Noise Control in the process of moving water by compressed air

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Abstract. Pressure oscillation or surging in pipes can cause noise problems to the environment. In this paper, noise control methods are investigated in the process of moving water by compressed air. An experimental setup is built according to the real system. First, the pressure, noise and vibration of the valve and the pipes are tested. Secondly, a new type of control valve is developed. Thirdly, the effect of shorting the valve-shutting time is tested. Finally, a noise reduction of 13~24dB is realized.

1. Introduction
Waterhammer is pressure variation induced by the quick change of fluid velocity. Pressure oscillation or surging is waterhammer continually happened [1]. It causes not only safety dangers but also noise problems. The waterhammer in systems with pumps are investigated a lot [2, 3], but the research is few when it comes to the air driven system.

In this paper, the surging in the process of moving water by compressed air and its noise control methods are investigated experimentally, where a waterhammer with a 3.2 times design pressure is detected.

2. Experimental Setup
An experimental setup was built according to the real system with a scale factor of 0.5. It consisted of two tanks and a ball valve. Compressed air was injected into Tank No.1 and when the valve opened, water was pushed from Tank No.1 to Tank No.2. Sound level meters were placed at a distance of 1m from the valve while pressure gauges and accelerometers were placed at the valve and the pipes.

As shown in Fig.2, waterhammers appeared both before and after the valve when the valve shut. The waterhammer before the valve (P5) was a typical excessive pressure hammer. The amplitude of the pressure oscillation decreased with time. The pressure peak and the lasting time of the first period were...
about 1.7MPa and 1s, respectively. Different from P5, the waterhammer after the valve (P4) showed the characteristics of a typical negative pressure hammer. The amplitude of the pressure oscillation also decreased with time, but the peak value of the pressure was much higher and the trough was near zero because Tank No.2 is opened to the air. The pressure peak of the first period was about 3.2MPa and the lasting time was very short which gave a steep rise. The sound level recorded at the time of waterhammer was about 96.0dB(A).

The vibration records at different locations were compared and they showed a simultaneous enlargement when the hammer appeared. A waterhammer propagating speed at about 1200m/s was recorded for the negative pressure hammer while a propagating speed at about 150m/s was recorded for the excessive pressure hammer. Both speeds gave a halfwavelength larger than the length of the pipelines.

The valve vibration became larger with its opening or closing, especially at frequencies higher than 1500Hz. The valve vibration could reach 115dB at 10~20Hz and 1000~1500Hz with its opening. It even reached 135dB at 15Hz with its closing. In the time domain, the vibration didn’t show apparent
relationship with the waterhammer. Maybe this was because the first two troughs of the negative pressure waterhammer met the peaks of the excessive pressure waterhammer.

3. Noise Reduction Experiments

3.1. Lowering the air pressure
To control the noise, lower pressure of the compressed air was used. As shown in Tab.1, the noise could decreased to 79.8dB(A) at the air pressure of 0.2MPa, which gave a noise drop of 16dB. Although the noise level was acceptable, the water-moving speed was lowered, too.

| Air pressure  | 0.2MPa | 0.4MPa | 0.6MPa |
|---------------|--------|--------|--------|
| 1             | 79.8   | 84.6   | 96.0   |
| 2             | 64.0   | 68.8   | 72.0   |
| Drop          | 15.8   | 15.8   | 24.0   |

3.2. New type of control valve
In the attempt to control the air noise at a faster water-moving speed, a new type of control valve was developed which utilized orifice structure.

3.2.1. Effects of the new valve. The valve vibration: After using he new valve, the valve vibration decreased from 135dB to about 120dB. The pipe vibration: The vibration near the valve was larger than the vibration far away from the valve. The pipe vibration decreased after the usage of the new valve.

As shown in Tab.1, the air noise decreased to 72dB(A) with the new valve. Its frequency spectrum was shown in Fig.4.

![Figure 4. Frequency spectrum of the air noise (new valve).](image)

3.2.2. Effects of shorting the valve-shutting time. Shorting the valve shutting time is usually effective and can be easily accomplished in this setup by changing the hydraulic resistance in the driving part of the new valve. As shown in Fig.5 and Fig.6, the peak pressure at P4 was about 1.9MPa with a valve shutting time of 2.1s and the peak decreased to less than 0.4MPa when the shutting time increased to 3.1s. At the same time, The peak pressure at P5 increased with a small amplitude, which was only 1.4MPa even for the 2.1s shutting time.
4. Moving water backwards
The noise control results were given in Tab.2 when moving water from Tank No.2 to Tank No.1. The noise drop were lower. This was due to two reasons: First, the noise using the old valve was much lower with a small excessive pressure waterhammer. Secondly, the noise using the new valve was higher with a bigger waterhammer.

Table 2. Noises when moving water backwards.

| Air pressure | 0.2MPa | 0.4MPa | 0.6MPa |
|--------------|--------|--------|--------|
| 1            | 83.0   | 86.2   | 88.0   |
| 2            | 66.7   | 72.0   | 75.0   |
| Drop         | 16.3   | 14.2   | 13.0   |

5. Conclusion
In this paper, noise control methods were investigated in the process of moving water by compressed air. First, the system noise could decrease by 5~16dB with a lower driving air pressure. Secondly, a new type of control valve was developed with a noise reduction of 13~24dB.

Acknowledgments
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