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Cavitation Effect of Shock Pressure about Nuclear Power Plant Component Cleaning or Crud Removal

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1. Introduction

In nuclear power plant, the problems are caused by corrosion phenomena on the pipe or fuel elements. It can cause the additional cost for plant component recycling or disassembly. Those solutions of problem are chemical method and physical method. Recently ultrasonic and laser methods for cleaning are developing.

If fluid flow is attached to the high speed surface of a blade, a large number of bubbles are developed. As it reaches vapor pressure, the fluid vaporizes and forms small bubbles of gas. This is cavitation.

Previous study of cavitation shows that predict the onset of cavitation within the pump blade and the degradation in the pressure rise due to the generation and transport of vapor. But cavitation erosion effect can be used for optimized corrosion cleaning. [1]

Cavitation can be created in restrict region such as static mixer and orifice. When the bubbles collapse later, they typically cause very strong local shock waves in the fluid, which may be audible and may even damage the blades. [1, 2]

Purpose of this study is using shock pressure by micro bubble collapse for second time cleaning in the fluid region of the on product surface.

2. Expected description of experiment

2.1 Experiment facility

Cavitation occurs when pressure at a region in high flow velocity is rapidly increased with pressure decrease. Therefore, orifice can be installed inside the test section pipe for making the pressure decrease.

To make this cavitation would require momentary pressure difference. For this, orifice and valve are installed in the test section. A restriction by valve or orifice in the pipe line creates a pressure drop if the fluid flows. The pressure drop is determined by the velocity of the fluid. When a fluid flow is passing through a restriction the pressure is reduced and the velocity of the fluid flow is increased.

When the liquid has passed through the restriction space the area is increased, the velocity decreases, and the pressure increases. This leads to the collapse of the vapor bubbles.

The shock pressure is produced in downstream of orifice by the collapse of bubbles. Therefore, the spatial distribution of cavitation shock pressure inside the pipe at the downstream of restriction orifices is examined by using the pressure transducer that is hold in the test section. [3]

Test section is 50mm in inside diameter and is made of the transparent acrylic pipe to observe the effect of the cleaning. The water which is pumped up by centrifugal pump ($35m^3$/h x 1.1MPa), flows through the 2 inch piping, goes to the test section, and returns into the test pond. Fig. 1 shows the experiment facility of cavitation test which shows the equipment.

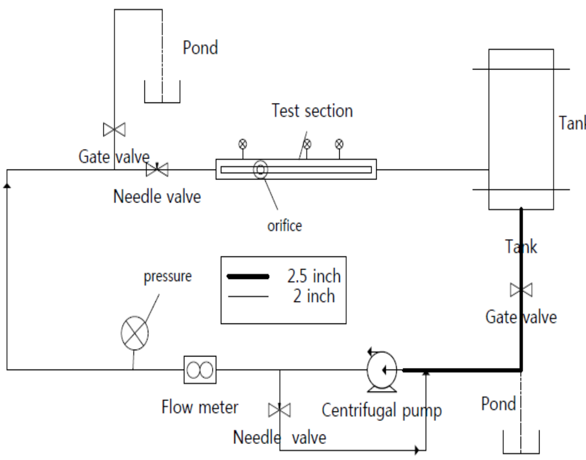

Fig. 1. Image of experiment facility

2.2 Experiment method

In this experiment, shock pressure effects connected with cavitation number. It is relied on cavitation number to generate cavitation. Before the experiments, the state of fluid was maintained at saturated pressure and flow rate. Cavitation number is defined by following equation:

$$\sigma_v = \frac{P_i - P_v}{\frac{1}{2}\rho \cdot v_o^{\,2}} \qquad (1)$$

Where, σ_v is cavitation number, P_i is static pressure just at downstream of orifice, P_v is vapor pressure of fluid, ρ is density of fluid, v_o is mean velocity through orifice hole.

Cavitation number can be checked for shock pressure magnitude by pressure transducer and cleaning effect by SEM image.

The method of bubble generation on test section is pressure drop. So flow rate can be changed for useful effect of cleaning. In the process, restriction orifices, such as single hole orifice, multiperforated orifice and cone type orifice are used to restrict the flow in the piping system.

Form of a cavitation bubble can be observed by super high speed camera. It is useful when bubble collapse observe in the fluid. In the experiment, flow rate can be change for variable cavitation number. Also, orifice diameter changed with inlet pressure and flow rate. The result of the calculated cavitation number graph is shown Fig. 2.

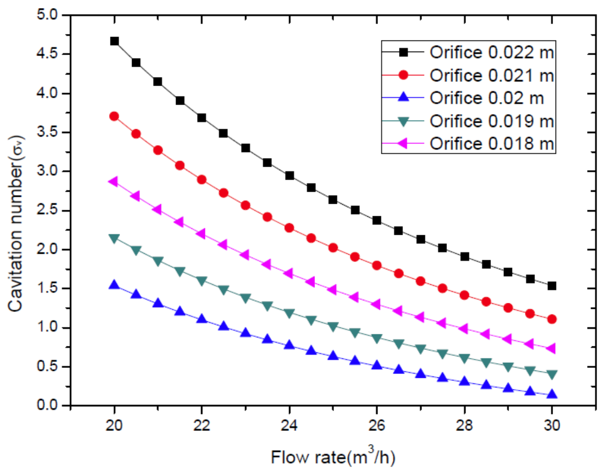

Fig. 2. Cavitation number curve at 1.1MPa pressure

Fig. 2 shows calculated cavitation number by orifice type in 1.1MPa pressure. The result can be adapted for real experiment. This calculation use 15°C vapor pressure.

The results show that if orifice diameter decrease, cavitation number decreased with the flow rate.

And next process, static mixer, such as twist type mixer which is look like impeller are used to mixing fluid in piping.

Using a combination of bubble generation by a static mixer with a cavitation tube will be adapted for flow boiling in tube.

4. Summary

The expected result is efficient of cleaning by shock pressure magnitude. In this experiment we can find shock pressure distribution and distance by the variable restrict component such as orifice and static mixer and valve.

By the super high camera image can be used for checking collapse bubble and forming bubble. Bubble distance from generation point could be used range of effect in shock pressure. All of this experiment results can be adapted for maintenance of nuclear power plant.

REFERENCES

[1] Fortes Patella, R., Reboud, J. L., and Archer, A., Cavitation Damage Measurement by 3D Laser Profilometry, Wear, 246, pp. 59–67, 2009.

[2] Chandan Mishra and Yoav Peles, Flow visualization of cavitating flows through a rectangular slot micro-orifice ingrained in a microchannel, Physics of Fluids, 113602, 2005

[3]Mishra, C. and Peles, Y, Cavitation in Flow Through a Micro-Orifice Inside a Silicon MicroChannel, Physics of Fluids, 17(1), p. 013601, 2005