conditions of weightlessness and of that moving from top to bottom in a vertical channel are approximately the same. In the latter case the light reaction products are found above the heavy combustible mixture. Under such conditions no natural heat convection is developed to deform the flame front.

A reverse situation is created with the ignition from below. Behind the flame front going out from the incendiary wall, hot gas is produced which begins to rise upward under the action of the Archimedean force. The maximum value of the gas velocity is reached in the plane of symmetry \( y = 0.5 \). With progress of time, the volume of the hot region increases, and the convection intensity becomes greater. Because the channel is closed, together with the rising motion of the hot reaction products, a descending flow develops of the initial cold mixture which is near the side walls. A circulatory gas motion develops in the channel, and the flame front becomes vertically extended (Fig. 4). In the computations carried out, a substantial drop in the chemical reaction rate was observed in the central portion of the front accompanied by a front break on the channel symmetry plane. In this case, the combustion is centered over two vertically elongated regions adjoining the channel side walls and undergoing upward motion. In Fig. 4 one of these regions is shown as a cross-hatched region \( (t = 2.51) \). The break in the flame front rising upward is caused by the cooling of the central front portion due to its rapid rise, as well as by the outflow of combustible mixture from the front by virtue of gas circulation.

To conclude, the feasibility has been demonstrated of a thorough computation of non-uniform flame front in a channel based on nonstationary two-dimensional equations for an aerothermodynamically reacting gas. Characteristic features have been determined describing the gas flow, shape and velocity of the front in horizontal and vertical channels as functions of the direction of the flame motion relative to the vector of the external mass force and of the magnitude of that force.

**LITERATURE CITED**


**EFFECT OF OXIDANT STREAM VELOCITY ON PROPAGATION OF FLAME IN CLOTH AND FILMS**

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Any study of the mechanism of flame propagation in thin films of burning material requires a knowledge of the relation between the gas velocity \( u \), and the velocity of propagation of the combustion wave, \( V_a \). This relation has been established already for paper [1, 2]. Further studies on paper "Vniiivlon" (V), "Vniiivlon-M" (V-M), and "Lola" (L) cloth, and on PMF-352 polyamide films of various thickness have been made by the authors.

In the experiments, the gas velocity was varied from 0.1 to 5.0 m/sec and the volumetric oxygen fraction \( Y \) from 0.21 to 1.0. The samples were 18 mm wide by 100-120 mm long and were held by a frame of 0.3-mm Nichrome wire in a vertical tube of quartz glass, 18, 25, or 78 mm diameter. The combustion front advanced from top to bottom, against the
Fig. 1. \( V_p(u) \) relations for 0.14-mm-thick paper (circles) and V cloth (dots). Y: 1) 0.6, 2) 0.4, 3) 1.0, 4) 0.8, 5) 0.21, 6) 0.6.

Fig. 2. \( V_p(u) \) relation for polyamide PMF-352 film. a) \( \delta = 0.24 \) mm, Y: 1) 1.0, 2) 0.8, 3) 0.6; b) Y = 0.6, \( \delta \) mm: 1) 0.06, 2) 0.12, 3) 0.24.

direction of the gas stream. Its velocity was found by measuring the time of combustion of a 40-mm control section. With a 0.95 reliability coefficient, the variation of the velocity of propagation did not exceed 10-15% of the average measured velocity. The experiments showed that the results for constant values of \( V_p \) were independent of the tube diameter.

The nature of the material affected both the velocity of propagation of the combustion wave and the character of the combustion. Paper and V burned with a gaseous flame. The gaseous phase was virtually nonexistent during the combustion of polyamide films and L and V-M cloth, which burned with a smoldering surface. The experimental results are given in Figs. 1 and 2. It will be seen that the form of the \( V_p(u) \) curve depended on the type of material and the conditions of combustion. The value of \( V_p \) for paper and V was independent of the value of \( u \) at low gas velocities. An increase in \( u \) led to a reduction in \( V_p \) and the collapse of the combustion when \( u = U_{cr} \). The range of values of \( u \), over which \( V_p \) remained constant, increased with increasing oxygen content, but the collapse of the combustion occurred at higher values of \( U_{cr} \). For example, the value of \( U_{cr} \) for paper was 0.6 m/sec when \( Y = 0.21 \), and 2.7 m/sec when \( Y = 0.4 \).

The form of the \( V_p(u) \) curves for materials which burned without a flame depended on the oxygen content of the gas stream and the thickness \( \delta \) of the sample (Fig. 2). For a single layer of polyamide film (\( \delta = 0.06 \) mm) and \( Y = 0.6 \), the form of the curve was similar to that for paper or V, and it may be assumed that these materials also have a range of gas velocities over which \( V_p \) remains virtually constant. An increase in the thickness of the film and a reduction in \( Y \) led to conditions where \( V_p \) and \( u \) increased simultaneously. This became more obvious with thicker samples and lower oxygen concentrations (Fig. 2).

The behavior for L and V-M cloth is shown in Fig. 2a. The mechanism leading to the behavior of these materials has been established. In general, combustion was due to heat conduction through the gaseous and condensed phases, and to radiation from the flame. Under the specified conditions, the main supply of heat to the condensed phase was provided by a single type of heat transfer. For example, the controlling factor in the combustion of paper was the transfer of heat through the gaseous phase \([1, 3]\). It can be assumed that for samples of paper and V, heat transfer through the gas governed the propagation of the combustion wave. This assumption was confirmed by the form of the \( V_p(u) \) curves, obtained experimentally and theoretically, for the propagation of the combustion wave in thermally thin materials burning in a heat flow transmitted through a gaseous phase from a flame \([4]\).

Increase in the thickness of the material or a reduction in the oxygen concentration in the gas stream, led to a maximum in the \( V_p(u) \) curves for materials which burned without a gas-phase flame (Fig. 2, curves 2 and 3). This was evidently because heat transfer to the condensed phase provided the essential contribution to heating the material and the magnitude of this contribution was dependent on the conditions of propagation of the combustion wave. This assumption agrees with the results of \([4]\), which explained the form of the \( V_p(u) \) curves for thermally thick layers of material, where heat transfer to the condensed phase played a significant role in heating up the components.