Application Example: Pixact Particle Monitoring

Application Example: Pixact Particle Monitoring

The online analysis of particle size and shape enables real-time process control to compensate for e.g. variations in raw material. The Pixact Particle Monitoring (PPM) system combines in-situ process imaging with advanced image analysis to produce detailed information on particle properties such as particle size and shape. The technology can be utilized in e.g. the measuring of mineral samples. The data produced by PPM is in this application note compared to reference data generated with a more conventional laser diffraction particle sizer (LDPS). The analysis shows that the results produced by the LDPS do not always match with the sieving analysis. The reason for this might be the measurement of particle size, which is not possible with LDPS.

Figure 1. Pixcell flow-through cuvette

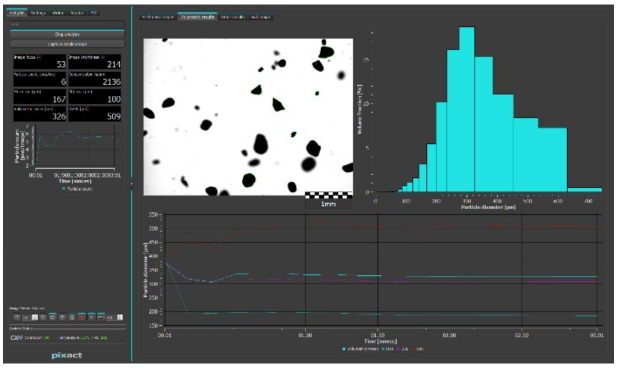

Figure 2. User interface of the Pixact software

Measurements

The PPM system consists of a Pixcell flow through cuvette, a camera unit and an illumination unit (Fig. 1). The cuvette is installed directly on the output line of the LDPS. Before the LDPS the measurement sample is diluted to control the particle concentration in the suspension, which helps to avoid overlapping particles in the captured images.

First, a reference sample of spherical glass beads of 75-90 µm is measured. After that a wash cycle is run to avoid contamination. Next, a mineral sample, which is a flotation concentrate containing more irregularly shaped particles, is measured. The measurements are synchronized by connecting the automation systems of the devices so that LDPS sends a **measurement ON** signal to the PPM system. PPM analyzes the images online and after finishing the sample the results are exported as an Excel file. During the measurement, the evolution of the size distributions and key statistic figures can be viewed in the GUI, which is shown in Figure 2. To analyze particle size and especially shape precisely, only in-focus particles are accepted (outline green). Particles with blurred outlines are rejected.

Size distribution with PPM vs. LDPS

The size classes of both measurement devices are set to vary from below 5 µm to over 740 µm to make exact comparisons possible. The PPM particle statistics are calculated based on over 3000 glass beads and over 6000 mineral particles recognized in the images. Size distributions are calculated based on the diameter of a circle with an equivalent area. Shape analysis is performed for all recognized particles.

As can be seen in Figure 3, the results generated by PPM and LDPS for the volumetric size distribution of the glass beads are very similar. The glass bead sample was screened to contain beads with a diameter of 75 to 90 µm. The peak size class is the same with both methods. PPM does not detect as many particles in size classes below 75 µm as LDPS. PPM matches better with the screening results since over 85% of the particles are in the size classes [73.7-102.5]. For LDPS the corresponding percentage is 64. On the other hand, PPM detects a higher fraction of particles in the size classes [86.9-102.5] and [120.9-142.6] than LDPS. A closer look at the image data reveals that the sample contains a few agglomerates of 2 beads and a few elongated beads, which can pass the screen with a 90 µm opening.

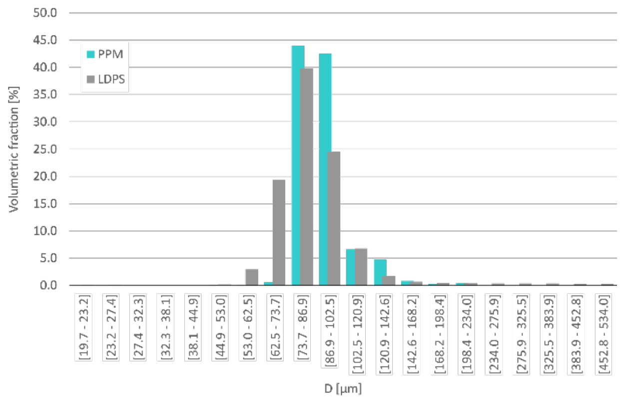

Figure 3. Volumetric size distributions for glass beads

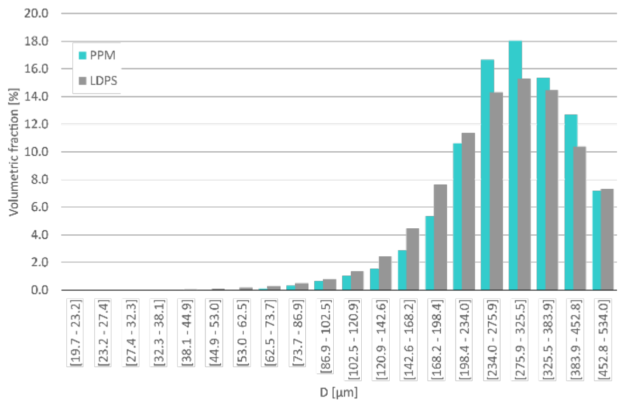

Figure 4. Volumetric size distributions for a mineral sample

Figure 4 shows the volumetric size distributions for the mineral concentrate sample. The agreement between the methods is good in terms of peak size class and distribution shape in general. The DV50% diameters are 296.4µm for LDPS and 305.5µm for PPM.

PPM shape analysis

The particle aspect ratio and roundness distributions for the glass beads and the mineral concentration sample are shown in Figures 5 and 6. Aspect ratio is defined as the ratio of the minor axis to the major axis based on principal component analysis (PCA). Roundness is defined on the basis of how circular the object outline is, given in the equation below, where r is the radius of a circle with an equivalent area and ri are the distances from particle outline pixels to the center point of the object. Perfectly round objects have roundness of close to 1 and stick-like particle's roundness approaches 0.

$$R = 1 - \frac{\sqrt{\frac{\sum_i^N (r_i - r)^2}{N-1}}}{r}$$

Glass beads can be considered as spherical. Nearly 70% of the glass beads have aspect ratio of 0.9 to 1.0 and nearly 90% of the glass beads have roundness of 0.9 to 1.0. For mineral concentrate the highest fractions are in class [0.8-0.9] for both aspect ratio and roundness. Aspect ratio distribution of the mineral concentrate also shows that there are a few very elongated, stick-like particles having aspect ratio below 0.2. Mean aspect ratios for the glass beads is 0.90 and for the mineral concentrate 0.75. Mean roundness values are 0.93 and 0.83 respectively.

Conclusions

Pixact Particle Monitoring system is successfully utilized to measure particle size and shape distributions. Good agreement of volumetric size distributions between PPM and LDPS is obtained. Shape analysis shows how spherical glass beads and irregularly shaped mineral concentration sample differ in respect of aspect ratio and roundness distributions. PPM gave better match for screened glass beads as LDPS.

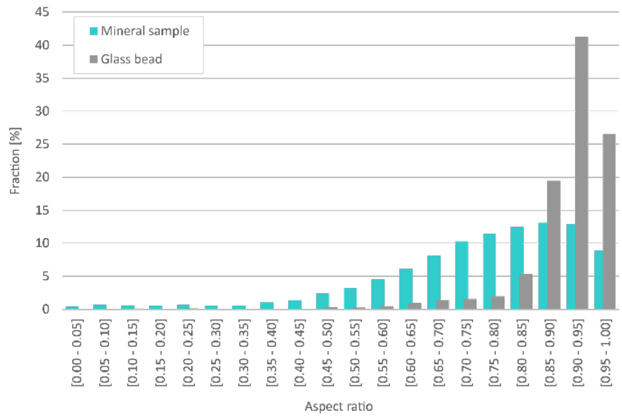

Figure 5. Particle aspect ratio distribution

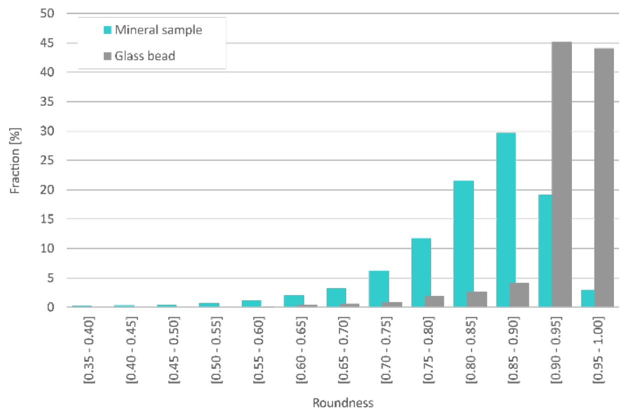

Figure 6. Particle roundness distribution