Combustion instability control in the model of combustion chamber

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Abstract. An experimental study of the influence of external periodic perturbations on the instability of the combustion chamber in a pulsating combustion. As an external periodic disturbances were used sound waves emitted by the electrodynamics. The purpose of the study was to determine the possibility of using the method of external periodic perturbation to control the combustion instability. The study was conducted on a specially created model of the combustion chamber with a swirl burner in the frequency range from 100 to 1400 Hz. The study found that the method of external periodic perturbations may be used to control combustion instability. Depending on the frequency of the external periodic perturbation is observed as an increase and decrease in the amplitude of the oscillations in the combustion chamber. These effects are due to the mechanisms of synchronous and asynchronous action. External periodic disturbance generated in the path feeding the gaseous fuel, showing the high efficiency of the method of management in terms of energy costs. Power required to initiate periodic disturbances (50 W) is significantly smaller than the thermal capacity of the combustion chamber (100 kW).

1. Introduction

The increase in thermal stress of work processes in the combustion chambers of power plants is accompanied by oscillatory processes (pressure fluctuations, temperature, speed, etc.) [1]. They emerge and develop spontaneously. Oscillation frequency depends on the geometry of the combustion chamber. The amplitude of the oscillations depends on the degree of coherence of pulsations of heat in the combustion zone with pressure fluctuations (Rayleigh criterion) [2] , gas mass flow , vortex shedding and other time-dependent processes. With pulsating combustion increases substantially complete combustion of fuel, heat transfer to the heating surface, marked increase in the rate of combustion. Thus, the use of pulsating combustion mode can substantially increase the efficiency of combustion processes.

In real pulsating combustion furnace devices, as the operating mode of the combustion chamber is not provided. This is due to the negative effects that accompany the pulsating combustion. First of all, this powerful sound waves that can reach 150 dB. In addition, the continued existence of a pulsating mode of combustion -chamber organization requires a special volume. This requires the use of special burners, make a concerted acoustic characteristics of the feed fuel lines, combustion chambers and pipes, which discharge the products of combustion, etc.

Currently, control of combustion instability using a number of methods [3] , including the method of external periodic perturbations. As an external periodic perturbation can be used sound waves emitted by, for example, electrodynamics. The control action is performed on the supply path of gaseous propellants or directly into the combustion chamber.

An experimental study was conducted to determine the feasibility of using the method of external periodic perturbation to control the instability of the combustion chamber in a pulsating combustion.

2. The method of investigation

Schematic of the experimental chamber is shown in Figure 1.

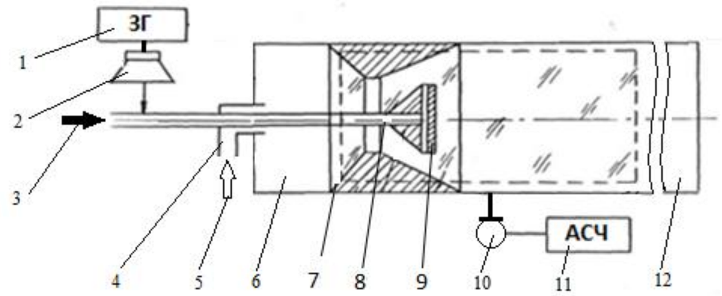

Figure 1. pulsating combustion chamber.

The combustion chamber (CC) consists of the supply of gaseous fuels tract 8 , the air circuit 4, the air tank 6, 7 diffuser, 9 of the flame , the resonance tube 12. Sound vibrations created by sound generator 1 and fed into the fuel supply path through electrodynamics 2. Pressure fluctuations in the combustion chamber detected by the microphone 10 and the frequency of the spectral analyzer 11. GHG created by burning propane mixture. Gaseous fuels reported by the anti- flame. The stabilizer had a chance to move in the cavity of the diffuser. This changes the conditions for vortex air flow regulator. When the optimum flow velocity v of the air flow regulator in the chamber was excited pulsating combustion. Sound pressure oscillations in the combustion chamber reaches 130-150 dB depending on the fuel consumption.The result of the influence of external periodic disturbances estimated by the change of the existence of pulsating combustion in the combustion chamber (Fig. 2, 3).

Construction of the existence regions of pulsating combustion was carried out in the following sequence. Asked a certain flow rate of gas and air in the combustion chamber. For the obtained ratio of fuel components made tests the excitation pulse combustion in the range of possible movements of the flame. The harmonic signal generator created a certain amplitude sound waves and fed on electrodynamics. When moving in the cavity of the flame cone and the fixed coordinates of the excitation termination of pulsating combustion in the combustion chamber . The boundaries of the regions of existence of intermittent burning in the coordinate system of thermal stress of the combustion chamber $\boldsymbol{q}$ and the flow rate at the edges of the flame $\boldsymbol{v}$ determined by calculation. Studies carried out in the frequency range from 100 to 1400 Hz.

3. Results and their discussion

The amplitude and frequency of the periodic disturbance entering the combustion chamber, depending on the amplitude -frequency characteristics of the feed path of gaseous fuel and the combustion chamber. The combustor is a complex cavity in which both exhibit the properties as a half-wave and quarter-wave resonators. As the frequency of the external periodic disturbances in the range of resonance frequencies of the combustion chamber there is the effect of synchronization with increasing amplitude of sound pressure oscillations. On the disturbance frequencies close to resonance are observed beats, which depending on the amplitude of the disturbance can disrupt pulsating combustion within the combustion chamber. At frequencies of periodic disturbances antiresonant frequencies close to the combustion chamber, there is the effect of suppressing oscillation. At the heart of these events are synchronous and asynchronous mechanisms of action [3].

Most clearly the effect of external periodic perturbations on the combustion instability manifests itself through a change of the existence of areas of intermittent burning. Figure 2 shows the existence of pulsating combustion for different sound pressure levels of external periodic perturbations proportional to the electrical power to the electrodynamic ***We***. The existence of regions constructed in the coordinate space of the combustion chamber thermal tensions q_S and flow of gaseous fuel to the edge of the flame ***v***. The length of the combustion chamber and the resonator was 138 cm frequency disturbance corresponded to the first antiresonant frequency of the combustion chamber as a half-wave resonator.

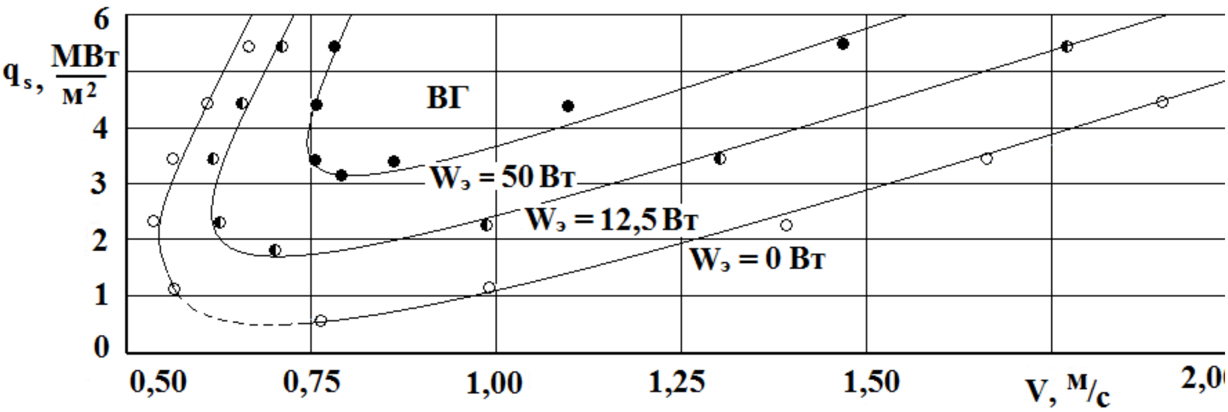

Figure 2. Changing the scope of the existence of intermittent burning (frequency perturbations generated 180 Hz)

The increase in electric power invested in the creation of periodic acoustic disturbances on electrodynamics, leads to a significant reduction of the existence of pulsating combustion. During the pilot study discovered the effect of " high- impact" external periodic disturbances on the oscillations in the combustion chamber. This effect is evident in the frequency range from 870 to 1320 Hz (Fig. 3)

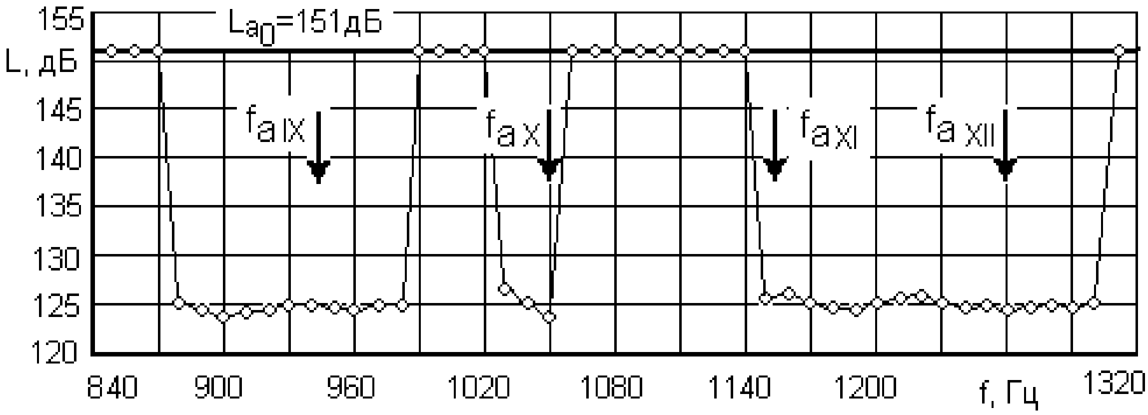

Fig. 3 . Graphs of the resulting sound level the pressure in the combustion chamber

The length of the combustion chamber was 138 cm , the heat intensity of the combustion chamber $q_S = 1{,}1$ MW/m^2. The initial level of sound pressure oscillations intrachamber was 151 dB. As a result of the perturbation level of sound pressure oscillations decreased milking 125 dB. The suppression of oscillation in the range IX - XII calculated resonant modes of the combustion chamber (the first mode oscillation is 105 Hz) . At the same time consumed electric power was 10.5 watts. Figure 4 shows the existence of pulsating combustion in the case of high- impact.

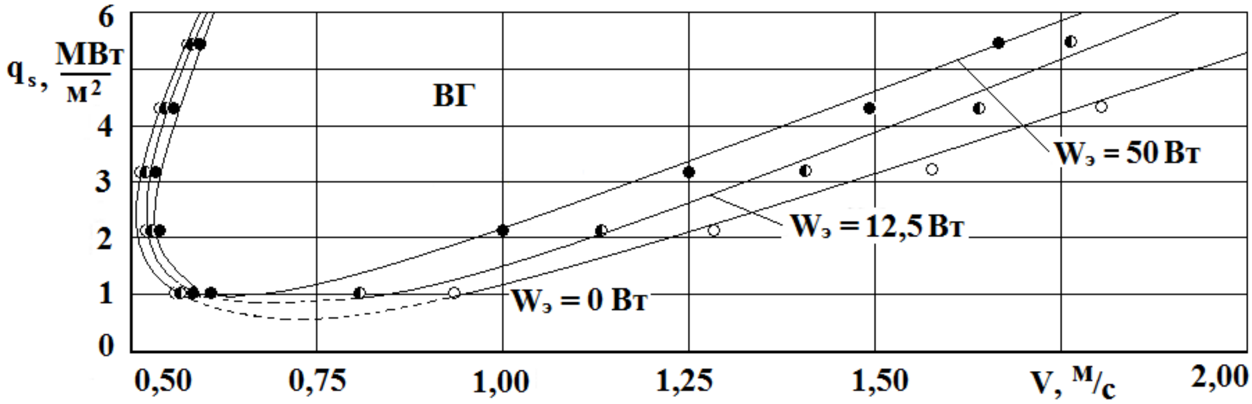

Figure 4 . Changing the scope of the existence of intermittent burning (The frequency of disturbances created in 1210 Hz)

The phenomenon of " high- impact" presumably due to the sensitivity of the gas jets sound vibrations . Sound vibrations lead to destruction of actively laminar and turbulent jets for active mixing of the external environment . In the case of combustion - the intensification of the process by reducing the preparation time of fuel to combustion.

4. Conclusions

- Method of external periodic perturbations may be used for controlling combustion instability in the combustion chambers of power plants highly stressed.
- Depending on the frequency of the external periodic perturbation is observed as an increase and decrease in the amplitude of the oscillations in the combustion chamber. These effects are due to synchronous and asynchronous mechanisms of action [3]
- External periodic disturbance generated in the path feeding the gaseous fuel , showing the high efficiency of the method of management in terms of energy costs. Power required to initiate periodic disturbances significantly less heat output of the combustion chamber.

References

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