Quantitative Evaluation of Effective Factors on Flow Accelerated Corrosion
− Correlation of Hydraulic Factors and Thinning Rate −

Background

Pipe wall thinning is an important problem for plant performance and management in nuclear power plants. Among several wall thinning phenomena, Flow Accelerated Corrosion (FAC)[*1] requires considerable care since it has the potential to cause catastrophic rupture of carbon steel pipes. FAC is often observed in typical elements where turbulence is generated, such as orifice downstream parts or elbows. However, detail profile of turbulence in those elements or correlation of hydraulic factors and FAC are not presented clearly in previous studies. Quantitative prediction of piping geometry-correlated hydraulic effects on FAC would help establish effective FAC measures and appropriate pipe wall thinning inspection and management.

Objectives

To obtain correlation data of wall thinning by FAC and hydraulic factors, and clarify those effects.

Principal Results

1. FAC experiment

FAC experiments of carbon steel (STPT480) were conducted in a rectangular contraction duct system for 30 days, and the following results were obtained. (Fig.1)

(1) Wall thinning amount by FAC of carbon steel test piece was measured with laser displacement sensor[*2], periodically. As a result, data of surface geometry change history was obtained, such as the process of oxide film thinning or production. (Fig.2)

(2) The test pieces showed different appearance in terms of velocity conditions. (Fig.3) For large velocity conditions, sharp edged dimples were observed and little oxide film could be seen on the test piece. (Fig.4)

(3) Maximum FAC rate was approximately proportional to the square of averaged velocity in the duct. Since a similar trend was observed in previous studies with an orifice[*3], this may be a qualitative tendency of FAC in contraction geometries, such as orifices or valves.

2. Numerical calculation

Flow characteristics of the experimental contraction system were calculated numerically with the original code “MATIS-I” utilizing LES (large eddy simulation) for turbulence model. (Fig.5) By comparing the results with the FAC experiment, local velocity and fluctuation velocity on the test piece surface were approximately proportional to the local thinning rate, except for a portion of experimental data with high FAC rate. (Fig.6)

Future Developments

Further investigation for the hydraulic factors affecting FAC will be conducted, experimentally and numerically, aiming for the establishment of a quantitative evaluation method for pipe wall thinning by FAC.

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Reference

K. Yoneda and R. Morita, 2007, “Quantitative Evaluation of Effective Factors on Flow Accelerated Corrosion (Part 1) -Correlation of Basic Hydraulic Factors and Thinning Rate- ”, CRIEPI Report L06007 (in Japanese)

＊1：A process whereby the normally protective oxide layer on carbon or low-alloy steel dissolves into a stream of flowing water or a water-steam mixture

＊2：KEYENCE LKG-150: Displacement measurement by triangulation principle with 0.5μm resolution

＊3：Bignold, et al., Proc. 8th Int. Cong. Metallic Corrosion (1981)

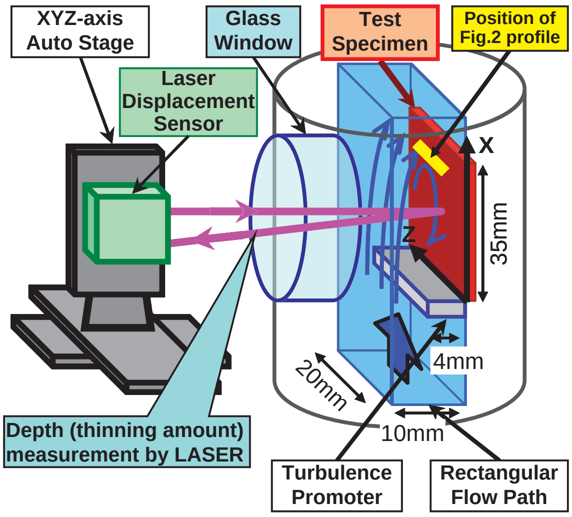

Fig.1 Test section of FAC experiment and measurement method of thinning amount

FAC of the carbon steel specimen is enforced by turbulence enhanced at the promoter upstream. Laser sensor is mounted on the auto stage so as to scan the thinning amount with regular routine periodically.

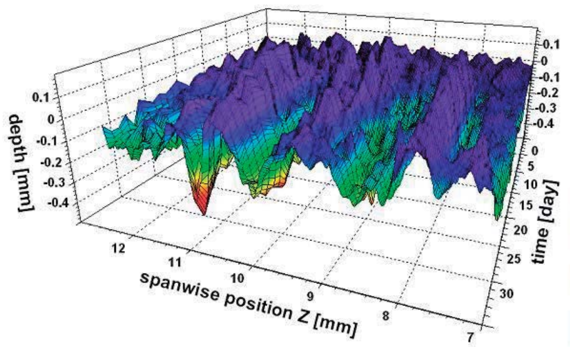

Fig.2 Variance of surface geometry at X=24mm on the specimen (Mean velocity = 9.9m/s)

Initial geometry with a little undulation grew into series of deep concaves after 30 days in high velocity condition.

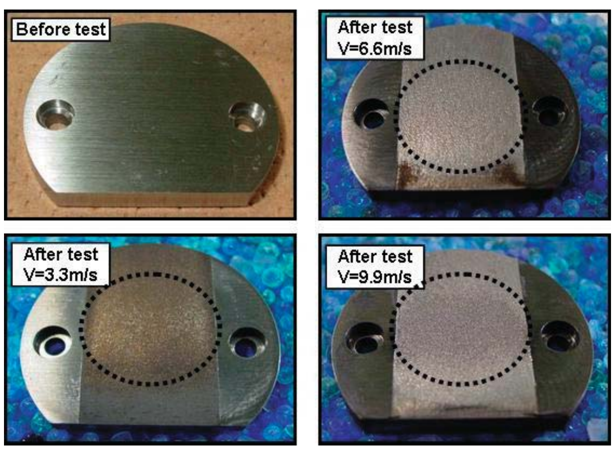

Fig.3 Photos of test specimens after test

FAC enhanced in dotted circle region. Very little oxide film seen in high velocity conditions.

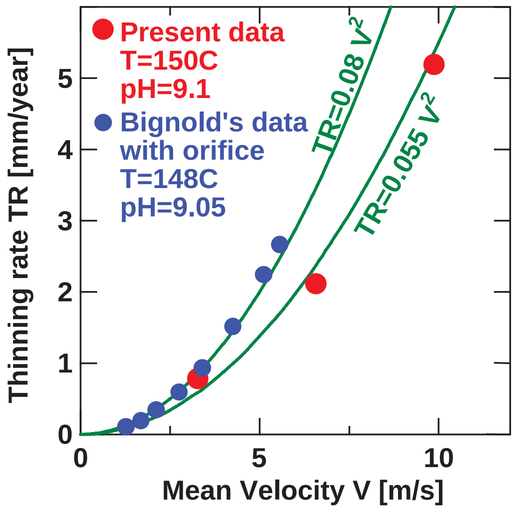

Fig.4 Correlation of maximum thinning rate and mean velocity in contraction geometry

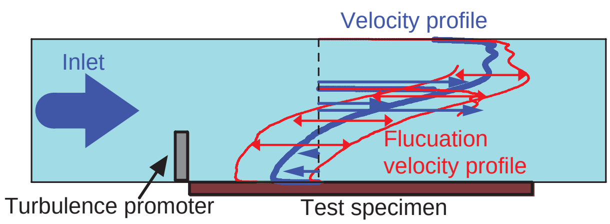

Fig.5 Profile sample of local velocity and fluctuation velocity around the test piece by numerical calculation

Velocity profile in the reverse flow shows very little damping towards the specimen surface, and so is the fluctuation component that is as equally scalar as the average.

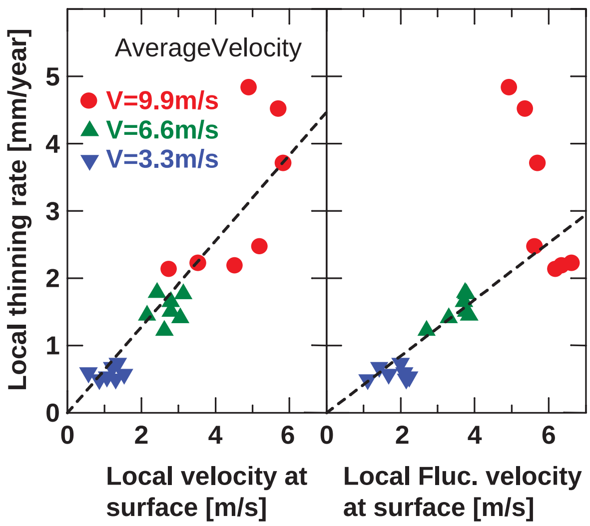

Fig.6 Correlation of local velocity and fluctuation velocity and thinning rate