How improving crystallization process leads to fast Return On Investment: a little nod to Pareto's law

It is widely acknowledged that any factory has to optimize its crystal sugar production and control its color to make good quality final product that meets customer's demands. This must be achieved under the ever increasing pressure on production costs, safety and environmental standards. Innovation and automation in the production process are the keys to ensure stability, better efficiency and to drastically reduce the losses that have a huge financial impact on the factory's overall performance.
By drawing on Pareto's law, stating that 80% of the effects come from 20% of causes, this paper describes how working on the root causes, responsible for the losses, brings substantial benefits with low investment.
It shows how ITECA pan camera CrystObserver® is used to optimize MA and CV, diminish steam usage and especially reduce the number of fines. These improvements increase pan yield, quality and overall production while minimizing the costly recycling. They directly translate into benefits from water and energy savings, to packing and conditioning enhancements.
The paper also studies the advantages of the centrifugal wash water control through the use of ITECA on-line colorimeter ColObserver® and the additional gains a low number of fines bring at the centrifugal floor.
The different steps in the process that are enhanced by ITECA online instrumentation are listed and the Return On Investment is analyzed and estimated whenever quantifiable.

Catherine Bouché - Catherine.bouche@iteca.fr

ITECA SOCADEI Color & Vision Department is specialized in on-line image analysis dedicated to sugar industry

ITECA on-line instruments precious contribution to automation

Crystallization and more specifically pan boiling is an 'art', making it a real challenge to approach the process from a scientific point of view. The phenomena involved are complex and have become even more complex as equipment increased in size.
When data feed is properly managed and integrated in the control system, process automation allows production to be stabilized with minimum manual intervention while reducing risks of failure.
We examine the impact of our equipment and estimate the Return On Investment:

- At the pan floor with the use of the on-line pan cameras to improve the massecuite quality and reduce the number of fines
- At the centrifugal floor with the use of the on-line colorimeters to optimize the washing time, reduce the amount of remelted sugar and detect non-conformities to avoid contamination of the drier.

On-line pan camera CrystObserver®

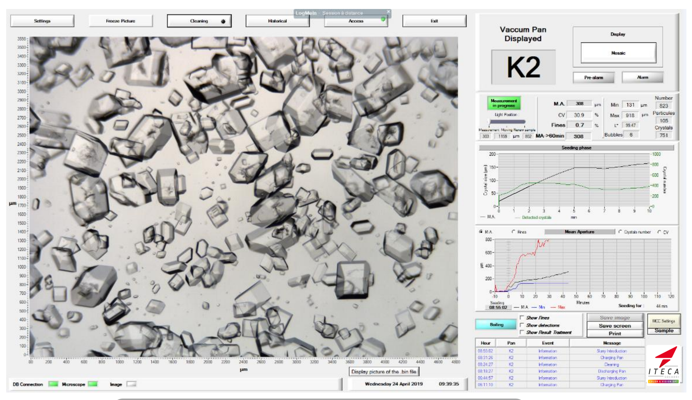
The pan camera is mounted in front of a sight glass on the pan wall.
Very sharp images of the crystals are sent to a computer in control room where dedicated software calculates **MA, CV** and **% of fines in real-time.**
Direct communication I/O must be set up between the pan camera and the plant PLC/DCS.

- **Before seeding**, detects contaminants and air bubbles from 4 µm; counts super coarse crystal
- **At the seeding stage**, counts and measures the seeds
- **During the graining phase**, monitors MA, CV and % of fines

→ **Alarms** are triggered anytime a threshold is exceeded

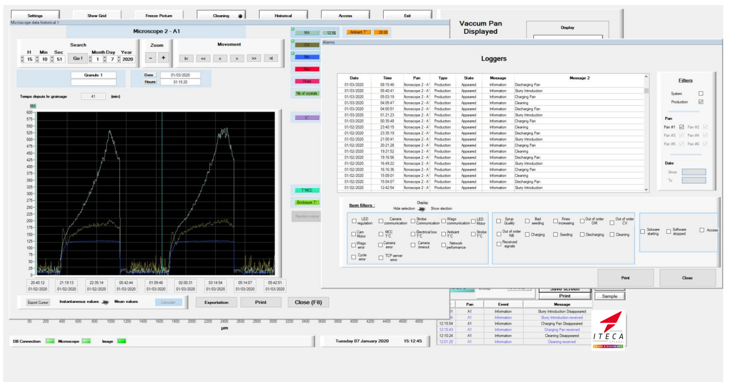
The pan camera is valuable for:

- Checking the syrup quality before seeding
- Setting up the seeding aspects of the pan control
- Making sure the seed has entered the pan as expected
- Optimizing the supersaturation level set point
- Avoiding the false grains creation (> x µm, x configurable)
- Limiting the use of water injections for remelting the fines
- Stabilizing MA and CV
- **Reducing the number of fines**



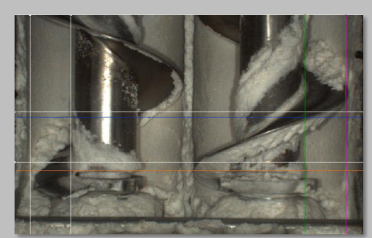
CrystObserver® main screen

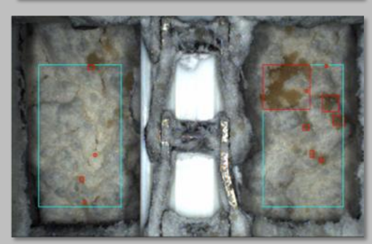
Strikes comparison from one or several pans for optimizing the boiling recipes



Example of stability at Hokuren - Japan. Historical shows repeatable trends

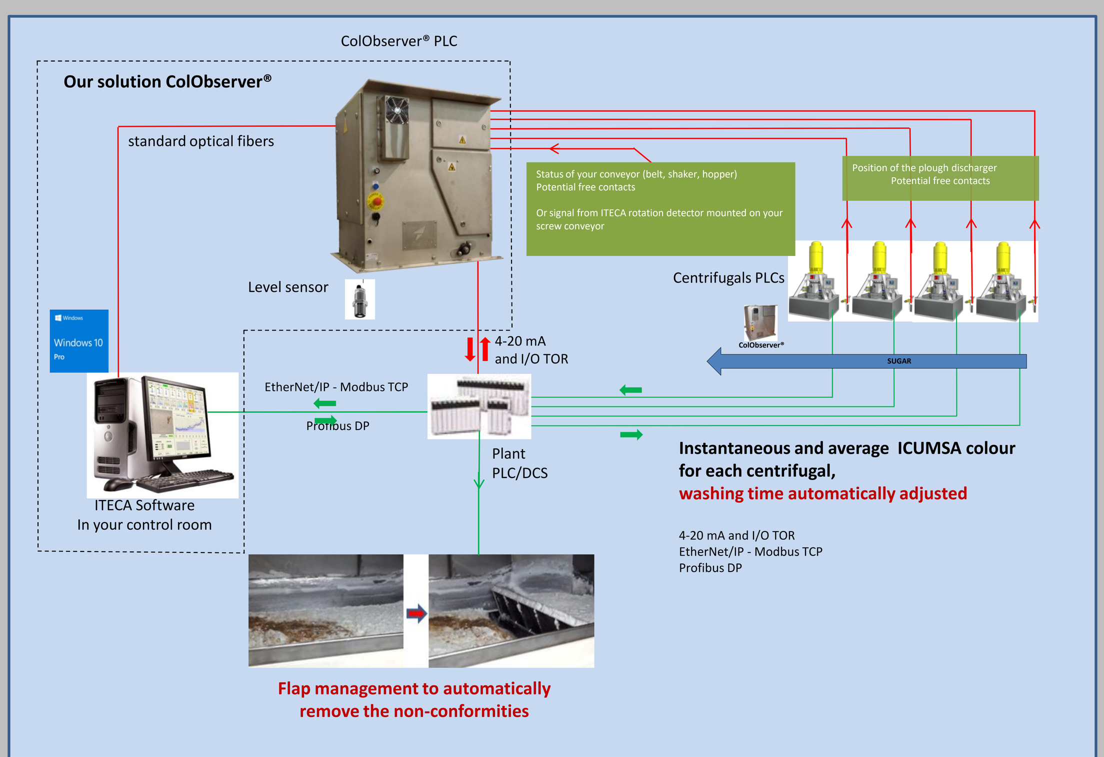
On-line colorimeter ColObserver®



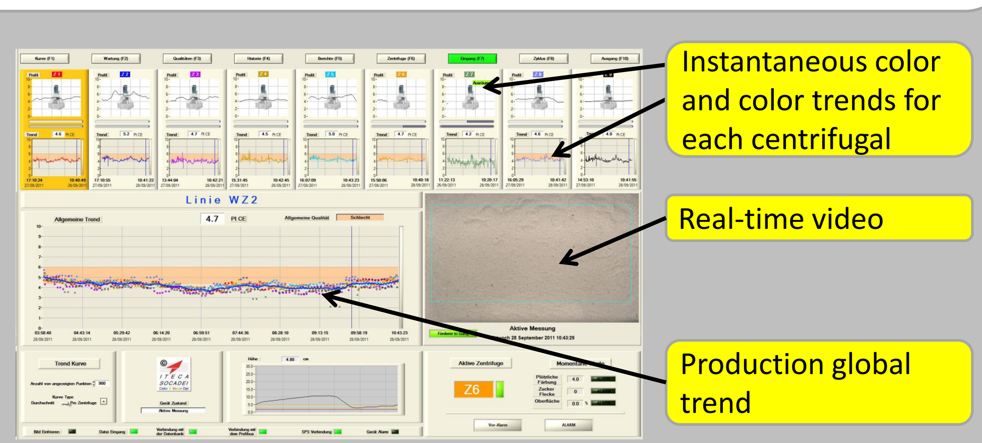


The colorimeter is mounted above any type of conveyor: screw, band, drag, vibrating, etc.., and measures the color of wet or dry sugar, white or brown.
High resolution camera sends real-time images/videos to a computer in control room where dedicated software calculates the colorimetric values.
The ColObserver® displays:

1. The color of the sugar measured in real time for each centrifugal and their global trends in ICUMSA Units
2. The automatic detection of non conformities – that can be used to open a flap and avoid contamination of the drier
3. The video of the sugar in real time or the video of the alarms that are systematically registered for future analysis.



Direct communication I/O must be set up between the colorimeter and the PLC of the centrifugals and/or the plant PLC/DCS.



ColObserver® main screen

The colorimeter is valuable for:

- Maintaining the sugar color within predefined limits
- Detecting the non conformities to avoid contamination of the drier
- Optimizing the centrifugal washing time
- **Reducing the level of recycled sugar**

Impact of the fine reduction at different stages of the process

The different stages of the process that are **directly impacted by a reduction of fines** are listed and commented. Although the consequences of the fine reduction are numerous and plain to sugar factory management, it is difficult to clearly measure their individual financial impact.
An estimate is proposed in the next block.

Process stage	Impact of the reduction of fines
Pan floor	• **Improved pan yield** • Reduction of wash water (sprayed during the process to wash the fines) • Better massecuite quality
Centrifugal floor	• Less clogging • Thicker cake in the basket • Less vibrations and less risks of unbalanced centrifugal • **Reduction in wash water usage**
Drying	• Reduction of the carried over particles sent to recycling
Conditionning	• Target bulk density more consistent • Less propensity to classify in bins • Less dust, lower risks of explosion • Reduced caking • Fewer bag sealing problems • Less unsightly fines classification in bags (negative effect on product appearance) • Less packing material wastage
Shipping	• Less caking in the tank trucks or in the containers on maritime transports • Decrease in the potential of creating fines through agglomerates destruction
Losses / recycle	• **Less recycle** • **Reduction in energy consumption** • Less constraints on production capacity

ROI calculation considering Pareto's law

By drawing on Pareto's principle, we estimate that the **recycling reduction**, taken alone, can generate over **80% of the possible ROI.** This recycling reduction is made possible by working on two main causes in the process:

- At the pan floor with the **fine reduction**
- At the centrifugal floor with the **wash water reduction**

Two different methods of calculation are proposed(*). Both are first based on the estimation of **the extra sugar produced by reducing the recycling**, but for one the ROI is calculated evaluating the **energy savings** and for the other one, the ROI is calculated considering an estimated reprocessing cost of **15% of the sugar sale price.**

Case study 1: Sugar plant in Europe – 100 days of production

Daily sugar production	**1 000,0**	**t**
Days per campaign	**100,0**	
Reduction of fines in % = Additional sugar produced in %	**2,0**	**%**
Total increased extracted sugar over the campaign	**2 000,0**	**t**
Recovery rate	**89,0**	**%**
Reduced remelted **sugar** = increased extracted sugar x (1-recovery rate)	**220,0**	**ton**
Syrup brix	**0,70**	**Bx**
Reduced remelted syrup equals Increased sugar production /0,7	**2 857,1**	**t**
Steam consumption for evaporating 1T of water of remelting syrup	**1**	**t**
Ratio steam/fuel when pan is boiled on exhaust steam	**1**	
Ratio steam/fuel when pan is boiled on lower grade evaporator bleed vapor	**1/2 or 1/3 etc**	
Energy necessary to recycle the extra sugar: = (Reduced remelted syrup - Total increased extracted sugar) ÷ Steam consumption for evaporating 1 ton of water of remelting syrup ÷ Vapor production	**857,1**	**t**
White sugar price / Tonne	**450,0 USD**	
Fuel price / Tonne	**180,0 USD**	
Recoverable value /campaign **= White Sugar price x Reduced remelting sugar + Fuel price x Energy necessary to recycle the extra sugar**	**253 286 USD**	

***Note: Excel files with updatable fields available upon request.**

We consider that a **2% reduction of fines induce the same quantity of sugar produced** and we add the cost of the **energy we would need to re-boil this** extra sugar, in this case considering the pan is boiled on exhaust steam.

Case study 2: Refinery in USA – 340 days of production

Number of centrifuges	**3**	
Days of campaign	**340**	days
Sugar discharged per batch per centrifuge/kg	540	kg
Number of cyles / hour	20	cy/h
Average charge / centrifuge	85%	
Centrifuge availability rate	90%	
Tonne of sugar / hour	**24,8**	t/h
Daily production of sugar (t)	**595**	t
Production of sugar / campaign	**202 254**	t

Reduction de 1 second(s) of washing time	**1**	s
1 sec washing = 2,5 l of wash water	**2,5**	l
1l of wash water = 3 kg of sugar (Peter Rein)	3	kg
Quantity of sugar that can be recovered kg/cycle	**7,5**	kg/cycle

For 3 centrifuges		
Quantity of sugar that can be recovered (kg /hour)	344	kg/h
Quantity of sugar that can be recovered (t /day)	8,3	t
Tonnes of sugar that can be recovered / campaign	**2 809**	t
% of extra sugar produced for a 1 s washing time reduction	**1,4%**	
Estimated Re-processing cost: % Sale price	**15%**	
Worldwide white sugar price / Tonne	**450 USD**	
Recoverable value / campaign	**189 613 USD**	

Customer Information
Calculated
Postulate

We start with the postulate that **1l of wash water remelts 3Kg** of sugar and that a **1 s washing time** corresponds to **2,5 l of wash water** reduction/cycle. We then calculate the annual extra sugar produced with a minimum washing time reduction of **1s** on **3 centrifuges.** ROI is evaluated considering the re-processing costs correspond to **15% of the sugar sale price**.

We have shown the huge impact of a fine reduction all along the process and how significant the induced reduction of the recycling is on the Return On Investment. This should be complemented by evaluating the cost-savings due to the fine reduction for each of the listed items at every stage of the process: even though some are difficult to measure, their combination may represent a sizable cost.
We hope this evaluation will allow further discussions on the impact of the recycling reduction, whether it is with the fine reduction using our on-line pan camera CrystObserver, or with the centrifuges' washing time reduction using our on-line colorimeter ColObserver. Significant quality and efficiency improvements can be achieved by fine-tuning the various parameters involved in the sugar production, and that is made possible by the use of on-line reliable instruments.