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Innovations in the Sugar Cane Industry – Enhancing Sustainability, Quality and Efficiency

Abstracts

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Circular sustainability of the sugar crop processing industry through by-product utilization

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Sugarcane bagasse, sugarcane field residue and sugar beet pulp are the largest sources by volume of fibrous by-products generated from harvesting and processing sugarcane and sugar beet. The profitable reutilization and conversion of these by-products into value-added materials and specialty products is an opportunity for the industry to enhance its sustainability and to facilitate a circular economy where by-products are reused, recycled, or reformed into economically viable industries. One such technology entails the thermo-chemical conversion of these by-products into biochars for agricultural and industrial uses. By varying pyrolysis temperature, residence time regimes and pre- and post-treatments, it is possible to strategically design biochar physico-chemical properties for specific applications. When applied to the field, in addition to increasing the carbon content of the soil, sugarcane bagasse biochar can improve the ratooning ability of sugarcane by lessening the decline in yield. By progressively implementing sustainable utilization of sugar harvesting and processing by-products, the sugar crop industries will be able to effectively respond to current environmental, economic, and consumer demands.

Digitation – Leading factory KPI dashboards

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Manufacturing digitalization in the sugar industry is essential for enhancing operational efficiency and competitiveness. By integrating advanced technologies like IoT and MIS, sugar mills can achieve real-time monitoring of production processes, leading to optimized resource utilization and reduced costs. For example, factory performance lead indicators enabled by digitalization allow shop floor operators to react more proactively, minimizing losses and enhancing overall plant effectiveness. Improved data analytics further ensures consistent product quality and regulatory compliance, crucial for meeting global standards.
To this end, Illovo Sugar has implemented digitized dashboards, incorporating wifi networks, live KPI visualisations as well as integration of data across different sources. This allows for real-time tracking and analysis across previously hard-to-integrate databases. This new capability has resulted in improved outcomes.

The 4.0 journey in sugarcane industrial business

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São Martinho 4.0 journey in the sugar-energy sector has organized and set clear goals for an industrial process through a structured, phased approach. There are many ways to understand our path, and each company has its own way. In São Martinho, we understood our main short and long-term goals together with our management team and built 5 main fundaments to guide us. For short-term works, we have structured 4 main phases where our industries understand and follow a “clear path”, as well as technology is better understood with field low-scale tests. In Phase 1, we are focused on infrastructure, such as new sensors (IIOT), new ways of connectivity (like 5G), and installing sensors to collect precise data from processes using new networks. In Phase 2, we developed simulation tools and a digital twin to replicate and analyse process behaviour in a virtual environment turning data into important information. Phase 3 implements Advanced Process Control (APC) techniques, optimizing efficiency and control of processes using Model Predictive Control (MPC) and Fuzzy Logic. Finally, Phase 4 introduces Artificial Intelligence (AI) to support the Operator 4.0, aiding decision-making and enhancing operational efficiency. This comprehensive journey modernizes processes and empowers the workforce, fostering a more strategic and data-driven environment. The integration of these phases results in improved profitability and sustainability, cementing the importance of Industry 4.0 in advancing industrial competitiveness, such as cost reduction, efficiency, and process and people safety.

SMRI progress with factory-based industry 4.0 projects

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Fourth Industrial Revolution (4IR) principles and technologies are being applied in the process industries to interpret big process data sets to better understand and control processes. The Sugar Milling Research Institute NPC (SMRI) is continuing to develop appropriate 4IR technologies for application in the South African sugarcane processing industry to assist the industry in improving sucrose recoveries and energy efficiency performance, coupled with the rapid analytical capabilities afforded by Near Infra-red Spectroscopy (NIRS) analytical technology. With co-funding provided by the national Department of Science and Innovation, several research projects are being undertaken in host factories, and this presentation will highlight progress with two of the projects, one to monitor sucrose losses across the juice preparation station and the other to provide information for better control of C-continuous centrifuges. Some results obtained and lessons learnt will be discussed.

Approach towards industry 4.0

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The Industry 4.0 revolution is a challenge for the sugar industry, but it brings several opportunities as well, such as:

- Quick decision making based on real time information
- Better process control
- Higher plant efficiency
- Minimum manpower requirement
- Minimum mechanical breakdowns
- Low maintenance cost
- Better product quality
- Operational flexibility

To achieve the mentioned benefits, the Industry 4.0 solution should be built on a fundamentally suitable and reliable plant set-up. Proper equipment sizing, selection of the right and reliable technology, proper equipment and piping set-up, correct selection and sizing of field devices, etc., are a few prerequisites. The absence of any of these prerequisites impacts the plant operation stability, control, results, and reliability, which may cause the failure of the essence of the Industry 4.0 concept.

Green field projects can be developed compliant with Industry 4.0 with modern engineering tools to meet the prerequisites. Existing plants require reverse engineering and a review of plant operation and set-up through the performance of a mass and energy balance (MEB), piping and instrumentation diagrams (P&IDs), capacity and condition review of existing equipment and piping, and 3D scanning of all process stations to move towards Industry 4.0. The equipment and plant setup should be upgraded wherever required to achieve a stable plant operation. Complete plant data should be stored on a central electronic database management system to ensure that the right information is available at the right time and at the right place. This helps to reduce downtime and save operating costs.

The advanced automation system and field devices should also be chosen carefully to meet the targets. The above-given prerequisites are also important for an automation control system to consistently operate the factory fully automatically and achieve the desired results.

The dark sugar factory. Conceptual design ideas and potential

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The “digitalisation” of the global sugar industry is driving investment globally. However, most of these investments do not show any return on investment or even improvements in operations. Understanding the specific needs of individual factories is essential to developing customized applications on all levels of operation. Understanding and answering the current pain points of operation is also necessary to solve them with a clear vision of a fully transparent and centrally operated factory.
Based on such fundamentals, it is possible to copy the success of other industries and to apply them to the sugar plants. Having a clear vision of the outcome, provides a fast and reliable return on investment and factual improvements.

Advanced Process Control in sugarcane industrial business

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Advanced Process Control (APC) has significantly enhanced continuous industrial processes efficiency, particularly in the sugar-energy sector in Brazil, compared to traditional PID (Proportional-Integral-Derivative) controllers, APC techniques such as Model Predictive Control (MPC) and Fuzzy Logic offer substantial benefits in terms of efficiency and productivity. Those improvements are seen as new set-point standards and more minor standard deviations in specific and important process variables. APC handles multiple variables and complex interactions, providing more precise and stable process control using raw material information to set new operational standards. Also, it anticipates and corrects deviations through predictive models, reducing energy consumption, minimizing waste, and ensuring final product quality. The implementation of APC transforms the role of operators, making them more strategic and focused on data analysis and informed decision-making, with less need to change set points, less need to continuously monitor surroundings to predict known behaviours and adding to a better systemic vision decision in the plant control. All those changes happen in line with the principles of Industry 4.0. By developing new skills, such as interpreting complex data and using advanced digital tools, operators enhance their contributions to the process. This integration of APC with Industry 4.0 leads to increased profitability and sustainability, highlighting APC's essential role in modernizing and enhancing industrial competitiveness. This is not only a technological approach for setting new levels of productivity but also matches business continuity needs and setting professional of the future.

Online Management Assisted by Digital Twin

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The Online Management Assisted by Digital Twin provides industrial managers with a virtual replica of the entire plant, integrating online data for quick decision-making to correct process routes, even when dealing, for example, with varying quality of sugarcane input to the crusher or other process issues. This approach was chosen to enhance decision-making and improve overall plant efficiency.

This technology offers a better understanding of the plant, an optimized production plan, and the ability to follow the production plan at all times across three shifts, quickly and accurately correcting process deviations, achieving targets, and maintaining a stable and controlled process.

By combining high Pentagro technology, expertise, and the knowledge and experience of the engineering team, sugar factories can optimize plant operations via creating the best production scenarios for the entire season, supported by swift and accurate decisions to maximize profitability through a stable process, reduce losses, and increase yields and production mix.

Cogeneration in sugarcane factories – past, present and future

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Due to the availability of bagasse that can be burnt in boilers to produce steam for heating and power generation, sugarcane factories are one of the few industrial processing facilities that are net exporters of electricity. Sugarcane factories are likely to become increasingly important suppliers of base-load electricity as the world transitions away from fossil fuels. This presentation discusses the past, present and likely future of sugarcane factory cogeneration around the world.

Tracking energy use in sugarcane processing

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Sugarcane processing facilities are characterised by complex interactions between different parts of the energy system and between elements of the energy system and the process streams. When process conditions vary, especially as a result of external, uncontrollable factors, such as cane supply or quality, or changes in the required product quality, these may have a material impact on the achievable energy performance of the factory. Similarly, process managers may deliberately sacrifice energy performance to achieve process performance targets. The integrated nature of the energy systems often makes it difficult to disaggregate changes in measured energy metrics such that the portion due to undesirable and avoidable actions or conditions can be identified and quantified.

The SMRI has been developing a practical system for monitoring energy consumption in sugarcane processing that provides clear guidance on what energy performance should be expected under specific operating conditions. A key feature of the proposed system is the ability to quantify the contributions of specific processing conditions to the differences between the factory energy demand and suitable targets for those conditions. Preliminary results will be presented based on a comprehensive modelling exercise that demonstrates the methodology underpinning the proposed energy monitoring system.

Reduction in water additions and increase of feed brix to the pans for steam saving

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Pans are the largest steam consumers in a sugar factory, and optimizing the pan operation is an important prerequisite to achieve a low process steam demand. Cutting down the water additions to the pans is very important to optimize the pan operation.

The authors have found in various cane sugar factory studies that water additions are not measured, and the factory personnel is unaware of the amount of water added to the process. The added water amounts up to 5% -16% on cane. The reduction of “unnecessary” water additions can be achieved to some extent with monitoring and awareness among the pan operators. With modern pan automation systems, water additions can be minimized.

Further steam saving can be achieved by increasing the brix of pan feed material. With increased feed brix, less water is added to the pans hence less heating steam or vapour for water evaporation during the crystallization process is required. The optimized plants are operated with up to 76% brix (refractometric) of the syrup and melt, whereas most sugar factories investigated by the authors operate with brix of the syrup and melt in the range of 60 – 68% (refractometric).

Along with saving steam, the pan operation optimization also helps to cut down the pan strike time, which offers several benefits, e.g., less pan capacity requirement, less sugar inversion, improvement in sugar colour, power saving, etc.

Power export potentials in the cane sugar industry

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The export of electricity to the public grid has become a significant source of income for many cane sugar factories over the last 20 years. Also in view of the fact that it is emission-free “green” electricity, the export of electricity offers good opportunities for additional income.
New factory concepts and the introduction of new technologies, such as falling film evaporators, have made it possible to reduce process steam consumption, which in turn has enabled an increase in electricity exports to 100–130 kWh/t of sugarcane.
A brief overview of the development and the prospects for the future is given.

Insights on green cane

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Sustainable green cane harvesting and processing methods are seen as key enablers of responsible manufacturing, aligned with the United Nations' Sustainable Development Goals and the Science-Based Targets Initiative. This presentation explores the option of separating the brown leaves at the factory for energy co-generation against co-processing the leaves.
The process evaluation included a literature survey, findings from interviews and visits of factories processing green cane, and trials performed at the Ubombo Sugar factory in Eswatini. About 225,000 tonnes of green cane was co-processed at the factory, representing approximately 12% of the season's crush. The factory observations were consistent with previous studies: There was an overall recovery drop of 2%, with losses to extraction and final molasses; bagasse moisture increased by 1%; and although the factory colour profile increased, the sugar product specification was maintained with the green cane blend rate and increased centrifuge washing. Trials with the pneumatic brown leaf separator were successful, and operational challenges in feeding and shredding were overcome.
The investigation concluded that both methods explored were more cost-effective than the current practice of using supplementary fuels to compensate for a fuel deficit.

The downside of post-harvest cleaning after green cane harvesting

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General experience is that the trash content of the cane supply increases with green cane harvesting. While trash content can be managed at low pour rates, the higher pour rates required to contain harvesting costs result in increased trash content. Higher extractor fan speeds are often used to contain trash content but at the expense of cane loss. Post-harvest cleaning was seen as a potential solution, allowing low-cost harvesting and a further cleaning step to contain trash content.
Experiments into post-harvest cleaning were conducted on the Atherton Tablelands in Queensland, Australia. The experiments showed that the extra handling associated with post-harvest cleaning resulted in greater cane loss. While these results may not hold true in all situations, they were replicated in all experiments during this project.

From harvest to milling: standardization of trash evaluation and an approach to its impacts

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Green harvesting in Colombia has increased significantly in the last decade, reaching 75% in 2023. These changes, along with climate variability, have increased the levels of trash entering the factory from 6.3% (2013) to 8.9% (2023), affecting the quality of juices, bagasse, and factory yield due to impurities such as reducing sugars, organic acids, ashes, phenolic components, and others. Additionally, the sector has two methods to evaluate the trash content, with differences between them. To address these challenges, various studies were undertaken.

Experimental studies with factories evidenced the variability of trash from the field to the transport in wagons. It was found that the major variability is inside the wagons (67% and 45% by core sampler and grab sampler, respectively). With these results, the two methods were standardized in parameters such as sampling configurations, confidence levels, limits of error, and criteria to classify the trash components, ratifying stool as mineral trash and defining immature canes as non-trash.

Other studies on a laboratory scale were conducted. One of them, related to the physicochemical characteristics of vegetal trash in two commercial varieties, showed that leaves and tops contribute significantly to non-sucrose contents. The other study on press juice showed that for each one percent of vegetal trash, the contents of conductivity ashes (0.07 units), color (330 UI), starch (0.90 units), and reducing sugars (0.02 units) increased.

In this way, due to the impact of trash on process quality and materials, reliable methodologies and the exploration of indirect alternatives to measure and track its impacts in the process from harvesting to sugar production are relevant.

NIRS progress within Illovo Sugar

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Illovo Sugar has adopted the NIRS analytical technique as the standard to be used across all sugar factories for the analysis of factory product streams. This presentation covers what was learned from rolling out as well as adopting this technology. The biggest hurdle to be overcome was found to be the change management required to land and embed this technology rather than the technical development and calibration of equations. Equations were developed within Illovo initially, however the SMRI was eventually selected as the supplier of equations as they had developed and demonstrated their set of equations to be most effective. The limitation of global equations was then another hurdle to overcome and this did not help with building confidence in the technology. Training and capability building was another key enabler. Illovo has succeeded and successfully implemented this technology in our laboratories for factory products. Some factories are producing weekly reports off NIRS generated analysis results whilst the rest are testing and fine tuning the equations and running comparisons. The benefits of this additional capability at the sites that have fully transitioned are evident.

Implementing near-infrared spectroscopy for quantifying trash/extraneous matter in the Louisiana cane payment system

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Near-infrared spectroscopy (NIR) is a powerful tool for determining the composition of materials and has significant applications in the sugarcane industry. This research addresses the challenges posed by local environmental conditions in Louisiana (LA), such as high levels of trash or extraneous matter (EM), which significantly influence the quality assessments of sugarcane. The study aimed to optimize NIR calibration models using wet methodologies and machine learning techniques to enhance the accuracy of predicting sugarcane quality parameters involves in the LA cane payment system, including EM. High-performing calibration models for Brix and pol in press juice and moisture in press cane were successfully developed utilizing Partial Least Square Regression (PLSR). Additionally, a calibration model for soil content in shredded cane was developed using incinerated ash as the primary calibration methodology. For quantifying EM, three different modelling approaches—PLSR, Artificial Neural Networks (ANN), and functional regression—were tested and compared using manually prepared mixtures of cane, soil, and leaves. Although these models proved effective, they also highlighted areas for potential further improvement.

Sugar characterization by SPIR measurement at line

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The monitoring of sugar quality is a major challenge for the sugar factory to certify the conformity of the finished product. The possibility of determining critical characteristics such as the granulometry or colour of the sugar directly on the production line would make it possible to better manage production and avoid downgrading of sugars.

To carry out this measurement online, the choice was to use visible and near-infrared spectroscopy equipment coupled to a multipoint probe with spatial resolution. The spatial resolution allows the processing of grain size information, and spectroscopy in the visible region should be able to process colour information. In addition, the processing time is very fast, and the analysis is non-destructive.

The sampling carried out during this 2023 campaign at Le Gol Factory (Reunion Island) is representative of the production throughout the campaign, with more than 1069 samples (of different sugar quality).

Measurements are carried out in dynamic flow, which corresponds to an estimated average flow rate of 50 kg/h. The spectra are acquired with 100 spectra per sample, and the measurement time is approximately 2min.

Quantitative models (PLS-R) based on raw spectral fingerprints present performances that allow prediction:

The colour of sugars with an uncertainty of ±160 IU.

The mean aperture size with an uncertainty of ±0.06 mm.

The coefficient of variation with an uncertainty ±2.16%.

An online configuration is possible for the 2024 campaign but will require adaptation of existing models and verification of prediction performance considering new constraints.

Finally, it will be necessary to develop a “quality control” interface. A complementary software which must manage the acquisition, filtering of spectra, application of models, display of results to operators and archiving of data.

Evaluation of auto filtration equipment for polarimetric analysis

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Polarimetry serves as a key method in the sugar industry for assessing polarimetric sugar content in various sugarcane and sugar beet products. To obtain accurate measurements, sugarcane factory materials have to undergo a crucial preparatory step involving clarification with a clarification aid, and it traditionally can be time-consuming. Therefore, there is a critical need to explore advancements in filtration/clarification technology not only to enhance measurement accuracy but also to reduce analysis time, thus improving overall efficiency. This study evaluates the Autofilt Z, a fully automatic pressure filtration unit, against conventional clarification procedures using Octapol or Clearpol aids for polarimetric analysis of factory cane products in Louisiana, USA. Comparative analyses were conducted on core lab juices, syrups, final molasses, and raw sugars from Louisiana factories. Results indicate that Autofilt Z, coupled with Celite, provides effective filtration, particularly at 880 nm, the predominant wavelength for polarimetric analysis in the sugar industry. While funnel filtration with Octapol and Clearpol aids led to increased Brix levels in the filtrate, Autofilt Z demonstrated no significant impact on Brix values. Moreover, Autofilt Z markedly reduced both filtrate turbidity and filtration time compared to traditional methods, indicating superior performance in an industrial setting. These findings underscore the potential of Autofilt Z to enhance sample preparation efficiency for polarimetric analysis in the sugar industry.

How can real-time measurement of sugar colour in solution help trimming the centrifugal washing, and how can the validity be checked by the lab?

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Are sugar samples from the production stream representative of the whole stream? How to handle dry sugar samples to avoid errors from segregation. How accurate can real-time instruments get?
These topics will be treated in the presentation, and it will be demonstrated how real-time measurements are able to detect problems not detectable by other methods. Examples:

- a small difference in performance between the centrifugals in a line,
- detection of clogged spray nozzles,
- immediate conveyor stop, if massecuite leaves a centrifugal without centrifugation,
- detection of small differences in the sugar quality between discharges from vacuum pans,
- immediate feed-back after adjustments of wash water, making it easy to trim the wash, so it is just below the limit and not above.

The risk of sudden quality jumps between check samples forces all factories/mills to work with a significant safety margin. The savings from reducing the safety margin will be indicated.

Estimation model for color increase in refined sugar

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Reason for choosing the topic:

- The color of sugar tends to increase during storage between production and shipment, influenced by sugar characteristics, storage conditions, and duration.
- This increase can be significant, impacting compliance with product specifications and maximizing the amount of sugar for sale. Therefore, it's crucial to estimate and manage this color increase effectively.

Results obtained:

- Identified variables affecting the color increase in refined sugar, including initial color, the concentration of invert sugars, packaging/storage temperature, and ash concentration.
- Determined the effect of storage methods on color increase, comparing direct packaging in bags with subsequent warehousing versus bulk storage in a Domo conditioning system.
- Developed a model to quantify the color increase in refined sugar based on the mentioned variables and storage method, highlighting the most significant factors.
- The model aids in optimizing sugar production by diagnosing variables affecting color increase, discouraging simple solutions like increasing water addition in centrifuges, which reduces sugar output.

Conclusions drawn:

- The color increase in refined sugar can be estimated based on initial color, invert sugars concentration, packaging/storage temperature, and ash concentration.
- The Domo conditioning system significantly reduces color increase by at least 70% compared to traditional storage methods.
- Among model variables, initial color has the greatest impact on color increase, followed by invert sugar concentration, and production temperature, with ash concentration having the least impact.

Insoluble starch contributes to lower sugar exhaustion from molasses

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The greatest loss of sucrose in a raw sugar factory is that which resides in the final molasses. A 2-year (2020 and 2021 Louisiana processing seasons) study of weekly final molasses from three sugarcane factories has recently delivered new information on the effect of starch on molasses exhaustion. Target purity difference (TPD) of final molasses is an important metric for factory performance to estimate final molasses exhaustion; generally, a lower TPD indicates greater recovery of sugar. During the 2021 processing season, LA factories experienced markedly higher target purity differences (TPDs) and, thus, lower exhaustion compared to the 2020 season (normal year). Differences in molasses exhaustion among the factories could not all be explained by conventional reducing sugar/ash (RS/ash) ratios, particularly in 2021. With new methods for the sugar industry to measure the amounts of soluble and insoluble starch as well as total starch, these three forms of starch were analyzed in weekly composite C molasses from the three LA factories in both seasons. For the first time, the starch form was shown to strongly impact molasses exhaustion. The greater the amount of insoluble starch in the molasses the lower the TPD value (R^2 = 0.886). This is most likely because the insoluble swollen starch increases the viscosity of the molasses which, in turn, impedes sucrose exhaustion. The factory which added high-temperature (HT) stable amylase to the clarification settling tank consistently had the lowest TPD values in both years. The risk of carry-over amylase activity in raw sugar, however, increases with the addition of HT amylase, but this problem could be solved at the refinery with the use of activated carbon.

Sugar quality to meet changing market requirements

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Until 2010, Indian Sugar Industry mainly produced plantation white sugar only which was neither readily acceptable in the international market nor by various bulk consumers viz. bakery, beverage, confectionary and pharmaceutical sector. To circumvent the situation and increase revenue, factories considered adopting greener and flexible processes to produce superior sugar quality.

M/s Triveni Engineering & Industries Ltd., Sugar Unit Sabitgarh was commissioned in 2005 as a sulphation sugar plant aiming to produce below 150 IU plantation white sugar. However, to meet changing market demand, the unit adopted changes in the process operations and converted to a back-end refinery. The 8500 TCD unit while undertaking conversion to produce raw-refined sugar by Defco Melt Phospho-floatation & Ion Exchange Process, considered various re-arrangements, installation of efficient process equipment and steam economy devices to incur minimum expenses while attaining higher technical efficiency. After that, the unit put up a state-of-the-art pharma sugar plant with a capacity of 150 TPD, subsequently expanded to 300 TPD. Later on, to take advantage of the government policies on ethanol production, the factory made changes in the process house to facilitate the diversion of intermediate process liquors without compromising on sugar quality. Thus, it became a flexi sugar factory producing sugar of different qualities and facilitating ethanol production as per market requirements and relative economics. The high-quality refined sugar and pharma sugar below 15 IU meet all international standards and have secured prestigious customers like G.C. Riber, Lupin Pharma, Amul, Rasna International, Wilmar Schwabe etc.

The modifications facilitated production of different sugar qualities as per sectorial demand, also enabled better liquidity and price premium. The objective of diverting intermediate process liquors to produce sugar and ethanol in desired quantities could be achieved.

The effects of mixing syrups from beet and cane origin on sugar quality

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This study addressed European sugar manufactures need to optimize processes and enhance factory utilization. Findings on co-producing beet thick juice and raw cane sugar may be of interesting to cane sugar manufacturers.
These were:

- The color transfer factors found in the literature for syrups made solely from beet or sugarcane have been confirmed
- In a blend of raw cane sugar and beet thick juice, color transfer behaves exponentially as function of raw cane sugar level as it seems that beet compounds suppress the inclusion of cane colorants
- The addition of 40 g/100 g of a typical raw cane sugar results in white sugar of highest quality with color values below 30 IU.
- High dextran levels in the raw materials promote color inclusion
- Color incorporation increases linearly with crystal growth rate
- A model was developed to predict final sugar color values based on the color of the individual source syrups.

Conclusions:
The study confirmed that color transfer in beet and sugarcane syrups behaves as previously reported, and in a blend, it follows an exponential pattern based on raw cane sugar level. The results indicate that the colorants from both sources mutually suppress their inclusion into the sucrose crystal.

Color transfer into sucrose crystals

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This presentation gives a brief overview of the theory of colorants and inclusion mechanisms and answers the question of why the color inclusion in cane sugar processing is higher compared to beet sugar processing.
Different components and mechanisms are responsible for the inclusion of colorants in the sucrose crystal. Knowledge of these can help find useful solutions to reduce color inclusion.
Results:

- Colorants have different origins: raw material and process
- Different colorant classes have different inclusion preferences related to the molecular structure/ composition and molecular weight
- Colorants from cane plant with high molecular weight are preferentially incorporated into the crystal
- Three different mechanisms are responsible for sugar color: adsorption, liquid inclusions, co-crystallization
- Process conditions such as high temperature and pH value increase the intensity of colorants and the final sugar color

Conclusions:
Colorants provided by the cane plant are mainly responsible for cane sugar color. These colorants have a high molecular weight and a high inclusion preference because they are included into the sucrose crystal like a “Trojan horse”. Temperature has the greatest impact on the color intensity and the inclusion of colorants.

The influence of dextran on color inclusion

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Dextran is present in cane sugar production and influences the process such as filtration, evaporation and crystallisation rates. This work investigates how dextran and its combinations with invert sugar and raffinose affect the colour of sucrose crystals and analyses the effects of dextran degradation on crystal colour.

Results:

- Dextran and its combinations with invert sugar and raffinose led to a significant reduction in the rate of crystal growth.
- With dextranase, the crystal growth rate could be returned to a level corresponding to that of reference solutions.
- The color value of the sucrose crystals increased with increasing dextran concentration
- Dextran is responsible for increasing inner color of the crystal, the outer color (adsorbtion layer) is not increased due to Dextran
- Treatment with dextranase led to a significant improvement in crystal quality and crystal growth rate and color value approached the values of the reference solutions
- Dextran, invert sugar and raffinose show no synergistic effects in colour inclusion

Conclusions:

The study shows that the influence of dextran on colour inclusion into sucrose crystals is considerable and can be effectively reduced by enzymatic treatment with dextranase.

Process analysis in evaporation stations: Comprehensive approach to improve performance and reduce sucrose losses

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The evaporation station plays a crucial role in the production of sugar and ethanol. Any difficulties in its configuration can negatively impact the dynamics of heating and crystallization operations. Additionally, in the Colombian sugar industry, changes in harvesting systems (mechanical harvesting increased from 39% to 75% between 2013 and 2023) and the impact of climate variability pose significant challenges in terms of scaling in evaporation stations.

By using specific models of Ceniprof 3.0, it was possible to analyze the performance of evaporation stations and identify opportunities for improvement. At one sugar mill, a roadmap for uninterrupted operation for over three months was established (initially, the sugar mill had to make short stops every 15 days to clean the evaporation train). The proposal included the rearrangement of equipment and the installation of valves to provide flexibility for cleaning. At another sugar mill, the analysis identified the effects of oversizing, resulting from a thermal integration project, which was a possible cause of the thermal degradation of sucrose. In yet another sugar mill, the in-line calculation of heat transfer coefficients was used as a criterion to define the extent of the cleaning cycles for the evaporation station and assess the cleaning procedures.

The implementation of process analysis tools (process simulators, measurement protocols, control strategies, and factory dashboards) has helped to extend the operational cycle of evaporation stations, improve their stability, and reduce uncertainty for sugar mill staff when making changes or adjustments.

Given the challenging scenarios that sugar mills typically face (variations in cane quality, variable milling rates, higher demands for uninterrupted operation), it is very important to have robust and easy-to-use tools to maintain stable and efficient factory operations.

Vertical continuous pans for high and low grade massecuites in cane sugar factories

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In beet sugar factories the BMA type vertical continuous pan (VKT) can be regarded as state-of-the-art, capable of operating on low-pressure vapours to further reduce exhaust steam consumption for sugar production. The cane sugar industry has until now predominantly used horizontal continuous vacuum pans (CVPs), however, in recent years, several cane sugar factories have installed VKTs. The recent of these VKTs are successfully operating in cane sugar factories for over 10 years. This paper discusses the implications of using a VKT on the steam economy, some updated design features of the VKT, and practical experiences with that. As a result, the VKT helps to stabilise the steam demand of the sugar house even at very high dry substance content of the feed solution.

Impact of evaporation configurations on the feasibility of greenfield cane sugar factory projects

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The concentration of sugarcane juice is undertaken in multiple-effect evaporators having due regard for energy efficiency, sucrose losses due to hydrolysis, and the capital costs of the installed heat transfer area. Modern cane sugar factories usually aim for high levels of steam efficiency for process consumption considering the demand for diversification (other value-added products). A higher number of effects provides a greater reduction in steam consumption, although this inevitably increases the capital costs of the project. For a greenfield cane sugar factory project, this paper provides a techno-economic assessment of different evaporator configurations (from quintuple to octuple) with regards to the overall feasibility of the project based on mass and energy balances.

Energy management through unique evaporator configuration

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Indian Sugar Industry is looking for value addition through better utilization of by-products, wherein bagasse has also assumed a greater significance for producing many value added products viz. pulp & paper, disposable crockery and particle board etc. besides its use as fuel. Looking to growing market for these products and increasing bagasse price, M/s Bindal Papers Mills Ltd (Unit – Sugar), in its new sugar plant installed an innovative evaporator configuration facilitating higher steam and thus bagasse saving.
In general, sugar factories adopt a mix of film-type and *Robert*-type evaporators, working mostly as quintuple-effect evaporators. Longer train of evaporators and extensive bleeding, particularly from last few bodies results in steam economy. However, considering multiple issues of sugar loss, colour development, steam economy, and added cost, quintuple effects has been used most conventionally. In this plantation white sugar unit, operated at 7500 TCD, a unique evaporator configuration was adopted after considering all such issues. The seven effect evaporator set has all falling film bodies and was operated at pressure and vacuum conditions different to the conventional. While I-IV bodies worked at pressure (0.95–0.15 kg/[sq · cm · g]), V–VII bodies operated at vacuum, 80–500 mm of Hg. Availability of high temperature vapours enabled pan boiling from V-VIth effect resulting in greater steam economy. No abnormalities with respect to sugar loss and colour development across the evaporator set were observed. With B Heavy molasses diversion for ethanol production, while working at rated capacity the factory achieved a steam consumption of around 26% on cane.
The unique configuration resulted in bagasse saving, on the one hand for use in the paper mills of M/s Bindal Group, on the other hand, the factory produced about 80% bold grain sugar having a colour less than 100 IU.

Energy efficient sugar complex – a success story

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The Indian paper industry is dependent on several raw materials, out of which 8% of the paper is made from agro-waste. Bindals Papers Mills Limited has a diversified Business Portfolio. They aim to preserve the environment and save trees for future generations by utilizing bagasse for paper production. To fulfill the demand of fibre to their paper plants, ISGEC has set up a state-of-the-art new sugar complex with 120 KLPD zero liquid discharge ethanol plant, captive power plants; no power exports. The plant uses minimal steam and power usage, allowing for the maximum bagasse to be saved for the paper plants exclusively.
Therefore, while setting up our 7500 t cane/day greenfield sugar project in Uttar Pradesh (India); 3 hours away from Delhi; energy-conservation measures are adopted in all sections of the plant without compromising the reliability and stability of its operations to maximize bagasse saving: Septuple effect configuration, batch pan design on 5th effect vapour, vertical continuous pan designed on 6th effect vapour, double stage condensate heating, rectifier column direct heat integration with a super heater of MSDH without recovery column, etc.
Plant operated on 26.5% steam consumption on cane and 3.5 kg/L on ethanol for production of white sugar during the first harvest (2023/24) when operated on full crush of 7500 TCD and we hope to better this figure during the next harvest.
This paper will elaborate on the energy efficient model of the sugar complex and will further explain the sustainable, profitable configuration of the complex without cogeneration.

Energy management in diversion era – Indian experience

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Indian Sugar Industry has gone for diversion of intermediate process streams viz. B Heavy molasses and partial quantities of syrup for ethanol production. The same has been considered to balance the sugar demand-supply scenario and to boost ethanol production for meeting requirement of ethanol blending in petrol. However, to undertake such diversions, issues were faced by the plants necessitating reworking of fuel-steam-power balance and evaporator configurations, in particular, and it was considered essential to work out economic yet efficient model to be followed during such diversion.
M/s Dalmia Bharat Sugar Mills Ltd., Nigohi, Shahjahanpur, Uttar Pradesh, India, a sugarcane based backend sugar refinery having crushing capacity of 9000 TCD, while making changes to facilitate such diversion i.e. syrup at 25% and complete B Heavy molasses, also kept in consideration modifications to attain better technical efficiency. The evaporator station was reconfigured and made somewhat unconventional, operating it as sextuple effect evaporator having initial four bodies as falling film evaporators. Further, to facilitate more vapour bleeding from 3-5th bodies to achieve steam economy and the desired temperature of vapours, the evaporator was operated at a relatively lower vacuum. With this & many other measures taken with respect to steam economy viz. utilization of waste heat and for power saving, the factory could achieve steam consumption of 28.50% on cane, while the process house power consumption remained 28.16 kW/TCH. Efficient water and condensate management made it possible to operate the plant without fresh water intake.
With the changed evaporator configuration and other modifications, the motive of diverting desired quantities of process intermediates could be achieved with better plant efficiency. The factory produced refined sugar of 15–20 IU while exporting power at 0.3 million units/day yet saving bagasse at 15% on cane.

Energy saving with platular heat exchangers in sugar factories

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As the energy prices becomes increasingly important, cost reduction and energy saving are more relevant than ever.
Platular heat exchanger allow recuperation of energy contained in low-pressure vapours that haven't been used before. The units combine the advantages of wide free-flow channels, allowing an efficient and fast cleanability on site, with the possibility of important thermal approach and high efficiency of plates. Combining sections with several vapours in one unit is also possible.
As conclusion, the Platular offers a compact, cleanable, efficient cost saving solution.

Mechanical Vapor Recompression (MVR) options and limits for juice evaporators and crystallizers with PILLER MVR blowers

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Energy efficiency involves reducing the amount of energy consumed to achieve the same outcome. Mechanical Vapor Recompression (MVR) has long been recognized as a key technology for reducing primary energy consumption in steam-reliant processes. The sugar industry, in particular, could significantly benefit from the MVR technology by recycling vapors that would otherwise be condensed, thus reducing net energy usage and enhancing overall process efficiency.
This presentation gives basic insights into the MVR technology based on blowers. It includes knowledge on mechanical features, operational limits as well as examples of integrating MVR into the juice evaporation and crystallization processes. The mechanical aspects and the operational limitations will be presented in detail using charts and graphics.
Challenges and considerations for integrating MVR into existing plants are also discussed to provide a holistic view. The potential for MVR to enhance by-product utilization and support a circular economy is also highlighted. The presentation concludes by emphasizing MVR's strategic relevance in meeting the global demand for sustainable and efficient sugar production, aiming to encourage industry stakeholders to adopt this technology.

Shaping the future of the cane sugar industry with significant energy savings

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For over three decades, De Smet Engineers & Contractors has been dedicated to enhancing sugar processing, prioritizing the design of efficient equipment and techniques to ensure top-quality sugar. In recent years, DSEC's cross-functional activity "Decarbonisation, Energy Efficiency, and Renewable Energies" has been deeply involved in developing energy efficiency projects tailored for the sugar industry.

In the cane sugar industry, the pursuit of energy efficiency is not merely about operational optimization but also a response to clients' demands for low-energy-intensive sugar products. Clients increasingly prioritize goods with a reduced environmental footprint, compelling cane sugar producers to innovate and invest in energy-saving technologies to meet these expectations. This paper explores the imperative of energy efficiency within the industry, showcasing its direct impact on fulfilling customer expectations and enabling sustainable production.

Building upon the current benchmark cane sugar factory, De Smet Engineers & Contractors has envisioned a strategy to guide clients towards optimal energy utilization in their plants. Understanding that investment projects cannot be undertaken all at once, we collaborate with our clients to develop projects incrementally. Leveraging our simulation tools and profound process knowledge, we propose coherent investment packages, starting with those that offer the greatest economic sense.

During our presentation, we will highlight several case studies for optimizing each part of the plant, from extraction to crystallisation, not forgetting the plant's energy core: evaporation. We will outline scenarios that we hope you will recognize as potential pathways for your plant's future.

Slurry, viscosity reducer and color remover for efficient and energy-saving sucrose crystallization

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Crystallization plays a key role in ensuring quality, maximizing yield, and minimizing energy consumption in the sugar industry. A well-optimized crystallization process, with the help of high-quality process chemicals, leads to a more efficient production process, improved yield, and stronger competitiveness.
KEBO has been a reliable partner for sugar manufacturers worldwide for many years, whether for beet sugar or cane sugar processors including refineries or for specialties manufacturers such as xylitol. Our specialty process chemicals help to significantly improve the crystallization process of sucrose – KEBO Slurry, viscosity (KEBOSOL) and color-reducing (KEBO Colour EX) agents are helpful additives. These products stabiles grain sizes and improve MA and CV values, the viscosity of the massecuite can be reduced by up to 50%, and the color (ICUMSA units) can be reduced by up to 30%.
A uniform crystal formation with a homogeneous size leads to fewer remelting and recrystallization steps. Deaeration of the massecuite, leading to a higher density by keeping the viscosity as low as possible, increases the sugar yield per crystallization batch (“strike”). In addition, a lower viscosity leads to a shortened washing of the sugar in the centrifuges and reduces sugar loss. Finally, the effective reduction of color intensity before, during and after crystallization in color-intensive sugar fractions, especially at the end of the campaign or when low quality raw materials need to be processed, results in longer periods of stable quality sugar production and thus in overall time and energy savings.

Cane juice softening through Ion Exchange: Unveiling a sustainable and cost-effective approach

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Scaling in sugar evaporators, a major bottleneck in cane sugar production, is primarily caused by calcium and magnesium hardness naturally present in the extracted juice.
Traditionally, chemical softening has been a go-to solution for tackling this kind of challenge, but it suffers from drawbacks such as chemical usage, waste generation, and pH control challenges.
Proven successful in the beet industry with Applexion™ NRS, ion exchange offers a cleaner and more efficient alternative.
However, adapting it to cane's complex juice matrix has been elusive due to high amount of divalent, organic fouling and higher operating temperatures.
The novel Applexion™ CSF ion exchange technology is specifically tailored for cane juice softening with the selection of optimal resins and regeneration strategies. The pilot scale trials at operational sugar mills showcase data on hardness removal efficiency, resin performance and operational stability. Beyond environmental benefits like reduced waste and water usage, the innovation promises to enhance evaporator efficiency by minimized scaling, reduced cleaning downtime, leading to extended run time. With this softening, the consistent juice quality leads to superior sugar crystal formation and purity.
In conclusion this work shows how Ion exchange can revolutionize cane juice softening and usher in a new era of efficiency and decarbonization for the industry. It unveils a game-changer for the cane industry, showcasing successful trials and quantifying the economic benefits of this sustainable and cost-effective solution.

Updated technology transfer possibilities between beet and cane sugar production

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There are still large differences in process steam consumption, sugar yield, and plant availability when comparing sugar production from beet vs. cane on a global scale. These differences are partly due to the higher sugar contents and purities of sugar beet but also due to more developed process technologies enabling more efficient usage of steam and energy.

The authors have many decades of experience working as process consultants for both industries and have successfully adapted technologies typically employed in European beet sugar production in many cane sugar factories in different countries. Specific areas of a cane factory that can benefit from this approach are heat transfer equipment, especially evaporators and condensers, sugar house work, including seed magma systems by cooling and improved vacuum pan designs, reduction of water input at all stages of the process, modern layout of the plant to reduce pressure drops as well as efficient electrical drives and automation systems. As a result, the improved factories have been able to increase significantly the amount of cogeneration power for sale to the national grid and increase profitability.

The presentation will show specific technological improvements and benefits obtained in some cane factories as a result of the above measures. A further example of the possibilities of processing sugar cane and sugar beet in an efficient dual-use plant will also be outlined. This is a worthwhile possibility in several countries where sugar beet and sugarcane can be grown successfully. Due to the low process steam consumption of the plant enough surplus bagasse is produced during the cane crop in order to be self-sufficient in fuel during the beet crop, which usually follows immediately after the cane crop. An added advantage is to be able to produce directly white sugar of high quality (colour less than 45 IU) during the beet crop.

Sugarcane and sugar beet processing: Similarities and differences to underpin sustainable practices

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Currently, approximately 110 countries produce sugar from either sugarcane (Saccharum officinarum) or sugar beet (Beta vulgaris), and 8 countries produce sugar from both of these crops. The sugarcane industry has been around considerably longer than the sugar beet industry (only introduced in the 19th century), and sugarcane currently accounts for approximately 80% of global sugar production. Like many other industries, both the sugarcane and sugar beet industries are facing urgent sustainability issues. Sustainable practices, however, need to be tailored to each sugar crop due to differences in composition which strongly impact harvesting and processing, although there are some similarities. Sugarcane (grass stalk) is produced in tropical and semi-tropical areas (raw sugar is produced at a factory and white sugar at a refinery) and sugar beet (tuberous root) produced in more temperate areas (white sugar is produced at one factory). As a general rule, sugar beet contains (based on total sugar solids) 98.9% sucrose, 0.12% fructose and 0.12% glucose, whereas sugarcane (grass stalk) contains 94% sucrose, 3% glucose and 3% fructose. Since sugar beet contains considerably less invert sugars and nitrogen-containing compounds than sugarcane, the invert sugars are deliberately degraded at higher alkaline pH processes in beet-sugar manufacture to prevent Maillard color reactions. In contrast, sugarcane is processed at the factory and refinery mostly at slightly acidic pHs. One of the most profound differences between beet and cane-sugar processes is that in white sugar manufacture, the colorants are more easily removed in the beet process, which also allows for industrial chromatographic recovery of sucrose. Sugarcane factories are essentially self-sufficient in fuel because they can burn the fibrous by-product bagasse, whereas the beet factory does not produce consumable fuel. Compared to sugar beets, sugarcane is a rich source of phenolic antioxidant compounds, which are mostly present as natural colorants which need to be better exploited. Other differences and similarities in the processing of the crops are discussed.

Using analysis of South African factory data to guide research and factory improvement plans

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The Sugar Milling Research Institute NPC (SMRI) has a vast repository of southern African factory data dating as far as back as 1969 which is admired by many sugar companies around the world. The repository started with a few sets of parameters from each factory but has grown significantly to a large data set collected from each factory on a weekly and monthly basis. The introduction and adoption of SMRI-NIRS technology in South Africa has meant that the data available for analysis has grown tremendously. The SMRI has undertaken an in-depth critical analysis of the available data which revealed that in general, South African sucrose recovery performance was steadily declining resulting in increases in sucrose losses to final molasses and undetermined loss with notable financial consequences. Aging factory infrastructure and loss of experienced personnel have largely been blamed for this decline, but the SMRI was convinced that it could help to reverse this decline. The SMRI started a factory improvement programme in 2022, which was based on conducting desktop audits using SMRI factory performance data of the various sugar factories, conducting on-site factory investigations and making recommendations tailored to each specific factory on what they needed to do in order to improve their recovery performances. Recent data trends showed that this intervention programme is yielding results. This presentation will report on some specific interventions that have been recommended for implementation by factories. SMRI has also used this data analysis to guide its research efforts. The data typically showed that factories struggled the most with boiling house recoveries, especially in the C-station. Consequently, SMRI has undertaken the development of a dynamic pan model to fully understand the behaviour of massecuites with different characteristics. The model will be validated and further developed using the SMRI's well-instrumented steam heated 50 L pilot pan. A project is also being undertaken to improve the performance of the C-station centrifugals by continuously monitoring the operating conditions inside the centrifugals and automatically adjusting the wash water requirements.

Pan operation optimization with online optical crystallization monitoring system

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A significant improvement and performance enhancement of the pan operation can be achieved by automating the pans with modern pan automation systems. For further optimizations, the online optical crystallization monitoring system (CMS) plays an important role.
The system captures high-precision transilluminated images of sugar crystals flowing through a 10 mm wide gap in the boiling pan and automatically analyses the sugar crystals in a size range from 8 µm to 4 mm visible in the images. This system reports the number of detected microcrystals (<30 µm) and crystals (>30 µm), mean aperture of crystals (MA), coefficient of variation (CV), crystal growth rate and volume fractions of crystals of different sizes in real-time. Due to wash water additions to the pans based on the number of fine crystals measured with CMS, the unnecessary water additions to the pans can be avoided which has cascading benefits. The crystal breakage and the reasons for fine grain formation can be detected, which helps to take remedial actions to avoid repeating such events. The information about quality of seed magma helps to take actions to improve it, which helps to improve the sugar quality in subsequent crystallization steps. The seeding point and amount of seed magma can be better adjusted with the help of the CMS.

Towards the on-line measurement of problematic polysaccharides present in poor quality cane

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Various known and unknown polysaccharides and impurities in the cane supply can reduce sucrose recovery and cause several issues during sugar processing. These issues caused by seasonal events (flooding, frost and standover cane) and pest damage (animals, microbes and fungi) can result in reduced clarification performance, causing haze in juice, elevating viscosity in downstream processing, reducing heat transfer and impacting crystallisation performance. Furthermore these impurities can also alter pol measurement in cane analysis, thus affecting both cane payment and reporting on the factory pol balance and performance. Several strategies are employed in Australia to manage the impacts of poor cane quality and include dilution of the cane supply with better quality cane, and chemical treatment with biocides, enzymes and surfactants. However treatment can be expensive and, as the symptoms show many hours after the cane is processed, more rapid, low cost and early detection methods are required to provide the tools for more effective factory management. Analytical methods can be time consuming and many sugar factories do not have advanced analytical equipment required for adequate characterisation of the different types of polysaccharides. However, near infrared (NIR) spectroscopic methods could present a solution. NIR is a common technique for assessing on-line the quality of sugar cane in Australia. It is able to detect acids, ethanol and other deterioration products but has not been thoroughly examined for correlation to 'problem' polysaccharides present in the sugar cane. Thus, an extensive analytical program to determine the problematic polysaccharides and develop NIR correlations that can be used for on-line measurements of cane or extracted juice samples would open opportunities for better management of in-factory processing and guide improvements in the development of cane varieties, pest management and harvesting practices.

Greater reliability with Twin-Con diagnostic system

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Minimizing maintenance costs is critical for sugar factories operating on tight budgets, particularly regarding the smallest yet essential components – valves. Airpower Europe GmbH has developed the Twin-Con diagnostic system, a groundbreaking technology that assesses valve torque through differential pressure measurement in the actuator. This system allows for precise, real-time monitoring of valve conditions. With a series of pneumatic actuators designed to accommodate the Twin-Con box, the system eliminates the need for traditional connection points. The introduction of this technology has led to significant cost savings and increased operational efficiency by enabling accurate identification and addressing of defective valves. The system's ability to monitor valve tightness and functionality continuously ensures that valves are only dismantled, repaired, or replaced when necessary, optimizing maintenance efforts and enhancing process reliability.
The Twin-Con diagnostic system represents a significant advancement in valve maintenance within the sugar industry. It offers a reliable, practical solution applicable across various process-controlled systems. By ensuring that maintenance is performed only when needed, this technology delivers substantial cost reductions and improves overall process reliability, contributing to the seamless operation of sugar factories.

Reliable, tracible at line colour and turbidity analysis

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Differences of liquid and crystal sugar analysis in accordance with ICUMSA Methods will be outlined.
The semi-automatic preparation of crystal sugar samples will be shown. Different parameters, such as turbidity, filterability, and ash content, can be added.
Automatic sampling of crystal sugar for ash content will be outlined.

Optimisation of process Brix monitoring during evaporation by advanced inline transmission technology

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During juice evaporation the inline Brix control creates advantage to run full evaporator line with best effeciency in all stages. Based on the experience of microwave transmission technology a state-of-the-art so called „time-of-flight“ measuring principle „TOF“ is already established in the sugar industry. Factory data are showing results correlating to laboratory sample analytics and in comparison with existing microwave transmission.

ITECA on-line crystal growth technology applied to improving pan stage performance: Review of some applications

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ITECA CrystObserver® pan camera has already proven to be an innovative optical technology that supports the study of crystal growth by generating Real-Time data such as MA, CV, number of crystals, or percent of fines.
As well as improving pan stage performance and supporting fast decision-making, the technology provides pan boilers the means for a deeper understanding of crystal growth characteristics and necessary tools to address specific operational needs. Even though the most common use of the CrystObserver® is associated with monitoring Real Time data, its strikes comparative tool, its false grain detection ability or its historical data storage capacity can be applied to several types of applications to help solving problems. A particular example is the automatic washing of the fines once a predefined threshold is reached. This is another step towards more control in the crystallization process, as targeted in the evolution of industry 4.0.
In this paper, we focus on various reported uses of the CrystObserver® on C seed graining applications and white pans.

Centrifugal safety by design: State of the art

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Batch centrifugals in beet and cane sugar factories turn large masses at high rotation. The energy stored in the operating phases of acceleration, spinning and deceleration has the potential to end catastrophically in the event of an accident. The manufacturers of batch centrifugals have always been aware of the dangers associated with this energy and have implemented measures to ensure operational safety. This paper describes the current status of passive safety measures that are taken into account in the selection of basket material, in the design of the basket and the composition of the entire rotating system. As a result of the basket material choice, the viscoplastic behaviour significantly limits cracks' growth. However, it should be noted that the components of batch centrifuges are exposed to cyclical loads, which leads to a finite service life of the basket. The local stress on the wall is reduced by designing the run-off openings in the basket shell. By applying these measures, the designed minimum service life of the basket can reach 20 to 30 years in beet and cane sugar factories that only produce seasonally. Furthermore, regular checks of the basket for cracks are necessary to ensure operational safety throughout the entire service life.

Honeycomb calandria – engineering case study

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This presentation shall outline the "potential" benefits of retrofitting/optimizing a batch operated vacuum pan (evaporating crystallizer) with a Honeycomb Calandria system on the crystallization process shown in an "Engineering Case Study".
Implementation of a Honeycomb Calandria retrofit project will be presented with a real "Engineering Case Study" – every single modification was implemented in various projects – however, implementation of all mentioned steps in conjunction has not yet been implemented in a single project (but engineered in detail). Hence, results cannot be put in figures precisely
Presentation of a vacuum pan prior to undergoing retrofit evaluation.
(Physical status; drawing, photo, technical data and current problems)
Presentation of a complete evaluation of the vacuum pan pointing out the potential strategies for improvements:

- Middle section: Looking to achieve Target: typical ratio of product mass and heat exchange area ($5m^2/t$).
- Retrofit set of Honeycomb Calandria in INOX, with increased heating surface, adapted tube length, significantly reduced crystal and syrup deposit areas, better massecuite flow properties and sampling, new condensable and non-condensable outlets, adaptation to existing steam inlets and other peripherical equipment, reduced cleaning time
- Bottom section with optimized W-shape design, massecuite discharge position and valves
- Upper section: droplet catcher and connection of agitator with optimized power drive, (general option to reduce shaft length in certain cases) , impellers and new set of sealing for the drive unit/ agitator shaft
- Possibilities to operate with a lower steam pressure, resulting in less energy consumption but maintaining the yield, or alternatively reduced cycle time at the same steam pressure.

Technological data:
Increase of heating surface / heat transfer area
Optimized agitator design, improved flow properties, pumping effect in axial direction and shorter shaft
Optimized bottom design in W-shape resulting in better flow, fewer turbulences, more homogeneous massecuite distribution and equalized temperature differences between bottom and top, less local overheating resulting in less color.
New discharge position resulting in more space under the bottom section and allowing two discharge points for faster discharge of the pan.

Experiences with low-temperature dryers in the cane sugar industry

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Low-temperature dryers (LTD) are well known for many different drying applications, i.e. pressed pulp in the beet sugar industry. The advantage of LTDs in the cane sugar industry is that they use waste heat and simultaneously dry bagasse destined for fuel use with an increased calorific value. This results in increased boiler steam output with the same amount of bagasse. During the last five years, 13 LTD units have been installed in China and Thailand for the drying of bagasse. The installations are used to pre-dry bagasse by utilizing waste process heat, such as hot water or low-pressure steam. Ambient air is heated by a series of heat exchangers, drying the wet bagasse on a belt conveyor system. A moisture reduction from ~50% to ~35-40% has been achieved, increasing the bagasse's low calorific value by >30%. Accumulation of dust and sand in the system requires special arrangements and materials. Experiences have shown the LTD as a robust, reliable and low-maintenance system with exhaust-air dust emission far below the EIA standard (Thailand). These experiences in the cane sugar industry with LTD installations are described. The direct use of boiler flue gas as a drying gas offers potential for further moisture reduction and reduction in the emissions of the combustion process.

New ICUMSA Method to determine total, soluble, and insoluble starch in raw sugars

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In recent years, it has been unequivocally shown that sugarcane starch in all three physical starch forms, i.e., soluble, swollen (larger insoluble starch), and insoluble starch, can persist into raw and refined sugars and sometimes in large quantities. All three forms of starch have also been shown to detrimentally impede refinery processes. Because of the new starch knowledge, it became imperative that an industrial method was developed to measure both insoluble and insoluble starch in cane products. The current official ICUMSA (International Commission for Uniform Methods in Sugar Analysis) GS1-16 and GS1-17 starch methods measure only total starch but still remain useful for the trade of raw sugars. The new industrial method to measure total, insoluble, and soluble starch is based on microwave-assisted neutralization chemistry and does not require any expensive equipment. It is corrected for color, utilizes a corn starch standard (corn starch is more similar to sugarcane than potato starch since both are grass crops), and has been validated for use in raw sugars after being subjected to a single laboratory validation study following ICUMSA guidelines. It was accepted as an ICUMSA GS7 (2024) Tentative Method "Total, Soluble, and Insoluble Starch in Cane Raw Sugars by Microwave-Assisted Neutralisation," at the 33rd Session of ICUMSA held in Austria in 2023, following acceptable single laboratory validation results. It will next be subjected to an inter-laboratory analysis test. Additionally, there has been strong interest from the international sugar industry for this method. For example, ASR (American Sugar Refiners), an international refining group, are currently using the method in their Research and Technology Laboratory.

Real-time evaluation of crystal size, distribution, and shape in batch vacuum pans in the Louisiana sugarcane industry

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Continuous evaluation and control of sucrose crystal size, shape, and distribution in a sugarcane factory is crucial for processing control, reducing sucrose losses, and manufacturing acceptable raw sugar, especially when fines and crystal elongation occur. The seeding step is the main determinant of the mean crystal size (mean aperture MA) and coefficient of variation (CV) or crystal size distribution in the boiling house. In Louisiana (LA), crystal size is usually monitored by visual observation of proof stick samples using a small, hand-held microscope (up to 8-fold magnification) on the pan floor. While this is roughly informative, it is inaccurate and unreliable. An in-line tool for the measurement of crystal size, shape, and distribution will allow: (i) operators to have real-time information, and (ii) comparisons to be may made between seeding in different batches. ITECA (France) on-line video microscope CrystObservers® were recently installed in vacuum pans at a few LA factories. This study objective was to evaluate the use of the CrystObserver® in one factory and monitor its accuracy. Comparison between the CrystalObserver® and manual measurements using a portable microscope (260-fold magnification) showed that the CrystalObserver® tended to report higher MA values, particularly in smaller crystals in the seed stage of crystal development. Reliable images were obtained that assisted the processors to monitor crystal development remotely. At a separate LA factory, the use of the CrystalObserver® during operations enabled the processors to make informed corrective actions, significantly enhancing the crystal CV. This improvement directly contributed to a substantial reduction in the purity of the final molasses. Additionally, the factory appreciated the ability to maintain detailed digital records of their strikes. This feature helped them identify the development of false grains in certain strikes, an issue they had previously been unaware about.