The Study on the Dynamic Characteristics of the Disc for the Lift-type Check Valve

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1. Introduction

Lift-type check valve of which the opening or closing stroke can be operated by the flow change through the disc is commonly used for the prevention of reversing flow and protection of the main components at many systems in nuclear power plants. Under the normal operating conditions, if the disc can not be fully opened due to the inadequate valve selection, many problems like corrosion, wear or stick by the foreign material can be occurred and they can give impact to the safety related system on their safety functions. Therefore, the exact understanding for the dynamic motion of the disc is very important.

In this paper, the dynamic motion of the lift check valve was investigated experimentally. The pressure and flow conditions were controlled by the opening position (OP) of air-operated valve (AOV) that is installed at the downstream of the check valve. In addition, the effect of upstream elbow on the valve opening was analyzed based on the experimental data.

2. Methods and Results

2.1 Test methods

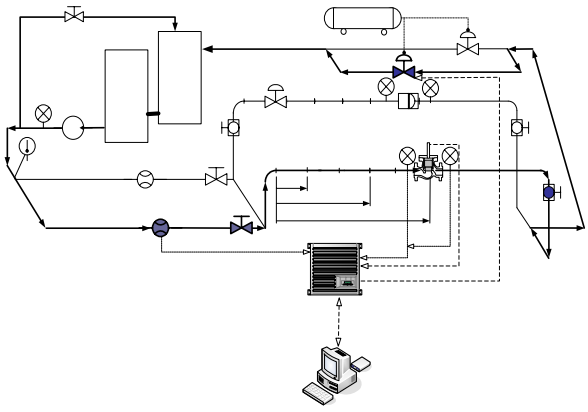

Figure 1. Flow test-loop for the check valve

Figure 1 shows the experimental apparatus for the check valve and Table 1 is the specification of the main components. Maximum flow rate at the test loop was controlled by the OP of 38%, 50%, 65%, 80%, 92%, 100% of the AOV. Flow rate passing the check valve was adjusted by using the manual hand-wheel of 3-inch gate valve which was installed at the upstream of the check valve. Disc position was measured by using the strain gage-type linear position sensor attached to the upper cover of the check valve. The distance from the check valve to the elbow was adjusted by the connection of the flanged pipes whose lengths are 2 times or 4 times of tube inner diameter.

Table 1. Specification of the components

Component	Specification
Pump	Head: 71.85m, Flow rate: 5.4m^3/min, Power : 92.52[Kw]
Flowmeter	0~100[m^3/hr]
Flow Control Valve	3-inch gate valve
Air-Operated Valve	Input voltage : 0~8[V]
Pressure Sensor	0~10[bar], Full scale: 0.15%
Position Sensor	LP-50F, Max. stroke: 50[mm]

2.2 Data Analysis

From the data acquisition system, we obtained the real-time data which was continuously measured 200 sets of data per 5/1000 seconds during the testing period. The acquired data was inlet and outlet pressure, flow rate, disc position, and temperature. And the average values of 50 sets of data were also measured at the stable flow condition, that is, less than 3 percent of standard deviation of the flow rate changing with the more than 3 seconds of stable time, to obtain the disc position change with the distance between the check valve and the elbow. The disc position variation with the flow rate was analyzed by the real time data because the disc moved until all of the forces such as disc weight, flow momentum force, disc-valve body friction force and so on above disc were equalized. The inlet pressure and the flow rate at the disc of the fully open state were defined as the average values between the point where the disc was abruptly lifted and the position at which the disc was just opened.

2.3 Test Results

Figure 2 shows disc position of the check valve variation with flow rate for the OPs of the AOV at L/D=2 respectively. In case of OP of the AOV less than 65%, the disc of check valve fully opened. But above OP of the AOV 65%, the disc only lifted up to approximately 4.5mm ~6.5mm at maximum flow rate in test loop. Also it showed that the more OP of the AOV

is small, the more the flow rate at just before fully open decreases.

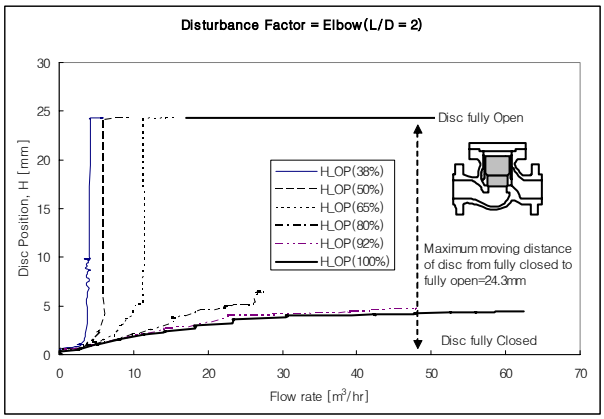

Figure 2. Disc position with the flow rate (L/D=2)

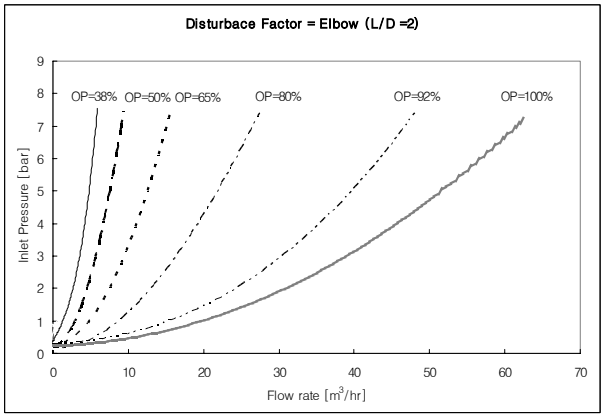

Figure 3. Inlet pressure with the flow rate (L/D=2)

Figure 3 shows the inlet pressure variation with the flow rate passing the check valve. It is noted that the maximum inlet pressure for all of the OPs of AOV was similar with approximately 8[bar] but build-up rate of the inlet pressure with the flow rate significantly differed. Fig. 4 represents the differential pressure variation with the flow rate. At the OP of AOV less than 65%, differential pressure decreased with the flow rate passing the check valve. But at above 65%, differential pressure gradually increased. From the above results, it can be seen that the disc in accordance with the decrease in the OP of AOV can fully open at the smaller flow rate due to the decrease in differential pressure force resisting the disc motion. This is because the downstream pressure of the check valve is built up to the upstream pressure by the increase in flow resistance at AOV.

Table 2 represents the minimum flow rate & inlet pressure at fully open position, where L/D is the distance between the check valve & elbow. For the OP 38%, all of flow rate and inlet pressure similarly appeared. But in case of the OP higher than 38%, flow rate and inlet pressure at L/D=10 which disturbance factor is negligible showed slightly bigger than those at L/D=2 and L/D=6. This means that disc dynamic motion was affected by the turbulence flow around the disc.

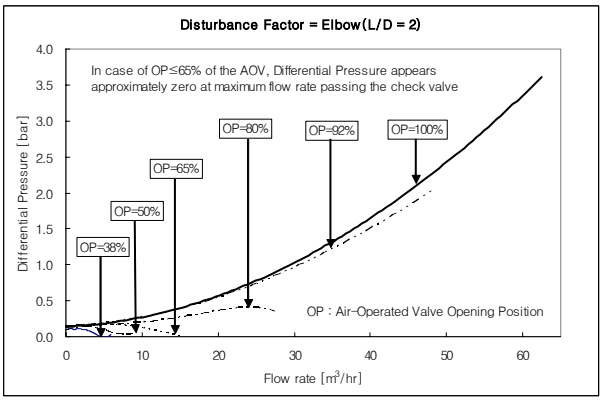

Figure 4. Differential pressure with the flow rate (L/D=2)

Table 2. Minimum flow rate & inlet pressure

Disc Fully Open												
OP / L/D	38%		50%		65%		80%		92%		100%	
	Q	Pin	Q	Pin	Q	Pin	Q	Pin	Q	Pin	Q	Pin
2	4.01	3.62	6.07	3.37	11.4	4.17	-	-	-	-	-	-
6	3.70	3.67	6.18	3.59	10.9	4.15	26.0	7.18	-	-	-	-
10	4.07	3.75	6.98	4.10	13.2	5.26	-	-	-	-	-	-

3. Conclusion

For the 3-inch lift check valve, disc dynamic motions with the flow rate are compared for OPs of AOV respectively. In addition, disc dynamic motion of check valve affected by the disturbance factor (elbow) is investigated. Like the swing type check valve, it is expected that the disc of check valve may be fully opened with the increase of the maximum flow rate passing the check valve. But the opening of the lift check valve seems to be strongly dependent on the valve inlet pressure as well as the flow rate. And it was verified that disc dynamic motion of the check valve was affected by the distance between the elbow and the check valve. Therefore, both the flow characteristics in system and the disturbance factor for the selection of the adequate check valve are necessarily considered.

REFERENCES

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[2] J. K. Wang, P. D. Alvarez, M. S. Kalsi, Application Guide for Motor-Operated Valves in Nuclear Power Plants, TR-106563, Vol.1, 1999.