A SYSTEM OF PLANE TURBULENT JETS IN A CHAMBER

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The results are given of an experimental investigation of the velocity and temperature fields in the resultant stream formed by five plane turbulent jets in a chamber.

Investigations of a system of plane turbulent jets [1] have shown that the jets interact in a mixing process, their axes deviate from the original direction, and the structure of the resulting stream is complex. In particular, the extent of reverse flow regions, the nonuniformity of the resultant field, and the hydraulic losses are increased appreciably over what might be expected if the jet axes were not deformed in the mixing process. These results were obtained in conditions which must be defined as mixing of the jets in free space, since spreading of the jets during the interaction was limited only by side walls, to conserve the plane-parallel structure of the stream, air entering the system freely at top and bottom.

Since mixing of turbulent jets in heat engines usually occurs in chambers, the greatest interest attaches to the study of these phenomena in a confined space, when interaction of each jet and of the system as a whole with the surrounding air is excluded. This article presents the results of an investigation of this kind.

A stream was formed in a chamber, as before, by the discharge of five jets from 8 × 30 mm slit nozzles, located at equal distances of 30 mm and oriented in the same direction. Air from one reservoir (A) was supplied to nozzles 1, 3, and 5 (Fig. 1), and from another reservoir (B) to nozzles 2 and 4, the air in B coming from a heater.

In contrast with experiments conducted earlier, the discharge from the nozzles entered a chamber of rectangular section, equal in width to the nozzles (30 mm) and of a height such that the outside jets (1 and 5) propagated directly adjacent to the walls.

Parameters of the Streams Entering the Nozzles

Regime	h^*_A, N/m^2	h^*_B, N/m^2	Δt_0, °C	δ, mm
IV-T40	980	980	40	8
IV-T60	980	980	60	8
IV-4	980	980	0	4
IV-4.5	980	980	0	1.5
V	3920	980	0	8
VI	3920	392	0	8

In the resultant stream measurements were made of the total and static pressures, direction of streamlines, and temperature at different distances from the nozzle exit (up to 350 mm). The data are presented in the form of graphs of variation of the stream parameters: axial velocity component u = u(y), and excess temperature Δt = Δt(y) for each of the sections investigated.

A more detailed description of the equipment, the measurement technique, and the reduction of the experimental data is available in [1, 2].

The characteristics of the regimes investigated are given in the table. Figure 1 shows the results of an investigation of the resultant stream in the case in which all five jets issued with an identical pressure drop (regime IV-T40). The structure of the stream indicates that the lateral jets (Fig. 1 shows the parameters of one lateral jet, No. 1) propagated along the wall. Jet 2 was deflected initially toward the wall (at x = 42 mm), and then toward the center of

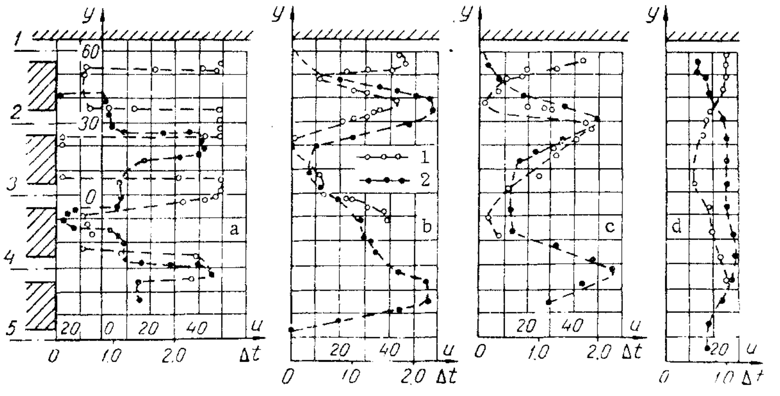

Fig. 1. Parameters of the resultant stream in regime IV-T40 at x = 2 mm (a), 42 (b), 52 (c), and 150 (d): 1) axial velocity component of the stream u (m/sec); 2) temperature change, Δt (mv).

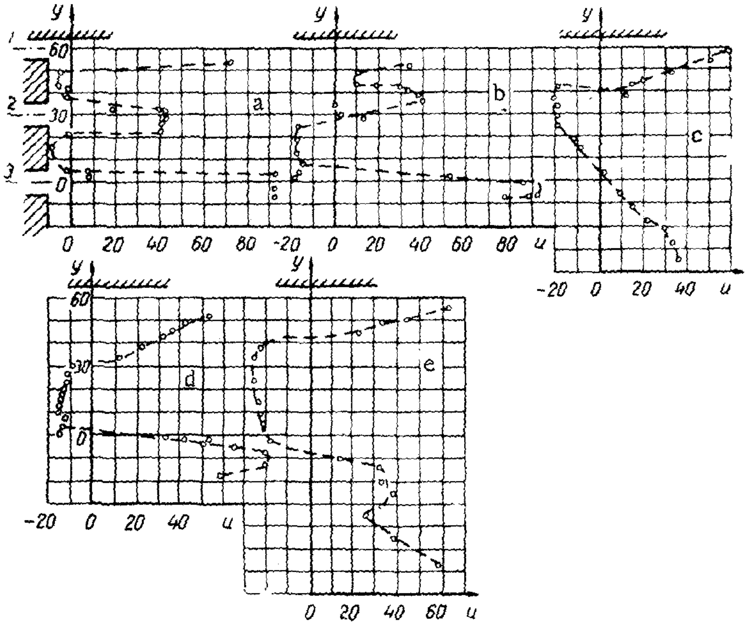

Fig. 2. Structure of the resultant stream in regime VI with a) x = 2 mm; b) 22; c) 52; d) 100; and e) 150. u in m/sec.

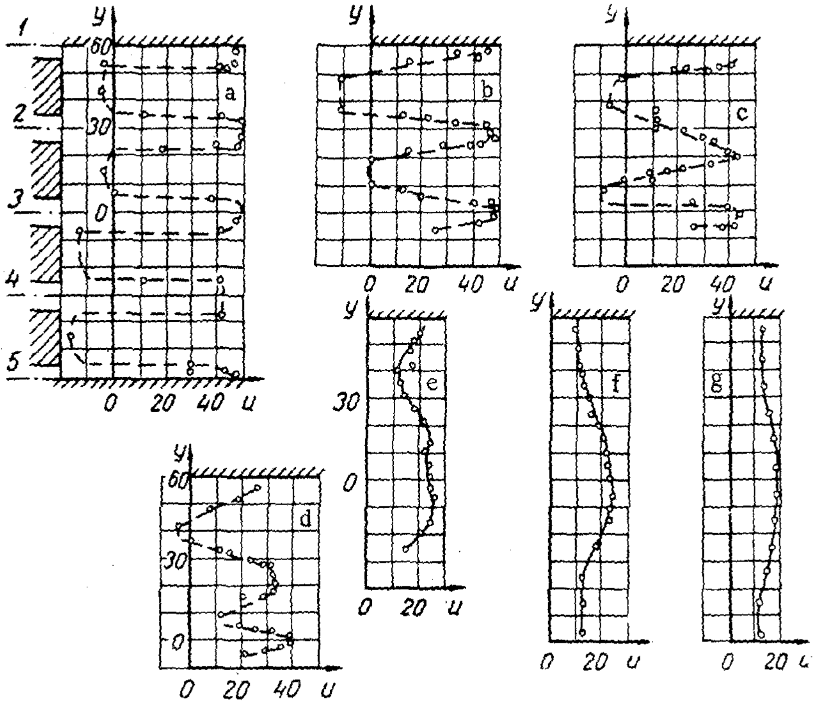

Fig. 3. Structure of the resultant stream in regime IV-4, with a) x = 2 mm; b) 22; c) 42; d) 52; e) 100; f) 150; and g) 350; u in m/sec.

the chamber (x = 52 mm). In the open stream the central jet 3 propagated in all cases in a straight line in the original direction, while in the chamber it was deflected toward one of the walls (the lower, in Fig. 1), the result being that in the central part of the chamber reverse motion of the stream was observed at rather large distances (up to x = 100 mm). An appreciable decrease in the stream velocity in the central part of the chamber occurred at all the sections investigated (up to x = 150 mm).

The temperature field of the stream in this regime, following the aerodynamic structure of the stream, proved to be asymmetric (section x = 42 mm, x = = 52 mm).

When the heating of jets 2 and 4 was increased to Δt_0 = 60° C (regime IV-T60), no qualitative changes resulted in the velocity and temperature fields.

In the case in which the jets issued from the nozzles with different velocities (regimes V and VI), all the peculiarities of the flow noted for regime IV were amplified. Attention is drawn to the existence in these regimes of a strong extensive reverse flow region in the central part of the chamber (up to x = 150 mm, Fig. 2).

The considerable nonuniformity of the resultant stream was due in this case to deformation of the central jet 3. Its deflection from the original direction in turn by the action of the side jets 1 and 5, propagated along the walls of the chamber, in connection with which the possibility was investigated of controlling the gasdynamic structure of the stream and achieving greater uniformity by changing the dimensions of the side jets.

With this objective, the side jet dimension δ was reduced to 4 mm (regime IV-4, Fig. 3) in one of the regimes. All five jets issued, as in regime IV, with identical pressure drop in the nozzle, but the character of their motion varied qualitatively (excluding the side jets 1 and 5, which propagated along the walls in all cases). Whereas the central jet 3 in regime IV departed from the general stream axis, leading to formation of a strong region of reverse flow in the central part of the chamber, in regime IV the jet was propagated without change of original direction in the mixing process. Jet 2, which was deflected first in regime IV toward the periphery of the stream, was gradually bent toward the stream axis. Both these factors led to earlier equilibration (compared to regime IV) of the velocity field in the resultant stream.

When the size of jets 1 and 5 was then increased to 4.5 mm (regime IV-4.5, Fig. 4), a tendency toward asymmetry of the resultant stream was again observed, although this was not as pronounced as in regime IV.

Thus, the deformation of the axes of the jets during mixing and interaction depends both on the discharge velocity of the individual jets and on their size. Each specific system of jets requires experimental investigation of the gasdynamic structure of the resultant stream.

Notation

h^*_A, h^*_B–total pressure drops corresponding to discharge of the jets from reservoir A (jets 1, 3, and 5) and B (jets 2 and 4); u–axial component of stream velocity at the measurement point; Δt–change of temperature measurement point in comparison with stream temperature in reservoir A (°C) mv; Δt_0–initial excess heat of jets discharging from reservoir B in comparison with temperature in reser-

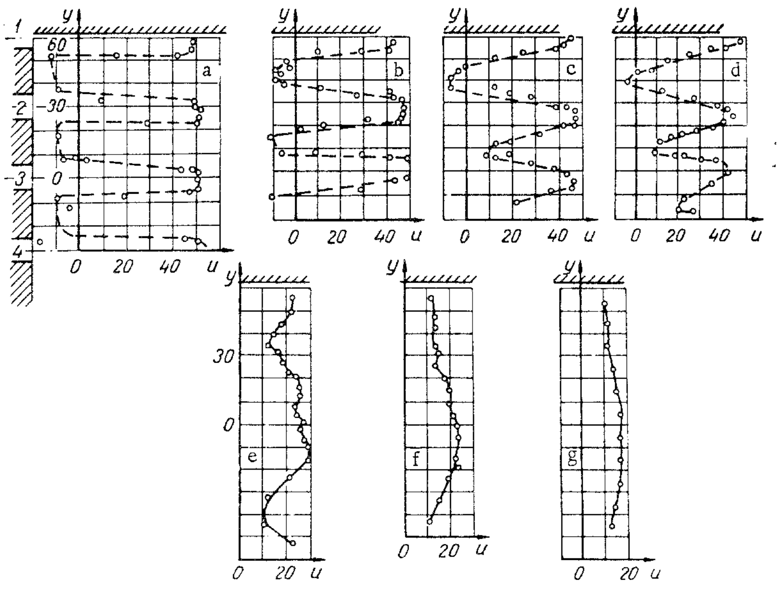

Fig. 4. Structure of the resultant stream in regime IV-4.5, with a) x = 2 mm; b) 22; c) 42; d) 52; e) 100; f) 150; and g) 350. u in m/sec.

voir A; δ–size of nozzles from which side jets (1 and 5) discharge.

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