EFFECT OF A TRANSVERSE MAGNETIC FIELD ON THE STRUCTURE OF A TURBULENT FLOW OF MERCURY BEHIND A SUDDEN EXPANSION

G. G. Branover, A. B. Tsinober, and E. V. Shcherbinin

Inzhenerno-fizicheskii zhurnal, Vol. 8, No. 1, pp. 114-115, 1965

The depth to which a magnetic field will affect a turbulent flow of conducting liquid has been determined experimentally. Laminar flow at very high Re numbers [1] has been observed in a sufficiently strong magnetic field. When an even stronger field is applied to turbulent flow, the value of the friction coefficient changes [2], and the processes of turbulent transfer are slowed down [3]. However, because the transverse velocity gradients in the core of a uniform turbulent flow are not large, the average velocity field undergoes comparatively little change in a transverse magnetic field [4]. The situation alters somewhat if the channel walls are very rough [5]. The greatest reorganization of the velocity structure may be expected, however, in a flow with appreciable transverse velocity gradients. This is the case, for example, behind a sudden expansion, where a turbulent stream, surrounded by eddy zones with a closed net motion, is observed. The authors have previously investigated [6] the influence of a magnetic field on the friction coefficient in a flow of this kind, and have now examined the influence of a transverse magnetic field on the velocity distribution. The channel used was rectangular and measured 2×10 cm; the first 15 cm had inserts, leaving a narrow slit measuring $0.2 \times \times 10$ cm. The channel had an overall length of about 120 cm, and was located in the gap of a magnet of the same length. The field induction can reach 0.5 Tesla. Velocities were measured with a Pitot-Prandtl tube with head diameter 0.15 cm. A differential micro-manometer made it possible to measure dynamic-static pressure differences to 19.9 newton/m^2.

Fig. 1 shows measured velocity curves at several sections in the expanding stream, where M is the Hartmann number, calculated from the hydraulic radius of the flow behind the expansion. In this test the Re number based on the same dimension was $3.35 \cdot \cdot 10^3$. Reverse flow velocity could not be measured.

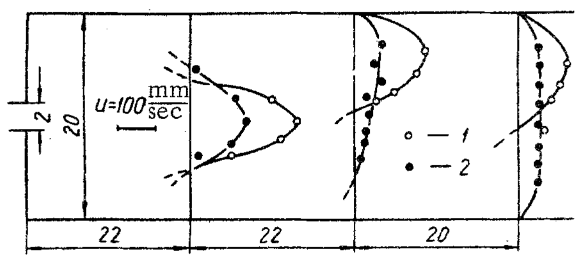

Fig. 1. Expansion of stream with and without the field. Values of Hartmann number are: 1 – M = 0; 2 – M = 88.2

The curves obtained are evidence of the very profound influence of the field on the average velocities. In the presence of a field, the stream expands more rapidly, and the volume of the eddy zones is reduced. In spite of the very considerable inertia of the velocity measuring system, suppression of turbulent velocity pulsations by the field was clearly observed in the measurements, in relation to oscillations of the manometer levels.

The change in velocity profile with increasing field strength is shown in Fig. 2, where it is seen that the influence of the field is already considerable at $M \approx 40$.

Because of the small number of experimental data and the comparatively low measuring accuracy, we have confined our conclusions for the present to the main features of the phenomenon.

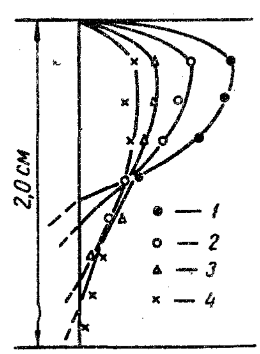

Fig. 2. Change of velocity curve at section 44 mm from expansion. Values of Hartmann number are: 1 – M = 0; 2 – 39.6; 3 – 68.2; 4 – 88.2

REFERENCES

1. W. Murgatroyd, Phil. Mag., 44, 1348, 1953.
2. G. Branover and O. Lielausis, Topics in Magnetohydrodynamics [in Russian], Izd. AN Latv. SSR, Riga, 1963.
3. G. Branover and O. Lielausis, Topics in Magnetohydrodynamics and Plasma-dynamics [in Russian], Izd. AN Latv. SSR, Riga, 1962.
4. L. P. Harris, Hydromagnetic Channel Flows. John Wiley, N. Y. -London, 1960.
5. G. Branover and O. Lielausis, Izv. AN Latv. SSR, No. 1, 1961.
6. G. Branover, P. Dukure, O. Lielausis and A. Tsinober, Izv. AN Latv. SSR, No. 11, 1960.

22 February 1964

DESIGN OF SPRAY DRIERS WITH MIXING

A. P. Fokin, A. N. Planovskii, and L. A. Akopyan

Inzhenerno-fizicheskii zhurnal, Vol. 8, No. 1, pp. 116-118, 1965

Spray drying is widely used in industry. Tests have shown that spray driers are indispensable for drying materials where lengthy contact with the heating stream is not possible, in particular for drying polymer materials.

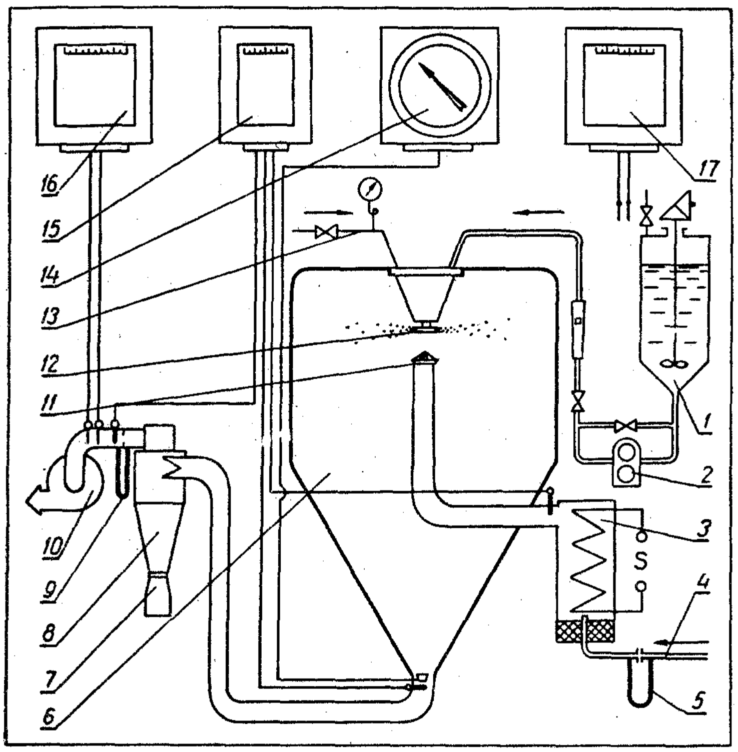

Fig. 1. Diagram of test apparatus. 1 – product to be dried; 2 – gear pump; 3 – electric heater; 4 – tube for adding helium; 5 – differential manometer; 6 – drying chamber; 7 – receiver for dried product; 8 – cyclone; 9 – differential manometer; 10 – blower; 11 – top-cap; 12 – spraying disc; 13 – compressed air line; 14 – gas analyzer; 15 – electronic potentiometer; 16 and 17 – electronic psychrometers.

In spite of the existence of published data [1-3], an accurate and reliable method of designing spray driers has not as yet been developed, due to lack of reliable heat and mass transfer relations. The concentration, in particular, is not known. In engineering calculations the motive power of the process is still computed as for equipment with ideal mixing or displacement, although actually real equipment only approximates to one or other of these ideal cases. Reduction of the harmful effect of mixing in spray driers can be achieved by logical control of the motion of the heating stream and sprayed material.

In designing real equipment, it is necessary to know the nature of the mixing of the flows, which determine the concentration field. Apart from other methods of calculating longitudinal mixing [4, 5], the concentration field may be expressed in terms of the effective motive power, or the ratio of the motive power in the actual equipment to that in equipment with ideal displacement: $E = \Delta P_i/\Delta P_d$. The effective motive power may conveniently be designated by the number of pseudo-sections n, which depends on the hydrodynamic conditions; for ideal displacement $n = \infty$, and for ideal mixing $n = 1$. This paper is devoted to an experimental determination of the number of pseudo-sections for a once-through spray drier.