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"Energy Management in Raw Cane Sugar Factories"

- Programme
- Report
- **Abstracts**

ABSTRACTS

Session A - Opening Session: Overview
Cane sugar industry cogeneration for export - considerations
Cogeneration in Brazilian sugar factories and tendencies

Session B - Energy conservation from cane yard to extraction plant
Energy Conservation from Cane Yard to Extraction Plant Development of a factory based dry cane separation plant for increased recovery of biomass fuel
Comparative energy consumption of hydraulic and electric drives on six-roll and two-roll crushers
Diffusers vs. mills with regard to energy conservation
Diffusion versus milling – energy implications

Session C - Energy management in boiling house
Energy conservation in boiling house operations
Boiling schemes and energy
Optimized crystallisation and its effect on energy demand in sugar house operation
Use of low pressure vapour for pan stage operations
Energy aspects of assisted pan circulation
Energetics of satellite processing to syrup - Tableland experience
Innovative technology for condensing and cooling system
Energy efficiency in vacuum system and waste heat utilisation
Operation parameters for batch and continuous centrifugals
Energy savings with new dryer/cooler concept

Session D - Energy conservation in refineries
The Energy Management Experience
Steam economy in boiling house - plantation white sugar
Centrifugal and pan yields – their impact on process steam consumption
Nordzucker experience with sugar boiling schemes and energy savings

Session E - Improvement of efficiency of boiler plant and turbo generator
Increased power output from sugar cane biomass using newly developed gasification technology demonstrated in project ARBRE, UK.
BIG/GT technology integration with a typical Brazilian Sugar Cane mill
The problem of small turbines
Steam turbines (backpressure and extraction-condensing)
Presentation of the gas turbine, waste heat boiler combined cycle from Klein Wanzleben sugar factory

Session F - Improvement of calorific value of bagasse
Calorific value of bagasse - an overview
Can bagasse be considered a reliable fuel in terms of calorific value per unit weight?
Improvement of the calorific value of bagasse using flue gas drying
Improving calorific value of bagasse through the implementation of modified Java method mill settings

Session G - Alternative boiler fuels
Alternative Fuels: an Overview
Cane field residues as boiler fuel
Other fibrous fuels: the problems

Session H - Efficient utilisation of steam
Efficient utilization of Steam – Overview and Perspectives
Implementation of a highly efficient evaporation scheme at Usina Barra Grande in order to increase its cogeneration capacity
How a 30% reduction in steam consumption was achieved at Harwood Mill
Energy conservation by efficient utilisation of steam and vapour
Optimal utilisation of exhaust steam in boiling house
Planning for the efficient use of process steam using software based on the Rillieux principles
Pinch technology – optimising thermal energy networks
Efficient utilization of steam by scale prevention and effective cleaning
Possible areas for increased electricity export in raw cane sugar factories

Session A - Opening Session: Overview

Cane sugar industry cogeneration for export - considerations

J. P. Komen
Australia

The increasing concern about the effect of emissions from the power industry, amongst others, on the environment is the driving force behind the development of cogeneration and the utilisation of renewable fuel sources. The cane sugar industry is eminently suited for cogeneration because it has been in this field for 150 or so years as well as the fact that it uses a renewable fuel that is C02 emission neutral.

Sustainable sugar mill cogeneration requires external and internal factors favourably directed towards this goal.

Government Legislation is necessary to facilitate the successful implementation and operation of cogeneration plants based on renewable energy sources. This will assist in mitigating effects of utility type of power generators using fossil fuels. The often monopolistic attitude of utilities, particularly in developing countries, provides barriers to the establishment of Independent Power Producers (IPP), including cogeneration facilities, and effective Power Purchase Agreements (PPA) are difficult to negotiate There are many exceptions to the negative approach and a general shift to a more pragmatic approach is becoming evident. For nations without a reliable local fossil fuel base co-generation will reduce expenditures an fuel import, increase the national wealth, employment, etc. whilst ensuring the viability of the sugar industry.

The development of cogeneration for power export in the cane sugar industry has proved to be slower then originally though, especially in countries like Australia and South Africa where the national cost of power production, based an hydro or fossil fuel, is low. Changes in pricing structures arc suggested to make economic use of the enormous amount of available bagasse.

For economic viability the cogenerator must maximise the abstraction of energy from the renewables to make as much of the extra power generated available to the grid system. This requires judicious technical and economic evaluation of possible alternative arrangements. Of the many possible arrangements, the stand-alone concept of the cogeneration plant seems to yield the best results for large sugar companies and in specific countries. It separates the miller's core business from power generation and each is likely to have a separate corporate entity. The arrangement is such that mill outages will not affect the power generation activity. Product Exchange Agreements regulate the supply of bagasse and condensate to the cogenerator as well as the miller's required steam and electricity. Steam requirements are set at low limits of 35 - 40% on cane and electric power in the range of 25 - 29 KWh/tc. It generally requires the replacement of steam driven prime movers by electric or hydraulic drives. The arrangement is thought to be the most efficient for year-round operation1 although the investment cost is higher than other schemes. For smaller sugar companies the more conventional in-house arrangement is quite adequate.

Apart from the highly efficient arrangement described above there are intermediate cogeneration arrangements such as *ad-hoc* or continuous supply during the crushing season only as well as year-round supply. Each of these arrangements requires the matching of energy efficiency to the specific circumstances and maximum efficiency is not always required.

Steam and power demand of cane sugar mills will continue to decrease with technological developments. However the practical limits are set by the economics of return on investment Gasification technology for bagasse, when developed commercially will vastly increase the scope for power export and substantially change the sugar industry.

Keywords: Cogeneration, environment legislation, energy, efficiency

Top

Cogeneration in Brazilian sugar factories and tendencies

Pedro E. P. De Assis
P. A. Sys Engenharia e Sistemas

The Brazilian Sugar Sector currently generates around 1.5 GW of electric energy, in 305 factories , just for self-sufficiency. Until recently there was no interest by those units to look for increased efficiency in the bagasse/energy use due to the fact that most of the electric energy consumed in the country, more than 90 GW, was completely supplied by government owned hydro-electric plants, and distributed, by concession to private companies, in a very closed market. Since a few years ago, with the privatization and deregulation of the electric sector and stimulated by a very severe crisis in the energy supply last year, the sugar sector is being given incentives to produce an excess of electric energy to fulfil part of the growing demand of the country.

The presentation shows how the sugar factories are now mobilizing themselves to achieve, using existing technologies, up to 190 KWh/tc, and even more, in order to add more than 20.000 GWh/year to the national grid. The related capital investment cost is also shown.

Top

Session B - Energy conservation from cane yard to extraction plant

Energy Conservation from Cane Yard to Extraction Plant

Peter W. Rein
Audubon Sugar Institute Louisiana State University AgCenter Baton Rouge, LA 70803, USA

An overview of energy usage in a sugar mill begins with a consideration of the effect of cane quality. Cane trash in the form of leaves and tops represents a valuable source of biomass fuel and needs to be transported to the mill for use in the boilers if power generation is to be maximized. Harvesting and transport costs need to be taken into account in deciding whether to separate the trash in the harvester or at the mill. Sand in cane is another issue that has significant energy implications.

Clean and fresh cane has a significant benefit. Separating trash reduces the power absorbed in cane preparation and milling, and increases mill capacity. Clean and fresh cane has a higher purity, which reduces the quantity of C massecuite produced, as well as the total massecuite quantity, and hence also reduces the steam used in the factory. Degradation of sucrose in the extraction plant has the same implications, leading to higher factory steam requirements.

Optimum cane preparation for an energy efficient factory probably requires intensive preparation, in a minimum number of steps, when the effect on milling power and bagasse moisture is considered. The energy implications of diffusion compared to milling make an interesting study and affect a key decision in planning a new energy-efficient factory. The lower energy requirement of two-roll mills further complicates the options. The different microbiological conditions pertaining in milling and diffusion plants and the implications on factory processing efficiency also need to be considered.

Top

Development of a factory based dry cane separation plant for increased recovery of biomass fuel

P. A. Hobson[1], M. G. Schembri[1], T. F. Dixon[1], B. Lamb[2], C. Wheeler[3] and N. Lindsay[4]

[1] *Sugar Research Institute, Mackay, Queensland, Australia*
[2] *New South Wales Sugar Milling Co-Operative Ltd, Australia*
[3] *Stanwell Corporation Ltd, Queensland*
[4] *Office of Energy, Queensland Treasury*

Cane residue in the form of leaf (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. This paper describes the development by the Sugar Research Institute (SRI) of a commercial scale, factory based, prototype trash separation plant. The prototype plant is described and technical and financial performance data provided with detail limited by the need to protect the intellectual property and commercial interests of the associated stakeholders.

After preliminary development carried out at SRI a prototype separation plant was constructed and commissioned in December 2000 at Condong Mill, New South Wales, Australia. The plant was designed to process all the above ground biomass associated with the cane plant at a rate of 150 t.h-1 and deliver cane to the mill with low levels of residual trash and minimal cane loss. Typically in the Condong Mill area, whole-of-plant harvesting delivers levels of leaf and tops in the cane supply of 32% (25% dry and green leaf, 7% tops) on a mass basis. An extensive period of testing over the 2001 crushing season demonstrated that the plant is able to

consistently achieve high levels of trash separation (91% to 95% trash recovery) at low levels of cane loss (less than 1%).

In addition to cleaning performance, two other major issues have been addressed during the development of the plant namely the shredding of trash to produce a combustible bagasse-like fuel and exhaust air clean up (removal of entrained trash and dust). Trials indicated that a modified industry standard shredder could reduce the separated trash to approximate bagasse like consistency with a power requirement of 12 kW.tonne.h-1 of trash. A shredded material suitable for combustion in a conventional bagasse boiler could be produced at a lesser power input of 6 kW.tonne.h-1 of trash although modifications to the bagasse handling equipment would be required to manage the resulting longer fibres. Conventional cyclone technology was demonstrated to remove at least 99% of the air-borne trash entrained in the cleaning chamber exhaust air.

Keywords: Co-generation, trash, efficiency, cane loss, shredding

Top

Comparative energy consumption of hydraulic and electric drives on six-roll and two-roll crushers

D. B. Batstone
Venace Pty Ltd, Australia

Replacement of some inefficient steam engines and turbines is typically necessary if steam consumption is to be reduced to below about 450 kg steam/t cane. Recent installation of electro-hydraulic and electro-mechanical drives on crushers in the same tandem in two different mills in Queensland provides an unusual opportunity to compare the efficiency of each type of drive. One tandem has four two-roll crushers. The other tandem has a conventional six-roll mill and two-roll mills. Extensive data logging at each tandem has confirmed that two-roll mills use about 30% less energy on average compared to six roll mills after due allowance for position in the tandem. Electro-mechanical drives with variable frequency speed control acting through shaft-mounted planetary gearing have a substantially higher efficiency compared to electro-hydraulic drives.

Drive conversion is justified financially when high-pressure boilers are installed. Conversion to efficient and cost-effective electro-mechanical systems may be justified at typical steam pressure of 20 bar.abs if a premium price is obtained for renewable electricity.

Keywords: cogeneration, efficiency, steam, renewable, electricity.

Top

Diffusers vs. mills with regard to energy conservation

U. Schwanke
Braunschweigische Maschinenbauanstalt AG, Germany

Since the introduction of bagasse and cane diffusers to the sugar industry the main focus was the increased extraction and recovery of diffusers in comparison with mills and the reduced cost for operation and maintenance. More recently the focus shifted to the advantages that diffusers have with regard to energy consumption. This is especially important for those factories which are introducing co-generation. Several details about the consumption of electric energy and steam of cane diffuser will be highlighted in the presentation. Furthermore the application of technologies developed for the beet industry, i. e. the selection of additional trays for a cooled raw juice will be demonstrated. However, this concept requires a general revision of the steam and condensate distribution scheme in a cane sugar factory.

Top

Diffusion versus milling - energy implications

P. Thompson[1], L. Warner Weiss[2]
1. Sugar Knowledge International Ltd. (SKIL)
2. Sugars International LLC

Heating and evaporation systems for milling and diffusion are presented for a sugarcane factory to illustrate the differences between these two sugar extraction technologies.

Each extraction method has different thermal and electrical characteristics that affect both the process steam consumption and the amount of electrical generation from the turbo generator that can be exported for sale.

Pinch technology is used to do a thermal analysis for each extraction method to optimize the heat exchanger, evaporator and heat recovery systems while maintaining similar operating conditions and process performance. Next, the designs are modeled and their operation is simulated using the SugarsT for Windows® computer program to provide an objective comparison of the two technologies.

Mass and energy balances along with the net process revenues from each simulation are shown and discussed.

Keywords: sugarcane, cogeneration, modeling, simulation, pinch technology

Top

Energy conservation in boiling house operations

R. Broadfoot
Sugar Research Institute, Mackay, Queensland, Australia

The boiling houses of raw sugar factories (and those with annexed refineries) are large consumers of low pressure steam or bleed

vapour. Typically, for a raw sugar factory, the steam/vapour consumption of the boiling house is about 14% on cane, which is equivalent to about 9 MW of thermal energy for each 100 tonne cane processed. Hence, to achieve major reductions in the energy consumption of factories, close attention must be given to reducing the energy usage for the crystallisation/centrifugalling/sugar drying processes.

For current (non-energy efficient operations) it is estimated that the steam/vapour consumption on pan stages is approximately 35 to 40% greater than the theoretical minimum evaporation requirements for crystallisation. This alone indicates the scope to which large reductions in steam/vapour usage on pan stages can be made. A major reduction in the process steam consumption of the total factory is obtained if low pressure vapours are utilised instead of process steam for the pan boiling operations.

In reality there are several features of the boiling house operations which present challenges (some are major) to achieving large reductions in energy consumption. These include:

- The (generally) discontinuous operations of pan stages and the influence on supervision, control and variable energy demand that this imposes;
- Large temperature differences are required between the supplied steam/vapour and the massecuite to provide adequate circulation and evaporation rate. For example, the minimum temperature difference is typically about 40 to 45 oC and the magnitude of this temperature differential reduces the available options for sourcing the heating steam/vapour. The productivity of individual pans is directly affected by the evaporation rate which can be achieved and the uniformity of massecuite conditions within the pans as induced by the circulation movement;
- The primary objective of the boiling house is to produce good quality sugar with maximum recovery of sucrose from final molasses. Up to the present, for most cane factories, the energy consumption of pan stages has been of minor importance;
- The variable production loading on the pan stage as the quality of the cane supply changes through the season;
- The high capital cost of the process equipment on pan/fugal and dryer stations so production throughput is usually a major consideration and few factories have surplus installed capacity.

There are numerous aspects to be considered for the pan boiling/centrifugalling and sugar drying operations to achieve cost-effective and appropriate reductions in energy consumption. Among these it is important to consider the energy consumption of associated utilities e.g. vapour condensation systems, cooling water supply, vacuum systems. Other matters that require attention include the supervision of boiling operations in an energy efficient context; condensate management issues etc. Major consideration must also be given to the ability to refurbish and retrofit changes to the process equipment in order to bring about energy efficiencies, as an alternative to the replacement with new, expensive plant. For most factories the economic viability of diversification into other industries such as cogeneration requires that energy savings in raw sugar manufacture are undertaken without major capital investment.

Keywords: Boiling house operations, energy efficiency, pan stage, centrifugals

Top

Boiling schemes and energy

H. Wunsch
IPRO Industrieprojekt GmbH, Braunschweig, Germany

This presentation deals with the optimisation of sugar house boiling schemes, especially the 3-product-standard-liquor-scheme? with reference to an optimised quality of white sugar with low energy demand.

Besides detailing the necessary prerequisites for equipment regarding discontinuous (batch) vacuum pans, the use of seed magma for various products will be dealt with.

The application of seed magma procedures is also one of the key requirements for optimised continuous crystallisation.

Further possibilities for energy reductions will be demonstrated, as for example the utilisation of standard liquor and high wash syrup for sugar washing in centrifugals. Also the optimisation of heating steam conditions with a corresponding temperature gradient during the boiling process as well as the optimisation of crystal sizes and CV-values will be shown.

Top

Optimized crystallisation and its effect on energy demand in sugar house operation

R. Hempelmann
BMA AG, Germany

Efficient crystallisation is the main issue to reduce the energy consumption in the sugar boiling house. The essential pre-requisites for a low energy consumption are: (1) high dry substance content in syrup to the sugar boiling house, (2) low wash water consumption at the centrifugals, (3) no dilution of runoffs, (4) lowest amount of additional water for i.e. re-melting sugar. Especially a high dry substance content in feed solutions creates special requirements on crystallisation procedures and controls. A low molasses purity must be achieved to ensure the maximum sugar yield. An efficient cooling crystallisation with massecuite conditioning is required for this step.

By comparing boiling schemes the effect of high concentrated feed solutions, high crystallisation yields and high quality sugars on the total mass and energy balance of the sugar boiling house will be shown. The main process steps providing the necessary improvements will be explained: (1) seed preparation, (2) continuous boiling, (3) cooling crystallisation.

Top

Use of low pressure vapour for pan stage operations

R. Broadfoot
Sugar Research Instit ute, Mackay, Australia

Substantial reductions in the process steam consumption of factories can be achieved by using the vapour from the evaporator station for pan boiling, instead of using low pressure (process) steam which is typically extracted from mill turbines.

The crystallisation pans in Australian sugar factories are, in general, natural circulation batch vessels of large size. Several factories employ batch pans of 100 m^3 to 160 m^3 massecuite capacity for the high purity strike massecuites.

There are major concerns that the operation of pan stages on lower pressure bleed vapour from the evaporator station may reduce pan stage productivity and massecuite exhaustion.

Investigations were undertaken at a factory during the 2001 season to determine the impact on the performance of each pan operating at a vapour supply pressure of 145 kPa (absolute), that is equivalent to using vapour from the first evaporator. Pan stage data were logged continuously for several weeks and, during two series of trials, the calandria pressures in the individual pans were restricted to this upper limit of vapour pressure.

The logged data provided information on the changes to be expected for each pan on the stage. In several of the pans, circulation velocities at a position below the calandria were measured to determine the effect of the lower calandria pressure on massecuite movement. A technique employing a hot film anemometer was used for these measurements (Rackemann and Stephens, 2002).

Based on the outcomes of these assessments, modifications to the feed systems, noxious gas removal arrangements, individual pan control, and pan stage scheduling were proposed to overcome, or at least minimise, the effect on the productivity of the individual pans.

Acknowledgments
Stanwell Corporation Limited funded this investigation. The assistance provided by the management and staff at Mossman Mill is acknowledged.

Reference
Rackemann, D.W. and Stephens, D.W. (2002). Determining circulation velocities in vacuum pans. Proc. Aust. Soc. Sugar Cane Technol., 24: 452-458.

Keywords: Productivity, circulation rates, anemometer

Top

Energy aspects of assisted pan circulation

B. StC. Moor
Bosch Projects, Durban, South Africa

"Assisted pan circulation" is practised with both batch and continuous pans. Two methods are commonly used: mechanical stirring by impellers, and bubble-lift systems, or "jiggers".

Mechanical stirrers: Mechanical stirrers are most common in circular batch pans with either a tubular or coil-type calandria incorporating a central downtake.

The impeller is usually an axial flow or screw type, mounted low in the downtake and impelling the massecuite downwards. To cater for increasing viscosity as a batch boiling progresses, the impeller may be driven by a variable speed drive or have variable pitch vanes. In continuous pans such as BMA's VKT, where each cell has approximately constant conditions, a fixed speed and pitch can be used.

The impeller cannot be stopped, even under slack massecuite conditions, since this will impose a restriction on circulation.

Apart from the mechanical hardware and maintenance involved, the main disadvantage of mechanical stirrers is their ***power requirement***. The energy requirements vary with the viscosity of the product being boiled, the design of impeller and the stage of boiling. Typically, mechanical stirrers for batch pans need 1.0 to 2.2 kW / m^3 of pan capacity. FCB have measured 5.0 to 6.5 kW/m^3 in the final, high-brix compartments of their CCTW horizontal continuous pans.

Bubble-lift circulators: Steam or air bubbles injected as a "jigger" medium under the up-flow zone can be used to promote circulation. Air adds to the incondensible gas loading (needs vacuum pump power) and steam is therefore usually preferred.

Bubble-lift agitation is not as positive as mechanical stirrers, but has the advantage of simplicity and is generally ***more energy-efficient:***

- Where heat is recovered from the vapour boiled off the pan for other low-grade heating purposes, the energy used is only the small difference in enthalpy between the jigger vapour and the pan vapour
- Unlike mechanical stirrers, jiggers can be shut off during boiling stages when supplementary agitation is not required.
- If calandria incondensible gases are used as the jigger medium, the energy loss is nil.

In C-pans the volume of incondensibles normally vented is less than that required for jigger purposes. The energy dissipated through the additional steam in C-pan jiggers is equivalent to about 0.25 kW/m^3 of pan capacity.

Keywords: Pan boiling, pan stirrers, jigger steam, incondensible gases.

Top

Energetics of satellite processing to syrup - Tableland experience

D. B. Batstone
Venace Pty Ltd, Australia

Tableland Mill commenced crushing in 1998. Current crushing rate is 200 t cane/h producing on average 40 t/h of syrup at 68 Bx. Syrup is railed to the coast for processing to raw sugar in three old-established mills. The decision to partially process cane to syrup was made to reduce the investment in a new factory in a new cane growing area - not to conserve energy. Prices for electricity generated from bagasse have improved substantially in the four years of operation. In hindsight, the Tableland and the host mills should have been reconfigured to be more energy efficient. Currently about half the generated power of 7 MW is exported from the syrup mill which has a 20 bar.abs steam pressure boiler that consumes nearly all the bagasse that is produced. The host factories are in a very wet area. Bagasse storage is problematic due to excessive storm water run off. At times, the host mills have struggled to secure enough fuel to process the extra syrup.

Lessons from the Tableland experience are discussed. The new mill has clearly demonstrated exceptional shaft-energy efficiencies with a single turbine coupled to an alternator, electric drives and low-energy consuming two-roll mills. Steam consumption for processing was not minimised in the original design. As capacity has been increased (faster than originally planned), a Balcke Durr falling film evaporator was installed. This is the first of its type in Queensland. Scaling rates and cleaning regimes have been investigated.

Tableland experience has highlighted the importance of bagasse as an energy source. Syrup processing is limited without changes to reduce steam consumption. Possible strategies to extend satellite processing by more efficient energy production and use are discussed.

Keywords: cogeneration, renewable, electricity, falling-film, evaporator.

Top

Innovative technology for condensing and cooling system

B. B. Paul
B. B. Consulting 'N' Engineering Pvt. Ltd, India

At present, the sugar industry utilises the maximum electrical power consumption for condensing vapour to create vacuum at the evaporator station and vacuum pans. Further, the hot water from the condensers is cooled down through a cooling tower/spray pond which requires extra power due to the high pump head. The author has developed an innovative technology for condensing and cooling which not only simplifies the operations but also reduces the power consumption by 40 % and reduces the capital cost. A higher vacuum of 67 cm Hg is achieved by condensation of vapour under isothermal conditions and drastically reduces the power consumption. Vapour phase at the entry point of multijet stainless steel condenser is accelerated to overcome inertial expansion. Accurate piping design and pump selection both reduce energy consumption.

Similarly, the innovative design of the spray pond cluster keeps the relative humidity well below the saturation humidity and achieves a minimum temperature drop of 12 °C. The design of the nozzles provides a downward parabolic projectile path which increases the contact time compared with vertical projection. The nozzles are made of stainless steel to eliminate maintenance and replacement. Since the pump head is reduced, the power requirement is also reduced considerably.

Keywords: Condensation, isothermal conditions, spray pond cluster, parabolic projectile path

Top

Energy efficiency in vacuum system and waste heat utilisation

Vivek Verma
Spray Engineering Devices, India

Direct contact spray and jet condensers are steadily replacing shower type condenser with vacuum pump in India. Electrical power required for additional water pressure in jet condenser is proving to be less than vacuum pump's power requirement. Vacuum and water control is easy with introduction of nozzle governing systems. These condensers are equally suitable for high vacuum applications requiring close approach temperature with minimum power. Isothermal Compression of entrained Non Condensable Gases in the tailpipe is more efficient in Jet Condensers. During the compression the water vapour in the gas mixture are simply

condensed in the tailpipe instead of getting compressed.

Jet Condensers can easily be adapted for direct contact heating of juice, syrup, molasses or melt. Mild dilution of direct contact heating is easily offset by utilization of vapours of much lower temperature than required for such heating and conditioning indirectly. Another advantage is simultaneous non-condensable gas removal and condensate recovery. These condensers have no moving parts and maintain same temperatures easily.

Keywords: Jet condensers, rain condensers, vacuum pumps, melt conditioning and heating, direct contact juice heating.

Top

Operation parameters for batch and continuous centrifugals

R. Hempelmann
BMA AG, Germany

Operation parameters for batch and continuous centrifugals are mainly set to reach the maximum capacity. With regard to energy management in the sugar boiling house, the sugar quality of all products has an influence on the total balance of the sugar house especially, on the quality of the final product.

The operation parameters considering the quality of the different sugars will be discussed as well as their influence on the mass and energy balance.

Top

Energy savings with new dryer/cooler concept

U. Schwanke
Braunschweigische Maschinenbauanstalt AG, Germany

Most conventional sugar drying and cooling technologies are based on the rotary principle. An essential advantage of these machines is their simple and study design, and they are regarded as relatively unsusceptible to sudden changes in sugar moistures and sugar quality. Their disadvantages are the comparatively high material and maintenance requirements. Technologically, most rotary machines produce very good drying results, but have an inferior cooling efficiency which leads to a higher energy consumption.

In the 1990s, dryer/coolers and coolers only practising the alternative fluidized-bed technology have become more and more successful. The stationary (non-vibrating bed) units were especially convincing by their light-weight design, their considerably reduced maintenance requirements and their excellent cooling efficiency. The only disadvantage observed by some operators is the somewhat higher susceptibility, especially of combined dryer/cooler units, to sudden occurrences of high sugar moistures or poor sugar quality.

One version which integrates the advantages of the technologies described above is the combination of a rotary dryer and a downstream fluidized-bed cooler, which results in a reduced energy consumption for the drying and cooling of sugar. This reduction is significant if the latest developments for the fluidized-bed cooler are applied.

These latest developments are aimed at reducing the screen bottom surface in fluidized-bed coolers by providing, within the area of the fluid bed proper, additional water-cooled heat exchangers, which dissipate much of the sugar's heat from the cooling water and substantially reducing the air requirements. This in turn allows air-carrying components, including the dust separating system, to be considerably reduced in size. This effect may even be enhanced by adding the heated cooler exhaust air to the drying air required for the rotary dryer and thus using it twice.

Top

Session D - Energy conservation in refineries

The Energy Management Experience

A. S Vawda
Al Khaleej Sugar LLC, Dubai, United Arab Emirates.

Al Khaleej Sugar is a standalone cane sugar refinery located in Dubai. The factory generates steam and most of its electrical power requirement from burning petroleum fuel oil, with a small portion of its electricity purchased from the local utility provider. Energy is one of the refinery's major cost components. The efficient use of steam is paramount to the profitability of the company. The refinery has undergone significant changes since its inception in 1995.

Since commissioning, the energy balance has been constantly scrutinised, and the principles of pinch technology rigorously applied. The results of the many changes have been positive and were mainly due to the following steps: -

1. Conversion to higher-pressure evaporation.
2. Use of low-pressure vapour for heating purposes.
3. Reduction of electricity consumption.
4. On site generation of electricity.
5. Maximum recovery of condensate for steam generation

Keywords: sugar refinery, steam, Al Khaleej Sugar, evaporation

Top

Steam economy in boiling house - plantation white sugar

Mangal Singh
Triveni Engineering & Industries Ltd, India

The key areas and conditions that determine the use of low pressure exhaust steam in the boiling house of plantation white sugar plants are:

a. The level of maceration and the temperature of maceration water used.

b. The quantity of water applied for the desugarisation of the filter cake.

c. The evaporation required for the concentration of clear juice to syrup (58 - 60° Bx), and the evaporator system design.

d. The requirement of steam or vapour for heating of the juice in various stages.

e. The boiling scheme adopted for the quality (grain size & colour) of the sugar desired and the exhaustion of the molasses.

f. Steam or vapour required for uses such as washing of pans, conditioning of molasses, melting of sulphur and superheating of water for washing of A massecuite sugar in centrifugals.

Measures of economy of steam comprise of the organization of multiple effect evaporator configurations with the introduction of multi point bleeding of vapours, the introduction of continuous vacuum pans in place of batch pans, recovery of flash heat and vapors, recovery of exhaust and live steam line condensates from drains, and the replacement of steam used for superheating the water for washing of the sugar in machines by semi-kestner condensates etc.

A case study of 11 000 TCD plantation white sugar plant, using double sulphitation process to produce bold grain white sugar of 75 - 100 I.U and exhaust molasses of 27 - 30 pol purity has been presented. The factory has adopted a four - boiling scheme with the evaporator station having double effect vapour cells followed by quadruple effect.

The impact of various measures for economy of steam have indicated reduction in the consumption of steam to the extent of 6% on cane. The use of continuous vacuum pan is identified as the main contributor to economy. Further potential is indicated in the change of quadruple effect to quintuple effect evaporators.

Top

Centrifugal and pan yields - their impact on process steam consumption

P. Thompson
Sugar Knowledge International Ltd. (SKIL)

It has been suggested that the theoretical steam consumption for a refinery is 0.33 t steam per t of sugar, assuming 75 brix feed to the pans. This presentation challenges that assumption by considering the real limits to crystal content in the vacuum pans and the impact of wash water addition and dissolution in centrifugals.

Practical pan yields should be over 55% crystal % massecuite and tend to be limited by physical constraints in high purity massecuite. The yield or crystal recovery of modern batch centrifugals should easily exceed 90% giving an overall yield of white sugar in excess of
50 % on massecuite.

In practice we see overall yields as low as 25% and the reasons for this are examined.

Finally the "target" steam consumption for a refinery white sugar boiling scheme is proposed based on achievable practical constraints. This provides a benchmark for comparison with current performance and with new designs.

Keywords: sugar, refinery, energy, crystal content, benchmark

Top

Nordzucker experience with sugar boiling schemes and energy savings

Sven Buhrmann
Nordzucker AG, Germany

The well-known conventional three product scheme with white run-off is presented. With this mode of operation the white run-off has been boiled again on the respective pan feed. The steam demand for the sugar house amounts with this mode of operation to 11 % to 12 % o. b. The centrifugal yield is at approximately 42 - 46 %. In the last years the mode of operation in the sugar houses was modified as follows: The footing work (seed magma scheme) has been introduced. This leads to a closer particle size distribution and a smaller proportion of conglomerates. Furthermore we started to work with wash-syrup. The white run-off is not taken back to the respective pan feed solution and boiled, but as washing medium re-circulated at each centrifuge stage, replacing the part that is added via wash water in the cycle. This reduces the viscosity of the massecuite sticking to the crystal, so that a higher centrifuge yield of 46 to 50 % is reached with less wash-water and the respective lower melting of already crystallised sugar. The steam requirement is much lower with 9 to 10 % o. b..

Top

Session E - Improvement of efficiency of boiler plant and turbo generator

Increased power output from sugar cane biomass using newly developed gasification technology demonstrated in project ARBRE, UK.

M. Morris and L. Waldheim
TPS Termiska Processer AB, Sweden

A huge potential for power generation from waste fuels exists within the sugar cane industry. 1 200 million tonnes of sugar cane is harvested annually, the resulting wastes (bagasse, trash) corresponding to a worldwide electricity production potential estimated at 40 000 MW or 300 TWh/annum in the eighty countries of the world where sugar cane is grown on a significant basis. Newly developed gasification technology, utilising combined gas and steam turbine cycles opens the way to fully exploit this potential, yielding more kWh's of electric power per tonne of cane than even advanced boiler technology.

A state-of-the-art wood-fuelled gasification combined cycle plant of a capacity of 8 MW, Project ARBRE, has been constructed at Eggborough, North Yorkshire, UK. The plant, which is the first of its kind, contains an atmospheric pressure circulating fluidised bed gasifier coupled to a tar-cracking vessel. After cooling and cleaning in conventional equipment, the energy-rich gas is compressed and fired in a modified gas turbine. The plant is now being commissioned.

Development work for Project ARBRE and also for other fuels has been carried out in a 2 MW thermal gasification pilot plant. Similar tests on bagasse and sugar cane trash have shown that these potential fuels can be used as feedstock for the gasification process. On the basis of these tests, conceptual engineering and costing of a bagasse- and cane trash-fuelled combined cycle power plant integrated into a typical sugar mill in Brazil was performed.

This presentation describes the Project ARBRE from its early conception through to the commissioning of the plant. It also describes in detail the technology employed and the knowledge gained in the design and operation of Project ARBRE, as well as that generated by on-going development work on gasification of other non-woody biomass fuels, in particular, bagasse and sugar cane trash. The paper concludes with a description of the conceptual engineering of a similar gasification system integrated into a sugar mill in Brazil, and the costing of a large-scale demonstration plant.

Top

BIG/GT technology integration with a typical Brazilian Sugar Cane mill

M. Regis L. V. Leal and H. M. Lamonica
Copersucar Technology Center, Brazil

Copersucar Technology Center (CTC) has started to analyze the alternatives of BIG/GT - mill integration based on the BIG/GT data provided by Termiska Processer AB (TPS), that has been produced the laboratory gasification tests of sugarcane bagasse and trash.

To organize this evaluation some basic assumptions were made:

- BIG/GT plant: based in GE LM-2500 gas turbine.
- Heat recovery steam generator (HRSG) pressure/temperature (bar/°C): 82/480, 22/300 and 2.5/saturated.
- Initial mill process steam consumption levels (kg steam/ton cane): 500 kg/tc.

The use of BIG/GT technology (combined cycle) in cogeneration mode requires a lower heat to power ratio than the conventional Rankine cycle; therefore it is necessary to reduce the mill steam consumption to adequate it to the new levels of power generation and fuel availability. To accomplish this with a minimum investment cost, two steam consumption levels have been established trying to use to existing equipment drives as much as possible:

1. Replace auxiliary equipment steam turbine drives by electric motors (feed water pumps, exhaust fan, etc...)
2. Besides the changes in 1 above, replace the knife and shredder steam turbines by electric motors.

In alternatives 1 and 2 the live steam consumption levels resulted in values around 340 kg/tc and 280 kg/tc, respectively. Now, the process steam consumption have to be reduced also to those values to maintain the appropriate balance between high pressure and low pressure steam.

Partial integration - process steam consumption reduction to 340 kg steam/t cane, the following basic modifications are required:

- Vapor bleeding from 1st, 2nd and 3rd effects for juice heating.
- Regenerative heat exchangers for juice/vinasse and juice/juice.
- Mechanical stirrers for vacuum pans.
- 2nd stage vapor bleeding for vacuum pans.

- Flegstil technology and molecular sieves in the distillery.

Full integration - process steam consumption reduction to 280 kg steam/t cane, the additional following modifications are required:

- Vapor bleeding from the 4th effect for juice heating.
- Add one more set of juice heaters.
- Vapor bleeding from the 5th effect for the vacuum pans.
- Falling film evaporators (5th effect).

Keywords: combined cycle, cogeneration, efficiency, renewable, electricity

Top

The problem of small turbines

P. Thompson
Sugar Knowledge International Ltd. (SKIL)

Cogeneration projects are often hampered by the high steam consumption of existing prime mover turbines which reduce the steam available for the condensing cogeneration turbine. Electrification of these drive systems is the conventional solution to the problem.

A similar problem occurs in many mills where multiple back-pressure turbo-alternators are used in parallel with consequently high specific steam consumption.

This presentation looks at the power v/s steam relationships for steam turbines and examines the range of efficiency that is found in industrial machines. The impact of optimization and load balancing on the total system performance is explored.

It can be concluded that small or low efficiency turbines have no place in modern systems seeking to co-generate electricity for profitable sale.

Keywords: steam, efficiency, cogeneration, turbo-alternator

Top

Steam turbines (backpressure and extraction-condensing)

R. Schaer
Siemens Ag, Germany

The steam turbogenerator has been a traditional equipment in sugar factories, due to the ideal relation of thermal power consumption to electrical demand of this application. The generation concept of the sugar industry until recently had been to mainly produce enough electricity and thermal power to satisfy the demand of the factory and this only during the crop season. In the last years it has been noted that the sugar industry has recognized that through an improvement of the factory efficiency and a modernization of the power plant it is possible to export excess energy to the grid during the crop season and generate electricity throughout the year, obtaining in this way an important additional revenue for the sugar factory.

In this presentation the following topics will be presented:

- benefits of utilizing steam turbine generators
- the two main types of steam turbines for industrial purposes, which are backpressure and condensing turbines, stating the technical features as well as advantages and disadvantages of every turbine type.
- the extraction condensing turbine, which is a combination of a backpressure and a condensing turbine. This type of turbine has found a great interest in the sugar industry during the last years since it can supply steam and electricity during the crop and intercrop seasons.
- the Siemens building block system and turbine family · a few examples of steam turbines · steam turbines in the sugar factory

Top

Presentation of the gas turbine, waste heat boiler combined cycle from Klein Wanzleben sugar factory

Sven Buhrmann
Nordzucker AG, Germany

A steam generation plant with steam boiler and back-pressure turbine normally generates the electricity and process steam required in a sugar factory. In the German sugar factories, the specific power requirements have been reduced by about 2/3 in the past 50 years, while the consumption of electric power rose until 1970 and has since then remained at that level. As a consequence, the power factor S of sugar factories, which is the ratio between electric and thermal energy requirements, has doubled in the past 20 years. The countermeasure taken to maintain a balanced combined heat and power system was to raise the steam parameters. While in the 1970s, it was quite common to start from 40 bar and 400 °C superheat, the 1980s increasingly employed 60 bar steam boilers and new boiler plants designed for 80-100 bar and 525°C superheat in order to raise the power factor S. One of the aims in

planning the new factory at Klein Wanzleben was to tap new additional potentials of saving energy. The combined heat and power system used was hence to provide for constant electric power generation even if the process heat requirements decrease. A gas turbine power plant with supplementary firing system offers the required operational characteristics. The power plant at Klein Wanzleben was conceived as a combined system with gas turbine, waste heat boiler and steam turbine.

Top

Session F - Improvement of calorific value of bagasse

Calorific value of bagasse - an overview

L. Wong Sak Hoi
Mauritius Sugar Industry Research Institute, Mauritius

Fuel values of bagasse had been found as early as the 1920's to be influenced principally by the moisture it contains, and to a much lesser extent, by its soluble solids content (Pritzelwitz van der Horst, 1927, and Hessey, 1937). As cane harvesting operation became mechanized, the ash level in bagasse was found equally important as its moisture content in contributing to the lowering of its calorific value (Seip, 1976, and Don et al, 1977). Nowadays, mill run bagasse has a gross calorific value (GCV) of about 9 000 - 10 000 kJ/kg, and a net calorific value (NCV) of about 7 000 - 8 000 kJ/kg, as compared to a GCV value of 19 605 kJ/kg in bone-dry, ash-free and Brix-free bagasse. As cane pith has a lower fuel value than cane fibre, comparison of fuel values of bagasse from different cane varieties therefore has to be on comparable plant age, and on the same basis of moisture, ash and soluble solids content.

An improvement in the calorific value of bagasse can be achieved by reducing the ash content in cane through the supply of good quality cane and by reducing the moisture content of bagasse leaving the mills through the use of hot imbibition, pressure feeders, pressure chutes, and good mill settings. Due to the energy crisis in the 1970's, efforts have been concentrated in further reducing the moisture in bagasse by drying with waste heat from flue gases, with the advantages of increased boiler efficiency from about 65% to 70%, decreased stack particulate emission and bagasse saved for other uses.

Furines (1976) first reported the operation of an industrial bagasse dryer of rotary drum type using boiler stack gases. Since then, bagasse dryers mainly of the rotary drum and flash types have been installed over the world in America, Brazil, Philippines, Australia, China, Cuba and India. Arrascaeta and Friedman (1987) compiled data of 14 such dryers installed up to 1987 with details of feed capacity, input and output moisture and the temperature of the flue gas used. Reports of bagasse drying with varying degree of success followed (Maranhao, 1986, Dixon & Jorgensen, 1988, Wang et al, 1990, Kinoshita, 1991).

A drying process was patented in 1981, it involves flue gas drying of bagasse after its separation into coarse and fine particles. The former is shredded before mixing with the latter and extruded as pellets, which can be stored for year round use as boiler fuel (Bouvet and Suzor, 1980). Pilot pellet plants were installed in 1980's.

in Hawaii and Mauritius, but due to the high cost of maintenance, its production cost was uncompetitive compared to the price of fuel oil, and the plants ceased to operate.

Keywords: gross and net calorific values of bagasse, flue gas drying, rotary dryer, flash dryer.

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Top

Can bagasse be considered a reliable fuel in terms of calorific value per unit weight?

G. Maurel
Riche-en-Eau sugar mill, Mauritius

Six sugar mills in Mauritius rely only on cane bagasse to produce electricity for sale to the grid during the crushing season.

The power purchase agreement with the grid is based on the potential steam and electricity production per ton of cane crushed during the season which lasts from June to November.

Cogeneration data for Riche en Eau mill, show that under the conditions prevailing during the past five years, the energy export level is not uniformly proportional to the amount of cane crushed throughout the season.

Monthly average values of kWh per ton of cane and per ton of fibre show that the calorific value of bagasse also depends on the 'quality' of the fibre, which shows monthly variations.

Top

Improvement of the calorific value of bagasse using flue gas drying

M. Narendranath and G.V.S. Prasada Rao
The Andhra Sugars Ltd., India

The existing sugar surplus and an acute energy shortage in India have prompted the examination of co-generation possibility using available surplus bagasse, and ways of saving more bagasse for off-season co-generation.

Out of 20% condensation loss in the boiler efficiency, 14% of the loss is due to the moisture in bagasse, which is around 50%. Reducing the bagasse moisture would help to increase the calorific value of bagasse, resulting in an increase in the quantity of bagasse saved. This reduction in bagasse moisture could be achieved in two ways:

1. by mechanically increasing the pressure on the mill rollers.

2. by using various sources of energy and equipment to dry the bagasse.

An energy efficient way to reduce the bagasse moisture is to use the heat from the flue gas. Over the years, rotary dryers, flash dryers, swirl burner system and other means of drying bagasse were tried with varying degree of success.

After looking at the various options available, the Andhra Sugars Ltd. installed an induced draft flash dryer at the Sugar Unit - I during the 1999 / 2000 season and had achieved substantial bagasse moisture reduction, bagasse saving and an increase in boiler efficiency. Based on the data and experience gathered, a forced draft flash dryer was commissioned during the 2000/2001 season at the Sugar Unit - II. The operation of this dryer had been smooth since its commissioning and had resulted in substantial bagasse moisture reduction, bagasse saving and boiler efficiency increase.

The installation of bagasse dryers at the two Sugar Units resulted in bagasse saving that had enabled co-generation for four months during the off-season and increased the energy generated from 12.5 to 16.4 million units per year.

Top

Improving calorific value of bagasse through the implementation of modified Java method mill settings

T. Sumohandoyo
Indonesia

The "Java method" of mill settings was known since before the World War II and it experienced good results for mill performances.

To obtain good overall extraction several conditions are specified by the "Java method", e.g.:

1. Operate the mills at a very low rotation (2.5-1.5 rpm, gradually decreased from the ultimate to the ensuing mills).

2. The actual fibre loadings should be as low as possible (gradually increased to the ensuing mills)

3. The top roller lifts should be limited precisely as calculated.

Since steam turbines are now in common use as mill drives some of the terms are no longer valid, especially the term first mentioned above. With steam turbines the mill rotations will be higher and approximately the same throughout the tandem; and consequently also the fibre loadings.

When MILL MATERIAL BALANCE (MMB, the system created by the author) is used as base for the mill settings calculation, which modifies the method with the inclusion of the same average value of fibre loadings throughout the tandem; the main objective of the Java method could be achieved although steam turbines are used as the drives.

The said MMB calculation defined the flow of material (mass and volumes) to and from each of the mill in the tandem individually; therefore the result could be used as base and reference for individual setting of the mills.

Bases for calculation are quantity and quality of cane to be crushed, quantity of mixed juice and imbibition water, the dimensions of all the rollers in use, the average analysis of the extracted juices and the last mill bagasse analysis.

Numerous calculations are required to complete a comprehensive MMB, but with the use of a computer simulation it becomes simple and easy. Beside the extractions it could also simulate the last mill bagasse for low pol and low moisture content even when a higher imbibition rate is applied. This means an improvement of the net caloric value of bagasse as fuel for the boilers could be projected (von Pritzelwitz van der Horst formula: NCV = 4250 - 10 s - 48 w).

An example of last mill bagasse produced by a tandem of 5 mills with steam turbine drives is compared here.

Average bagasse analysis during previous campaign (mills were set without MMB):
pol = 2.08%
moisture = 50.23%
caloric value = 1818 kcal/kg.

Average bagasse analysis when mills were set based on MMB (next campaign):
pol = 1.16%
moisture = 48.30%
caloric value = 1920 kcal/kg.

It is concluded that with the proper mill settings based strictly on MMB (modified Java method) the caloric value of bagasse will certainly increase and the total bagasse consumed as fuel for the boilers for process requirement will be reduced and additional excess bagasse will be obtained that could be used for other purposes.

Keywords: Mill material balance

Top

Session G - Alternative boiler fuels

Alternative Fuels: an Overview

M. Inkson

There are two scenarios where an alternative fuel is relevant to the operation of a cane sugar factory: where the available fuel energy does not match demand and when one wants to export electricity to the grid.

As this workshop is all about improving the energy balance of the factory and generating for a heavy irrigation load, a township or a co-located industry can be treated as export co-generation, alternative fuels have no real role in a correctly operated factory unless it is co-generating for export. [We need to remember that when the factories were designed they were designed to be energy balanced.] The one exception to that rule is bagasse export but we can treat that too as a form of energy export.

The alternative fuels available at economic prices vary from location - although even an economically priced auxiliary fuel is not a guarantee of the wisdom of operating in export co-generation mode. There are two main groups : the fossil fuels and the 'renewable energy' fuels, many of which are derived as waste products from agro-industry, just as bagasse is. In today's environment the renewable fuels are receiving more of the focus.

The fossil fuels, coal, oil and gas are well defined and the problems of using them understood, although not necessarily by the sugar industry. Most of the difficulties seem to arise when trying to burn one or more of them in the same boiler as bagasse, particularly when trying to co-fire with bagasse.

Fibrous fuels - including cane trash - are much less well defined and are more variable than some of their fossil cousins. This is a topic which will be discussed a little later in the session.

In examining the alternative fuels with respect to energy management it is important to bear in mind what dictates the efficiency of the boiler. Boiler energy losses in the sugar industry are typically in the range of 30 to 40% but in the relevant sector - export co-generation - one expects to see this down at the lower end of the range if not below the range. The most significant contribution by far comes from stack losses and the characteristics of the auxiliary fuel will frequently dictate how much the design engineer can do to reduce these.

The next most significant factor in energy losses is the unburnt fuel, again something which is frequently dictated by the nature of the auxiliary fuel, particularly the solid fuels. However, the characteristics of the fuel also dictate many other aspects of boiler design and when considering efficiency in the export co-generation sector, reliability and maintenance requirements can be equally significant when the penalties associated with the typical Firm Power PPA are considered. Whether these factors are dictated by the bagasse or the auxiliary fuel depends on the selection of the auxiliary fuel.

One final point to bear in mind : an auxiliary fuel, even in the export co-generation sector, is not necessarily the correct solution. There are circumstances where building an export facility on bagasse alone or bagasse and trash makes sense although this too brings special problems.

Top

Cane field residues as boiler fuel

K. Deepchand
Mauritius Sugar Authority, Mauritius

Sugar cane biomass comprises of the cane stalk, the green tops and leaves, the dry trash and the underground rhizome with the roots. Of these various components, only the cane stalk is harvested for recovery of sugar. The other fractions, except for a minor amount of the green tops and leaves collected as fodder for ruminants, are normally left in the field. Although such fractions are associated with some agronomic benefits when left in the field, it is considered that there is a significant excess that can be diverted to other uses.

In Mauritius where electrical energy cogenerated from bagasse for export to the public grid is a commercially adopted option, the cane field residues constitute a complementary source of combustible for the boilers. This option has been the subject of studies and large scale industrial trials over the past decade or so. It is contemplated that these biomass fractions would constitute the next generation of combustible to be fed to the industrial units.

Results on industrial scale trials will be presented and will include issues such as the set-up for the preparation of feedstock, the ensuing particle size of the prepared material, its calorific value and the potential amount of electricity that may be exported on the basis of material and energy balances.

Top

Other fibrous fuels: the problems

M. Inkson

The sugar industry well understands the characteristics of bagasse as a fuel*. The same cannot be said for other fibrous fuels even though the ultimate analyses of many fibrous fuels are almost the same as that of bagasse.

There are many possible fibrous fuels available as auxillary fuel for a bagasse fired boiler but few of them are relevant to a particular project due to availability issues. Wood and wood waste are the most common and generally available throughout the world. Materials such as grain husks and/or stalks, vegetable oil processing wastes and similar agro-industrial by-products and wastes depend on the location. There are three key technical characteristics which have to be examined in deciding the suitability of these potential fuels and then in engineering the boiler to suit: the specific energy value, the ash chemistry and, finally, the mechanical handling properties.

Fibrous fuels are metered into boilers volumetrically [control is achieved by feedback from the steam pressure] because mass meters would be too expensive. The specific energy value which is of interest is therefore the volumetric one: MJ/m3. As soon as one examines the various fuels on an 'as fired' basis it becomes apparent that they differ markedly in their specific energy value, even if other characteristics are similar. It is therefore not appropriate to utilise a single fuel system for both fuels. Their mechanical handling properties also frequently dictate a separate fuel handling system.

The ash characteristics of the fuels are important because they determine the clinkering/slagging/fouling and erosion potentials of the fuels. Ash can, of course, be extraneous as well as inherent, as in the case of bagasse. There is also an added dimension of interactive chemistry if dual firing is being contemplated. A range of indices are available to assist in the prediction of combustion problems arising from the ash chemistry. Once these have been calculated a view can be taken on the risk and more thorough investigation undertaken if warranted. In general the nature of extraneous ash in bagasse means that the boiler will be engineered for an erosive gas flow. There is little action to be taken when burning other fibrous fuels. The exception is rice hulls which have an extremely high silica content and suffer from considerable carry-over of material into the convection bank.

*Characterizing Fuels For Biomass - Coal Fired Cogeneration

Magasiner, van Alphen, Inkson and Misplon: 75th Annual Congress of the S.A. Sugar Technologists Association, 2001

Top

Session H - Efficient utilisation of steam

Efficient utilization of Steam - Overview and Perspectives

P. Avram-Waganoff
IPRO Industrieprojekt GmbH

Efficient utilization of steam has always been a topic in the cane sugar industry. Even in the most primitive plants producing "gur" or "panela" the resulting bagasse is burnt and low pressure steam at around 7-8 bar is produced for concentrating the juice. An efficient gur plant will make do with the available bagasse and not consume additional firewood. This philosophy has also been generally followed over several centuries for the production of raw and plantation white sugars.

With the advent of refineries it became necessary to employ additional fuels (generally fuel oil or coal) in order to satisfy the additional process steam demand. In the face of rising fuel costs however, factories the world over have increasingly striven to reduce process energy consumption, i.e. use steam (and electrical power) more efficiently.

Since cogeneration has been proven to be a viable alternative in several countries (like Hawaii, Mauritius, Guatemala and Brasil) efforts have been made for reducing energy demand in all areas of the sugar factory in order to maximize the export of electricity. In countries where cogeneration is still not economically viable (or there are no alternative uses for excess bagasse) raw sugar factories typically have process steam demands in excess of 50% on cane.

By employing available technologies it is possible to reduce process steam demand to values at or even below 30 % on cane. Some advantageous technologies in this respect would be:

- Moving-bed cane diffusers instead of cane mills
- High pressure steam boilers (up to 85 bar, 525°C)
- Generation of electrical power in extraction-condensing turbogenerators
- Fully electrified factory drives with frequency converters
- Falling film evaporators and plate heat-exchangers allowing vapour bleeding from all effects
- Continuous vacuum pans for all products
- Seed magma produced in dedicated batch pans
- Continuous centrifugals except for first product

In order to illustrate the effects of incorporating all of these technologies a conceptual design of a 24.000 t/d cane sugar factory producing a superior type plantation white sugar and cogenerating at an annual rate of 112 kWh/t cane was performed. During the 150 day crop the factory will export 35 kWh/t cane (i.e. 126.000 MWh of electricity) saving approx. 45% of the available bagasse. This excess is baled and employed after the crop for firing the boilers and operating the turbogenerators totally in condensing mode. This way 77 kWh/t cane (i.e. 278.000 MWh) can be generated additionally, providing for year-round supply of electricity to the public grid. This will ensure better acceptance of cogeneration by the power distribution companies and result in economically viable price structures.

At current world market white sugar and molasses prices and assuming US$ 40 net revenue per MWh exported, the cogeneration of the above factory will add approx. 14 % to its annual revenue. In a number of cane sugar producing countries this could be an attractive proposition.

Base data, basic flow schematics, main results of the technological calculations, a general layout and cost estimates for the whole factory will be shown during the presentation.

Keywords: State-of-the-art technology, energy efficient layout, year-round electricity export.

Top

Implementation of a highly efficient evaporation scheme at Usina Barra Grande in order to increase its cogeneration capacity

J. G. Darcie
Zillo Lorenzetti, Brazil

In November 2001 Higher Management at Usina Barra Grande decided to significantly increase its cogenerating capacity. To reach this objective, a new 64 bar boiler operating at 520°C and a new extraction-condensing turbogenerator of 32 MW were purchased. Further, some turbine drives will be changed to electric motors and process steam consumption in the sugar factory will be substantially reduced.

These measures will be operational for next crop, starting in May 2003.

Optimization of process steam usage will be accomplished in particular by the following measures:

- step-wise heating of raw and clarified juice with vapours 1 to 5
- heating of sugar boiling pans with vapour 2
- rearranging the existing 5 lines of evaporators in order to allow parallel connection of vapours from all stages
- installing 4 new first bodies of the falling film plate (hybrid) type
- installing completely new heat exchangers of plate and platular type
- installing a C.I.P. system for evaporators and heaters to allow uninterrupted operation of the factory during the whole crop
- making maximum use of vapours from condensate flashing
- installing agitators in most vacuum pans

Top

How a 30% reduction in steam consumption was achieved at Harwood Mill

R. M. Dephoff
Harwood Mill, The NSW Sugar Milling Co-operative, Australia

Some 13 years ago, a sugar refinery was built adjacent to Harwood Mill drawing all power services including steam and electricity from the existing raw sugar mill. At the time of construction in 1989, the energy consumption of the raw mill was 1510 MJ/tonne (67% steam on cane) at a processing rate of 4500 tonnes of cane/day with a total cane crop of 540 000 tonnes. After commissioning the refinery steam consumption stabilized at 45 t/h. Since then the refinery production rate has been increased in conjunction with a reduction in steam consumption to 40 t/h. The additional boiler fuel required was sourced initially from coal and subsequently from woodwaste. The increased steam demand initially placed excessive load on the boiler resulting in some damage.

Harwood Mill was chosen as the site for the refinery because of the fibre content of its cane and the availability of spare steam generating capacity. Since 1989 the raw factory energy consumption has been steadily reduced to 1100 MJ/tonne (49% steam on cane) by implementing a number of strategies including evaporator re-configuration, the use of vapour bleeding for juice heating and some boiling of pans. These strategies significantly reduced the supplementary fuel consumption as well as reducing the excessive demand on the boiler. Implementation of further strategies planned for 2004 will reduce the specific raw mill energy consumption to 970 MJ/tonne (43% steam on cane). These strategies include the generation of significant amounts of electricity for sale.

The steam plant consists of a single boiler built in 1982 with a steaming capacity of 160 tonnes/h at 18.2 bar.abs and 254OC. It was designed to consume excess bagasse having a very large furnace and draft system, no economizer and a very small air heater. The maximum gross thermal efficiency of the boiler was, and still is 64%. Future strategies include the recovery of heat from boiler exhaust gas via a conventional economizer. In addition, investigations are being carried out into the feasibility of heating sugar juice using boiler gas exhausting from the economizer. The implementation of this latter strategy presents considerable technical difficulties but if solved, offers considerable energy savings. Specific energy consumptions of approximately 900 MJ/tonne (less than 40% steam on cane) appear possible.

The heat load of the sugar refinery is directly analogous to the heat load of a condensing steam turbine generator set. The strategies implemented to date at Harwood along with those planned for the future may be applicable to other organizations contemplating the generation of electricity for sale. These aspects are discussed.

Keywords: Heat recovery, woodwaste fuel, vapour bleeding, boiler efficiency, steam usage

Top

Energy conservation by efficient utilisation of steam and vapour

K. Mosich
GEA Ecoflex GmbH, Germany

Environmental implications, including air pollution, CO_2 emission and the protection of the forests are good reasons why bagasse should be used as raw material for electrical cogeneration, for paper, cellulose board, charcoal, furfural or cattle feed. Therefore, it is reasonable to reduce its combustion in the boiler as much as possible.

As there is no bagasse in the beet sugar industry, it has always been essential to save energy. The following points illustrate that plate heat exchangers in the cane sugar industry are specially suitable for saving energy by efficient utilisation of steam.

1. To increase heat economy the temperature in the extraction plant should be kept as low as possible. Instead of direct injection steam, juice heating by a plate heat exchanger should always be preferred since in that case, lower temperature steam can be utilized. Therefore, it is also reasonable to produce mixed juice as cold as possible which can then be heated up with a low quality vapour or, if the condenser loss is already at zero, with waste energy free of charge. Waste energy includes seal water from the condenser with a low temperature (approx. 45° C) but in high quantity, and condensate with higher temperature but lower in quantity.

   The raw juice should at first be heated up with seal water and then with condensate. Due to strict counter-flow the plate heat exchanger is especially suitable for liquid-liquid heat transfer and is able to heat up the juice to an approach temperature of 5° C to the warm water. It is therefore very reasonable and economical to keep the temperature of the seal water and the quantity of the condensate as high as possible. That means reduction of injection water in the condenser and collecting all condensate sources for heating, which reduces the load of the cooling tower or spray pond.

   Those sugar mills, which also produce alcohol have another good heating medium in vinasse! This hot vinasse is not only a good heating medium, it is also a good cleaning medium of raw juice heaters. When you change the sides of the plate heat exchanger after some days or weeks, you can go on heating continuously and clean the scaling by the raw juice at the same time.

   Like the back flush system, this is a very effective and often used cleaning method which does not interrupt the heating process. Whereas the backflush system only removes the fibres in the gap inlet, the vinasse cleans the whole surface like an acid.

2. When you have used all waste energy, sealwater, condensate and vinasse, then the juice must be heated up with vapour. The aim should be to use a low vapour in order to evaporate as much water as possible free of charge, and to keep the condenser loss as low as possible, which otherwise means a loss of steam. We all know that one ton of vapour going to the condenser involves a loss of one ton of fresh steam. Therefore, the temperature of the last stage of the evaporator station should be kept such that even the last vapour can be used for juice heating, as Wittwer and Avram recommended. A lower vapour has also the advantage that the danger of scaling can be reduced. Obviously, if we use exhaust steam directly, this will result in a high surface temperature and thus increased scaling and juice colouration. Despite high inert gas loads in the vapour, plate heat exchangers, in contrast to tube heat exchangers, are suited to heating up the juice economically to within 5° C of vapour temperature.

   In order to evaporate as much water as possible free of charge, the clear juice should be heated up stage by stage before coming to the evaporator station, i.e. before the first effect with first vapour, and as high as possible with turbine exhaust steam in order to increase the K-Value in the first effect and the temperature of first vapour by the flash effect. By this means, in the design of a new evaporator, heating surface, price and residence time in the first effect can be kept as low as possible, which is also most important to avoid sugar degradation and colour formation. On the other hand, the performance of an existing evaporator can also be improved, which may be the most important consideration.

3. Another important example of PHE use for efficient utilisation of steam is in heating of syrups in the sugar house with simultaneous dissolution of fine crystals. This requires heating-up to a temperature approximately 5° C lower than with injection steam (approx. 80° C due to the turbulence induced by the plate). The turbulence on the plate helps to dissolve the fine crystals; therefore, a lower vapour can be used. It also saves the injection steam twice, i.e. once in the syrup vessel and once in the boiling pan, where the condensed injection steam must be evaporated again. The dissolution of fine crystals with water in the boiling pan also requires a corresponding quantity of steam and increases the load on the pan unnecessarily.

4. Finally, molasses cooling should be mentioned. Mills in Australia are penalized if the molasses temperature exceeds 38° C at the customer. Therefore, molasses coolers have become essential in each factory. In this case again, plate heat exchangers have proved to be the best heat exchange units for liquid/liquid and steam/liquid duties (Quinian and Viana), especially if they must be made of stainless steel or even Titanium (sometimes necessary for molasses) because every surface in contact with the juice is made of stainless steel and only the frame is made of carbon steel.

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Top

Optimal utilisation of exhaust steam in boiling house

B. B. Paul
B. B. Consulting 'N' Engineering Pvt. Ltd, India

Most of the exhaust steam is utilised at the evaporator for juice boiling. Ever since the Robert type multiple effect evaporator was introduced in the sugar industry, the best combination was DEVC (Double Effect Vapour Cell) and Quad. Of late, long tube evaporators (rising film and falling film) have been in use, but both have their inbuilt deficiencies. The author has introduced a duplex evaporator to eliminate deficiencies of both types of pre-evaporators (long tube rising film and falling film). It gives the best result with respect to utilisation of heating surface and reduction of sugar loss in the evaporator station. The introduction of two-calandria system along with sweeping effect has resulted in conservation of thermal energy. The design of the duplex evaporator is such that the exhaust steam gets desuperheated in the body itself and the available latent heat is maximally utilised with a sweeping calandria. This presentation deals with the theoretical aspect of the design as well as the performance of the duplex evaporator for any conventional system design. A study has also been presented for a 6 500 TCD sugar plant.

Keywords: Duplex evaporator, dropwise condensation, sweeping calandria, thermal energy conservation

Top

Planning for the efficient use of process steam using software based on the Rillieux principles

R. Broadfoot
Sugar Research Institute, Mackay, Australia

For sugar factories undertaking large scale cogeneration of electricity, substantial reductions in the consumption of low pressure (process) steam in the raw sugar process stations will be sought in order to increase the revenue from export power. This paper describes the procedures and software which have been developed to estimate relatively quickly the low pressure steam consumption for nominated process configurations for juice heating, juice evaporation and pan stage operations. The Rillieux principles for steam consumption in multiple effect evaporation and energy conservation laws for estimating the steam/vapour consumption for juice heating and for estimating injection water consumption in barometric condensers are employed for the calculations.

The application spreadsheet is a useful tool to determine relatively quickly and accurately the low pressure steam consumption and injection water usage for a nominated plant configuration. Through successive applications of the software, suitable practical plant configurations for minimising low pressure steam consumption can be established. The most promising options can then be analysed in greater detail, using purpose built computer models, for planning the processing changes to raw sugar mill operations to suit integration with a cogeneration facility.

The Rillieux software has also been used by SRI in workshops for training sugar mill staff in the implications on process steam consumption through changing the configuration of the process operations of the factory.

Acknowledgments
The development of the spreadsheet program was funded by Stanwell Corporation Limited. This funding assistance and permission for the presentation of the paper by Stanwell Corporation Limited are appreciated.

Keywords: Steam consumption, energy efficiency, juice evaporators

Top

Pinch technology - optimising thermal energy networks

B. C. Schulze
Advanced Services & Engineering, Berlin, Germany

The term "Pinch Technology" was introduced by Linnhoff and Vredeveld to represent a new set of thermodynamically based methods that guarantee minimum energy levels in design of heat exchanger networks. This engineering tool was developed in the late 1970's while oil prices continued to climb, thus energy conservation remained the prime concern for many process industries.

The idea is to detect the maximum process to process heat recovery potential. The flow streams of a heat exchanger network are subdivided into those which are heated from a low to a higher temperature and those, which are cooled. The flow streams are drawn into a T-H-diagram, in which the specific heat capacities are considered. According to the second law of thermodynamics, heat energy can only flow from hot to cold. This prohibits a temperature crossover of the hot and cold stream profiles.

When a hot flow stream which has to be cooled is used to heat a cold flow stream, the hot stream can only be cooled to a certain approach temperature. This approach temperature is defined by the heat exchanger unit and is the minimum temperature difference in the stream temperature profiles. This temperature level is the "pinch condition" or the "pinch point". The pinch defines the minimum driving force allowed in the heat exchanger unit.

Pinch technology is used to compare energy costs with exchanger network capital costs, considering the pinch point. Developments of software programs have proved to be very useful in pinch analysis of complex industrial processes with speed and efficiency. In the beet sugar industry and lately also in the cane sugar industry, pinch technology is being adopted.

Keywords: heat recovery, composite curve, energy analysis

Top

Efficient utilization of steam by scale prevention and effective cleaning

H. Haucke
Keller & Bohacek GmbH & Co. KG, Germany

The performance of a factory with regard to the sugar quality, sugar recovery and energy consumption is significantly affected by the formation of scales in evaporators and heaters as well as by the success in cleaning the heat transfer surfaces during the campaign.

The author reports about the background for the application and performance of KEBO DS, a specific chemical formulation for the prevention of scales in the sugar industry. The product based on polyacrylic acids is also used in an increasing number of cane sugar factories. The total dosage of 15-25 ppm/t cane is distributed to the different effects according to the specific chemical, thermal and hydrodynamical conditions. Cleaning is also facilitated by the fact that the scales formed when applying KEBO DS are easy to remove.

The duration and performance of a chemical cleaning with caustic soda can be improved by the addition of KEBOPLEX SC, a formulation with wetting, complexing and dispersing properties. With a concentration of 12% caustic soda instead of >20% and 1,5% KEBOPLEX SC significant savings of NaOH can be achieved. A complete alkaline/acid cleaning procedure for carbon and stainless steel tubes is described.

The report is completed by tables indicating the heat transfer coefficients for different materials and scale thicknesses.

Top

Possible areas for increased electricity export in raw cane sugar factories

A. F. Lau, K. T. K. F. Kong Win Chang and L. Wong Sak Hoi
MSIRI, Réduit, Mauritius

Export of electricity by Mauritian sugar factories to the grid has gradually increased from 15 kWh/t cane in 1992 to reach 52 kWh/t cane in 2001. One factory exported 112 kWh/t cane with 80 bars condensing extraction generator set. Should all the factories reach this level of electricity export with this technology, Mauritius has the potential of exporting around 700 GWh of electricity annually to

the grid.

Various factors, such as bagasse moisture, fibre content, steam characteristics, process steam consumption, electricity needs of the factory, all have an impact on the net electricity export. Actual measurements and derived data are used to identify areas where there is most substantial energy saving thus enabling the maximum export of electricity.

Top

Session I - Efficient utilisation of electrical power

Efficient utilization of electrical power in sugar factory - an overview

S. Pusch
Siemens, Germany

The efficient use of electrical power in sugar factory depends on the right sizing of fans, pumps, motors etc specially for the design of new factories or for complete refurbishment.

Topics covered will be:

- HV: 6 or 10 kV supply voltage, single or double busbars, draw-out-type or fixed mounted switchgear; vacuum c.b. or SF_6-insulation
- LV : 400 or 690 V supply voltage, fuseless design, open or closed design
- Oil - or cast-resin transformers
- System perturbation by speed controlled drives
- Power factor improvement, conventional or electronic, with regard to speed controlled drives
- Large drives for mills, crushers, shredders . Communication with DCS
- Case study from executed plants for factories such as Uelzen 15.000 t/d (existing factory) and Könnern 6.500 t/d (new factory, started in 1993).

Top

he utilization of variable frequency drives at various stages of raw sugar manufacture to minimize overall power consumption of the factory

R. Rivalland
Union Saint Aubin Milling Co, Mauritius

With the greater awareness for power saving in raw sugar manufacture at a cogeneration factory exporting all its excess power to the national grid, a comprehensive power saving plan has been initiated at Union Saint Aubin sugar factory in Mauritius.

This plan has justified the gradual replacement of conventional variable speed electrical drives (such as slip couplings for carriers) and slip-ring motors and resistance banks on travelling cranes by variable frequency converters capable of delivering the necessary torque at start up.

Frequency converters have also been installed on juice, water and syrup pumps involved in level or flow control operations, eliminating at the same time costly regulating valves on such circuits.

Finally, frequency converters have also found a successful implementation in bagasse-fired boilers where they are now used for boiler drum water level control as well as induced draught fan speed control.

Significant annual energy savings up to 30% for boiler drum water level control, have been recorded since the implementation of this plan.

The major limiting factor with such installations is the reliability of the frequency converters electronic circuits cards, which require a number of (expensive) spare cards to be kept in stock.

Keywords: Raw sugar, frequency converters, power saving, process control, variable speed control, level control, flow control, Mauritius, Union Saint Aubin, cogeneration.

Top

Efficient utilization of electrical power

N. C. Msangi
Mtibwa Sugar Estates Ltd, Tanzania

The efficient utilization of electrical power in any enterprise, whether own generated or fed from a centralized grid, cannot be over-emphasized. Maximum benefits have to be reaped from the power consumed.

Several ways of achieving maximum benefits from the consumed electrical power are discussed with emphasis on two main steps which most electrical power consumers may easily apply:

- **Power factor control**
  The power factor, which is the ratio between the real or rather active power consumed and the total power or apparent power drawn from the source, needs to be controlled to as near as possible to unity (1.0).
- **Equipment loading**
  Equipment using electrical power has to be loaded to their maximum capacity. With this respect drives have to be proportional to their loads so as to minimize the unused installed power of the drives.

This presentation discusses the above topics with the aim of utilizing electrical power as efficiently as practically possible.

Top

Reduction of the electric energy consumption in a sugar factory

Siegfried Pusch
Siemens AG, Industrial Solutions and Services, I&S IT PS2, Germany

The reduction of the electric energy and with that a reduction of the costs for fuel of the sugar factory is becoming an important point for the economic work of a factory.

The main application of drives in the sugar industry is for pumps , to regulate the flow of juices instead of throttle flaps , which results in a significant energy saving .

As the sugar house needs approx. 25% of the total power consumption of a white-sugar beet factory and from the sugar house the centrifugal drives have a portion of approx. 40% , it is important , to optimize these drives .

Top

Reduction in thermal & electrical energy for sugar from sugar cane

B. B. Paul
B. B. Consulting 'N' Engineering Pvt. Ltd, India

The sugar industry is the only industry blesssed with captive regenerative fibre to meet its own energy demand for processing sugar cane to sugar. The optimal use of energy is the theme of the day. The cane sugar industry with its own captive fuel was not very concerned with the effective utilisation of energy to generate a surplus for other utilisations. In the present context newly developed technologies have proved very effective in releasing energy (thermal & electrical) and in saving utilities.

This presentation lists means and methods for achieving capacity and for release of energy and utilities in a non-conventional manner. The author has introduced an overall energy balance for the plant by introducing a duplex evaporator, vapour bleeding scheme, multijet condensers and spray pond cluster to reduce the power requirement. The author has tried to establish the use of by-product energy by optimising the thermal & electrical energy in the process. A 6500 TCD plant has been used to set an example for the optimisation of thermal & electrical energy.

Top

Power consumption of batch v/s continuous centrifugals

S. Jooriah, L .Wong Sak Hoi and K. T. K. F. Kong Win Chang
MSIRI, Réduit, Mauritius

The power consumption of batch and continuous A-centrifugals was compared. Results showed that the power drawn by continuous machines was low and did not vary appreciably, whereas with batch centrifugals, there were large variations over a centrifuging cycles (respectively between 0.5 - 0.6 compared to 1.2 - 3.1 kW h-1t-1 of massecuite). A batch centrifugal with pole changing circuitry requires higher power/tonne of massecuite compared to a batch machine driven by a variable speed drive, as the latter has greater regenerative capacity which considerably lowers the net energy imported from the grid. The electrical running costs increase progressively for continuous centrifugals, batch machines driven by inverter and batch machines with pole changing units.

Top

Monte Rosa Sugar Mill Cogeneration

C. R. Pérez Estrada
Pantaleon Sugar Holdings, Guatemala

Since 1998, Monte Rosa sugar mill is an operation owned by Pantaleon Sugar Holdings that has two other sugar mills in Guatemala. This presentation basically shows the results of last sugar crop (December 08 - June 02) at Monte Rosa, which is located in Chinandega Nicaragua.

This mill was modified from a conventional 3 500 short tons daily capacity sugar mill to an electrified 6 000 tons factory with sells electricity to the spot market in Nicaragua.

The expansion required the following changes in equipment:

- hydraulic and electrical drive for the mills
- electrical distribution in the factory
- new boiler and generator
- equipment to interconnect a 69 000 volts line from the mill to the national grid.

General information of the Nicaraguan electric market is presented.

Top

Cogeneration - additional profit for cane sugar factories

Rodolfo Schaer
Siemens AG, Germany

Sugarcane mills are a particularly interesting application for cogeneration, since bagasse is available at no cost as feedstock to fuel steam generators.

To date, sugarcane mills had however limited power and heat generation to only meeting their own demand, hence their existing energy potential had not been exhausted.

A number of countries have in the meantime recognised that bagasse can make a considerable contribution toward the substitution of non-renewable primary energy sources.

Here, reasonable remuneration for the surplus electricity fed into the grid is making it increasingly attractive to sugar producers to design their power generating facilities for higher capacities, in order to make more intensive use of the available bagasse.

Siemens has accumulated decades of experience with the operation of steam turbines in the sugar industry and is the world leader in automation systems tailored to the needs of this industry.

Since 1950, almost 500 turbines have been supplied to the sugar industry world-wide.

Beside hundreds of Back-pressure Turbo-Generator-Sets and beside the standard solutions for cogeneration with Extraction-Condensing Turbines or with topped straight Condensing Turbines, Siemens had successfully delivered the first and largest Extraction Back-pressure Turbine-Generator-Set with auxiliary condenser for non-crushing season operation, which nowadays is a successful money-maker.

For the Australian sugar industry it is the first Turbine Generator Set for off-season operation and to utilise the high pool prices during that period.

The supply of surplus electricity into the utility grid generates a remarkable additional revenue for that sugar mill.

The standard solution for the future however, has to fulfil its two requirements i.e.

- the supply of electricity and steam to the mill during the crushing season, and
- the generation of surplus electricity during the whole year in a more efficient way, as a back-pressure turbine with auxiliary condenser can do it.

Therefore extraction-condensing turbo-generator sets designed to fulfil both are required.

Top

Session J: New technologies/processes for energy economy

Overview : New technologies/processes for energy economy

Boris Morgenroth
IPRO Industrieprojekt GmbH, Braunschweig, Germany

The pressure to reduce investment and operating costs is a constant factor for the application of new and challenging technologies. Besides sugar, other "products" can become valuable for the sugar industry or have already done so.

The cane separation technology described by H. Bourzutschky offers a new approach for product diversification and energy economics by separating the sucrose rich core of the sugar cane from waxes and the cane stalk surface layer (rind). The concept is quite different from the conventional milling extraction and has also positive influence on the power demand for the extraction and subsequent processes.

Technologies that offer the potential to decrease the process steam demand of cane sugar factories like plate heater and falling film evaporator technologies as well as many others like full electrification are major steps to operate cane sugar factories with a steam demand of below 30 % on cane and have been already introduced in recent years. High pressure boilers combined with extraction and condensing turbines allow achieving specific power generation ratios of up to 120 kWh/t cane. The implementation of the gasifier technology (P. A. Hobson) is an important step to improve the power yield up to 300 kWh/t cane when applied in conjunction with combined gas and steam turbine cycles. Bagasse drying technologies offer the potential of increased boiler efficiency (B. Morgenroth).

The use of near Infrared spectroscopy (D. Mackintosh) is another measure to improve sugar mill and boiler plant management.

Keywords: near infrared spectroscopy, process steam reduction, gasification, cogeneration, cane separation

Top

Benchmarking analysis for maximum power generation of a cane sugar factory considering the latest state of technology and potential future development

Boris Morgenroth
IPRO Industrieprojekt GmbH, 38114 Braunschweig, Germany

Considering the "green energy" potential, just a few countries have identified bagasse as a source of electric power production until today and created the legislative and economic framework to make excess power production for cane sugar factories attractive. More than 1 Billion tons of cane are harvested annually. The average power production of cane mills lies in the range of 10 - 20 kWh/t cane and often only covers self consumption. The improvement of the process steam economy from present values of more than 50 % steam demand on cane (o.c.) to the range of 20 - 30 % o.c. offers the prospect to increase the power production significantly. Only a couple of cane sugar factories worldwide have achieved today a process steam demand of 30 - 35 % o.c. and there is still great potential in reduction of energy consumption. The implementation of high pressure boilers combined with backpressure-, extraction- or condensing-turbines are another prerequisite to improve the power generation. By decreasing the steam demand for the sugar process and implementing the above mentioned technologies some mills have already achieved specific power production ratios of 100 - 120 kWh/t cane.

Technologies used in other industries already, offer further potential for an increased power production. Flue gas and steam drying of bagasse helps to improve the boiler efficiency. Circulating fluidised bed gasifiers linked with combined gas and steam turbine cycles and modified waste heat recovery schemes offer a new approach. By combining these technologies a specific power production of 200 - 300 kWh/t cane corresponding to more than 200 TWh/a of "green energy" or 20 - 40.000 MW power generation capacity becomes achievable. There is no doubt, that there will be many challenges for adaption to the requirements of the cane sugar industry but it is only a matter of time when this will happen.

Keywords: steam reduction, cogeneration, benchmark analysis, green energy

Top

Near Infrared Spectroscopy as a Tool in Sugar Mill and Boiler Station Management

D. L. Mackintosh
Bureau of Sugar Experiment Stations Indooroopilly Q 4068, AUSTRALIA

The Bureau of Sugar Experiment Stations (BSES) in Queensland Australia has developed on line near infrared spectroscopic analytical systems for the sugar industry. The work has been taken to commercial reality in association with Foss Tecator marketing the Cane Analysis System (CAS) and Sugar Analysis System (SAS). Currently, installations are used in cane payment or cane quality monitoring in six Australian sugar mills and two in Fiji.

The presentation will deal briefly with the development and capability of the CAS and SAS systems and then report on very recent work where the system is shown capable of measurement of constituent parameters such as pol, moisture, ash in final and intermediate bagasse. The experimental work will be discussed leading to a strong relationship between constituent calibration equations developed for cane and bagasse to the extent of the data sets being a continuum.

Benefits are being found from the use of NIR in the mill and potentially the boiler station for more relevant process control operations based on a real time knowledge of the cane supply to the mill. This is enhancing mill efficiency, reducing variability in juice flows and allowing better steam management.

Keywords: cane and bagasse composition, real time process adjustment, smoothed process streams, enhanced extraction

Top

The development of bagasse gasification technology for increased cogenerationin the Australian cane sugar industry

P. A. Hobson[1], T. F. Dixon[1], C. Wheeler[2] and N. Lindsay[3]
[1] Sugar Research Institute, Mackay, Queensland, Australia
[2] Stanwell Corporation Ltd, Queensland
[3] Office of Energy, Queensland Treasury

Phase I of a major research, development and demonstration program at the Sugar Research Institute to develop advanced (gasification) cycles for increased power export from the cane sugar industry, has been completed. This first phase is aimed at providing the necessary technical and financial input required to progress the research program to the full prototype development and demonstration stage. The paper describes developments in five critical path components of the project. Progress in these five areas is summarised below.

Bagasse char gasification kinetics

An experimental facility has been constructed and used to determine initial char yields from bagasse and cane trash as well as the subsequent reactivity of the residual char with carbon dioxide and steam. Data of this nature is essential in the selection of the preferred gasification technology.

Bagasse feeder for pressurised gasification
A continuously feeding device for bagasse and blends including other biomass fuels has been developed at SRI. A test facility has been constructed and an extensive test program has demonstrated that sufficient driving force can be generated by the feeder device to deliver bagasse continuously across a pressure boundary up to 25 atmospheres with very low gas leakage rates.

Economic evaluation of bagasse gasification
A site-specific analysis has been carried out based on a factory currently under consideration for expansion in its cogeneration capabilities. In terms of the relative (financial) performance of steam and BIG/CC projects, the latter out-performs conventional steam technology for scenarios where the biomass fuel costs are relatively high (around A$ 2.5 per GJ).

Bagasse ash characterisation for gasification
A 50 mm diameter experimental reactor, internal components and support structure have been fabricated and await assembly and commissioning in the next stage of the project. Planning issues relating to the timing of construction and physical location of this facility are currently under review.

Development of a dry cane separation plant
The development of factory based cane separation technology is an essential hurdle to overcome in making large-scale recovery of cane harvest residues for fuel a viable operation in Australia. Construction and extensive testing of a 150 tonne/h-1 prototype cane separation plant have been successfully completed.

Key words: Kinetics, feeding, economics, ash, fuel

Top

Cane Separation A technology destined for integral sugar cane utilization

H. C. C. Bourzutschky
CBTC

More than 40 years ago the technique of splitting sugar cane stalks longitudinally and removing the interior pith cells developed, yielding in three basic components of the sugar cane stalk: pith, rind and dermax, the waxy outside layer of the cane stalk.

Years of engineering achieved the development of soundly functioning Cane Separator Machines, which are today available up to 2.000 t/d capacity.

Subsequent modifications of processing technologies or the selection of different technologies were required either for handling the juice extracted from the pith or utilizing the rind and removed dermax.

With regards to extracting juice from pith alone the quality and composition of this juice improved significantly from conventional mill/diffuser juices. Cane Separation could, therefore, also be considered as mechanical pre-clarification, achieving purity rises of more than 5 purity points before the actual clarification steps. Consequently clarification, concentration and crystallization change allowing the recovery of sucrose and invert sugar present in the juice as one (combined) product in a liquid or solid form.

Various options exist for utilizing the rind fraction as it is or after further extraction of the low quality juice from it. Direct use as fuel or compound utilization with a preceding pyrolytic process for charcoal and gas production, create an additional marketable product (charcoal) and the fuel source (gas) for the complete sugar and non-sugar process.

Extracted pith becomes available as a very clean product (originating from the cane interior only) and could ultimately become a source for human dietary fiber or is more conventionally usable as animal feed or fuel.

Yields in terms of total sugar recovery compare favorably with conventional operations, increasing the revenue potential of sugar cane from different marketable products beyond revenue from sugar alone. Ultimately food and non-food products are available.

Direct processing, utilization of modern processing technologies, simple and straight-line operations reduce energy demands to the 30%-range, which is the reason for the availability of raw material for additional commercial products.

Keywords: processing technology cane, by-products, energy savings, sucrose/invert sugar co-crystallized, dietary fiber, organic sugar/products

Top

Session K - New equipment/control technology

New equipment and control technology - an introduction into the topic

Bernd Langhans
Siemens AG, Erlangen, CoC Sugar

The session K "New equipment / Control technology" will lead us into world which can already be seen in some plants all over the world but have so far not found their way into most cane sugar factories with the exception of some recently built and modern refineries.

To look over the fence, to have a vision of what will be available tomorrow for the use in your own factory is one of the key aspects of this ISSCT workshop.

Doing so, with the background knowledge that these ideas have already been proven to be applicable in the industry will give you the assurance that we will not only hear of "White elephants" but to hear from excerpts of the real world.

Without the increasingly fast development of control technology the sugar industry will not be able to face the rough sees of international markets for a long time to come. Either developing or a slow but definite death, these two paths are available.

Be it in the field of laboratory improvement in order to meet the high expectiations of the sugar buying corporations.

Be it the increasing need of organising and optimising the operation of the plant in view of energy balancing.

Be it the improvement of the existing instrumentation and control devices towards an integrated and fully automated plant.

All these aspects, to name just a few, should find their way into your personal vision for your plant in order to maintain a secure operation for the upcoming decades of global competitiveness.

Top

Status and future trends of process instrumentation, control and statistical process control principles

B. Langhans
Siemens AG, Erlangen, CoC Sugar

Instrumentation, and automation of cane or beet sugar factories will lead to a higher degree of efficiency and also toward a sophisticated control and operation strategy of these plants.

Instrumentation however is the basic investment on this track. From the beginning of instrumentation more then 50 years ago until today not too many major changes have found their way into the industry. Today however we see a brand new way of integration of this very initial and basic equipment into the next higher level of equipment, the automation level.

Especially the field bus technology is the key for this development; not only by reducing the amount of cable reducing but especial in integration of installation.

On the level of automation today we do see a second generation of integration. The once separated binary control units PLCs are being combined with the highly sophisticated DCS units. Thus allowing for a plant wide concept based on low cost standardised hardware and highly efficient software modules which will allow for an extension of the control philosophy into the management and execution level of the plant.

In parallel it becomes possible to use advanced control strategies with these high end control systems which were never thought of several years ago. Fuzzy control, Neuro Fuzzy algorithms and so called "statistical process control" procedures find their way into the operation of the sugar factory.

The outlook is bright for the plant operation in view of the increasing efficiency demands for sugar factories all over the world.

Top

Viscosity as a measurement and control parameter for sugar boiling

O. Tzschätzsch, R. Schick and L.-G. Fleischer
Technische Universität Berlin, Berlin Sugar Institute, Germany

Sugar boiling is a central issue in sugar processing in terms of energy economy and product quality. Thus process control is of major importance. The search for suitable physical parameters to control the boiling process has led to numerous measurement methods.

The Marimex ViscoScopeâ torsional in-line viscometer appears to be a reliable alternative to established systems.

Technical sucrose solutions show a clear relation between the viscosity, the dry substance content, the temperature and the purity. An accurate measurement of the viscosity and temperature in concentrated sucrose solutions together with suitable evaluation technology allows the output of the dry substance content and/or the supersaturation. The applications include the thickening and seeding control steps in batch pan boiling as well as thick juice brix control, melting stations or molasses.

In suspensions, the solid matter has an additional influence on the viscosity, which makes the viscosity an outstanding process parameter - in particular during the first part of the crystal growth process. This crystallisation step is characterised by the presence of a large number of small crystals with little overall surface area. For economic and qualitative reasons, the supersaturation during this process step should neither be too small (dissolution of previously added crystals) nor should a critical value be exceeded (formation of fine secondary crystals) - both resulting in deviations from the desired product crystal size.

The physical parameters "suspension viscosity" and "total dry substance" are compared with respect to their ability to control the supersaturation after seeding within the technological appropriate bounds. It could be shown that the viscosity is more suitable to meet these requirements. The viscosity is also optimal for indicating the end of the boiling process, making it the long desired instrument capable of controlling the entire boiling process.

Keywords: Rheology, dry substance measurement, supersaturation, seeding

Top

Modern process and lab control as a tool for improved energy management

Mathis Kuchejda
Schmidt & Haensch, Berlin, Germany

The sharp distinction between Laboratory Analysis and process control is gradually disappearing. Modern sugar factories built their lab facilities virtually back to back to the process control room. One reason is that lab results as well as communication between these two entities need to grow together in order to produce better results.

One goal is the "real time " availability of lab data's to the process control in order to intervene in the online control of the sugar manufacturing process. Modern tools of software to organise the data acquisition in the lab need well defined measuring points.

The results are linked to the process monitoring system making the interpretation of lab results to the process control much more efficient.

The continuous monitoring of alkalinity, carbonation and liming for the juice purification as an example to reduce the amount of limestone consumption by up to 30 % is achieved by using "laboratory automates "which work man less around the clock.

Other online monitoring devices measuring Pol in waste water lead to a reduction of losses, and the reduction of waste water treatment.

Tools to better distinguish the sugar house products "on-line" reduce the risk of wrong storage or a better discrimination of sugar qualities.

Modern tools to monitor the quality of sugar versus losses through waste will lead to a reduction of energy and resources consumed in the sugar production opening the opportunity to produce excess energy for outside use.

Top

Laboratory automation - a proven way to better process management and higher sugar yield

W. Kernchen
Dr. Wolfgang Kernchen GmbH, Germany

Crystallising most of the sugar received with the cane, and keeping sugar losses in byproducts and undetermined losses at the lowest possible level should be the main objective of every sugar factory. Good process management based on chemical process control by a well equipped laboratory is a proven way to better sugar sugar yield and higher factory profits. The necessary investment in an automated laboratory system for tight process control is usually returned within a short time, i.e. in less than one season.

Requirements for a satisfactory sugar yield are Pol, Brix and Purity determinations through all stages of sugar production. For good statistical relevance, such control should be based on a sufficient number of samples representing the actual state of the process, and analysed without much delay. These requirements deserve for an automated system that is capable of analysing dark coloured samples on Polarization and Dry Substance (Brix) without tedious clarification by lead subacetate or alternative clarifiers. Further, the system should include equipment for analysing samples on pH, conductivity ash, solution colour, etc.

The ECO SUCROLYSER automated laboratory system offers all these features. The system is PC operated, and a flexible SUGARLAB software program permits easy configuration to international or local analytical methods. The operation is menu-guided, easy to handle, and does not require skilled laboratory staff. Avoiding poisonous clarifier protects health and contributes to good ecology.

Keywords: Laboratory automation, good process management, reduction of losses, environment protection

Top

Energy Management Systems - online tools for operating personnel

B. C. Schulze
Advanced Services & Engineering, Berlin, Germany

Process Control Systems and Laboratory Data Systems are more and more standard in the sugar industry. Combining the information, given by process data from the control system and analytical data from the laboratory, sugar technologists are able to locate and solve problems which arise during the operation of a sugar mill.

It is desirable to have an online tool, which combines the given information and monitors the technological process. This would allow the operating personnel to be informed at any time about problems that already occurred or which soon will have an influence on the factory performance.

Consequently, a process management system is the next step to be in factory control technology. An interesting field to implement such a software system is the thermal energy network of a sugar factory. The Energy Management System is an online tool which permanently calculates the thermodynamic performance of the sugar factory. It falls back on the measured thermodynamic data from the process control system and the analytical values, measured in the laboratory and filed in the local laboratory information system. If a problem occurs, which has an influence on the energy consumption, some data will be outside a given range. For example this can be a temperature or a pressure difference, decreased or increased by fouling of heat exchanger or evaporator surfaces. The Energy Management System locates the problem, due to fixed set-points for analytical and thermodynamic values within the process.

With this flexible online tool, the factory process is permanently monitored by an early warning system. Any occurring bottleneck within the process, that already has an influence on the energy consumption or soon will generate a higher primary energy demand, is located and the operational personnel is informed about the value, which is out of range and the reason for its deviation from the set-point.

Keywords: control technology, process management, online control, process control

Top

Advanced monitoring systems for process control

by Boris Morgenroth
IPRO Industrieprojekt GmbH, Braunschweig, Germany

The first simple automation systems were established in the sugar industry around the year ~ 1963. Process control systems started to be implemented in ~ 1978 followed by process and laboratory information systems around 1990. All these systems have been developed further to a high standard today. They offer the advantage of a tremendous decrease in labour costs and an improved factory operation.

Anyhow, until today there are no real online monitoring systems available that are capable to show the total mass and energy balance of a sugar factory. It will be the challenge of the next years to develop these systems. These systems shall not only offer the possibility to countercheck on-line data measured with various instruments in the process but also to obtain direct information about energy and auxiliary materials flows.

A principal demand here is, that these systems are easy to handle and based on standard modules that can be easily modified by factory personnel. Data from the processing stations as well as the laboratory information system - as far as established - has to be automatically imported into the monitoring system. This raw data has to be processed in a calculation module, that is easy to handle and based on visual objects. Excel programs or specifically programmed tools are often too complicated in handling or there is a reliance on the manufacturer. While there are many tools available for data management and exchange there is currently only the program SUGARS on the market that allows portraying the main sugar process stations with all its special sub processes in a simple way. The sugar processing scheme for extraction, juice purification, evaporation and crystallization is fully visualized with SUGARS and all process stations can be easily modified in order to show a particular factory.

By linking the process data with the SUGARS module and visualizing the calculation results in a proper way, the technologist achieves a complete overview about the process including mass, energy and colour balance as well as auxiliary materials. Much more information - especially concerning process optimization measures - is available compared to what is offered by processing systems currently operated today. This development step opens also the prospect for the implementation of expert systems that offer further advanced control possibilities.

Keywords: process control, process monitoring systems, expert systems

Top

Session L - Energy-efficiency index for sugar factories

Improvements in Guatemala cogeneration to increase electrical output

M. M. Rodriguez and L. Verdugo
Consultores de Ingenios Azucareros, Guatemala

The cogeneration process in Guatemala started in 1992 in a step by step basis with improvements each year by replacing first existing low pressure boilers with larger and more efficient units. During that period we replaced also, older 1.40 bars back-pressure turbogenerators with steam rate near 18 Kg/KW to second hand units with efficiencies between 8.25 and 10 Kg/KW.

Further, steam consumption in the process was lowered below 400 Kg/Metric Ton (40%) to produce raw sugar and below 450 Kg/Metric Ton (45%) to produce around 50% raw sugar, 33% refined sugar and complement as plantation white sugar. Six sugar mills installed Annex Independent Power Plants (AIPP), burning the surplus bagasse obtained from this lower process consumption, two of them working at steam conditions of 42.5 bars - 440 ºC and four at 60 bars - 485 ºC with boilers and condensing type turbogenerators.

All cogeneration plants with AIPP working at 60 bars - 485 ºC, since last year are developing plans to improve cogeneration output over 50 KW./Metric Ton. This paper gives a broad overview of steps, conditions and installation description to reach this electrical output in Guatemala power cogeneration.