SeedMaster 2: A universal crystallization transmitter and automatic seeding device

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Abstract

There is a growing realization of the importance of supersaturation in sugar crystallization. It has a profound effect on product quality and on the cost of production as well, parameters which determine the chances of survival of plants all over the world. It is also well known that seeding is a very critical step of crystallization, and therefore at least this step should be carried out in a reproducible, reliable way, that is: automatically, based on the on-line monitoring of supersaturation. The *SeedMaster* optional software [1], which can be run directly in the PR-01-S type process refractometer of the K-PATENTS OY Company (Finland), addressed these needs and has already proved its worth in mills in the USA, Peru, Colombia and Iran. Due to the hardware limitations it was designed to display and transmit supersaturation data only (4-20 mA standard current output), and to implement fully automatic seeding of crystallizers based on supersaturation or density (the former is preferred) set-point selected by the local technologist. SeedMaster 2 is a logical further step in establishing a new class of instruments for crystallization control. It has a wide range of advanced features implemented in dedicated hardware and software, capable to serve two crystallizers simultaneously. It uses liquid concentration data provided by refractometers from the K-PATENTS family of products, and data from any one of the already existing sensors measuring massecuite solids content, density, or power / current consumption of the stirrer motor. Based on involved on-line calculations *SeedMaster 2* provides data on 6 massecuite parameters (per pan), including supersaturation and crystal content for transmission to external control equipment. It can be used to implement automatic seeding on its own as well. It has advanced local Operator's Station features, including strike history archives and data trends

SeedMaster 2: Un transmisor universal de cristalización y dispositivo de siembra automático

La importancia de la sobresaturación en la cristalización de azúcar va siendo reconocida cada vez más. Esta tiene un efecto significativo sobre la calidad del producto y también sobre el costo de producción. Dichos parámetros pueden determinar las probabilidades de que las fábricas alrededor del mundo sobrevivan o no. Se sabe también que el sembrado es un paso muy crítico de la cristalización y por lo tanto esta etapa debería ser llevada acabo de manera confiable y reproducible, es decir: automáticamente, y basándose en el control en línea de la sobresaturación. El software opcional [1] del SeedMaster, que se puede poner en funcionamiento directamente en el refractómetro de proceso del PR-01-S de la compañía K-PATENTS OY Company (Finlandia), ha tenido en cuenta dichos requerimientos y ya ha demostrado su utilidad y valor en ingenios de los EEUU, Perú, Colombia e Irán. Debido a las limitaciones del equipo, se diseñó de tal manera que pueda presentar y transmitir datos de sobresaturación (4-20 mA de salida estándar de corriente), y para implementar plenamente la automatización del sembrado de los cristalizadores basándose en la sobresaturación o densidad (se prefiere la primera) es que el punto de activación es seleccionado por el técnico local. El SeedMaster 2 representa el lógico paso siguiente ya que simboliza una nueva clase de instrumentos para el control de la cristalización. Posee una amplia variedad de características avanzadas tanto en el equipo como en el programa de computador, ambos especializados, y que son capaces de abastecer dos cristalizadores simultáneamente. Utiliza datos de la concentración del líquido provista por los refractómetros de la familia de productos K-PATENTS, y datos provenientes de cualquiera de los sensores ya existentes que miden el contenido

SeedMaster 2: Ein universales Übertragungs- und Impfgerät für die Kristallisation

Zunehmend wird die Bedeutung anerkannt, die bei der Zuckerkristallisation der Übersättigung zukommt. Diese hat eine tief greifende Wirkung auf die Produktqualität und auf die Produktionskosten – also die Parameter, die die Überlebenschancen von Zuckerwerken in aller Welt bestimmen. Es ist zudem gut bekannt, dass das Animpfen (Seeding) ein besonders kritischer Schritt der Kristallisation ist, der daher auf reproduzierbare, zuverlässige Weise durchgeführt werden sollte – das heißt, automatisch und auf Grundlage einer On-line-Überwachung der Übersättigung. Die optionale SeedMaster Software [1], die direkt im PR-01-S Typ des Refraktometers der K-PATENTS OY Company (Finnland) eingesetzt werden kann, hat sich dieser Erfordernisse angenommen und sich bereits in Fabriken in den USA, in Peru, Kolumbien und im Iran bewährt. Aufgrund von Hardware-Beschränkungen wurde die Software jedoch lediglich dazu konstruiert, Übersättigungsdaten anzuzeigen und zu übertragen (4-20 mA Standardstromausgabe) sowie das vollautomatische Animpfen mittels Kristallisatoren vorzunehmen – basierend auf dem Übersättigungs- oder Dichte-Einstellungswert (vorzugsweise den ersteren), der vom jeweiligen Techniker vorgenommen wird. Der SeedMaster 2 ist ein logischer weiterer Schritt zur Etablierung einer neuen Klasse von Instrumenten zur Kristallisationskontrolle. Er verfügt über ein breites Spektrum von fortschrittlichen Merkmalen, die in seiner dedizierten Hard- und Software implementiert sind, und ist in der Lage zwei Kristallisatoren gleichzeitig zu bedienen. Er nutzt die Flüssigkonzentrationsdaten, die von Refraktometern der K-PATENTS Produktfamilie geliefert werden, sowie Daten bereits vorhandener Sensoren, die

sólido de la masa cocida, la densidad, o el consumo de energía / corriente del motor agitador. Basándose en complicados cálculos en línea, el SeedMaster 2 provee datos de seis parámetros de masa cocida (por tacho) incluyendo la sobresaturación y contenido de cristal para la transmisión al equipo externo de control. También puede ser usado para realizar únicamente el sembrado automático. Tiene características avanzadas para la estación local de operaciones. Estas incluyen, los archivos de la historia de templa y las tendencias de los datos.

den Festkörpergehalt und die Dichte der Füllmasse oder die Leistung/Spannung des Rührmotors messen. Basierend auf On-line-Berechnungen liefert der SeedMaster 2 Daten zu 6 Füllmasse-Parametern (pro Kristallisator), inkl. Übersättigungs- und Kristallgehalt, zur Übertragung an externe Kontrollgeräte. Er kann aber auch dazu eingesetzt werden, lediglich automatische Animpfungen vorzunehmen. Er verfügt über fortschrittliche lokale Betreiberstation-Merkmale, inkl. Historienarchive und Datentrends.

Introduction

The impressive and long history of sugar crystallization has been governed mostly by "artisan" pan-men often without any instrument in use. These times seem to be over now. Reflecting a need for change, the Association Andrew VanHook had organized recently a symposium on "Seeding in industrial crystallization". Not surprisingly the papers presented there emphasized the importance of supersaturation and its role in seeding practice and in achieving high and constant product quality coupled with low cost of production. In one paper [2] the authors advocate seeding instead of the traditional nucleation (or shock seeding), while another one [3] presents the details of good quality seed magma production. It is characterized by very low crystal growth rate (due to low supersaturation), which is required to produce good seed crystals with low conglomerate content. The importance of crystallization in sugar manufacturing is more and more realized [4].

Constant product quality requires reproducible and reliable seeding practice, not subject to human neglect or error. It should be based on the constant monitoring of supersaturation and on the automation of this critical step. It is often forgotten that supersaturation is a multivariable function of several parameters. Therefore, sensors measuring only a single parameter (density, solids content, viscosity, capacitance / conductivity etc.) of the sugar solution or massecuite, contrary to often misleading claims are unable to meet this requirement [5], [6].

Though, as generally acknowledged, seeding is a very important and critical step in crystallization, it has also been proved by many researchers and technologists that final product quality depends very much on the crystallization control strategy followed *after seeding has been completed*. Here again, supersaturation plays a key role in the process. If it is too low, dissolution of already crystallized sugar may result, or boiling time will be longer than necessary. Too high supersaturation any time during the strike or during the operation of a continuous crystallizer will result in the formation of unwanted fine crystals and conglomerates.

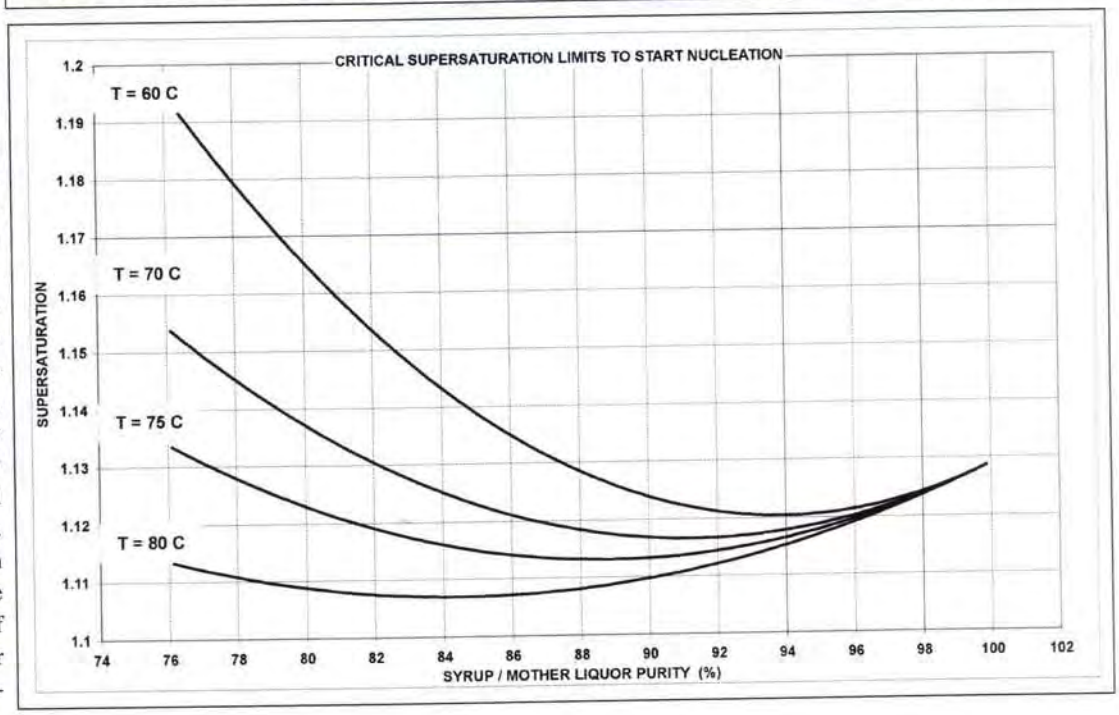
Photographs of crystal samples taken from sugar drier outputs most often show fines and conglomerates of different sizes. It is logical to assume that smaller fines and conglomerates (the "youngsters") have been formed towards the end of a strike due to high supersaturation, while the large ones (the "old boys") had more time to increase in size. *This clearly contradicts statements stating that the control of supersaturation is not important in the later stages of a strike.*

A considerable amount of the small crystals escape later detection by being directly re-circulated with the syrup through the holes of the centrifuge screen. Conglomerates degrade crystal color. The practice of washing the crystals may help, but only at the cost of dissolving sugar. Screening the end product does not solve the real problem, but results in additional losses. What went wrong during crystallization can not be put right later on. Poor seeding and crystallization control practice leads to re-melting and re-circulating already crystallized sugar into the process, resulting in waste of time, energy and increased cost of production.

Critical supersaturation limits

Supersaturation is a number defined as the ratio of sugar in solution to sugar needed to saturate the solution at the same temperature. If it is equal to 1,0 the solution is saturated, while a less than 1,0 number characterizes an undersaturated one. It is a multivariable function of

Figure 1. Critical supersaturation limits to start nucleation



several variables and can only be calculated based on acquired data [7], [8].

Supersaturation = f (C_l, Q_l, T, m, b, c) ( ) Eq. 1.

where

C_l:	liquid (mother liquor) concentration	(%)
Q_l:	liquid (mother liquor) purity	(%)
T :	process temperature	©
m, b, c:	feed syrup quality parameters	( )

Supersaturation shows the strongest correlation (dependence) to liquid concentration, but in order to get the required accuracy of data, all of the listed parameters have to be taken into account when calculating supersaturation. *The highest accuracy of liquid concentration measurement, even when crystals are already present in the massecuite can be achieved only by factory calibrated digital process refractometers*, pioneered by K-PATENTS OY. The *only other alternative* is measurement of boiling point elevation (BPE) [9]. It is correlated to liquid concentration, but depends on liquor purity and composition of the non-sugars as well and is much less accurate. Common sensors (density, solids content, viscosity, conductivity / capacitance (RF sensors)) are unable to provide selective data on liquid concentration in the presence of crystals in the massecuite, because their output will be dominated more and more by increasing crystal content. It is therefore logical to use them to provide *indirect information* on crystal content, which is the second valuable parameter to be used in crystallization control.

One can find contradicting data in the literature on the recommended value of supersaturation when seeding and in the later stages of crystallization. The graph in Fig.1. is based on the equation published in [9]. It shows critical supersaturation limit curves to start nucleation versus syrup / mother liquor purity and process temperature.

Fig.2. is a crystal photograph showing the result of poor crystallization control: conglomerates and a large number of fines due to excessive supersaturation all over the strike (the net of squares in the background are printed on paper, size: 1 by 1 mm).

Basic requirements of advanced crystallization control

Instead of a single one commonly used nowadays, advanced control of crystallization requires real-time data on two parameters of the syrup / massecuite.

The first one is supersaturation acquired during the complete process of crystallization. It has to be monitored with fairly high accuracy and reliability. The data should be used to implement *reliable, automatic seeding based on supersaturation* preferably by the same equipment used to monitor supersaturation. It should be located close to the pans, right on the plant floor to improve seeding practice even when expensive process control systems are out of reach for some of the plants wanting to improve their operations and chances to survive. The device should have *operator-friendly* means to provide vital information in real time for the operators to help them when manual strike control is practiced in the plant.

The same equipment should be used as a dedicated front-end device, too, transmitting supersaturation and additional data to an advanced Process Control System (PCS), if required. Flexibility in transmitting these data as a *crystallization transmitter* is an advantage. Automatic seeding in this case can be implemented based on transmitted supersaturation data by the PCS, or by the dedicated front-end device itself. After seeding has been completed, further control of crystallization is left to the PCS.

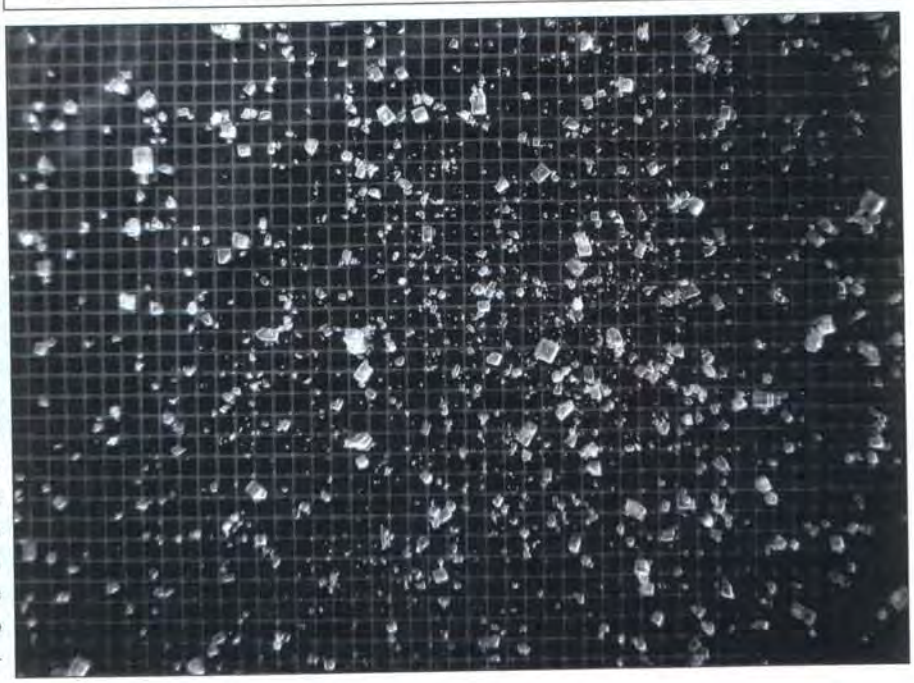
The second parameter required for crystallization control provides indirect information on crystal content. Common sensors in use (density, solids content, stirrer motor power or current consumption transmitters) can do the job.

These were the considerations taken into account when developing SeedMaster and SeedMaster 2. They were backed by over 25 years of accumulated experience in implementing several large process control projects in the sugar industry in Hungary and in the United Arab Emirates (Dubai), and in visits for tests, or to provide consultancy services to a large number of plants from Australia to Canada. SeedMaster 2 has been thoroughly tested during the last campaign season in a beet sugar plant in Hungary and in a refinery in Finland.

The SeedMaster concept

The basic concept of the small SeedMaster family is in-line measurement and on-line calculation of supersaturation symbolized by Eq. 1. In-line indicates the use of sensors inserted in the technology, while on-line means that the calculations are implemented continuously, that is in real time. All parameters of the equation are taken into account, including feed syrup quality and changing (during the process of crystallization) syrup purity. Syrup / mother liquor concentration data are provided by 1 or 2 (PR-01-S, PR-23-GP type)

Figure 2. Crystal photo documenting poor control practice



process refractometer(s) from the K-PATENTS family of products, which have become the workhorse of (among others) the sugar industry in thousands of applications worldwide. The optional SeedMaster software [1] can be run in the K-PATENTS PR-01-S process refractometer itself, while SeedMaster 2 is implemented in dedicated hardware, connected to PR-01-S, or PR-23-GP refractometers of the family. Both devices have operators' station features (of course, with different sophistication), can transmit at least calculated supersaturation data to external devices, and are able to implement automatic seeding based on supersaturation or density set-point selected by the local operator.

Sensor calibration and location selection

Sensor calibration is one of the issues facing decision-makers when deciding which type of sensor should be used in crystallization control. The K-PATENTS process refractometers are factory calibrated using standard and certified calibration liquids. Their accuracy is + / - 0,1 %, and naturally it will not change after installation.

Most of the common sensors in use today (radio frequency, nuclear, microwave) have to be calibrated after they have been installed, and this is not an easy task. There are cases when a process refractometer had to be installed in order to be able to calibrate a density transmitter. Accuracy specifications are very often missing.

Sensor location selection is another sensitive issue, independently of the type of sensor in use. In an earlier paper [1] this problem was already treated in detail.

Supersaturation depends on, among other factors, the temperature and concentration of the syrup / mother liquor. Crystallizers, however, are not perfectly mixed vessels, which means that depending on the effectiveness of circulation, variations in these parameters can occur.

When measuring some parameter of the massecuite on-line with any type of sensor the aim is to have reliable data which are representative for the majority of the massecuite. How representative these data will be depends very much on the location of the sensor relative to the feed syrup inlet. This is, therefore a common problem, and the way it is solved will determine to a large extent the usefulness of data collected.

Unfortunately, the mechanical construction of vacuum pans have not changed significantly despite advances in instrumentation and automatic control. As a rule, the best location for sensor location is the pan bottom, if the path length from feed inlet to the sensor is long enough to avoid collecting data in a diluted, unrepresentative massecuite volume. Test results on how fast a sensor responds to an abrupt opening of the feed valve should be studied carefully. Too fast response is probably due to the closeness of the sensor relative to feed inlet, and this should be avoided. The most favorable configuration is to feed syrup into the pan at several points through a ring pipe under the calandria. This feed design, contrary to the traditional feed inlet directed downwards in the downtake, helps circulation in the pan. The sensor should be mounted under the ring pipe.

The SeedMaster optional software [1]

The SeedMaster optional software can be used running in the PR-01-S refractometer of K-PATENTS. It is characterized by robust design and high accuracy. Concentration data are not influenced by liquid color, crystal, vapor or gas bubble content. There is no need for additional hardware. Besides concentration the refractometer provides temperature data for the calculation of supersaturation, too. SeedMaster is marketed by K-PATENTS OY.

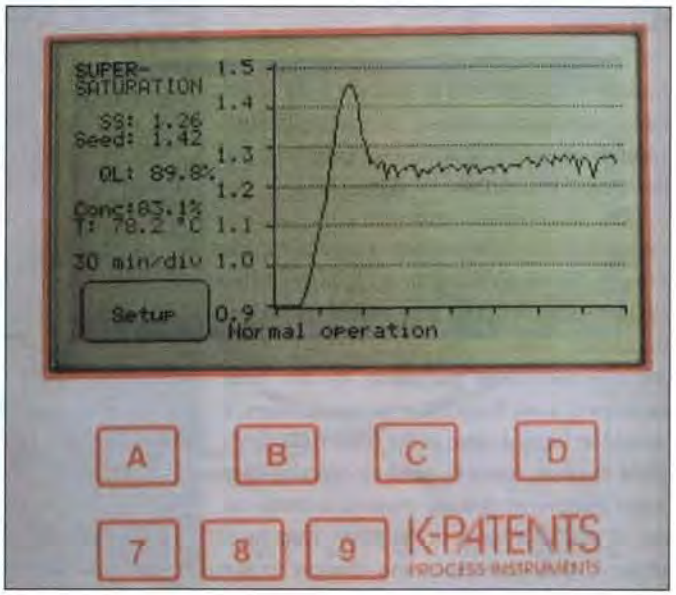
Figure 3. The PR-01-S refractometer

Basic SeedMaster features:

- on-line calculation and display (numeric and trend) of supersaturation;
- transmission of calculated supersaturation data (standard 4-20 mA current output);
- automatic seeding based on supersaturation, or density (the former is advised) set-point.

The SeedMaster display trends supersaturation data versus time for a complete strike.

Figure 4. The SeedMaster display



Numerical data:

SS	: last value of supersaturation	( )
Seed	: set-point (supersaturation) selected for seeding	( )
QL	: mother liquor purity	(%)
Conc	: mother liquor concentration	(%)
T	: process temperature	©

It can be seen that shock seeding was practiced in the plant where this picture came from. When compared with data of Fig.1. it is evident that supersaturation was well above the critical limit all over the strike. The repeated drops on the curve are due to syrup feeds.

The Setup soft-key can be used to call up new screens to provide some laboratory data, the selected set-point for automatic seeding etc.. When configured, a digital output will be used to open the seeding valve for the configured time interval (a few seconds). A second digital output can be used to warn the pan-man (lit a lamp, or sound a horn) on approaching seeding, that is to fill the seeding vessel with slurry in time.

Calculated supersaturation can be transmitted as standard analog current output (4-20 mA) to any external device. The text "Normal operation" is a diagnostic message from the refractometer.

SeedMaster 2: A unique crystallization transmitter and automatic seeding device

As already discussed, besides supersaturation some additional information, correlated in most cases to crystal content is required for the advanced control of crystallization. Though, unfortunately, not providing crystal content data directly, common sensors in use meet this requirement.

The sugar syrup / mother liquor and the massecuite inhabited by sugar crystals have quite many parameters, which might be of interest to a plant manager, sugar technologist, or a process control professional all wanting to improve their crystallization practice. Some of these are accustomed data, like density, or solids content (quite often the only single source of information), but some of them have never been made available on-line for direct use. The same way: easily available, well organized information on the critical parameters of a strike during its course – a kind of strike history – can be used to help making decisions on crystallization control practice. All of this should be made available for plant personnel right at the pans on the plant floor, and simultaneously, in the plant PCS, if one is available.

SeedMaster 2 was designed to meet these requirements. It has a robust, dedicated hardware with a powerful built-in computer and large memory combined with a wide range of input / output combinations resulting in high flexibility. The software is based on original research and experience gained in sugar crystallization over 25 years. It has a large number of new features as well, not available in its predecessor. A single SeedMaster 2 can serve 2 crystallizers simultaneously. It is manufactured by Process Control Ltd..

SeedMaster 2 configuration basics

Inputs

K-PATENTS refractometers

PR-01-S: 1 or 2 refractometers can be directly connected to the SeedMaster 2 through serial communication lines (COM1, COM2, COM3 ports), or by standard current (4-20 mA) inputs.

PR-23-GP: It can be used with 1 or 2 sensor heads (serving 1 or 2 crystallizers). It is possible to connect it directly to the SeedMaster 2 by using standard TCP/IP Modbus high speed communication (Ethernet), or by standard current (4-20 mA) inputs.

Any combination of the two refractometer types is possible. Besides concentration, the refractometers transmit temperature data as well, but existing temperature transmitters (4-20 mA output) can also be used. However, concentration and temperature data from the same location are preferred.

"Third input" transmitters

In order to realize all of the features provided by SeedMaster 2, in addition to the two obligatory data (liquid concentration and temperature) it is recommended to use data from one of the transmitters (numbered 1...3 with standard current output (4-20 mA), or Modbus data transfer from a PCS) listed below:

1. Density	(kg/m^3, g/l)
2. Solids content	(%)
3. Stirrer motor consumption (power or current, power is preferred)	(kW, A)
Level input (option)	(%)

The least expensive solution is to use a probably existing motor consumption transmitter, but if a density, or solids content transmitter is available, its output should be used (SeedMaster 2 has 4 standard current input channels per pan). If none of these is available, it is possible to use a single laboratory data on crystal content (by volume) determined time to time at the end of a selected strike. In this case calculations are based on an advanced crystal growth simulation. Whenever available, on-line data from a transmitter are preferred. If there is a PCS in use, refractometer and transmitter data may be transmitted to the SeedMaster 2 from the PCS via its Ethernet port, too.

SeedMaster 2 outputs

All calculated and measured (by the refractometers and transmitters) data are available for transmission to a PCS using the TCP/IP Modbus protocol with one of the COM ports, or the Ethernet port. There are 2 standard current outputs (4-20 mA) available per pan to transmit the selected 2 out of the 6 available massecuite parameters.

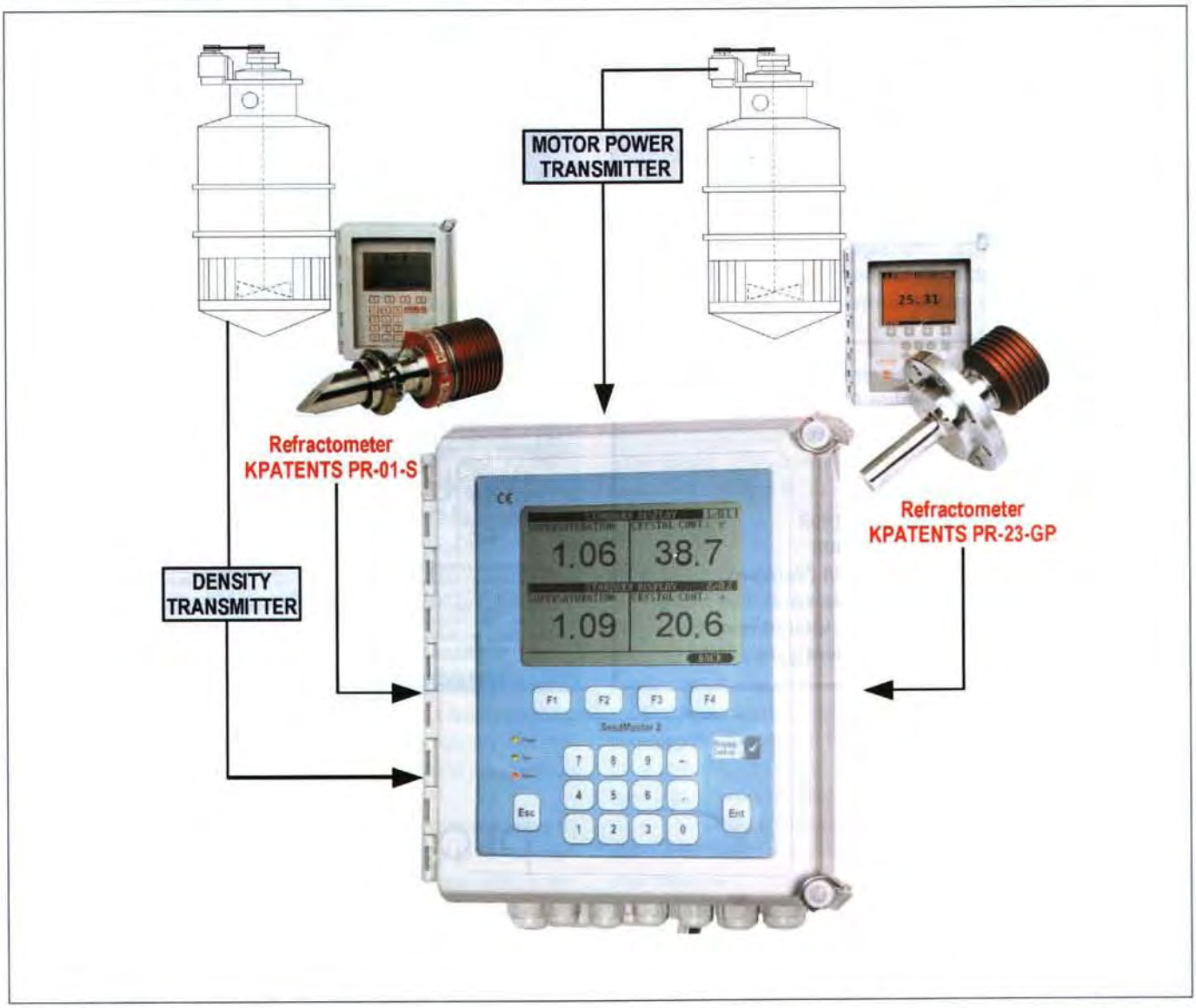
Digital outputs (2 per crystallizer) can be used to warn the pan-man on approaching seeding and to operate the seeding valve(s).

The configuration shown in Fig.5. consists of a PR-01-S and a PR-23-GP refractometer (the last one with a single sensor head), a (third party) density and a motor power consumption transmitter. The refractometers are directly connected to the SeedMaster 2 via digital communication.

Data acquired by SeedMaster 2 are used to calculate on-line 6 (per pan) important parameters of the massecuite for further use. These are:

1. SUPERSATURATION ( )

Figure 5. One of the possible configurations



2. CRYSTAL CONTENT (by volume)	**(%)**
3. MOTHER LIQUOR PURITY	**(%)**
4. DENSITY	(kg/m^3)
5. SOLIDS CONTENT	(%)
6. CONSISTENCY	(%)

Parameters 1...3 represent a quite new range of data not available from any single instrument known to this author. The other 3 (numbers 4...6) are the data provided by one or the other common single-parameter sensor. The 6 calculated massecuite parameters provide the backbone of the advanced features implemented in SeedMaster 2.

SeedMaster 2: the Crystallization Transmitter

One of the important features of SeedMaster 2 is its use as an *intelligent front-end transmitter*, making the calculated data available online for a PCS or a computer with compatible communication features.

Data like supersaturation, crystal content or mother liquor purity are the ones which up till now have (or have not) been determined off-line by occasionally taking samples and analyzing them in the laboratory. This is an error-prone process including considerable time delay (dead-time); therefore these data are completely useless in implementing closed-loop feedback control in real time. These data are now available in real time for transmission and control by a PCS. This fact alone may lead to *fresh approaches in crystallization control*, as it has already done so in some of the plants, where at least online monitoring of supersaturation by SeedMaster is already current practice.

Density, solids content and consistency sensors belong to the more accustomed set of instruments in use today. SeedMaster 2 provides these data as well and leaves the decision to the user which one(s) out of the 6 he or she wants to use.

Besides the 6 calculated massecuite parameters another 4 measured data are also available for transmission.

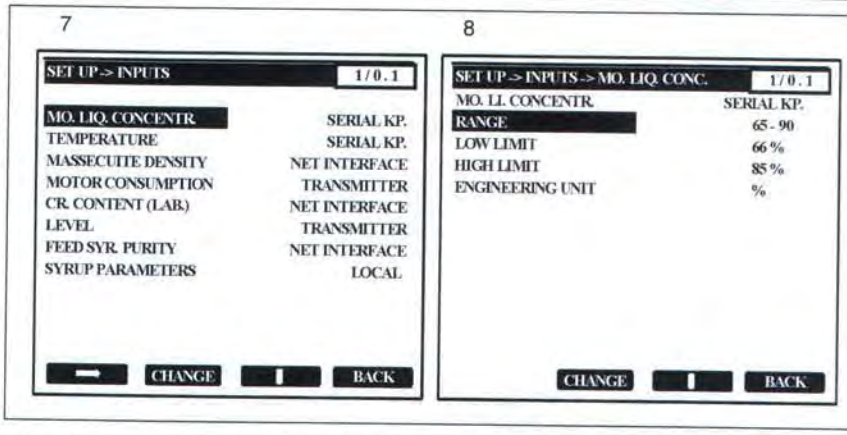
These are:

7. SYRUP / MOTHER LIQUOR CONCENTRATION	(%)
8. MASSECUITE TEMPERATURE	©

9. MOTOR CONSUMPTION (kW, or A)
10. LEVEL (option) (%)

Summing up: there are 10 (maximum, per pan) data available for transmission to a computer or a PCS. All of these can be transmitted via the net interface of SeedMaster 2 (TCP/IP Modbus protocol, COM port or Ethernet port). Any selected 2 (per pan) out of the 10 can be transmitted as standard current output (4-20 mA).

Figure 7. Set up data inputs Figure 8. Specifying range and alarm limits



SeedMaster 2: the Automatic Seeding Device

Seeding is a very important step in the process of crystallization, which has a large influence on the quality of the product. When completed, the crystals begin to grow in size if supersaturation is larger than 1,0.

Shock seeding is the traditional way of seeding. It relies on maintaining high supersaturation in the solution, when a small amount of seed crystals entered into the pan results in the *formation of new crystals (nucleation)*. The number of these crystals keeps growing as long as the value of supersaturation is above a "safe" (nucleation-free) limit. The final number depends on the

1. actual value of supersaturation maintained in the "seeding point" and during nucleation;
2. length of nucleation and
3. limit value of supersaturation above which nucleation begins, if there are already crystals in the solution (Fig.1.).

Fig.4. shows the supersaturation profile typical of shock seeding.

Full seeding is the advanced mode of seeding. In an ideal situation, there are no new crystals formed during seeding: the full required crystal crop is supplied during seeding in the form of well prepared *slurry*. It is assumed that *only crystal growth and no nucleation* will take place during the complete length of crystallization (during a strike in batch pans), that is the number of crystals in the end product is in ideal case equal to the one of the seeding material.

Full seeding can be implemented by using crystal footing (magma), too. However, the use of slurry (or crystal footing) alone is *no guarantee for correct full seeding*. Besides the right amount of slurry or footing (with the right number of crystals in it) *supersaturation must not exceed its limit value*. This requirement may result in somewhat longer times of crystallization than accustomed, but will result in better sugar quality. In both cases of seeding on-line monitoring of supersaturation is required.

Automatic seeding is a basic requirement when constant product quality is at stake. When well implemented, this alone can result in a large improvement in stabilizing sugar crystallization from strike to strike, *even during the night shift*.

SeedMaster 2 has 2 (DO1, DO2) digital (ON / OFF) outputs (per pan) which can be used to implement *reliable and repeatable automatic seeding* of the vacuum pans. Automatic seeding can be based on

- supersaturation or
- density

set-point (use of supersaturation is advised). *It is the local technologist's responsibility to select the correct set-point for seeding.*

DO1 can be programmed to warn the operator on approaching seeding, while DO2 can be used to open the seeding valve for a configurable time interval, when the selected set-point for seeding is reached.

Besides automatic seeding manual seeding by the local operator, and *seeding commanded via digital communication by a Process Control System* can be carried out, too.

SeedMaster 2: the local Operators' Station

SeedMaster 2 has very advanced local Operators' Station features, including alarm limit excursion detection, signalization and logging, too. It has all the tools for customizing the device to local circumstances and preferences organized in *Configure, Set Up and Display*.

Figure 6. Configuring automatic seeding

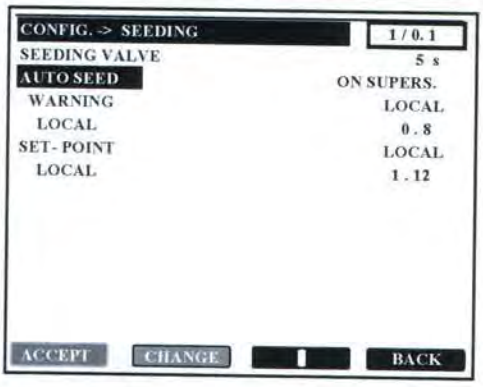


Figure 9. Main display

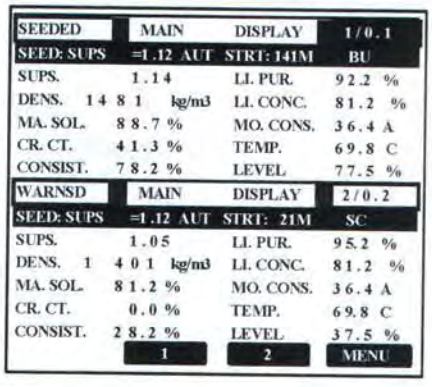


Figure 10. Trend display

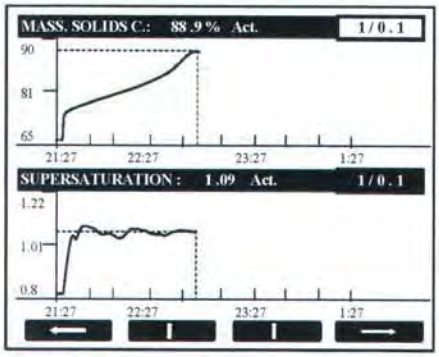


Figure 11. Standard display

Configure

SeedMaster 2 configuration involves the specification of

- active instruments (1 or 2 crystallizers are served),
- the sources of inputs (refractometer(s), "third" input(s)),
- seeding details,
- digital communication / net interface and
- password.

Example: Fig.6. shows how automatic seeding can be configured. Selected data:

Mode of seeding: automatic, based on supersaturation set point.
Seeding valve: keep it open for 5 seconds.
Warning on approaching seeding: when supersaturation equals 0,8.
Set point for seeding: 1,12 .
Data are entered by using the device keyboard (LOCAL input).

Set Up

Set up involves the specification of

- data display (date and time, Standard Display),
- inputs and outputs (analog, digital (ON / OFF)),
- feed syrup type and parameters (beat / cane, purity, quality parameters "m", "b" and "c"),
- signal range and alarm limits.

Fig.7. shows the flexibility of data inputs:

SERIAL KP: Serial communication with a K-PATENTS PR-01-S type refractometer.
NET INTERFACE: Data from a PCS or computer via the net (Ethernet).
TRANSMITTER: Standard current input from a transmitter (4-20 mA).
LOCAL : Local data entry using the keyboard of SeedMaster 2.

Display

SeedMaster 2 has a large number of well-designed, combined (character and graphic) LCD data display screens providing a high level of user-friendly Operators' Station features right on the plant floor, including:

- Main Display (Fig.9.)
- Trend Display (Fig.10.)
- Standard Display (Fig.11.)
- Strike History (Fig.12.)
- System Information (Set Up summary)
- Test Data (analog / digital inputs and outputs)
- Test Communication (COMx and Ethernet ports)

Main Display: 6 massecuite parameters and up to 4 measured real-time data per pan. Pan tags (/0.1, /0.2), strike status (SEEDED, WARNSD (warning on approaching seeding), BU: boiling up, SC: syrup concentration), seeding (AUTOMATIC, set-point SUPS = 1,12) strike time (STRT 144 M) information for 2 pans.

Trend Display: (any 2 of the 6 calculated and 4 measured data (per pan) can be trended for the actual (Act.) and 3 previous strikes (Act.-x, where x = 1, 2 or 3). Trends can be zoomed. Displays numerical data when moving the cursors.

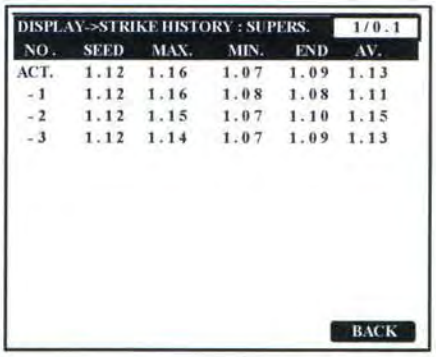
Standard Display: large-character display of 2 selected massecuite parameters per pan. Pan tags and strike status information.

The Strike History screen (Fig.12.) contains condensed supersaturation data on the actual (Act.) and 3 previous strikes, namely:

SEED:	when seeding (automatic and manual seeding).
MAX.:	maximum value after seeding.
MIN. :	minimum value after seeding.
END :	value at the end of strike.
AV. :	average supersaturation from seeding to the end of strike.

Strike History data can be used very effectively to check the quality of crystallization control. If automatic seeding was configured, supersaturation data in the seeding point (SEED) should be the same

Figure 12. Strike history



and equal the set point selected by the local technologist. MAX. data should be below the critical level to start unwanted nucleation. A value below 1,0 (MIN.) is a clear indication of poor control ("washing" unwanted fines, or too high temperature). Too low END value may indicate good syrup exhaustion, but may be due to too high temperature as well. Finally, AV. data are closely related to the effective time of crystallization and final crystal content: low AV. supersaturation data results in long crystallization time, or low crystal content when the charge is dropped. In ideal case it should be close, but below the critical limit to start nucleation.

Trends on supersaturation and crystal content combined with strike history data are extremely powerful tools to diagnose crystallization control problems.

SeedMaster 2: hardware specification basics

Enclosure:
IP66, NEMA 4X
Size (mm / inch): H: 267 /10.5; W: 226 / 8.9; D: 159 / 6.25
Power supply:
110 / 220 VAC, 60 / 50 Hz; 25 VA
18 – 30 VDC
Temperature range (ambient):
Operation : 5 – 50°C
Storage : - 25…70°C
Display:
Backlit 320 x 240 pixel graphical LCD
Keyboard
Metal foil protected membrane keyboard.
Front panel:
There are 3 LED-s on the Front panel : POWER (SeedMaster 2 power is on)
RUN (blinking) : the CPU board is active
ALARM (blinking, steady, or dark) : events / alarm signalization

Conclusion

When controlling different processes it is evident without explanation that if pressure, flow, level etc. are critical parameters of a process, then pressure, flow, level etc. have to be measured on-line and kept reliably under control. The same way it should be evident, too, that if as acknowledged, supersaturation is the most critical parameter of sugar crystallization, instead of being satisfied with controlling only density, or solids content, or conductivity etc., supersaturation should be carefully controlled on-line all over the process of crystallization.

By the same reasoning: if seeding is a very critical step in sugar crystallization, then it should be relieved of human error or eventual neglect by *automation, based, evidently, on the parameter that really counts, that is supersaturation and not on something else.*

For quite a long time there were no instruments and tools capable of meeting these requirements. Surprisingly enough, expensive automatic control systems use instruments, are programmed and in use imitating methods and practices dating back to several decades.

In a recent paper [4] Mark Twain was quoted writing in his book "Life on the Mississippi": "To make sugar is one of the most difficult things in the world. And to make it right is next to impossible." The introduction of the optional SeedMaster software was the first step in trying to offer help addressing *the real difficulty: reliable on-line monitoring of supersaturation with added automatic seeding capability*, if required, right on the plant floor.

The development of SeedMaster 2 is a further large step to provide the tools for advanced sugar crystallization control. It was designed to inspire fresh approaches "to make it right", and help to get as close as possible to what was once, in the great writer's time "next to impossible".

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