A Study on Adjusting Method for Orifices for Flow Balancing

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1. Introduction

The purpose of this study is to establish feasible orifices adjusting method for flow balancing which can be used in site. Then, the results of the method is verified compared with actual test results in site and intended target values. Also, reliability of the results including occurrence of cavitation at the orifices has been reviewed by CFD.

2. Methods and Results

The following diagram is a schematic of a system which is dealt in this paper.

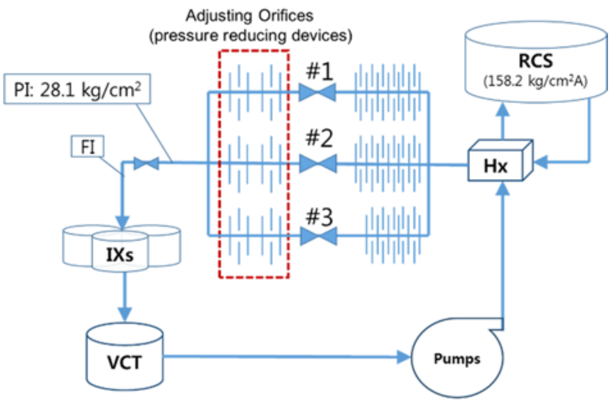

Fig. 1. Schematic of Operation

This system has three parallel letdown piping to be operated in three modes and each piping has a valve and orifices. The valve positions in the operations are as Table 1.

Table 1: The Minimum, Normal and Maximum Operations

Modes	Valve #1	Valve #2	Valve #3
#1 (Minimum Letdown)	Open	Close	Close
#1&2 (Normal Letdown)	Open	Open	Close
#1,2&3 (Maximum Letdown)	Open	Open	Open

Each line has 5 or 6 stages of multistage orifices and two adjusting orifices as Figure 1. In general, these multi stage orifices are helpful to restraint cavitation.

2.1 Orifices Adjusting

If measured flowrates deviate from the allowable range, the deviations can be compensated by adjusting the adjusting orifices. To be specific, if the deviations make the processing flowrates deviate from allowable ranges, the same amount of the deviations will add or remove through the adjusting orifices to restore it.

The compensation is conducted as following steps in this study.

1) Measuring pressures and flowrates at PI and FI, respectively, and calculating K, resistance coefficient
2) Selecting target flowrates and calculating K at the target flowrates
3) Adding or removing the amount of the difference of the Ks between the present K and the target K on the adjusting orifices

Measured pressures and flowrates are as Table 2.

Table 2: Measured Pressures and flowrates

Modes	RCS Pressure (kg/cm^2)	PI (kg/cm^2)	ΔP (kg/cm^2)	FI (L/min)
#1	158.3	28.1	130.2	143.4
#1&2	158.3	28.1	130.1	285.3
#1,2&3	157.5	28.1	129.4	480.6

As a result of the above steps, K and their bore sizes for the adjusting orifices which make the letdown system have target flowrates are as Table 3.

Table 3: Ks and New Bore Sizes

Adjusting Orifices Numbers	K	Bore Size (mm)
#1-1	0.000012	23.60
#1-2	0.000012	10.53
#2-1	0.000480	30.19
#2-2	0.000320	23.60
#3-1	0.000002	30.19
#3-2	0.000002	30.19

Also, it is expected that no cavitation occurs at the re-sized adjusting orifices because the cavitation index of the system, σ_{sys}, is larger than the incipient cavitation index, σ_i.

Table 4: Cavitation Indexes of the Re-sized Orifices

Adjusting Orifices Numbers	σ_i	σ_{sys}
#1-1	2.9846	101.4285
#1-2	2.9846	101.4285
#2-1	1.7929	3.3826
#2-2	1.8269	4.5776
#3-1	5.0561	189.1241
#3-2	5.0561	189.1241

2.2 Computational Model for the Letdown Orifices

CFD simulations were performed as Fig. 2 using the commercial code, STAR-CCM+ [1] to verify reliability of the system including occurrence of cavitation and effects of dynamic pressure. A grid with about 3 million cells is generated and the polyhedral mesh was chosen so as to perform CFD simulations.

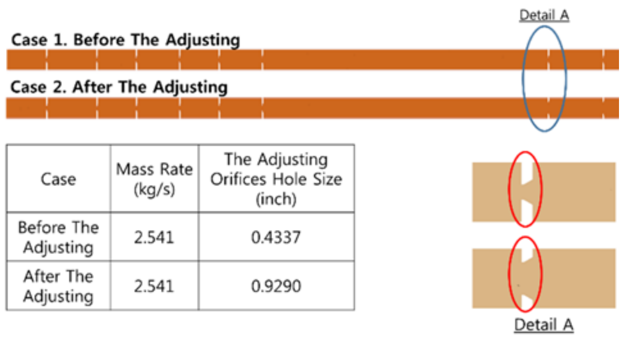

Fig. 2. Configuration of Geometry and Boundary Conditions

As a result of the simulation, the pressure is descending as following Figure 3.

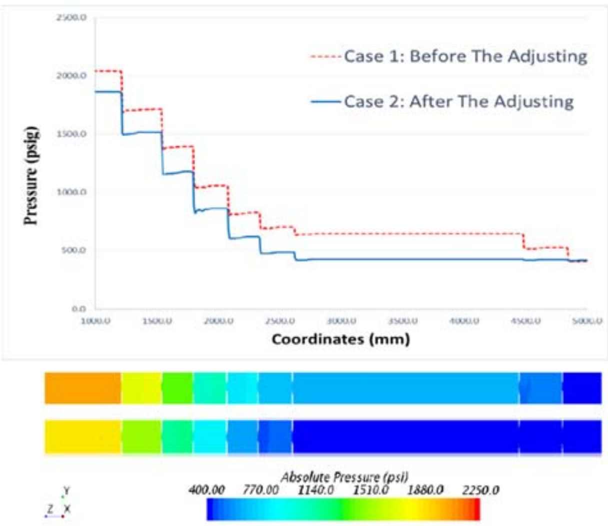

Figure 3. Pressure Drops at the CVCS Letdown Orifices

And, velocity vector at the multi-stage orifices is as follows.

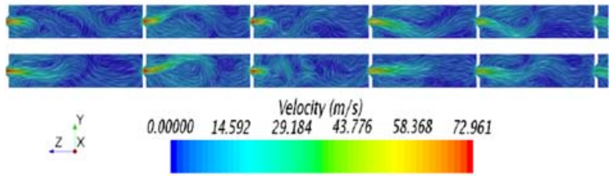

Figure 4. Velocity Vector at the Multi-Stage Orifices

The above CFD result shows that the adjusting result are reasonable considering the fact that there are no cavitation and that the total pressure drop of the letdown system is changed from 2040 psid (143.4 kg/cm^2) to 1860 psid (130.8 kg/cm^2) as a result of the adjusting.

2.3 Results and Verification of the method

To verify the feasibility of the above adjusting method, the result of site test using the method should be not only within allowable ranges but also relatively closed to intended target values. Table 5 shows errors between the site test result and the intended targets.

Table 5: Errors between Site Results and Intended Targets and Allowable Ranges

Modes	Allowable Ranges at FI (L/min)	Site Test Results at FI (L/min)	Intended Targets at FI (L/min)	Errors
#1	146.9～155.9	154.0	151.4	1.72%
#1&2	293.7～311.9	303.1	302.8	0.08%
#1,2&3	514.1～530.0	521.0	522.0	-0.20%

The errors are quite low compared with the tolerance for the allowable flow rates and indicator error, which are 3% and 2%, respectively. Thus the adjusting method introduced in this study is feasible and can be used in site.

3. Conclusions

Orifices adjusting for flow balancing should be carried out up to site condition and the above method can be used as it is very feasible and verified. These can help for commissioning team to save time and cost in nuclear power plants.

REFERENCES

[1] STAR-CCM+, Version 12.04 USER GUIDE