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DISPERSION OF DROPLET STREAM IN VIBRATING ORIFICE AEROSOL GENERATOR

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Berglund-Liu vibrating orifice aerosol generator is a suitable device for generating liquid and solid aerosols in the size range 0.5-50 μm.

This generator has been used for thorough investigation of the conditions for generating monodisperse droplets. These investigations have been based on the theory of break-up of cylindrical liquid jets and experimental data [1,2].

By direct microscopic measurement of several thousands of droplets and statistical analysis it has been proved that the size distribution of primary droplets is very narrow (geometrical standard deviation σ_g is below 1.01) [3,4].

On the basis of the experimental data of Berglund and Liu, Wedding et al., and Tamme and Koppelmaa [1,2,4] it can be claimed that a correct choice of the dispersion parameters makes it possible to completely exclude the generation of the so-called satellite droplets which are smaller than the primary droplets, however, it is not possible to rule out the generation of the so-called multiplets which are larger than primary droplets.

The multiplets can be defined as compound-droplets formed in the coagulation of two or more droplets, the diameter of such compound-droplets can exceed that of a primary droplet 1.26; 1.59; etc. times. In the best dispersion mode the main droplets are accompanied only by doublets formed in the coagulation of two primary droplets [4].

Statistical processing which, in addition to the primary droplets, takes into account the multiplets yields a wider size distribution and σ_g is in the range 1.038-1.1 [4,5].

Using an optical aerosol counter Berglund and Liu [1] have studied the relative multiplet content of aerosols in dependence on the consumption of dispersion airflow. They demonstrate that the content of multiplets in the output aerosol depends strongly on the consumption of dispersion air, but it is not indicated, how it would be possible to choose the optimal consumption which would ensure maximum quality of the output aerosol (minimal multiplet content).

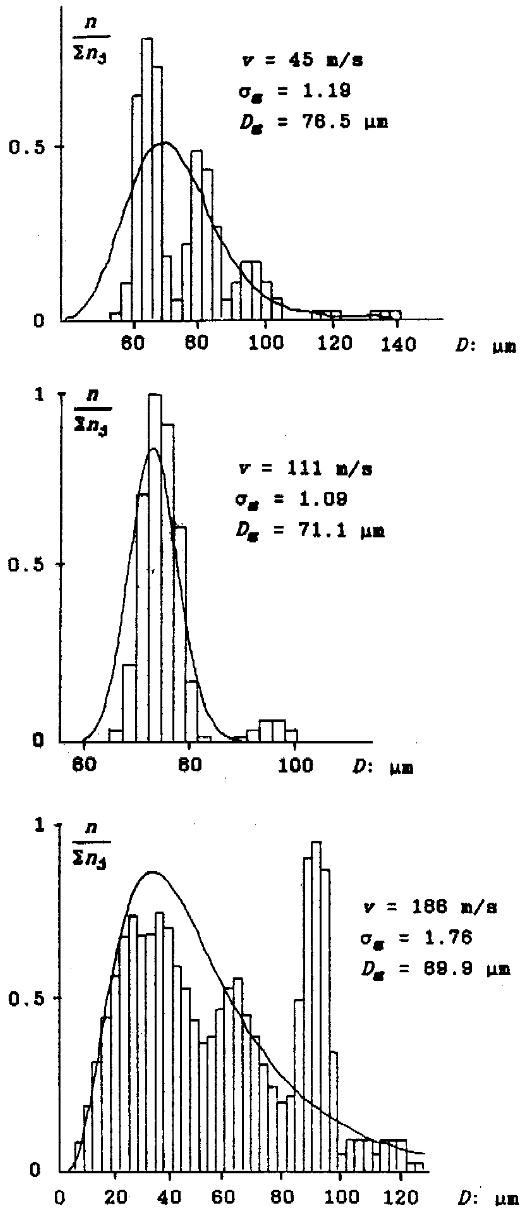

Fig. 1, 2 and 3. Droplet size distribution.
v = 45 cm/s, 111 cm/s and 186 cm/s.

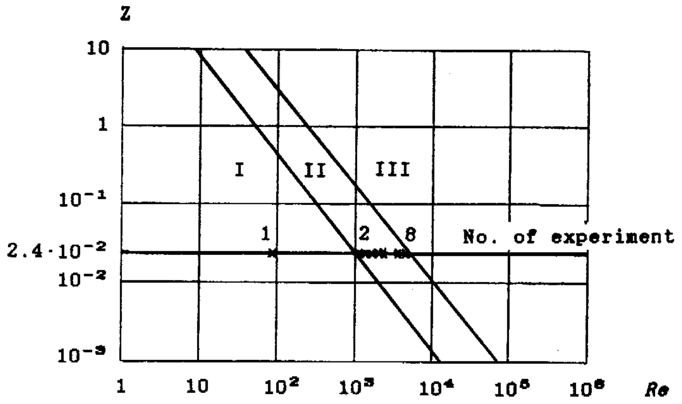

Fig. 4. Graphic dependence of the disintegration of the jet on the Reynolds number.

Tamme and Koppelmaa [4] have made an experimental study of the change of spontaneous jet dispersion, if the jet is submitted to low-amplitude axis-symmetrical mechanical vibrations. This investigation was based on the study by Ohnesorge [6] and showed that the use of mechanical vibrations turns the size spectrum into a discrete entity, i.e. there are separate peaks for primary droplets, doublets, and triplets (see Figs. 1 and 2). This made it possible to connect the peculiarity of the droplet spectrum with the hydrodynamic and geometrical parameters of the dispersion process (e.g. the Reynolds number *Re* and the jet diameter D_j).

In the experiments an aerosol generator with vibrating orifice designed at Tartu University was used to study the influence of the relative speed of the dispersion air and the jet (distilled water) on the percentage of multiplets in the stream of monodisperse droplets. The jet diameter D_j = 25 μm, the voltage on piezoelectric ceramic U_c = 20 V and 50 V, the relation of the disturbance wavelength and the jet diameter was λ/D_j = 4.5. In these conditions a stream of monodisperse droplets was produced.

In the experiments the droplets were collected on Petri's disks covered with a thin layer of vaseline oil, shortly after that the disks were photographed. The measurement and counting of the droplets was done on a film using a semi-automatic coordinate digitizer *UT-7603* [7].

The speed of the air in the nozzle was computed according to the classical method [8] using the measurement of static and total pressures in the atomizing air. The results of the experiments are summarized in Table 1.

Table 1

Comparison of U_c (ceramic voltage), v, Re, σ_g and the relative multiplet content for different velocities of atomization air.

No. of experiment	U_c V	v m/s	Re	Multiplets %	σ_g	D_g mm	No. of figure
1	50	4	94	-	1.26	104.1	
2	50	45	1090	-	1.19	76.5	Fig.1
3	50	70	1688	2.5	1.04	66.6	
4	20	108	2596	11.1	1.10	69.8	
5	50	111	2660	5.6	1.09	71.1	Fig.2
6	50	114	2729	6.7	1.09	68.1	
7	20	152	3645	6.9	1.22	62.7	
8	20	186	4455	-	1.76	69.9	Fig.3

For some dispersion modes figures depicting the size distributions of droplets are added.

Conclusions

From Table 1 the results of the experiment have been transferred to Ohnesorge's graph [6] (Fig. 4). For the liquid used (distilled water) and the jet diameter D_J a line parallel to the abscissa is formed. The discrete change of the size distribution of the droplets makes it possible to observe clearly the transition from region II to the region of complete dispersion (III) (see Fig. 3). The most monodisperse dispersion mode is in region II.

Consequently, it can be said that Ohnesorge's graph makes it possible to determine optimal linear velocities of the atomizing air in a Berglund-Liu type device for several dispersed agents and orifice apertures D_A.

The ratios of D_A/D_J are linear and range from about 0.84-0.96 for jet velocity range of 7 m/s to 25 m/s [3].

Thus in addition to the parameters λ, D_J, U_c [1] the region of monodisperse dispersion is determined by the parameters

$$Re = \frac{vD_J\rho}{\mu} \quad \text{and} \quad Z = \frac{\mu}{\sqrt{\rho\sigma D_J}},$$

where v - relative speed of liquid and air jet, D_J - jet diameter, ρ - liquid density, μ - dynamic viscosity of the liquid, σ - surface tension of the liquid.

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