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by

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ABSTRACT

Discharge coefficients were determined for organosilicon liquids PMS-1,5, PMS-10, PMS-20, and PES-1 discharged through small orifices (0.2 to 0.5 mm in diameter, wall thickness--less than the radius of opening). The experimental results were then compared with those obtained for water under identical experimental conditions. Three thousand measurements were made, and the results are shown graphically in Fig. 1. These experimental results did not agree with those produced by the universal formula of A. D. Al'tshul' (Mestnyye gidravlicheskiye soprotivleniya pri dvizhenii vyazkikh zhidkostey. Gostoptekhnizdat, 1962). It is concluded that the process of discharging liquids through small orifices in thin walls is far more complicated than was heretofore assumed. Orig. art. has: 1 table and 4 figures.

DISCHARGE COEFFICIENT FOR ORGANOSILICON LIQUIDS DURING DISCHARGE THROUGH SMALL OPENINGS

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In modern technology wide use is made of various devices – regulating, dosing, damping, etc. – whose action is connected with the discharge of liquids through small openings. The design of such devices must be based on the coefficient of discharge during the outflow of the liquid. The determination of the discharge coefficient has been the subject of a large quantity of experimental works, relating mainly to the discharge of water and oil.

This article presents the results of work on determination of the discharge coefficient during discharge of polyorganosiloxane fluids through openings of 0.2 to 0.5 mm in diaphragms whose thickness is no more than half of the aperture diameter (which corresponds to the concept "opening in a thin wall").

In application to hydraulic systems polyorganosiloxane fluids have a number of valuable properties, in particular: a broad selection of liquids in terms of viscosity (from fractions of a centistoke to thousands of stokes at normal temperature); a low pour point; an insignificant change in viscosity with temperature; and chemical inertness.

In our work experiments were conducted with PMS-1.5, PMS-10, and PMS-20 polymethylsiloxane liquids and PES-1 polyethylsiloxane liquid. For comparison, analogous experiments were conducted with water using the same diaphragms and the same pressure heads.

The values of the kinematic coefficient of viscosity γ in cSt and of the coefficient of surface tension σ at 20°C are given in the following table:

Liquid	ν, cSt	σ, dyn/cm
PMS-1.5...	1.5	18.2
PMS-10....	10	20.2
PMS-20....	20	20.5
PES-1.....	3.7	25.3

Figure 1 shows the diagram of the experimental setup designed for a pressure head up to 50 mm H_2O.

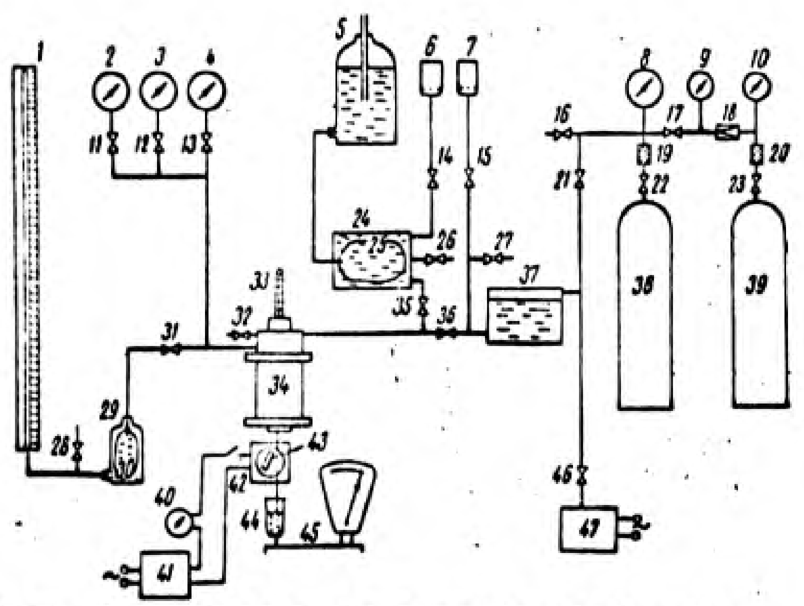

Fig. 1. Diagram of experimental setup.

In the range of small pressures, for the creation of a constant pressure head during discharge we used a Mariotte vessel 5, set at the required height (in our case, up to 3 m); the pressure head was measured by piezometer 1. To simplify the work intermediate vessels 24 and 29 with separating diaphragms 25 and 30 inside them were included in the installation. The Mariotte vessel 5 and piezometer 1 were filled with distilled water and the entire remaining track between them was filled with the test fluid. This made it possible:

a) to reduce the amount of fluid used in the tests;

b) to isolate it completely from the ambient medium;

c) to eliminate the need for washing the piezometer and Mariotte vessel when changing from one fluid to another (when working with polyorganosiloxanes this can be difficult);

d) to unify the measurement of the pressure head, always using the height of the water column regardless of the density of the tested fluid.

A higher pressure head was created in the installation by the pressure of compressed gas (nitrogen) in tank 38, then fed through reductor 18 from high pressure tank 39. The pressure and, consequently, the pressure head during discharge was measured by manometers of a high class of accuracy — 2, 3, and 4 on the figure (for different ranges of measurement). In these experiments tank 37 was used as a pressure vessel; it was preliminarily filled through filter funnel 7 (pours 10-15 μm) by the vacuum created vacuum pump 47.

During measurement of the flow of fluid discharged through openings in the diaphragm installed in flow vessel 34, rotating relay 42, connected by pressing the button of the electric timer 40, was used to cut off the flow.

In the total complex, more than three thousand experiments were run on the described installation. The temperature of the fluid in the experiments was 15-20°C; the pressure head was measured at 0.3 to 50 m H_2O. Experiments were conducted on three diaphragms for each of the openings.

As a summary of the obtained results, Fig. 3 shows the graph of the change in the discharge coefficient as a function of the value of the Reynolds number (calculated according to the ideal rate and the diameter of the opening).

The range of change of the Reynolds number is different in different series of experiments. This is connected with the fact that for each of the liquids the flow in the form of a jet began at a certain unique pressure head, the magnitude of which depends on the coefficient of surface tension, on viscosity, and on the diameter of the opening; these factors determine the minimum value of Reynolds number. As regards the maximum value of Reynolds number, it was determined by the coefficient of viscosity and by the diameter of the opening, since the limit pressure head in all cases was one and the same – 50 m H_2O (and therefore the ideal rate of discharge was also identical).

The accuracy of the experiments can be judged from the first of the graphs on Fig. 3. Experiments on the discharge of water through openings with diameters of 0.2 mm were conducted on three diaphragms which differed insignificantly, in fact inappreciably, in terms of surface configuration (ideally it should be flat) and in sharpness of edges of the apertures. As far as we were able to establish, diaphragm number 1 was the best. Experiments were conducted twice on this diaphragm at an interval of about two months. As the graph shows, the coincidence of points was excellent.

The remaining four graphs in Fig. 3 are summarizing (for all diaphragms); they show the presence of a definite dependence of flow rate during discharge on Reynolds number, related to experimental conditions.

It was found that for all the test liquids the general character of the change in the discharge coefficient was approximately one and the same: as the Reynolds number increases the discharge coefficient first grows, reaching a maximum value (ranging from 0.72-0.75 for the different liquids) and then gradually decreases; later, at high values of Reynolds numbers, it is stabilized at approximately 0.62.

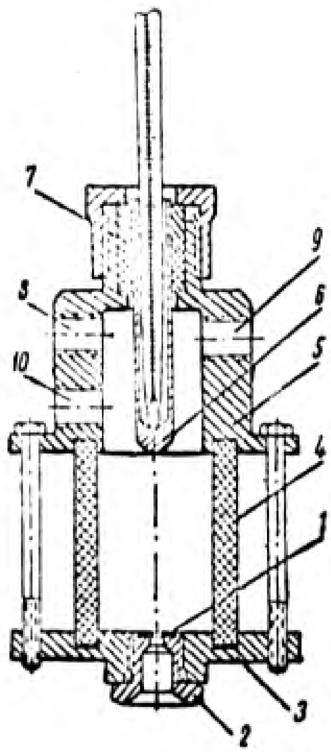

Fig. 2. Flow vessel: 1 – diaphragm; 2 – nipple; 3 – bottom; 4 – housing; 5 – cap; 6 – capsule for thermometer; 7 – packing; 8 – opening for release of air; 9 – opening for supply of liquid; 10 – opening for connection of manometer and piezometer.

However, with an effort to superimpose the graphs it was found that with summary regularities the changes in the curves are different for different liquids. The curves obtained as a result of mathematical treatment of all discharge rate values found by us are shown on Fig. 4. On the same graph there is plotted the curve constructed by A. D. Al'tshul' [1] and proposed by him as a universal curve, under the condition that the Froude number be greater than ten and the Weber number exceed two hundred. In our experiments the indicated conditions were met and there was thus a basis for comparison of the curves.

In comparing the curves relating to one class of liquids – polymethylsiloxanes PMS-1.5, PMS-10, and PMS-20 – it is evident that with an increase in the viscosity coefficient the region of increased values of the discharge coefficient is displaced to the left, to the side of smaller Reynolds numbers. The curve of polyethylsiloxane fluid PES-1, which is related to the polymethylsiloxane fluids but belongs to another class, passes on the graph at approximately the place where the curve of polymethylsiloxane liquid, identical in viscosity, would appear.

However, the curve for water, whose viscosity at our temperatures is comparatively small with respect to viscosity of PMS-1.5, is distributed quite differently. Evidently a difference in physical properties of the liquids is operative. The curves which we obtained do not coincide with the universal curve. Thus the question of the discharge coefficient during flow of viscous liquids through openings in a thin wall at small values of Reynolds number is more complex than has been assumed and will require further study.

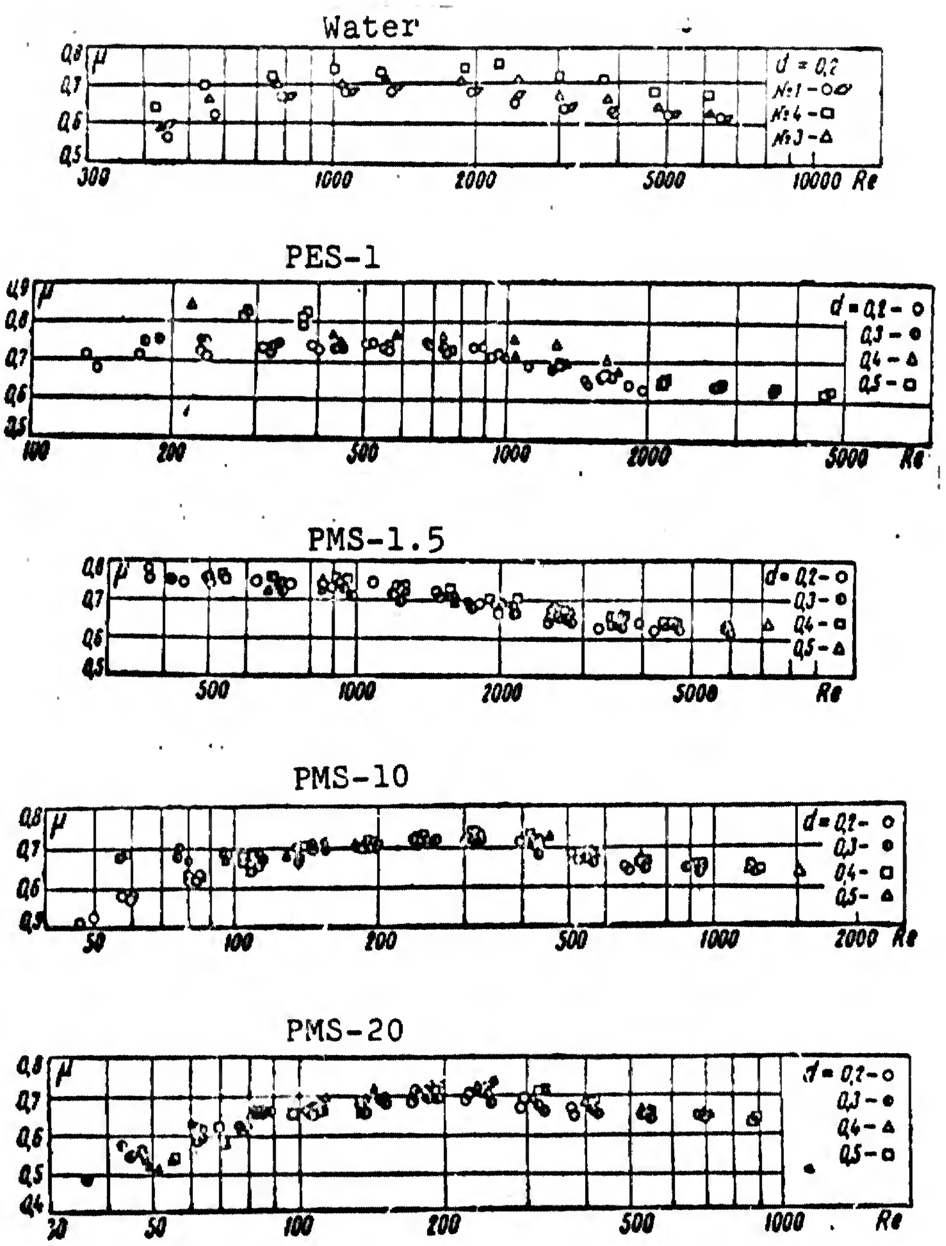

Fig. 3. Graph of change in discharge coefficient versus Reynolds number.

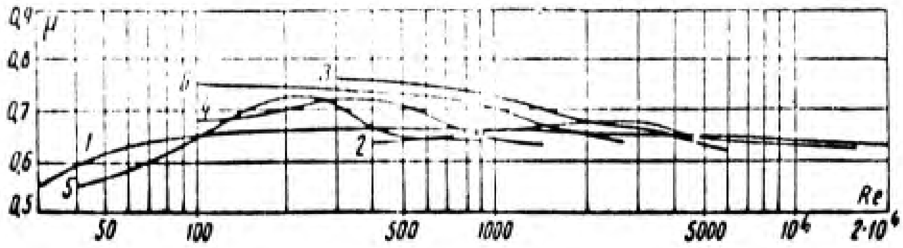

Fig. 4. Summary graph: 1 – Al'tshul' curve; 2 – water (ø0.2 and 0.5); 3 – PMS-1.5 (ø0.2 to 0.5); 4 – PMS-10 (ø0.5); 5 – PMS-20 (ø0.2-0.5); 6 – PES-1 (ø0.3).

References

1. Al'tshul', A. D. Mestnyye gidravlicheskiye soprotivleniya pri dvizhenii vyazkikh zhidkostey (Local Flow Friction During Motion of Viscous Fluids), Gostoptekhizdat, 1962.

2. Khatton, R. Ye. Zhidkosti dlya gidravlicheskikh sistem (Fluids for Hydraulic Systems), "Khimiya," 1965.

3. Andrianov, K. A. Teplostoykiye kremniyorganicheskiye dielektriki (Heat Resistant Organosilicon Dielectrics), "Energiya," 1964.

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