RESEARCH ARTICLE | MARCH 15 2023

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AIP Conference Proceedings 2612, 020021 (2023)
https://doi.org/10.1063/5.0113711

Monitoring of Water Level in Pump Station Forebay

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Abstract. Data from the cascade of pumping stations showed rapid changes in water levels and consumption in the forebay. Experimental observations on the study of changes in the water level in the advance chambers of pumping stations were carried out at the Jizzakh pumping station. Mathematical-statistical and systematic analysis methods were used to determine the change in water level using a rail mounted on the front chamber of the pump station. According to the design, when 5 pumping units are operating at the main pumping station, the water level in the advance chamber should be 6.85 m. In the following months of 2020, it should be 3.95 m in March, 4.97 m in August, 3.60 m in September, 2.90 m in October. Based on the data, a graph was developed showing the change in water level during the year. It was found that the formation of water bubbles in front of the pump suction pipes was reversed in an average of 5.5 - 8 minutes due to changes in the water level in the forebay. In the presence of 2400V 25/40 type suction pipes when the water level drops below 3.4 m, in front of 1600V 10/40 type suction pipes when the water level drops below 2.8 m, water whirlpools were observed. In this case, developing and improving a special device in front of the suction pipes to prevent the pumping device from operating in the cavitation mode is an important direction.

INTRODUCTION

In the Republic of Uzbekistan, more than 55% of arable land is used for mechanical lifting systems. Rapid fluctuations in water consumption and levels in the Syrdarya, affecting the operation of the Jizzakh pumping station, falling below the water level in the forebay, changes in hydraulic processes, and the formation of whirlpool in the water, causing the infiltration of air with water [1]. When developing new technologies for the use of hydromechanical equipment of pumping stations, it is necessary to consider the long-term reliable operation of their technical characteristics. The main methodological goal of the research work in this direction is to improve the hydraulic conditions at the pumping station and ensure the smooth movement of water through the efficient use of vibrations in hydromechanical equipment and prevent distortions caused by stresses [2].

The probability of changes in the technical parameters of the pump station and their level of danger depends on the type, size, operating conditions of hydromechanical equipment, the state of control, and automation. For example, increasing the water lift height above the calculated value is not a problem because centrifugal pumps transmit small water consumption. Still, centrifugal pumps, which transmit large amounts of water, lead to dangerous situations for pumps, especially axial pumps [3]. To ensure that a portion of the water discharged upstream using cascade pumping stations supplies water to each other following each other, their operating modes must be optimally organized. It is important to ensure that the required amount of water is supplied at the first head and subsequent pumping stations, as a breach of the plan at any pumping station can lead to overflow and overflow of the channel between the pumping stations. High-capacity pumping units ensure optimal water delivery and high efficiency. Ensuring the supply of the required amount of water in the coming years is causing its problems. From a technological point of view, the water supply system of the Jizzakh pumping station depends on the water supply of the 1st main pumping station, which supplies water from the Syrdarya at great expense. According to the number of scientists, as a result of water whirlpool in open water sources, the pump consumption is reduced by 22-45%, and the efficiency is reduced by 12-33%. As a result of the drop in the water level in the source, water coils are formed in front of the suction pipes. Air entering the pump unit along with water reduces the performance. The pump unit

The Third International Scientific Conference Construction Mechanics, Hydraulics and Water Resources Engineering (CONMECHYDRO 2021 AS)
AIP Conf. Proc. 2612, 020021-1–020021-6; https://doi.org/10.1063/5.0113711
Published by AIP Publishing. 978-0-7354-4337-2/$30.00

operates in cavitation mode [4]. P.G.Kisilev [5], Dj.Sharp [6], V.A.Volosukhin, E.N.Belokonev [7] researched the field of substantiation and generalization of the formation of water deposits in open water intake facilities.

As a result of scientific research conducted by V.A.Volosukhin, E.N.Belokonev, the dimensions of water piles formed in front of suction pipes and water intake structures were 15 m in diameter. They were found to be unevenly moving on the water surface without standing still [7]. One of the main reasons for the formation of piles on the water's surface has been found to occur as a result of rapid changes in the water level in front of the suction pipes, falling below the design parameters [8].

Scientific observations at the Jizzakh pumping station in 2019-2020 revealed that the avalanche caused a change in the waterway due to a decrease in the water level and a decrease in water movement. It has been found that water from an artificial barrier formed due to turbid sedimentation in the forebay compulsorily changes its direction, complicating access to the suction pipes, leading to the formation of water swells in front of the suction pipes [9].

The study's main purpose is to study the state of water buildup in front of the suction pipes in the event of a drop in the water level in the forebay and to obtain solutions to ensure their elimination.

The following issues have been resolved to achieve the goal:

-study of information on changes in the water level in the forebay of large pumping stations, detection of cases of whirlpool in front of the suction pipes of pumping equipment

-determine the direction of elimination of whirlpool formed by the suction pipe when the water level in the forebay of the pump station falls below the minimum height.

METHODS

Experimental observations on the study of changes in the water level in the forebay of pumping stations were carried out at the Jizzakh pumping station. Mathematical-statistical, systematic analysis methods were used to analyze changes in water level using a rail mounted on the advance chamber of the pump station. The experiments were carried out during the operation of up to 5 pumping units at the pump station. When the water level fell in March, August, September, and October, 3 pumps, two 2400V 25/40 type and one 1600V 10/40 centrifugal pumping units were operating.

RESULTS

Proper organization of their operating modes is important in ensuring the required water supply using pumping units. Data were obtained from Jizzakh pumping stations to study the state of the water level in the forebay in cases where the flow movement in the channel-pumping system is rapidly changing. One of the main factors is the processes in the Syrdarya River, which lead to uneven flow in the delivery of water to the first pumping station through the channel, which directs the flow of water throughout the year [10-12].

The drop in water level in the forebay of the main pumping station [13, 14]:

- the river changes its course and reduces the flow of water flowing into the canal;
- turbidity due to changes in the flow rate in the water intake channel to the pumping stations;
- Cases of large-scale leakage of leaks and failure to clean and remove leaks in front of the grids were identified in a timely manner.

Several measures are being taken to eliminate the main causes of the drop in water levels in the forebay. It is proposed to carry out monitoring works to control the longitudinal change of depth in the directional channel, clear the sediment sitting in the channel, and increase the amount of water flowing from the Syrdarya and receiving to the main pumping station [15, 16]. However, these measures do not fully ensure the reduction of water consumption in the canal and the prevention of fluctuations in the flow in the forebay when the water level falls. In the pumping station forebay, whirlpools are mainly formed in front of the suction pipe (Fig. 1).

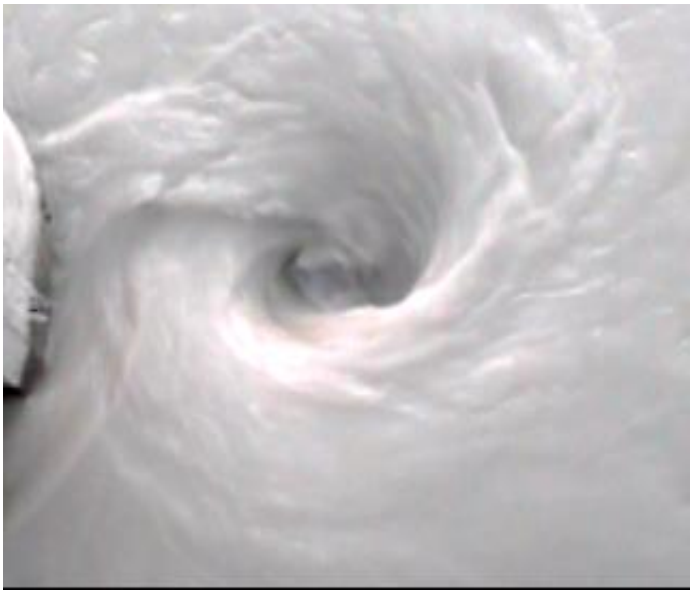


FIGURE 1. Formation of a whirlpool in the chamber

As a result, the inflow of large amounts of air and the water absorbed through the suction pipe leads to the operation of the pumping device in the cavitation mode [17, 18]. To prevent such a situation, the norms of the minimum water level in the forebay are set depending on the number of pumping units operating simultaneously on the project [19-24] (Table 1).

TABLE 1. Variation of water level according to the number of pumping units operating simultaneously at Jizzakh main pumping station

	The number of pumping devices operating at the same time				
Number of pumping devices	1	2	3	4	5
Normal water level in the project chamber (m)	5.0	5.40	5.50	5.70	6.85

In 2020, based on the data obtained as a result of experimental monitoring conducted at the Jizzakh main pumping station, changes in the water level in the forebay were identified. Depending on the number of pumping units operating at the same time, the minimum required water level in the forebay is higher than 6.85 m. The data obtained from the experiments conducted at the pump station showed a rapid and abrupt change in the water level in the forebay. Cases of water level drop were chronic, especially in March, August, September, and October. (Table 2).

TABLE 2. Information on the months when the water level in the chamber fell below normal.

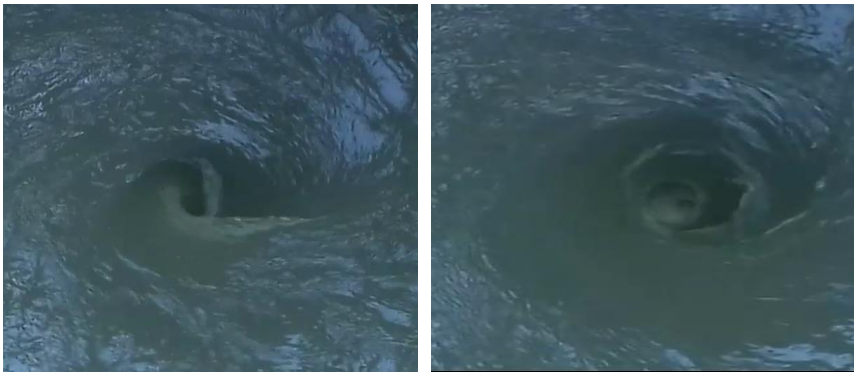
Water level	**Chamber water level (m).**		
	Highest water level	**Lowest water level**	**Average water level**
march	4.53	3.38	3.95
august	4.54	3.41	4.97
september	4.00	3.20	3.60
october	3.00	2.80	2.90

The data show that the water level in the lower basin is 4.75 m, i.e., in front of the suction pipes of two types of pumping equipment with water consumption of 2500 m3/s and water consumption of 1600V10/40 - 10 m3/s. It was found that the duration and recurrence of occurrences of water masses varied (Table 3), as well as the size of water masses also differed from each other (Fig. 2).

TABLE 3. Information on the months when the water level in the chamber fell below normal.

№	Water whirlpool processes	Pump mark	
		1600B 10/40	*2400B 25/40*
1	Repetition of water cycles (times / hour)	10-12	21-24
2	Duration of water turbulence (min.)	1.5-2.0	3.5-4.0

At the Jizzakh main pumping station, two types of 2400V 25/40 and 1600V 10/40 centrifugal pumping units were installed, and only a 1600V 10/40 pumping unit was used to supply water in October when the water level dropped to 2.80 m. The dimensions of the water coils formed in front of the suction pipes when the water level in the forebay dropped were studied. The part of the forebay that supplies water to the pumping units is divided into spaces in the frontal plane, with a width of 2.5m allocated to each suction pipe. As a result of the observations, the formation of surface ridges at a distance of 1.7 - 2.2 m from the wall of the water distribution structure is 40%, the formation at a distance of 1.0 - 1.7 m is 50%, and 1.0 m was found to be 10-15% of the formation in the distance range. The time intervals of occurrence of water intakes depend on the water level and the number of operating pump units, on average 4-7 minutes in front of 2400V 25/40 type suction pipes when the water level is 4.5- 5.0 m, was found to occur once every 1.2-1.5 minutes when the water level was 3.5-4.2 m.



(a) (b)

FIGURE 2. Occurrence of whirlpool in the forebay: a) 1600V 10/40 mark pump in front of the suction line; b) 2400V 25/40 mark pump in front of suction pipe in different sizes

It has been found that when the water level falls below 3.4 m, the whirlpools are constantly uninterrupted. The appearance of water coils in front of the suction pipes of the 1600V 10/40 type pumping unit began to occur when the water level dropped below 4.0 m. When the water level dropped to 2.8 m, it was observed that the water in front of the suction pipes formed continuously.

Analysis of the study results showed that a drop in the water level in the forebay leads to the formation of bumps in front of the suction pipes and the operation of the pumping device in cavitation mode. As a result, the pump consumption was reduced to 22–45%, and the efficiency was reduced to 12–33%. Therefore, it is important to improve the devices to prevent the ingress of sediments into the suction pipes, which are formed when the water level in the forebay falls. Scientists from Russia, Ukraine, and Uzbekistan have conducted several scientific studies to improve the design of the advanced chambers of pumping stations and develop methods for calculating the hydraulic processes. In particular, artificial barriers have been installed in front of the suction pipes to ensure that the suction pipes are at least 0.5 m deep above the water level to prevent the formation of water swells[20]. The proposed technical solutions and research on the application of technological devices in large pumping stations are formed when the water level in the forebay falls below normal. It requires scientific research in the field of the development of devices for the prevention of whirlpools.

CONCLUSION

Data from the cascade of pumping stations showed rapid changes in water levels and consumption in the forebay. Experimental observations on the study of changes in the water level in the advance chambers of pumping stations were carried out at the Jizzakh pumping station. Mathematical-statistical and systematic analysis methods were used to determine the change in water level using a rail mounted on the forebay of the pump station. According to the design, when 5 pumping units are operating at the main pumping station, the water level in the advance chamber should be 6.85 m. In the following months of 2020, it should be 3.95 m in March, 4.97 m in August, 3.60 m in September, 2.90 m in October.

As a result of the observations, the formation of surface ridges at a distance of 1.7 - 2.2 m from the wall of the water distribution structure is 40%, the formation at a distance of 1.0 - 1.7 m is 50%, and 1.0 m. was found to be 10-15% of the formation in the distance range.

The time intervals of occurrence of water intakes depend on the water level and the number of operating pump units, on average 4 - 7 minutes in front of 2400V 25/40 type suction pipes when the water level is 4.5 - 5.0 m; was found to occur once every 1.2-1.5 minutes when the water level was 3.5-4.2 m. It has been found that when the water level falls below 3.4 m, the whirlpool is constantly uninterrupted.

The appearance of water coils in front of the suction pipes of the 1600V 10/40 type pumping unit began to occur when the water level dropped below 4.0 m. When the water level dropped to 2.8 m, it was observed that the water in front of the suction pipes formed continuously.

A whirlpool was observed in the presence of 2400V 25/40 type suction pipes when the water level drops below 3.4 m in front of 1600V 10/40 type suction pipes when the water level drops below 2.8 m. In this case, developing and improving a special device in front of the suction pipes to prevent the pumping device from operating in the cavitation mode is an important direction.

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