UDC 621.9

Part 3

ASH AND SLAG HANDLING

3.3. Ash and slag properties

3.3.9. Shape and grain size measurement of microspheres

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In commonly adopted opto-electronic measuring methods [1] each measured grain is compared to a sphere, independently of its actual shape, only having in mind the calculation simplicity. With such a method the grain-size characteristics of the given material is explicitly defined. In case when such results are compared with the mechanical sieving results, it is possible to make conclusions about the grain form, because the measurement of spherical particles should give similar results in both methods, while the larger are the differences in measurements, then the particles are more elongated or flattened.

A method has been developed for the particle sphericity control, which provides a concurrent measurement of two perpendicular particle dimensions. Such a method [2] requires the use of significant measuring frequencies, i.e. the high-speed and high-resolution A/D converters.

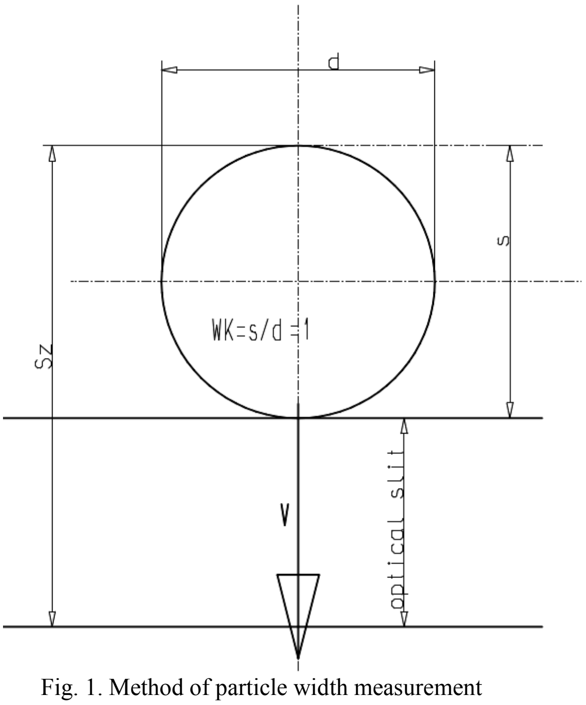

Fig. 1. Method of particle width measurement

When measuring the **d** diameter presented in Fig. 1 and counting down the number of measurements caused by a particle moving through the optical slit, one can calculate such an s, which after calibration will be equal to **d** for the spherical particles.

The problem cannot be fully resolved by the considerations presented above. The particles can be of smaller or greater weight and this highly influences the measuring time. Let's consider the sedimentation speed of a **d** particle in a tube of diameter **D**. According to Orzechowski [3] the speed of such particle drop is different from the speed in the open space due to the fact that the particle sedimentation speed near the tube wall is different than the speed on the tube's axis of movement.

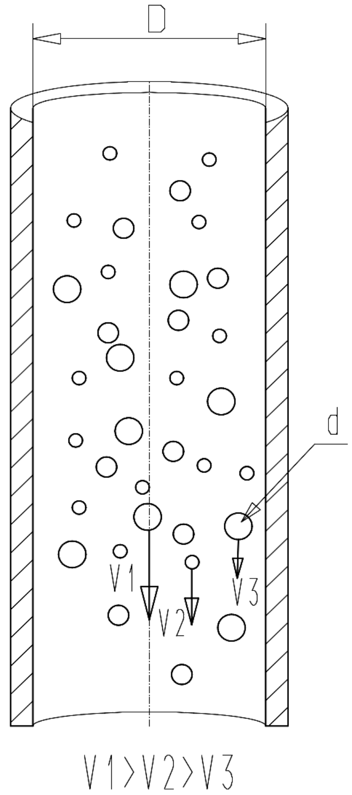

Fig. 2. Variations of particle speed in the suction tube

The average speed of particle sedimentation is illustrated by the curve "***b***" in Fig. 3. If the particle suction speed **Vp** (suction performed by the analyser) is added to the particle sedimentation speed, then the curve "***a***" can be obtained (Fig. 3).

When calibrating the spherical particles according to size and density, one can use a curve "***c***", which represents particles of the same specific weight and differing in the dimension. The curve "***c***" in Fig. 3 presents the particle width characteristic for spherical particles of the same specific weight equal 2,5 g/cm^3.

Having more of such curves "c" will allow to determine the measuring spectrum of different spherical particles. In order to obtain that it is necessary to have many spherical samples of different materials and specific weights.

Different particle speeds in the suction tube give dispersion of results for spherical particle width, but the mode value obtained from such measurements only for few tens of particles has a precise and repeatable value

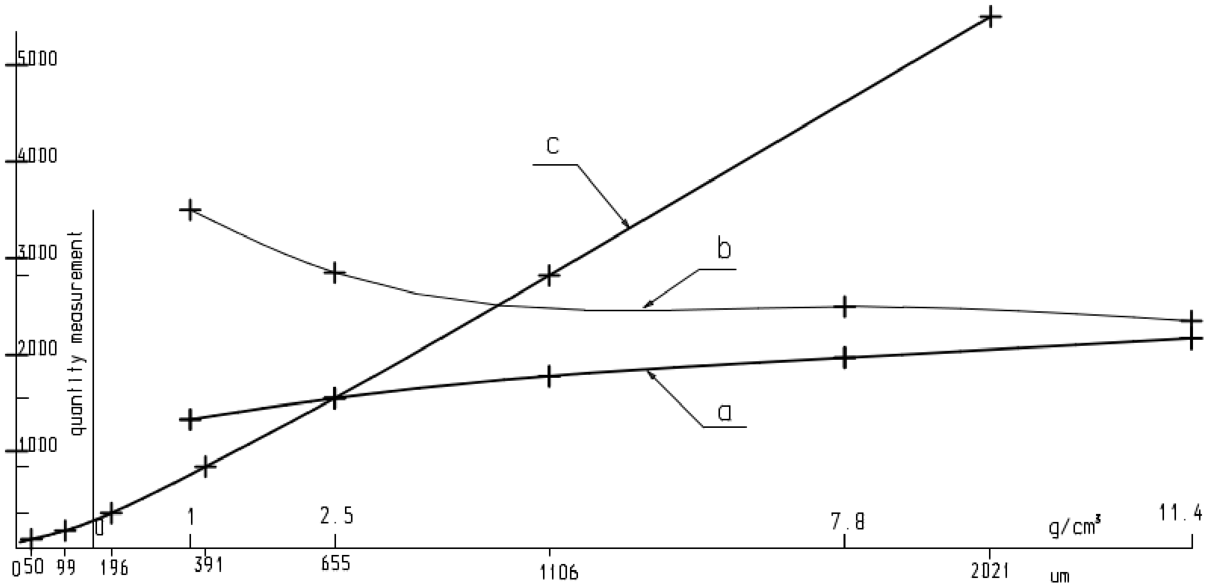

Fig. 3. Particle speed variations in dependence on the particle specific weight and dimension in the function of the measurement number

Fig. 4 presents the image of microspheres **F150** at high magnification, where one can see structure the microspheres. The set consists of a nearly perfect spheres (Wk = 1), with particles of irregular shape and broken shells. This explains the scatter of the particles' measurements results. For the results' scatter also contributes differences of microspheres' composition, which changes the specific gravity of the individual particles.

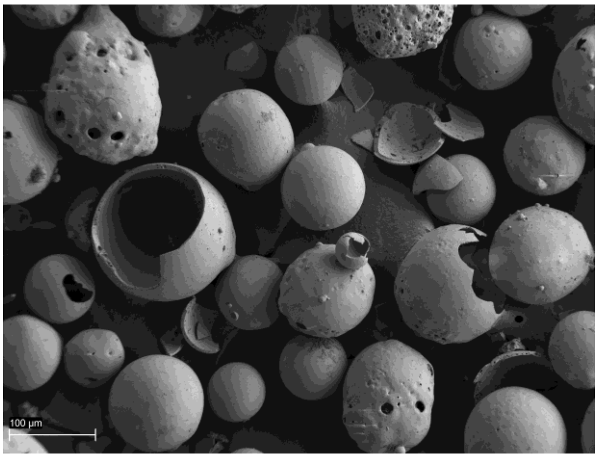

Fig.4. Image of microspheres **F150** at high magnification

Measurement results for microspheres are presented in Fig. 5, 7, 9. Microscopic photos 6, 8, 10 correspond to the measurements. On the diagram 5 the horizontal axis presents the distribution of amplitudes, i.e. the particle dimensions, while the vertical axis corresponds to the distribution of particle width. Majority of particles is situated in the diagonal zone. The diagonal line defines the position for ideal spheres, while the longer are distances from the line, the lower are the corresponding particle speeds, what can be caused by the particle form or specific weight. More frequently the form of small particle is a result of the destruction of the larger one and this is why the left-side peaks appear in the diagram. Long and thin particles can be situated there, which particles during their movement across the measurement space are orientated in accordance with the lowest aerodynamic resistance.

Measurement results for **F500** on **Omega SG** microspheres are nearly identical, only **F150** microspheres have narrower dimension range and higher contents of fine impurities. The **F150** has more concentrated spherical particles, more than the two remaining microsphere sets, what can be observed on photos, and though the average particle form coefficient Wk has similar values for the three microsphere samples, it can be seen that Wk variations significantly differ within the dimensional range of each microsphere set (Fig. 4 and Fig 10). This is the reason why there are such variations in scales located on the left side of the main diagram.

For comparison we performed measurements for the sample of bentonite, which has a lamellar structure, that is presented on Fig. 11. The average particle form coefficient has changed from 1.16 for microspheres to 5.08 for bentonite. The whole zone of bentonite distribution is located in the completely different diagram zone than the microsphere distributions.

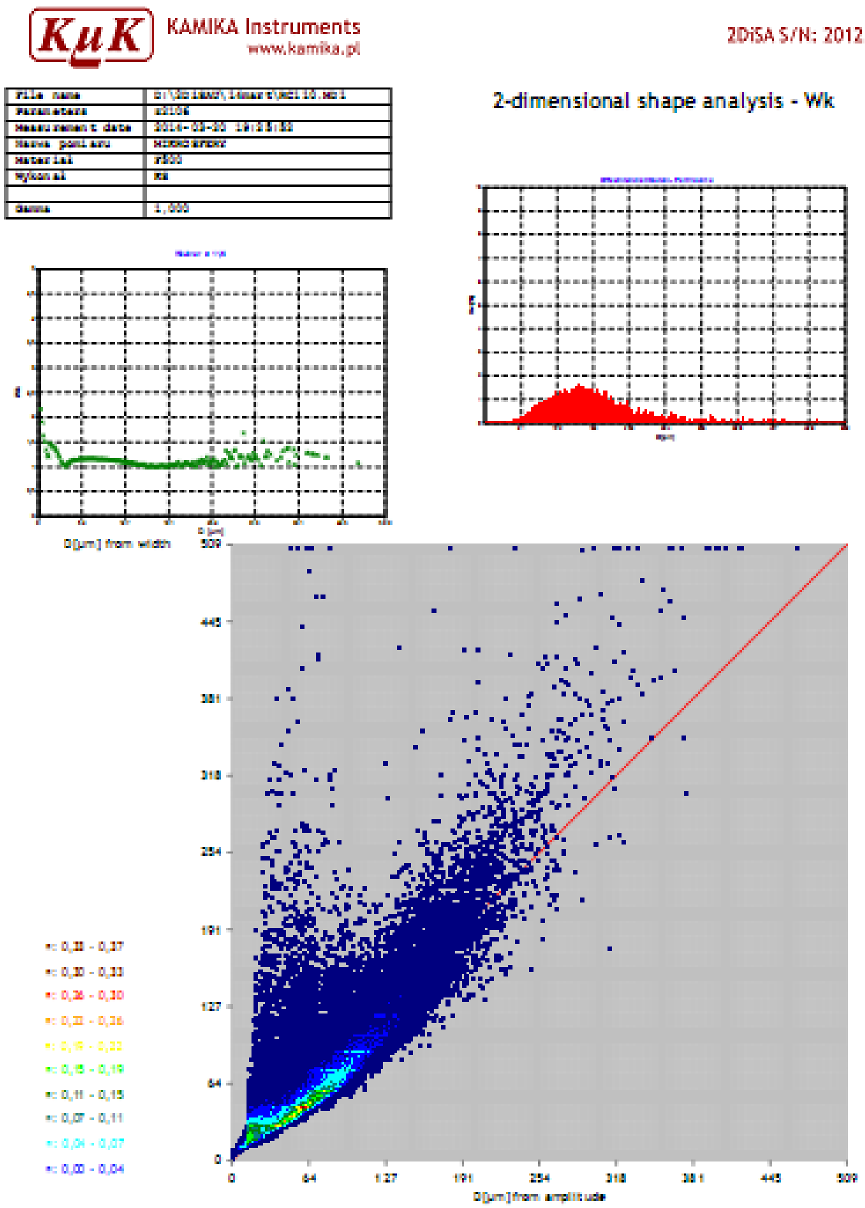

Fig. 5. Measurement results for the F500 microspheres

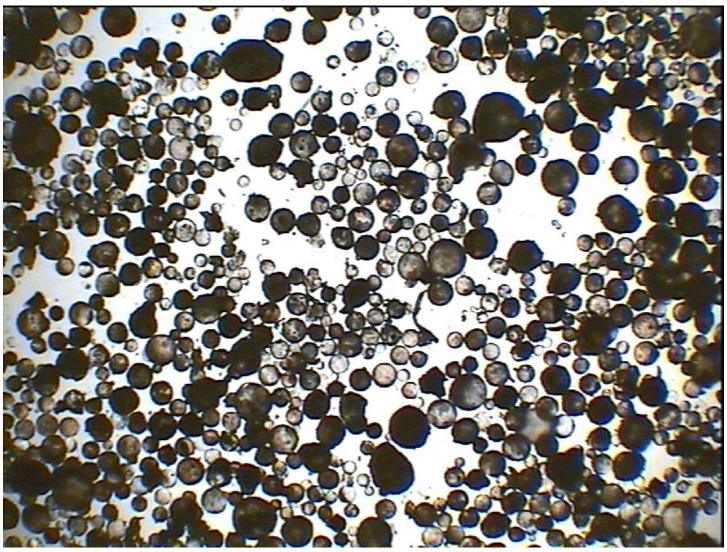

Fig. 6. View of the F500 microspheres

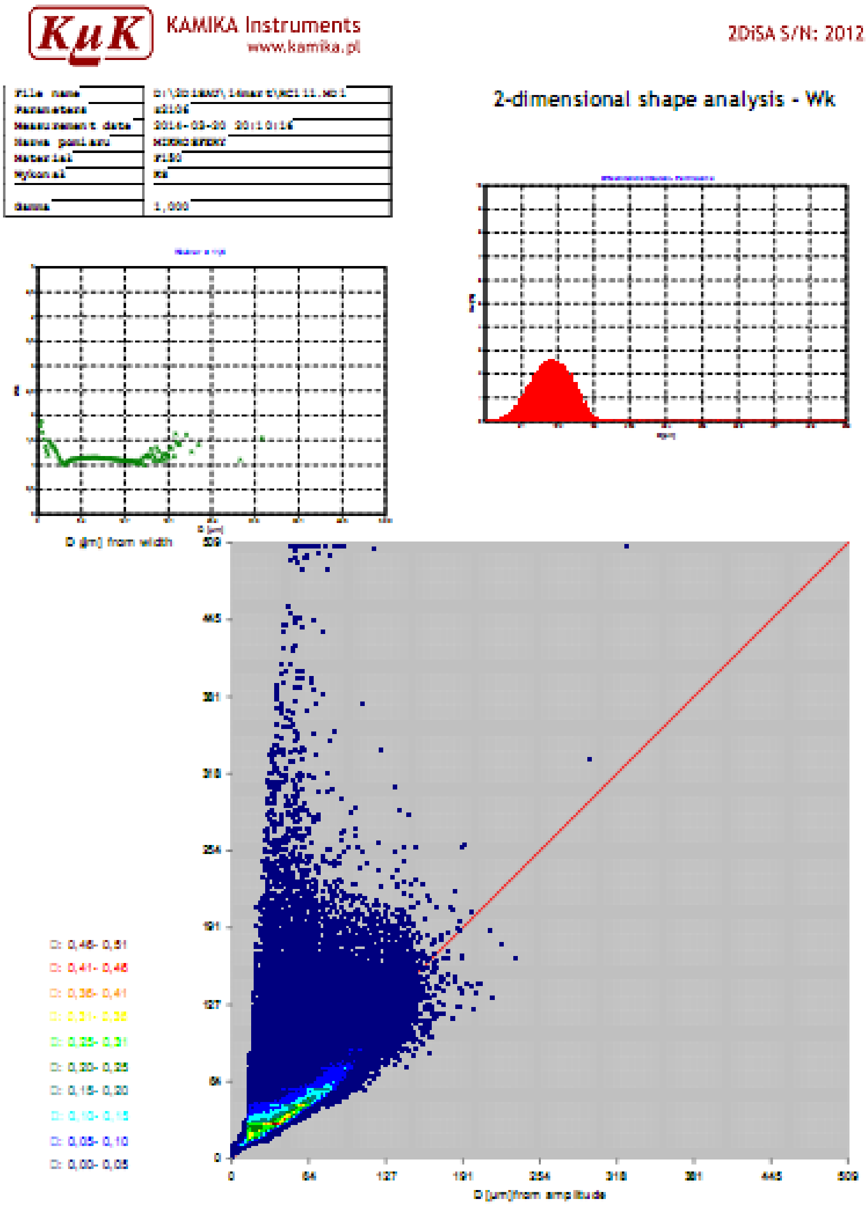

Fig. 7. Measurement results for the F150 microspheres

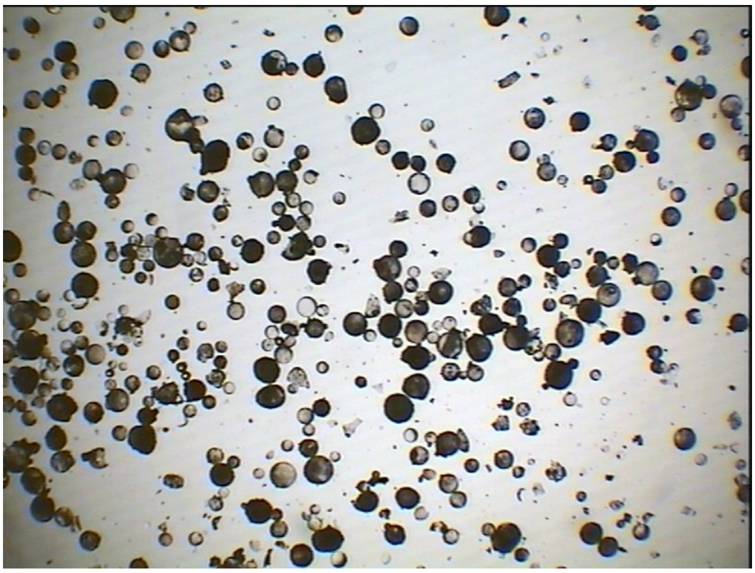

Fig. 8. View of the F150 microspheres

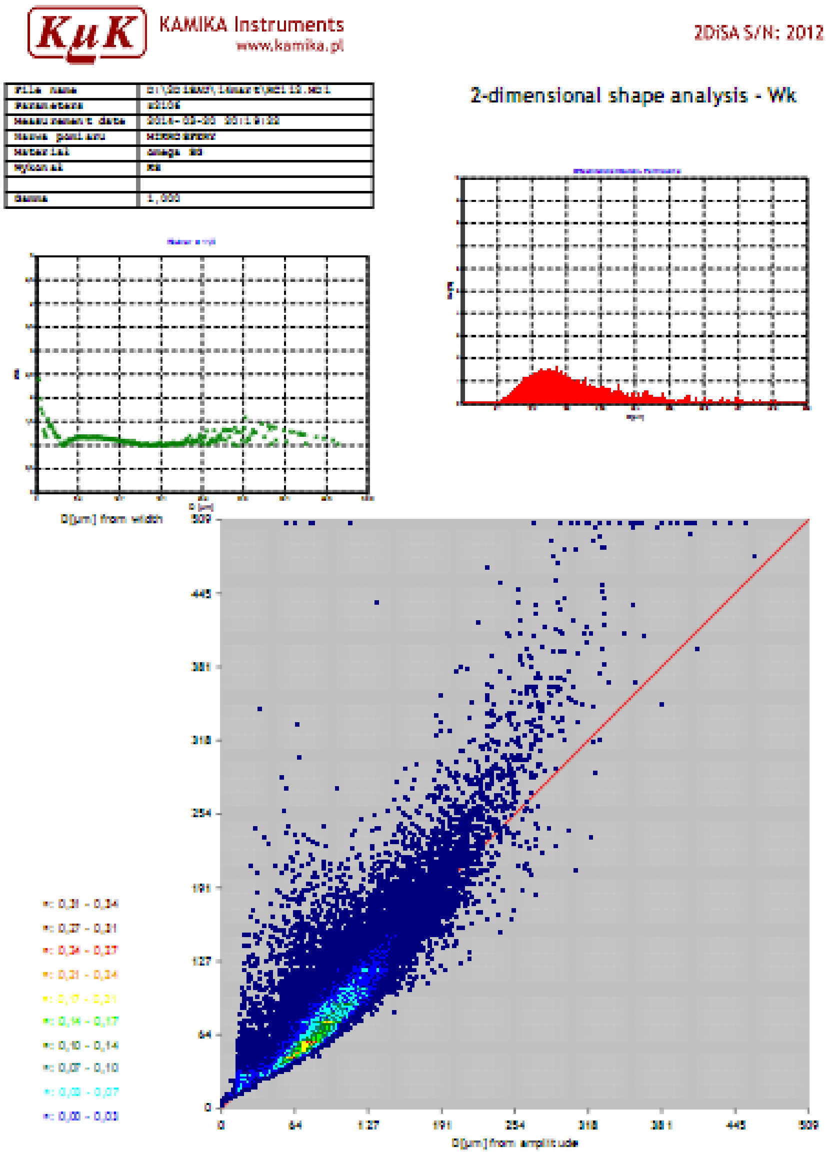

Fig. 9. Measurement results for the omega SG microspheres

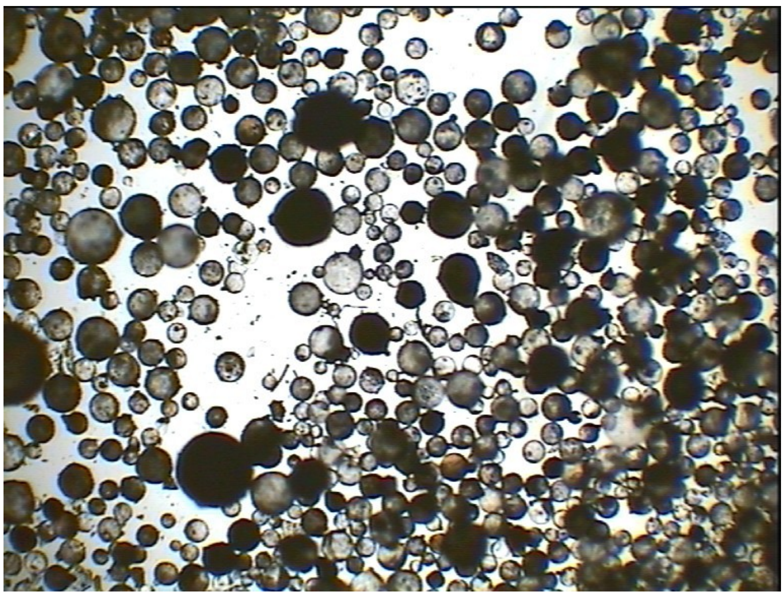

Fig. 10. View of the omega SG microspheres

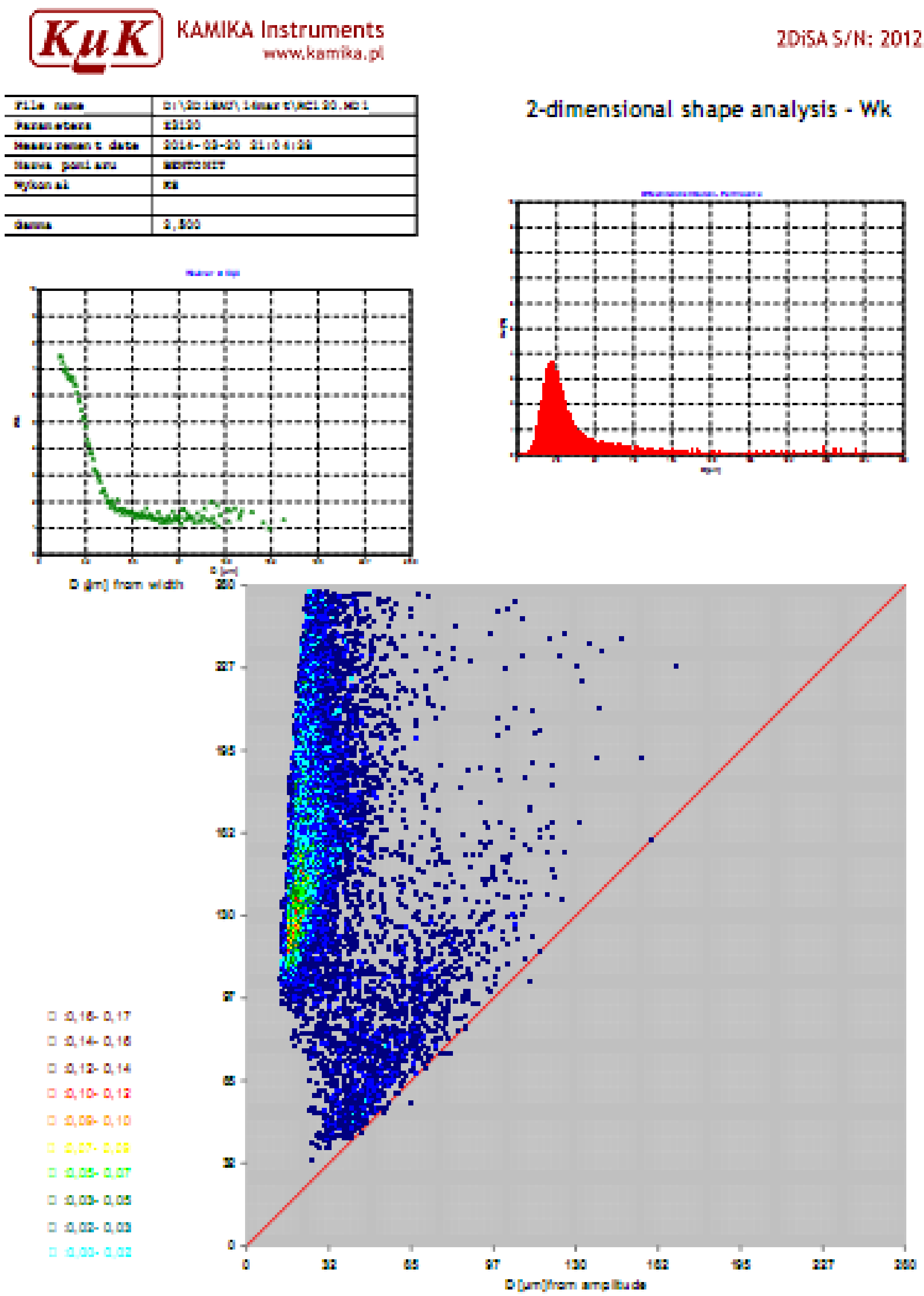

Fig. 11. Measurement results for the bentonite

The Fig. 12 presents another set of results, which is supplemented with a table containing different average diameters and specific surfaces. It is possible with the use of the same programme to determine the sieve distributions of particles together with values of the particle form coefficients for each sieve. Furthermore the spatial diagram presents also the distributions of particle dimension: the combined diagram for the two dimensions and separately for each of the two dimensions.

The measurement results presented here do not exhaust the possibilities of the software package, which assures optimization of many important industrial processes.

Conclusions:

1. The 2DiSA analyser presented here is able to measure and describe efficiently the form of particles in two dimensions on different planes.
2. It can be especially useful for estimation of materials composed of microspheres.

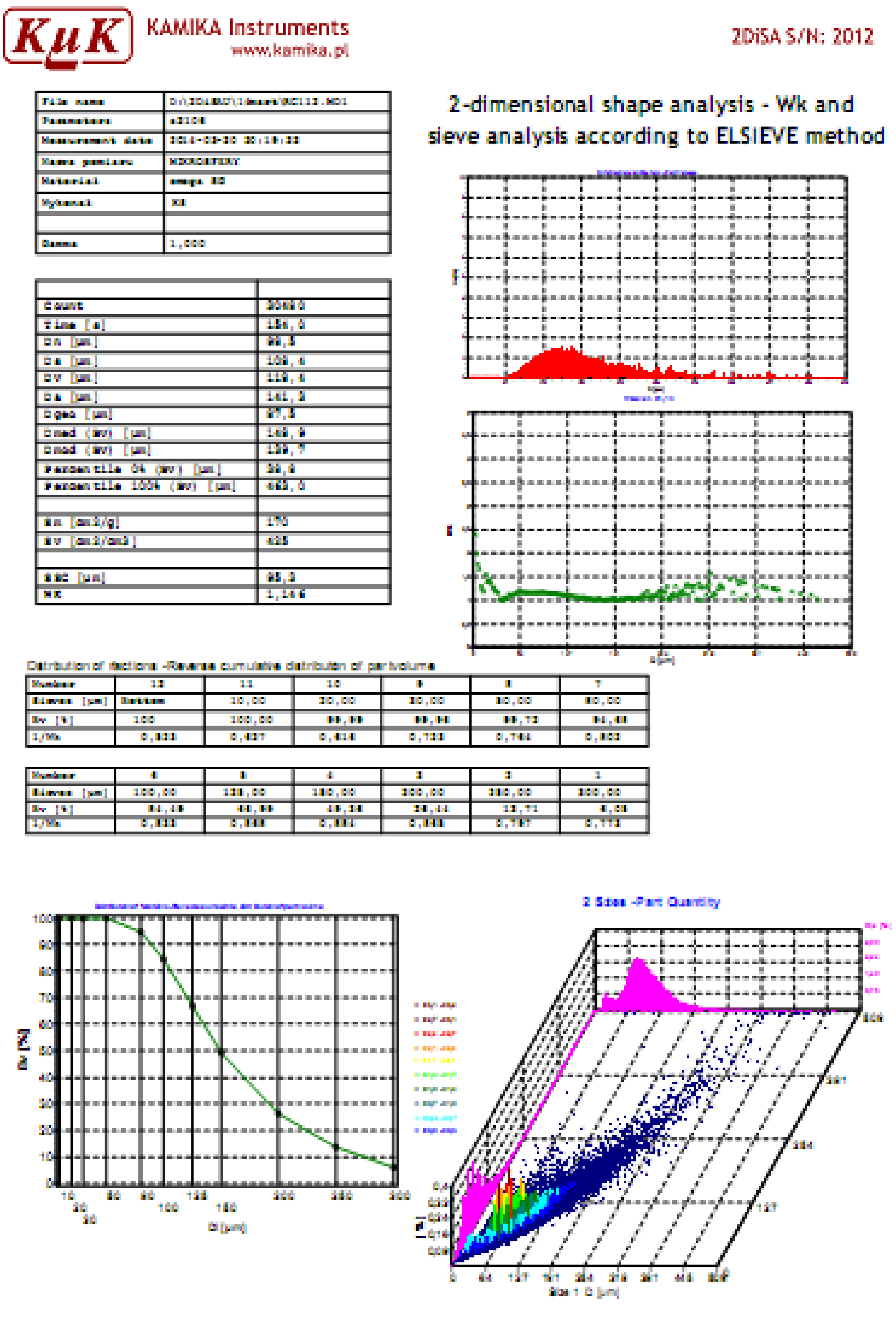

Fig. 12. Advanced measurement results for the omega SG microspheres

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2. **Kamińska D., Kamiński S.** The use of Kamika equipment for examination of distributions of particles in coal dust and ash, as well as for measurements of dust content in flue gases - proceedings of the IV International Scientific and Practical workshop "Ashes and slags from TPPs – removal, transport, processing, landfilling", Moscow, 19-20 April, 2012 - M: MPEI - Publishers, 2012 P173-178.
3. **Orzechowski. Z.** "Two-phase flows", the Polish Scientific Publishers, Warsaw, 1990.

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