Study on the Check Valve Diagnosing by Ultrasonic Signals

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1. Introduction

Check valves play important roles in nuclear power plants in order to prevent the reverse flows in pipes and to maintain the pressure difference between the channels, which protects the important components. Therefore, the performance of the check valves has to be monitored and diagnosed. However, the motion of the disc which indicates the performance, is hardly detectable outside while operating since it is operated by the flow.

In this paper, the ultrasonic signal which can be measured outside the valve without disassembly, is chosen as the diagnostic signal. The disc position is estimated and fluttering is detected by using the experimental ultrasonic signals. Furthermore, in order to overcome the limitation of the measurable range and to improve the signal-to-noise ratio, multi-channel signals and changeable threshold values are applied.

2. Check Valve

There are several types of check valves like swing check valves, tilt disc check valves, double disc check valves and nozzle check valves. The swing check valve is the most widely used type of check valve in power plants due to its relatively simple design, low pressure drop, good seat tightness, ease of maintenance, and low cost. Figure 1 shows one of swing check valves.

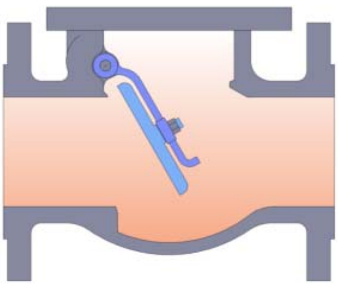


Figure 1. Typical Swing Check Valve

3. Experiment

Swing check valves are operated by the system flows. When the flow is developed and hydrodynamic force can be enough to overcome the weight of the disc assembly, the valve opens. On the contrary, when the amount of the flow is reduced and can not be sustain the disc assembly, the valve is closing. Therefore, the experiments of the swing check valve were carried out in a flow system. Figure 2 shows the experimental flow system. The ultrasonic signal was measured outside the valve.

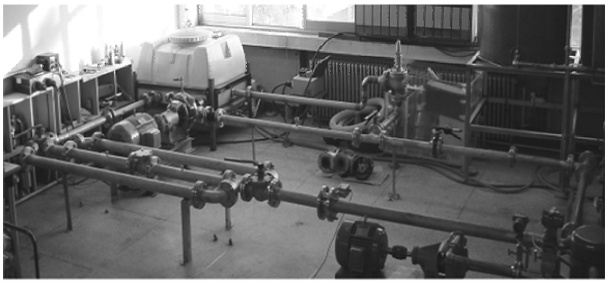


Figure 2. Experimental Flow System

4. Check Valve Diagnosis

4.1 Disc position

For diagnosing a check valve, the position of the disc assembly needs to be evaluated. Its position can be calculated by multiplying the wave-speed to the time of the reflected ultrasonic signal from the surface of the disc. Figure 3 shows the measured ultrasonic signal in the check valve. In this figure, red peaks about 0.03msec are the reflected signal from the disc when the valve opens fully. From these data, the disc position is calculated by connecting the peaks. Figure 4 shows the disc position.

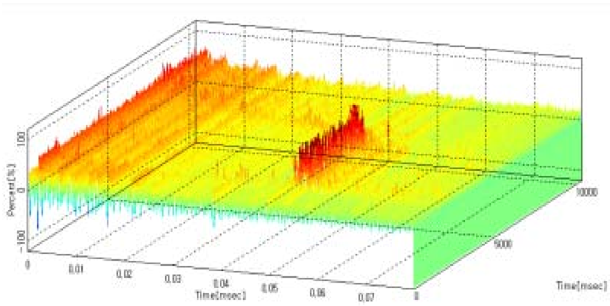


Figure 3. Ultrasonic Signal in Check Valve

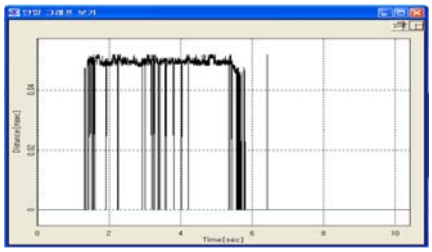


Figure 4. Disc Position with Optimal setting

4.2 Fluttering

The flutter means rapid reciprocating motions of the valve disc without the disc contact to the seat or body. When the check valve is wrongly selected or it degrades, it happens. This symptom is detected by monitoring the disc position. Figure 5 shows the fluttering of the disc. This ultrasonic signal was measured from the bottom of the check valve. This is the case when the flow was not fully developed due to the lack of the amount of the flow.

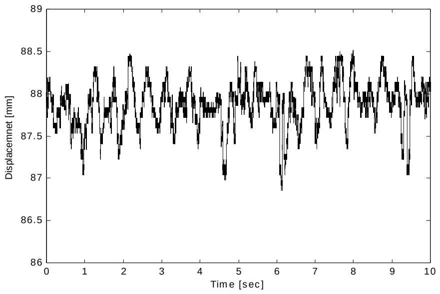


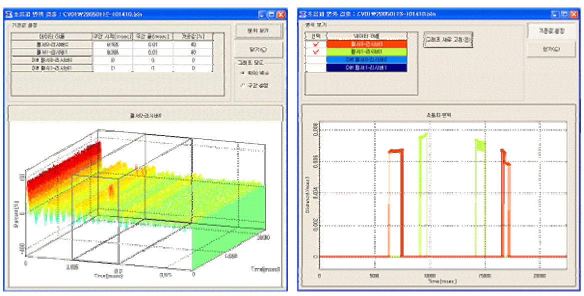
Figure 5. Fluttering

The measured ultrasonic signals can be used in order to diagnose other faults in check valves like the wear of the disc stud, that of hinge pin and tapping frequencies.

5. Improvement of the Check Valve Diagnosis

5.1 Multi-channel ultrasonic signal

The Ultrasonic has the limitation of the measurable range. It depends on the beam spread angle of the transducer. Ultrasonic signals could be measured in about 10-degree range of the disc motion. Therefore, to overcome this limitation, 4 channel ultrasonic signals are measured. Figure 6 shows the result when two sensors are used simultaneously. Figure 6(a) shows the ultrasonic signal from one of the transducers and figure 6(b) shows the disc position from both the transducers. As shown, the measurable ultrasonic signal range is expanded. The red line comes from one transducer near seat and the green line comes from the other which monitors the mid-range of disc motion. Figure 6(b) shows the disc motion while the disc opens and then closes.



(a) Data from one transducer (b) Disc position
Figure 6. Multi-channel ultrasonic signals

5.2 Selection of the threshold values for calculating the disc position

When the field test is performed, current ultrasonic test systems are necessary to be set the threshold values ahead of the test for calculating the disc position. Sometime, the setting is enough to acquire the test results, but in general, it is not optimal. Therefore, from time to time, the disc motion can not be obtained because of noise. Therefore, in this study, the measured ultrasonic data are acquired and saved, and then the disc position is calculated by changing the threshold values. Figure 7 shows the estimated disc motion with the fixed setting. In comparison with the result of the optimal setting in figure 4, there is a lot of noise in figure 7. Therefore, to enhance the signal-to-noise ratio, we need to change the threshold value properly.

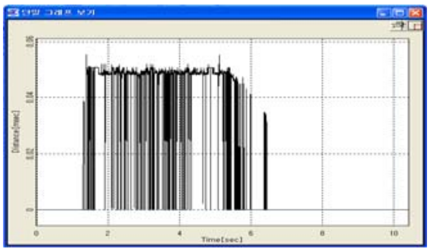


Figure 7. Disc position with Fixed setting

6. Conclusion

The Check valve is one of the important components in nuclear power plants. In this paper, in order to diagnose check valves, ultrasonic signals were used for evaluating the motion of the disc which indicates the operability of the check valves. In order to improve the diagnosing accuracy, multi-channel ultrasonic signals and optimal threshold value for the calculation of the disc position were applied. The developed method in this paper will expand the monitoring range as well.

Acknowledgement

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