Application of Air-Water Pulse Technology in Feed-Water Pipes Flushing

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Abstract: If we take traditional unidirectional-flow method to sterilize or flush large-caliber and long-distance water supply pipes, it usually fails and newly-installed pipes cannot be grid-connected or used because of low pressure, low velocity and shortage of water in some pipe networks. Air-Water Pulse Technology, which has good economic and social benefits, has solved the problem effectively.

Keywords: feed-water pipes, Air-Water Pulse Technology, pipes flushing

1. INTRODUCTION

As the lifeline of a city, feed-water pipes play a vital role in social production and the lives of local residents. There are feed-water pipes with length of more than 9,300 kilometres in downtown Beijing right now, and the area for which we can provide water supply services has reached 710 square kilometres. However, as time goes, feed-water pipes in some areas are in urgent need of transformation and renovation after a long time, and at the same time some new feed-water pipes should be installed along with the city widening.

Although constructors will clean the pipes and its inside during installation, there is a large quantity of dusts and sundries inside pipes. According to *Standard for Construction and Acceptance Check of Water Supply and Drainage Pipeline Project (GB50268-2008)*: "The feed-water pipes can only come into use after hydraulic test, cleaning, disinfection and water quality test." If we take the traditional unidirectional-flow method to sterilize or flush water supply pipes with minor calibre (less than DN300), short distance or in area of high water supply pressure, it usually can reach water quality standard. But for pipes with large calibre (greater than DN400), long distance or in area of low water supply pressure, the traditional method can hardly work, especially for those with many kinks. Lots of manpower and material resources have been wasted, but the desired result cannot be achieved. In addition, it has caused loss of water and failure of grid-connection and operation of newly-installed pipes.

The new air-water pulse technology, which takes full advantage of the theory of air-water mixed-order kinetics, has solved the problem effectively and created a new situation for flushing feed-water pipes.

2. BRIEF INTRODUCTION OF AIR-WATER PULSE TECHNOLOGY

Air-water pulse technology is late-model, intellectualized and on the basis of pulse theory, water-air-slag three phases flow theory, partial water hammer theory and projectile flow of steam theory. Controlled by computer automatic process, the high-pressure air from air compressor can be injected into pipes and then release enormous energy which will increase turbulent fluctuation and shearing stress of flow and finally remove sediment and attachment in pipes effectively. In addition, there is just physical operation during process of cleaning and no chemical pollution, so the flushing effect is stable and reliable. The technology is a major breakthrough for solving the problems of low pipe pressure, water shortage, low velocity and long-distance flushing. At the same time, we can save time and water with the technology, so it has gained approving in whole water industry.

3. EQUIPMENT NEEDED FOR AIR-WATER PULSE CLEANING

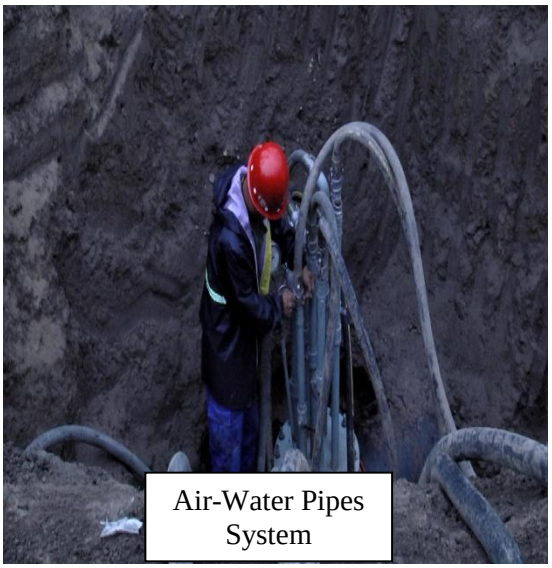
(1) Portable Air Compressor: It is the power source and able to generate high-pressure air (1MPa at most).

(2) Gas Tank: The high-pressure air from air compressor can be injected into gas tank. It offers a buffer and helps to store energy.

(3) Fully Automatic Control System: Controlled by computer program, magnetic valve starts and stops automatically. By controlling frequency of air entrapping and stopping, pulse operation can be formed. And there are branch pipes connected with the air-ejecting device of pipes which need to wash.

(4) End of the pipe is installed with an outlet line and a buffer tank. Connect the outlet line to the buffer tank and then put it into current river course or sewage conduit. Make sure the enormous impulse from air-water pulse cleaning will not destroy municipal facilities.

(5) Portable Turbidimeter: We can monitor turbidity change of the water sample from each delivery port with it and feedback information, according to which the command staff can regulate pulse frequency and time.



4. EXAMPLES FOR ITS APPLICATION

On June 19-20, 2014, air-water pulse technology has been adopted by Beijing Waterworks Group to sterilize and flush the DN600 main pipes and DN300-400 water-distribution pipes in SHAYANG Road, Haidian District. And ideal results have been achieved.

4.1 Project Background

SHAYANG Road, located in northwest Beijing, is an arterial street which connects Shahe and Yangfang in Changping District. There are DN600 feed-water pipes under northern side road of SHAYANG Road. And in order to satisfy the need of engineering construction along the line, it has already supplied water sectionally in 2012. Xinruijiayuan District, built by Beijing Sanyuanjiaye real estate agency, is located in SHANGZHUANG East Road. To meet water demand for people there, we flushed pipes around the district in November, 2013. Yu Tong Municipal Engineering Co., LTD. has flushed the section of current DN600 pipes, which haven't supplied water in SHAYANG Road, DN300 and DN400 loop wires in November, 2013, April, 2014 and May, 2014. But we all failed because of the high-turbidity of water we took. In addition, we have also found that the turbidity of water from the section of DN600 pipes, which has already supplied water in upstream of SHAYANG Road, has also increased (5-25 NTU). The Customer Service Department of Beijing Waterworks Group convened a meeting to analyse the flushing work and found the problems finally. (1) The current DN600 pipes in SHAYANG Road is used to supply water unidirectionally, and the water is from DN1,200 water distribution pipes at Xinzhuang Bridge, Badaling Expressway. The pipes go westward through BEIQING Road to WENYANG Road, and then northward to SHAYANG Road. The pipes twist and turn for more than 20 kilometres. And the area where the pipes go through is high, which causes low pipe pressure and velocity. So the requirement to flush downstream pipes cannot be satisfied. (2) Since DN600 pipes have already supplied water in subsection in 2012, there are only a few consumers along the line and the water consumption is quite low. Besides, because of the complex topography, the pipes are very rugged, thus increasing the sediment inside pipes. Along with velocity variation during flushing, the sediment made turbidity increase and caused failure of flushing. The Customer Service Department of Beijing Waterworks Group convened another meeting on June 16, 2014. And we agreed upon adopting air-water pulse technology to flush pipes from the night on June 19 to the morning on June 20,2014, including the 5.8-km DN600 pipes in SHAYANG Road (from west side of West Sixth Ring to Xinruijiayuan District) and the DN300 and DN400 pipes of the newly-built district. The total length is about 7.8 kilometres.

4.2 First-Phase Preparations

(1) We obtained GIS information of DN600 pipes in SHAYANG Road, confirmed the location and status of pipes, sluice gates in main line and branch lines, air evacuation valves and fire hydrants, implemented the geographic environment of bent section by site-investigation and located the air-water pipe system for current pipes.

(2) According to the water sample we took for the last three flushing, we made clear of the sanitary condition of current pipes. There was some sand inside upstream pipes which have already supplied water, while some big stones, pebbles and sand in pipes that haven't supplied water. So we sterilized these pipes by the standard of 40mg/L.

(3) According to the real situation, we simulated to flush pipes in computer and then made sure the relevant technological parameter for air-water pulse flushing.

(4) We made up detailed programs to flush, including making clear of deployment of equipment for air-water flushing, time controlling for each flushing stage, open-close operation of sluice gates and exhaust valves along the line, layout of water quality monitoring stations and request for a report, inspection system during flushing and management for emergency situation.

(5) Treating air-water flushing as cutting off water, so we notified consumers along the line.

(6) We installed temporary air-water pipe system and debugged equipment. In addition, we installed temporary off-let pipes, which were connected with buffer tank. The water needs to drain into current water wells, so we made sure that the wells were able to meet the requirements to receive water.

4.3 Process of Air-Water Pulse Flushing

According to simulated data, the inlet pressure was set to 0.4-0.5 Mpa, the flushing time to 10-15s and the calibre of outlet to DN300. At the outlet, the turbulent flow formed by air and water was obvious. Concrete time is as follows:

(1) 23:00: Close sluice gates of DN600 inflow main line, air evacuation valves along the line and sluice gates of branch lines. Open sluice gates of DN300 off-let lines and make sure that the workers at water quality monitoring stations are in place.

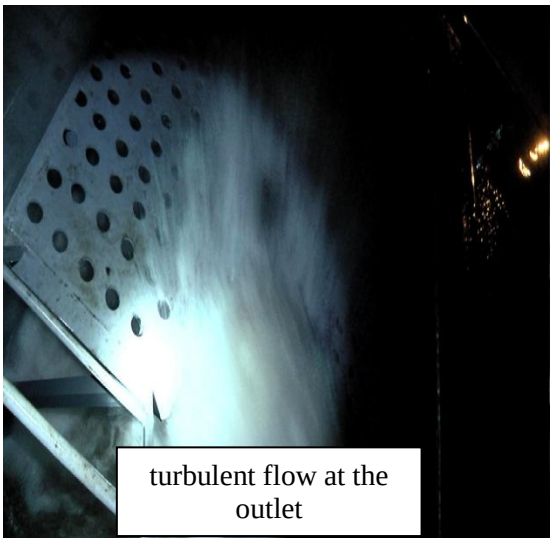
(2) 23:00- next-day 0:15: Push out storage water in pipes by air-water pulse cleaning.

(3) 0:15-1:45: Open one third of sluice gates of DN600 inflow main line and clean for 90min.

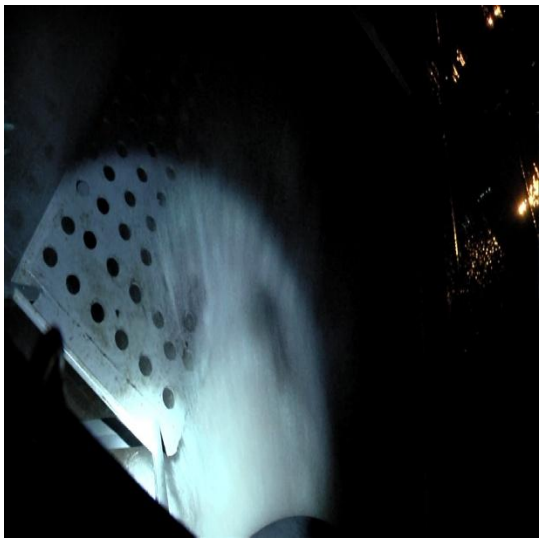
(4)1:45-3:30: Open one second of sluice gates of DN600 inflow main line, increase quantity of water intake and clean for 105min.

(5)3:30-6:00: Completely open sluice gates of DN600 inflow main line and flush pipes with unidirectional-flow after closing air-water pulse system. At the same time, open air evacuation valves along the line and monitor water quality at the place where six fire hydrants lie.

(6)6:30: Restore water supply for consumers along the line and sample water to centre of water quality monitoring.



turbulent flow at the outlet



4.4 Data Analysis during Flushing

(1) Turbidity Monitoring

During flushing, we monitored water sample every 15 minutes at the end of the outlet with a portable turbidimeter. And we can see in Figure 1 that because of the strong rolling effect caused by air-water pulse flushing inside pipes, rocks and sand deposited in pipes released intensively, so the turbidity was high and unstable. And along with continuing effect of air-water pulse flushing, the turbidity became stable and began to decline continuously when adopting unidirectional-flow method. When we restored water supply, the turbidity has already reached water quality standard.

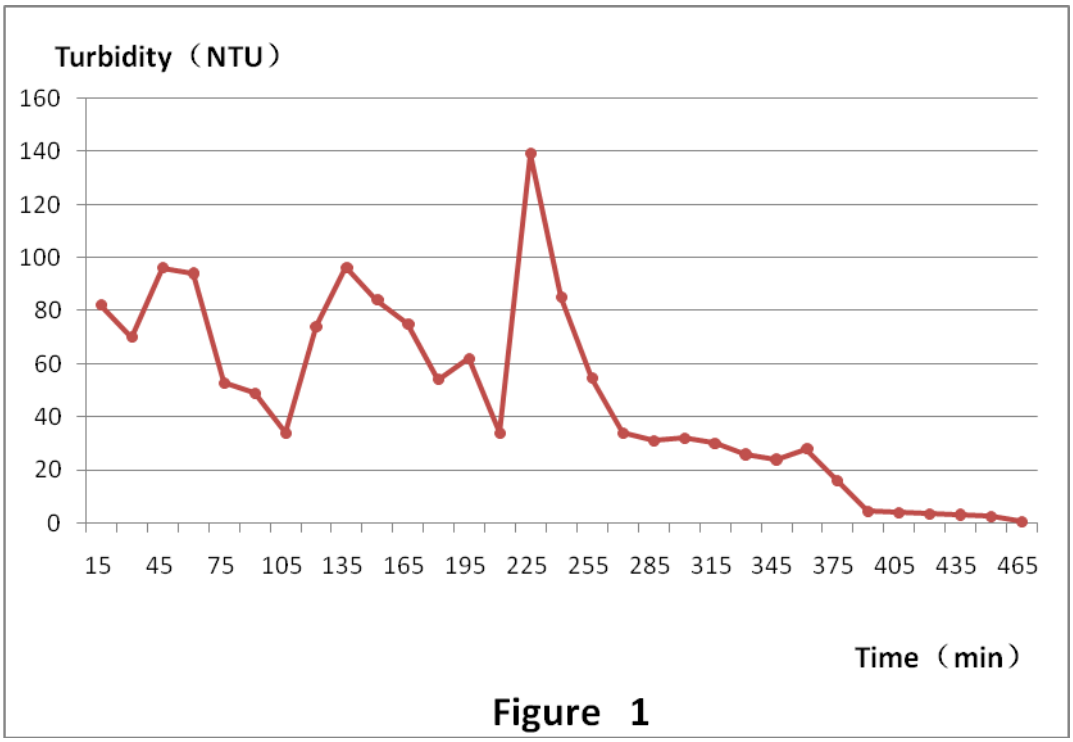


Figure 1

(2) Residual Chlorine Monitoring

We also monitored residual chlorine in water sample. We can see in Figure 2 that during air-water pulse flushing, along with the increased consumption of residual chlorine by sundries and attachment in pipes, the residual chlorine decreased rapidly. But due to the decrease of sundries and attachment in pipes, the residual chlorine increased gradually. When we adopted unidirectional-flow method to flush pipes, along with the outflow of sundries and attachment in pipes, the index of residual chlorine became stable.

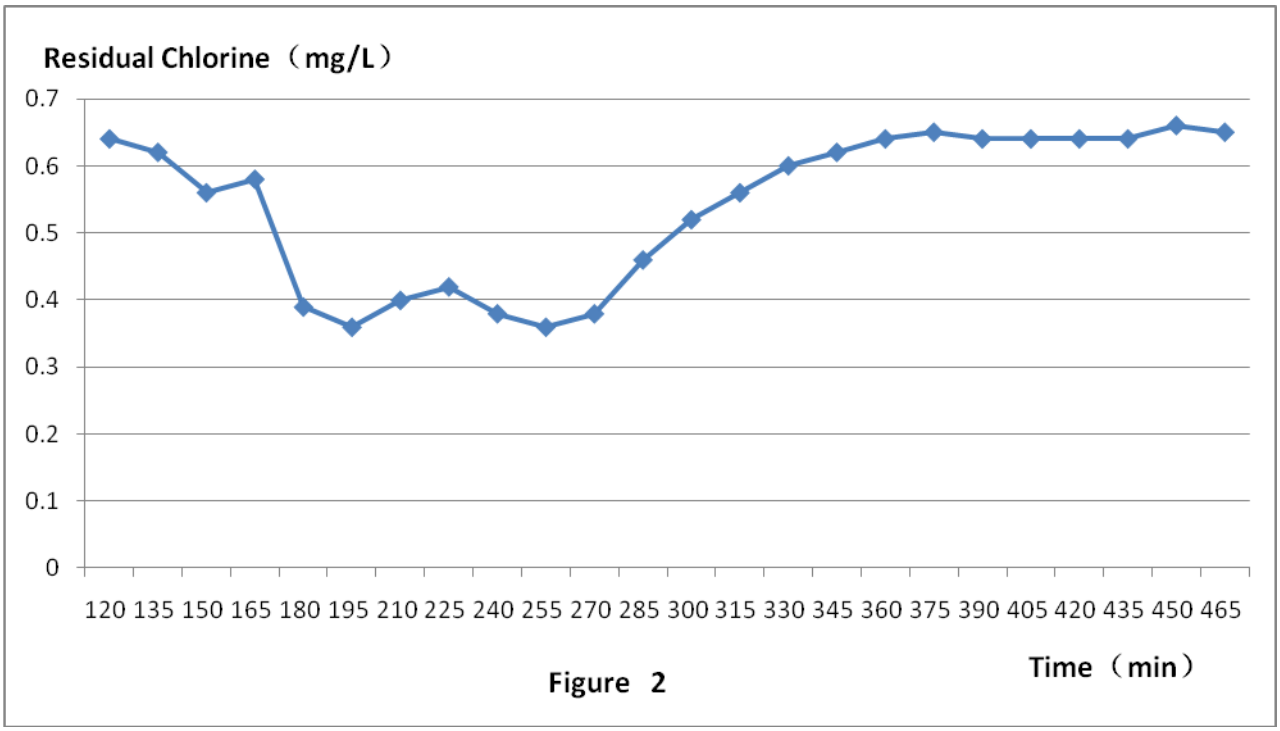


Figure 2

5. ECONOMIC AND SOCIAL PROFITS OF AIR-WATER PULSE TECHNOLOGY IN THIS PROJECT

5.1 Economic Profits

According to *Standard for Construction and Acceptance Check of Water Supply and Drainage Pipeline Project*, we must control the flow rate of pipe flushing at 1.0m/s at least. The comparison of water consumption and cost between unidirectional-flow method and air-water pulse technology is shown in the following table:

Method	Time-taken（h）	Water Consumption（m^3）	Water Price（Yuan/m^3）	Cost（Yuan）
Unidirectional-Flow Method	18	18312	6.4	117196.8
Air-Water Pulse Technology	7.5	6147	6.4	39340.8

Table 1

In Table 1, the corresponding data of unidirectional-flow method show the total time and water consumption in the last three flushing, which are much higher than data of air-water pulse technology. Adopting unidirectional-flow method, we devoted considerable manpower and material resources and consumed large amount of water, however, the desired effect has not been achieved. We have saved time by 63.89% and water by 66.43% and guaranteed water quality with air-water pulse flushing. In addition, the newly-installed pipes can be grid-connected or used.

5.2 Social Profits

In 2012, the price of power (per unit water amount), which is mainly electric energy, is 0.27 Yuan/ m^3 and the electricity price is 1.2 Yuan/kw in Beijing Waterworks Group. So electricity consumption of water-treatment units is 0.225kwh/ m^3. So the social profits of air-water pulse technology are listed below.

Water-Saving Amount（m3）	Electricity-Saving Amount（kwh）	Coal-Saving Amount（kg）	Reductions of Co2（kg）	Reduction of Carbonaceous Dust（kg）	Reduction of So2（kg）	Reduction of Nox（kg）
12165	2737.1	1094.9	2364.0	644.9	71.1	35.6

Table 2

Note: According to statistics, if we save one kilowatt hour, it equals to save 0.4kg of coal and reduce emissions of 0.997kg of Co2, 0.272kg of carbonaceous dust, 0.03kg of So2 and 0.015kg of Nox.

6. CONCLUSION

Sterilizing or flushing pipes is key link to project of feed-water pipes in a city and the cleaning effect has a direct influence on that whether newly-installed pipes can be grid-connected or used. Compared with traditional unidirectional-flow method, air-water pulse technology offered us help to flush large-calibre and long-distance pipes effectively, which usually failed before because of low pressure, low velocity and shortage of water. Besides, the technology can help to save lots of water, which meets the requirement to build a resource-economical and environment-friendly society so it has broad application prospects in Beijing which faces severe water shortage.

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