TECHNOLOGIES FOR PROFITABLE COGENERATION  
(FACTORY WORKSHOP, 2011)  

By  
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Abstract  
The ISSCT Factory Workshop 2011 in Australia was well attended with 67 participants including 33 overseas visitors from eight countries.  
The workshop addressed the theme Technologies for profitable cogeneration. There are significant non-technical issues to consider that have a significant impact on the installation of a cogeneration plant including the type of contact, development approval conditions and method of finance. Maximising cogeneration involves minimising factory energy use. There have been significant improvements in reducing energy use including the recovery of heat from low grade evaporator vapours and condensates. High fibre canes and trash are both of great interest as supplementary fuels for cogeneration. The use of trash has significant challenges to ensure it can be processed economically with minimal impact on sugar production and sugar quality. Minimising water use is a further requirement since cogeneration is a consumer of water.  
The workshop was held in conjunction with the annual ASSCT (Australian Society of Sugar Cane Technologists) conference. A pre-workshop tour was arranged in the Mackay district to make use of the time between the end of the ASSCT conference and the start of the ISSCT workshop.  

Introduction  
An ISSCT Factory Commission Workshop was held on the Gold Coast, Australia from 8 to 12 May 2011. The theme of the workshop was Technologies for profitable cogeneration. It was a combined workshop for the Engineering and Processing sections.  
The workshop was held in conjunction with the annual ASSCT (Australian Society of Sugar Cane Technologists) conference held in Mackay, Australia from 4 to 6 May. ASSCT offered a discounted registration cost for ISSCT delegates. Twelve delegates including nine overseas delegates took up this offer. A pre-workshop tour was arranged in the Mackay district on 6-7 May to make use of the time between the end of the ASSCT conference and the start of the ISSCT workshop. This tour was attended by 21 delegates including 20 overseas delegates.
The workshop was attended by a total of 67 participants including 33 overseas visitors from eight countries. Attendance included the authors Rod Steindl (ISSCT Factory Commissioner and ISSCT Processing Section Chairman) and Geoff Kent (ISSCT Engineering Section Chairman) along with five members of the ISSCT Engineering Section Committee (Morne Bester, Paulo Delfini, D.K. Goel, Adolfo Gomez, and Boris Morgenroth) and two members of the ISSCT Processing Section Committee (Laurent Corcodel and Paul Schorn). Rod Steindl, Boris Morgenroth, Morne Bester, Ross Broadfoot, Paul Schorn, Adolfo Gomez, DK Goel, Laurent Corcodel and Geoff Kent chaired the workshop technical sessions.

Sponsorship

Financial support for the workshop was provided by the Sugar Research and Development Corporation, Norris Energy Crop Technology, NQEA, SEW Eurodrive, RCR Energy Systems and Sugar Research Limited.

International Sugar Journal and Zuckerindustrie provided free one-page advertisements in their respective journals in advance of the workshop.

Pre-workshop tour

The pre-workshop tour visited three sites:

- Sarina Distillery. This distillery is the largest producer of ethanol from sugarcane in Australia and uses biostil continuous fermentation technology that results in concentrated dunder and lower steam consumption.
- Proserpine Mill. This factory has one of the highest capacity milling trains in Australia and has installed a flue gas dryer.
- Farleigh Mill. This factory has one of the largest milling units in Australia (108 inch) and supplies surplus bagasse to an adjacent factory for fuel to supply steam to a refinery during the non-crop period.

Opening session

The opening session of the workshop, chaired by Rod Steindl, included presentations from the following invited speakers:

- The official opening of the workshop by Chris Connors, Chief Executive Officer of New South Wales Sugar Milling Co-operative.
- Overview of the sugar industry in Australia by Sharon Denny of the Australian Sugar Milling Council.

Sharon Denny’s presentation provided a good overview of the sugar industry in Australia. The decline in cane land that had occurred in recent years appears to have stopped and millers and growers are both reacquiring new land for cane. She showed the cogeneration capability in the industry, indicating that mills currently supply half of Queensland’s renewable energy. She highlighted the opportunity for further growth in cogeneration.
Technical sessions

Introduction

The conference included eight technical sessions. The session topics and their respective chairmen are listed in Table 1.

Table 1 – Session topics and chairmen

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From project initiation to electricity production

**Design considerations for a cogeneration plant (Rex Farrell)**

Rex Farrell described the process involved in designing a cogeneration plant. As well as the technical requirements such as plant capacity, fuel types and quality, fuel handling and storage, water sources and cooling method, there are significant influences on the design coming from the type of contract, development approval conditions and method of finance.

**Implementation issues in the first ten years of a bio-energy project – from idea to operation (David Moller)**

David Moller provided a different perspective on the development of the same cogeneration plants discussed by Rex Farrell. He indicated the main drivers for the development of cogeneration plants were the need to replace old boilers and the need to eliminate burning of cane. Some of the main lessons learned included the long (ten-year) time frame from initial planning to implementation and that business concerns (such as sugar price) and legislation can change over that time. He stressed the need to dedicate staff to the project, the need for a detailed environmental impact assessment and warned of high overheads associated with project finance.

**Cogeneration projects and boiler evaluations in the Colombian sugar industry (Adolfo Gomez)**

Adolfo Gomez gave a presentation describing the current status of the Colombian sugar industry including the current cogeneration status. He described the methodology used to engineer the integration of a cogeneration plant into a sugar
factory, including the mass and energy balances, methods of reducing steam consumption and the need for electrification.

_Cogeneration at Sucrogen Australia (Brian Edwards)_

Brian Edwards gave an overview of the cogeneration business for Sucrogen, Australia’s largest raw sugar manufacturer. He described the design of the newest cogeneration plant at Pioneer Mill and their processes for bagasse storage. He also spoke about the economics of cogeneration in Australia.

**Discussion**

Similarities were noted between the regulatory requirements in Australia and South Africa. Changes in the requirements have introduced significant uncertainty. It is difficult to compete with the low cost of coal as a source of fuel. In South Africa, it was expected that the government would regulate for the value of energy from bagasse to be higher than the value of energy from coal. There is a need for policy change in Australia to make cogeneration more profitable.

In comparison, the time frame for establishing a cogeneration plant in Brazil is typically three to four years compared to the ten year time frame discussed in the Australian context.

**Maximising cogeneration, minimising steam consumption – system design**

_Cogeneration from sugarcane (David Gent)_

David Gent spoke of the process of integrating cogeneration into a sugar factory and the ongoing development path to achieve higher levels of cogeneration. He presented a case study for a 12 000 t/d factory where reduction of steam use, electrification of drives, conversion from a milling train to a diffuser, installing a high pressure boiler and reducing lost time can yield 49 MW. He saw utilisation of trash offering the capability of increasing cogeneration up to 111 MW and gasification increasing cogeneration to 150 MW.

**Integrated sugar complex with minimum energy consumption and maximum cogen (DK Goel and Sanjay Awasthi)**

Sanjay Awasthi discussed two new 3500 t/d integrated sugar, cogeneration and ethanol plants constructed in India. He discussed the benefits of using high pressure and temperature boilers, diffusion over milling, compact design to reduce pipe losses, direct contact heaters, extensive vapour bleeding, recovery of heat from condensates, variable frequency drives, planetary gearboxes, gravity flow of massecuite, belt conveyers and automation for increasing the cogeneration output of the factory.

**Cogeneration concepts and power export potential (Boris Morgenroth)**

Boris Morgenroth provided energy demand benchmarks for beet sugar factories as targets for cane sugar factories. He discussed a range of technologies that could be used to maximise cogeneration potential including direct contact heaters, falling film evaporators, diffusers and steam drying of bagasse. Steam drying was preferred over
flue gas drying because of the higher temperature of the steam and the relatively low temperature of flue gas from efficient boilers.

**Factory energy balances (Steffen Kaufmann)**

Steffen Kaufmann discussed a range of technologies used to reduce the steam consumption in two factories. They included extensive bleeding of vapour from all effects to pans and heaters, stepwise heating of juice, utilisation of heat from condensate and low pressure vapour, stepwise flashing of condensate, electrification of drives, diffusion with recycling of clarifier mud, falling film evaporation and the use of continuous vacuum pans.

**Discussion**

With the extensive use of vapour bleeding in factories with low steam consumption, the issue of running out of water in the juice is significant but was not discussed in the session presentations. There is a need to minimise vapour use, not just transfer to lower pressure vapours. For lowest steam consumption, there appears to be a trend to using condensate rather than vapour for juice heating and continuous pans to achieve consistent pan stage steam consumption. Pan and centrifugal procedures need to be examined to ensure low water use.

Vapour bleeding introduces a lot of interdependency between stations so a central control room would have benefits.

**Maximising cogeneration, minimising steam consumption – process technologies**

**Technologies for profitable cogeneration**

Sanjay Awasthi discussed a new 24 000 t/h factory in Sudan, designed to achieve 30% steam on cane and white sugar of 60 to 65 IU in a raw factory. The white sugar is produced by a defecation process followed by filtrate clarification, micro filtration of filtrate, syrup clarification, syrup sulfitation and low grade sugar melt clarification. The factory adopted many of the technologies discussed in his earlier presentation (*Integrated sugar complex with minimum energy consumption and maximum cogen*).

**Towards improved bagasse dewatering (Floren Plaza)**

Floren Plaza discussed the importance of reducing bagasse moisture content in order to achieve efficient steam generation. He discussed research aimed at improving the capability to model the milling process as a means of identifying methods to reduce bagasse moisture content.

**Diffusers versus mills with regard to energy conservation (Hans Cramer)**

Hans Cramer presented information about the diffusion process and the advantages of diffusion over milling. He indicated capital costs are about 60% that of a milling train, maintenance and operating costs are about 40% that of a milling train and there are fewer hygiene problems. The extra low-pressure steam consumption
traditionally associated with a diffuser can be eliminated by use of vapour 3 for heating purposes. Total power consumption is typically half that of a milling train.

**Rocky Point Mill process steam control strategy for cogeneration (Bruce Tyson)**

Rocky Point Mill supplies bagasse to an independent cogeneration plant and in return gets steam and electricity provided. To minimise the cost of steam, they have electrified their shredder and milling train, installed two two-roll mills, installed a large No. 1 evaporator that is essentially treated as their boiler, installed direct contact juice heaters and made extensive use of vapour bleeding. They have a steam control strategy to minimise steam fluctuations by varying juice flow and utilising a secondary juice buffer tank.

**The application of regenerative feed water heating to power cycles in the sugar industry, where and how much (Morne Bester)**

Morne Bester discussed the use of feed water heating using small amounts of high pressure steam. He discussed the types of feed water heaters and the constraints on operating parameters to maximise steam generation efficiency.

**Discussion**

Management of pan stage operations using cane receipt data and centrifugal station data can also help to manage pan-stage steam consumption.

Dewatering of bagasse following a diffuser remains a problem. Many factories have two dewatering mills following a diffuser. A dewatering device at the end of a diffuser can generally reduce the moisture content to about 80%, enabling a single dewatering mill to reduce the moisture to an acceptable 50%.

**Supplementing the fuel supply – alternative fuels**

**High fibre cane impact on sugar and cogeneration plant (Laurent Corcodel)**

Laurent Corcodel described an experiment to compare the processing of a regular cane variety and a high-fibre (22% increase) cane variety on factory throughput, extraction, juice colour and cogeneration output. He found lower rate, lower extraction, lower juice colour and greater electricity export with the high-fibre cane.

**Cane harvest residues: experiences in Colombian sugar industry (Adolfo Gomez)**

Adolfo Gomez described several research activities being undertaken in Colombia to make use of trash for energy use. Computational fluid dynamics methods are being used to model trash separation to define optimal geometry and specify required air flow. Processing of trash by knifing and briquetting is being examined to provide a suitably high density boiler fuel. Pyrolysis of trash to produce bio-oil and biochar is being studied. The production of ethanol from sugarcane biomass is also being examined.
**Determining the relative benefits of different leaf collection strategies based on the performance of components in the system (Chris Norris)**

Chris Norris described a range of approaches being used to recover trash with the cane harvest and after the cane harvest. He described measurements made to define the quantity of trash available, estimates of the benefits of leaving trash in the field, measurements of the effect of trash on harvesting and transport operations and measurements of the effect of trash on factory operations. He described designs for factory-based trash separation plants. Considering all these effects, he presented an economic analysis to determine the most cost effective trash-handling strategy.

**Discussion**

The economics of trash recovery is quite dependent on the reduction in cane loss achieved by not separating billets with the trash. Different studies have put the saving to be made in cane loss between 3% and 10%. These different values have a significant impact on the benefits of trash recovery.

Given a choice between cane with high fibre (energy cane) and cane with trash to increase the fibre content, clean high fibre cane is preferred. It is important to maintain high pol content as well since sugar sales are more secure than energy sales.

**Supplementing the fuel supply – handling trash**

*Developing best practice guidelines for particulate emissions from cane cleaning systems (Chris Norris)*

One of the most significant impediments to the installation of a trash separation plant is the high concentration of particulate emissions due to the exhausting of large volumes of air. Chris described the problem and indicated recirculation of air was one possible solution (used in Mauritius). The New South Wales Sugar Milling Cooperative has to meet 20 mg/Nm$^3$ emission limits. One solution considered was the feeding of air from the trash separation plant into the boiler but this strategy was considered high risk.

*An update on work done to investigate the effects of green cane harvesting in the factory (Gavin Smith)*

Gavin Smith reported on work undertaken at SMRI to measure the effect of trash on the factory. He reported the results of experiments undertaken at two factories in South Africa with different levels of trash in the cane supply. He presented the results of cane analysis and mixed juice analysis. Samples of mixed juice were processed in laboratory equipment to produce sugar. He presented purity, reducing sugars, ash and colour results from mixed juice to A massecuite. He concluded that trash reduced purity through the factory and increased sugar colour.

*The effect of whole crop processing on sugar production and sugar quality (Geoff Kent)*

Geoff Kent reported on work undertaken at two Australian factories to measure the effect of trash on sugar recovery and sugar quality. Experiments were undertaken
over 3-14 days. The results showed a significant reduction in recovery with trash, increases in sugar ash and colour and a reduction in sugar filterability.

**Development of cane dry cleaning and trash preparation for combustion in Brazil (Paulo Delfini)**

Paulo Delfini described the history of dry cleaning in Brazil and the reasons for its use which were primarily to reduce cane burning, reduce sugar losses (from wet cleaning), and reduce throughput and associated wear. He described the experimental and modelling work undertaken to optimise the cleaning chamber design. He also described the processes used to prepare trash for combustion including the use of knives and hammers and dirt removal processes.

**Discussion**

Storage of trash is an issue. A pile of 20 000 t of dry trash spontaneously combusted. The solution to spontaneous combustion appears to be to mix the trash with bagasse before storage.

High colour is not always a problem. In Réunion, they produce a high colour sugar product and so extra colour from trash can be an advantage.

**Boiler technology**

**Boiler design considerations for cogeneration (Anthony Mann)**

Anthony Mann gave a summary of the high pressure boilers in use in Australia for cogeneration and described their features. He described the approaches being taken to improve their performance to reduce fuel carryover, increase heat release for a given furnace size and for handling alternative fuels. He showed the use of computational fluid dynamics in improving design for greater capacity and efficiency and described a swirl spreader for increased capacity.

**Advanced controls for a biomass boiler (David Moller)**

David Moller described the problem of controlling a boiler for handling different fuel types and the particular problem of controlling boiler output and emissions when changing from one fuel type to another. He described some modifications to the standard boiler controls to improve control. These modifications included a calorific value corrector, an oxygen trim and steam temperature control using secondary air.

**BFB boilers for bagasse (Nick Holmes)**

Nick Holmes described the bubbling fluidised-bed furnace design as an alternative to the conventional stoker and grate design most commonly used in sugar factories. He indicated the main benefits of the technology were lower emissions due to lower temperature and improved efficiency due to less unburnt fuel and less excess air. He described one BFB boiler in Brazil using a combination bagasse and orange peel fuel.
Discussion

The optimum pressure for a boiler varies according to a range of issues including the price of power and the available supplier.

Water management

*Roadmap for zero water requirement of a modern sugar mill with cogeneration (DK Goel)*

DK Goel indicated that a typical sugar mill generates excess water but a typical cogeneration plant consumes water. He indicated technologies to reduce water use in a sugar mill include air cooled AC motors, Defeco Re-melt Phosfloatation (DRP) and reducing process steam consumption. Technologies for reducing water use in a cogeneration plant include using an air cooled generator, air cooled AC motors and using make up water heating from exhaust condensate to reduce vent loss.

*Isis cogeneration water requirements (Phil Woods)*

Phil Woods described the water issues that had to be addressed with the installation of a condensing turbine for cogeneration. He described the water balance analysis necessary to maintain essentially zero water use, including the use of significant on-site storage of water for later reuse and water quality issues associated with the reuse.

Case studies

*LLT juice clarifier (Raoul Lionnet for Mullapudi Narendranath)*

Raoul Lionnet gave a presentation prepared by Mullapudi Narendranath where he compared a Louisiana Low Turbulence (LLT) clarifier against a multi tray clarifier and an SRI-NG clarifier. He indicated the LLT clarifier was significantly cheaper than the alternative designs. The experiments showed lower retention times and hotter juice with the LLT clarifier compared to the multi tray clarifier.

*Flotation clarification of mill juice (Raoul Lionnet for Mullapudi Narendranath)*

Raoul Lionnet gave a presentation prepared by Mullapudi Narendranath where a flotation clarifier was used to improve the quality of juice from a bagasse diffuser station. His results showed the flotation clarifier reduced juice turbidity and colour.

*Determination of options to generate surplus bagasse – two case studies (Ross Broadfoot)*

Ross Broadfoot described two investigations to increase the bagasse surplus, one for off season steam generation and the other for sale to an adjacent factory. The studies considered reducing the variability in pan stage steam consumption, increasing boiler efficiency using economisers, air heaters and hotter feedwater, reducing high pressure steam demand with electric drives and balancing high pressure – low pressure steam use.
Reduction in energy consumption in manufacturing (Eduardo Calichman)

Eduardo Calichman described work undertaken at Maracai factory to reduce process steam use and increase cogeneration output. The work was conducted in stages and included using plate heat exchangers, using flash tank vapours to heat demineralised water and condensate from the cogeneration turbine, heating raw juice with vapour 5, increasing beer ethanol content, using vapour 2 for boiling A massecuite and using electric motor mill drives.

Discussion

In Australia, there is an Energy Efficiency Opportunities program which is driving a continuous improvement culture for reducing energy use.

Syrup clarification may hold some benefits for removing impurities from cane supplies with high trash levels.

Closing session

The final technical session of the workshop involved revisiting each of the session topics and providing opportunities for further discussion. The discussion sections under each topic present the main issues raised during this discussion.

Workshop tour

The workshop tour visited three sites:

- Condong Mill. This mill has recently installed a cogeneration plant and upgraded the factory for processing whole crop.
- Rocky Point Mill and Rocky Point Green Power. Rocky Point Green Power runs a cogeneration plant that received bagasse from the factory and green waste from a variety of sources and supplies steam and electricity to the factory.
- Carlton Brewhouse. This large brewery has implemented significant water and energy saving measures and is recovering energy from waste streams.

Conclusions

The ISSCT Factory Workshop 2011 in Australia was well attended with 67 participants including 33 overseas visitors from eight countries.

The workshop addressed the theme Technologies for profitable cogeneration. From the technical sessions, the following conclusions were drawn:

- There are significant non-technical issues to consider that have a significant impact on the installation of a cogeneration plant including the type of contract, development approval conditions and method of finance.
- Maximising cogeneration involves minimizing factory energy use. There have been significant improvements in reducing energy use including the recovery of heat from low grade evaporator vapours and condensates.
- High-fibre canes and trash are both of great interest as supplementary fuels for cogeneration. The use of trash has significant challenges to ensure it can be
processed economically with minimal impact on sugar production and sugar quality.

- Minimising water use is a further requirement since cogeneration is a consumer of water.