Application Example: Control of Continuous Crystallization

Motivation

Modern pulp mills are striving for the maximal recirculation of chemicals. The driving force is the reduction of both effluents and chemical costs. Because of their corrosive and fouling properties, chlorine and potassium have a negative impact on the chemical recovery process. Crystallization is used for the selective removal of these components from the recovery cycle. However, inevitable variations in the feed of the crystallization stage result in a drifting crystal size distribution. This in turn causes problems in the following stages, especially in the separation phase. A non-optimal crystal size distribution affects the separation efficiency in centrifuges and may even cause breaks in their operation. This application note presents a novel method for controlling an industrial scale continuous crystallizer to optimize the crystal size distribution for the efficient removal of chlorine and potassium. To optimize the crystallization stage, real-time measurement data on the crystal size distribution is required. With this data, conventional control strategies (based on steam, feed, etc.) can be used to adjust the saturation level.

Measurements

The online measurement of crystal size is implemented with a Pixact Crystallization Monitoring (PCM) system. The PCM system is installed on a DN50 bypass line of the crystallizer. The crystal suspension flows through the measurement section, where a high-magnification camera system captures images of the crystals. Figure 1 presents the PCM installation. Example images of the crystal suspension are displayed in Figure 2. Real-time data reported by the measurement system includes crystal size distribution and the number of crystals in the measurement volume. The crystal size distribution is used to compute a selection of derived quantities, such as mean crystal size, the standard deviation of the crystal size and the fraction of fines.

Results

The measurements show that the characteristics of the crystal population vary significantly over time. Figure 2 gives an example of an optimal (top) and a non-optimal (bottom) crystal population. In the optimal case the population is homogeneous whereas the non-optimal case includes both very large crystals and fines. Figure 3 presents a one-week trend for the crystal count (number of crystals in the measurement volume). Peaks in the crystal count trend indicate a high fraction of fines. In fact, small changes in the saturation level results in a sudden increase of the nucleation rate.

The data produced with an online analysis provides the means to react quickly to such sudden changes. An increase in the fraction rate of fines can be immediately observed in both the live image and the fraction of fines measured. Figure 4 presents a one-week trend of the crystal count after process optimization and the implementation of the online control strategy.

Figure 1. Installation of the PCM system on the crystallizer bypass line

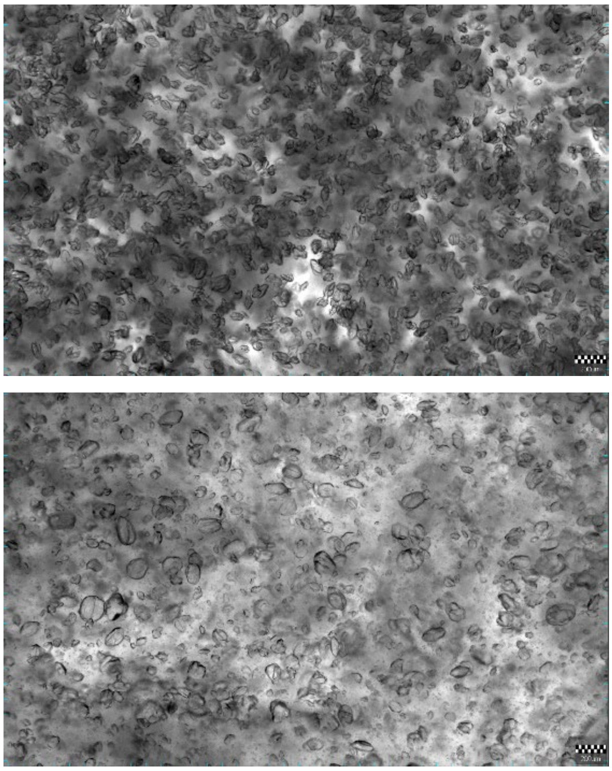

Figure 2. Example image of an optimal and non-optimal crystal population

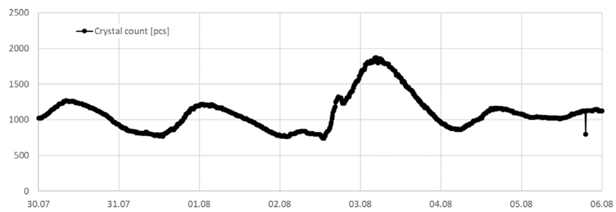

Figure 3. Example crystal count trend

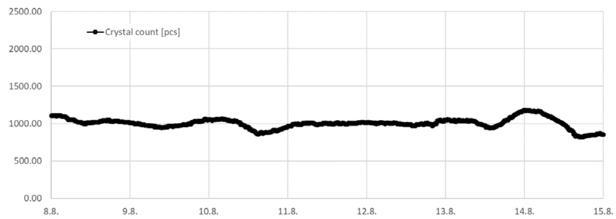

Figure 4. Example crystal count trend with online control

Benefits

The continuous measurement of crystal size distribution and especially the fraction of fines helps to identify challenging conditions in the separation stage. The online data on the crystal population is used to control the feed and the temperature of the crystallization process to keep the saturation level in an optimal range. As a result of the optimization of the process and the online control of the key process parameters, the yield improved slightly. However, the main benefit of having control of the process is seen in the separation stage, in which the operation of the centrifuges is improved significantly, and the breaks caused by clogging are eliminated.

Technical implementation

The PCM system was installed on a DN50 bypass line. A Pixscope 32-50 probe was fitted in a DN50 measurement section also delivered by Pixact. A schematic layout of the system is presented in Figure 5. All components of the measurement system are located in the field near the measurement location. A live camera view is transmitted to the control room monitor system over an HDMI encoder. The connection to the factory DSC is implemented with OPC-UA.

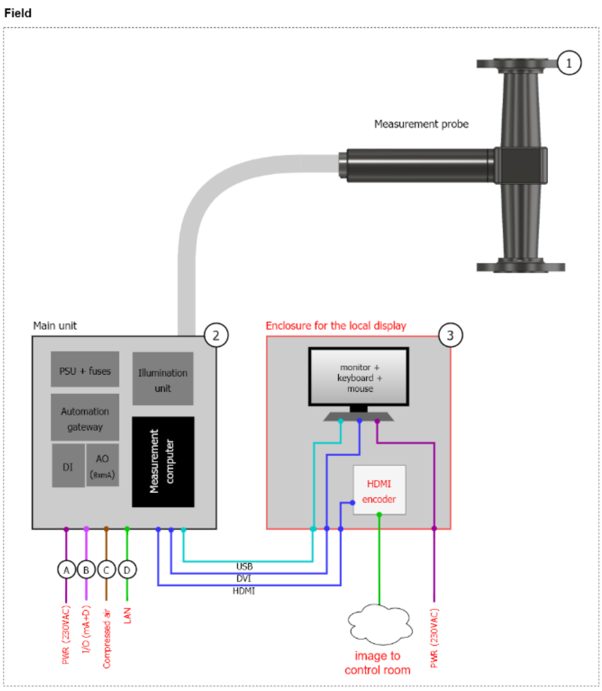

Figure 5. Schematic layout of the measurement system

System specification

Imaging unit	
Hardware	
Design	Pixscope 32-50 / fitted in a DN50 measurement section
Magnification / image area / resolution	M=2 / 4.2x3.5mm / 1.7µm
Materials	
Wet part	Stainless steel (AISI904L)
Optical windows	Sapphire
Gaskets in the wet part	Kalrez
Environment	
Protection	IP67
Probe ambient temperature	T = 0...45˚C
Flow medium	T = 0...85˚C

Main Unit	
Hardware	
Model	Pixstation M
Computational unit	Industrial PC (i7)
Automation interface	OPC-UA
Environment	
Protection	IP67
Operating/ambient temperature	T = 0 ... 45˚C

Process parameters	
Product	Na2SO4, Na2CO3
Size distribution	20-1000µm
Solids concentration	Up to 45 w-%
Temperature	85˚C
Pressure	4 Bar
Other remarks	pH 10-11

More information on the Pixact Crystallization Monitoring technology and configuration options can be found in the Pixact Crystallization Monitoring brochure.