Application of Ultrasonic Technology in Flow Measurement System in Irrigation District

Qing Liu1, 2, 3, 4 a, Simin Feng1, 2, 3, 4, b

1Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co. Ltd. 710075, Xi’an, China
2Shaanxi Provincial Land Engineering Construction Group Co., Ltd. 710075, Xi’an, China
3Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, 710075, Xi’an, China
4Shaanxi Provincial Land Consolidation Engineering Technology Research Center. 710075, Xi’an, China

553664133@qq.com, b871787254 @qq.com

Abstract. Irrigation area measurement of water volume is to optimize irrigation area water use scheduling, and is the key to realizing irrigation area total water control and irrigation water quota management. In order to improve the management level of irrigation districts, speed up the construction of current irrigation districts, and gradually realize digital irrigation districts, it is imperative to transform the automatic construction of water measurement and water measurement in irrigation districts. This project takes the Erba Main Canal of Fenhe Irrigation District in Shanxi Province as the research site. The ultrasonic equipment installed on the irrigation open channel is used to study the measurement of the non-uniform flow of the open channel. According to the cross-sectional area obtained by the water level, the flow rate is calculated.

1. Introduction
With the rapid development of social economy, the contradiction between supply and demand of water resources has become increasingly prominent. Scientific water planning, rational water dispatch, accurate water measurement and measurement, and full use of irrigation water-saving potential are increasingly being highly valued by the whole society. Water measurement in irrigation areas is the basic work for strengthening irrigation management and strengthening water conservation. Water measurement in the irrigation area is an important part of water saving in agriculture. Irrigation water measurement is inaccurate and water saving is difficult to be implemented; water measurement in the irrigation area is also the basic work for agriculture to gradually achieve precision irrigation. Irrigation water management in China’s irrigation districts is increasingly based on informatization and efficient development. The real-time monitoring of irrigation districts 'automatic water measurement is the basis of irrigation districts' automatic transformation. Therefore, it is an inevitable result to use ultrasonic flow meters to replace traditional flow measurement methods.
2. Relevant background of Erba main canal in Fen he irrigation area
The Fen River, the mother river of the people of Sanjin, originated from the foothills of Ningwuguan, Shanxi. It has been gurgling and surging for thousands of years. The Fen he Irrigation District is located in the Taiyuan Basin in the central part of Shanxi Province. The area is distributed on both sides of the Fen he River. It starts from Shang lan Village in the northern suburbs of Taiyuan City in the north and Hong xiang Village in Jie xiu County in the south to Jin zhong District. (Taiyuan) Fen (Fen yang) highway and Ci yao River are bounded by Taiyuan Three Highway and South Tong pu Railway. The irrigation area spans the three cities of Taiyuan, Jin zhong, and Lv liang. There are 488 villages in 56 counties (towns) in 12 counties (cities and districts). The total area of the irrigation area is 2,055,500 mu, of which 1,568,400 mu is cultivated land. The designed irrigation area is 1.495 million mu, and the benefited area accounts for nearly one tenth of the province's water area. It is one of the largest gravity irrigation areas in Shanxi Province. In addition to agricultural irrigation, Fen he Irrigation District is also responsible for the supply of water for industrial purposes such as Taiyuan No. 1 and No. 2 Thermal Power Plants, Tai gang, East-West Lake in Qing xu County, Jiao cheng Industrial Park, and Taiyuan Fen he Park and Forest Park.

The average rainfall in the irrigation area is 4531mm. The interannual rainfall varies greatly, and the distribution is extremely uneven during the year. The rainfall during the flood season accounts for 72% of the annual rainfall. The interannual variation of precipitation in the irrigation area is very large, with an average annual precipitation of 453.1mm, of which 72% is in the flood season, especially in July and August, and the total precipitation in the six months of winter and spring accounts for only 12.7% of the annual precipitation about. The average annual evaporation of the irrigation area is 1031.9mm, and the average annual evaporation is 2.28 times of the annual average rainfall. Due to the lack of rain and snow in winter and spring, the spring drought is very serious. At the same time, due to the uneven distribution of rainfall, coupled with the huge difference between evaporation and rainfall, there are often continuous droughts or continuous rains and floods across the year. Therefore, the "nine years of drought and spring drought interlace" is a natural feature of this area.

3. Application of Ultrasonic Flow meter in Measuring Water in Irrigation District
Ultrasound is a kind of mechanical wave. It has good directivity and strong penetrating power. It will produce significant reflection when it encounters impurities or interfaces. Ultrasonic waves have many advantages for fluid and gas flow rate measurement. Compared with traditional mechanical flow meters and electromagnetic flow meters, it has high measurement accuracy, strong adaptability to pipe diameter, non-contact fluid, easy to use, and easy to digitize. In recent years, with the development of electronic technology, digital technology and acoustic wedge materials, the technology of using ultrasonic pulses to measure fluid flow has developed rapidly. Based on different principles, various types of ultrasonic flow meters suitable for different occasions have appeared one after another. Their application fields involve industrial and agricultural, water conservancy, hydropower and other departments. Ultrasonic flow meters have many unique advantages, overcoming the limitations of traditional flow measurement methods, greatly improving the efficiency of flow measurement work and saving manpower.

Ultrasonic flow measurement is a flow measurement method that is increasingly used with the development of electronic technology and material technology. Compared with traditional measurement methods, it has the advantages of simple installation and construction, high measurement accuracy, high applicability, and high degree of data collection automation. It can be promoted as a method for accurately measuring the flow of open channels.

4. Classification of ultrasonic flow meter
According to the working principle, the flow measurement principle of the ultrasonic flow meter is classified into the propagation velocity difference method, the Doppler method, the beam deviation method, and the listening method. However, the method of propagation velocity difference and Doppler method are mostly used.
The speed difference method includes a direct time difference method, a phase difference method, and a frequency difference method. The basic principle is to measure the difference between the velocity of ultrasonic pulses along the water flow and counter water flow to reflect the flow rate of the fluid, thereby measuring the flow rate. The advantage of the speed difference method is high measurement accuracy and a wide range of applications, but it is not suitable for fluids containing a large number of bubbles or solid particles. Doppler method. The basic principle is to use the Doppler effect in sound waves to measure the frequency difference between the downstream and upstream currents to reflect the flow velocity of the fluid to obtain the flow rate. The advantage of the Doppler method is that it can measure fluids containing a large number of bubbles or solid particles. But its accuracy is low.

At present, there are many ultrasonic flow meters with propagation velocity difference method, which can be divided into single-channel ultrasonic flow meter and multi-channel ultrasonic flow meter according to their channel arrangement. According to the applicable flow channel, it can be divided into pipeline flow meter, irrigation channel flow meter, open channel ultrasonic flow meter and river ultrasonic flow meter.

5. Design Scheme of Flow Measurement System in Irrigation District

Ultrasonic open channel flow meter is mainly composed of instruments and sensors. This kind of open channel flow meter not only intercepts the channel, produces unrecoverable pressure loss, but also facilitates installation, reduces costs, and ensures and improves the measurement accuracy. It can be applied to non-standard open channel flow measurement. The measurement principle is to calculate the flow rate according to the \( Q = V \times A \) equation, that is, the actual flow cross-sectional area of the fluid is converted by the liquid level and channel size, and the average flow rate is calculated from the measured flow rate, and then the average flow rate and the actual overflow Multiply the area to get the fluid flow. Figure 3-1 shows the application of ultrasonic open channel flow meter in open channel flow measurement.

The ultrasonic liquid level sensor is installed on a bridge on the channel, the probe is aligned with the water surface, the instrument controls the probe to send and receive ultrasonic waves to the water surface, and is converted into the liquid level by the operation of the internal processor of the instrument.

Ultrasonic flow rate sensors are installed on both sides of the channel and can measure flow without standard weirs or grooves. The time difference method is used to measure the water flow velocity. It inputs the collected signal into the open channel flow meter as a speed signal. Using the liquid level and velocity data, the open channel flow meter can calculate the flow rate of the open channel, and can obtain the cumulative flow rate and record it. This instrument has a data storage function. In addition to storing the flow record of this instrument, it can also be connected to the 4-20mA signal of other instruments and record simultaneously (such as water quality measuring instruments: COD, PH, etc., up to 4 channels). The stored records can be viewed through the buttons on the meter, or printed via a printer, or transmitted via remote communication. The RS-232 serial port of the open channel flow meter can be connected to a computer or other data collector, and can also be connected to a modem or a wireless communication module to achieve wired or wireless remote communication.

This article mainly introduces the principle of time difference measurement. An acoustic wave sensor is installed on both side walls of the river channel, at an oblique angle of 0 to the channel axis and at a distance of \( L \), forming a pair of acoustic channels (Figure 1).
Figure 1. Schematic diagram of ultrasonic flow measurement

The velocity of the water flow is \( V \) and the velocity of the sound wave is \( C \). When the sound wave propagates downstream and upstream, the propagation time is respectively:

\[
T_2 = \frac{L}{(C - V \cos \theta)} \quad (1)
\]

The propagation time difference is:

\[
\Delta T = T_2 - T_1 = \frac{2VL \cos \theta}{(C^2 - V^2 \cos^2 \theta)} \quad (2)
\]

Because of \( \cos \theta \leq 1, V^2 << C^2 \), \( \Delta T \) can be approximated by the following formula:

\[
\Delta T \approx \frac{2VL \cos \theta}{C^2} \quad (3)
\]

\[
\bar{T} = \frac{T_1 + T_2}{2} = \frac{CL}{(C^2 - V^2 \cos^2 \theta)} \approx \frac{L}{C} \quad (4)
\]

\[
V \approx \frac{\Delta TL}{\bar{T}^2 2 \cos \theta} \quad (5)
\]

Because the velocity of the water flow in the channel is different along the depth of the water, the ultrasonic sound path should be installed at several elevations to obtain the flow rate of each layer; another sensor for measuring the height of the water level is installed, and the water depth \( h \) can be obtained formula:
In the formula, \( Q \) is the incremental area of the measuring point. From this, the channel flow rate \( Q \) can be calculated.

6. Conclusion

In this paper, the application of ultrasonic technology to the channel flow of the Erba East Main Canal of Fenhe Irrigation District to measure and set a plan can draw the following

1. Ultrasonic open channel flow meter is a measuring instrument obtained by the combination of ultrasonic probe and water measuring weir trough to obtain open channel flow information. It has the advantages of convenient installation and maintenance, long service life, strong environmental adaptability, stable operation, and wide measurement range. Currently widely used in petroleum, chemical, pharmaceutical, food processing and other wastewater discharge enterprises, it plays an important role in environmental protection and pollution control.

2. Compared with the traditional flow measurement, the flow measurement is more accurate and the management is more in place, which avoids the confusion of the water fee calculation and collection caused by manual flow measurement, so that the water resources are effectively regulated and managed, and the water supply is achieved.

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