# Application Example: Sucrose Boiling Crystallization

## Motivation

The efficiency and yield in sucrose boiling crystallization are determined by the crystal forming characteristics of the process. Accurate control of crystal growth rate and morphology results in a higher yield through shorter lead-times and fewer off-spec crystals. The savings are realized both in the crystallization phase and in the subsequent steps including washing and screening. Final size distribution is an important quality parameter in sugar crystallization. Narrow size distribution equals better processing properties of the end product and promotes efficient filtration. A large number of fines in the final crystal population results in a decreased yield in the washing and screening phases.

The inline diagnostics of the crystallization process provides highly desired opportunities for optimizing both the crystal growth and the final crystal size distribution. The main objective is to minimize batchwise variation and produce a narrow crystal size distribution. There is always some variation in the performance and quality of individual boiling pans, which makes the ability to generate measurement data for each boiling pan individually valuable. This provides useful information for mill-scale optimization.

## Measurements

A Pixact Crystallization Monitoring (PCM) system was installed on a sucrose boiling pan. The system is designed for the inline analysis of crystallization and produces real-time measurement data on the size and shape of the crystals as well as the crystal count (nucleation rate). Information on the liquid turbidity, suspension flowability and precipitation of other particles than crystals (i.e. different morphology) is also provided. To demonstrate the system performance, a two-week measurement campaign was carried out.

## Results

In this application note, a few example batches are used to explain the results and demonstrate the performance of the PCM system. Figure 1 displays example images from one batch. Figure 2 shows that the mean crystal size trends of all six batches follow a similar path: fast initial growth is followed by a steady but slow growth until the end of the batch. At 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. Two batches (B and E) clearly deviate from the other examples. Both exemplify slower growth, and the mean size in batch E remains smaller because the boiling is not extended as in batch B.

Figure 3 shows the time trends for crystal count. 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 batches with smaller mean crystal size (B & E) actually contain a higher number of crystals. This means that the liquid sugar has distributed over a larger number of crystal seeds, slowing down the growth. These differences are already visible in the seeding phase: the crystal count right after seeding is high in batches B and E, whereas the peak is significantly lower in batches C and D. Interestingly, the number of crystals after seeding is high in batches A and F, but soon drops to the level of batches C and D. This emphasizes the critical role of seeding, but also shows that the differences in seeding can be compensated for in the later stages of boiling.

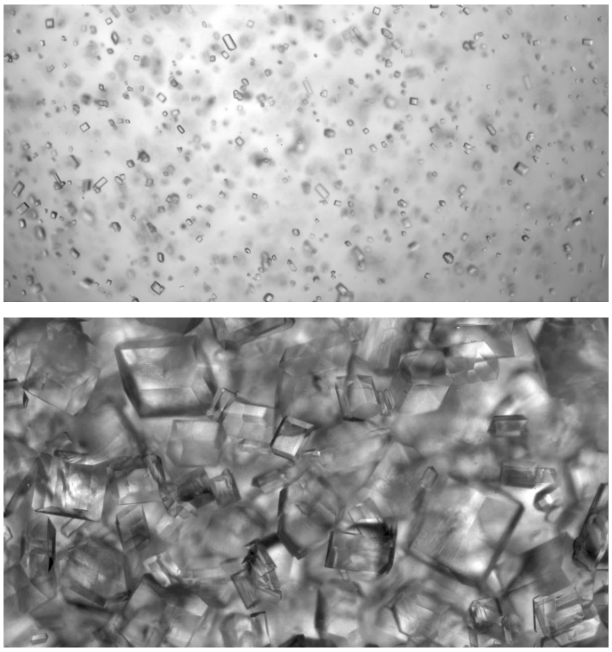

*Figure 1. Example images of sugar crystals*

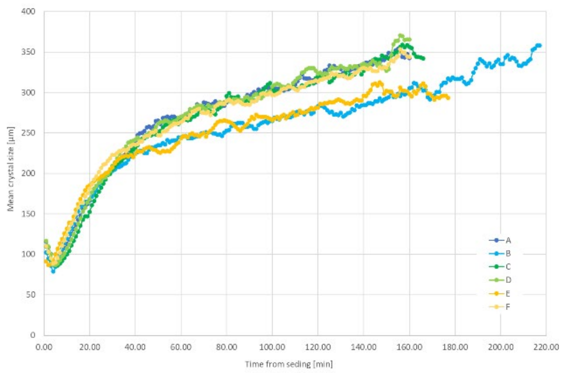


*Figure 2. Mean crystal size time trends*

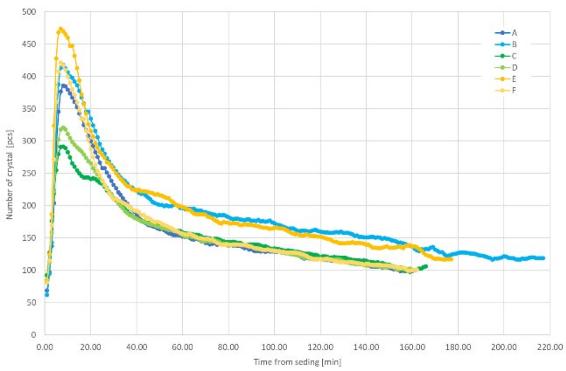


*Figure 3. Crystal count time trends*

## Benefits

The real-time monitoring of sucrose boiling crystallization has been demonstrated to work well with the PCM technology. The data produced indicates that information crucial for controlling the process can be generated. The differences between the batches are already observable in the early stages of the boiling process, which means that corrective measures can be taken later in the process.

## Technical implementation

The Pixact Crystallization Monitoring system utilized in this application note is a customized model fitted on a DSSE adapter flange in the boiling pan. The installation location is on the side of the boiling pan, just above the calandria level. Figure 4 displays a picture of the imaging unit and Figure 5 presents the installation layout of the system.

The PCM system was connected to the factory automation system to receive information on both the seeding and the end of the batch. With these start and stop signals, batchwise measurement reports are automatically generated. Naturally, the automation connection also enables real-time data transfer to the factory DCS. The system operates without any operator intervention. A live camera view with the real-time measurement data is displayed in the control room.


*Figure 4. Customized Pixscope imaging unit*

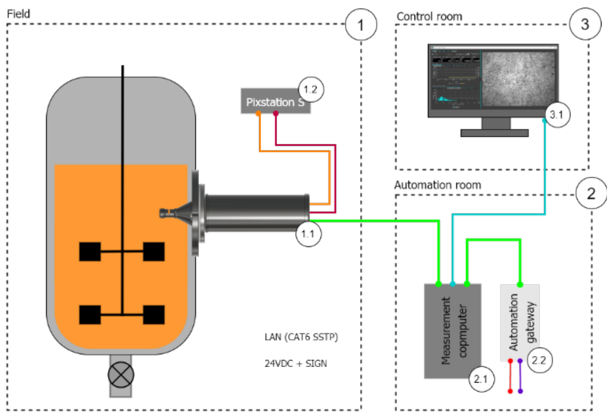


*Figure 5. Schematic layout of the measurement system*

## System specification

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|---|---|
| **Imaging unit** | |
| **Hardware** | |
| Design | Pixscope 32-xxx / custom fitting |
| Magnification / image area / resolution | M=2 / 4.2x3.5mm / 1.7µm |
| **Materials** | |
| Wet part | Stainless steel (AISI316L) |
| Optical windows | Sapphire |
| Gaskets in the wet part | Silicone (food grade) |
| **Environment** | |
| Protection | IP64 |
| Probe ambient temperature | T = 0...45˚C |
| Flow medium | T = 0...75˚C |
| **Main Unit** | |
| **Hardware** | |
| Model | Pixstation S |
| Computational unit | Tower PC |
| Automation interface | Profibus |
| **Environment** | |
| Protection | IP67 |
| Operating/ambient temperature | T = 0 ... 45˚C |
| **Process parameters** | |
| Product | Sucrose |
| Size disrtibution | 20-600µm |
| Solids concentration | Up to 50 w-% |
| Temperature | 20-70˚C |
| Pressure | Atm / vacuum |
| Other remarks | FDA compatible |