for the condition $\bar{l} > \bar{l}_0$, where l_0 is defined from the cited formula.

NOTATION

M_a is the Mach number at nozzle outlet; l is the mixing chamber length; $\bar{l}$ is the relative mixing chamber length; d_u is the diameter of useful cross-section of mixing chamber; $\bar{f}_u$ is the relative area of useful cross-section of mixing chamber; P_c is the pressure in chamber; P_0 is the stagnation pressure before nozzle; L is the chamber length; $\bar{L}$ is the relative chamber length; d_a is the diameter of outlet cross-section of a nozzle; f_a is the area of outlet section of a nozzle; n_{lim} is the limiting degree at which it is impossible to predict outflow of a jet; $\bar{l}_0$ is the relative optimum length of mixing chamber.

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THE PROBLEM OF THE THICKNESS OF A LAYER ENTRAINED BY A ROTATING DRUM PARTIALLY IMMERSED IN A LIQUID

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Results are presented from experimental studies of the thickness of a layer of viscous normal liquid entrained by a drum rotating at a speed greater than the boundary for the retention of shape in the static meniscus.

An estimate of the magnitude of the liquid layer entrained by rotating bodies of cylindrical shape is of great significance in studying problems relating to the application of a layer of dissolved substance onto the surfaces of bodies extracted from solutions; it is also important in the transmission of liquid lubricating materials, in the metering out of paints and adhesives in polygraphic and automatic packing machines, etc.

The problem of the slow withdrawal of a body from a nonmoving liquid has repeatedly been considered in the literature [1–8]. It has been established that the thickness of the entrained liquid layer is a function of the velocity of body motion, as well as of the viscosity, density, and surface tension of the liquid, and also of the distance of the point in question from the free surface of the liquid.

In this paper we have stated the following problems: 1) to determine the thickness of the layer entrained by a horizontal drum rotating at a speed in excess of the boundary for the retention of shape in the static meniscus; 2) to determine with greater accuracy the conditions under which the effect of surface tension ceases to make itself felt; 3) to establish the boundaries of applicability for the resulting relationships.

Characteristics of the Tested Liquids

Liquid	μ, (N · sec)/m^2	ρ, kg/m^3	σ, N/m
Transformer oil	0.0285	883.0	0.0315
33% transformer oil + 67%	0.069	884.5	0.0298
Compressor oil	0.250	896.0	0.0340
75% transformer oil + 25% compressor oil	0.038	887.0	0.0323

The work was carried out with viscous normal liquids (table) which wetted the drum surfaces very well. The viscosities of the liquids were determined by means of a capillary viscosimeter, the surface tensions were determined by a bubble-jumping method, and the density was determined with a pycnometer. Two steel-45 drums 80 and 60 mm in diameter and 100 mm long were used for the study. The thickness of the layer was measured with a micrometer screw to whose end a needle was attached. The idea behind the use of this method is not new [6]. It has been established that the boundary effect is sensed at distances to 13–14 mm from the ends of the drum, and the measurements were therefore carried out at points removed from the ends by no less than 20 mm. The experiments were carried out at a temperature of 24–30° C within a range of velocities at the drum surface from 0.03 to 0.35 m/sec for initial angles of $\varphi_0 = -12°30'$, $-20°50'$, $-33°30'$, and $-44°$, and for values of $\varphi = 10$, 45, 90, 130, and 155°.

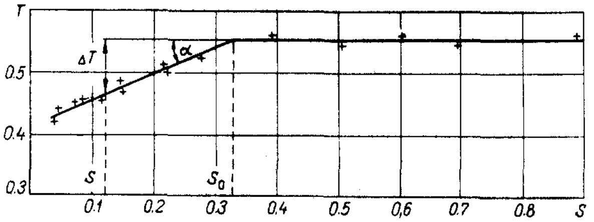

Fig. 1. Dependence of thickness of entrained layer on surface tension at P = 2.18.

In processing the experimental results, we obtained three dimensionless parameters by applying dimensional analysis, and these characterize the subject phenomenon:

$$T = h\left(\frac{\rho g}{u_0 \mu}\right)^{\frac{1}{2}}, \quad S = \frac{u_0 \mu}{\sigma}, \quad P = \frac{2\pi\Delta\varphi}{360}.$$

The parameters T and S account for the effect of the force of gravity and surface tension, while the parameter P characterizes the position of the subject point relative to the free surface. In the general case we can write

$$T = f(S, P).$$

Using the method of least squares to process the functions $T = f_1(S)$ for various values of P yields the equations of two straight lines:

$$T = 0.427\ S + \text{const}, \quad T = \text{const}.$$

In particular, Fig. 1 shows the function $T = f_1(S)$ for the case P = 2.18, which corresponds to values of $\varphi_0 = -33°30'$ and $\varphi = 90°$. The straight lines intersect for a value of $S_0 = 0.3225$, identical for all values of P. Figure 2 shows the function $T' = T + \Delta T = \psi(P)$. The method of determining ΔT follows from Fig. 1.

Each point in Fig. 2 represents the average of sixteen values of T' determined for four liquids at various points on the two drums, at various speeds and temperatures. The standard deviations from the mean fall within limits of 1–1.5%, with the greatest deviations occurring for the smaller values of P.

The processing by the method of least squares for the segment $P > P_0$ yields

$$T' = 0.657 - 0.045P \tag{1}$$

or, after substituting the values of T' and P,

$$h = \left(\frac{u_0 \mu}{\rho g}\right)^{\frac{1}{2}} [0.657 - 0.785 \cdot 10^{-3} \Delta\varphi]$$

$$\text{for } S \geqslant 0.3225, \tag{2}$$

$$h = \left(\frac{u_0 \mu}{\rho g}\right)^{\frac{1}{2}} [0.519 + 0.427\ S - 0.785 \cdot 10^{-3} \Delta\varphi]$$

$$\text{for } S < 0.3225. \tag{3}$$

In the region $P < P_0$ (Fig. 2) the thickness of the entrained layer is a function of the various extraneous phenomena defined by the influence exerted by the motion of the liquid in the bath. The experimental points here are therefore greatly scattered, the scattering all the greater, the closer the subject point to the free surface and the lower the viscosity of the liquid. The experiments carried out on the more viscous liquid demonstrated that the function $T' = \psi(P)$ in the region $P < P_0$ has the form

$$T' = \frac{0.306}{P} + 0.136. \tag{4}$$

The control experiments on the remaining liquids yielded a deviation from the values calculated according to formula (4) ranging from 3 to 15%. Since the region $P > P_0$ is most important for practical purposes, we can be satisfied with such accuracy. The combined solution of (1) and (4) yields $P_0 = 0.62$.

The experiments show that beginning with values of $S > 0.05$–0.06, the parametric relationship between the thickness of the entrained layer and the surface tension is linear. For values of $S < 0.05$, which corresponds to a drum speed of up to 0.05 m/sec, the following formula [1, 3] is valid:

$$h = \left(\frac{u_0 \mu}{\rho g}\right)^{\frac{1}{2}} 0.93\ S,$$

which yields the deviation from experimental data in the range 2–5%. With increasing rotational velocity the shape of the static meniscus is not retained and the divergence is increased, reaching 30% at a speed of 0.268 m/sec. Thus formula (3) is valid in the region $0.05 < S < 0.3225$. In the region $S > 0.3225$ formula (2) takes effect. With an increase in S there is pronounced agitation of the liquid in the bath, with the limit value of S being a function of the relationship between the speed and viscosity. The lower boundary for the appearance of waves lies within the range S = = 2.3–2.5.

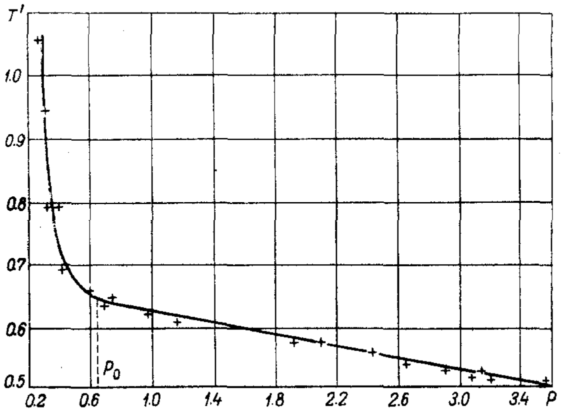

Fig. 2. Dependence of reduced thickness of entrained layer on position of point under consideration at drum surface.

NOTATION

h is the layer thickness; μ is the dynamic liquid viscosity; σ is the surface tension of the liquid; ρ is the liquid density; g is the gravity acceleration; u_0 is the linear speed of body extraction; φ is the angle between the horizontal axis of the drum end and the radius-vector of the point under consideration; φ_0 is the angle between the horizontal axis of the drum end and the radius-vector of the boundary at which the drum is immersed into the liquid.

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THE SPECIFICS OF THE SHOCK COMPRESSION OF MATTER IN CYLINDRICAL BOMBS

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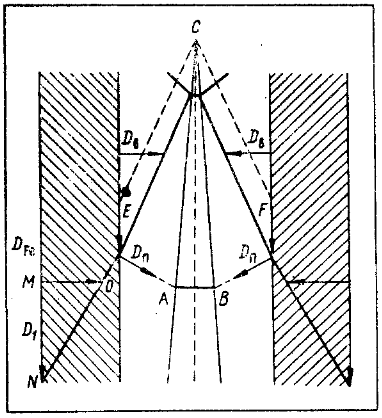
The dynamic pattern of the shock compression of a substance in cylindrical bombs is examined. It is demonstrated theoretically and experimentally that conditions are established in the center of the bomb for nonregular Mach repulsion.

In studying the shock compression of powders in cylindrical bombs, we noted that a narrow region ("filament") is established along the axis, this region noticeably different from the remaining mass of the substance in form and properties [1]. Thus, in compressing carbonates [2] in this region we find predominant decomposition of the substance, while with NaCl, CsBr, and the nitrates [3], we find the formation of defects. Within the "filament" we frequently encounter voids in the form of channels or vacuoles whose walls are fused. The "filament" usually appears in the case of a small bulk density for the material being compressed. As the bulk density is increased these effects are reduced.

It is interesting to examine the reasons for the appearance of the "filament" within the substance. The most important moment in the explosive compression of a steel bomb contained within a cylindrical explosive charge is the formation of the oblique shock-wave front within the substance (figure). This configuration arises as a result of the fact that the bomb is not simultaneously compressed over the entire surface, but successively.

As a matter of fact, at a certain instant in time the detonation front reaches the point M. From the point M the perturbation is propagated in the walls of the bomb at a velocity D_{Fe} and reaches the point O within a unit of time. Within this same period of time the



Shock wave configuration in a cylindrical ampul: ABC $= 2\beta$, opening angle of a head wave; ECF $= 2\alpha$, angle of impact of oblique shock waves; NO, shock wave front in ampul; EC, shock wave front in a substance.