

The Study of the Gas Valves of Convection Boilers of Low Power

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ABSTRACT: The article looks into operation and adjustment of gas valves of wall-mounted low-power gas boilers with atmospheric burners. These boilers are commonly used as heat generators in individual heating and hot water supply systems. Proper selection and adjustment of gas valve operation affects the energy efficiency indicators of the heating system and amount of CO₂ emissions.

KEYWORDS: gas boiler, valve, boiler power, energy efficiency, ecology, atmospheric burner

I. INTRODUCTION

The article discusses the issues of operation and tuning of gas valves of wall-mounted gas boilers of low power with atmospheric burners. These boilers are widely used as a heat generator in individual heating and hot water supply systems. The correct selection and adjustment of the gas valve operation affects the energy efficiency of the heating system and the value of CO₂ emissions. The work defines the values of the dynamic resistance of gas valves and the necessary values of the dynamic gas pressure in the pipelines, ensuring the full functioning of the boiler equipment. The graphs of the power output of wall-mounted boilers are obtained depending on the static and dynamic values of the gas pressure in the pipeline.



According to research conducted in EU countries, the share of heating and hot water supply in total energy mix of buildings is 70% and 14% respectively [1]. With the aim of reducing annual energy consumption in the EU adopted the Directive 2010/31/EC [2], in Russia developed the GOST R 56295-2014 "energy Efficiency of buildings. Methodology of economic assessment of energy systems in buildings" [3].

Research modern variants of these systems are presented in a number of works by Russian and foreign experts, e.g. [4, 5]. In most cases the use of wall-hung gas boilers for heating are reduced to the appropriateness of a condensing wall-mounted boilers of small capacity, having higher coefficients of energy efficiency and higher environmental performance.

The use of condensing boilers in the EU is regulated by directives that allow the use of individual heating systems only boilers of this type. In the Russian Federation there is no such restriction. In [6] it is shown that the share of condensing boilers for households on the territory of Russia is less than one percent and mostly uses traditional

convection wall-mounted boilers with open and closed combustion chambers with atmospheric burners. In the near future this situation will not change [6].

The main elements of the convection boiler that affect efficiency and emissions into the atmosphere the products of combustion are atmospheric gas burner and gas valve, which determines the quality of a mixture of air and natural gas – primary fuel used for heating.

Wall-mounted gas boilers appeared in Western Europe in the mid 60-ies of the last century and have been used massively since the early 70-ies, simultaneously with the gasification of the whole of Europe. In Russia the use of wall mounted boilers has spread with a lag of 20 years in connection with the development of gasification of the country and the rapid growth of private housing. Since 2005, the boilers of this type have been used in the construction of apartment buildings as an alternative to district heating in areas of new construction.

However, in terms of the parameters of the gas as a fuel in the provision of services to the population, there are still rules that generated historically for modern boilers individual use and for the supply of natural gas as fuel for gas stoves and gas appliances hot water (gas column). In particular, the lower limit of the normative pressure of gas in pipelines for individual use is defined in 12 mbar [7]. In order to determine the main parameters of the gas valve of low-power convection wall-mounted boilers that affect the parameters of energy efficiency and the level of CO₂ emissions, studies have been conducted, the results of which are given below.

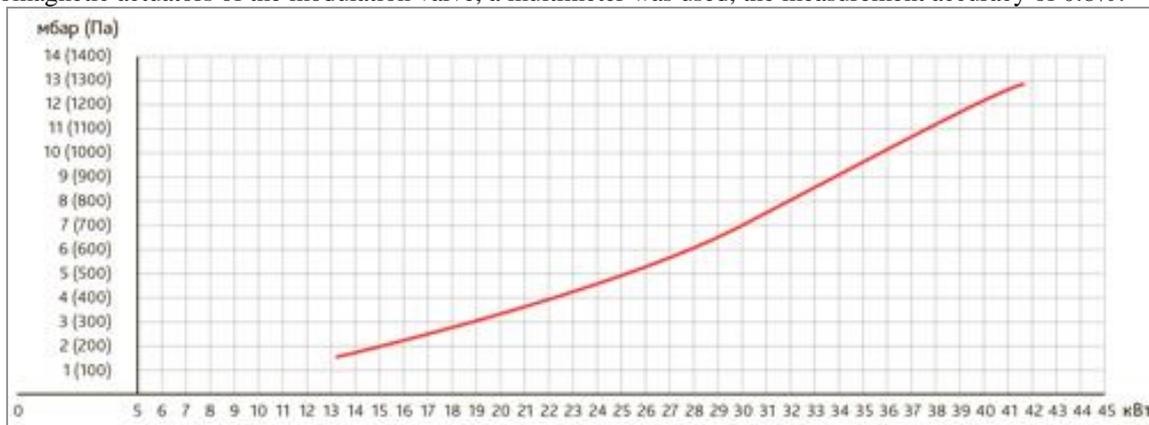
II. SIGNIFICANCE OF THE SYSTEM

A. Material and research methods

The tests were carried out on a bench with a wall-mounted single-circuit convection type boiler with a closed combustion chamber, an atmospheric burner, forced smoke exhaust with an upper fan position (boiler model with a three-way valve for operation in heating mode and an indirect heating boiler with a volume of 150 liters).

The object of research is a gas valve with automatic adjustment of operation parameters, designed for operation of gas boilers up to 50 kW. The thermal power in this boiler is realized by a gas atmospheric burner.

To determine the characteristics of the gas valve, differential gas manometers were used with a measurement accuracy of +0.3% and a resolution of 10 Pa. To determine the magnitude of the response currents of the electromagnetic actuators of the modulation valve, a multimeter was used, the measurement accuracy of 0.8%.



Picture 1. Schedule of change in thermal power, kW, atmospheric burner with 17 nozzles with a diameter of 1.35 mm depending on the gas pressure in front of the burner, mbar (Pa)

In fig. 1 shows the dependence of the power of the atmospheric burner on the pressure at the outlet of the gas valve. Recommended maximum pressure 1200 Pa.

Research results and discussion

The test results showed the following.

The static gas pressure in front of the gas valve is 2450 Pa. The dynamic (with the boiler operating at maximum power) the gas pressure in front of the gas valve is 2350 Pa. As a result of the tests, a graph of the dynamic resistance of the gas valve as a function of the gas pressure at the valve inlet was obtained (Fig. 2). It can be seen from the graph that at the recommended dynamic gas pressure by the manufacturer for the boiler to reach maximum power of 1200 Pa, the dynamic resistance of the gas valve is 265 Pa.

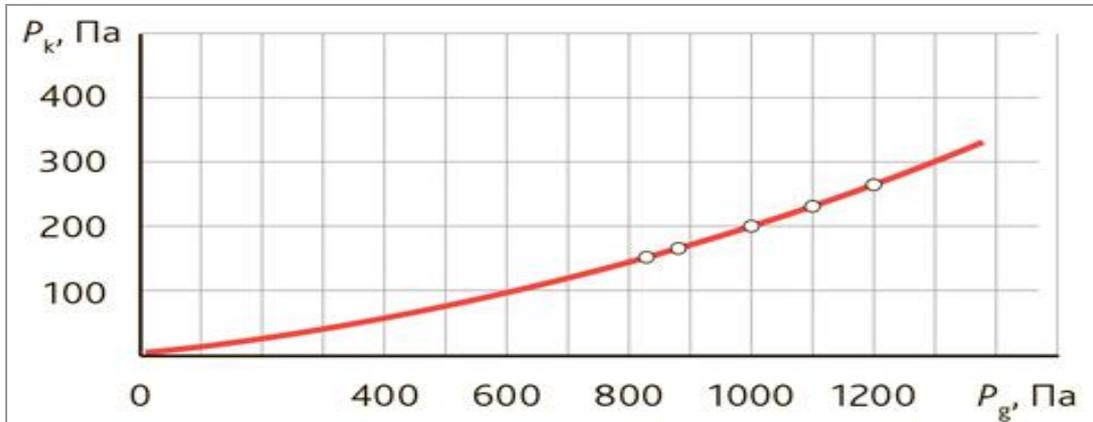


Figure 2 The graph of the dynamic resistance of the gas valve P_k , Pa, depending on the dynamic gas pressure at the inlet to the valve P_g , Pa

Accordingly, in the present case to ensure gas pressure 1200 PA at the outlet of the valve, the dynamic pressure at the inlet of the valve must be equal to 1465 PA. If the inlet to the gas valve the dynamic pressure of gas is equal to 1200 PA, which corresponds to the tolerable value of the pressure of the gas according to [7], the gas pressure at the outlet of the valve is equal to 935 PA. From the graph in Fig. 1 shows that when the value of gas pressure, equal to 935 PA heat power burner gas equals 34 kWh, or about 85 % of the manufacturer's recommended maximum power of the boiler at a pressure of 1200 PA. The maximum capacity of the boiler is possible only if the value of dynamic gas pressure at the valve above 1465, PA (14,65 mbar) above the set limits for the minimum value of 1200 PA at 22 %. The dynamic resistance of the gas valve at maximum power operation of atmospheric burners convection wall hung boilers of other brands are in the range from 200 to 400 PA – therefore, the value of the dynamic natural gas for individual heating systems when using a boiler of this type shall not be less than 1600 PA. Otherwise boilers are not able to provide the declared characteristics maximum heat output. Guides for operation of boilers imported or Russian origin provided that the equipment features are valid for the dynamic pressure of the gas in the line of 2,0 kPa. This is because the burners provide maximum power at a gas pressure before burner 1.2 kPa. The gas valve has resistance to flow and is considered as a local resistance. The difference between static and dynamic gas pressure at the valve is determined by the length, diameter and condition of the arteries supplying gas to the boiler, the resistance of the gas flow meter. The minimum requirement to the values of the static gas pressure equal to 2000 PA at the highways end-user is justifiable and correct.

Another important characteristic that determines the speed of valve actuation as electrical devices signal system control the operation of the boiler, is the characteristic hysteresis – the dependence of the current change of the coil control modulating gas valve and gas pressure at the exit. These parameters for the studied gas valve shown in Fig. 3 depending on the direction of change of the current control, increase or decrease. Measurement results show excellent control performance of this valve. The width of the hysteresis loop is only 40 PA, and the nature of the change in the area of control of boiler capacity from 200 to 1200 PA is linear.

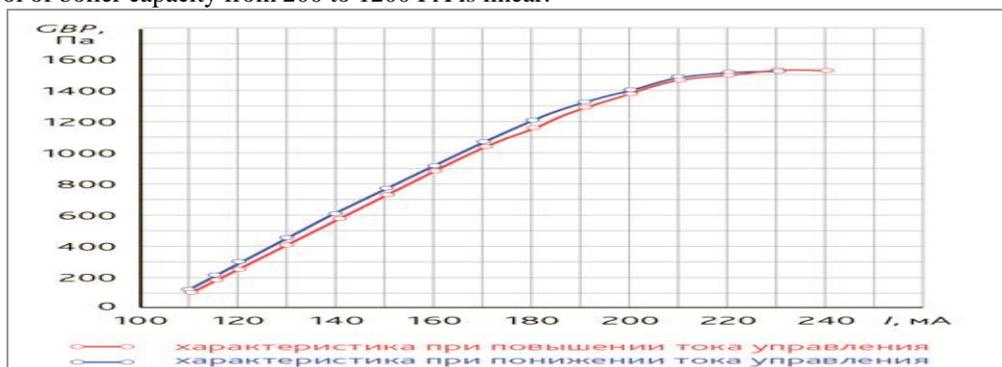


Figure 3 Graphs of changes in gas pressure at the valve outlet depending on the direction of change of the control current of the modulation coil

In the Russian regulatory documents for the provision of natural gas supply services to the population, the lower value of the dynamic gas pressure is defined as 1200 Pa [7]. If the boiler burner reaches its maximum power with an inlet pressure of 1.2 kPa, and the valve dynamic resistance in the operating range is about 200–400 Pa, then at the standard dynamic gas pressure with a lower threshold of 1200 Pa, the boiler will never reach the declared power. It can only work at 85% of the declared maximum power. The requirements for the dynamic gas pressure in front of the gas boiler valve in 2000 Pa are justified and guaranteed. In fig. Figure 4 shows a generalized dependence of the thermal power coefficient on the dynamic gas pressure in front of the valve for different wall convection boilers (with different burners and valves). The coefficient value shows the fraction of heat power from the maximum power declared by the manufacturers of boilers determined at a test pressure of 2000 Pa.

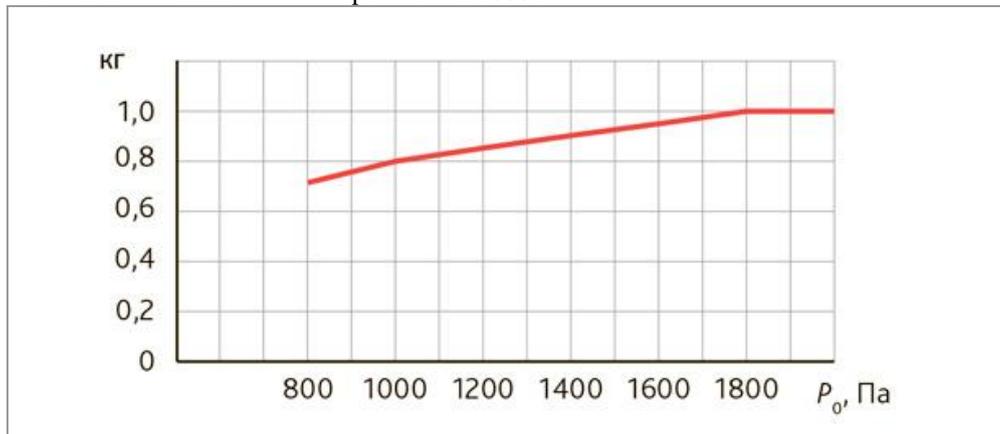


Figure 4. Graph of the coefficient of thermal power of a convection wall-mounted boiler depending on the value of the dynamic gas pressure in front of the valve

Insights

1. The dynamic resistance of the investigated gas valve wall-hung boiler is 265 PA.
2. The provision of gas supply for the population with a value of the lower threshold gas pressure of 1200 PA does not allow to ensure that the boiler manufacturers stated capacity. When the pressure of the gas maximum capacity of the boiler will not be more than 85 % of the declared in the technical documentation.
3. The value of the dynamic resistance of the gas valve at rated pressure valve 1200 PA. This parameter indicates, as applicable, the valve in the operation of boilers at low dynamic pressure. The smaller this value is, the higher the capacity of the boiler can be achieved at low values of gas pressure in the arteries.
4. The width of the hysteresis loop of dynamic pressure of the valve depending on the direction of change of the current control coil of modulation is an important characteristic of controllability of a gas boiler.

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