GREEN CANE IMPACT ON SUGAR PROCESSING: ISSCT PROCESS WORKSHOP 2008

By

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Abstract

THE ISSCT Process Section workshop held in Réunion 20–23 October 2008 was attended by 51 delegates from 10 countries. The theme was *Green cane impact on sugar processing*. The workshop provided a valuable and timely opportunity to review and discuss the impact on factory operations and performance from a green cane supply that could include significant levels of trash. It was particularly relevant to those mills that were considering options to boost their biomass intake for increased co-generation capacity. Several of the speakers related their experiences with processing 'whole of crop' cane supplies through the factory. Speakers detailed the problems and increased losses that were incurred when processing cane with high trash levels. The consensus of the delegates was that the best scenario would involve a cane-cleaning plant at the factory so that only clean cane would be processed through the factory. The forum recommended that more research was required to address the issues of increased impurities in the process streams associated with high trash levels. Site visits to the two factories and a cane-delivery station were arranged as part of the workshop.

Introduction

The Process Section Workshop was held at the Hotel Mercure Créolia, Saint Denis, Réunion from 19 to 23 October 2008 and was hosted by CERF (Centre d'Essai de Recherche et de Formation).

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It was attended by 51 delegates representing 10 countries including some delegates who had travelled from as far away as Brazil, Nicaragua and Japan. All of the organisational matters for the workshop were handled extremely well by CERF and, in particular, by Laurent Corcodel and Carmille Roussel.

Opening session

The opening session of the workshop included presentations by Jean-François Moser, President of CERF, and Laurent Corcodel.

Moser's presentation provided an insight into the sugar industry in Réunion and its significant importance to the local economy. He described how infrastructure had been developed to allow water collected on the eastern side of the island to be transferred to the western side to irrigate the crops. A modernisation program had resulted in the closure of all but two mills. Cogeneration plants using both bagasse and coal were established at each factory and both had been upgraded to handle the full crop. Cane delivery stations were developed in several areas (mostly on old mill sites) to allow farmers to deliver the cane to local collection points. Each load is sampled on arrival before being transferred to semi-trailers for transport to one of the mills.

Corcodel reviewed the performance of the cane sugar industry in Réunion since 1984. Some of the important changes to the industry have included:

- The sugar industry in Réunion was consolidated to two factories (Le Gol and Bois Rouge), each processing about 1 000 000 t per year between July and December and producing 100 000 t of raw sugar each;
- The cane crop comprises two main varieties: R570 (high trash) and R579 (self trashing);
- Each field can be ratooned up to nine times;
- All cane is harvested green and much of the trash is included with the cane supplied to the factories;
- Cane is delivered to one of 12 transfer stations or directly to one of the two factories;
- Only 10–30% is mechanically harvested;
- The true purity of the mixed juice ranges between 86 and 90;
- Ash % brix in mixed juice trends down from about 5% at the start of the milling season in July to less than 4% in December;
- Reducing sugars % brix range from about 3% in July to 3.5 to 4.0 in December; and
- Plant reliability has improved significantly over the 20-year period from about 12% downtime to an average of 4% breakdown rate in 2007.

Technical sessions

Session 1—Sugar losses in storage: green cane versus burnt cane

Determination of sucrose loss in storage of green billet cane (Michael Saska, Stuart Goudeau, Irina Dinu and Mike Marquette. Presented by Rod Steindl)

Tests measured sucrose loss during 24-hour storage of green billet cane. Several tests were also organised in a sugar factory where, in addition to the storage on the ground, some damage or loss of cane may be expected from handling the cane with front-end loaders. The mass loss of sucrose in storage of green billets of 24 hours or less was adequately represented by a linear model based on the length of time (hours) within three temperature ranges: <17°C, 17–27°C and >27°C, representing cold, moderate and warm conditions, respectively. The predicted relative sucrose change (tonnes of sucrose lost or gained for each 100 tonnes of initial sucrose per hour) in the three temperature ranges are 0.022 (gain), –0.017 (loss) and –0.323 (loss), respectively.

An analogous model applied to the cane weight loss during storage of green billet cane. The predicted relative cane weight loss (tonnes of cane per 100 tonnes initial per hour) in the three temperature ranges <17°C, 17–27°C and >27°C was 0.02, 0.02 and 0.26, respectively. The six factory cane yard tests broadly agreed with the conclusions from the pilot storage tests done at Audubon Sugar Institute, indicating that the cane and sucrose mass losses from handling the cane in the cane yard were relatively small compared with the losses from the enzymatic and microbial action within the stored cane.

It was uncertain whether the small sucrose gain predicted by their model for cold storage of green billets was related to enhanced activity of sucrose synthesising enzymes, or suppressed invertase activity in post-harvest cane as a reaction to low temperatures, or was an artefact of the experimental technique.

The financial impact of the sucrose loss predicted for storage of cane at high temperatures

(3.2% in 10 hours at over 27°C) is serious, and consideration should be given to improving through their design the natural or forced ventilation of cane wagons and piles, and to the scheduling of harvest and storage of cane.

Cane deterioration: Comparison green cane versus burnt cane – Researching a green cane deterioration indicator (Camille Roussel, Arnaud Petit and Laurent Corcodel)

During 1990–1995, the Process Department of CERF compared cane deterioration of whole cane and burnt cane to find a criterion to gauge cane deterioration. Those studies showed that ethanol was a good criterion in burnt cane, but not in green cane. As cane is no longer burnt in Réunion, deterioration trials undertaken since 1995 have dealt only with green cane. Decreases in weight, sucrose content and purity mean that growers lose about €1/tonne of cane per day from post-harvest delays.

Biochemical measurements were undertaken during deterioration trials in 2005 and 2007. In 2005, aconitic acid ratio appeared to be a good indicator of deterioration. In 2007, other deterioration criteria were tested using chromatography (HPIC and HPLC) to measure organic acids, polyols, and amino acids. Of particular interest was 1-kestose, which increased linearly with post-harvest delays. Results showed also that citrate, alanine, proline, cysteine, isoleucine, and leucine correlated well with the post-harvest delay.

NIR evaluation of the post-harvest deterioration of sugarcane quality (M. Ueno, E. Taira, Y. Kawamitsu, K. Kikuchi and Y. Komiya)

All Japanese sugarcane is harvested green, because burnt cane is not accepted by the mills. The trash is transported with the cane and separated at the factory. About 60% of the sugarcane is harvested manually. Mechanical harvesters include small machines that load billets into bags on the back of the harvester through to large machines that load directly into trucks. Manual harvesting requires considerable labour, is hard work, and 1–3 weeks is required to load the transport truck. Deterioration that occurs in this period results in sugar losses and deteriorated cane affects the milling process and lowers the efficiency of the mill.

To measure the quality of sugarcane for payment, a 5 kg sample of cane is collected by the core sampler from every vehicle at the entrance of each factory. These samples are fibrated and a near infrared spectrometer (NIR) is used to measure the pol in cane (PIC) as a quality index. If the mill staff can quickly and easily know the degree of deterioration, the information becomes very useful for process control. An NIR calibration equation to measure the ethanol content was investigated as an index of deterioration of cane. VIS/NIR absorbance spectra (570 to 1848 nm) were measured using an NIR instrument (Foss InfraXact), and the calibration equation for ethanol was developed by partial least squares (PLS) regression analysis. As a result of PLS regression, the values of R^2, standard error of calibration (SEC), and standard error of cross validation (SECV) were 0.908, 0.09%, and 0.11%, respectively. The developed calibration equation successfully measured the ethanol concentration of deteriorated cane with simultaneous measurement of PIC. Ethanol concentration was examined by the developed calibration equation for 0, 21, 28 and 36 days after harvesting. Although ethanol was not detected in fresh cane, ethanol content increased dramatically as the delay increased. Ethanol content of all sugarcane samples of 11 sugar mills in Okinawa Prefecture were calculated by the developed calibration equation. About 5% of all samples showed more than 1% ethanol content. It was concluded that the NIR method gave information of the sugarcane deterioration to support the operation of all sugar mills in Okinawa without any chemicals or apparatus.

Session 2—Mill de-trashing equipment: Design, operation, optimisation

Development of a prototype factory-based trash separation plant (Phil Hobson. Presented by Rod Steindl)

Several sugarcane industries are actively seeking an efficient way of bringing the biomass to the factory to increase the co-generation potential. As well, some countries have or are about to ban the burning of cane. This has increased the interest in trash separation plants located either at the factory or in centralised locations closer to the cane supply areas. This presentation discussed investigations by Sugar Research Institute (SRI) to separate the trash at the factory.

Trash left in the field after harvest constitutes a large, currently untapped source of available biomass. Harvesting the whole cane plant and subsequently separating the trash from the cane stalk in the cane supply entering the factory could potentially double the amount of fuel available for power generation. The Queensland Treasury (Office of Energy), Stanwell Corporation Ltd, and the NSW Sugar Milling Co-operative funded the development by SRI of a commercial scale prototype cane-cleaning plant. Funding by the Australian Greenhouse Office assisted with the installation of a fully commercial cane-cleaning plant at Condong Mill. Preliminary trials carried out at SRI in 2000 provided much of the basic information for the design of the prototype cleaning plant. Construction at Condong Mill of the prototype trash separation plant was completed by, and initial commissioning began, in early December 2000. Extensive testing and further development of the plant was continued through 2001. The performance testing program showed that the plant was able to achieve high levels of trash separation at low levels of cane loss (less than 1%), at commercial pour rates. Trials with an industry standard shredder indicated that the shredder could reduce the trash to approximate bagasse like consistency, but with a power requirement of about 12 kW/t of trash per hour. Conventional cyclone technology removed at least 99% of the air-borne trash that flowed from the cleaning chamber.

Cane field residues as supplementary boiler fuel (Kassiap Deepchand and A.F. Lau)

Cane field residues (CFR) consist of the dry cane trash and the green leaves left in the field after harvest and last for about 6 months of the year (June to Nov/Dec). CFR confers a certain number of agronomic advantages such as soil moisture conservation in dry areas, control of soil erosion and maintenance of soil organic matter, but it also imparts a number of disadvantages in that it harbours pests and affects cane re-growth especially in areas with high rainfall. Investment was made in a dry cane-cleaning plant with a capacity of 150 tonnes of whole cane per hour and operated next to a sugar factory. The concept was to reduce sugar loss in bagasse and minimise sugar manufacture difficulties due to the CFR adhering/brought together with cane while, at the same time, targeting the long term additional CFR recovery to increase fuel availability for power plants and thus displace coal. Difficulties were encountered in continuous operation of the plant due to a lack of a constant flow of cane and of an inefficient separation of the trash from the long cane. Subsequently, some modifications were made to the plant, but it could not run beyond 90 t/h, although an improvement in the separation process was noted.

An alternative approach of using CFR as an additional fuel to bagasse is being looked into, and the objective is to increase and extend electricity generation period from these resources by displacing coal. The total amount of CFR (which normally contains around 25% moisture depending on climatic conditions prevailing at harvest and in the subsequent days) is around 15 t/ha. The project aims to collect up to 50% of the CFR from the fields under ratoon crop and almost all the CFR from fields which are to be replanted after 7–8 year crop cycle. Whereas equipment for collection (windrowing and baling – square or cylindrical) and transport are available for industrial applications, those for debaling/shredding have still to be identified or developed for such applications. The emphasis on current R&D has thus been focused on this particular aspect. Analysis of naturally dried CFR shows that it has a moisture content of 9–11%. Its calorific value at 10% moisture is about 15 MJ/kg. Industrial-scale trials using existing conventional mills have shown that such naturally dried CFR can conveniently be burnt in existing boilers. However, in view of the fact that the naturally dried CFR has a relatively higher ash content (8%) compared to bagasse (2.5%), it is proposed that it will, after preparation, be mixed with bagasse in a proportion of up to 25%.

Preliminary estimates indicate that, if 30% of the CFR is collected, prepared and mixed with bagasse from an annual cane production of 5.0 million tonnes, it can potentially generate 250 GWh of electricity. This will replace 150 000 t of coal and avoid the generation of 400 000 t of CO_2 and 30 000 t of coal ash. In monetary terms, the foreign exchange saved will be US$30 million assuming a projected future coal price of US$200/t.

Session 3—Effects of trash on factory operations

Ledesma's green cane project (Mario Rostagno, Carlos Bada, Federico Knauff, Miguel Ullivarri, Juan Carlos Mirande and Rodolfo Dofonzo. Presented by Rod Steindl)

Ledesma, a cane sugar factory in Argentina, has recently seen a significant increase in mechanised harvesting of cane. In 2007, 85% of the cane was harvested mechanically. The progression to mechanised harvesting has seen the proportion of green cane delivered to the factory increase from 11% of the crop in 2002 to more than 50% in 2005. The proportion of green cane has remained static in the following years. As part of their effort to maintain factory efficiency and product quality, factory staff have undertaken a number of investigations to quantify the effects of the increased proportion of green cane in the raw sugar factory, refinery, distillery and on their energy production. During the 2005 season, trials were undertaken to determine the green cane effect on milling capacity, sugar losses and bagasse moisture. The results can be summarised as follows:

- Final bagasse moisture increased by 7.3%;
- There was an increased frequency in chute blockages along the milling tandem due to the extra trash;
- Pol loss in bagasse increased from 0.64% to 0.70%;
- Throughput capacity of the milling tandems decreased by 7%;
- Although the molasses % cane remained relatively steady at about 3.66, pol loss in molasses increased by 8%;
- Raw sugar colour increased by 10%; and
- Because of the higher starch content of the trash, the consumption of α-amylase increased from 40 kg/day to 120 kg/day.

In the refinery, the consumption of chemicals such as decolorant, phosphoric acid and filter aid increased significantly. In the distillery, the total production of ethanol increased by 5.8% as a result of the higher sugar content in the molasses. However, the efficiency decreased to 79% because of the problems associated with the higher ash levels in the fermentation broth. The additional bagasse for combustion allowed the factory to reduce its consumption of supplementary fuel (natural gas).

New laws in São Paulo state and a new agreement between the state and the mills have started a green revolution in the Brazil sugarcane business. By 2014, the cane fields where the harvesters will be able to operate must be harvested as green cane. By 2017, all the cane fields will be harvested as green cane and cane fires will be eliminated.

This green revolution impacts on both the growing sector and the mills. The crop of green cane has a strong impact in the agriculture and industry areas. The challenges for the agricultural sector will include:

- Varieties that withstand the impact of cutter blades on harvesters;
- Effects of trash blanketing on ratooning ability and pest activity;
- Increasing the row spacing to 1.5 m;
- Changes to farm implements to better cultivate the soil and apply fertiliser through the trash blanket; and

- Adoption of 100% mechanical harvesting.

The impact on the factory processes will include:

- Increased impurity loading from the higher extraneous matter in the cane supply;
- Reduced milling throughput;
- Increased dirt loading in the bagasse going to the boilers;
- Potential for lower sugar quality;
- Higher costs for maintenance and chemicals; and
- Greater sugar losses in the mud and bagasse.

The option being favoured is to transport the cane and trash to the factory and separate the trash through dry cleaning plants. The cleaning plant is based on pneumatic separation of the trash followed by cleaning of the trash to remove soil and then shredding of the trash. However, the cane cleaning technology was still only in its infancy.

Clarification properties of stalk and trash tissues from U.S. sugarcane varieties (Gillian Eggleston and Michael Grisham. Presented by Barbara Muir)

The effect of the U.S. change from burnt to unburnt or green sugarcane harvesting on processing has not been fully characterised. Furthermore, the current trend to investigate sugarcane trash (leaves and tops) as biomass for the production of bioproducts has made the processing quality of trash more important.

Sugarcane whole-stalks were harvested from the first ratoon crop of five commercial sugarcane varieties (LCP85-384, HoCP96-540, L97-128, L99-226, and L99-233) with varying yield and harvest characteristics. Four replicated tissue samples of brown, dry leaves (BL), green leaves (GL), growing point region (GPR) or apical internodes, and stalk (S), were separated. Juice from each tissue type was clarified following a hot lime clarification process (operated by most U.S. factories). Only GPR and GL juices foamed on heating and followed the normal settling behaviour of global sugarcane juice, although GL was markedly slower than GPR. GPR juice was critical to clarification. S juice tended to 'thin out' rather than follow normal settling, and much more upward motion of flocs was observed. Most varietal variation in settling and clarified juice characteristics occurred for GL.

The quality and not the quantity of impurities in the different tissues affected the volume of mud produced. Tissue juice brix (% dissolved solids) had no relationship with the amount of mud produced. After 30 min settling, mud volume per unit tissue juice brix varied markedly among the tissues (S=1.09, BL=11.3, GPR=3.0, and GL=3.1 mL/brix). Heat transfer properties of tissue juice and CJ were described. Clarification was unable to remove all BL cellulosic particles. GL and BL increased colour, turbidity and suspended particles in the clarified juice with BL worse than GL. This would cause difficulty downstream in the factory boiling house and make the future attainment of Very Low Colour (VLC) raw sugar more difficult. Strategies to reduce the delivery of green and, especially, brown leaves to the factory need to be identified and implemented urgently.

The effects of extraneous matter on factory operations (Rod Steindl)

Several separate investigations that considered the effects of extraneous matter (tops, trash, roots and soil) on the composition of mixed juice and the downstream processes were summarised. The objectives in each case were to quantify the effects of green cane harvesting with increased levels of trash on factory throughput and sugar quality so that economic models could be developed. Although different methodologies were used, the outcomes were similar.

In the first investigation, estimates were determined for the composition of a cane stalk by separating the stalk into clean cane, trash, tops and top leaf components. The averaged values for a number of varieties were:

- Clean cane 81.2%;
- Trash 7.1%;
- Tops 6.1%; and
- Top leaf 5.6%.

It must be accepted that these quantities depend on many factors and can only be used as a guide.

In laboratory trials, composite samples of clean cane and added tops and trash were milled and samples of mixed juice and clarified juice were analysed. As expected, the samples of ‘dirty’ cane had higher levels of non-sugars, ash and colour. In another series of trials conducted at a factory, paired tests of dirty and clean cane were milled and the factory process streams were analysed to provide data to determine the economic impact of the trash content. Trash levels were up to 15% of the cane supply. Statistically significant effects included reductions in the sugar content for cane payment, crushing rates and syrup quality and an increase in the production of final molasses.

In a further series of factory trials, harvesting operations were organised into clean and dirty cane periods of up to 6 days each and the effects measured in the factory operations. The main effects were statistically significant increases in the starch, phosphorus and mud solids content of juice from dirty cane. The filter cake % cane increased by up to 37% and the pol loss in cake % pol in cane increased by 16%. The A massecuite quantity dropped marginally while the B massecuite % cane increased by 7% and the final molasses % cane increased by about 20%.

Interestingly, there was no statistically significant difference in the quality of the sugar produced. It should be noted that the factories involved in these trials only produced raw sugar with a typical pol of 98.8 to 99.0.

Improving the exhaustion of C-sugar magma through on-line measurements of the crystal content (Teddy Libelle, Michael Benne, Bridgitte Grondin-Perez and Jean-Pierre Chabriat)

On-line measurements and supervision tools become essential when trying to optimise the boiling crystallisation process and limit the impact of the variability of incoming feed streams. Here, on-line measurement of the crystal contents of the sugar magma (massecuite) was based simply on the comparison between the brix of the massecuite (Bx_{MC}) and the brix of the mother liquor (Bx_{ML}). Thus, its implementation was simplified due to the fact that both these types of sensors are often present at industrial sites. The complete mass of crystals in the C-sugar magma, C_m, depends on the crystal contents. From industrial measurements collected at Bois Rouge sugar mill (Réunion), we showed that C_m can increase, decrease or be stable during a boiling crystallisation. When analysing the evolution of C_m, we proposed some methods to optimise the exhaustion of C-sugar magma.

Impact of trash and high fibre cane on sugar recovery: CERF preliminary results (Laurent Corcodel, Camille Roussel, Eslyne Lemoine, Audrey Thong Chane and Laurent Barau)

The effect of cane composition on sugar processing has been discussed worldwide. With the development of high-fibre cane, an investigation into the high-fibre effects on sugar processing was considered important. A high-fibre, elite variety was at the end of the CERF breeding program, and the effect of this variety on the sugar milling processes had to be investigated. Firstly, the theoretical impact in sugar plants (sugar losses and milling capacity) was described and secondly, laboratory extractability trials were done. Those experiments were conducted jointly between the CERF breeding department and the sugar processing department.

Different CERF cane varieties were pressed at different pressures (50–250 bar) by a hydraulic press to calculate their extraction rate. Results showed significant differences between those varieties which could be explained by their pith / fibre ratio. Those indicators will be studied further with the aim to integrate them into the CERF breeding program to select high-fibre clones with a good milling ability.

Factory trials to determine the effect of green trash on downstream processing (Barbara Muir, Gillian Eggleston and Bryan Barker)

There is a worldwide shift to green cane from burnt cane harvesting. In South Africa 89% of the cane is still burnt and most of it is hand-cut. Some areas are changing to green cane harvesting due to environmental pressures, increasing labour costs and the current trend to investigate sugarcane trash as biomass for the production of bio-products. This paper reports on the effects of harvesting green billeted and/or whole-stalk sugarcane compared to burnt billeted and/or whole-stalk sugarcane at three South African mills that operate either a tandem mill or diffusers. Sufficient cane of each treatment was harvested and processed at each mill to purge the extraction plant of other cane. Trash tissues, shredded cane, juice and bagasse samples in the front end were collected and analysed. A bulk sample of mixed juice was then transported to the SMRI in Durban and further processed in the SMRI pilot plant to clarified juice, syrup, A massecuites, molasses and raw sugar.

Some of the differences reported include:

- There was a 6–10-fold increase in trash for mechanically harvested burnt and green cane over manually cut burnt cane;
- Cane and juice purities decreased with increasing trash content;
- RS/ash ratios in juice, syrup, massecuite and A molasses increased from burnt billets to green billets in some cases or were similar in other cases; and
- At one factory, there was a slight increase (~10%) in affined sugar colour while the samples from another factory showed a decrease of ~22% in affined sugar colour from burnt to green cane.

Session 4—Whole crops

Whole crop harvesting and processing (Michael Saska and Nicolas Gil Zapata. Presented by Rod Steindl)

This report presents results from tests done in 2006 in a Louisiana factory with harvesting and processing of the whole crop or ‘complete cane’ (stalk plus trash). The objective was to determine if there was any benefit if the whole crop was harvested green and transported to the factory and then to process the cane with or without the extraneous matter.

For complete cane (CC), the mill harvested green cane with the extractor turned off on the harvester, and the normal green cane (NC) was harvested with the fans on as usual. On December 15, 2006, 367 tonnes of CC were processed in about 4.5 hours at an average of 82 t/h. Sampling of normal cane as a reference could not be done on the same day, because cane delivery problems delayed the start of processing the cane. Sampling of the normal cane (NC) was therefore done on December 20 for a total of 7 hours. The mill operation was interrupted because of boiler problems for about 2 hours, about 2 hours into the test. Based on the information regarding the code and weight of the wagons that arrived at the mill, an estimated 974 tonnes of cane were processed within the period of the test, for an average rate of 139 t/h. The code, weight, and core lab analysis of the cane wagons delivered during each test were averaged and compared with the analysis of prepared cane taken at regular intervals during the test. Because of the time difference between the two tests, the variations reported here between NC and CC may be due in part to other factors than the trash content, e.g. cane and processing conditions, etc. Freezing temperatures at the start of December affected the cane quality, and the four-day delay between the tests probably resulted in further deterioration of the freeze damaged cane and skewed the comparison between complete and normal cane.

No problems were noted when processing whole green cane although the mill operated well below capacity at the time of both tests for other reasons.

An Excel model was used to estimate the economic viability of harvesting, transporting and processing cane with a variable amount of extraneous matter, including the case of whole crop processing, with co-generation with the extra bagasse. Other factors included in the model were the cane composition, sugar content and price, extra cane yield above the 'normal cane' case, the power generation efficiency and sale price, and harvester fuel requirements, with the extractor fans either on or off. The field-to-factory distance and the fuel cost were the decisive factors whether whole-crop harvesting could be profitable. The model also shows the critical effect of pol in bagasse, when milling cane with increased amounts of extraneous matter.

Experiences gained from whole crop milling (David Moller)

Whole cane milling (WCM) has been undertaken at two of the factories in the NSW Sugar Milling Co-operative to supply enough biomass to power a co-generation boiler of 30 MW during the 6 months of the non-crushing season. Whole crop milling is the supply of the whole crop (cane billets, leaves and trash) to the factory for processing through the milling tandem.

The initial plan was to transport the whole crop to the factory and then separate the leaf and trash material from the billets prior to milling. However, the prohibitive capital costs were such that this proposal was later rejected. After a short trial, it was decided that all the material would be processed through the milling train. This method of processing was trialled for three weeks during the 2007 crushing season before the factory returned to burnt cane processing.

In the 2008 crushing season, the factory has been processing whole cane for the first eight weeks. Due to an extreme frost in the 2007 growing period, the cane supply during this eight week period has included approximately 30% of frost-affected cane. Assessing the effects of processing the whole crop has been complicated by the inclusion of this frosted cane. Processing whole cane has impacted on every part of the factory. Changes have been made in the feeding, milling and boiler stations, but no changes have been made to the clarification, evaporation, pan or fugal stages until the effects of whole crop processing can be better determined. The observed effects in the factory include:

- Cane feeding – lower bulk density, trash binds together more than billets alone;
- Milling – the fibre rate increased from 40 t/h to 77 t/h and with greater variability;
- New cane payment formula needed;
- NIR system needed to measure fibre in each sample for cane payment;
- Clarification – lower settling rates, additional phosphate not effective in assisting clarification, and higher turbidity of clarified juice;
- Evaporation – poor HTC, faster scaling rate and scale harder to remove;
- Pan boiling – pans operating at only 60–70%, poor circulation (it is possible that frost affected cane contributed to this);
- Sugar quality – higher colour in molasses layer, no real impact on refinery operations; and
- Recovery – pol recovery dropped by 9%, bagasse loss increased by 4%, and molasses loss increased by 5%.

Composition of non-stalk components of sugarcane and field residues and their effects on composition of mixed juice (Michael Saska and Nicolas Gil Zapata. Presented by Rod Steindl)

This presentation summarised four independent investigations, carried out at different times and following somewhat differing methodologies. However, the objective was the same: add to the understanding of the composition of the various components of the sugarcane plant, with a focus on the effects of non-stalk components on the composition of the mixed juice, and to some degree on the potential new industrial uses for field residues after cane harvest, or after separation from stalk billets.

Specifically, the various facets of the work included the 2002 tests in Louisiana of the cane composition during the growth and harvest period, a one-time sampling and determination of composition in 2003 of non-sugars in a major sugar cane variety grown in Colombia, determination of the effects of a commonly used chemical ripener on non-sugar composition of the cane in 2005, and a 4-year (2002 to 2006) test to determine the chemical composition of both the biomass remaining in the field after harvest and the juice extracted from these field residues using laboratory milling equipment.

It is well known that the non-sucrose content of the juice (e.g. ash, reducing sugars, starch, and colorants) extracted from cane trash is higher when expressed on the dry solids basis, than in juice from clean stalk, and, therefore, the purity of the industrial mixed juice is lower than it would be if only clean stalks were milled. However, even though the present data are far from complete and may have been affected by various experimental factors, it is quite apparent that the ratio of reducing sugars over the sum of concentrations of potassium and aconitate (the two major contributors to ash in cane juices) tends to be larger in juices from tops and leaves, than in the juice in the clean billets. This would seem to indicate that cane trash (tops and leaves) in commercial cane supplies may increase the overall RS/Ash ratio and therefore lower the target molasses purity.

Session 5—Forum review and discussion

Processing of green cane through sulphitation process (J.J. Bhagat)

An overview of the Indian sugar industry was presented that included:

- Importance of the sugar industry to the national economy;
- Value-added products that are generated from the 260 Mt crop of sugarcane;
- Major constraints being faced by the industry; and
- Strategies being adopted to improve productivity including new varieties, sustainable farming systems, extensive upgrades and modernisation of factories and energy conservation, optimisation and power export.

Indian factories produce a bold grain sugar with a very low colour of 50–150 IU typically. The process includes double sulphitation and usually syrup clarification. Trash and other extraneous matter that would cause an increase in the sugar colour are avoided. Mixed juice colour can vary from about 14 000 IU for clean cane up to more than 30 000 IU for cane plus tops and trash.

Some of the disadvantages of the high extraneous matter present in the cane supply when all the biomass is delivered to the factory include:

- Reductions in grinding capacity and sucrose extraction;
- Mill efficiency reduces by 5% and milling capacity by 10–15%;
- Lower quality clear juice (increases in turbidity, residual CaO and PO_4, lower purity, and additional consumption of chemicals);
- Leaf matter introduces an extra high loading of colorants, ash and RS;
- Increases the purity of final molasses; and
- Net benefit to a factory processing 0.5 Mt of clean cane rather than cane with extra trash was estimated at US$1.3m (without a co-generation facility).

Literature review of burnt/green cane effects on factory processing (Laurent Corcodel)

A brief summary of some papers to past ISSCT and SASTA conferences was presented. The summary highlighted the difficulties confronting current technologists when trying to reconcile the range of previous investigations because the focus of individual investigations is usually different and this makes comparisons difficult.

Poster papers

A pilot plant developed in-house for yield and quality increasing of sugar crystallisation (Cédric Damour, Patrick Jeanty, Yannis Hoarau, Michel Benne, Brigitte Grondin-Perez and Jean-Pierre Chabriat)

Crystallisation process is the key stage of sugar production. Increasing demands for yield and quality created a need for optimisation and control of the process. To reduce the influence of variations in cane quality and changes in agro-climatic conditions on the process efficiency, it is essential to perform manufacturing protocols and to develop predictive control strategies. These steps require a series of experiments to reach the best trade-off. In an industrial context, each experiment could damage or stop the production.

Development of a pilot offers the opportunity to run many tests and experiments in the same experimental conditions but at a reduced scale. This poster describes a 1:1000 scale pilot plant for sugar crystallisation developed in-house at the Laboratory of energetic electronic and processes (LE2P) at University of La Reunion. This pilot plant should allow us to test and implant some new advanced control methods that have not been tested *in situ*. Results obtained on C-sugar crystallisation and experimental design of the seeding point study justify the scientific interest in the pilot plant development.

Site visit to Casernes cane delivery and transfer station

Cane is delivered to one of the 11 transfer stations by the farmer, usually as single trailer loads towed by a tractor. A core sample is taken from each delivery to the station on arrival. The cane is then transferred to a stockpile if whole stick or transferred directly to a waiting 20 t trailer if billet cane.

The core sample is then sub-sampled into a 5 kg lot and analysed at the site. The subsample is shredded and a 1 kg aliquot is placed into a press at 200 bar for 90 s to provide a juice sample for pol and brix. The fibre is calculated from a regression equation and the weight of the press plug.

Concluding forum

The forum discussed the use of the word 'trash' and what it represented. This arose because there were variations between research groups on what constituted trash and what was extraneous matter. The consensus within the workshop delegates was:

- Trash—the fibrous non-stalk material from the cane plant. This includes all leaf matter and the growing point of the cane stalk.
- Extraneous matter—everything left in the field or delivered to the factory that is not processable stalk.

There was general agreement that the best practice for factories to produce good quality sugar was to process clean cane. However, it was also recognised that future economic conditions will dictate that factories will need to maximise the amount of biomass brought into the factory for energy and bio-commodities. Individual conditions will define the most economical and sustainable balance for each organisation.

There was some discussion about future research needs. Papers delivered to the workshop identified a range of problems that factories have faced when processing cane with high levels of trash. The forum concluded that more research should be directed towards:

- An economical trash separation system to handle a cane supply with high levels of trash;
- Identification of suitable chemicals that would assist to alleviate the problems associated with the additional impurities in trash when processing a 'whole of crop' cane supply through the factory; and

- Consideration of a joint workshop for both agricultural scientists and factory engineers to consider the operating constraints of each sector of the industry and to consider options that benefit the operations of both the field and the factory.

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ATELIER FABRICATION ISSCT: LES EFFETS DES CANNES VERTES SUR LA FABRICATION A LA SUCRERIE

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**MOTS CLEFS: Cannes Vertes, Paille,
Non-Canne, Pertes, Atelier.**

Resume

L'ATELIER de la section Fabrication de l'ISSCT, «Effets de la canne verte sur le process», a eu lieu a la Réunion; 51 délègues représentant 10 pays étaient présents. On a discute les effets des cannes vertes avec de la paille en quantités variables, sur les performances et l'opération a l'usine. Ces discussions ont été particulièrement intéressantes pour les sucreries ou la cogénération est une option. On a aussi discute les difficultés associées au traitement des cannes vertes entières et des cannes avec beaucoup de paille. On a pu conclure que la meilleure façon de résoudre les problèmes est l'installation d'un système de nettoyage des cannes vertes, produisant des cannes propres pour la sucrerie. On a aussi conclu qu'il faut continuer à faire des recherches sur les effets des impuretés contenues dans la paille sur la fabrication. Deux sucreries et une station de stockage des cannes ont été visitées.

TALLER DE PROCESO DE LA ISSCT—IMPACTO DE LA CAÑA VERDE SOBRE EL PROCESAMIENTO DEL AZUCAR

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PALABRAS CLAVES: Caña Verde, Material Extraña, Pérdidas, Taller.

Resumen

EN REUNIÓN se realizó un taller sobre proceso organizado por el ISSCT, al cual asistieron 51 delegados de 10 países. El taller fue una ocasión importante y oportuna para revisar y discutir aspectos relacionados con el impacto en las operaciones de la fábrica y su desempeño por el suministro de caña verde que podría incluir altos niveles de materia extraña. Fue particularmente interesante escuchar las experiencias de aquellos ingenios que estaban considerando incrementar su contenido de biomasa con el objetivo de incrementar su capacidad de cogeneración. Muchos de los delegados relataron sus experiencias procesando 'caña completa' en la fábrica. Los delegados detallaron los problemas e incrementos en las pérdidas que incurrieron durante el procesamiento de caña con alto contenido de materia extraña. El consenso de los delegados fue que el mejor escenario podría involucrar un sistema de limpieza de la caña en la fábrica de forma tal que solo caña limpia podría ser procesada. El foro recomendó más investigación sobre el efecto del incremento de impurezas en las corrientes de proceso asociada con los altos niveles de materia extraña. Como parte de las actividades del taller, se realizaron visitas a dos ingenios y una estación de entrega de caña.