

ON DETERMINING THE SIZE DISTRIBUTION OF  
MACROPORES IN CAPILLARY-POROUS MATERIALS

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It is shown by experiment that the trend of the size distribution of macropores in quartz sand or in porous ceramics does not depend on the surface tension in the wetting liquid and on the specimen thickness.

Many methods [1-6] of determining the size distribution of pores are based on displacing the liquid which a body has absorbed by another liquid or by compressed gas. The wetting liquid is, usually, distilled water. When the porous material contains small pores ( $r < 10^{-7}$  m), however, then a determination of their size distribution requires higher pressure for displacing the absorbed liquid. In order to avoid the use of higher pressure with all the attendant difficulties, it is worthwhile to use, instead, wetting liquids with a smaller surface tension coefficient for a determination of small pore sizes.

In order to find out how the nature of the wetting liquid influences the measured differential characteristics of a porous structure, the authors made determinations of the pore size distribution in three fractions of quartz sand by wetting them with various liquids: water, ethyl alcohol, and sodium dodecyl-sulfate solution.

The differential size distribution curves were obtained by the method of compensating the negative capillary pressure [6].

The distribution curves for the three fractions of quartz sand are shown in Fig. 1. Curves 1, 2, 3 have been obtained by displacing water from the following three quartz sand fractions: 0.063-0.16 mm, 0.20-0.40 mm, and 0.40-0.63 mm. Curves 1' and 2' have been obtained by displacing ethyl alcohol from the first two fractions, curve 3' has been obtained by displacing sodium dodecylsulfate from the third fraction.

According to Fig. 1, the pore size distribution curves obtained by displacing the different liquids are identical within test accuracy ( $\pm 15\%$ ).

The peak of curve 1' (ethyl alcohol) corresponds to  $3 \mu$  smaller pores than the peak of curve 1 (water). For the middle fraction of quartz sand there is an excellent agreement between most likely pore sizes ( $92 \mu$ ) in both cases. As to the displacement of different liquids from the coarsest sand fraction, the peak of curve 3' corresponds to  $4 \mu$  smaller pores than the peak of curve 3.

Thus, the use of wetting liquids with different surface tension coefficients does not influence the results of a pore size determination. The differential curves are identical: their peaks correspond to approximately the same pore size, and they cover the same range of pore sizes.

Consequently, wetting the test specimens of disperse materials with a liquid whose surface tension is lower makes it feasible to apply a lower compensating pressure for its displacement.

In determining the differential characteristic of a porous structure by various methods [1-8], there arises the question concerning the effect of specimen thickness on the results.

In order to answer this question, the authors made determinations of the pore size distribution in quartz sand specimens of various thicknesses (25, 60, 90, 120 mm) and in porous ceramics (30, 50, 70

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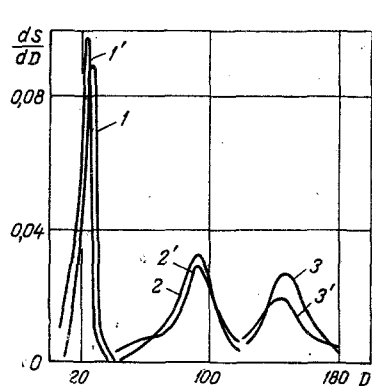


Fig. 1

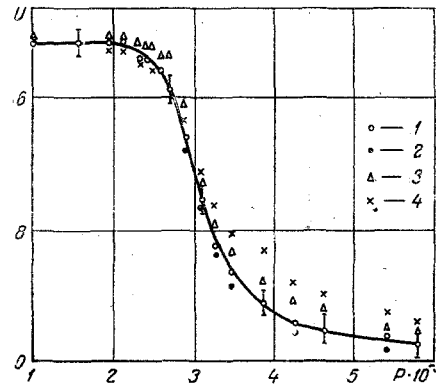


Fig. 2

Fig. 1. Differential  $dS/dD$  ( $\mu^{-1}$ ) =  $f(D)$  curves of pore size distribution ( $D, \mu$ ) for quartz sand fractions 0.063–0.16 mm, 0.20–0.40 mm, 0.40–0.63 mm, obtained by wetting with various liquids: 1) 0.063–0.16 mm fraction with water; 1') 0.063–0.16 mm fraction with ethyl alcohol; 2) 0.20–0.40 mm fraction with water; 2') 0.20–0.40 mm fraction with ethyl alcohol; 3) 0.40–0.63 mm fraction with water; 3') 0.40–0.63 mm fraction with sodium dodecylsulfate solution.

Fig. 2. Percent moisture content  $U$  (%) as a function of the excess pressure  $P$  ( $N/m^2$ ) in 0.20–0.40 mm quartz sand, for layers of thickness  $l$  (mm): 1)  $l = 25$ ; 2) 60; 3) 90; 4) 120.

mm). The distribution curves were determined by the method of compensating the negative capillary pressure [6].

In Fig. 2 are shown test data representing the percent moisture content per layer of 0.20–0.40 mm quartz sand, as a function of the excess air pressure, in layers of the various thicknesses.

During these tests the compensating pressure was raised by the same amount in all four cases. According to Fig. 2, the pressure at which the displacement of absorbed liquid began was the same  $2.3 \cdot 10^3$   $N/m^2$  regardless of the specimen thickness. The pressure at which this process ended was  $6 \cdot 10^3$   $N/m^2$ . The scatter of test points for each specimen thickness is within the limits of measurement error.

Differential curves of the pore size distribution in these quartz sand specimens are shown in Fig. 3a.

The distribution curves cover the same size range (40–120  $\mu$ ). The most likely pore size is 92  $\mu$ . The peak of curve 2 (specimen thickness 60 mm) is shifted to 2  $\mu$  smaller pores, but such a shift is within the accuracy limits for this case.

The curves in Fig. 3b represent the size distribution of pores in porous ceramics of various thicknesses.

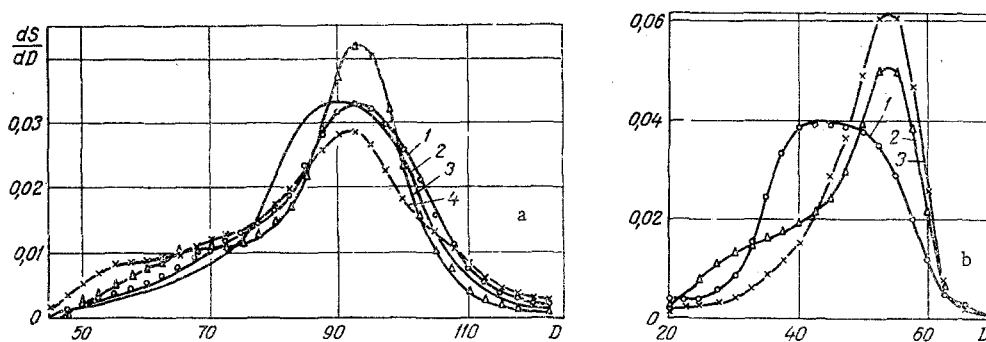


Fig. 3. Differential  $dS/dD$  ( $\mu^{-1}$ ) =  $f(D)$  curves of pore size distribution ( $D, \mu$ ). a) For quartz sand (0.20–0.40 mm fraction) specimens, thickness  $l$  (mm): 1)  $l = 25$ ; 2) 60; 3) 90; 4) 120. b) For porous ceramic specimens, thickness: 1)  $l = 30$  mm; 2) 50; 3) 70.

All distribution curves for the ceramic specimens cover the same range of pore sizes (20-70  $\mu$ ). The peaks of curves 2 and 3 correspond to 52  $\mu$  pores. The peak of curve 1 is shifted to 6  $\mu$  smaller pores, which is also within the accuracy of this method.

Thus, a comparison between the distribution curves, which have been obtained for porous specimens of various thicknesses by compensation of the negative capillary pressure, indicates that the specimen thickness does not influence the results of a determination where the differential curves cover a range within the error limits of the method.

In the case of porous ceramics, the distribution curves differ somewhat in their trend and peak sharpness. Thus, curves 2 and 3 (specimen thickness 50 and 70 mm, respectively) have sharper peaks than curve 1. For thicker specimens, the curves become asymmetrical with respect to the peak ordinate.

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