIEPI LDI evaluation system. A 3-dimensional flow simulation and droplet behavior calculation were conducted on the high-speed wet steam flow through an orifice (Fig.2 (a)), and the thinning shape at the elbow was evaluated with simulation result. As a result of comparison with plant data, a good agreement was observed (Fig.2 (b)).

3. Seismic evaluation of wall thinning elbow

Hybrid tests were conducted incorporating a numerical analysis of whole piping system with a loading test of wall-thinning elbow model, in order to compare seismic strength of different thinning profile between overall thinning and locally thinning. The test conditions of wall thinning depth were three cases, 25%, 50% and 75%. The local thinning profile was applied as the conservative LDI degradation covered over the actual plant condition. It was discovered that the seismic strength of elbow is not reduced in the case of 75% local thinning, although the seismic strength is considerably reduced by increasing thinning depth in overall thinning (Fig.3). These results implied that the overall thinning condition is too conservative to evaluate seismic response of wall thinning piping system.

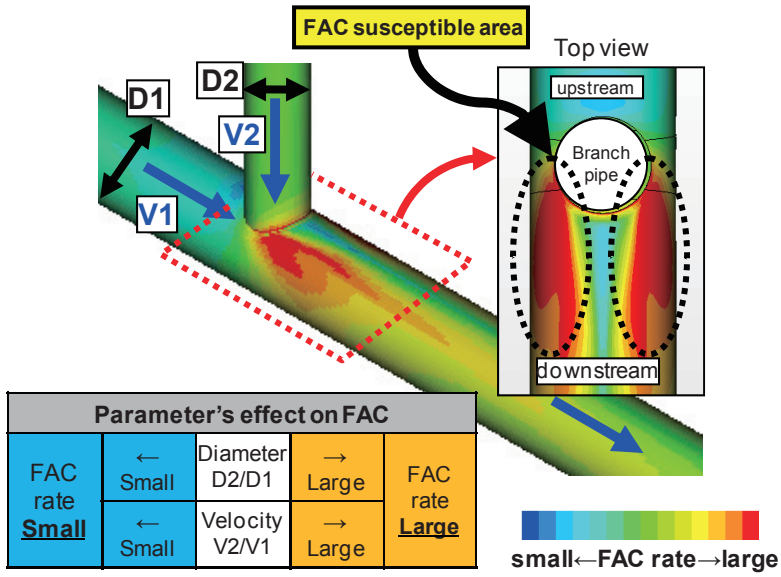
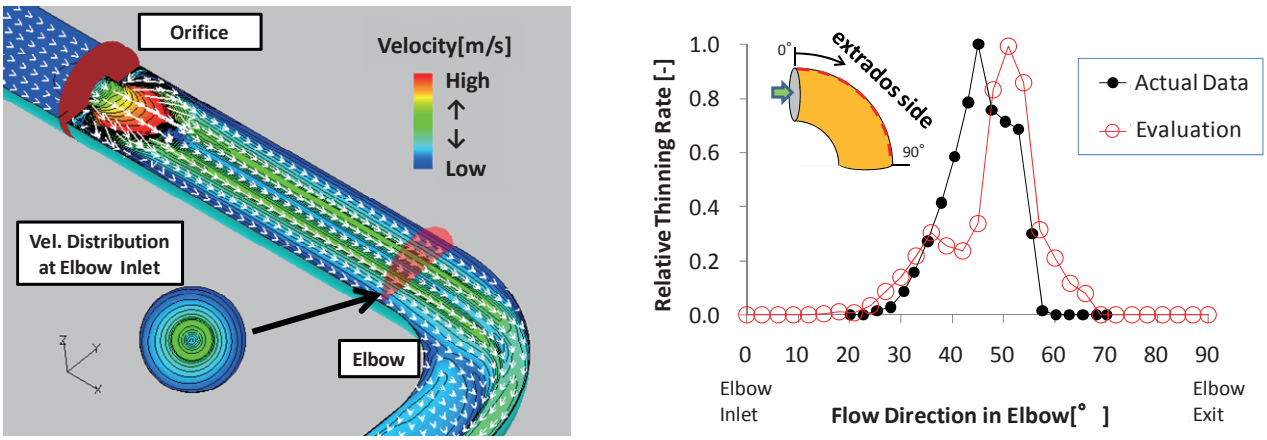


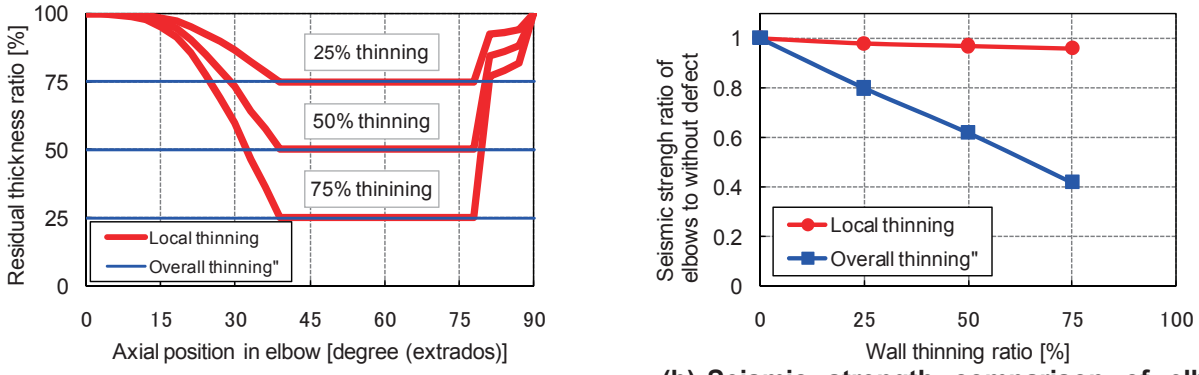
Fig. 1 Effect of geometric and hydraulic parameters on FAC rate and profile in T-junction downstream
Susceptible area to FAC spread axisymmetrically on top in T-junction downstream.



(a) Steam velocity and droplet behavior profiles from orifice to elbow

(b) Comparison of prediction and measurement results of thinning profile in elbow extrados

Fig. 2 CFD calculation for a vent pipeline elbow and evaluation example of LDI profile in elbow extrados
LDI susceptible area around 45o predicted where orifice-generated jet collapse.



(a) Thinning profile of elbows

(b) Seismic strength comparison of elbows between local thinning with overall thinning

Fig.3 Typical thinning profile and evaluation results of seismic strength ratio of elbows to without defect
Seismic strength of elbow is not reduced in the case of 75% local thinning compared with overall thinning.