STRUCTURE OF A TURBULENT JET STRIKING A SEMIPERMEABLE BARRIER (PLANE GRID)

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The results of an experimental investigation of the structure of a free turbulent jet striking a semipermeable barrier (plane grid) are given. The results were obtained by measuring the excess total and static pressures in the jet and by visualization of the jet.

One unresolved problem in the theory of turbulent jets is the problem of a jet striking a semipermeable barrier situated in unbounded space. This problem arises in agriculture, for instance, in connection with tree spraying.

As a model of a semipermeable barrier we take a plane grid situated normal to the axis of a jet emerging from a round nozzle.

We investigated the structure of the jet by measuring the total and static pressures in different cross sections and by shadow photography of the jet, using the IAB-451 instrument [1].

In the experiments with the IAB-451 instrument the plane grid was 0.8 mm thick; the values of K were 0 (solid plate), 0.20, 0.44, 0.63, and 1.00 (no grid). A vertical round turbulent jet of air (d_0 = 8.5 mm; L = 57 mm; u_0 = 40 m/sec) was directed upwards onto the grid. For visualization the air was heated to 30-40°C.

In the experiments in which the total and static pressures were measured the scale was increased by a factor of 3.5 (d_0 = 30 mm; L = 200 mm; u_0 = 120 m/sec). The values of K were 0 (solid plate); 0.05, 0.32, 0.63; 1 (no grid).

The structure of the jet in the absence of the grid corresponded with the formulas in [2] with the empirical coefficient a = 0.068.

Table 1 gives the results of determinations of u_x/u_0 and ΔP_{st} in relation to l/L for various values of K. Table 1 shows that the introduction of the grid into the jet alters the structure of the free stream only in the immediate vicinity of the grid; the smaller K, the larger the increase in ΔP_{st} immediately in

TABLE 1. Values of ΔP_{st} and u_x/u_0 for Different Values of l/L and K

K	1,00	0,63	0,32	0,05	0,00	1,00	0,63	0,32	0,05	0,00
l/L	ΔP_{st}, mm water					u_x/u_0				
0,45	0,00	8,5	8,0	7,5	12,0	1,0	1,0	1,0	1,0	1,0
0,60	0,00	8,5	8,5	27,0	34,0	1,0	0,98	0,98	0,98	0,98
0,80	0,00	11,0	24,0	34,0	70,0	0,95	0,95	0,95	0,95	0,93
0,90	0,00	82,0	195,0	260,0	575,0	0,94	0,90	0,86	0,83	0,73
1,10	0,00	0,0	0,0	0,0	0,0	0,85	0,40	0,27	0,08	0,00
1,30	"	"	"	"	"	0,78	0,37	0,18	0,06	"
1,60	"	"	"	"	"	0,63	0,34	0,15	0,04	"
2,10	"	"	"	"	"	0,47	0,29	0,14	0,02	"
3,00	"	"	"	"	"	0,33	0,21	0,09	—	"
5,00	"	"	"	"	"	0,18	0,12	0,05	—	"

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TABLE 2. Values of u/u_x for Different Values of y/d_0, l/L, and K

K	1,00	0,63	0,32	0,05	0,00	1,00	0,63	0,32	0,05
	l/L=0,8					l/L=1,3			
y/d₀	u/uₓ								
0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
0,16	0,91	0,90	0,90	0,91	0,91	0,93	0,95	0,89	0,71
0,32	0,77	0,80	0,81	0,82	0,84	0,79	0,83	0,64	0,45
0,50	0,61	0,63	0,63	0,62	0,62	0,65	0,71	0,50	0,31
0,66	0,46	0,45	0,46	0,45	0,45	0,51	0,59	0,38	
0,84	0,32	0,29	0,30	0,32	0,30	0,38	0,50	0,24	
1,00	0,21	0,15	0,15	0,16	0,17	0,26	0,42	0,15	
1,17	0,12	0,10	0,11	0,08	0,06	0,16	0,35		
1,34						0,09	0,29		

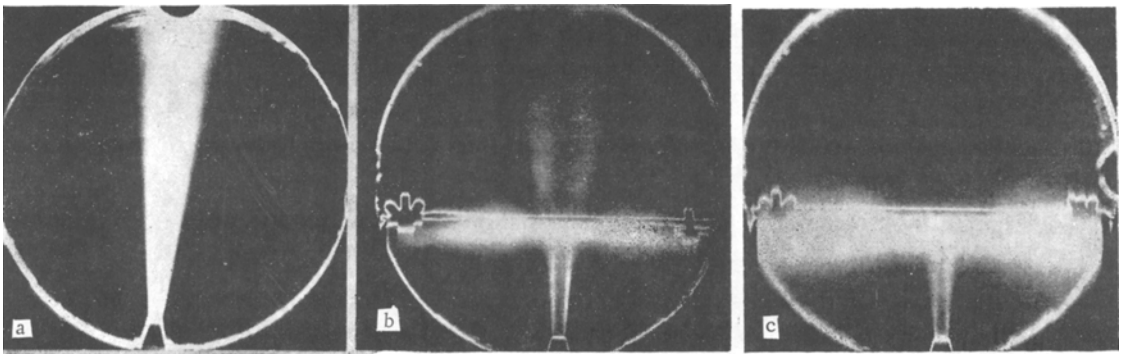

Fig. 1. Shadow photographs of turbulent free jet striking plane grid: a) K = 1 (no grid); b) K = 0.44; c) K = 0 (solid plate).

front of the grid; in the case of the solid plate it was 575 mm of water at a distance of 20 mm from the grid. On passage through the grid the velocity on the jet axis changes abruptly and the change is greater, the smaller K.

Table 2 gives the results of determination of the profiles of u/u_x for different values of K. Before the grid all the profiles coincide, and after the grid the jet either expands slightly, or contracts.

The abrupt decrease in axial velocity of the jet after the grid with the width of the jet remaining constant or decreasing means that the air flow rate in the jet after the grid is less than before the grid, i.e., that only part of the jet passes through the grid.

Measurements of the radial velocity heads showed that the rest of the jet spreads radially over the front of the grid and forms a wide fan. The smaller the meshes of the grid, the more of the jet is directed into the fan. With the solid plate (K = 0) the whole jet is converted to a fan.

The described structure of a jet striking a plane grid is illustrated clearly by the shadow photographs (Fig. 1).

NOTATION

K is the relative area of holes;
L is the distance from nozzle to grid;
l is the distance from nozzle to investigated section of jet;
y is the distance from jet axis;
u is the velocity of air in jet;
u_0 is the velocity in initial cross section of jet;
u_x is the velocity on axis of jet;
d_0 is the diameter of initial section of jet;
a is the empirical coefficient of jet;
ΔP_{st} is the excess static pressure on jet axis.

LITERATURE CITED

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