It is interesting to note that in the tests with the shortened nozzle the inversion could be detected at thermocouples mounted at a distance of 95 mm from the inlet to the mixing chamber, consisting in the fact that at a certain ratio of pressures p_{01} and p_{02} the heating zone extended for a considerable length of the mixing chamber from the blank diaphragm. The sound of the jet discharging from the forechamber changed simultaneously with the change in the readings of these thermocouples. In the transitional mode of a rise in the pressure p_{01} with the opening of throttle 7 the inversion set in at $p_{01} = 28.5$ bar. In the steady mode for $p_{01} =$ 40 bar the inversion was achieved as follows. With $p_{02} = 1$ bar and $t_{01} = +1°C$ we had $\Delta t_{0c} = 11.3°C$ in the forechamber, $\Delta t_{0h} = 36°C$ at the end of the mixing chamber, and $\Delta t_{0h} = 24°C$ at the inlet to the mixing chamber. An increase in the resistance to $p_{02} = 7$ bar led to a change in the temperatures. They became $\Delta t_{0c} = 9°C$ in the forechamber, $\Delta t_{0h} = 40.5°C$ at the end of the mixing chamber, and $\Delta t_{0c} = 2.3°C$ at the inlet to the mixing chamber.

NOTATION

p, pressure; t, temperature; Δt, temperature change; m, mass flow rate; $\mu = m_3/m$, relative mass flow rate. Indices: 0 pertains to stagnation parameters; 1: at the inlet to the ejector; 2: in the forechamber; 3: at the end of the mixing chamber; 4: parameters behind the diaphragm; c: cooling; h: heating.

PECULIARITY OF THE EFFECT OF PREHEATING THE MIXTURE ON THE PRESSURE DURING COMBUSTION IN A SEMIOPEN TUBE

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Data are presented on the effect of the mixture temperature on the propagation of a flame in a semiopen tube. It is found that preheating of the mixture can increase or decrease the combustion intensity depending on the coordinate of the ignition source.

The method of preliminary heating of the mixture has been tried in experimental searches for possibilities of increasing the efficiency of operation of pulse chambers [1, 2], which represent one variant of semiopen tubes.

A nichrome wire which was located along the axis of a tube 0.02 m in diameter and 0.31 m long served as the heater. A propane—air mixture, which was ignited with a spark ignition source, was burned in the tube.

It follows from the experimental data that preliminary heating of the mixture can have a twofold mutually opposed effect on the maximum pressure in the tube during the flash of the mixture. Thus, when the mixture is ignited near the open end of the tube a considerable increase in pressure is observed with an increase in heater power (curve 1 in Fig. 1), while when the mixture is ignited near the closed end of the tube a decrease in pressure was even observed (curve 2 in Fig. 1), which indicates a decrease in combustion intensity in this case.

Before the experiment it was assumed that in both cases the pressure should increase with heating because of the gradient increase in the normal propagation velocity of the flame. Near the heater the velocity will be higher than at points far from it. This leads to the elongation of the flame front, an increase in its area, and at the same time to a decrease in the combustion time of the mixture. And the faster the mixture burns, the less will be the energy dissipation and consequently the higher will be the pressure.

The arguments presented above are confirmed by the experimental data, but only for the case of propagation of the flame from the open end of the tube. In fact, as follows from interference motion pictures of the propagating flame, with heating the flame front is stretched out (Fig. 2b) in comparison with the case of a cold mixture (Fig. 2a) and the average propagation velocity of the flame increases by several times.

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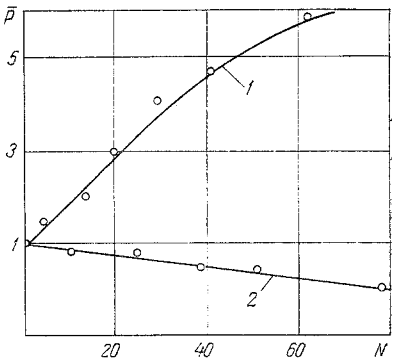

Fig. 1

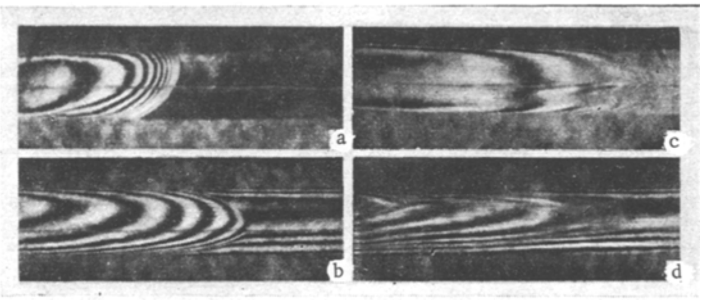

Fig. 2

Fig. 1. Dependence of dimensionless pressure on heater power with ignition of mixture: 1) near open end of tube; 2) near closed end of tube. N, W.

Fig. 2. Interference pattern of a flame propagating from the open (a, b) and closed (c, d) ends of the tube.

In the case of the ignition of the mixture near the closed end of the tube, however, the very same factor leads to the opposite effect, i.e., to a decrease in the average propagation velocity of the flame and to a decrease in the pressure.

This can be explained by a distinctive feature of the propagation of a flame from the closed end of a tube. With ignition near the open end of the tube the flame propagates in an almost stationary mixture while with ignition near the closed end it propagates in a mixture moving under the effect of the expanding combustion products which drive the mixture to the open end of the tube. Hence, in the second case there will also be a turbulization factor on which the propagation velocity of the flame depends importantly.

The preheating of the mixture leads to an increase in the normal velocity, on the one hand, while it increases the viscosity of the mixture and consequently decreases the turbulence, on the other. The effect of the second factor is considerably stronger, and therefore the pressure decreases with an increase in the heater power.

A confirmation of this is an analysis of high-speed motion pictures, from which it follows that the velocity of propagation of a flame from the closed end of the tube decreases with heating. The profile of the flame front also changes. Without heating the flame front is distorted, which can be judged from the distortion of the interference bands (Fig. 2c). With heating such distortion of the bands is not observed because of the stabilizing effect of the viscosity (Fig. 2d).

Thus, the experimentally discovered peculiarity of a decrease in the combustion intensity of a preliminary heated mixture with propagation of the flame from the closed end of a semiopen tube is a consequence of the stabilizing effect of the viscosity.

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