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DEVELOPMENT OF THE ENERGY CIRCUITS OF DEVELOPMENT OF CONTOUR REGULATION OF THE SUPPLY OF HOT WATER FOR BUILDINGS WITH VARIABLE FLOW

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РАЗРАБОТКА ЭНЕРГЕТИЧЕСКИХ ЦЕПЕЙ РАЗВИТИЯ КОНТУРНОГО РЕГУЛИРОВАНИЯ ПОДАЧИ ГОРЯЧЕЙ ВОДЫ ДЛЯ ЗДАНИЙ ПЕРЕМЕННЫМ ПОТОКОМ

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Abstract. The hot water supply system is one of the important components of the water supply and drainage system of high-rise civil buildings. With the development of the national economy and the improvement of people's living standards, people's requirements for popularizing hot water supply and improving hot water supply technology are becoming more and more urgent. In the process of hot water supply, the flow pressure of the pipeline is increased, and the purpose of hot water supply in high-rise buildings is achieved. The experiment analyzes the effect of the pressure ratio on the pipeline in front of the accumulator and the impact valve on the flow of coolant through the check valve. First, through the periodic opening and closing of the shock valve, the pressure continues to rise and fall, and the spring hose exhibits periodic pulsation. The effects of different pressure ratios on pipeline pressure and flow rate are studied, and the data of simulation calculation and actual measurement are analyzed through experiments. The research results have practical significance for improving the water supply efficiency of the hot water supply system of high-rise buildings.

Аннотация. Система горячего водоснабжения — одна из важных составляющих системы водоснабжения и водоотведения многоэтажных гражданских зданий. С развитием народного хозяйства и повышением уровня жизни населения потребности населения в популяризации горячего водоснабжения и совершенствовании технологий горячего водоснабжения становятся все более актуальными. В процессе горячего водоснабжения давление потока в трубопроводе увеличивается, и достигается цель горячего водоснабжения в многоэтажных домах. В эксперименте анализируется влияние перепада давлений в трубопроводе перед гидроаккумулятором и ударным клапаном на поток теплоносителя через обратный клапан. Во-первых, в результате периодического открытия и закрытия ударного клапана давление продолжает расти и падать, а пружинный шланг периодически пульсирует. Изучается влияние различных соотношений давлений на давление в трубопроводе и расход, а данные моделирования и фактические измерения анализируются посредством экспериментов. Результаты исследований имеют практическое значение для повышения эффективности водоснабжения системы горячего водоснабжения многоэтажных домов.

Keywords: high-rise building, water hammer, hot water supply, pipeline flow and pressure.

Ключевые слова: высотное здание, гидравлический удар, горячее водоснабжение, трубопровод протока и давления.

Introduction Research Background and Theoretical Research

The hot water supply system is one of the important components of the water supply and drainage system of high-rise civil buildings. With the development of the national economy and the improvement of people's living standards, people's requirements for popularizing hot water supply and improving hot water supply technology are becoming more and more urgent. However, some problems in the weak link of the building water supply and drainage profession are also increasingly prominent. For example, due to improper selection of the hot water supply system, there are problems with the safety and stability of the hot water supply, affecting the comfort and safety of hot water use. In short, the hot water system should develop in the direction of high efficiency, automation, energy saving, etc. Therefore, it is necessary to strengthen the optimization design of the hot water supply system.

In recent years, with the rapid development of high-rise buildings, the water supply and drainage technology for high-rise buildings supporting it has also been continuously improved. The hot water supply system is one of the important components of the water supply and drainage system of high-rise civil buildings.

The calculation of wave velocity of water hammer was carried out earlier in foreign countries. In 1858, Menbrea [1] was the first to study the phenomenon of water hammer. He took into account the elasticity of pipe wall and fluid and explained the basic principle of water hammer with the theory of energy. In 1898, on the basis of experimental research and theoretical derivation, Joukowsky [2] first obtained the basic equation of direct water hammer pressure, which was the first time to calculate the water hammer pressure with the formula. The water hammer theory in water pipe and the pressure calculation formula of direct water hammer were put forward for the first time. The equation was as follows:

$$\Delta P = \pm \rho a \Delta V \tag{1}$$

The formula ignores the compressibility of the liquid and the elasticity of the tube wall, so the accuracy is not high [3]. In 1945, Rich used Laplace transform to analyze the law of water hammer pressure change. In 1965, Pearsall [4] studied the water hammer wave velocity of gas-liquid two-phase flow. Considering the compressibility, volumetric strain and pipeline elasticity of gas and liquid, and ignoring the weight of free gas, he obtained the calculation formula of water hammer wave velocity influenced by gas. The formula is applicable to the two-phase flow problem in which trace gas is uniformly dispersed in liquid.

In 1992, Muhlbauer [5] pointed out that the propagation speed of water hammer wave depends on the characteristics of pipe material and fluid, and water hammer wave will cause deformation of pipe wall. Therefore, the greater the elasticity of pipe wall, the more it can slow down the wave speed of water hammer, and the larger the ratio of pipe diameter to wall thickness is, the smaller the wave speed will be. Similarly, the compressibility of the fluid also consumes the energy of the water hammer wave. The speed of the water hammer wave is inversely proportional to the compressibility, and the incompressible flow will make the water hammer wave spread rapidly. The water hammer pressure is directly proportional to the wave velocity of the water hammer wave, which is consistent with the calculation formula. In 1997, Stephenson [6] not only considered the liquid compressibility and pipe properties, but also the external constraints of the pipe and the influence of the protective layer and deduced the calculation formula of water hammer wave velocity.

China's research on unsteady flow theory started relatively late, but the translation and publication of a large number of foreign literatures, as well as Chinese scholars' study, summary and development of predecessors' theories, have greatly promoted the research on unsteady flow theory in China, and fruitful research results have been achieved in recent decades. In the 1960s, wang shouren, long shitai and others laid a foundation for later calculation and protection of water hammer based on a large number of experiments. Afterwards, wang shuren and ding hao have done a lot of research on the water hammer of the pressure diversion system of hydropower stations, which has laid a foundation for the further development of the water hammer theory in China.

In 1990, Zhang Changling [7] put forward a general formula for the pressure and flow relationship of pressure pipe under different boundary conditions. The formula is a simple linear equation, which is applicable to pressure pipe under different boundary conditions. In 1996, Guo Wenzhu, Suo Lisheng [8] from water hammer extremum approximate analytic expression is deduced by the reservoir, pipeline and valves of the simple pipe water hammer of the biggest booster analytical probability distribution, introduces random numerical simulation method, this method is a random sampling technique, each time according to certain principle to simulate the results of the equivalent of a random sample, with the increase of the number of simulation, simulation solution of the true solution of overall statistical properties gradually approaching the problem. In 1997, starting from the basic equation of unsteady flow, and drawing on the ideas of literature, Suo Lisheng proposed the characteristic line method for the calculation of spinal canal water hammer. The equation is as follows:

$$g\frac{\partial H}{\partial x}+\frac{\partial V}{\partial t}+\frac{\lambda V|V|}{2D}=0 \qquad (2)$$

$$g\frac{\partial H}{\partial x}+a^2\frac{\partial V}{\partial t}+\frac{2\alpha a^2}{r_0+\alpha x}=0 \qquad (3)$$

This method simplifies the water hammer problem of variable section pipe. In recent years, the use of Lattice Boltzmann method to calculate the pressure pipeline water hammer has developed rapidly. However, the research on Lattice Boltzmann method is still focused on the theoretical field, and the application of Lattice Boltzmann method in hydropower projects has not been found [9].

In 2000, Zhang Qinfen, Suo Lisheng and Guo Wenzhu [10] considered more random factors on the basis of literature and derived the analytical probability distribution of the maximum annual water hammer pressure from the approximate analytic expression of the water hammer extreme value of simple pipe.

After in 2000, Zhang Xuefang [10] on the pipeline network of water hammer calculation of simulation has achieved fruitful results, Liu Zhuxi, Guang Linliu in water conveyance system of pumping station, water hammer and its protection on the research work of a lot of work, the characteristics of pump valves closed curves and stop when the pump process have done in-depth research, Jin Pingli, Li Xiushu and others in the transient process of water pipe friction on research done a lot of work, in the simulation of unsteady flow friction has obtained certain achievement.

In 2008, Cao Huizhe [11] constructed the accurate analytical solution of the water hammer pressure before and after the closing of the terminal valve using the D'Alembert traveling wave principle and analyzed the linear water hammer fluctuation process and its optimal control by using the Ritz method, and obtained the optimal speed change law at the valve. The effect of reducing the water hammer pressure is better than when the speed changes linearly.

Experimental unit

In Russia, there is a centralized heat supply. Many houses and buildings are connected to one boiler house. The pressure in the lower zone is often high. This extra pressure should be used.

The coolant is circulated in the system using a pump 1 with a frequency drive, while part of the coolant flow is directed through the bypass valve 9, which ensures a slower increase in pressure in the pressure pipe of the pump during the closing of the shock valve 3. The flow of coolant through the shock valve 3 was regulated with the help of valve 4. The hydraulic accumulator 8 is connected to the pipeline through a non-return valve 5 through a flexible rubber sleeve 6 (inner diameter 20 mm, length 1.2 m). An impact valve with a drive was used in the work. The use of the design of a pulsation generator based on shock valves with a drive gives clear advantages compared to those designs where the valves are closed due to the forces acting on the side of the fluid flow to the valve. Based on the meter readings, the required flow rate was set through the shock valve 3. The shock valve 3 was slightly closed, as a result of changes in the hydraulic characteristics of the network, the pressure in the pressure pipe increased and the accumulator 8 pumped the liquid until the pressure in the accumulator 8 corresponded to the pressure in the pressure head the pipeline. As evidenced by the steady reading of the balance 7. This procedure is necessary so that water is pumped into the battery only due to water hammer arising when the shock valve 3 is abruptly closed. After that, the shock valve 3 was opened, and as soon as the flow in the system was installed, it was abruptly closed shock valve. As a result of a sudden slowdown in fluid flow, a pressure jump occurs. Under the influence of this increase in pressure, a part of the liquid is squeezed through the check valve 5 into the accumulator 8. As a result, with each closing of the shock valve 3, the liquid is pumped into the accumulator 8 and its weight increases. The weight of the accumulator 8 with water was initially recorded after each closing of the shock valve.

Analysis of experimental results

As a result, with each closing of the shock valve, fluid is pumped into the accumulator and its weight increases. The weight of the accumulator with water was initially recorded after each closing of the shock valve. But in view of the fact that the increase in the weight of the accumulator was commensurate with the error of the scales, it was decided to take the readings of the balance after a series of hydroshocks (Figure 3) and average them inside this series.

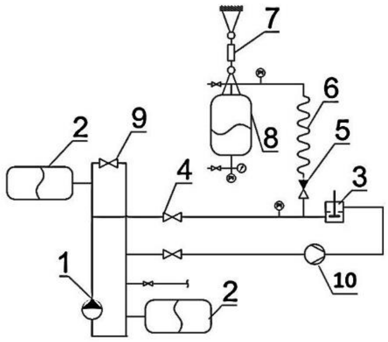

Figure 1. Schematic diagram of the experimental setup: 1 — circulation pump; 2 — accumulator; 3 — shock valve; 4, 9 — control valves; 5 — check valve; 6 — flexible sleeve; 7 — electronic scales; 8 —accumulator with pressure sensors; 10 — Flowmeter.

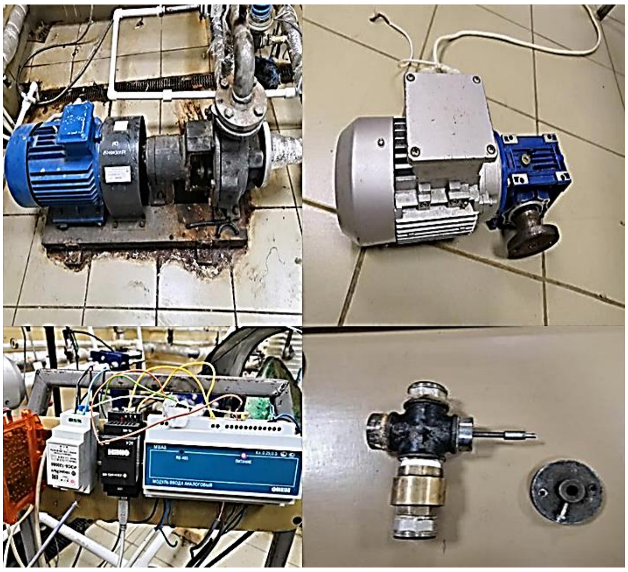

Figure 2. Experiment apparatus.

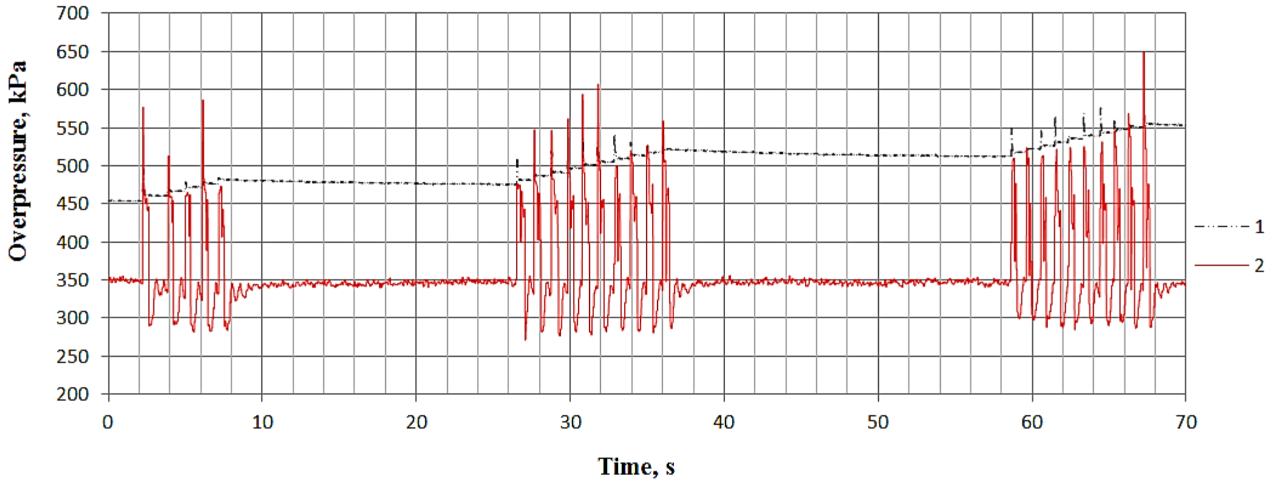

Figure 3. Change in pressure in the accumulator (1) and pressure pipe (2) during the experiment (flow rate 2 m^3 / h).

Based on the experimental data, we plotted (Figure 4) the dependences of the mass of water pumped into the accumulator 8 = on the ratio of the pressures in the pipeline and the accumulator for various steady-state flow rates with the shock valve open.

From the graphs presented, it is seen that when a certain value of the pressure ratio is reached (for a fixed flow rate), the mass of water pumped into the hydraulic accumulator in one hydraulic shock practically does not change.

To compare the experimental and calculated data of the dependences of the volume of water pumped into the accumulator in one shock, on the pressure ratio in the accumulator and the pipeline in front of the shock valve, the graphs are plotted, which are presented in Figure 5.

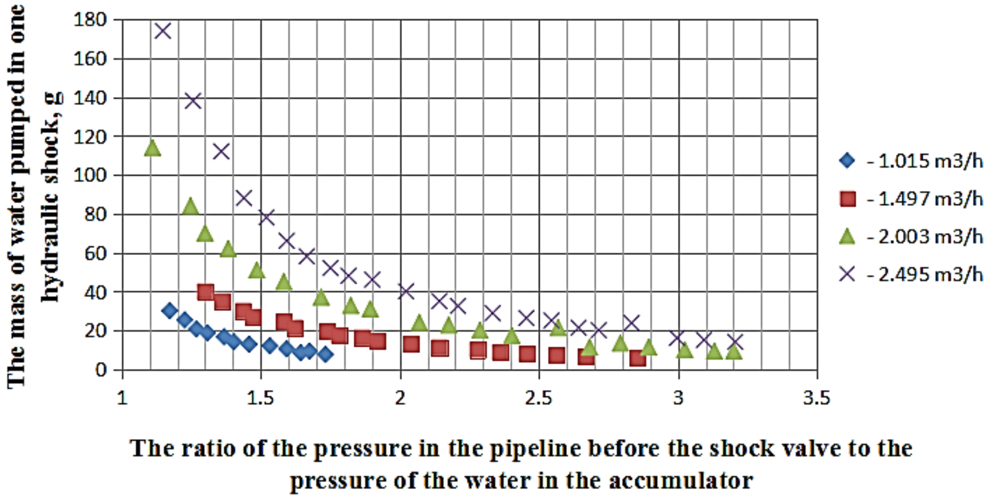

Figure 4. Dependences of the weight of the liquid squeezed through the non-return valve in one hydraulic shock on the pressure ratio in the accumulator and the pipeline in front of the shock valve.

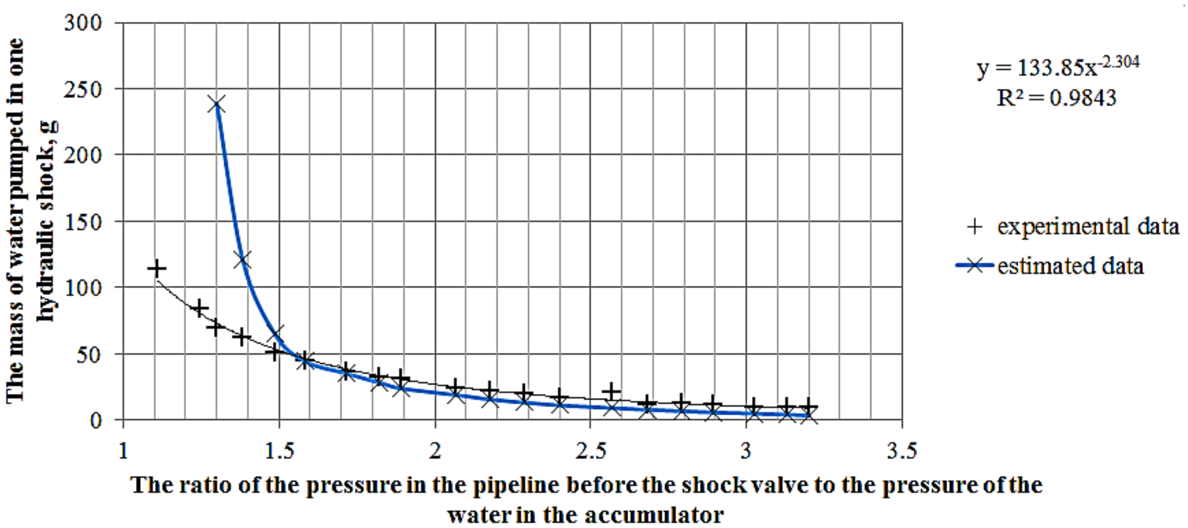

Figure 4. Dependences of the weight of the liquid squeezed through the check valve in one hydraulic shock at a flow rate of 2 m^3/h.

The use of a hydraulic ram in closed systems is possible, but the installation of a flow converter with a drive is recommended. The capacity of a hydraulic ram (the amount of fluid supplied to the accumulator at a constant pressure in it) in a closed system and a fixed pipe length depends on the flow (speed) of the fluid and the pressure ratio in the accumulator and the pipeline. There is a limit to a reasonable increase in pressure in the accumulator (with a further increase in pressure, the productivity varies slightly). It is possible to use a hydraulic ram in a closed hydraulic system as a booster pump.

Conclusion

In this paper, an experimental simulation was carried out by simulating the relationship between different pressure ratios and flow in the pipeline, and the pressure ratios on the pipelines in front of the different accumulators and impact valves were simulated respectively to test the flow. We obtained the following experimental conclusions:

1) Different pressure ratios correspond to different coolant flow rates. The flow of coolant through the check valve decreases as the pressure ratio on the line in front of the accumulator and the impact valve increases.

2) According to the experimental data, when the flow rate of the pipeline is 2 m^3/h, when the shock valve is opened and closed in the cycle, the pressure change in the accumulator is less affected by the opening and closing of the shock valve. The pressure change has obvious pressure fluctuation when the shock valve is opened.

3) When the different flow rate changes in the pipeline, the flow rate of the coolant through the check valve decreases as the pressure ratio on the pipeline in front of the accumulator and the impact valve increases. Under the measurement conditions of pipeline flow of 1.015~2.495 m^3/h, when the pressure ratio on the pipeline in front of the accumulator and the impact valve is the same, the greater the pipeline flow, the greater the flow of coolant through the check valve.

4) In the case of experiments and simulations, when the pipeline flow rate is 2 cubic meters per hour, when the pressure ratio on the pipeline in front of the accumulator and the impact valve is less than 1.5, the simulated coolant flow through the check valve The value of is much larger than the experimentally measured value. When the pressure ratio on the pipeline in front of the accumulator and the impact valve is greater than 1.5, the numerical value of the simulated coolant flow through the check valve gradually matches the experimentally measured value.

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