Development of Evaluation System of Liquid Droplet Impingement Erosion

Background

Liquid droplet impingement erosion (LDI) is defined as an erosion phenomenon caused by high-speed droplet attack in a steam flow. In a power plant, pipe wall thinning by LDI is observed in steam piping systems. Because LDI usually occurs very locally and is difficult to detect, prediction of LDI location is required for the safety of the plant system.

Therefore, as the ultimate objective, we set the development of a tool for predicting LDI location that can be easily used in power plants (LDI Prediction Code).

In previous researches, we were able to evaluate all the local flow conditions that affect LDI materially [*1]. But, as LDI is a complex phenomena affected by fluid and material, it is difficult to predict the LDI position by applying these results and past knowledge individually.

Objectives

This study aims to suggest the evaluation method for LDI position (LDI prediction system) through organizing the previous results and past knowledge systematically.

Principal Results

1. Suggestion of LDI prediction system

We constructed the LDI prediction system by providing "fluid conditions at the inlet and exit of piping system" and "piping isometrics" as input conditions (Fig.1). The steps are as follows;

1. Global flow evaluation: Calculation of the flow condition in arbitrary piping position by in-house code "MATIS-SC [*1]" or "MATIS-SP [*2]"
2. Local flow evaluation: Calculation of the droplet behavior at the elbow and definition of "the percentage of droplet collision"
3. Evaluation of the LDI sensitivity: Evaluation of the LDI sensitivity by past findings, knowledge and the results of 1 and 2.

2. Test calculation of LDI prediction system

Test calculation of suggested LDI system is conducted in steam piping model with orifice (Fig.2). After the calculation of global and local flow (Fig.3), we constructed the model to evaluate the ranking of LDI possibility by using a function of LDI sensitivity considering the percentage of droplet collision in addition to the velocity and wetness, the effects of which on LDI are well known as conventional knowledge.
As a result, we found that the percentage of droplet collision affects LDI in addition to the velocity and wetness (Table1).

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Reference

R. Morita, 2007, "Investigation of Flow Characteristics Affecting Liquid Droplet Impingement Erosion (Part 2) - Improvement of Flow Evaluation Method -", CRIEPI Report L07016 (in Japanese)

R. Morita, 2006, "Development of "MATIS-SC Code" for High Speed Steam Flow with Non-equilibrium Condensation", 4th ICCFD

＊1：Multi-dimensional Accurate Time Integration Simulation for Steam with Condensation
＊2：Multi-Phase Accurate Time Integration Simulation for Steam in Piping

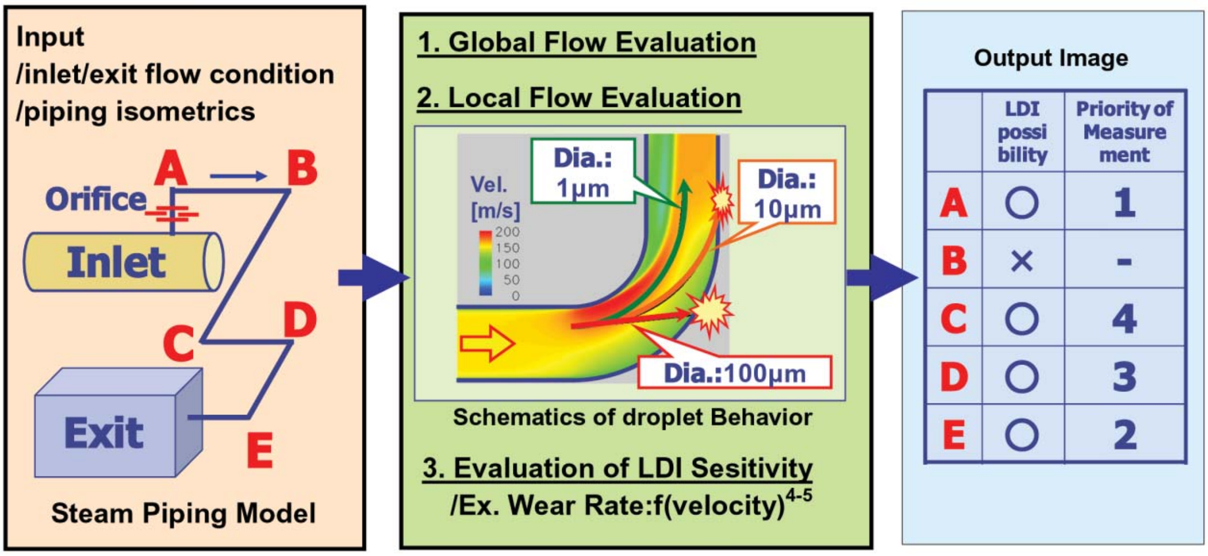

Fig.1 Overview of LDI Prediction System

Assuming "fluid conditions at the inlet and exit of piping system" and "piping isometrics" to be the input conditions, possibility of LDI at all elbow positions is evaluated.

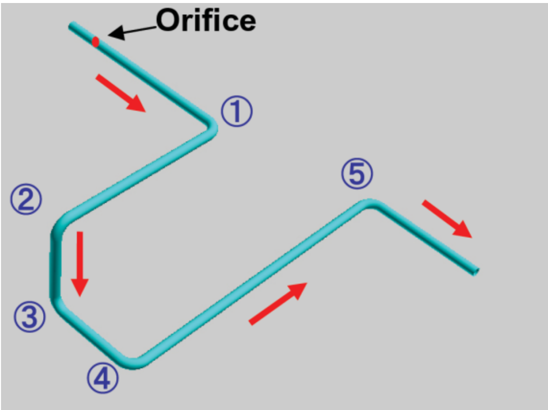

Fig.2 Steam Piping Model

As a test calculation of LDI prediction system, steam piping flow with orifice is calculated and LDI sensitivity is evaluated at elbow 1-5.

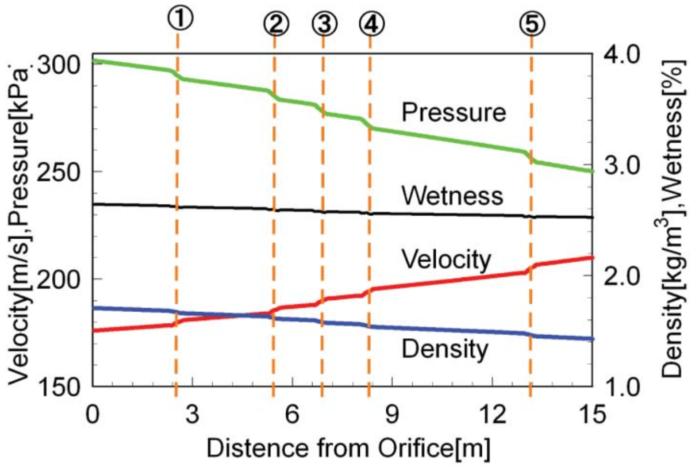

Fig.3 Flow Distribution along Flow Direction in Piping

Global flow condition is calculated by 1D code.

Table 1 LDI Evaluation Results at Elbow ①-⑤

LDI possibility is calculated at elbows ①-⑤ by using a function of LDI sensitivity considering the percentage of droplet collision in addition to the velocity and wetness.
We found the percentage of droplet collision affects the LDI possibility.

Elbow	Velocity u [m/s]	Wetness β [%]	Percentage of Droplet Collision, w [%]	LDI Possibility	
				f (u^4, β)※	f (u^4, β, w)
①	178.4	2.62	40.7	5	5
②	183.8	2.59	44.0	4	4
③	187.8	2.58	56.9	3	**2**
④	192.1	2.56	40.9	2	**3**
⑤	202.8	2.53	42.8	1	1

※In case of not considering the percentage of droplet collision, w

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