LETTERS TO THE EDITOR

COMBINED ACOUSTIC AND HIGH-FREQUENCY DRYING OF CAPILLARY-POROUS MATERIALS

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Inzhenerno-Fizicheskii Zhurnal, Vol. 10, No. 4, pp. 542–544, 1966

UDC 66.047

Acoustic drying permits accelerated removal of moisture from a material along with simultaneous reduction of the process temperature [1, 2]. Further intensification of drying is possible under combined (simultaneous) action on the material of elastic mechanical and high-frequency electrical oscillations. The premise here is that the high-frequency electrical oscillations constitute an internal heat source in the material, shifting the moisture to the surface, while the elastic mechanical oscillations in the sonic range secure its intensive removal from the surface.

The experimental arrangement for carrying out comparative investigations of acoustic, high-frequency, and combined drying techniques (Fig. 1) consisted of a gas-jet radiator 1 [3] (type GSI-4), a chamber 2, a modernized high-frequency oscillator 3 (type LDl-2) with electrodes 4, a recording balance 6 [4] with a frame 8 suspended from a nylon fiber arm, a potentiometer 7 (type EPP-09M), and a teflon adapter 9 for holding the specimen 5. Measurement of the sound pressure level and of the sound frequency was effected with the barium titanate sensor 13, amplifier 14 (type AZ-2), the vacuum-tube voltmeter 15 (type VKS-7B), and the frequency meter 16 (type ICh-7). The pressure and the air flowrate were controlled with the help of the manometer 17 (accuracy class 0.4%), and the flowmeter with secondary instrument 18.

The capillary-porous specimen was a cylindrical ceramic plate of diameter 110, thickness 24 mm, and moisture content 0.28 kg/kg. Three copper-constantan thermocouples of length 50 mm and wire diameter 0.2 and 0.15 mm were fixed into the specimen in predrilled holes. One thermocouple was in the center of the specimen, and the other two at a distance of 4 mm from the faces of the plate. The free ends of the thermocouples were connected periodically to the millivoltmeter 12 (type M195/1) through the mercury contacts 10, immediately after switching off the high-frequency oscillator, as recommended in [5].

During a test the weight loss and the temperature in the three layers of the specimen were recorded. The sensitivity of the balance was 0.5 g per division, and the accuracy 0.7%; for temperature measurement the corresponding figures were 0.7° C per division and 0.7%.

The acoustic field during the tests was described by a sound pressure level of 168 dB at frequency 7 kc, and the high-frequency electrical field—by a voltage of 0.6 kV on the electrodes at a frequency of 40.68 Mc.

The combined drying was carried out in three regimes. As may be seen from Fig. 2, acoustic drying occurred in the first period at a greater rate than high-frequency drying. After the moisture content had dropped by almost a factor of three (from 0.292 to 0.104 kg/kg), the rates became equal (the curves intersect). Thereafter the high-frequency drying rate is greater than the acoustic rate. Meanwhile the temperature of the material under acoustic drying is lower by 2–3 times.

The drying rate in the combined method is greater than under separate drying in the acoustic or high-frequency field, throughout the entire drying process. The temperature of the material in the combined method (78° C) is lower than in the high-frequency case (96° C), but higher than in the acoustic case (32° C).

Under the combined drying a positive temperature gradient is maintained in the material, reaching a maximum of 8° C/cm in our tests. The drying rates were as given in the table.

The tests carried out with various drying methods have shown that the combined method permits an increase in drying rate of 30–90%, as compared with the acoustic method, and of 60–30%, as compared with the high-frequency method. In the latter case

Comparative Drying Rates

Drying method	Moisture content, kg/kg		
	0.28—0.20	0.20—0.10	0.10—0.04
	Drying time, min.		
Acoustic	21.0	45	85
High-frequency	26.5	45	59
Combined	16.5	30	44

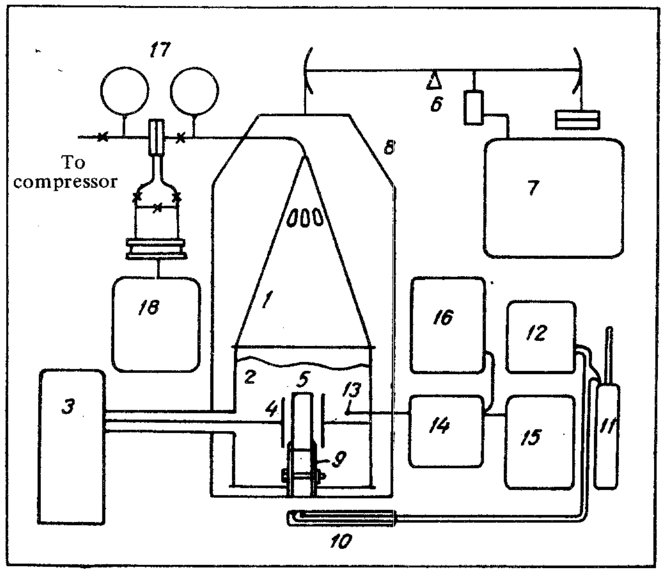

Fig. 1. Experimental setup (11—Dewar flask with melting ice).

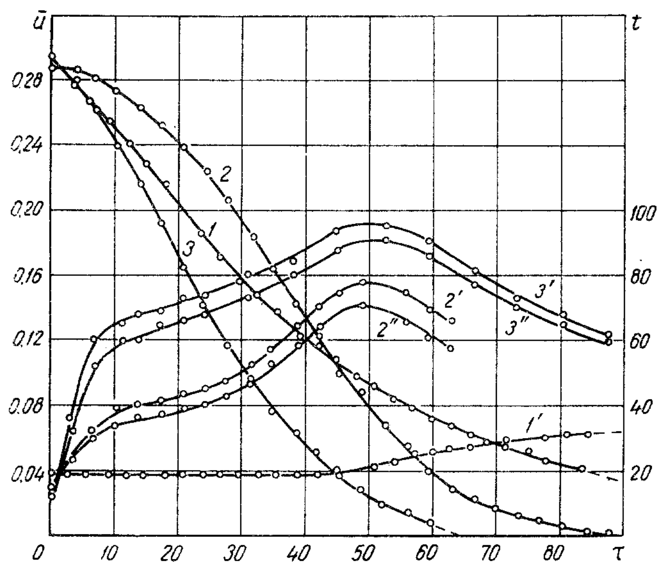

Fig. 2. Drying kinetics of a ceramic plate (1) acoustic; 2) high-frequency; 3) combined drying) and the corresponding temperature curves (1') for the case $t_0 = t$; 2', 3', and 2", 3") for temperatures in the middle of the specimen t_0 and at a distance of 4 mm from the faces t). The moisture content $\bar{u}$ is in kg/kg, t in °C, and τ in min.

the temperature of the material is reduced at the same time.

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19 May 1965

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