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FOCUS: Liquor decolourization, nitrates and nitrites in beet sugar production, breeding and genetics

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A taste of things to come...

Editorial Comment

Policy makers and political masters

To paraphrase Balzac[1], when the recommendations of policy makers are in harmony with the agenda of their political masters, then, fruitful progress is likely. The reform of the EU sugar regime over good many years which has made the sector globally competitive and invariably market driven is arguably a forceful reminder of this. The painful rationalization of the industry by practically half was the price the political masters were prepared to shoulder to jettison continued support to the sector. Sadly, though, in the global sugar sector, this remains an isolated example of effective policy making, endorsed by political masters that was proactive in its conception.

In response to rocketing oil prices in the '70s, the Brazilian government initiated the National Alcohol Programme 'ProAlcool' in 1975. The intention was to substitute gasoline with cane-based ethanol in automobiles. This reactive policy making was evident when it became evident that alternate energy sources will need to be tapped to meet rising energy needs of a growing economy - hydroelectrical power was insufficient. Only than attention was focused onto biomass power, but even then, during the early phase, millers used to complain of lack of incentivisation by the government. After the credit crunch in 2008, bankruptcy in the sugar/ethanol has been extensive. Some 80 factories have closed down. More may follow. The industry has been left at the mercy of market with little evidence that policy makers nor political masters care for their plight, save for the industry organizations like Unica.

In India, cyclical trend in sugar production with surplus one year followed by deficit, the other finally prompted an attempt to overhaul the existing sugar policy informed by market and production controls. In 2012, the committee, led by C. Rangarajan, Chairman of the Prime Minister's Economic Advisory Council, favoured complete decontrol of the sugar industry. But the political masters were reluctant with wresting the production arm largely because of the debt they owe to their fairly influential political constituency – millions of cane growers. As Mala Lalvani[2] pointed out, "economists have failed to recognise the political dimensions of policy prescriptions". The close links between the sugar co-operatives with politics in general are palpable with the former enjoying economic regulation which serves its "private interests". During the period 1952-1972 "21 chairmen of sugar co-operatives have held important positions in the Congress party". With cane payment system skewed towards benefitting growers, the government is happy to subsidise millers to export surplus sugar, rather than make the industry globally competitive by taking the bold measures outlined by the Rangarajan committee.

China has been a major sugar importer for many years. To address declining supply, the government instituted a five-year plan (2011 to 2015) to target 85% self-sufficiency in sugar production. This would be supported by investment in R&D and price incentives for both farmers and processors. But this target has simply not been met amidst entrenched structural problems in the industry (impacting cane and beet production). The government turned a blind eye to smuggling of sugar when it suited them. In response to local producers protesting against smuggled sugar affecting their livelihood through lower prices in the domestic market, last June the government acted swiftly to crackdown on smuggling and hiked tariffs to up to 95% for out-of-quota imports. In their latest quarterly report, Rabobank says China will need to import 4 million to 5 million tonnes sugar in the coming year to satisfy local demand. Only time will tell whether all of these will be through the legal trade.

With few exceptions, the global sugar industry is simply not well served by thoughtful policy makers – proactive and focused in their ambition - nor their masters who are invariably swayed by their political agenda rather than the greater good of the sector.

Arvind Chudasama

References

[1] Honore de Balzac. His original quote was "when the sympathies of the heart and the mind are in harmony with each other, they go far".
[2] M. Lalvani (2009) Sugar co-operatives in Maharashtra: A political economy perspective, *Int Sugar Journal*, 111 (1328) :496-518

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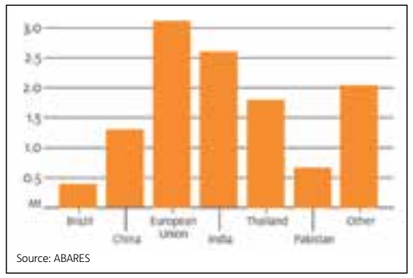
Monthly Snapshot November

Global supply/demand balance, million tonnes raw value

Forcast changes in world sugar production, by country, 2017-18



World sugar production by region Oct/Sep (1000 tonnes, raw value)

	2017/18f	2016/17	2015/16	2014/15	2013/14	2012/13	2011/12
EU	20,580	17,081	15,122	19,186	17,110	17,420	19,072
Europe*	33,867	30,344	25,913	30,343	27,656	28,596	30,837
Africa	12,522	11,351	11,519	11,404	11,301	10,964	10,295
N. & C. America	23,132	22,780	22,143	22,770	22,240	23,809	20,163
South America	48,160	48,083	46,529	42,826	47,389	48,885	43,016
Asia	70,122	80,679	81,499	86,841	88,471	87,072	86,131
Oceania	5,211	5,113	5,216	5,371	4,302	5,243	3,820
Total	193,014	176,350	172,819	181,555	181,389	184,171	174,293

*Includes EU + other countries in the continent including Turkey
f= forecast
Source: FO Licht 2016 Note: May not add due to roundings

World raw sugar prices: New York # 11

Market Overview

With the prospect of sugar surplus in 2017/18 widely acknowledged by analysts, it is not surprising to note, as Tobin Grey of the Commonwealth Bank of Australia states that "the interminable, directionless zig and zag in the sugar market," will cast a long a shadow barring no major weather impact in the top producing countries. As Rabobank points out in its latest (Q3) quarterly report, "any support for prices arising from ....

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USA – Hurricane Irma’s damage to Florida’s sugar industry estimated at US$383 million

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India – Sugar mills in the southern states surrender import quota

Ecuador decries sugar smuggled from Colombia

Review of the 2017 South African Society of SugarTechnologits' Association's congress held in Durban

The 90th SASTA Congress was well organised and ran smoothly at the Durban Convention Center.

The S African industry has been negatively affected by droughts and by poor rainfall distributions, particularly during the last 3 seasons. Both the total cane tonnage and the yield (15.1m tons and 59t/ha respectively) were low in 2016-17; over the past 10 seasons, the cane tonnage has decreased by 15%. The area under cane is also decreasing. Although the drought receded in 2016/17, cane quality was the second lowest and mixed juice purity the lowest over the last 10 seasons. Recoveries were poor; the loss of sucrose in molasses increased by 20% over the last 3 seasons, while the undetermined loss increased from around 2.4 to 3.6% over the last 5 seasons.

Although infestations by Eldana were relatively low, 6 papers dealt with the management of this borer. The presence of a new pest, Cacoceles (Zelogenes) newmannii (Thompson), has been identified in a S African commercial field. Investigations have been started.

Keynote speaker, Dr Hennie Groenewald, Biosafety South Africa

The Bronze award at the 90th SASTA Congress and Exhibition for best stand was presented to Dube Agrilab

The Gold award for best exhibition stand at the 90th SASTA Congress and Exhibition was presented to Bearings International

The Silver award for best exhibition stand was presented to MECOSA (PTY) LTD

Betrand Gaillac, Iteca Socadei

Shaun Madho (L, SMRI), Carolyn Baker (R, SASRI)

Ivan Voigt, Royal Swaziland Sugar Corp.

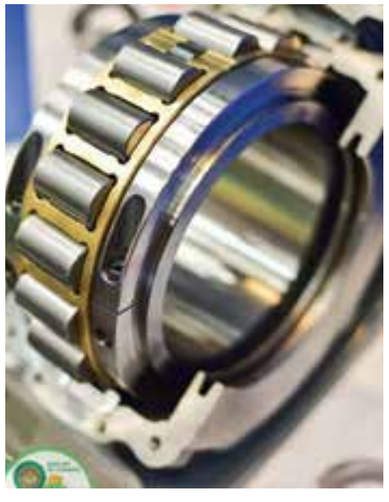
Tim Diringer, Neltec

Phumla Nxumalo, SASRI.

An interesting paper on the origin of sugarcane used genomics, history, archaeology, geophysics, ethnobotany and ethnolinguistic to reveal a new history of sugarcane. The authors state " ... the claim that New Guinea is the site of origin of sugarcane is refuted".

There was no paper on the use of bagasse for co-generation in S Africa. This is unfortunate as sugar prices are not optimal; in addition, it appears that the implementation of import tariffs for sugar has not yet been finalised. It also appears that other means to generate electricity are being considered by the government. A paper titled "Solar live steam generation and solar bagasse drying for South African sugar mills" discussed the use of solar energy at S African sugar mills. The capital and maintenance costs of the required equipment would be high and, although an economic assessment is planned, it would have been instructive to give an idea of costs.

A good review of post-harvest cane deterioration in S Africa was presented. A 12-hour reduction in cane delays between burning and crushing would have increased the revenue of the mill studied by R9.5m



in the 2016-17 season.

Another paper dealt with biogas from sugarcane and concluded that the concept has practical potential.

Twelve papers on biorefining were presented by young scientists completing various university qualifications. The subjects included lignocellulose, bio-polymers, nano-tubes, biogenic silica and hydrate technology. Although these investigations are all directed towards obtaining post-graduate qualifications they deal with new possibilities and will provide basic information.

Finally, an interesting paper on the ash quantity and quality deposited on a field after pre-harvest burning was presented. The mean ash yield from a well-fertilised cane field was 130kg/ha, equivalent to 19kg of silica/ha, 0.47kg of N, 0.22 of P and 0.17 of K. The author concludes that, unfortunately, the economic value of the ash is negligible under S African conditions.

Raoul Lionnet

The Blackboard

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Target purity

Recovering the maximum amount of sucrose from molasses has been a major objective in the sugarcane industry for a long time. HC Prinsen Geerlings investigated melassigenic substances in cane molasses in 1892; Van der Linden in 1919 exhausted molasses by rotating them in bottles with sucrose crystals until equilibrium was reached. It was found that the ratio sucrose/water could be a function of the non-sucrose/water ratio in exhausted molasses (Honig 1959)...

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Results from the commercial operation of a fractal shallow-bed ion exchange decolorizer

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Abstract

The use of relatively shallow resin beds, in conjunction with efficient fractal fluid distribution, has been shown to reduce both the capital and operating costs of ion exchange systems. The use of highly efficient fractal distributors reduces the amount of waste regenerant produced and minimizes process dilution, which are critical factors in a successful sugar refining application. Regenerant use can further be optimized by means of partial recycle and the membrane filtration of regenerant waste (either using nanofiltration or high pressure reverse osmosis) for brine recovery. The shallow resin depth allows for the use of more kinetically-efficient resins of a smaller size, without resulting in an excessive pressure drop across the bed. Although employed in the beet industry in a number of instances, the first fractal shallow bed system was only installed in a refinery decolorization application in 2008. The principles employed in the design of a more recent system in Malaysia, using an acrylic resin, are reviewed and the results of some data collected during the first two years of commercial operation are presented. Even at higher flow rates and color loadings than originally anticipated, a sustained color removal of more than 75% was achieved, yielding an average fine liquor color of less than 200 ICUMSA units and exceeding the design specification of 70% color removal. The performance achieved on an industrial scale demonstrates the effectiveness of the fractal shallow bed technology.

Keywords: ion exchange, decolorization, effluent minimization, fractal shallow bed

Conventional ion exchange decolorization systems

The use of strong base ion exchange resins in the sugar industry has a relatively long history, having been used for the decolorization of syrups from the early 1950s. The creation of styrene / divinylbenzene macroreticular resins in the 1960s led to an enhanced practical capacity for color removal, while the advent of acrylic resins in the 1970s offered effective decolorization and efficient regeneration using a 10% brine solution[1] (Fries and Walker, 1980).

Styrene resins are limited in the level of liquor colorants that can be treated. Beyond a certain color level, brine regeneration is incapable of completely desorbing the color bodies, leading to a loss of decolorization capacity (Getaz, 1988). Over the years, therefore, many ion exchange systems have been built using an acrylic resin for primary decolorization, followed by a styrene resin for secondary decolorization / polishing down to low color levels, with the more effectively-regenerated acrylic resin protecting the secondary styrene resin from organic fouling.

Using an acrylic resin alone for decolorization is usually more cost effective, but yields a lower color removal (Kirkiridis, 1992). Where two-stage decolorization using the same resin is practiced, it is usual to cascade the resin from the secondary columns into the primary columns halfway through its life, with new resin then being placed sugar liquors results in the formation of complexes with colorant molecules and with the active ...

The content of nitrates and nitrites in the semi-products in the final stages of white sugar production process

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Abstract

Neither nitrates nor nitrites can be removed during purification process and therefore they are encountered in all steps of white sugar production. This is undesirable because the nitrites can react with sulfur dioxide, that leads to an increase in ash content in white sugar, and also causes a significant reduction in sulfitation efficiency and a substantial increase in the color of sugar juices. The nitrites and nitrates also adversely affect the quality of molasses used as feed materials. The analysis of samples of semi-products and by-products from one of the European sugar factories showed that during the final stages of the technological process a significant reduction of nitrites content may occur. The content of nitrites was significantly reduced during crystallization of magma A, magma B and C and during cooling crystallization.

Keywords: nitrites; nitrates; molasses; white sugar

Introduction

The nitrates are introduced into the production process of white sugar with the raw material. The content of nitrates in sugar beet depends on weather conditions during the growth and on the nitrogen fertilizer rates. Thus the nitrates content in sugar beets is very variable (Hoffmann and Märländer, 2005), while the content of nitrites is minor (Van der Poel *et al*., 1998). Owing to the activity of thermophilic bacteria, significant quantities of nitrites can be formed from nitrates in the extraction process (Emerstorfer *et al*., 2014; Frenzel, 2014; Waterlander *et al*., 2011).

Neither nitrates nor nitrites can be removed during purification process and therefore they are encountered during all steps of the technological process (Mikoś *et al*., 2015). This is undesirable because nitrites can react with sulfur dioxide which leads to the formation of a sparingly soluble salt - potassium imidodisulfonate. This salt is able to co-crystallize with saccharose that significantly increases ash content (Magne *et al*., 1998; Mikoś *et al*., 2015). Furthermore, if sulfur dioxide is used in the presence of nitrites, its concentration decreases and is insufficient to optimally inhibit the formation of colored compounds. Even small nitrites amounts produced by thermophilic bacterial activity may lead to a significant reduction in sulfitation efficiency and a substantial increase in the color of sugar juices (Oldfield *et al*., 1974).

The nitrites and nitrates not only adversely affect the quality of white sugar but also the quality of molasses that is used as feed materials. Molasses is only temporarily exempted from the maximum limit for nitrites, which was set at 15 mg/kg expressed as sodium nitrite, relative to a feeding stuff with a moisture content of 12 % (Waterlander *et al*., 2011).

Many authors examined the changes in the content of ...

Pan life cycle management*

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Abstract

Mackay Sugar Limited routinely carries out pan vessel inspections and non-destructive thickness testing as part of a pan's life cycle management system. This paper details the previous thickness testing regime and how, due to inconsistent readings and recording, a new approach to thickness testing was required and how this was achieved. In addition, the paper provides details as to how and why the new testing method was adopted and how the information is tabulated. It also describes how the measurements are used to determine the inspection intervals and the pan vessel life. As a continuation of the Mackay Sugar pressure equipment strategy the same thickness testing regime will be applied to other process pressure vessels.

Keywords: AS/NZS 3788, life cycle, pan, pressure vessel, thickness testing, wastage

Introduction

Mackay Sugar Limited routinely carries out pan vessel inspections including non-destructive testing (NDT) of thicknesses as part of a pan life cycle management system in accordance with Australian/New Zealand Standards (Standards Australia, 2006).

The pan thickness tests were previously conducted using generic pressure vessel inspection documents, that is, documents that were not specific to a particular vessel. Although the tests were conducted, the results were typically attached to the work order and filed away.

The results were not formally tabulated or stored and only compared if a thickness measurement looked out of place.

Another problem with the previous testing regimen was that the thickness test points and the people taking the measurements would vary from year to year. Such inconsistencies made it very difficult to predict the wastage rates of the pan vessels.

Methodology

To help with the Mackay Sugar's pan life cycle management strategy, Fraser Engineers Pty Ltd was engaged due to their intimate knowledge of the Mackay Sugar pressure vessels. They determined the minimum pan vessel thicknesses and provided the number and location of the measuring points required.

The number of measuring points varied, as the pans are of different sizes and designs. The eight Farleigh mill pans required 392 measuring points, the ten Marian mill pans required 540...

Doubled haploid sugar beet: An integrated view of factors influencing the processes of gynogenesis and chromosome doubling

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Abstract

Haploid and doubled haploid plant production through unpollinated ovule culture, with diverse benefits and applications, is considered among the effective and advantageous breeding methods for sugar beet (*Beta vulgaris* L.). Sugar beet is not responsive to androgenesis that is widely used for most plant species. It is a recalcitrant plant in vitro due to the very low spontaneous chromosome doubling and low gynogenesis rates. Thus, a steadily increasing gynogenesis efficiency has always been an important target. Given the lack of papers focusing on gynogenesis in sugar beet, this review covers haploid and doubled haploid production through ovule culture of unfertilized flowers as a practical method. Besides haploid and doubled haploid methods, factors affecting both gynogenesis and doubling rates are also reviewed. In addition, outlooks and possibilities for doubled haploid production are discussed, trying to capture the elusive concept of the factors applied and taking into account some of them, e.g. genotype, plant growth regulators, plant/explant physiology and growth condition, chemicals, in vitro and in vivo methods, and transgenic method. By providing enough information and new groundwork through novel and wide perspectives on factors affecting gynogenesis, it should be easier to collect knowledge useful for future research.

Keywords: sugar beet, gynogenesis, haploid, doubled haploid, gynogenesis

Introduction

Haploid is a name referred to plants, diploid or polyploid, containing gametophytic chromosome numbers, i.e. one set of unpaired chromosomes (n). A haploid plant can be generated either spontaneously or artificially by different induction techniques. The latter can be either *in vivo* by parthenogenesis, or *in vitro* by androgenesis (microspore and anther culture) and gynogenesis (ovule and ovary culture) (Brian *et al*. 2005; Niu *et al*. 2014; Palmer and Keller 2005; Murovec and Bohanec 2012). Haploid plant production as a research tool has various beneficial applications ranging from plant breeding and genetic manipulation to plant genome/gene mapping (Niu *et al*. 2014). Its significant advantage is to achieve a complete homozygosity in a single generation (Niu *et al*. 2014). Instead, in conventional breeding, an acceptable level of homozygosity can be obtained after 6-7 generations followed by selections (De La Fuente *et al*. 2013). Of course, the time span can be doubled for biennial crops. Another remarkable advantage of haploid plants is the concurrent expression of recessive alleles masked in heterozygous condition (Doctrinal *et al*. 1989), which eases identification, evaluation and selection of useful traits (Klimek-Chodacka and Baranski 2013)....

Sugarcane outgrower schemes in Mozambique: Findings from the field*

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Abstract

Agro-industries have been widely acknowledged as a way to kick-start agricultural development in developing regions. A number of pro-poor organizations promote production models that include the engagement of smallholder farmers as potential enablers for employment generation, economic development and livelihood improvements. Initiatives such as this appear in Sub-Saharan Africa with a focus on food and bioenergy crops. However, the large-scale production of cash crops, such as sugarcane, also raises concerns. A critical aspect is the impact of land-use on food security, particularly if local communities are constrained in cultivating traditional crops. In this paper, we explore the relationship between a sugarcane mill and smallholder farmers in Maputo province, Mozambique. Our main goal was to investigate some key characteristics of sugarcane outgrower schemes and the implications for sustainable local development. We also complemented local findings with lessons learnt from other regions, such as Brazil. In August 2015, a field assessment examined the interplay between the sugarcane industry and local communities in southern Mozambique. We interviewed three smallholders' associations of sugarcane producers in Xinavane, together with researchers, non-governmental organizations and agricultural government bodies. Our assessment finds that the impacts of sugarcane remain somewhat unclear. Government bodies and some of the consulted NGOs claim benefits, both on income and local food production. However, these benefits are less evident to farmers. While they acknowledge labour and social services as opportunities brought by the sugar mill, progress on capacity building and irrigated areas for food production fall short of expectations. Moreover, there is also tension as to the sugarcane outgrower contract. Incomplete information seems to undermine trust from farmers who become increasingly sceptical of their contracts with the sugarcane mill, especially the payment system. Transparency, coupled with more effective food production strategies, are decisive to ensure sustainable agro-industrial development along with poverty reduction.

Keywords: rural development, sugar, food security, bioenergy

Introduction

The sugarcane industry has maintained its foothold in rural Mozambique for decades. In spite of the industry being near collapse during the civil war, in the years following independence in 1975, the 1992 peace-accord gave new strength to the sugar sector. Thanks to a combination of government initiatives and foreign investment, the sugar industry has seen a gradual recovery. In 2013, national sugar output was 380,000 t, 17% above the so-called golden years of the colonial period (Cepagri 2013; Kegode 2015).

Over the last decade, a significant development has been the engagement of smallholders in outgrower schemes as an alternative to the traditional plantation model to produce sugarcane. A set of European Union (EU) measures to strengthen the Mozambican sugarcane industry against looming reforms in the European sugar market underpinned this process (EC 2011). The EU, as well as local stakeholders, believe that...

Detection, breeding and selection of durable resistance to brown rust in sugarcane*

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Abstract

Brown rust, caused by *Puccinia melanocephala*, is an important disease of sugarcane in Louisiana. The adaptability of the pathogen has repeatedly resulted in resistant cultivars becoming susceptible once they are widely grown. The frequency of the brown rust resistance gene *Bru*1 was low in the breeding and selection populations in Louisiana. Through markers-assisted screening and selection, the frequency of *Bru*1 is increasing in the breeding populations being developed for gene introgression. *Bru*1 has provided resistance in diverse germplasm across widespread regions. However, over reliance on one resistance source is inadvisable. Development of a controlled conditions inoculation method allowed evaluation of cultivar reactions to pathogen urediniospore populations collected from major cultivars that had become susceptible. These experiments demonstrated virulence specialization within the pathogen to host genotypes. In addition, quantitative resistance providing a partial but effective level of resistance to all pathogen urediniospore populations under conditions highly favorable for infection was detected in one cultivar, L99-233. Researchers are attempting to identify genes associated with quantitative resistance in this cultivar and develop molecular markers. A small-scale transcriptome analysis of L99-233 through suppressive subtraction hybridization identified genes involved in primary metabolism, signal transduction, nucleic acid binding and protease activities to be differentially expressed in response to fungal infection. Analysis of expression kinetics of a selected set of genes showed transient upregulation of their mRNA accumulation in susceptible cultivars, but their transcripts were also upregulated up to 1 week post-inoculation in the resistant cultivars. The maintenance of high amounts of mRNAs of the genes for a prolonged time period appeared to be the contributing factor for resistance to brown rust. Breeding and selection for *Bru*1 and other genes for quantitative resistance could provide effective and durable resistance to brown rust in future cultivars.

Keywords: sugarcane, pathology, brown rust, resistance

Introduction

Brown rust is one of the most important diseases of sugarcane worldwide (Raid and Comstock 2000). The development and cultivation of resistant cultivars has been the primary means of disease management. Unfortunately, resistance durability is uncertain, since the pathogen, Puccinia melanocephala H. & P. Syd., is able to adapt and overcome host plant resistance. Shifts from resistance to susceptibility have been reported for cultivars in different regions (Dean and Purdy 1984; Hoy 2005; Purdy *et al*. 1983; Raid 1989). Three studies have detected differential disease severity reactions in cultivars resulting from inoculations with different pathogen isolates indicating specialization in *P. melanocephala* to host genotype (Hoy *et al*. 2014; Shine *et al*. 2005; Srinivasan and Muthaiyan 1965). The Louisiana study confirmed pathogenic variability related to cultivar and also detected quantitative resistance in cultivar L99-233. Nine of the last 12 cultivars released in Louisiana have become susceptible...

Abstracts

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Abstracts from the proceedings of the 2017 South African Sugar Technologists' Association's annual conference: Factory papers

Sugar Industry

Ninety-second annual review of the milling season in southern Africa (2016/17)

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Performance, throughput and other relevant aspects of the sugar industries in southern Africa for the 2016/17 milling season are presented and discussed. Data from sugar mills in South Africa, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe are included. In South Africa, the quantity of cane crushed in 2016/17 was the second lowest in the past 10 seasons, whilst the quality parameters of cane recorded 10-year low values; about 15 million tonnes of cane was crushed, and quality in terms of Recoverable Value % cane and Estimated Recoverable Crystal % cane was 11.45 % and 10.65 %, respectively. Overall Time Efficiencies over the past 10 seasons were generally high due to low No-cane stops. The Overall Time Efficiency in 2016/17 decreased slightly due to increases in No-cane stops and Lost Time % Available. Extraction performance remained low due to reduced imbibition usage; this was to improve factory energy efficiency. The decreased Corrected Reduced Extraction suggests that there were slight improvements that could have been made by factories to improve extraction. In 2016/17, the Boiling House Recovery was 83.67 %, which was the lowest recorded value in the past 10 seasons. The cane and juice quality indicators, Corrected Reduced Boiling House recovery and the Molasses factor all suggest that this may have been because of the poor cane quality of cane processed rather than just poor factory operations in 2016/17. Regarding the Sugar Milling Research Institute NPC (SMRI) B2 Affiliate Member mills in neighbouring countries, extraction was generally lower. The average pol-based Boiling House Recoveries decreased, but were still generally high, with only three mills recording values less than 85 %.

Juice Extraction

Sleeve-Kamal, an innovative three piece sugar mill roller for high performance and lower operating cost

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Most sugar mill rollers are manufactured in two parts; steel shaft and cast iron shell fitted over it. The shell has circumferential grooves for juice extraction. Due to corrosion/erosion during crushing operation and juice flow, the shell grooves wear and need to be re-grooved to form the profile required. However, during this re-grooving, the shell diameter is reduced. Eventually, the shell needs to be replaced although the rest of the shell is intact. The process is known as re-shelling. In the case of internal bleeding rollers, the juice channels are drilled/embedded in a straight line, normally parallel to the axis of the shaft despite the fact that varied geometry skewed channels are beneficial in some of the rollers. Further, the conventional shell may have provision for integral juice rings but even if they are in good condition they get replaced with the shell during each re-shelling. After considerable research and experimentation in design as well as shell material, S.B. Reshellers Pvt. Ltd., patented the geometry of a roller with three major parts. This roller has the normal shaft over which a sleeve is shrink fitted and which is of equal length to the main shaft, i.e. shell length, plus both side juice rings' width. A shell is shrink fitted over the sleeve as per a normal shell, completing the roller. This geometry, with the use of a stronger proprietary material, SBR Alloy, opened up various options for internal bleeding rollers. This paper discusses the mill roller indicated above and the advantages and other possibilities derived through this geometry.

Monitoring juice holdup in a cane diffuser bed using electrical conductivity – evaluation on a laboratory scale

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The control of percolation within the bed of shredded cane is a critical aspect of the design and operation of cane diffusers. The extraction of an operating diffuser can be optimised by the suitable setting of adjustable sprays to alter the percolation rate to maximise the juice holdup within the cane bed. Without an online measurement of juice holdup within the cane bed, the adjustment is conventionally done by operators using visual observation, judgement and experience. There is clearly an incentive to operate substantially below the maximum percolation rate to avoid the possibility of flooding and thus the best possible extraction performance will seldom be achieved. An on-line measurement of juice holdup within the cane bed creates the opportunity to implement feedback control of juice holdup by automatic adjustment of diffuser sprays – avoiding the inevitable compromise of manual operation. Previous work using a pressure measurement on the side of a diffuser as an indicator of juice holdup showed some potential but two local installations failed to gain the confidence of operating staff and have fallen into disuse. This work describes the evaluation of electrical conductivity through the cane bed (from top to bottom) as a measure of the juice holdup within a cane bed. Tests were done in the laboratory on a glass column diffuser. Suitable instrumentation and data logging allowed online measurement of electrical conductivity and liquid holdup within the cane bed. The prevailing percolation rate could be measured and logged using a simple manual intervention. The results confirmed the close correlation between percolation rate and juice holdup and also the potential of electrical conductivity to be used as an indicator of juice holdup within the cane bed.

Monitoring juice hold-up in a cane diffuser bed using electrical conductivity – evaluation on a plant scale

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The extraction of sucrose in a sugar cane diffuser depends on the percolation rate of juice through the cane bed. High percolation rates promote mass transfer and increase the wetness of the cane bed (i.e. liquid hold-up within the bed) thereby improving sucrose extraction. However, increasing the rate of juice applied to the surface of the cane bed above the maximum percolation rate results in flooding, causing uncontrolled mixing of juice, destruction of the brix profile and reduced extraction. Flooding in the diffuser can be avoided by installing feedback control of adjustable sprays that alter the application area of juice onto the bed surface and automatically keeping the percolation rate optimised. Electrical conductivity of the cane bed, measured between the bed surface and the bottom screen of the diffuser, has been investigated as a possible online indicator of juice hold-up within the cane bed to provide the necessary measurement for implementing feedback control that can optimise percolation rates. Full scale tests were conducted on the Tongaat Hulett design of cane diffuser at the Maidstone factory. The experimental data show the relationship between conductance and flow rate with liquid hold-up. Reproducibility tests were done to confirm the results shown in this research.

Experiences with the millability of drought-affected cane varieties in the 2016 season

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The performance of selected cane varieties on milling performance in 2016, a drought year, are described and compared to 2015, a normal year. Samples of N46 taken after the shredder showed that this variety was pulping instead of making long fibres suitable for extraction. This also occurred when preparing N25, but to a lesser extent. When crushing these varieties, excessive dropping of fibre in the mills was observed and this was limiting maceration of the preceding mills, resulting in high bagasse pol and low individual mill extraction. Mill capacity was also greatly affected, resulting in overflowing of the mills and dropping of throughput from 420 to less than 380 tons cane per hour (TCH). With the filling up of the final mill's Donnelly chute, the mill was either bypassing or running at maximum speed, resulting in high bagasse moisture, low steam pressure and subsequent plant stoppages. Good extraction and throughput were realised when crushing cane varieties such as N23, NCO376 and N36. Both N46 and N25 performed better in 2015 than in 2016.

Sugar mill multi-drives

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Crushing mills have historically been driven by a single prime mover with gearing reduction to turn the Top Roll of the mill. Multi-drive installation allows each main roll to be driven independently, mounted at the end of each roll shaft. Hydraulic multi-drives have been available for many years now and more recently, electro-mechanical drives have been gaining popularity with Mill operators. The two options will be compared together with advantages and disadvantages of all types.

Process
Separate drives allow for fine tuning of the linear speed of each roll to match exactly with the speed of the adjacent rolls, minimising fibre shear and re-absorption. The Feed Roll can be increased in speed by up to 5 % compared to the other rolls to create a force-feed into the delivery nip, reducing voids.

Mechanical
Drives on each roll reduce the individual roll torque. Top roll headstock loadings are significantly reduced, increasing the life expectancy of the headstocks due to fatigue failure and reducing the possibility of shaft failure due to excessive torque. Protection of the mill is improved as excessive shock loads on the mill are limited due to torque monitoring and limitation.

Affordability
There is a significantly lower cost of each individual drive allowing for the affordable retention of spare drives. The amount of civil works is reduced due to compact installation. Torque reaction is spread across the civil structure.

Operation
Consistent Donnelly chute operating levels are easier to maintain due to increased sensitivity of the drive compared to a turbine.

Purification

Energy footprint and operating costs, a comparison of ion exchange resin and activated carbon in the application of sugar decolourisation

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Both ion exchange resin and activated carbon are well established technologies used in final stage decolourisation of sugar liquors for the production of high quality white sugars. These technologies are often seen to be in direct competition, but there are unique advantages and disadvantages to both, and they are applicable in different circumstances. This paper attempts to clarify the distinction. The colour removal mechanism between these technologies differ, resulting in slightly different colour causing molecules being removed and, as such, have been used as complementary processes. Activated carbon is made reusable by thermal reactivation, a process that is highly energy demanding. The advantage of this is that there is no chemical addition to the process, and it can be run effectively as a zero liquid discharge system. This is in direct contrast to the ion exchange system, which in its traditional format requires very little energy to run. The effluent volumes produced by regeneration of ion exchange resin have been identified as a disadvantage of the technology. There has been research into the recovery and reuse of regenerant chemicals. This causes a reduction in chemical costs that is balanced with a rise in energy consumption by membrane and evaporation processes. The key operating costs of energy footprint and chemical demand are compared, as well as secondary costs of effluent treatment and energy recovery systems applicable to both unit processes.

Abstracts

Powdered activated carbon (PAC) with membrane filter press for secondary decolourisation system to produce refined sugar in backend refinery

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In India, most of the backend refineries currently use Ion Exchange Resin (IER) or the Activated Carbon Process for secondary decolourisation. The problem in the IER process is the disposal of a dark brown brine effluent. Due to stringent norms of the pollution control board, this brine solution cannot be discharged as is. To treat the brine solution, the factory had to install a Brine Recovery System and Brine Concentrator and Dryer to dispose of the effluent as solid waste. This is capital intensive. The paper deals with an innovative way to produce good quality refined sugar in Indian sugar plants by using an energy efficient membrane filter for the Powdered Activated Carbon (PAC) process as secondary decolourisation.

Energy Economy

A strategy for monitoring and reporting continuous energy consumption in a typical raw sugar mill

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While many parameters relating to sugar processing and factory performance are monitored and reported, there are no standard measures for monitoring and reporting energy consumption and efficiency in sugar factories. Since energy constitutes a large cost for many sugar mills, there is value in establishing a monitoring and reporting system for energy. This study was part of a larger project to develop a standard energy monitoring and reporting system in sugar mills. This paper focusses on the selection of a set of energy indicators and considers the data collection requirements for this indicator set. The researchers spent time in a South African raw sugar factory over a crushing season to determine which of the identified measurements were already available in the factory. The information was sourced from factory daily reports, online measurements available on the distributed control system (DCS), local instrumentation, the mill and the South African Sugar Association Cane Testing Service laboratories. This paper presents a summary of all the types of information required to calculate energy indicators (EI) and the data sources used. A prototype set of 21 EIs was selected for analysis. To calculate these indices in a generic mill with the same level of instrumentation as the hosting mill, 95 parameters were needed, of which 50 % were not available as existing measurements. Only 33 % of the data required was available on the DCS. A full snapshot mass and energy balance (MEB) calculator of the raw sugar factory was constructed using all available factory data. While many of the important measurements were available from existing reporting systems, a substantial proportion of temperature data had to be measured by researchers. The other information was estimated or calculated indirectly based on personal communication with factory staff. Assumptions and the MEB calculator were then used to account for the missing data. Additional instrumentation would be required to reliably calculate all the EIs in the prototype set.

Experiences of reducing steam consumption in a sugar plant

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In the Indian sugar industry steam consumption is a vital parameter as the steam saving will be converted into either power for export or a saving in bagasse which will be sold at a high price. Steam conservation therefore plays a vital role in the Indian sugar industry. Since the cane price is rising continuously, the margin from sugar is narrow and power export is inevitable to run the sugar industry profitably. The paper deals with innovative ways to reduce the steam consumption by utilising low vapour heat for pan boiling, waste heat recovery for juice heating, molasses conditioning and condensate flash steam recovery.

Solar live steam generation and solar bagasse drying for South African sugar mills

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Two solar heat integration concepts have been identified as promising options for implementation in South African sugar mills in the near future as a result of work with the steering committee of the Sugarcane Technology Enabling Programme for Bio-Energy. These are the drying of bagasse using solar heated air and the generation of live steam using concentrating solar thermal collectors. By generating live steam from solar energy, electricity production can be increased up to 34.5 %, and bagasse or coal can be saved as well. Solar drying of bagasse can reduce bagasse usage up to 20.8 % and increase the boiler's efficiency. The average solar fractions for live steam generation and bagasse drying are 12.34 % and 17.34 % respectively. This can be increased if the integration points are allowed to operate outside of the crushing season, if thermal storage is implemented or if the solar collector area is increased.

Crystallization

An investigation into the viscosity of C-massecuite using a pipeline viscometer

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Most product streams within the sugar process have physical properties that are well defined. However, upon crystallisation, the behaviour of the two-phase product becomes more complex. The physical properties of massecuite affect the design of all equipment and piping in the back-end of a sugar factory, however, the performance of equipment is only as reliable as the data on which the design is based. The massecuite viscosities used within the South African sugar industry were determined over 20 years ago using a rotating viscometer, however, this instrument is believed to be unsuitable for the application due to the heterogeneous nature of massecuite. A pipeline viscometer was thus constructed and experiments carried out to better understand the behaviour of massecuite. This research project aimed to use non-Newtonian theory and data from a pipeline viscometer to determine a correlation for the viscosity of massecuite for varying conditions of temperature, concentration, purity and crystal content taking into account the effects of dextran and crystal size.

The transfer of non-sucrose species into the sucrose crystal: Can it be useful?

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The crystallisation of sucrose has been, and still is, extensively investigated both in academia and in industry. The literature is reviewed to summarise the main points which have been well established, the many areas where work still needs to be done, and more particularly to highlight the effects of non-sucrose species both on classical crystallisation to produce food grade sugar, and on the possibilities of manufacturing co-products through co-crystallisation processes. The literature shows that the non-sucrose species which affect the crystallisation process can be categorised in two groups: those which enter the crystal but do not alter the crystal shape, and those which enter into the crystal and cause deformation. This second group can also severely slow down the sucrose crystallisation rate. Investigating the mechanisms through which sucrose crystallises is difficult; various models have been tested. Finally, recent work used mathematical models, based on industrial data, to improve the quality of the sugar produced. The financial impacts of the modifications were also investigated. It was suggested that apart from improving sugar quality the knowledge obtained about the crystallisation of sucrose should be used, and extended, to investigate the possibilities of producing high value co-products through co-crystallisation with sucrose. Here the goal is not to prevent or reduce the incorporation of non-sucrose species (usually called impurities in classical literature) but, on the contrary, to increase and control the concentrations of selected species incorporated in the sucrose crystal. Secondly, the possibility of producing white sugar directly should also be re-visited. Obviously, these projects will require extensive technical and financial investigations.

Machinery and Equipment

Cail & Fletcher E-Crystal: Innovation never stops

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Fives Cail, known as EPC and OEM, decided to extend its range of sugar equipment in the 1960s with continuous and batch centrifugals. In 1976, Fives Cail launched an innovative continuous centrifugal named the FC1000. Fives Cail was then, and continues to be, a pioneer in the sugar industry, more specifically in higher capacity and crystal preservation through a "large casing" design. As a world leader, both in cane and beet sugar applications, Fives Cail continues to develop its range of continuous centrifugals with increased capacity, following the ever-increasing size of sugar mills: FC1250, FC1300, FC1550. These continuous centrifugals are recognised for their reliability, robustness and high productivity, reducing both sugar losses and energy consumption. Fives Cail remained at the forefront of innovation by introducing the STG in the early 80s, the first continuous centrifugal to process high purity massecuite of raw and refined sugar, which satisfied a need in the sugar process. The concept of a double stage basket, first created for the STG, still prevails in Fives Cail's new continuous centrifugal, the E-CRYSTAL, which also benefits from the 50 years of proven experience in processing B and C massecuite. It is equipped with sensors and a PLC, and the sugar is only in contact with SS components. This new centrifugal is also smart and connected, and meets all the reliability and productivity requirements of efficient sugar factories of the future.

Material Science

New manufacturing requirements – how material selection plays a key factor

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For many years, the materials used for sugar production equipment have been selected on the basis of criteria such as material strength, corrosion resistance, availability and current prices. Today, additional requirements, which are defined by the location at which the equipment is to be installed, have to be considered. Examples would be food safety (hygiene), operational reliability and maintainability. Even a few decades ago, mild steel was the standard material choice for the production of white sugar based on sugar beet. Since then, the demands of this industry have shifted to equipment made from stainless steel, either completely or at least in sections that are in contact with the product. Nowadays, these requirements may even have to be accounted for in cane sugar production. To meet product quality specifications, stainless steel is therefore now included as a standard option in offers for vacuum pans, centrifugals and drum driers. Some examples are given to explain the selection of materials made in view of modern requirements. These include compliance with hygienic standards, such as the use of inert materials, non-breakability, low surface roughness, cleanability, low abrasion, detectability, and resistance, but also a long service life and ease of maintenance.

Analysis and Control

Insights in dextran analysis and dextran affected processing problems

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The presence of polysaccharides in sugar cane and beet raw juices causes several negative effects during the sugar production process, which are usually mitigated by enzymatic decomposition. An accurate process control requires detailed knowledge about the existing dextran level and also about the specific effects of the different dextran fractions and dextran fragments resulting from enzymatic decomposition. Determination and characterisation of dextran in raw juice is hence a requirement to assess occurring dextran related processing problems and also to decompose dextran in a controlled manner. Different methods (Haze and Roberts' Copper method, chromatographic measurements) were used to determine remaining dextran levels in sucrose solutions after different degrees of enzymatic decomposition. These two combined analytical tools were not only useful to determine the remaining dextran levels but also to get an idea of the resulting molecular size distribution. This combined knowledge is a necessary prerequisite for the subsequent process effect analysis, which was at first investigated for the sucrose crystallisation process. Lab scale crystallisation experiments were conducted to investigate the effect of high as well as low molecular weight dextran on the crystal size and shape. Results show the generally known dextran-based crystal shape modifications but also give additional details with respect to precise effects of varying molecular weights present. The improved understanding of the specific effects of the different dextrans combined with adequate analytical tools allows a more targeted and hence improved mitigation of dextran induced processing problems.

Dynamic simulation on a spreadsheet as a tool for evaluating options for mixed juice flow control

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Abstracts

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Dynamic simulation is a powerful tool for both predicting and interpreting the behaviour of systems that change with time. This is particularly true for understanding and optimising the performance of feedback control loops. A spreadsheet program is a powerful, simple and widely available tool that allows dynamic simulations to be generated and operated.
The use of a mixed juice tank as buffer storage to smooth out flow fluctuations and provide a more stable mixed juice flow to the juice clarifiers is an example of a dynamic system where there is no clear agreement on the best strategy to implement. Dynamic simulation provides a method for objectively comparing different strategies under varying operating conditions.
A simple method for creating dynamic simulations using an Excel spreadsheet is described. Alternative mixed juice flow control strategies are described and simulated on a spreadsheet. An example of a control strategy that performed poorly at a particular factory is simulated, demonstrating the cause of the problem and allowing suggested solutions to the problem to be evaluated.

Are gums produced in the factory? Quantification of gums isolated from mixed juice and final molasses

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Gummy massecuites in sugar factories are associated with exhaustion problems in pans and inefficient purging in centrifuges. Gums originate in stale cane because of microbial activity during burn/harvest-to-crush delays, especially in the rainy season, but are also thought to be generated by microbial activity within the factory. The proportion of gums generated within the factory is not known. This study investigated the phenomenon of gum formation in the factory by comparing the total amount of gums in mixed juice and in final molasses and considering the fate of gums in a factory. Gums were precipitated with acidified alcohol from weekly composite mixed juice and final molasses samples for a single factory over a period of 35 weeks in 2014. The total gum flows passing the mixed juice and final molasses scales were estimated from gum concentration and weekly flow data. The total amount of gums in the final molasses over the entire 35-week test period was 1 567 tonnes, and was less than the total amount of gums in mixed juice, at 1 655 tonnes. This indicates that overall, gums are not produced in significant quantities between the two sampling points for most of the crushing season. The result also shows that some of the gums measured in mixed juice leave in other factory streams, viz. raw sugar and filtercake for the factory in question. Data from the South African Sugar Terminal were used to estimate that dextran and starch in raw sugar from this factory may have accounted for approximately 40 tonnes of polysaccharides leaving the factory. An increase in gum flow in final molasses above that in mixed juice was only observed in the last few weeks of the season, indicating that some gum production had occurred in the factory during this period. Conditions conducive to gum production may be expected to occur during periods of unsteady operation such as interrupted cane supply. Measures to target and prevent gum production can therefore be justified when factors outside of the factory's control may lead to gum production in the factory.

Where do you go to, my saccharides? A preliminary saccharide analysis of refinery streams

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The Sugar Milling Research Institute NPC (SMRI) has a long history of determining minor saccharide constituents in sugar process streams. These include the common monosaccharides (glucose and fructose) and trisaccharides such as kestoses and oligosaccharides. Within a refinery, minor saccharides can not only originate from the incoming raw sugar but can build up due to the use of recycle streams and may also be formed as a result of sucrose deterioration in low brix process streams. The presence of some of these minor constituents can have a detrimental effect on crystal habit. A study was undertaken to determine the fate of some of these saccharides at the Tongaat-Hulett Sugar Refinery. Sampling was conducted over a three-month period during 2016 and analysis of the samples was undertaken using the methods developed by the SMRI. The results showed that not only was a large proportion of the kestoses being recycled but an unequal division of selected kestoses occurred between refined sugar and High Test Molasses. The results also indicated that the commonly assumed pol:sucrose ratio of one is not true for High Test Molasses.

Instrumentation

Automation of white pans at the Tongaat Hulett refinery

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Pan boiling relies substantially on "art" rather than "science", thus requiring skilled and experienced operators to optimise crystal sugar production. This puts heavy demands on staffing, training and skills transfer. Particularly in this context, automated pan boiling has the potential to provide substantial benefits in terms of plant capacity, process performance and product quality. Successful pan automation relies largely on the following aspects: instrumentation that reliably measures appropriate process parameters, a suitable control strategy that relies both on crystallisation fundamentals (science) and practical considerations (art), and control hardware that implements the strategy in a manner that is easy to understand, operate, configure, modify and maintain. Building on past experience with pan automation, an updated control system was installed on a fourth boiling batch pan at the Tongaat Hulett refinery. Existing measurements were supplemented with a pan stirrer power measurement, an online refractometer and an online microscope.
New control hardware, a Yokogawa Distributed Control System (DCS), was installed. Pan boiling control strategies, using the expanded range of measurements available, have been developed. The control strategies have been implemented on the DCS, tested and then operated in production mode for an extended period. The new control strategy has changed the previous manual shock seeding to automated seeding with ball milled slurry in an attempt to approach the ideal of "full seeding". Work is continuing to replicate the success of this automation to the other four refined sugar batch pans. This paper describes details of the instrumentation installed, the control strategies implemented and the preliminary results that have been obtained.

Optimisation of white sugar colour management through the utilisation of on-line colour cameras

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The priority for any factory operation is to produce sugar that meets its customers' specifications while minimising the financial impact of such compliance. To ensure low colour sugar, the default position tends to be to over wash it. It leads to substantial water volume and energy consumption with a high amount of melted sugar which should instead be reduced. The over washing at the sugar end of the process can also mask significant variations occurring within the beet end operation. This paper describes the optimisation of a Thai centrifugal workshop that is particularly subject to significant variations in the quality of the massecuite. The Erawan sugar refinery installed two Colobserver® from Iteca Socadei in early 2016 to successfully address this issue, stabilise its production within a few months, and improve its productivity.

Quality determination of sugar inside continuous centrifugals

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The performance of continuous sugar centrifugals and the quality of the delivered sugar are dependent on the massecuite quality, the steam addition and the water addition. Until recently, the impact of the combination of the above-mentioned parameters on the sugar quality in continuous centrifugals was not fully known. The centrifugals are usually trimmed by the trial and error method. An inline colour measurement instrument has been developed and installed on top of continuous centrifugals, allowing real-time monitoring of the changes of the sugar colour inside the centrifugals. While monitoring the sugar quality online, it was observed that the sugar colour inside the centrifugals varied rapidly and with larger variations than expected. By optimising the water addition, the centrifugals were trimmed to produce a more uniform sugar quality.The results showed that online monitoring of the sugar colour inside continuous centrifugals, would give the factories the possibility to reach the required sugar colour with less sugar loss to molasses.

Product Storage

Learnings from the 2015 Pongola silo failure

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During June 2015 the refined sugar silo at the Pongola Sugar Mill suffered a severe buckling failure. The failure occurred with the silo in operation and full of sugar. During the months which followed the silo was stabilised, strengthened, the sugar was removed, the damaged sections were safely dismantled and a thorough investigation into the cause of the failure was undertaken. This paper reports on the steps taken to safely dismantle the silo and on the various mechanisms by which silos can fail which were considered during the investigation. Most importantly, the paper provides a list of recommendations to be followed to reduce the likelihood of future silo failures.

Health & Safety

To bee or not to bee (stung) Hulref's intervention in reducing bee stings

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As sugar refineries are a source of food for bees, one of the major contributors to injuries at the Tongaat-Hulett Sugar-Refinery (Hulref) is bee stings. In 2013, management at the refinery observed that the number of employees stung by bees was on the increase and 47 % of the medical treatment cases (MTC) were for bee stings. In view of this an urgent intervention was needed to reduce the number of bee stings. Bees play a vital role as pollinators in the environment and as a result the approach adopted was to find a "win/win" solution to the bee problem. The steps taken to reduce the number of people being stung at the refinery are listed below:-

- Minimisation of spillages in the factory;
- Installation of bee catch boxes;
- Planting of bee attracting flowers on the periphery of the plant;
- Installation of bee feeding stations in the plant; and
- Location and re-locating of bee hives.

In this paper each element will be discussed in detail. Data on the effectiveness of the approach taken to reduce the number of bees visiting the refinery for food will also be presented.

Byproducts

Inclined perforated drum dryer and separator for cleaning and drying of sugarcane bagasse

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Sugarcane bagasse is a renewable energy source that has the potential to be used to generate electricity in sugar mills. The moisture content of bagasse as generated in the normal sugar extraction process is typically around 50 %. Its energy value could significantly be enhanced if the moisture content was reduced to 20 % or below. The bagasse contains a significant amount of pith, a fibrous component of the biomass that has a lower calorific value than the remaining constituents, as well as sand. In this work it was shown that pith and sand removal as well as drying of the bagasse could be effectively carried out using a perforated rotating drum dryer. Hot air passes counter-current through a rotating drum inclined a few degrees to the horizontal where bagasse moves down through the drum by gravity and heated air flows upward through the tumbling bagasse. The pith and sand are able to pass through the perforations in the drum whilst the remaining bagasse exits at the bottom end. The extent of moisture and pith/sand removal were found to be dependent on the rotational speed of the drum, feed rate of biomass, angle of inclination, and flowrate and temperature of the air. The initial modelling study assumed plug flow of bagasse and a constant air temperature in the drum. The full model is able to adequately predict the performance of the dryer.

Biorenewables

Lignocellulose biorefineries as extensions to sugar mills: Sustainability and social upliftment in the green economy

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The sugar industry has to "re-invent" itself to ensure long-term economic survival, opportunities for job creation and enhanced community-level impacts, given increasing pressure from fluctuating and low global sugar prices, increasing energy prices and sustainability demands. Biorefineries were proposed as means to revitalise the sugar industry, by annexing new product plants to existing sugar mills to convert low value lignocellulosic biomass (sugarcane bagasse and brown leaves) to a spectrum of high

Abstracts

value platform chemicals along with biofuels, bioenergy and electricity. The opportunity is presented for greener products to mitigate climate change and overcome economic challenges. A series of biorefinery scenarios have been modelled using Aspen Plus® software to better understand the biorefinery processes, estimate the CAPEX and OPEX, environmental impacts, and overall sustainability. This approach allows for potential products such as alcohols, organic acids, electricity, furfural and other biochemicals to be compared in terms of their desirability for inclusion in biorefineries based on sustainability and the need to maximise the benefits of social, economic, and environmental factors on a lifecycle basis. This offers an opportunity to provide societal needs for greener products and to mitigate climate change while simultaneously meeting the challenges of the sugar industry.

The development of a partial equilibrium economic model of the South African sugar industry in a biorefinery scenario

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The South African Bio-Economy Strategy was launched in 2013 and identifies agriculture as the sector with the highest economic impact. The need to explore the revitalisation of mature industries such as the sugar and wood/forestry product industries in order to achieve "eco-efficiency and innovation in a low-carbon future", was explicitly mentioned. In the Industrial Sector Strategy, it was stated that "South Africa will need to progressively source second generation biofuels", in particular, by converting agricultural residues. One of the strategic interventions in the industrial sector is to develop integrated biorefineries from bio-based feedstocks. In order to implement these strategies, specifically for the sugar industry, a step change will have to take place by extending sugar mills to fully fledged biorefineries, and by adding further downstream products (materials, chemicals, fuels) to the existing product portfolios. The objective of this study is to develop a partial equilibrium mathematical programming economic model of the South African sugar industry (encompassing all stakeholders along the value chain) that allows for inclusion of biorefining investments from the cane to the biorefinery product production. The model will be used to project biorefinery investments under a range of division of proceeds scenarios, and to investigate the implications thereof for sugarcane farming. The purpose of this article is to present a conceptual model that includes representative farms (representing the supply of sugarcane to the mills) and representative mills (representing the derived demand for sucrose, molasses and bagasse by the mills), and allows for sale of products on both domestic and export markets. The model will subsequently be developed by incorporating the results of techno-economic analyses (TEAs) of a limited range of biorefinery investment options.

An economic analysis of the potential bio-polymer industry: the case of sugarcane

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The South African sugar industry faces both external economic competition and internal adversity. Such difficulties have led to a decline in sugar production and revenue over the past seasons. Strategies to enhance revenue and secure production may protect against longer-term industry decline. Data gathered from individuals within the associated industries propound varying reasons for the negative growth in production and revenue. However, the consensus view converges toward a product diversification scenario, for example, the Brazilian sugarcane-to-ethanol programme. This study analyses the economic potential of converting portions of South Africa's sugarcane to selected bio-polymers (plastics). An economic and environmental cost-benefit analysis may measure the relative viability of producing bio-polyethylene and polylactic acid from sugarcane in a South African bio-refinery. However, despite a potentially positive net-present value calculated from quantitative research, the market landscape was further revealed in this short paper by assessing the qualitative features of agents within the sugarcane and polymer industries. An interview-based questionnaire examined the rate and likelihood of the industries to adapt to bio-based diversification. European, American and Asian markets have attained bio-refining success. By conducting simultaneous quantitative and qualitative analyses, it is clear as to what the future holds not only for the South African sugarcane industry, but for the bio-based chemical industry too.

Economic recovery of biobutanol - a platform chemical for the sugarcane biorefinery

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In recent years, the South African sugar industry has faced challenges such as drought and labour issues that have impacted negatively on its perceived sustainability. The adoption of the sugarcane biorefinery concept by the sugar industry is a possible solution to improve the sustainability of the industry amid these challenges. In this envisioned biorefinery, 'multiple products are created within an integrated system that maximises sustainability', as opposed to relying on producing one, or very few, commodities. This paper explores the potential economic recovery of butanol from sucrose fermentation (biobutanol) with the aim of using it as a platform chemical for the production of higher value products, e.g. esters. Biobutanol production was characterised by very low butanol concentrations in the fermentation broth (around 2 % (m/m)) due to high inhibition, resulting in a very high cost of recovery and the need for several downstream purification steps. According to literature, there are promising technologies that can make the recovery and purification processes viable. Gas stripping, adsorption, extraction and distillation process steps were simulated on Aspen Plus® to determine the profitability of the process to produce pure butanol. Simulation results were verified by experimental measurements in the case of extraction and gas stripping. Overall, techno-economic analysis results were used to determine the best performing arrangement of technologies or unit operations.

Reactive extraction and reactive distillation: A new recovery process development for levulinic acid from fermentation broths

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Levulinic acid is sourced either from petrochemical or bio-based feedstocks. Although its production from fossil resources is still more cost efficient, the application of fermentation technologies has gained attention as carbohydrate-based feedstocks can be used, giving access to the fine chemical, nutraceutical and pharmaceutical markets. One of the biggest challenges in this process alternative is that an aqueous solution with inherently low product concentrations is produced. Various separation processes (liquid-liquid extraction, ion exchange, chromatography, precipitation) have been proposed, but they all suffer from some limitations such as waste generation, large energy input and material requirements leading to high costs of production (estimated to be above 60 % of the overall costs). As a result, much research is being undertaken to find a successful technology with the potential for industrial application. In this paper, the direct conversion of levulinic acid to esters from the primary aqueous solution using hybrid reactors is investigated as a potentially promising separation process. It has the advantage of being substantially cheaper than other separation processes. It also provides esters as intermediate products that can be used either directly, or hydrolysed to levulinic acid. A meta-analysis of the kinetics and thermodynamics of esterification reactions of levulinic acid to ethyl levulinate is under way. The aim is to create a chemo-technological toolbox that can be used to predict the operation performance of integrated reactive separation strategies, and to work towards a scale-up to commercial production.

Nitrogen-doped carbon nano-tubes synthesis from biorefined sugarcane bagasse

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The need for socio-economic sustainability in modern societies has triggered the introduction of various concepts and technologies with regards to biorefining. By-products of the processes involved in a biorefinery have numerous applications when produced or upon further processing, thus positively contributing to the three pillars of sustainability, i.e. encompassing environmental, social and economic aspects. Sugarcane bagasse, for example, can be further refined to produce cellulose, amongst other by-products. Cellulose from sugarcane bagasse can be advantageously utilised as a starting material for the synthesis of various carbon nanostructured materials. Carbon nanostructured materials have applications in different key areas, such as in catalysis, energy storage and conversion, and water treatment. In this work, we describe our recent efforts to produce nitrogen-doped carbon nano-tubes (N-CNTs) using sugarcane bagasse as the starting material, 1-butyl-3-methylimidazolium chloride [C_4MIM]Cl as the solvent and ferrocene as the catalyst source. N-CNTs were synthesised using the chemical vapour deposition method at temperatures of between 800-1 000 °C. The synthesised N-CNTs were characterised using transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and Raman spectroscopy. Typical hollow tubular structures of N-CNTs were observed using TEM. These observations correlated morphology from SEM which showed spaghetti like structures and EDS, showing the presence of nitrogen. Raman spectroscopy indicated typical CNTs bands, G-band and D-band, due to graphitic carbon vibrations and defects, respectively. Thermogravimetric analysis (TGA) was also conducted to study the thermal stability of the N-CNTs. The study showed that N-CNTs were successfully synthesised from bagasse.

Organic acid treatment of sugarcane residues for the production of biogenic silica

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Biogenic silica was extracted from sugarcane leaves through an organic acid thermo-chemical treatment method. Two sugarcane leaves batches were investigated: one batch with a midrib and the other without the midrib. Both produced amorphous silica with high purity (> 90 % (m/m) silica) but their textural properties were distinctly different. The sugarcane leaves were leached with 7 % (m/m) citric acid at 80 °C for two hours prior to being washed, dried in the oven for 24 hours and burned using a four step programme ranging from room temperature to 873 K in a furnace. The characterisation of the final products was performed by X-Ray Fluorescence (XRF), X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), nitrogen sorption and Elemental Analysis (CHN). The produced white ash had an insignificant amount of carbon and the pore structure was mainly formed by mesopores.

The development of a screening tool to identify new products for the South African sugarcane industry

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The production of new revenue streams within the sugarcane industry would represent an opportunity to enhance economic stability and sustainability of the industry. However, identifying the most commercially feasible new product option from the numerous possibilities available is a challenge. The Sugar Milling Research Institute NPC developed the New Products Greenhouse (NPG) toolbox as a screening tool for generating a first-pass assessment of the commercial feasibility of new products. The NPG screening approach considers key aspects pertaining to the successful implementation of a bio-based product in a South African sugarcane biorefinery and integrates feedstock competition, market, technology and economic criteria into the assessment. A standardised pre-defined set of criteria and a scoring scale are used to assign risk scores based on data gathered for a product candidate. Once a product is assessed, the NPG toolbox uses built-in algorithms to calculate an economic potential index (termed economic constraint), a business risk and a technology risk score. These outputs can be used to rank new product candidates according to their commercial potential. The toolbox excludes consideration of capital and operating costs and therefore the results should not be interpreted as a recommendation to invest in a particular product but rather that there may be merit in undertaking further technoeconomic analysis on that product. The toolbox also includes a system to store information gathered for products of sugarcane in a structured manner. The NPG project team intends to further refine the toolbox and validation of the NPG approach will be performed to strengthen the credibility of the outputs. This paper describes the development of the NPG toolbox and demonstrates its ability to enable quick and crude assessments to reveal where opportunities lie in the field of bio-based products. It is anticipated that this toolbox will facilitate the identification of promising commercially feasible products, providing a rational basis for the selection of sugarcane derived products for detailed techno-economic research studies.

Meetings Calendar

28-29 November 2017
ISO Seminar
Canary Wharf, London, UK
Web: www.isosugar.org

5-7 December 2017
Antigua, Guatemala
FO Lichts Ethanol Latin America
www.ethanollatinamerica.com

11 - 14 February 2018
International Sweetener Colloquium
Orlando, USA
Contact: +1 202 737 4332
http://www.idfa.org/forms/meeting/MeetingFormPublic/view?id=D2F630000021C

25-28 March 2018
Sugar Industry Technologists Inc Annual Conference, Bonita Springs, Florida, USA
Contact: Edgar Aguirre
Tel: +1 863 983 3637
Fax +1 863 983 7855
Email: sit@sucrose.com,
Web: www.sucrose.com/sit

12th April 2018
26th Symposium AVH 2018
Reims, France
Contact: Prof M. Mathlouthi
Tel: +33 608 93 81 41
Email: mathlouthi3@gmail.com
Web: http://www.avh2015.associationavh.com

18-20 April 2018
Australian Society of Sugar Cane Technologists Conference,
Mackay, Australia
Contact: ASSCT Secretariat
Tel: +61 7 4954 3956
Email: assctadmin@ozemail.com.au
Web: www.assct.com.au

15-18 May 2018
Advances in Sugar Crop Processing and Conversion 2018 Conference
New Orleans, LA, USA
Contact: Gillian.Eggleston@ARS.USDA.GOV
www.ars.usda.gov/ASCPC

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