INFLUENCE OF THE DIELECTRIC MATERIAL AND THE INTERELECTRODE GAP ON THE SPONTANEOUS ROTATION EFFECT IN ELECTRORHEOLOGICAL SUSPENSIONS

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The results are presented of an experimental investigation of the influence of the interelectrode gap and the dielectric properties on the velocity of rotor rotation in electrorheological disperse systems.

Various investigators [1-3] noticed at the end of the last century the existence of dielectric rotation in a constant electric field in nonconducting homogeneous media. The first efforts to interpret this effect qualitatively are contained in [4-7]. According to the hypothesis in [7], parts of the dielectric surface immersed in a liquid of low electrical conductivity must acquire charges of the same polarity as the sign of the corresponding nearby electrode. Then there is dielectric rotation because of the electrostatic repulsion of the slowly relaxing charge on its surface. The authors of [8, 9] constructed a dielectric motor on this principle. These investigations were not, however, carried any further because of the low intensity of the rotation in homogeneous single-phase liquids.

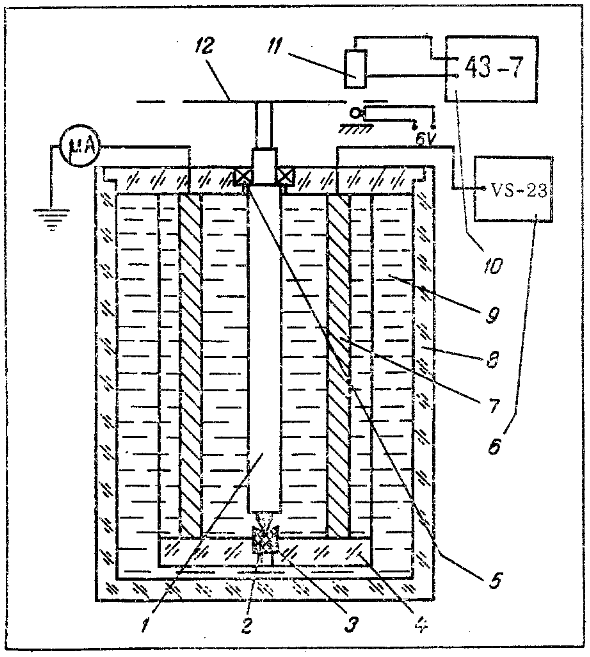

Fig. 1. Scheme of the experimental setup.

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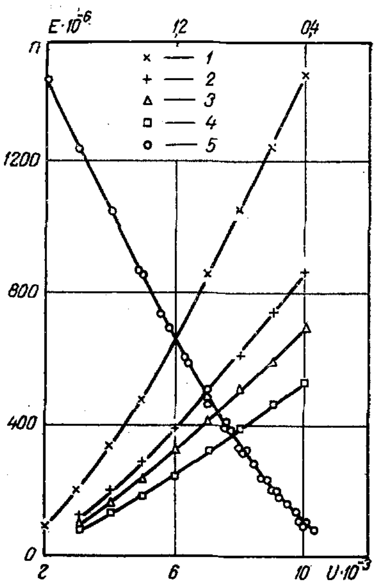

Fig. 2

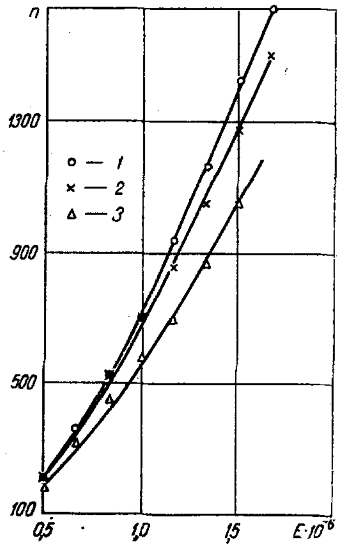

Fig. 3

Fig. 2. Velocity of ebonite rotor revolution n versus voltage U at different interelectrode gaps l: 1) 5; 2) 7; 3) 8; 4) 9 mm; 5) the same, versus electric field intensity E at gaps l corresponding to curves 1-4. E, V/m; n, rpm; U, volts.

Fig. 3. Velocity of dielectric rotor revolution n, rpm, versus electric field intensity E, V/m, for: 1) ebonite; 2) vinyl material; 3) plastic.

The demonstration that it is possible to intensity significantly the spontaneous rotation effect by using electrorheological systems as the working media [10] aroused heightened interest in the problem [11-12]. There is already an extensive list of possible practical applications of this effect, such as micromotors, various devices for determining the humidity of the dielectric substance, dispersion-phase concentrations, electric field intensities, automatic system elements, etc.

In our tests we have tried to establish the interrelation between the basic features of the process, especially the influence of the interelectrode gap and the properties of the material on the velocity of rotor rotation in electrorheological suspensions.

Figure 1 shows the experimental setup. A rotor 1 was made from various dielectrics and supported by a hardened metal needle 2 on a ruby point 3, fastened in the lower portion of the frame 4. A miniature rocker bearing 5 was the upper support. The electrical field was fed to the electrode 7 from a stabilized VS-23 power source 6. A hollow Plexiglas cylinder 8 was filled with an electrorheological suspension 9, A photoelement 11 determined the number of rotations by a perforated disk 12 lit from below, fit onto the rotor. The signal was read by the ChZ-7 frequency meter 10.

It is important to explain the scale effect, i.e., to determine the effect of the interelectrode gap, since investigations are usually performed on setups with various relations between rotor size and the dielectric gap. In a number of works [3, 9], the distance between electrodes is not even indicated; only the voltage supplied is given. Figure 2 shows the velocity of dielectric rotation n versus the homogeneous voltage U for varying interelectrode gaps l. As l increases, the steepness of the function n(U) decreases. Using the intensity $E = U/l$ instead of voltage, these four functions coincide (Fig. 2), which shows that there is no scale effect.

Sumoto [13] attempted to show in qualitative approximations the influence of the dielectric material on the rotation effect in homogeneous liquids of low electrical conductivity. However, he did not obtain any quantitative functions. Furthermore, tests reported in [13] used the same rotor, a hollow glass tube filled with various liquids. Consequently, the conditions at the dielectric separation boundaries, i.e., the working liquid, were unchanged, whereas they were precisely what should have been changed because of the rotor material.

In our investigations, we used five kinds of dielectric material. The working liquid was a diatomite suspension in 2.5% (by weight) concentration transformer oil.

Figure 3 shows that the material of the rotating body does not change the velocity of rotor rotation n as a function of the electric field intensity E, which is almost linear except for the beginning portion. The rotation speed, all other things being equal, is highest for an ebonite rotor; for other materials it is lower.

Textolite and asbestos-cement samples generally do not rotate, but stall in the interelectrode gap.

Figure 3 shows the connection between the change in the velocity of the dielectric rotor rotation n and the electrophysical properties of the material: between the specific resistance ρ and the absolute dielectric onstant ε. An increase in the rotation speed with a constant electric field intensity is connected to the increase of the specific resistance ρ and the decrease in the absolute dielectric constant ε. When $\rho < 10^{10-12}\ \Omega \cdot \mathrm{cm}$ and $\varepsilon > 5$, generally no rotation effect is observed (textolite and asbestos-cement samples). The rotation effect can be increased by lowering the specific resistance of the material. (A textolite rotor dried to a constant weight rotates.)

The possibility was shown earlier of increasing the stalling capacity of dielectrics under the action of shearing force on the condition that their humidity is regulated [14], which confirms this work. In this way, by changing the electrophysical properties of the dielectric rotor material, it is possible to intensify significantly the rotation effect in electrorheological suspensions.

NOTATION

U	is the voltage;
E	is the electric field intensity;
n	is the number of rotations;
l	is the distance between electrodes;
ρ	is the specific resistance;
ε	is the dielectric constant.

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