ULTRASONIC SPRAYING OF THERMOLABILE MATERIALS AND THEIR DRYING IN THE ACOUSTIC FIELD

The improvement of spray-drying of materials possesing low thermal stability is connected with increasing spray-drier capacity due to raising the temperature of the drying agent fed into the tower. The biological value of the finished product, however, decreases, its protein is denaturated and product incineration increases (most fine particles are burnt out).

In the meat industry blood, bouillons and such solutions as a proteinaceous enricher are spray-dried. Spray-drying has not become popular as it is of low efficiency. The improvement and an increase of the economic efficiency of spray-drying are important and urgent.

Drying process utilizing powerful acoustic vibration is advantageous over the conventional method of drying: drying potential is reduced and the process proper is improved; here, if a material is suspended, its treatment with acoustic waves becomes easier, and therefore, acoustics utilization is most perspective in spray-driers.

Technico-economical indices of a spray-drier and drying rate are affected with the quality of spraying of the material being processed. It is especially important when drying thermolabile materials which include almost all the proteinaceous substances processed at meat packing plants /1, 2/.

In the VNIIMP an ultrasonic spraying pilot plant was built for drying thermolabile materials in the acoustic field. Its schematic diagram is shown in Fig. 1.

The acoustic field in the drying tower is developed with gas-jet rod emitters which are fed with compressed air from a compressor house. An ultrasonic sprayer can be replaced with a disk one having a reducer. This allows to perform comparative experiments on ultrasonic and conventional drying processes.

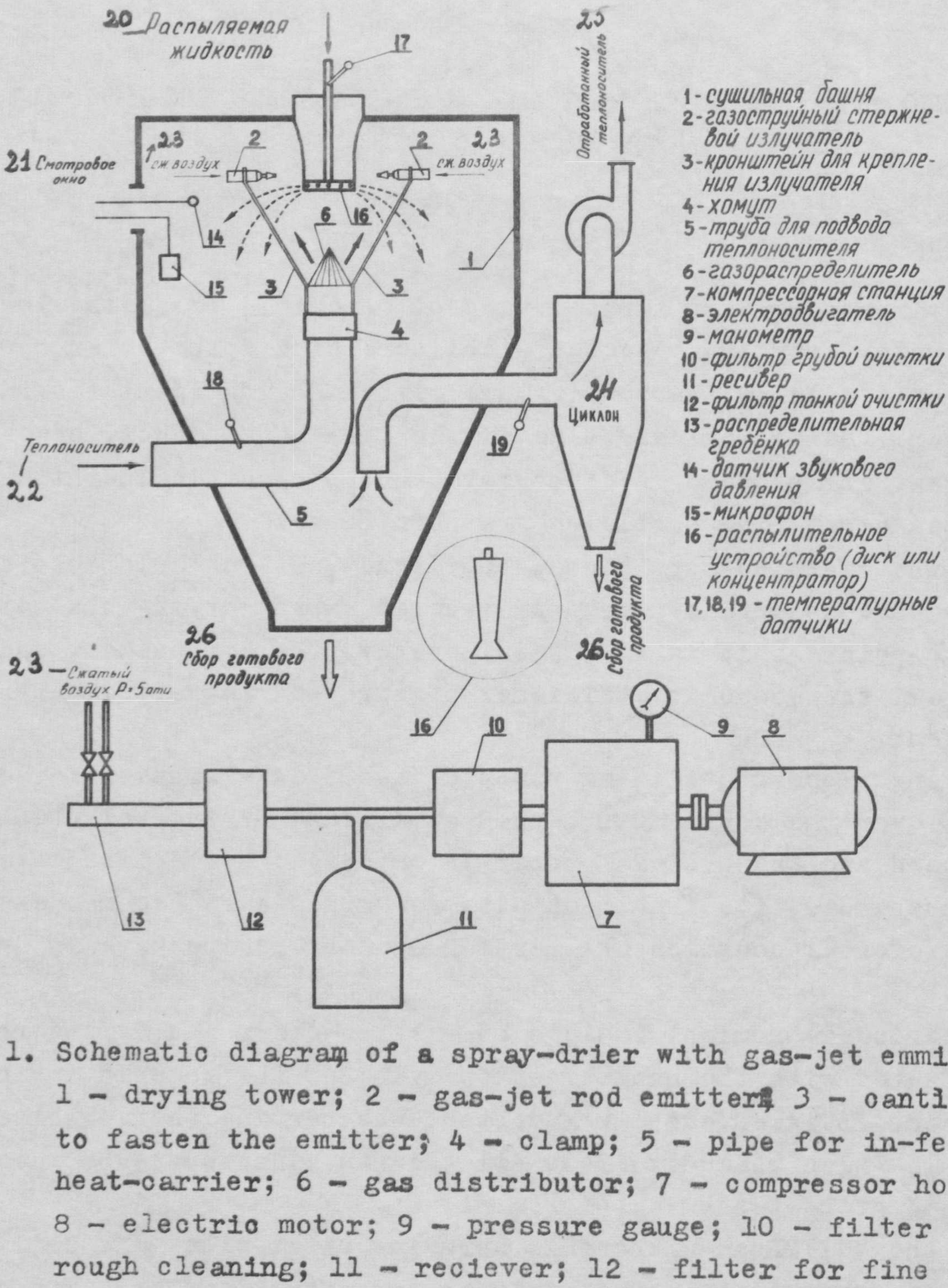


Fig. 1. Schematic diagram of a spray-drier with gas-jet emmitter
1 – drying tower; 2 – gas-jet rod emitter; 3 – cantilever to fasten the emitter; 4 – clamp; 5 – pipe for in-feed of heat-carrier; 6 – gas distributor; 7 – compressor house; 8 – electric motor; 9 – pressure gauge; 10 – filter for rough cleaning; 11 – reciever; 12 – filter for fine cleaning; 13 – distribution comb; 14 – transducer of sound pressure; 15 – microphone; 16 – spraying device (disk or concentrator); 17,18,19 – temperature sensors; 20 – liquid being sprayed; 21 – inspection window; 22 – heat-carrier; 23 – compressed air; 24 – cyclone; 25 – used heat-carrier; 26 – collection of the finished product

Gas-jet rod emitters operate stably at frequences 14.5-15 kcs and develop sound pressure up to $1x10^4$ w/m^2. An ultrasonic sprayer is an acoustic transformer in the form of a rod with a round cross-section and with an outside exponential surface. The rod ends with a visor which serves as a sprayer proper. The driving generator for a magnetostrictive packet is an ultrasonic generator operating at the frequency 20 kcs.

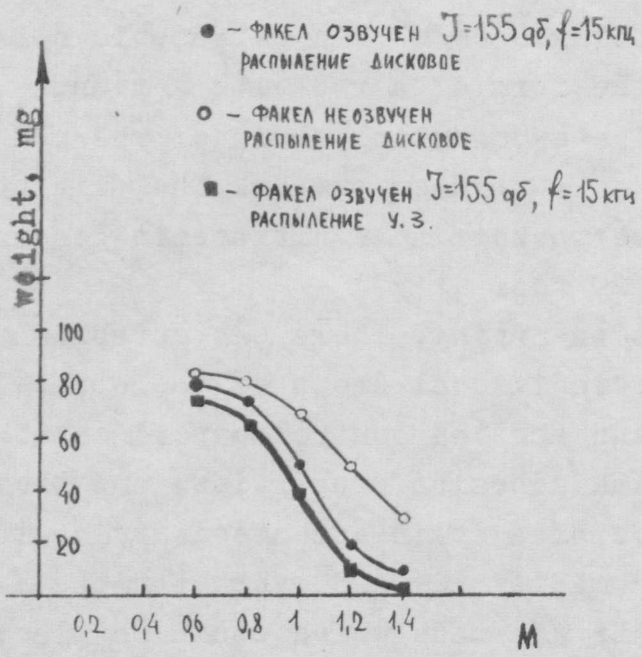
When performing experiments on drying, there was established a ratio of the drying times for individual drops of the sprayed liquid for spray sonification and for the control experiments.

The particles dried have weak adhesion properties, and their sticking onto the inside surface of a stainless steel drying tower takes place only at their humidity 10% and over. For the experiment, a stainless steel plate was made which could be placed at any point of the spray through an inspection window by means of a rod.

The plate was equipped with a protective screen, this permitting the exposure of the former in various points of the spray for a certain period of time. Exposure time for the plate without such a protective screen in all the cases was 5 min. Then the plate was removed from the tower, dried to the constant weight and weighed (in case of the control experiment the weight of the particles sticked onto the plate was determined). For spraying protein solutions of the same batch were used.

The curves of Fig. 2 shows changes in the weight of the adhered particles as related to their distance from the centre of the spray for ultrasonic and disk spraying, during sonification and under the control experimental conditions, Fig. 2 shows that in case of ultrasonic spraying and of sprayed particles drying in the acoustic field, the particles have the least adhesive properties, i.e. the drying process proper takes shorter periods of time. This is indicative of the fact that ultrasonic spray-drying can be carried out at lower temperatures without affecting the capacity of the equipment used.

During ultrasonic drying and in the control experiments the temperatures of the drying agent and of the material being dried were measured by the height of the drying tower.



● - with sonification of the spray J=155 db, f=15 kcs, disk spraying

o - without sonification of the sptay, disk spraying

■ - with sonification of the spray J=155 db, f=15 kcs, ultrasonic spraying

Fig. 2. Relationship between the weight of the particles, which did not lose their adhesion, at ultrasonic and disk spraying, and the distance from the centre of the spray

Sprayed particles temperature was measured by means of the device developped by Z.R.Gorbis. A chromel-copel thermocouple (the diameter of the measuring junction was 1 mm) was placed into a fluoroplastic container, which was fastened to a rod and put into the drying tower through an inspection window. The sprayed particles filled the container and their temperature was taken. This method allowed to measure the temperature of the total polydispersed particles of the material sprayed at any point of the drying tower volume.

The curves in Fig. 3 shows the relationship between sprayed material temperature and the height of the drying tower with and without acoustic field; for the sake of comparison, experiments were performed on the material of the same ultimate humidity dried by means of acoustic transformers and under the control conditions. From the Figure it is obvious that the sprayed material, dried in the acoustic field, was heated maximum up to 110°C, whereas the control one - up to 120-125^{o}C, the rate of temperature rise during sonification in the zone between the spraying level and heat-carrier inlet being higher as compared to the control experiment.

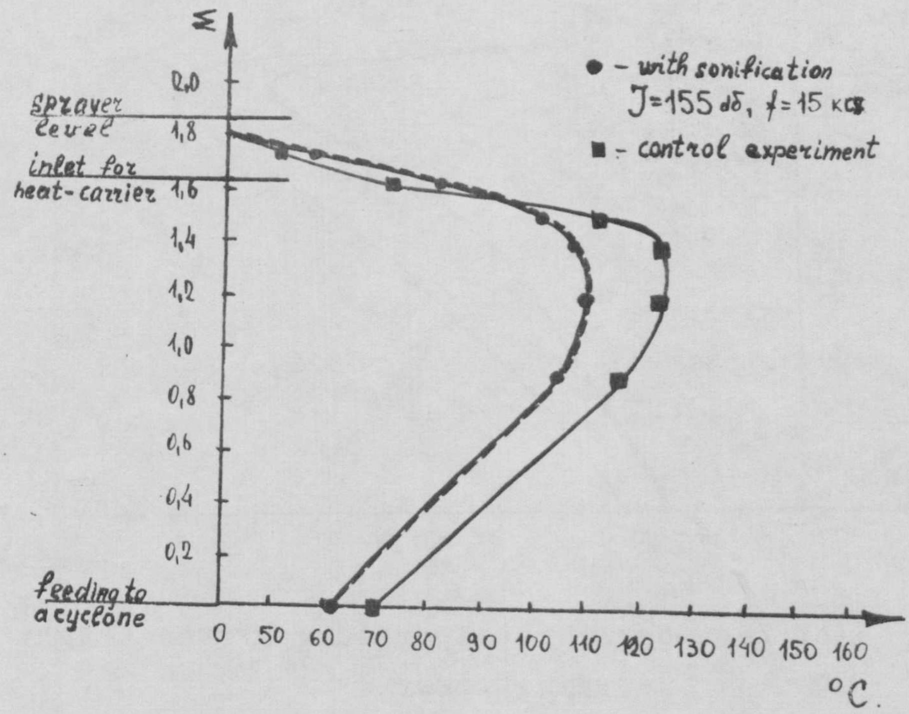


Fig. 3. Changes of the temperature of the material sprayed by the height of the drying tower

The curves in Fig. 4 show changes in heat-carrier temperature as related to the height of the drying tower, when drying blood plasma with the acoustic field and without it. To prevent drops and particles from contacting the measuring junction, the method of passive mechanical prevention was used. For this, above the junction of the thermocouple a thin-walled metallic cup was secured, and the sensor was oriented in space so that the particles did not touch the sensing element.

The data of the graph in Fig. 4 were chosen from the total number of the experiments carried out, so that the ultimate humidity of the dried-up product in the test and control experiments were similar.

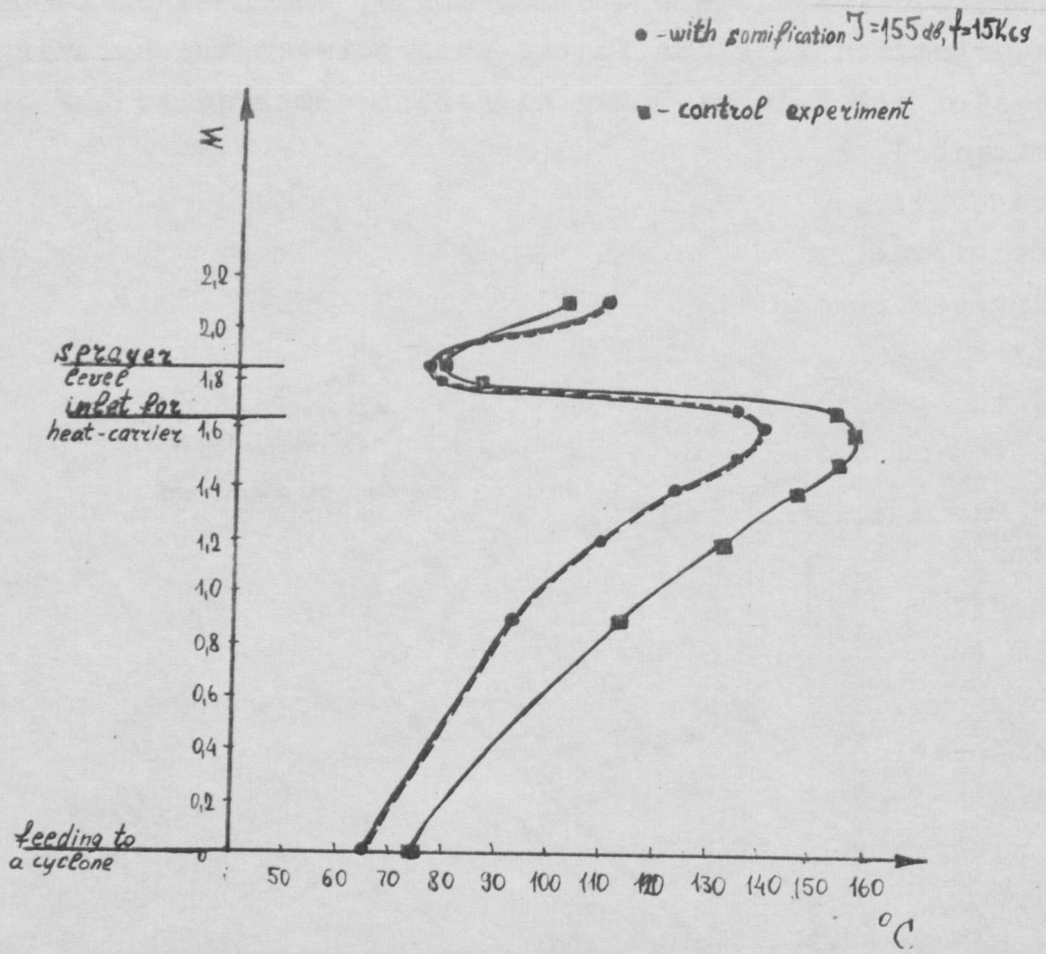


Fig. 4. Changes of heat-carrier temperature by the height of the drying tower

By the averaged data, product humidity in the drying tower was 3.49% and in the cyclone - 5.36%. Spraying and drying processes were milder in case of acoustics application. The percentage of ash in the dried product was found to fall with acoustic drying, on the average, by 10-15%, as the temperature at the inlet to the drying tower was lower in this case.

To study the possibility of ultrasonic dispersion of solutions, a series of experiments was conducted, which related the acoustic power of the ultrasonic sprayer, solution relative viscosity and the average diameter of particles resulted from spraying. The analysis of the data obtained showed that acoustic power influenced significantly the character of dispersion, as with its increase particles average diameter became smaller. It was also established that, with increasing acoustic pressure from 1 w/cm^2 up, solutions of different viscosities were dispersed practically similarly. This means that, when the threshold value of the acoustic power of the spraying acoustic transformer is exceeded, the physical properties of the liquid do not affect the degree of fineness of the particles sprayed. This is important because many biological thermolabile solutions being spray-dried possess high viscosity.

One of the basic parametres, by which the operation of a spraying device can be evaluated, is the distribution of spraying density along spray radius. To determine spraying density in the spray, the pre-set rate of the liquid fed for spraying was first calculated. Then, the measuring cups were sprayed for a certain period of time. And, finally, the volume of the liquid collected was measured in each cup.

In our experiments we varied liquid rate fed for spraying from 10 to 40 kg/hr (2.78 to 11.1 g/sec., respectively).

The investigations showed that a concentrator with the exponential outside surface developed a symmetrical circular spray. Spraying density in the ultrasonic spray rises up to a certain limit with increasing the distance from its centre. With liquid rate from 15 up to 40 kg/hr, the maximum spraying density in the ultrasonic spray shifts, respectively, from the centre from 0.3 to 0.7 m (Fig. 5), this being optimal for such sprayers.

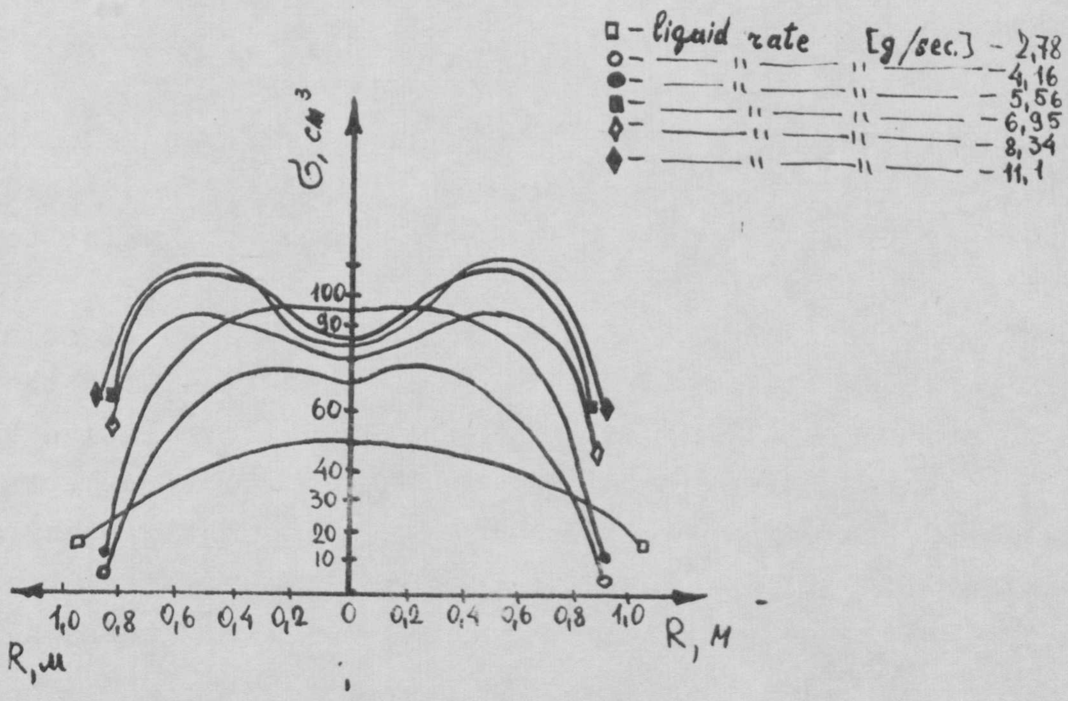


Fig. 5. Spraying density during ultrasonic dispersing

During liquid dispersion by means of an acoustic transformer, a symmetrical circular spray is developed with the degree of fineness sufficient to qualitatively dry a thermolabile solution (finished product humidity is about 5%, ash content decreases by 10-15%).

When drying the dispersed solution in the acoustic field, it is possible to reduce drying potential without affecting the capacity of the drying tower, by this improving the quality of the finished product.

LITERATURE

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