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OPTIMAL DESIGN OF HEATING BOILERS

©Liu Jiapei, *Jiangsu University of Science and Technology, Zhenjiang, China, 1432184336@qq.com*
©Zhang Zongnan, *Jiangsu University of Science and Technology, Zhenjiang, China*
©Kudashev S., *Ogarev Mordovia State University, Saransk, Russia*

ОПТИМАЛЬНОЕ ПРОЕКТИРОВАНИЕ ТЕПЛОВЫХ КОТЛОВ

©Лю Цзяпэй, *Цзянсуский университет науки и технологий, г. Чжэньцзян, Китай, 1432184336@qq.com*
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©Кудашев С. Ф., *Национальный исследовательский Мордовский государственный университет им. Н.П. Огарева, г. Саранск, Россия*

Abstract. Instead of a regular flywheel, it is possible to install a lightweight, with a variable moment of inertia on the electric unit, which will accelerate faster, which means it is faster to enter the mode of the rated frequency of the generator output voltage. In a mode close to the nominal speed of rotation, the moment of inertia will increase sharply, which will allow more mechanical energy storage, which will not allow to slow down the speed of the internal combustion engine, so it is better to damp (smooth out) the low-frequency external disturbances from the side of the electrical network.

Аннотация. Вместо обычных маховиков на электрической установке можно установить маховик с малым весом и изменяемым крутящим моментом инерции, что ускорит скорость, а значит, и скорость ввода номинального частотного режима напряжения на выходе генератора. В режиме приближения к номинальной скорости вращения количество инерции будет резко увеличиваться, что позволит большему количеству механической энергии хранить, что не позволит снизить скорость двигателя внутреннего сгорания, поэтому желательно подавлять (устранять) низкочастотные внешние помехи сбоку сети.

Keywords: flywheel, engine, moment of inertia, angular velocity, mechanical energy storage.

Ключевые слова: маховик, мотор, момент инерции, угловая скорость, механический накопитель энергии.

In today's industrially developed era, the generation and transmission of heat energy by boilers has become more and more important. Therefore, it is very meaningful to conduct optimization research on boilers.

In terms of hydraulic cylinders: With the rapid development of hydraulic technology, hydraulic machinery is widely used in various fields of production and life. The hydraulic cylinder has the advantages of simple structure, reliable operation, and good low-speed stability, and is the key hydraulic transmission actuator [35-38]. During the working process, the strength and stiffness of the cylinder under the action of internal and external pressure, as well as the bending deformation and critical force of the piston rod when the piston rod reaches a large stroke are all important design parameters of the hydraulic cylinder Hydraulic cylinder is the executive component in the hydraulic transmission system. It is an energy conversion device that converts hydraulic energy into mechanical energy. The hydraulic motor realizes the continuous rotary motion, while the hydraulic cylinder realizes the reciprocating motion. There are three types of hydraulic cylinders: piston cylinder, plunger cylinder and swing cylinder. Piston cylinder and plunger cylinder realize reciprocating linear motion, output speed and thrust, and swing cylinder realizes reciprocating swing, output angular velocity (rotation speed) and torque. In addition to being used singly, hydraulic cylinders can also be used in combination of two or more or in combination with other mechanisms. to perform special functions. The hydraulic cylinder is simple in structure and reliable in operation, and has been widely used in the hydraulic system of machine tools [39, 40].

In terms of heat exchangers: heat exchange is a container that realizes heat transfer between two or more different temperature media, so that heat is transferred from a higher temperature medium to a lower temperature medium, to meet the process requirements. The medium temperature can also be used as a device to improve energy utilization. Heat exchangers involve nearly 30 kinds of industries such as chemical industry and petroleum, and domestic heat exchangers have made remarkable achievements in the research of energy saving and efficiency, improving heat transfer efficiency, reducing heat transfer area, reducing pressure drop, and improving device thermal strength [41].

In terms of experiments: domestic structural thermal test control methods mostly use temperature control or heat flow density control. The common point of the two methods is that the time sequence command curve of temperature or heat flux needs to be given in advance The temperature or heat flux time series command curve is usually calculated based on a simple one-dimensional thermal analysis model of the structure, and the coupling effect of aerodynamic heating and the thermal response of the structure cannot be taken into account [42]. In addition, due to the lack of high-temperature thermophysical parameters of some materials, the calculated temperature or heat flux timing command has a large error compared with the real thermal load on the structural member. According to the increasing test task requirements, it is imperative to develop a set of structural thermal test control methods with higher simulation accuracy, so as to meet the evolving structural thermal test requirements [43].

In addition, considering the shortcomings of traditional thermal test control methods, a new structural thermal test control method—full equation heat flow control method is developed. The control process is as follows: The aerodynamic parameters and heat loss terms are input to the control computer; Substitute into the full-equation heat flow control equation to calculate the heat flow to be applied to the test piece; Use the calculated heat flow value as the control load command value at the next moment, and the current moment The feedback value of heat flux density is compared; according to the error signal generated by the difference between the two, the output voltage of the electric power regulating device is adjusted, thereby realizing the full equation heat flux control. This control method truly embodies the real-time coupling effect of aerodynamic heating and structural thermal response [44]. It can take into account the change of high temperature thermal physical properties of materials with temperature, more accurately simulate the structural thermal load environment, improve the test accuracy, and make up for the traditional control method. It is suitable for complex structures where temperature and heat flow curves cannot be accurately given [45].

Recirculation is a piping system for a heating circuit, as well as a drinking hot water (DHW) line, designed for the constant movement of heat transfer fluid or hot water. It is designed to increase the efficiency of using boilers, as well as to increase the comfort of consumers when using hot water. With a remote location of the DHW supply tap from the boiler, the water in the pipes cools quickly. You must skip it for a long time until the temperature rises to the desired value. If recirculation is used, water is constantly moving from the boiler to the draw — off point and back. It does not cool

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down, which makes it possible to use the DHW immediately, without waiting. In heating systems, circulation ensures optimal thermal conditions. A hot coolant enters the heating circuit, which passes through a cascade of radiators and gives off its thermal energy. Returning to the boiler, the cooled heat transfer fluid heats up again and enters the heating circuit for a new cycle. The efficiency of heating, uniform heat transfer at the beginning and end points of the circuit depends on the speed of water movement. As a rule, the boiler itself provides the circulation of the heat transfer agent. For recirculation of hot water, an additional piping equipped with a circulation pump is used.

The impact node is the most critical node of the pulsed coolant supply system, the reliability of which depends on the performance of the entire system. The shock unit converts the stationary mode of the coolant flow into a pulsed one by periodically blocking the flow. The impact node is the basis of impulse systems; therefore, the design of the impact node is necessary, which is capable of independently adjusting to the flow through it.

The solution to this problem was the use of a flexible connection between the valves. In the case of an axial-type impact assembly, the replacement of a rigid connection between the valves is carried out by installing a spring between the impact valves. As shown in Figure 1

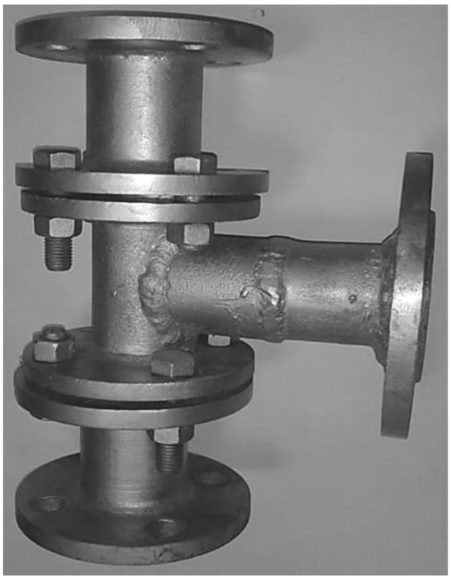

Figure 1. Appearance and diagram of a two-valve axial shock unit

Percussion valves that perform vertical rocking movements, as a rule, are able to operate at low available pressures, have low hydraulic resistance, but at the same time have a longer closing time and lower productivity.

Percussion valves with vertically translational movement move relative to any guide device. Such valves are equipped with TG and YerPI rams. Percussion valves with vertically translational movement are poppet and cup. Poppet-type valves of various modifications are more widely used. These valves have a short closing time, so they create a direct impact even with short feed pipe lengths. However, they have greater hydraulic resistance and greater stresses generated in the shock valve stem.

Cup-type percussion valves are free from these disadvantages. When a flow occurs through the shock valve, the friction force and the pressure difference on the end platforms begin to act on it, due to which the valve closes, hitting a fixed disk mounted on a rubber shock absorber. Cup percussion valves, compared to other percussion valves, have a large flow capacity, and the stresses that occur on the disc are minimal. The cup valve has two significant drawbacks: a long closing of the valve and exactingness to the purity of the feed water.

The element for creating pulsations is the generator of flow oscillations - the impact node. One of the designs of the shock assembly is shown in Figure 1. The shock assembly, which includes a body consisting of two parts, each of which has an inlet and outlet, a centering rod inserted into bushings fixed in each part, at the ends of which shock valves are fixed, each entering the inlet holes located on one of the sides of each part, on the opposite sides of which permanent magnets are rigidly fixed, between which there is a disk consisting of two parts rigidly fixed in the central part of the centering rod and tightly pressing the elastic membrane located between them, clamped along the edges between two parts with the possibility of axial movement of the free part of the elastic membrane; the disk may be made of magnetic material.

The operation of the hydraulic ram is based on the use of the phenomenon of water hammer - a short-term sharp increase in pressure when the fluid flow suddenly stops in a rigid pipe. As shown in Figure 2.

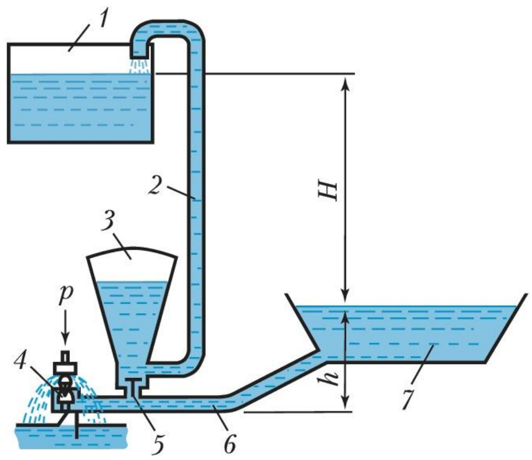

Figure 2. Scheme of a hydraulic ram: 1 — upper tank; 2, 6 — pipelines; 3 — pressure cap; 4, 5 — valves; 7 — reservoir; p — the force required to open the valve; h — the height of the waterfall; H — the height of the water rise

The principle of operation of the “hydraulic ram” — a pump that uses the phenomenon of water hammer. On the left is the flow acceleration phase, on the right is the injection phase (moment of water hammer). 1 — supply tank (upper level of natural flow); 2 — injection (accelerating) pipe; 3 — impact (shock) valve; 4 — pressure (pressure) valve; 5 — air cap; 6 — pressure (outlet) pipe. H is the height of the water rise relative to the level of the drain; h is the level of the supply tank relative to the level of the drain.

Hydraulic ram, a device that, due to hydraulic shock, raises water to a height significantly higher than the level of the source. Water from the source (1) is supplied by gravity through a long pressure pipeline (2), which goes with a slight decrease. Under the action of the growing dynamic pressure of the water, the stop valve (3) located at the lower end of the pipeline closes, and due to the inertia of the moving water and its incompressibility, the pressure here rises sharply. A brief increase in pressure is enough to lift a small part of the water through the pressure valve (4) to a height of more than 50 m. Then the kick valve opens, and everything repeats again.

The Figure 2 shows a slightly more complex device — it contains an air cap 5, which plays the same role as hydro accumulator tanks with a rubber membrane in modern autonomous plumbing systems. This cap accumulates water under pressure and smoothest the pulsations of the flow of injected water, although theoretically the maximum lifting height is somewhat reduced, since the discharge pipe 6 no longer receives a sharp impulse from a hydraulic shock that occurs when the valve 3 is closed, but the average pressure smoothed out by the "pneumatic shock absorber" — air in cap 5. However, a little further we will see that the smoothing of pulsations is only an additional "bonus" of the air cap. Its main function is different, and without such a node, the rise of water through a more or less long pressure channel will be very difficult.

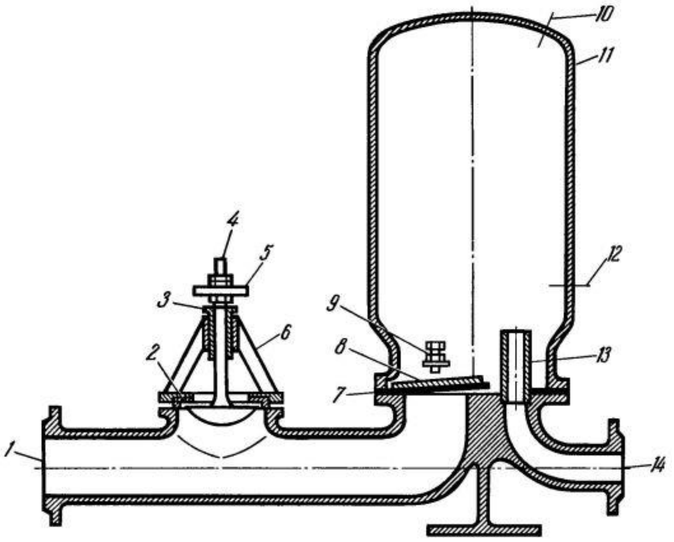

Figure 3. The design of the hydraulic ram: 1 — inlet pipe, water inlet from the supply pipeline; 2 — shock valve seat; 3 — bronze guide and control sleeve; 4 — shock valve with a stem; 5 — additional weight of the shock valve; 6 — impact valve support; 7 — rubber gasket, on which the discharge valve is fixed; 8 — discharge valve; 9 — lock-bolt, limiting the stroke of the delivery valve; 10 — place of the fitting for connecting the pressure gauge; 11 — air cap; 12 — place of the device for supplying air to the air cap; 13 — restrictive sleeve; 14 — discharge pipe, water outlet to the discharge pipeline

A typical design of a hydraulic ram is shown in Figure 3. From the supply pipeline, water enters under a shock valve with a stem moving in a guide bronze bushing. The latter is mounted in a threaded support, which allows you to adjust the valve stroke. When closed, the valve is pressed against the seat. An additional weight is attached to the valve stem. On Figure 3 does not show a device for preliminary opening of the shock valve when starting the ram. The fact is that the pressure of the feed water (which can reach several atmospheres) presses the valve against the seat, so that the valve must be forced to open in order to start the installation.

Another option is a funnel-shaped expansion of the inlet to the injection pipe. It works according to the same principle: in the zone of liquid-air contact, due to the large cross section, the flow velocity is low and air entrapment is unlikely. A decrease in the cross section and an acceleration of the flow occurs at a depth where atmospheric air already separates a sufficient layer of water.

And one more note: in accordance with the recommendations of Viktor Schauberger, confirmed by experience, the creation of spiral guides at the inlet in the direction of the natural swirling of water in the funnel contributes to the organization of the most efficient flow and its fastest advance into the pipe. But, of course, it is important to observe the measure — there is no need to block the spiral channels, trying to force the water to move within strictly specified limits, it is quite enough to simply tell it the way with a shallow spiral relief on the surfaces restricting the flow, and even better, simply organize a tangential water supply to the inlet funnel.

To describe the operation of an open shock valve, we present it in the form of a simplified diagram, Figure 4.

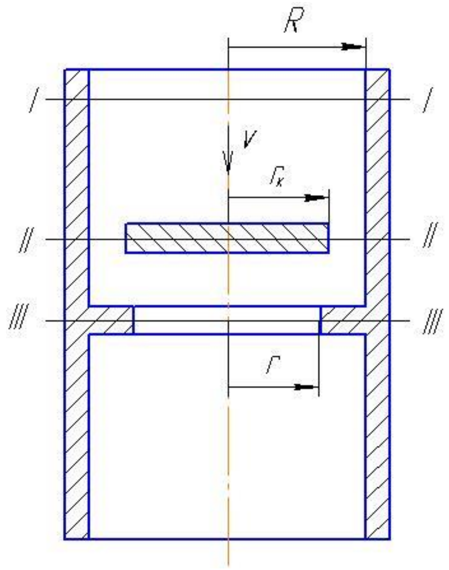

Figure 4. Simplified diagram of a shock valve

In the case of an open impact valve, there is a fluid flow through it with a velocity v1 in a section with a radius R. Above and below the valve, a zone is formed where the fluid velocity is zero and only the static component of the fluid acts on the valve. And since the radius of the passage section above and below the valve are different, the velocity in the pipeline section I-I $v_I = v$ will be less than the speed in the section III-III vII.

$$v_{III} > v_I \tag{31}$$

Accordingly, the dynamic components of the pressure in the sections I-I и III-III:

$$\frac{(v_{III})^2}{2}\rho > \frac{(v_I)^2}{2}\rho \tag{32}$$

And increments of static pressures (without taking into account accelerations) satisfy the reverse inequalities:

$$\Delta p_{III} < \Delta p_I \tag{3}$$

$$\Delta p = \frac{\rho}{2}(v_{III} - v_I)^2 \tag{4}$$

On the valve in the direction of the axis of movement, static pressure forces act along the normal to horizontal surfaces. The pressure forces (normal stresses) from the sides, directed along the normal to these surfaces, are balanced, and the shear stresses, due to the small surface area of the valve sides, can be neglected. Denoting the pipe radius R in section I-I and the radius in the valve seat section r (section III-III) from the continuity law QIII=QI, we obtain that:

$$\Delta p = \frac{\rho(R^4 - r^4)}{2r^4} v^{\,2} \tag{5}$$

means

$$F_{в} = \Delta p \cdot \frac{\rho(R^4 - r^4)}{2r^4} v^{2} \quad (33)$$

In the case of a closed valve, the constant component of the coolant flow rate is equal to v0=0, and only the oscillatory component of the velocity acts on the valve. When analyzing the operation of a two-valve PP, it is necessary to take into account the following forces: inertia of moving parts; spring elasticity F_c; fluid pressure; hydraulic resistance $F_{\Delta p}$, due to the speed difference between the shock valve and the coolant. Scheme of the PP with the indication of forces, acting on impact valves is shown in Figure 4.

Differential equations describing the operation of a two-valve flow converter:

$$\begin{cases} m\ddot{x}_1 = -F_c + F_{c1} + F_{в2} + F_{\Delta p2}, \\ m\ddot{x}_2 = F_c - F_{c2} - F_{в2} - F_{\Delta p2}, \end{cases} \quad (7)$$

$$\begin{cases} m\ddot{x}_1 = -c(\Delta x) - c_1(x_1 - h) + \frac{\mu\rho S}{2} v_1^2 + \frac{\varsigma_1 \rho S}{2}(v_1 - \dot{x}_1)^2 \\ m\ddot{x}_2 = c(\Delta x) - c_2(x_2 - h) - \frac{\mu\rho S}{2} v_2^2 - \frac{\varsigma_2 \rho S}{2}(v_2 + \dot{x}_2)^2 \end{cases} \quad (34)$$

where m — shock valve weight, kg; x_1, x_2 — coordinate of shock valves K-1 and K-2, respectively, m; c, c2, c1 — coefficients of elasticity of springs 3, 2, 1 respectively, N/m; Δx — shock valve movement K-1 и K-2, $\Delta x = H + h + x_1 - x_2$, m; v_1 , v_2 — fluid velocity in sections 1-1 and 2-2, respectively, m/sec; S — shock valve's square, m^2.

Hydraulic processes in a circuit with a two-valve flow converter are considered using the theory of circuits. The energy chain of one arm of the hydraulic network is shown in Figure 5 it includes two links. Heat exchanger with plate compliance l1, water mass in channels m1, active hydraulic resistance r1, connecting pipeline with water mass m2, active hydraulic resistance r2, and pipeline material compliance l2.

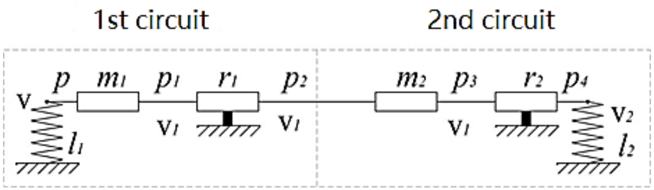

Figure 5. Hydraulic circuit of the supply pipeline with a heat exchanger installed on it

Circuit equation:

$$\begin{cases} p = m_1\dot{\mathrm{v}}_1 + r_1\mathrm{v}_1^{\,2} + p_2, \\ \mathrm{v} = l_1\dot{p} + \mathrm{v}_1, \end{cases} \quad (9)$$

$$\begin{cases} p_2 = m_2\dot{\mathrm{v}}_1 + r_2\mathrm{v}_1^{\,2} + p_4, \\ \mathrm{v}_1 = l_2\dot{p}_4 + \mathrm{v}_2. \end{cases} \quad (10)$$

where p, p4 – the pressure of the coolant at the inlet to the supply pipeline and at the outlet from it, respectively, Pa; v1, v2 – volumetric flow rate of the heat carrier at the inlet to the supply pipeline and at the outlet from it, respectively, m3/s.

Pressure and volume flow at the inlet to the circuit:

$$\begin{cases} p = m_1\dot{v}_1 + r_1 v_1^2 +_2 \dot{v}_1 + r_2 v_1^2 + p_4, \\ v = l_1\dot{p}_2 + l_2\dot{p}_4 + v_2. \end{cases} \quad (11)$$

The volume flow and pressure of the coolant were presented as a constant component and a deviation:

$$v = v_0 + \bar{v}, \; p = p_0 + \bar{p} \quad (12)$$

In this case, due to the smallness:

$$v^2 \approx v_0^2 + 2\, v_0\bar{v}, \; \dot{v} = \dot{\bar{v}}, \text{ etc} \quad (13)$$

Pressure equation:

$$\begin{gathered} p = (m_1 l_2 + m_2 l_2)\ddot{\bar{p}}_4 + \bar{p}_4 + p_{40} + (m_2 + m_1)\dot{\bar{v}}_2 + \\ +(2r_1 v_{20} + 2r_2 v_{20})\bar{v}_2 + (r_1 + r_2)v_{20}^2. \end{gathered} \quad (14)$$

Taking into account the introduced coefficients, $a_1 = m_1 l_2 + m_2 l_2$, $a_2 = 1$, $b_1 = m_2 + m_1$, $b_2 = 2r_1 v_{20} + 2r_2 v_{20}$, we represent equation (2.5) in the form:

$$p = a_1\ddot{\bar{p}}_4 + a_2\bar{p}_4 + a_3 p_{40} + b_1\dot{\bar{v}}_2 + b_2\bar{v}_2 + b_3 v_{20}^2. \quad (15)$$

Image equation:

$$(a_1 s^2 + a_2)P_4(s) = -(b_1 s + b_2)V_2(s) \quad (16)$$

After appropriate transformations, the complex resistance of the circuit:

$$Z(s) = \frac{P_4(s)}{V_2(s)} = \frac{-b_1 s - b_2}{a_1 s^2 + a_2} \quad (17)$$

Frequency function:

$$Z(\Omega) = \frac{-b_1 j\Omega - b_2}{-a_1\Omega^2 + a_2} \quad (18)$$

The real part of the frequency function:

$$U(\Omega) = \frac{b_2}{a_1\Omega^2 - a_2} \quad (19)$$

The imaginary part of the frequency function:

$$V(\Omega)=\frac{b_1\Omega}{-a_1\Omega^2+a_2} \quad (20)$$

Amplitude-frequency response of the circuit:

$$A(\Omega)=\sqrt{U^2(\Omega)+V^2(\Omega)} \quad (21)$$

Phase-frequency function:

$$\varphi(\Omega)=-arctg\frac{U(\Omega)}{V(\Omega)} \quad (22)$$

The values of the parameters of the system and the coolant with pulsed supply for modeling the frequency response are presented in the Table.

Table

THE VALUES OF THE PARAMETERS
OF THE SYSTEM AND THE COOLANT WITH PULSED SUPPLY

	r_1 $\frac{Па \cdot с}{м^3}$	r_2 $\frac{Па \cdot с}{м^3}$	V_0 $\frac{м^3}{с}$	m_1 *кг*
1	0,1	0,5	0,07	60
2	0,1	0,5	0,07	80
3	0,5	0,5	0,07	110
4	0,5	0,5	0,07	60
5	0,5	0,5	0,07	60
6	0,5	0,5	0,07	60
7	0,5	0,5	0,07	60
8	0,5	0,5	0,1	60
9	0,5	0,5	0,15	60
	m_2 *кг*	l_1 $\frac{м^3}{Па}$	l_2 $\frac{м^3}{Па}$	
1	4,5	0,00017	0,00011	
2	4,5	0,00017	0,00011	
3	4,5	0,00017	0,00011	
4	4,5	0,0002	0,00011	
5	4,5	0,00006	0,00011	
6	4,5	0,00017	0,00011	
7	4,5	0,00017	0,00011	
8	4,5	0,00017	0,00011	
9	4,5	0,00017	0,00011	

Graphs of the theoretical frequency response (of a supply pipeline with a heat exchanger installed on it, calculated in accordance with the values of the parameters for modeling are shown at the Figure 6. The frequency response practically does not depend on the resistance of the pipelines.

From the graphs (Figure 6) it can be seen that with an increase in the mass of liquid in the pipeline, the elasticity of the system, as well as the velocity of the liquid through the flow converter, the amplitude of pressure fluctuations increases at a unit flow through the system. This is due to the fact that an increase in the elasticity of the system leads to an increase in the velocity of propagation of elastic waves in the liquid, an increase in the velocity of the coolant reduces the closing time of

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shock valves, and an increase in the mass of the liquid at constant system parameters (pipeline length, diameter, etc.) is possible only with a change in the density of the coolant, which affects the velocity of propagation of elastic waves in the liquid.

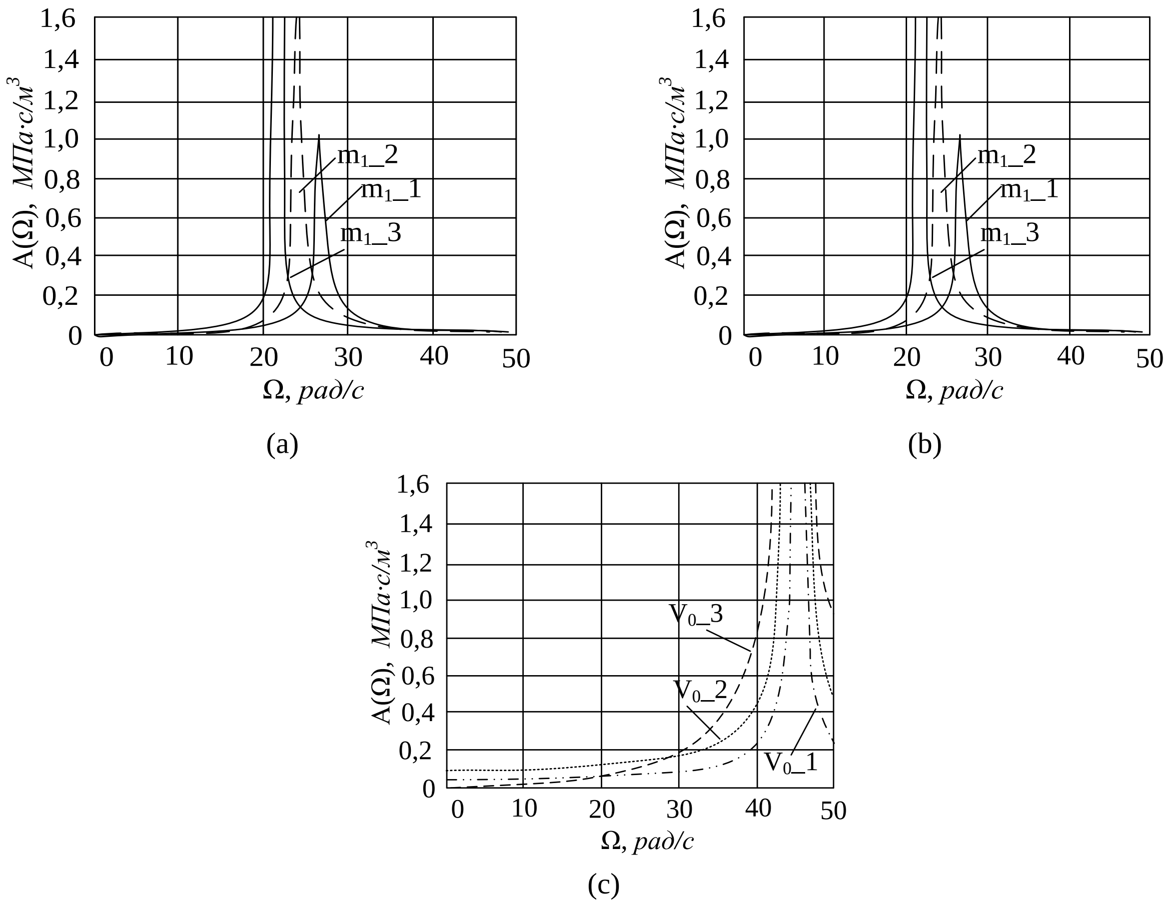

Figure 6. Theoretical amplitude-frequency characteristics of the supply pipeline with a heat exchanger installed on it

As a result of theoretical studies, dependences, models were obtained, in the solution of which analytical dependences were obtained, in accordance with which the scheme of the experimental setup was developed. To solve the tasks set, an experimental setup was developed and implemented. It is designed to study the possibility of increasing the boiler water circulation ratio during the transition to the pulse feedwater flow regime.

Further, the structural and functional was determined and the schematic diagram of the laboratory installation of the layout of the boiler DE-10/13 with a pulsed feed circuit was developed to solve the following problems:

– implementation of a pulsed flow regime in the boiler feed circuit;

– experimental verification of the operation of the impact unit with a drive when operating at different frequencies;

- quantitative and qualitative assessment of the flow rate created by membrane pumps in the circulation circuit of the boiler unit;

– study of energy consumption in the scheme of the laboratory installation of the boiler model DE-10/13 with a pulsed feed circuit;

- determination of the dependence of the flow through the shock valve on the frequency of its closing.

The experimental setup is a model of an individual heating point with a pulsed coolant supply. It allows you to adjust and test the shock assembly: two-valve. The experimental setup has two hydraulic circuits: a circuit with a working medium and a pumped one. The first consists of an accelerating pipe of a plate heat exchanger, a membrane pump flow converter. In the scheme shown in Figure 7, a line with a return heating system is installed, which in this case allows organizing a system for recirculating the coolant supply from the return pipeline T2 to the supply pipeline T1, that is, it turns out to be used as a hydraulic converter.

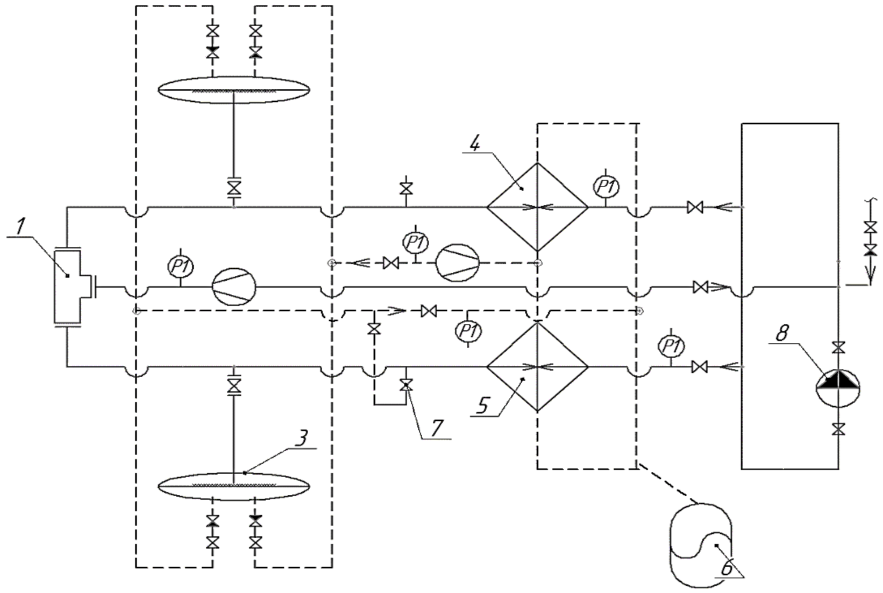

Figure 7. Schematic diagram of the experimental setup

The coolant enters the shock assembly through two pipelines, they are individually approached to each shock valve. The presence of a flow in the heating system determines the hydrodynamic forces, the flow converters act on the valves, which causes the closing or opening of one of the shock valves. When one of the shock valves is closed, a process of pressure fluctuation occurs in the pipeline in front of the shock valve. With an increase in pressure, and then a sharp deceleration of the flow, the pressure in the pipeline increases, and the liquid from the return pipeline T2 through the check valves 7 enters the supply pipeline 6. The increase in pressure in the pipeline that is supplied to the shock valves is replaced by its decrease below or higher value. The hydrostatic forces that act on the closed shock valves are reduced due to the occurrence of a negative wave, due to which the position of the shock valves changes. Liquid pressure fluctuations in the pipeline, generated by shock valves, propagate through pipelines with a certain attenuation coefficient, i.e. with movement along the length of the pipeline, the amplitude of the pressure fluctuations of the coolant decreases.

To reduce the amplitude of fluctuations in pressure fluctuations, a hydraulic accumulator is installed in the return pipeline. Since the closing of the shock valves occurs alternately, at any time one of the shock valves is in the open position, which reduces the hydraulic resistance. It is required to set the required stroke value of the shock valves to control the flow in the heating system. When the shock valve is closed, the pressure of the liquid in the pipeline increases. As a result of the increase in pressure, the blower membranes move to the upper point, and part of the liquid is pumped through the outlet valves into the accumulator and further into the supply pipeline. With a decrease in pressure in the pipeline, a suction period begins, during which the membranes of pumps 3 move down and part of the liquid from the return pipeline T2 is sucked into the pump cavity through the inlet valves.

This laboratory equipment uses the following measuring instruments as, pressure sensors “Овен ПД100”, Pressure sensor BD, Electromagnetic flowrate sensor “Masterflow DU 15”.

Sensors «Овен ПД100» whose task is to transform pressure with a measuring membrane of stainless steel AISI 316L, technology - based sensor SIS (silicon in silicon) and cable input. This model is characterized by increased measurement accuracy (от ±0,25% full scale value), resistance to hydraulic shock and relatively low output noise (no more ±16 мкА). The converters of these models are designed for automatic control and control systems at the main and secondary industries in industry: hydraulic systems and pneumatic systems, water supply and heat supply systems, automation of water utilities, heat points, gas facilities, etc., where increased accuracy, stability of the signal output is required. The converters of these models are designed for automatic control and control systems at the main and secondary industries in industry: hydraulic systems and pneumatic systems, water supply and heat supply systems, automation of water utilities, heat points, gas facilities, etc., where increased accuracy, stability of the signal output is required pressure type **“**КРТ-9-00-ИР-С-МС-М20-1,6-0,5-1Т2”, presented in the Figure 8. The pressure sensor has a linear characteristic and is equipped with a current output of 4-20 mA, which allows you to connect the CRT sensor-9 to the PCI L-783 PCI sensor by means of current shunts.

Figure 8. The appearance of the excessive pressure converter “КРТ – 9”

The consumption converter Electromagnetic Masterflow serves to convert the consumption of hot or cold - water supply, as well as others, it is possible to set up a given sensor for other liquid liquids, but just so that the specific electrical conductivity was at least 10-3 cm/m in electrical signals: impulse, current, frequency. The appointment of this meter of consumption and accounting for consumption of the amount of fluid in filled pressure pipelines of water supply and heat supply systems, with air content, particles not more than 1%.

Sensors can be used as a primary device with heat meters in the heat meter, with a secondary device in the counter -flow meter, as well as in automated data collection systems, regulation and control of technological processes.

Masterflow class “Э” can be used as part of flowmeter equipment as measuring or technological converters.

Masterflow's modification converters convert the volume of fluid which passed through them in a proportional amount of impulse output with a standard sizes of the price. The device has a current output of 4-20 mA, which allows you to connect it by means of a shunt resistance to the data collection board L-783.

The value of the output current signal in the presence of a flow through the converter is defined as:

$$I_{вых} = \frac{g(I_{макс} - I_0) + I_0 g_{макс}}{g_{макс}} \tag{23}$$

Where: $I_{вых}$ – the value of the output current, mA; Iмакс – the value of the maximum output current 5 mA or 20 mA; I0 – current value at zero consumption – 0 mA or 4 mA; gмакс – maximum volumetric flowrate for this, m^3/h; g – current flowrate, m^3/h.

MF-h modification converters convert the fluid consumption into a sequence of electrical impulses with a frequency proportional to the consumption, and also have an impulse output with a pulse ratio normalized for a group of sizes. MF-T modification converters convert the fluid consumption into a direct current's output, proportional to the consumption, and also have a pulse output from a pulse ratio normalized for a group. MF modification converters can be performed in the performance of "P", designed to measure both direct and reverse flow.

In this work, an experimental laboratory study was carried out to determine the performance of a hydraulic ram in a system with a pulsed coolant supply to the recirculation line.

The following results are obtained: there was an equation obtained, depending on the performance of the hydraulic ram on the length of the supply pipeline and the pressure in the heating network for use in individual heating points. Based on the obtained data, a graph of the dependence of the flow rate created by the hydraulic ram on the available pressure in the heating circuit in which this unit is installed was plotted, the number of significant coefficients of the regression equation was obtained.

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