Crystallization – a central competence, the key to success

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Answers for industry.
Crystallization - a central competence, the key to success

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Abstract

An overview is given of the development of the automatic crystallization. Starting from the early basic ideas until today’s fully automatically controlled batch pans in beet and cane sugar factories. The key to this development is a close study of the process and the ability to translate this into control systems. Seemingly simple tasks are now being coordinated by the use of a computer, which requires support from new instruments. This paper describes the needs of instrumentation and control using an example from a completely automated sugar house with 19 batch pans in Larissa, Greece.

Introduction

The production of high quality sugar requires great skill and excellent technological know-how. And even sugar experts who know the theory of crystallization may recall the words of Mark Twain noted in his book “Life on the Mississippi”:

“The thing looks simple and easy. Do not deceive yourself. To make sugar is really one of the most difficult things in the world. And to make it right is next to impossible.”

The key to sugar crystals as we all know them, be it in Fiji or in Hamburg, is the skill of crystallization. For centuries, sugar was produced from cane. It was in the 1840’s under the Napoleon ban of imports that the idea of sugar production from beet was developed in the heart of Europe south of Berlin.

A rapid development in beet research as well as improving technology increased the efficiency of the early industrialized sugar factories. But the secret of crystallization was known only to the men on the pan floor. They were the kings of the factories and still are, where no automation is installed. They determine whether the sugar produced was of good or low quality.

Approximately 10 - 18% of sugar content can be found in the juice and has to be extracted. Therefore every loss in sugar during the production process is a loss for the entire plant.

Several process steps are required for clarification and evaporation until finally the juice has reached a sugar content of 70% just by evaporation of water.

This “thick juice” sweet and solid yellow in color is the basis out of which the crystals have to grow.

Cristalización – una capacidad central, la clave del éxito

Se ofrece una reseña y vista general del progreso en la cristalización automatizada, comenzando con las primeras ideas básicas hasta los tachos en batch totalmente automatizados de hoy en día en las fábricas de azúcar de caña y remolacha. La clave de este desarrollo es el estudio detallado del proceso, y la capacidad de trasladar esto a sistemas de control. Tareas aparentemente muy simples están ahora coordinadas mediante el uso de una computadora la que requiere apoyo de nuevos instrumentos. En este trabajo se describe la importancia del uso de instrumentos y control tomando como ejemplo una casa de azúcar completamente automatizada con 19 tachos en batch en Larissa, Grecia.

Figure 1. The “typical” sugar factory. Similar processes in beet and cane sugar require similar but still specific solutions

Automating crystallization

Siemens has its own sugar department supplying a solution for that process. More than 50 years of experience and know how are represented and are used for the benefit of the customers.

In many countries the crystallization is considered as too difficult for automatic process control. And even in Europe the automation of this process started only about 40 years ago with relay based sequence control, using pneumatic controllers and a lot of manual settings to perform.
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It took some time to transfer the knowledge on the principles of crystallization into the logic of automatic control. With the development of the first true DCS system TELEPERM-M this know how was used to implement a complete software package for this process in the early 1980ies.

In 2002/2003 the sugar department touched its own history again when the Hellenic Sugar Factory in Larissa / Greece, requested modernizing the sugar house by replacing its 30-year-old installation of the relay based control units with a fully automated one.

Using Simatic PCS7 and the latest version of the 2Sugar solutions suite” crystal control software which had its origin in the old TELEPERM package, this order was won against tough competition. The major fact for the success was the long lasting history and the deep process know how within Siemens.

19 batch pans producing around 1,000 Tons of sugar daily during the 60 days of sugar campaign had to be automated.

In order to estimate the task, knowledge about which factors determines sugar quality and what obstacles have to be met need understanding.

Sugar is white. In principle yes, but – not quite. Pure Saccharose is white but the juice itself is of a light brown color. It contains non sugar ingredients. Also sugar tends to caramelize under the influence of heat. So the task of the automation is to let the crystals grow in an optimized environment in order to avoid the formation of additional color by long standing times within the batch pans.

Also the crystals should be equal of size, not only to meet the second most important requirement from the sugar factories’s customers, be it for industrial or private consumption. An equal crystal size allows for an optimized centrifugation process which separates the crystals from the juice remaining, molasses.

In order to have these and several other parameters like energy optimization under control, it requires great skill to perform an optimized crystallization.

Now, assuming a liquid juice contains a certain amount of sugar – in the sugar factory, prior to crystallization around 70% - then the only question remains how to extract this sugar in a controlled way.

And here starts the solution package “crystallization control”. The idea is to introduce so called mother crystals, seed crystals into the supersaturated juice. In many plants world-wide these mother crystals are referred to as “slurry”. The quality of the slurry defines the quality of the final product. So the application software must be matched in its parameters to the quality of the slurry. Fine grain need to be eliminated in early stages of the process without diluting the desired grain size. So that a uniform basic crystal seed is available to start the process. This seed will then act as nucleus for the extraction of saccharose from the juice.

Under the permanent control of temperature, pressure and the density of the massecuite within the pan sugar starts to crystallize around these mother crystals. Each of these starting crystals will eventually grow to the desired size. No secondary crystals should be
generated during the process. A very fine balanced calculation is needed to evaluate the amount of crystals which will use the sugar in the juice to the maximum. And the same accuracy is needed to control this crystallization process until the end.

The above mentioned sugar solution suite packages have been doing that for many years now and have proven to more then 100 customers world-wide in more then 900 of such batch pans that crystallization can be automated and that an investment in such equipment is returned in a very short period of time, normally within around 200-300 days of operation.

For the HIS Sugar Factory in Larissa which is now going into the second campaign, the new equipment has proved to be a good investment as it consistently produces sugar of high quality, every day, batch by batch during the 100 days of sugar production campaign.