Pixact application note: Sucrose boiling crystallization

This application note presents the online monitoring and analysis of sugar boiling crystallization process using the Pixact Crystallization Monitoring technology (PCM). The PCM technology offers powerful tools for the diagnostics, control and trouble-shooting of the crystallization processes. The main advantage of the Pixact technology is its ability to measure the crystal size distribution and other suspension properties in real time, directly from the process.

Benefits

The efficiency and yield of the crystallization process are determined by the crystal forming characteristics. In general, accurate control of the crystal growth rate and morphology results in higher yield through shorter lead-times and smaller amount off-spec crystals. The savings are realized in increased capacity and decreased energy consumption both in the crystallization phase and in the subsequent steps including washing and screening.

The final size distribution is an important quality parameter in sugar crystallization. Narrow crystal size distribution means better processing properties of the end product and promotes efficient filtration. Large amount of fines in the final crystal population results in decreased yield in the washing and screening process.

Online diagnostics and real-time control of the crystallization process offer highly desired possibilities to optimize the crystal growth and the final crystal size distribution. The main target in the optimization of crystallization process is to minimize batch wise variation and produce a narrow crystal size distribution. There is always some variation in the performance and quality produced by individual boiling pans. Thus, the ability to generate measurement data for each individual boiling pan is important and gives useful information for process steering.

The batch-wise data provided by the Pixact Crystallization Monitoring can be used to:

- Generate real-time information on process behavior which can be used for process steering and optimization purposes
- Assess the role of the changing solution quality to the crystal growth
- Troubleshoot disturbance situations
- Benchmark the process in individual boiling pans
- Benchmark and compare different plants with each other. Promote Best Practice concept in multi-plant environments.

Pixact Solution

The Pixact Crystallization Monitoring system combines in-situ process microscopy and advanced image analysis techniques. The PCM system is designed for online analysis of crystallization producing real-time measurement data of the crystal size and shape and crystal count (nucleation rate). In addition to the statistics for the crystal population, the PCM system can also produce information of the liquid turbidity, suspension flowability and precipitation of other particles than crystals (i.e. different morphology).

For in-situ imaging of the crystal suspension, the measurement head is installed in the crystallization pan. The installation is done to the sight glass flange on the tank side wall. The measurement head is presented in Fig 1. The imaging of the suspension is based on trans-illumination. The crystal suspension flows through a gap in the measurement head.

Fig 2 presents a schematic layout of the measurement system. Live view from the process is displayed to the operators in the control room. The workstation controlling the system and performing the analysis is typically located in the automation space. Fig 3 presents the user interface of Pixact software, i.e. the control room view.

Figure 1. The measurement head of the Pixact Crystallization Monitoring system

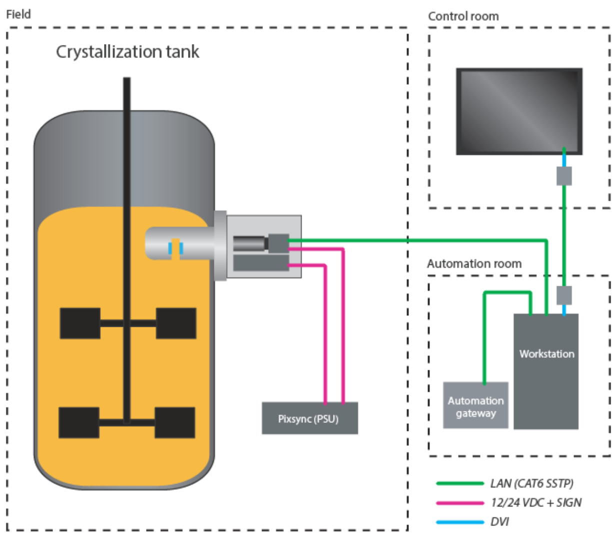

Figure 2. A schematic layout of the Pixact Crystallization Monitoring system

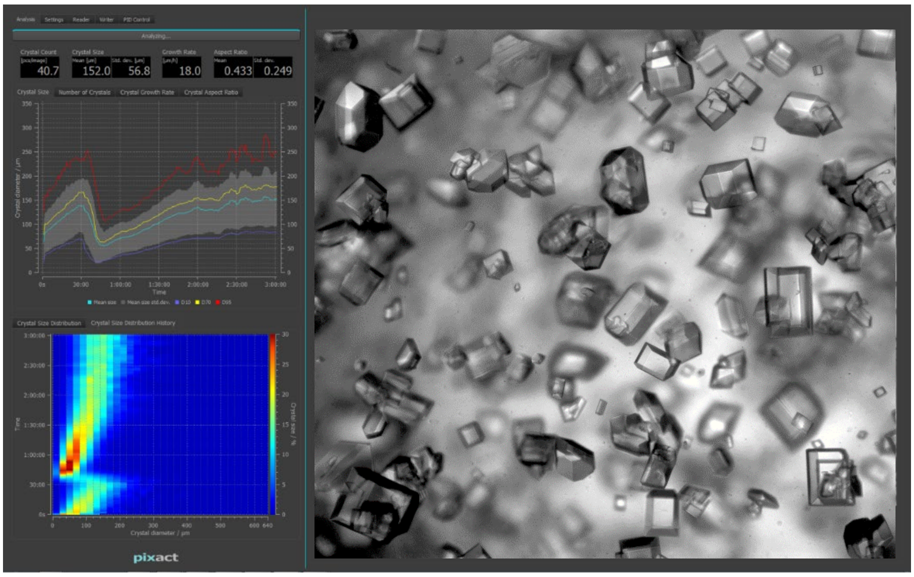

Figure 3. The user interface of the Pixact Crystallization Monitoring system

In addition to the online measurement data, the system produces a continuous image stream from the crystal suspension. The visual images provide a lot of information for the operators. Furthermore, the images can be stored to a database for later inspection. This database will play an important role in understanding the process variations and support troubleshooting.

Results

This paper presents some results from a measurement campaign carried out in sugar boiling crystallization. The PCM system is installed in an industrial scale boiling pan to measure the crystal size distribution and crystal count in real time. Selected results from the campaign are summarized below.

Example images collected from one batch are presented in Fig 4. The images show how the crystals grow and a dense packed crystal mass is formed by the end of the batch.

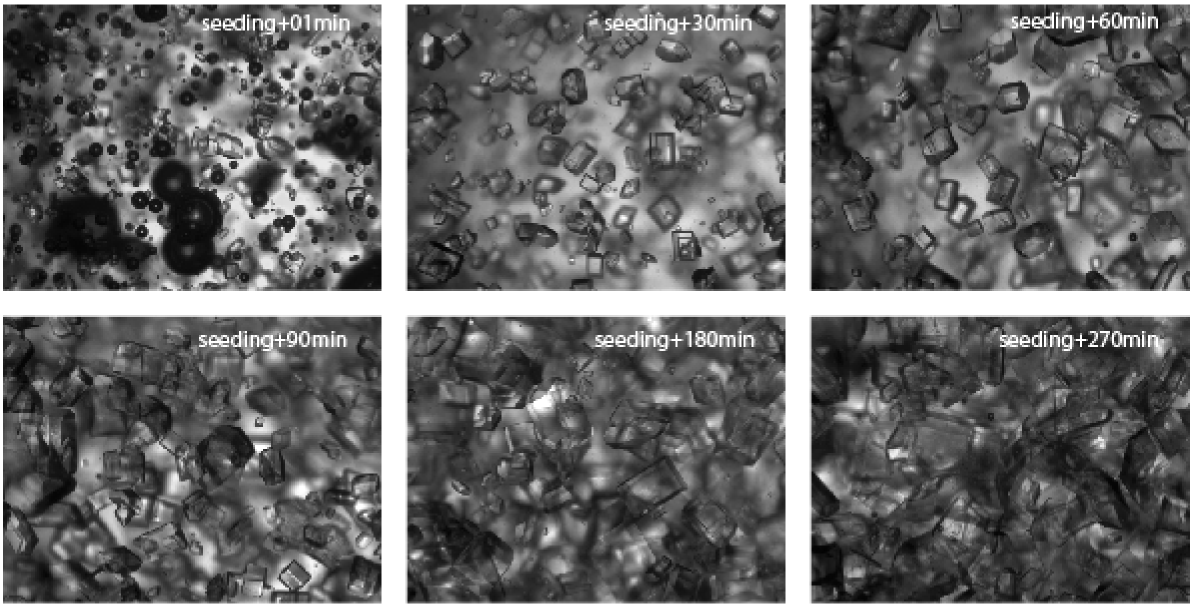

Figure 4. Example images captured with the PCM system at selected moments after the seeding

Four batches are selected as an example to demonstrate the results and performance of the PCM system. Fig 5 illustrates the time-trends for the mean crystal size and the crystal count. All size trends follow a similar path: fast initial growth is followed by a steady but slow growth until the end of the batch. In the end of the batch there is more variation in the mean size, which is most likely related to reduced mixing and slow movement of the crystal suspension. The crystal count follows an inverse trend: the number of crystals decreases quickly in the beginning and then levels off. These plots indicate that the differences present after the fast initial growth remain until the end of the batch. Small crystal size after 100 min indicates small crystal size also in the end product. For example, the batch labeled 20141117-2322 shows smallest crystals already after 100 min and the trend remains the lowest one throughout the boiling. Furthermore, it is obvious that the small crystal size correlates with large crystal count. The crystal count typically decreases monotonically towards the end of the batch. However, the batch labeled 20141117-0701 shows a dramatic increase of the crystal count in the end. This is related to uncontrolled nucleation in the end of the boiling. In the previous plots, only the development of the mean crystal size is presented. However, more detailed information can be obtained. For example, the d10, d50 and d70 are typically evaluated.

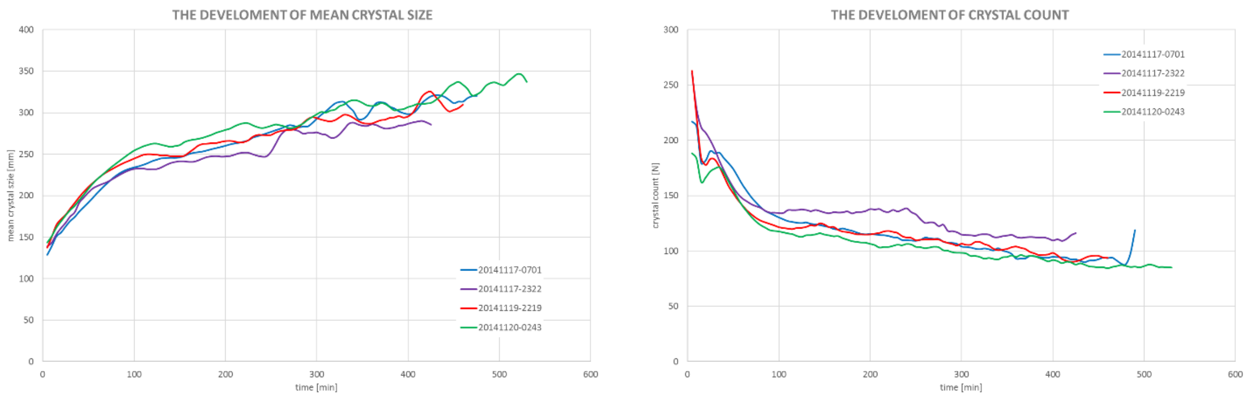

Figure 5. Time-trends for the mean crystal size and crystal count for four example batches.

Figure 6 presents the final crystal size distributions for the example batches. The size distributions as pdf are on the left and the cumulative size distributions are on the right. These plots reveal the population behind the mean crystal size. The width of the distributions is quite similar in all the cases. It's merely the peak that has shifted towards the small scales for the batch labeled 20141117-2322. The size distributions are further processed to estimate the fraction of fines and coarse crystals. The results of this analysis are presented in Fig 6. The batch with the smallest mean crystal size also contains the highest fraction of fines.

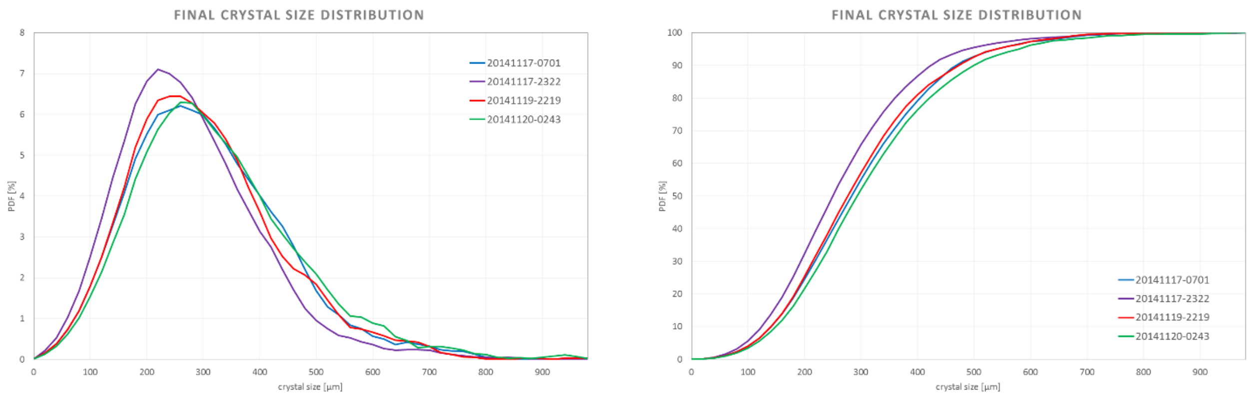

Figure 5. The final crystal size distributions (pfd on the left and cumulative distribution on the right) for the example batches

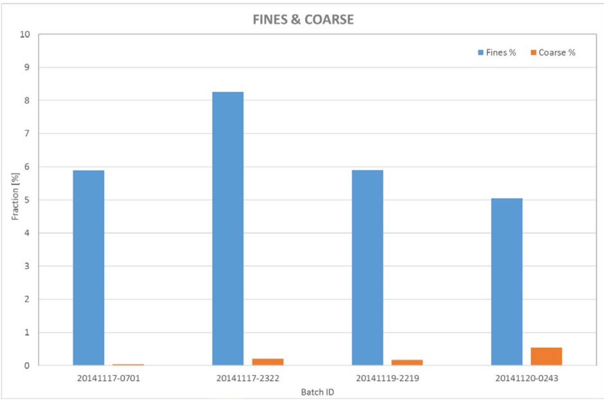

Figure 6. The fraction fines and coarse crystals in each batch

Conclusions

Real-time measurement of sucrose boiling crystallization is demonstrated with the Pixact Crystallization Monitoring system. The data produced indicates that highly useful information for process steering purposes is available. Differences between the batches can be seen already in the early phases of the boiling process which allows corrective actions to be made in the later phases.