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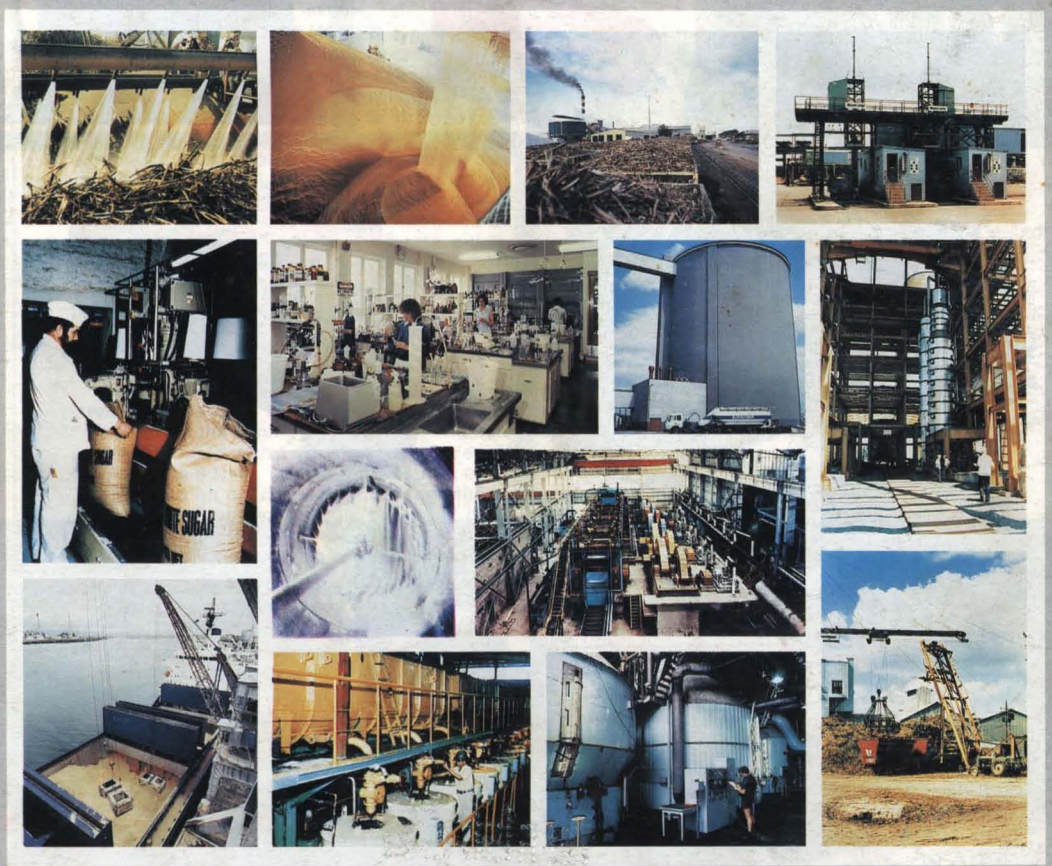

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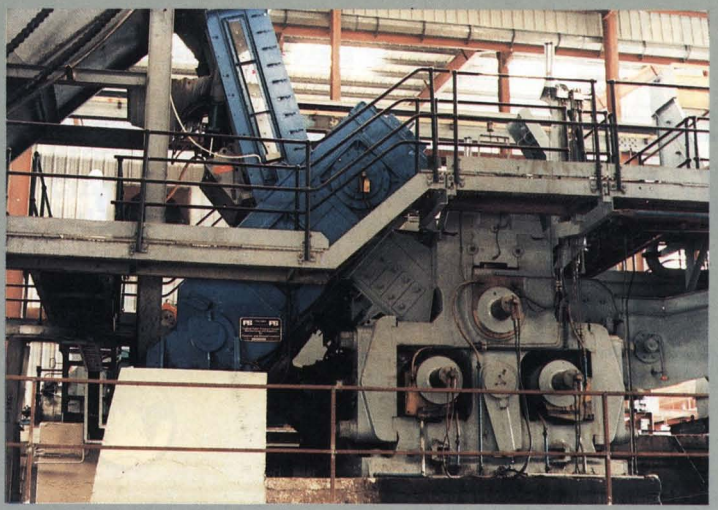

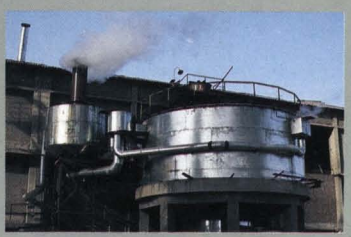

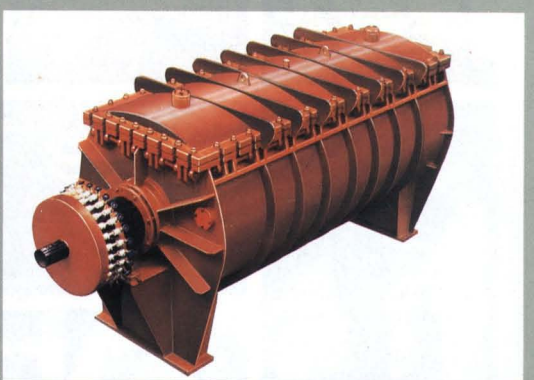

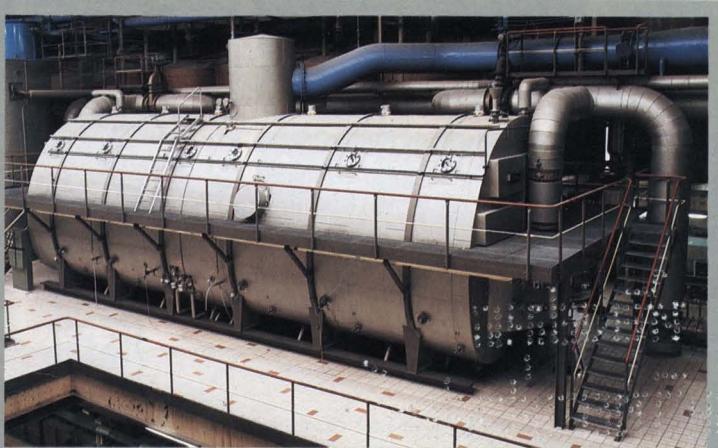

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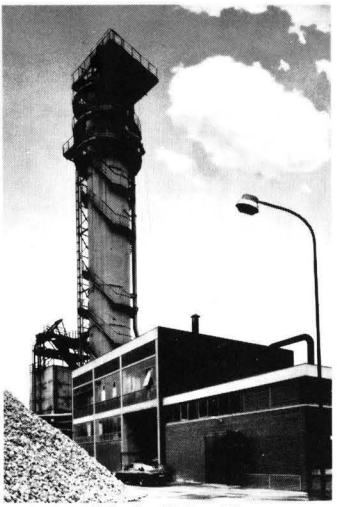

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News and views

World sugar prices

Towards the end of September the slide in the London Daily Price for raw sugar was halted, following a large purchase by a broker rumoured to be for China. There was nothing in the freight market to support this supposition, however, and when it was then reported that the sugar would return to the world market the price slipped again. From $252.320, which it had reached by October 3, the first trading day of the month, it dropped to $247.60 on October 11. Confirmation was then received that at least 200,000 tonnes would be going to China, whereupon the market strengthened and the LDP rose to $265.60 by October 18, aided by additional white sugar buying by East Europe. Cold weather had been reported from the USSR and it has been known for purchases by other East European countries to reach the Soviet Union, when direct buying interest might have spurred increases in prices which would be unwelcome.

While there was little to promote higher prices during the remainder of the month, sentiment was positive, with expectation of purchases to come from the USSR and China and doubts about availabilities from a number of suppliers. As a consequence the LDP rose to $276.60 per tonne by October 27 before falling back to $273 on October 31.

White sugar values followed a similar pattern during the month, the LDP(W), at $254 on October 3, showing a small premium above the raw sugar price which increased when the purchases from East Europe were recorded. Towards the end of the month, however, the premium virtually disappeared and the LDP(W) ended the month only $3.00 higher than the LDP, at $276 per tonne.

World Association of Beet and Cane Growers

An Executive Board meeting of the Association was held in Guadalajara, Mexico, during October 24 - 25 and it was decided to urge members throughout the world to seize the opportunity of a better balance on world sugar markets to explore measures to stabilize prices and growers' incomes. Growers were very concerned about the damaging effects that the opening of the sugar sector completely to free market forces, nationally or internationally, would have on primary producers, the rural economy, and rural structures without necessarily any benefits being passed on to consumers.

One of the actions being promoted by growers is to introduce more flexibility into the sugar sector through diversification which would also have benefits for the environment and the development of the economy. Another action is to reduce production costs so as to limit the market penetration of substitute sweeteners, and to make more economical the use of beet and cane as a raw material in industry.

A third recommendation is to make an in-depth analysis of the new environment in which the sugar sector operates in order to understand better how to stabilize world sugar markets effectively. Of particular concern to beet and cane growers are the concentration of sweetener production in the hands of a few large multinational companies, the activities of financial institutions in the sugar sector, and the place of sugar substitutes in the sweetener market. The World Association of Beet and Cane Growers recommends that the International Sugar Organization undertake this analysis since it has the necessary experience and competence. The need to stabilize international sugar markets is important to producers in many countries, especially those whose agro-industry largely depends upon sugar.

South African sugar crop, 1987/88

The 1987/88 season in South Africa started on April 2, 1987 and ended on February 16, 1988[1]. It was longer than expected, mainly owing to the effect of the September floods and to exceptionally high rainfall during the summer months. Three factories were flooded and a fourth suffered serious damage to its road infrastructure and water supply. Crops and cane lands were also severely damaged but, despite the fact that in the case of certain individuals the loss was of disastrous proportions, the effect on production as a whole was not significant. Average sugar content fell from 12.80% in 1986/87 to 12.00%, the lowest industrial average ever recorded.

Relatively favourable weather conditions over the past two growing seasons has enabled the industry to maintain a stable level of production. From an output of 2,234,893 tonnes, raw value, in calendar year 1987 (which compares with 2,248,300 tonnes in 1986), exports amounted to 1,104,922 tonnes (against 873,677 tonnes in 1986), while consumption rose from 1,380,964 tonnes to 1,433,481 tonnes in 1987[2]. End-year stocks fell from 993,069 tonnes to 689,559 tonnes. No official details are available as to the destinations of the exports but F. O. Licht reports[3] that 403,000 tonnes were shipped to Japan and 384,000 tonnes to South Korea in 1987, against 364,000 and 194,000 tonnes, respectively, in 1986.

India sugar production, 1987/88

India's Food Minister has stated that sugar production in the season which closed at the end of September, exceeded 9.1 million tonnes, white value, which is 600,000 tonnes more than that of the previous season. Early in the season it had been expected that output would be reduced, following a prolonged drought and delayed monsoon rains which were not thought adequate.

C. Czarnikow Ltd. note that the cane harvest yielded 180 million tonnes, or 2 million tonnes less than the level reached in 1986/87[4]. This highlights a feature of the Indian sugar industry where just over 40% and occasionally as much as 60% of the cane crop has been used to produce gur and khandsari. After

1 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 449.
2 *I.S.O. Stat. Bull.*, 1988, **47**, (7), 31.
3 *Int. Sugar Rpt.*, 1988, **120**, 411.
4 *Czarnikow Sugar Review*, 1988, (1777), 133 - 135.

some 12% is used for seed cane, chewing and other purposes, the balance of between 47% and as low as 30% is delivered to sugar factories for processing. The proportion does not remain constant from season to season and these variations can lead to significant swings in the amount of sugar produced which far exceed the apparent changes in the total cane crop.

Current indications are that in 1987/88 the open-pan sector has taken one of the lowest portions of the total cane crop ever recorded of only 35.6% and, in view of this, it is not surprising that sugar factories have performed so well, given that they have had more than 52% of the crop to process. The other side of the picture is the impact on consumers' buying patterns as supplies have switched away from gur and khandsari to more factory sugar. Demand has been strong and official monthly releases had to be raised in January and again more recently to damp down rising prices.

It is likely that the total cane crop will show an improvement in the 1988/89 season, if only because there has been no drought this year and weather conditions have been more favourable for development. The Indian Sugar Mills Association has already indicated that a crop in the region of 195 - 200 million tonnes of cane is expected. Early indications suggest that as much as 10.2 - 10.5 million tonnes of sugar might be achieved but this presupposes not only a record extraction rate but also that more than 50% of the crop will be delivered to sugar factories. However, deliveries to factories have only to slip marginally to 45% and the extraction rate to equal the previous best of 10.24% reached in 1984/85 for sugar output to finish no better than in 1987/88. Consumption is showing every sign of continuing to move ahead strongly; from an offtake of 9.35 million tonnes in 1987/88 there would seem to be little to prevent a rise to at least 9.7 million tonnes in 1988/89.

Local sources have suggested the possibility that India may return to the export market in the 1988/89 season – that is, outside her preferential entitlements to the USA and EEC – but at present Czarnikow would be surprised if exports were to be negotiated to the world market.

World sugar balance, 1988/89

F. O. Licht GmbH recently published their first estimate of the world sugar balance for the period September 1988/August 1989[5] and the figures appear below. Production is estimated at 108.5 million tonnes, raw value, some 4 million tonnes up on the previous period, with most of the increase occurring in Asia and half in importing countries so that the volume of international trade is likely to be eroded.

Global consumption of vacuum pan sugar is expected to continue its upward trend in 1988/89 and a rise of 1.4% is forecast, although this could be reduced if world market prices markedly exceeded 10 cents/lb since importers among the developing countries, which now account for more than 50% of world gross imports, cannot afford to insulate their retail prices from international price movements and respond clearly to changes in world market prices. Imports are further limited by a lack of foreign exchange in some countries, such as China and Indonesia, where an acute shortage of sugar exists.

An important factor will be the effectiveness of the rationing scheme established in the USSR. The official policy of discouraging alcohol sales led to diversion of sugar to illicit distilling, but with the relaxation of controls on sales of wine, beer and brandy, and the rationing of sugar, consumption growth may be kept in check after the steep rise in 1986/87.

In spite of the sharp rise in sugar production, stocks as a percentage of consumption are likely to remain at a critically low level. If production should not come up to expectations, prices must be expected to rise sharply, depending also on where the crop shortfall occurs. Surplus stock calculations signal that supplies must be expected to remain tight, although there could be a slight build-up of surplus stocks in exporting countries. This will not be large enough to serve as a cushion for unforeseen production shortfalls, however, and the world market is likely to remain in a precarious state, with the danger of a full boom not yet removed.

	1988/89	1987/88
	tonnes, raw value	
Initial stocks	32,434,000	34,860,000
Production	108,511,000	104,528,000
Imports	27,697,000	28,307,000
Total	168,642,000	167,695,000
Consumption	108,313,000	106,817,000
Exports	28,012,000	28,444,000
Final stocks	32,317,000	32,434,000
" " % consumption	29.84	30.36

Sugar in the newly industrialized Asia countries

Based on its economic performance in recent years, South Korea is expected to be a medium-sized industrial power by the end of the century. The same goes for Taiwan and these two, together with other expanding manufacturing centres such as Hong Kong and Singapore are being talked of by economist as a new category, the newly industrialized countries of Asia. F. O. Licht has recently published a survey of development in the four countries, based on ISO statistics[6].

Taken as a group, their annual consumption nearly doubled from 700,000 to 1,300,000 tonnes, raw value, between 1974/76 and 1984/86, or more than $2^1/_2$ times the rate of growth of world consumption. Moreover, apart from Singapore, per caput consumption is still far from saturated.

This rapid growth is a pointer to what may eventually happen in other parts of the region; however, a steep rise in free market prices, such as occurred in 1974 and 1980, would probably cause temporary contraction of imports and consumption in most of these countries.

5 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 529 - 537.
6 *ibid.*, 453 - 454.

Product news

Process instrument calibrators

A six-page, short-form catalogue, illustrating their comprehensive range of process instrument calibrators and simulators, is available from Beamex of Leicester. Covering pressure, temperature, voltage, current, resistance and pH, Beamex calibrators offer accuracy, repeatability, traceability and a 2-year guarantee. The pressure and temperature calibrators are also available as intrinsically safe.

For more information contact:

Beamex Divn.,
Sarlin Ltd.,
Imperial House,
St. Nicholas Circle,
Leicester LE1 4LF,
England.

Relative humidity measurement in the sugar industry

Sugar can be greatly affected by air humidity, particularly in drying and storage. Lee-Integer have developed two rugged combined temperature/humidity probes which have been successfully field tested in the sugar industry over the past four years.

The probes use PTFE membrane filters which, being specific to water molecules, prevent sugar deposits forming on the sensing elements. Sugar deposits on the probe itself do not affect the measurement, and deposits up to 20 mm thick serve only to slow the speed of response in still air.

The two probes use the same measurement techniques and are similar in technical specifications, the differences being in the mechanical designs. The CH3O probe is for machine installation, and is similar in appearance to a DIN type thermocouple or resistance thermometer. The temperature and humidity sensors are mounted in the tip of an 8 mm diameter stainless steel probe body, with the electronics all mounted in the terminal head. This design lends itself to mounting through the insulated walls of dryers, and into ducts and airways.

The RVT90 probe is designed for temperature/humidity measurement and control in production area, storage and warehousing. This is wall-mounted, and fan assisted to enable it operate under still air conditions and in applications where it might be required to achieve dry-down after saturation.

Both probes can be linked to standard controllers, loggers, recorders, etc., and a range of back-up instrumentation is avilable from Lee-Integer.

Both probes measure humidity in the range of 0 - 100% RH and can give a range of current or voltage outputs. The CH3O probe can operate in temperatures up to 130°C and in pressures of up 10 bar. The RVT90 is limited to work in temperatures between –25 and +50°C.

Further details:

Lee-Integer Ltd.,
1-3 Bowling Green Road,
Kettering,
Northants. NN15 7QW,
England.

New encapsulated level sensors

Two new sensors have been introduced, one of them a flush mount sensor and the other a V-top sensor. Both are designed to mount through the side wall of the vessel or spout and are adjustable to the nature of the product being sensed. Their unique patented design allows them to be used at any point in a system where corrosion and abrasion is severe.

The new units are the only commercial sensors that can withstand the direct impingement of abrasive materials like fly ash, sand, and other similarly abrasive materials. A new brochure describing these new level sensors, and other sensors in the Rhino Hyde line, is available from Tandem Products Inc., 10800 Lyndale Ave. South, Suite 320, Valley Office Park, Bloomington, MN 55420, USA.

Microprocessor-based conductivity monitors

The introduction of microprocessor control to conductivity instrumentation has culminated in the production of the models 4510 and 4520 conductivity monitors manufactured by Kent Industrial Measurement Ltd. These instruments have been designed to provide compact units having an enhanced capability and flexibility with improved accuracy, reliability and ease of programming. The Model 4510 is a wall mounting version of the monitor housed in a robust moulded plastic case of modern appearance and environmentally protected. The Model 4520 is suitable for panel mounting, being housed in a DIN standard sheet metal enclosure with glazed, hinged door.

The instrument uses a blue filtered vacuum fluorescent display for indication of the measured value with a separate 20 character dot matrix fluorescent display of additional information such as alarm set points and delays, sample and reference temperature, units of measurement etc. Programming of the various functions is by eight finger tip operated membranes switches which provide for: mode selection; input of appropriate calibration information; set point function; "enter" and "hold" modes; setting of calibration data; and "raise/lower" switches for data.

The set point values, measured conductivity and temperature values can be read. All other parameters are accessible by use of a programmable security code which maintains instrument integrity and protects against unauthorized changes. Operator facilities include programming of the units of measurement: for conductivity microsiemens/cm, microsiemens/m, millisiemens/cm, millisiemens/m; and for resistivity meghom-cm and meghom-m. An available option is a serial data interface to RS485 enabling the instrument to be linked directly to a host computer through which the operator may read/change the various parameters.

Further details:

Kent Industrial Measurements Ltd..,
Howard Road, Eaton Socon,
St. Neots, Huntington,
England.

Loadstar – the truck scale only inches high!

The well proven Howe Richardson product range includes pit mounted truck scales, above-ground truck scales, portable vehicle scales and is complemented by various weight indicators/controllers.

Recently added to the truck scale range, the Loadstar electronic truck scale is truly low profile with an overall installation height of only $10^1/_2$ inches, including loadcell assemblies. The Loadstar design reduces installation/servicing costs when compared with other truck scale designs, minimizes costly downtimes and provides simple relocation if required.

Loadstar has a modular construction which allows the combination of standard 15 feet and $17^1/_2$ feet sections, (rated at 35 ton capacity/35 ton sectional capacity or 45 ton capacity/45 ton sectional capacity, respectively), to provide 60 to 100 ton capacity truck scales in standard sizes from 15 feet to 150 feet.

The low profile modular sections are 10 ft wide and have been designed to allow for installation beneath silo outloading stations. Steel deck or precast concrete deck modules can be supplied, the choice being based on particular application requirements. The Loadstar design also provides easy service accessibility with all electronics serviceable from the top of the deck.

Further details:

Chronos Richardson Ltd.,
Arnside Road, Bestwood,
Nottingham NG5 5HD,
England.

New brochure for high purity solvents

Riedel-de Haen has issued a new brochure in four languages to present its extended range of high purity solvents. The products are arranged according to their fields of use and characterized by comprehensive specifications. The guaranteed analytical data document the suitability for the appropriate uses in chromatography, residue analysis, spectroscopy and as analytical grade material.

The high quality of the solvents is due to the setting up of a new production plant built to the latest concepts and with massive investment. The glass bottles are cleaned and filled completely automatically under clean room conditions. The production rooms are under a slightly increased pressures of filtered air to exclude the possibility of contamination. The qualities are in this way improved to such an extent that they determine standards.

The printed brochure contains a compilation of all the solvents for analysis, extraction, etc., together with extensive analytical data. A collection of UV spectra and a table of important physical data makes the brochure an interesting reference work. It can be obtained free of charge from :

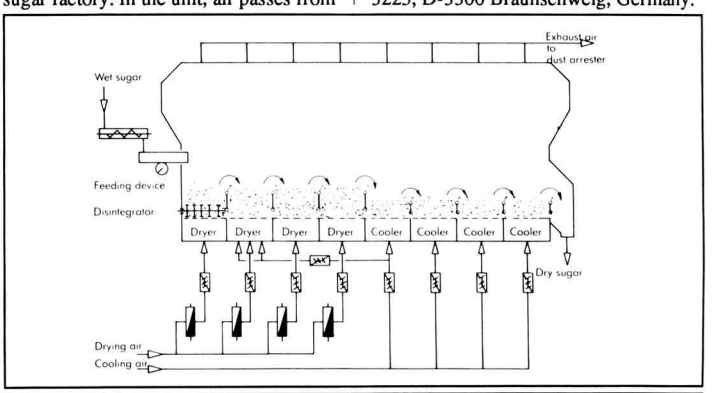
Riedel-de Haen AG,
Verkauf LC, Postfach,
D-3016 Seelze 1, Germany.

Fluidized bed sugar drying and cooling

BMA's range of dryer/coolers now includes a unit for crystal sugar that operates on the fluidized bed principle. Developed at the Magdeburg Technical University in East Germany, a 20 tonnes/hr dryer was installed and has operated for two campaigns at the Artern sugar factory. In the unit, air passes from below through a bed of sugar resting on a distributor plate, enlarging the voids volume in the feed so that individual particles are fluidized. A minimum of mechanical equipment is sufficient to keep the sugar in motion and prevent the formation of unwelcome lumps in the dryer. The high heat and mass transfer coefficients that can be achieved provide for optional thermal utilization of the drying and cooling air. The velocity of approach to the distributor plate is much less than the velocity of the air in rotary dryers, which means gentle treatment of the sugar in the fluidized bed and minimization of the amount of dust to be removed.

The specific shape of the distributor plate conveys lumps entering the dryer along with the wet feed directly to the lumps disintegrator. Speed and operation of the latter such as to properly crush the lumps but not subject the crystals in the bed to any additional strain. The drying air is delivered beneath the first part of the bed while cooling air is delivered to the following part. For correct residence time adjustment in each section overflow baffles are provided above the distributor plate at right angles to the direction of flow, over which the product cascades from one compartment into the next within a narrow residence time distribution.

Details of the equipment are available from Braunschweigische Maschinenbauanstalt AG, P.O. Box 3225, D-3300 Braunschweig, Germany.



Automation of cane juice purification in India

By G. N. Acharya, L. N. Chaudhury and K. S. N. Rao
(Central Electronics Engineering Research Institute, Pilani, Rajasthan, India 333031)

Introduction

The relevance and long-term significance of appropriate automation for improving the productivity and quality of cane sugar has been well recognised in India and progressively more and more microprocessor-based systems for process control are being introduced in the Indian sugar industry.

One of the critical processes in the production of plantation white sugar in which the introduction of an advanced electronic control system has been essential for replacing crude manual controls, is the juice purification stage involving the removal of non-sugars in a controlled manner.

In the process generally practised in India the preheated mixed cane juice undergoes two stages of operations, viz.

(i) juice purification involving precipitation of non-sugars and decolorization by the action of reagents such as lime and SO_2, and

(ii) settling, secondary heating and treatment in a flash tank and juice clarifiers (or subsiders) to provide a clear juice for feeding to the evaporator. Of the above two processes, the first is the more critical and involves the addition of special reagents in a controlled manner in a carefully designed reaction vessel. The present paper gives a brief analysis of the most commonly used juice purification processes, their automatic control and experimental results obtained on some of them.

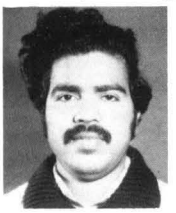
Objective of juice purification

Removal of the non-sugars or so-called impurities from cane juice is not an easy task, needing careful control of the quality and quantity of the reagents used, their temperature and the level of acidity or alkalinity suitable for good precipitation as indicated by the pH values during different reactions. It is well known that different impurities are precipitated at different values of pH so that accurate control of pH using appropriate automatic means is necessary for optimum purification.

The experience of sugar technologists over the years, using phosphoric acid, lime and SO_2 reagents at different stages of operation, indicates the advantage of using appropriate automatic control of the various measureable parameters like pH, temperature, flow rate, etc. The following main and subsidiary objectives can be achieved:

G. N. Acharya

L. N. Chaudhury



S. N. Rao

(i) Removal of impurities by (a) precipitation of the dissolved inorganic impurities through control of pH and (b) separation of insoluble solids suspended in the juice in colloidal state;

(ii) Bleaching of the juice through suitable chemical treatment to render it brilliant and light in colour, with practically no turbidity;

(iii) Reduction of viscosity to some extent and increasing the flow rate effectively by optimizing sulphitation reaction time and treatment;

(iv) Improvement of the settling rate by forming heavy precipitates and flocs which can entrap undissolved impurities;

(v) Ensuring removal of impurities which tend to form undesirable scaling in vessels and tubes used in settling, heating, evaporation, etc.; and

(vi) Last, but not least, is ensuring that the reagents themselves do not leave impurities and precipitates to the extent that they cause difficulties in further processing stages (e.g. rise in CaO content after purification in the reaction tank).

All this has to be achieved without affecting the sucrose content, while decomposition of invert sugar has also to be avoided.

The first important observation is that sucrose is inverted into glucose and fructose at high acidity and high temperature levels. The extent of inversion depends upon the nature of the acidity, the temperature and time for which the sucrose and acid in the juice remain in contact. Best operating conditions for minimum inversion are a pH of 7 and temperature not exceeding 75°C.

Since juice is naturally acidic, lime and heat treatment is used as the cheapest technique for treating the raw juice. The overall effect of lime and heat treatment on the removal of non-sugars was studied by Pieter Honig. His observations, more or less corroborated by other workers, indicate that removal of the various non-sugars is a function of pH and most impurities are removed at below pH 9, except SiO_2 and Al_2O_3 and MgO which need a pH greater than 9 (Figure 1).

The above two observations need to be considered together in designing automatic control since cane juice with very high or very low pH values, in contact with the reagents for a long time, can suffer inversion, undesirable lime salts, colour formation, etc., depending upon the actual conditions of the reaction. General opinion throughout the world now opposes the so-called high liming (above 8.5 pH) for long times. Disadvantages of such treatment are excessive soluble lime salts, decomposition of reducing sugars with attendant colour increase and re-solution of some nitrogenous bodies.

In view of this, any treatment of the juice to give a high pH value has to be for a very short time, just enough to precipitate some of the most undesirable impurities like silicate and compounds of aluminium and magnesium which form troublesome scale in evaporators.

Juice purification process and their relative merits/demerits

Of the many processes for juice purification for white sugar production involving sulphitation, the following three deserve some special consideration, since they have been widely used or tried out in India.

(i) liming and sulphitation in the same tank at a temperature of about 70 - 75°C (followed by syrup sulphitation after evaporation),

(ii) a three-stage process involving preliming, shock liming for a short time and sulphitation in the main reaction vessel (followed by syrup sulphitation after evaporation), and

(iii) the carbonatation process (involving double carbonatation and double sulphitation).

Flow charts of the three processes are shown in Figures 2, 3 and 4, respectively.

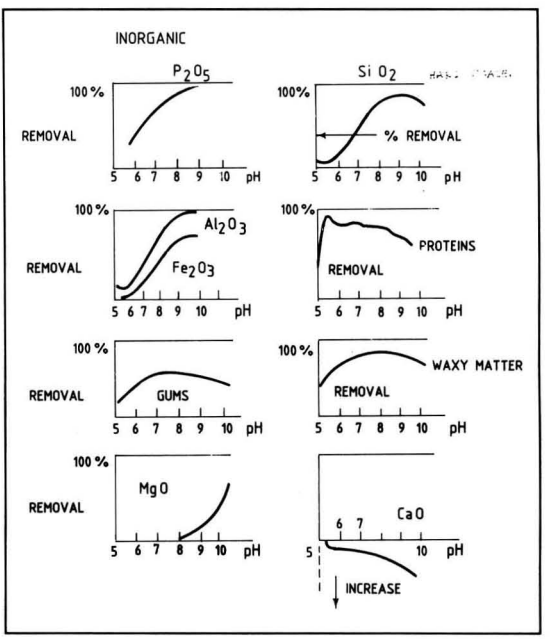


Fig. 1. Effect of lime and heat on the removal of non-sugars

Liming and sulphitation in one tank

Whether sulphitation should be done before liming or after liming depends primarily upon the actual processing method used. In the opinion of the authors, liming after bringing the phosphate level to a little above the desired value of 300 ppm of P_2O_5 leads to the formation of calcium phosphate and removal of colloids at an early stage and this process should be preferred for automatic control. Indian technologists have been following the method of simultaneous liming and sulphitation in the same tank. Recently, an automatic lime feed control system with digital dual set point control (DDC) developed by the authors has received acceptance in the sugar industry because it can maintain the final pH value of

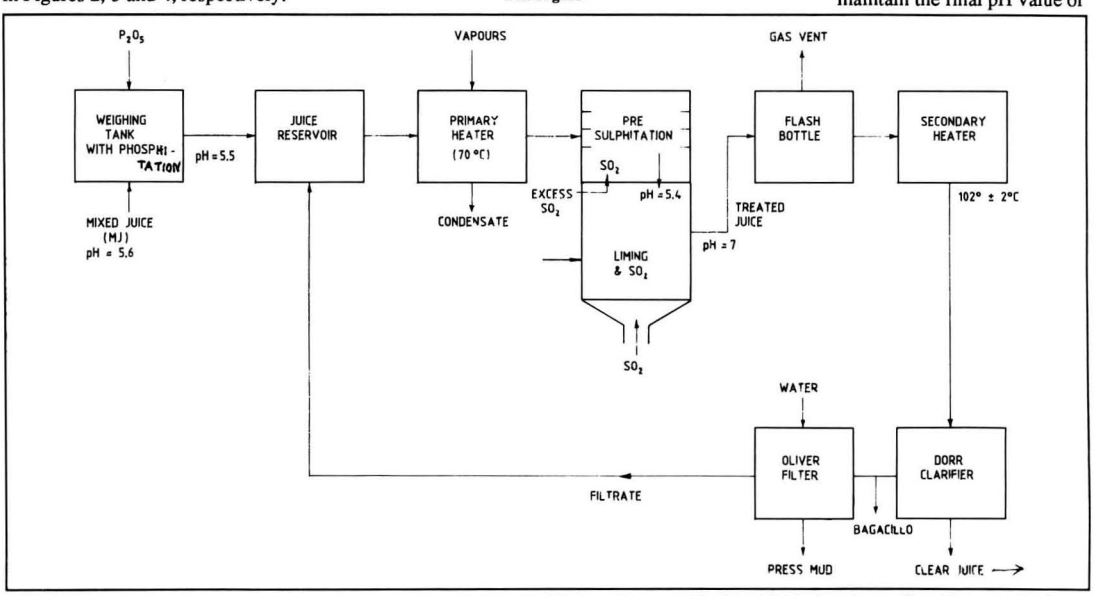


Fig. 2. Conventional juice clarification process involving the use of excess SO_2 for mild presulphitation which brings down pH and increases the lime requirement proportionately

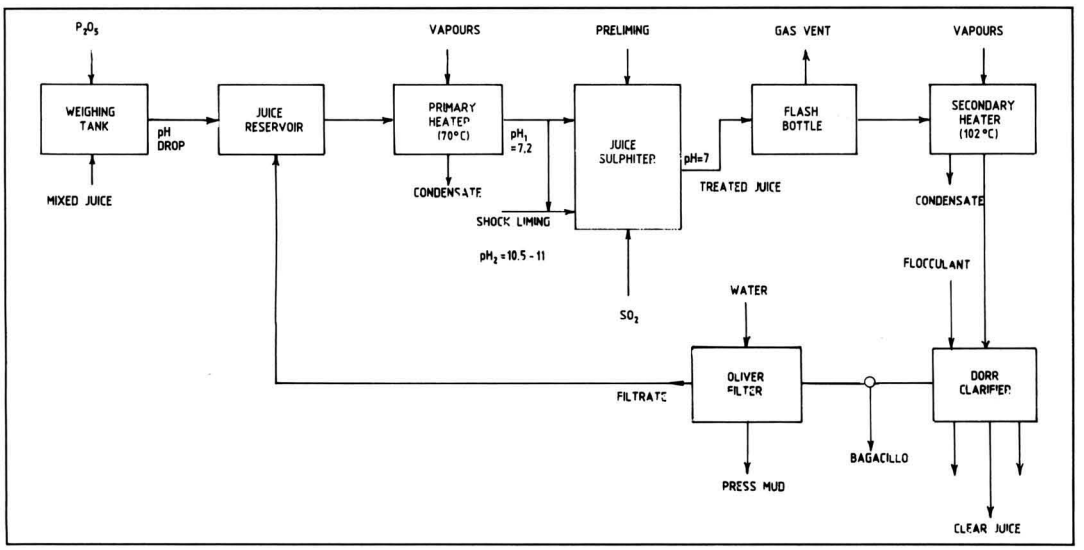


Fig. 3. Typical juice clarification stage using JPMA design for juice purification by preliming, shock liming and sulphitation

the treated juice within ± 0.15 units of the set value of pH 7. This system, however, controls lime feed only and SO_2 is manually controlled. Furthermore, the main drawbacks of combined liming and sulphitation, which is practised only in India, cannot be totally eliminated by simply introducing automatic lime feed control.

Figure 5 is a diagram of the DDC system developed at the Central Electronics Engineering Research Institute (CEERI) for automatic control of lime feed. As in other processes, the treated juice goes through syrup sulphitation after evaporation.

Double liming and sulphitation

A second method introduced by J. P. Mukherjee & Associates in India involves preliming, shock liming and sulphitation in three different stages (Figure 6). Good results have been observed with the introduction of a microprocessor-based automatic pH control system (MAPCON) designed by CEERI. In this system automatic control is achieved in three stages.

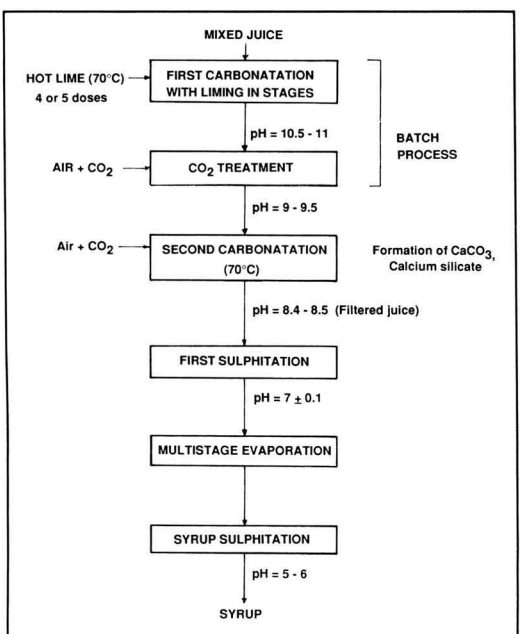


Fig. 4. Carbonatation process

The first stage is preliming of the mixed juice at between 70°C and 75°C so as to raise the pH to a value corresponding to precipitation of phosphate thereby reducing the latter to about 50 ppm. Normally pH is raised to about 7.2 from the average mixed juice pH of 5.3. Alternatively, the pH value may be adjusted to bring about colloid removal. The pH chosen as the set point for control of preliming may be the higher or the average of these two pH values. Experimental observation indicating the variation of P_2O_5 content with pH of prelimed juice is shown in Figure 7. It is clear that for pH values higher than 7.5 there is very little effect on P_2O_5 content. Furthermore, most of the colloids are also removed before 7.5 pH. The second stage involves shock liming of the prelimed juice so that the pH rises to about 10.5, over a period of 6 to 10 seconds depending on flow rates of juice

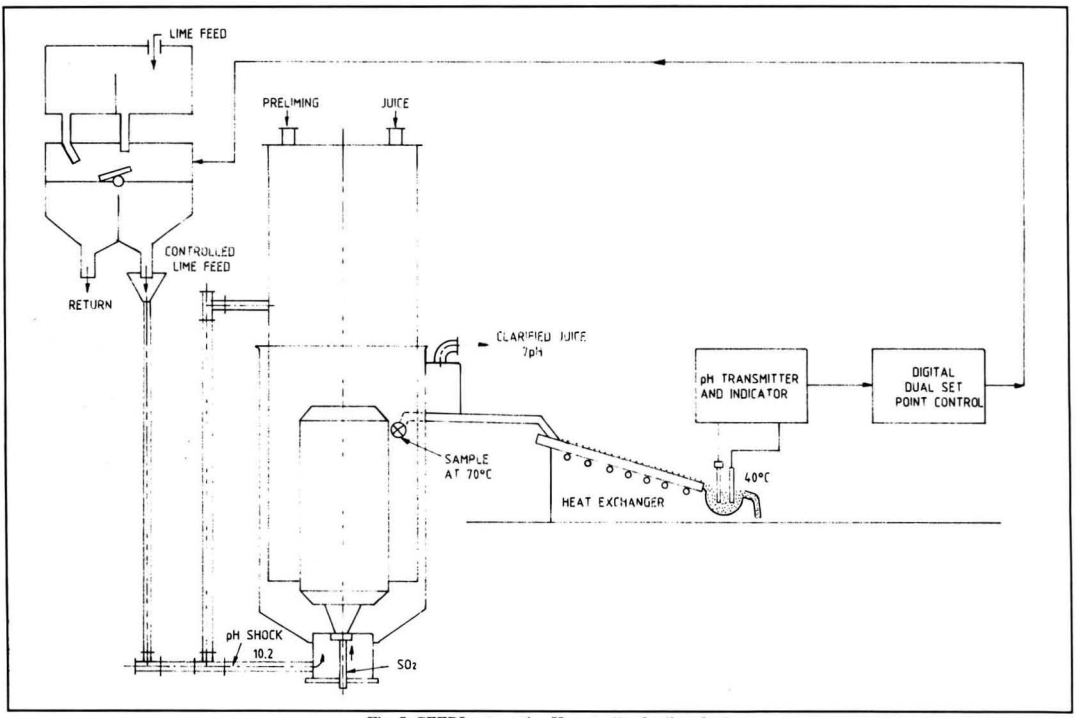


Fig. 5. CEERI automatic pH controller for lime feed

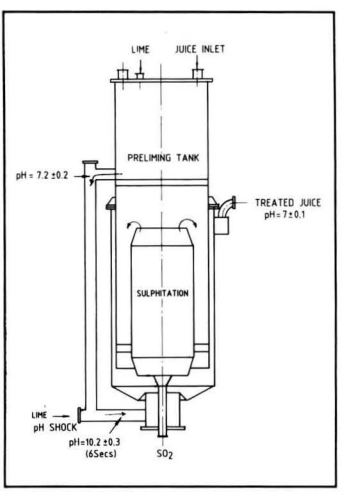


Fig. 6. Sulphitation tank with preliming (JPMA design)

and lime in the short length of the feeding tube indicated in Figure 6.

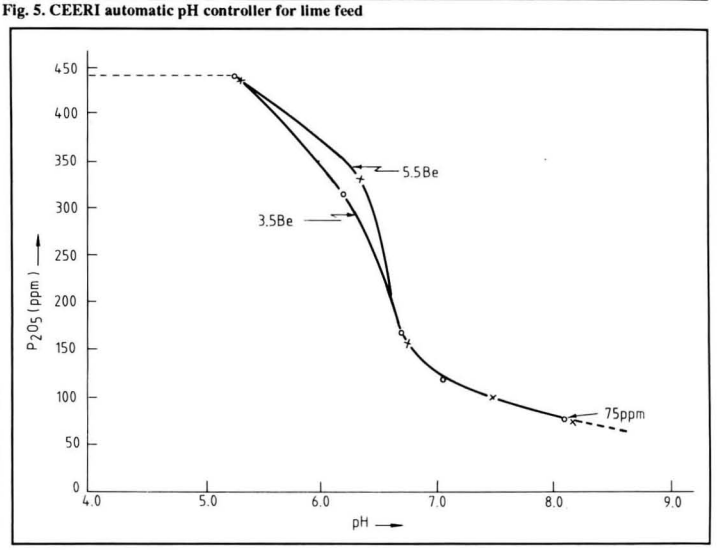


Fig. 7. Variation in P_2O_5 content of prelimed cane juice with pH for different values of lime Brix

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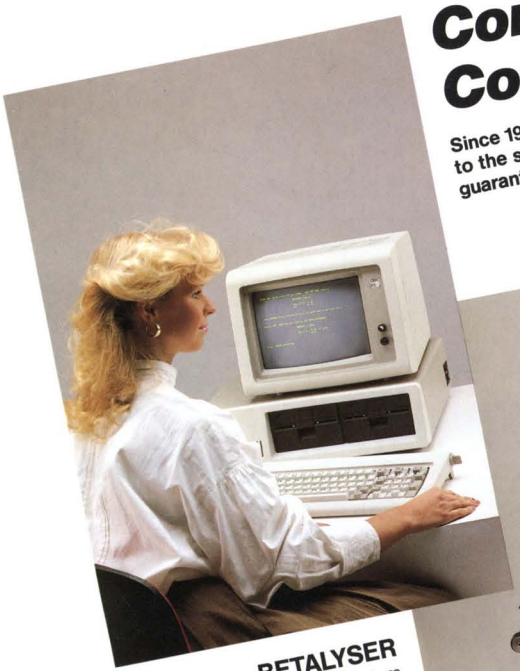

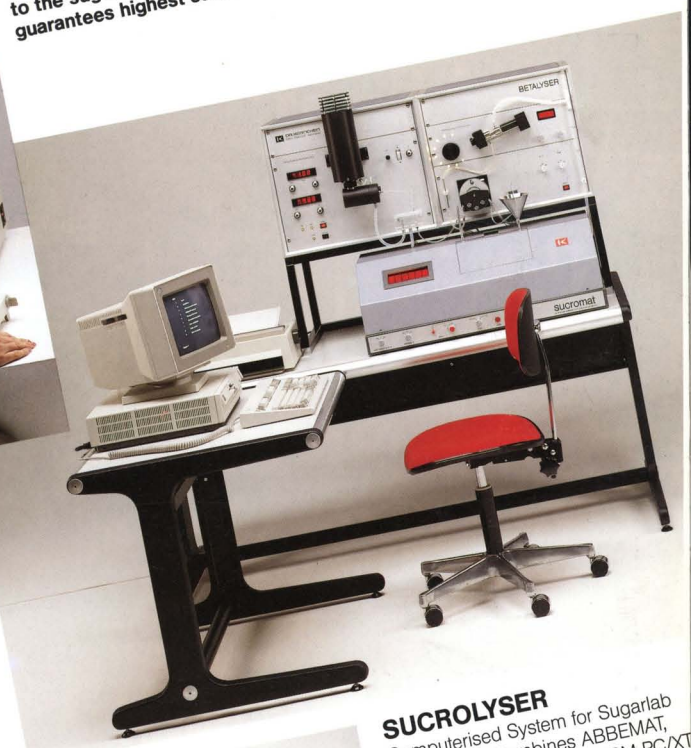

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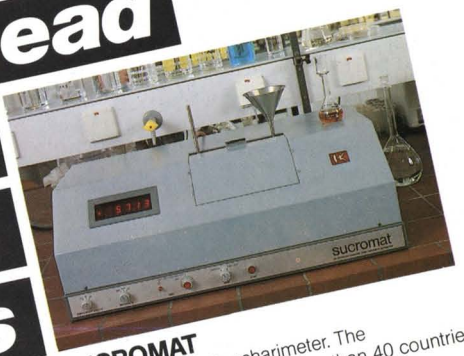

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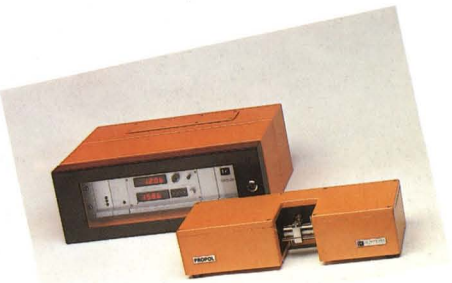

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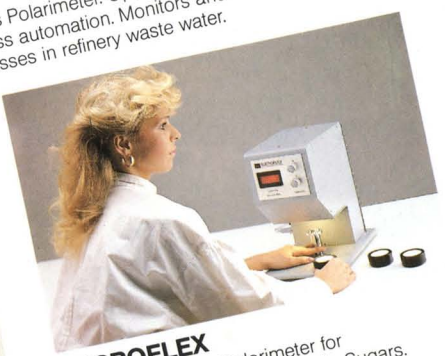

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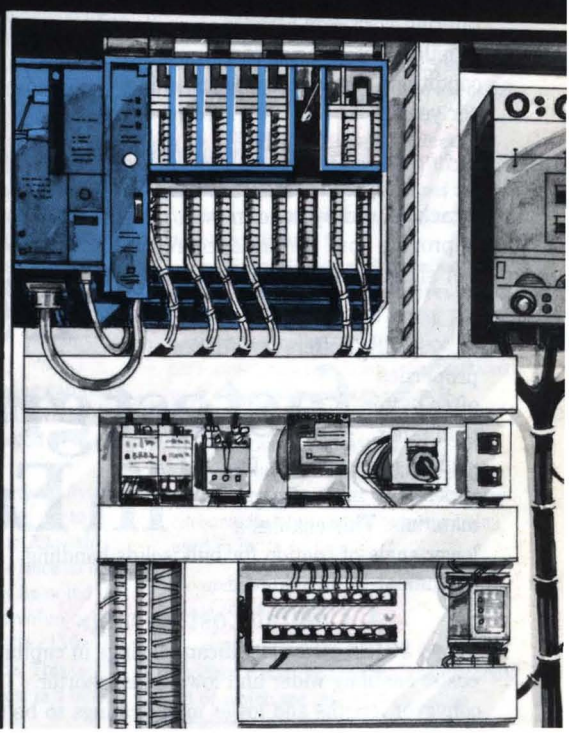

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Here the actual value set for shock liming will depend upon the minimization of CaO content of the finally treated juice after sulphitation. The chemist has first to make a plot for his factory of the value of shock pH and CaO content of the final sulphited juice and choose that value of shock pH which will correspond to the minimum value of the CaO content (Fig. 8).

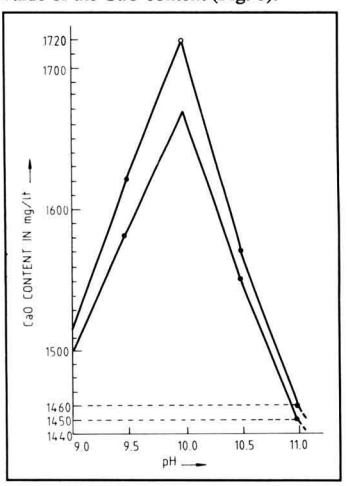

Fig. 8. Variation in CaO content of treated juice with pH of shock limed juice

Finally in the sulphitation stage SO_2 is bubbled in a controlled manner so that the treated juice becomes neutral and the value of pH is brought down to 7 ± 0.1.

Once the above three pH values, determined by the criteria based on the chemical reaction discussed above, are entered in the microcomputer, the MAPCON system senses the three pH values and controls them automatically within ± 0.15 pH by controlling the lime or SO_2, as applicable. If juice or lime quality changes considerably, new pH values can be determined and entered.

Finally, the treated juice passes through further process stages and after evaporation, the resultant syrup (62° Brix) is sulphited to a pH of 5.5 or 6.

Carbonatation process

In the system involving carbonatation of cane juices, the following sequence is normally followed in Indian sugar factories.

(i) first carbonatation, involving hot liming at 70°C, raises the pH to about 10.5 to 11 and then a CO_2 - air mixture is bubbled into the juice to bring the pH to about 9.5. It may be noted that this process involves large volumes of lime to the tune of 10 to 12% (15% Baumé) by volume of juice. This is normally done in five doses, in a batch process.

(ii) In the continuous process of second carbonatation a CO_2 - air mixture is bubbled in at about 70°C; the treated juice has a pH of the order of 8.4 to 8.5. This helps in the formation of precipitates of $CaCO_3$, calcium silicate, etc, which are removed by filtration.

(iii) First sulphitation is then carried out by bubbling SO_2 through the pretreated juice of pH 8.4 to 8.5 in the sulphitation tank, bringing it to about 6.9 to 7.1.

(iv) Syrup sulphitation is done after evaporation of the above juice to about 58 - 60°Brix and continues for a maximum of 30 minutes, bringing down the pH to about 5.5.

Generally the carbonatation process described above involves a high consumption of lime and during 1938 a new process called "middle juice carbonatation", involving two filtrations with evaporation in between, was introduced in Java. This saves 40% of lime by comparison with normal carbonatation, but is too sensitive for control. In view of this the middle juice carbonatation process is not now being used in India.

Comparison of the three methods of juice purification

Having discussed the basic processes involved in the three methods, all of which are practised in Indian factories, we can attempt to make a comparison of the overall advantages and disadvantages of the three methods.

1 Hugot: "Handbook of cane sugar engineering" (Elsevier, Amsterdam), 1986, p. 420.
2 Podder: *Proc. 9th Congr. ISSCT*, 1956, 520 525.

Table I. Comparison of juice purification processes

	Method I	Method II	Method III
(i) Lime consumption, % CaO on cane	0.15 to 0.25	0.14 to 0.2	2.0 to 3
(ii) Sulphur consumption, % on cane	0.08 to 0.09	0.06 to 0.08	0.02[1]
(iii) Non-sugar removal, %	-	11 to 12	28
(iv) Mud volume, %	4.2	4.9	Very much higher
(v) Average rise in apparent purity	0.5 to 0.6	0.6 to 0.7	0.7 to 1
(vi) Removal of amino-acids, %	42 to 46	49.5 (Higher with preliming)	- (Lower than with sulphitation)
(vii) Rise in CaO content mg/litre	580 to 600 4	30 to 470	-
(viii) Settling rate	-	Higher with automatic control of pH	-
(ix) Steam consumption[2], % on cane	55	55	66
(x) Recovery of sugar, %	10 (average)	Slightly higher with proper controls	Higher by about 1.0% on average
(xi) Cleaning operations	Every 15 to 18 days (About 60 hours per operation)	Every 25 to 30 days (about 37 hours per operation)	

Method I. Simultaneous liming and sulphitation
Method II. Preliming shock liming and sulphitation
Method III. Double carbonatation and double sulphitation
Please see separate table for comparison of results obtained with manual and automatic control for rise in purity and rise of CaO content

Experimental data collected from various published sources and from Indian sugar factories are presented in Table I. Analysis of some of the results obtained in some Indian sugar factories using the automatic pH control equip ment manufactured by CEERI collaborators are given in Table II. Here a word of caution is necessary; the rise in apparent purity cannot be considered as an absolute measure of efficiency of juice purification, unless it is under identical conditions without any loss of invert sugars.

Table II. Rise in apparent purity due to the introduction of CEERI automatic control equipment, observed under identical operating conditions

Factory No.	Manual pH control	Automatic pH control
1 (Average over 7 days)	0.4%	0.65%
2 (Average over 3 days)	0.49%	0.58%
3 (Average one season)	0.5%	0.6%

Regarding rise in CaO content in the juice purification stage, practically all factories which have used the MAPCON equipment have confirmed that the relative rise of CaO content after purification is definitely smaller with automatic pH control than with manual control. Results obtained from some factories during the 1986/87 season are given in Table III.

Table III. Rise of CaO content from raw juice to treated juice, mg/litre

Factory	Manual	Automatic
1	858	390
2*	1450 (absolute value after clarification)	1205 (absolute value after clarification)
3*	584	450
4	Not given	Reduction by 200 - 300 compared with manual control

* Averaged over one season

In addition to the above, some improvement in settling rate and a reduction in sulphur consumption with proper control using the MAPCON system have been reported by the users. Although the mud volume has been observed to increase by 10 to 15% in the JPMA design, the loss of sugar in mud is not higher by any measureable amount and overall there is a higher rate of production owing to better purification and subsequent clarification. In fact, the higher mud level is an indication of better removal of non-sugars.

Action of lime on cane juice

The action of each reagent and combination of reagents (lime, phosphoric acid or phosphate and SO_2) on the cane juice during sulphitation has been studied.

Lime which is the cheapest alkaline reagent available, is used in the form of "milk of lime" or "lime cream" which is basically a suspension of $Ca(OH)_2$ in water, usually at 12° - 15°Bé (10 to 13% CaO) for normal control and 3° to 7°Bé for automatic control. Whether it is a matter of simple defecation for raw sugar manufacture, the conventional sulphitation process, or the three-stage process used in the JPMA design with CEERI automatic control, the use of hot liming (70° to 75°C) of the mixed juice is now universally accepted. It eliminates the problem of *Leuconostoc* infection experienced in cold liming.

Hot liming at about 72°C gives best results, requiring 15 to 20% less lime than cold liming. It helps to remove oxalic acid, tartaric acid, and many other organic acids, the lime salts of which are insoluble, while albuminoids are also coagulated. Sharma & Johri[3] have observed that preliming before the sulphitation process gives better removal of amino-acids (49%) than does pre-sulphitation (46%).

Lime consumption increases very rapidly with the pH value required to be reached, and is also considerably dependent on the amount of phosphate in the juice.

Removal of colloids and other impurities

The quantity of colloids in raw juice is in the range of 0.2 to 0.29%. Their main detrimental effect is that they retard settling and filtration and thus reduce the overall capacity of the plant. Furthermore, they increase the viscosity of the syrup rendering boiling and curing more difficult. The gums and proteins prevent proper coagulation of precipitates. Colloid reduction by the action of lime must be considered in conjunction with the role of phosphates present in the cane juice.

The main reaction of lime is with the phosphate content of the juice to form ultimately tricalcium phosphate $Ca_3(PO_4)_2$, but slowly going through the stage of $CaHPO_4$. The calcium phosphate formed in the process is not a pure compound, but an amorphous mass of widely varying composition and physical character. The calcium phosphate particles formed during defecation by the action of milk of lime on the juice carry a negative charge and naturally do not carry down any amount of the negatively charged colloids, but they sweep out the coarse dispersions which have a very small charge per unit weight.

The action of milk of lime during the preliming stage can be summarized as follows:

(i) Formation of calcium phosphate by reaction with inorganic phosphates in mixed juice.

(ii) Precipitation of colloids by neutralization of their negative charge, resulting in floc formation.

In the system involving a three-stage process recommended by the authors the chemist is required to carry out a simple experiment in liming the hot cane juice and making a plot of pH *vs.* P_2O_5 content of prelimed juice, as in Fig. 7. He should then enter in the microcomputer that pH value which corresponds to change of slope of the curve as discussed. This value is normally around 7.2.

Effect of high levels of phosphate on liming

As already indicated, high levels of phosphate added beyond 325 ppm are

3 *I.S.J.*, 1984, **86**, 7 - 11.

ISJ Abstracts

Cane sugar manufacture

The choice between diffusion and milling

J. P. Lamusse. *Rev. Agric. Sucr. Maurice*, 1984, **63**, (2/3), 35 - 45 + i.

Examination of the cost factor involved in choosing between a cane mill and a diffuser to be installed in a new factory shows that, in the case of a plant designed for about 97% extraction, the relative capital costs of a diffuser (including dewatering mills) and a mill tandem under South African conditions are in the approximate ratio 1:1.5; the corresponding labour cost ratio is between 1:2 and 1:3 and that of maintenance costs between 1:1.4 and 1:1.7. However, possible layout problems when a mill tandem is replaced with a diffuser could reduce the cost advantage of the latter plant. Other factors discussed include: the differences between the steam balances, with a diffuser requiring less high-pressure but more low-pressure steam; higher boiler maintenance costs as a result of erosion caused by the greater amount of sand in diffuser bagasse used as fuel; the higher colour but lower suspended solids content in diffusion juice; the smaller amount of mud and hence lower filter capacity requirements with diffusion; the lower calorific value of diffuser bagasse and its poorer quality as a raw material for by-product utilization; and the greater ability of diffusers to cope with fluctuations in cane quality and cane throughput, but the need to empty diffusers in the case of long stoppages. No significant effect of diffusion on boiling house recovery has been measured. In South Africa, there is a definite preference for diffusers after some years of experience.

Application of multivariable analysis methods to process control in a cane sugar factory

J. L. Dupouey and C. Rigo. *Rev. Agric. Sucr. Maurice*, 1984, **63**, (2/3), 62 - 66 + iv *(French)*.

About 70 variables are measured each week in Réunion sugar factories, ranging from cane fibre to final molasses analysis; multi-dimensional statistical analysis is applied to the data to provide a means of chemical control of the manufacturing process. Using purity as an example, the authors demonstrate how the results of the analysis can be plotted and used to identify causes of abnormal behaviour throughout the season and to compare factory performances.

Installation of the Langreney continuous vacuum pan and hydraulic mill drives at Union Saint Aubin sugar factory

R. Raffray. *Rev. Agric. Sucr. Maurice*, 1984, **63**, (2/3), 67 - 71 *(French)*.

Two major items in a modernization program at the title sugar factory included installation of a Langreney continuous vacuum pan for *A*-massecuite (reasons for this as against continuous low-grade boiling are given) and replacement of turbines with individual hydraulic drives for the five mills in the tandem because of problems with the gearing; possible alternative approaches were considered but hydraulic drives chosen because of their cost advantage and because of major steam economies and the possibility of increasing mill capacity. Other advantages of the drives are discussed.

A review of the expansion and modernization of Illovo mill

J. P. M. de Robillard. *Rev. Agric. Sucr. Maurice*, 1984, **63**, (2/3), 72 - 79 + iv.

Details are given of the program launched in 1980 to allow the crushing capacity at Illovo in South Africa to be raised from 160 to 200 tch and to modernize the processes by e.g. replacing mills with a BMA diffuser, modifying the clarification and evaporation stations as well as boiling house equipment and installing a computer for process control. Despite a number of teething problems, results indicated no adverse effect on overall recovery, while operating and maintenance costs were reduced.

Restructuring problems

L. Lincoln. *Rev. Agric. Sucr. Maurice*, 1984, **63**, (2/3), 80 - 100 + iv *(French)*.

The author describes his experiences in modernizing and conversion of sugar factories, with particular reference to Bois Rouge and to the advantages of continuous processing; he considers conversion of a sugar factory to the manufacture of syrup as the sole product risky under Réunion conditions and lists a number of reasons for his views. However, such a solution could prove practical in Mauritius, and a hypothetical case of three factories is described where one possible change to the system involves a 25% increase in crushing capacity and continuous operation of one of the factories as a syrup plant; advantages of the change, particularly the financial benefits, are analysed.

Microprocessor controls for bagasse-fired furnaces

W. Keenliside and K. McGrew. *Indian Sugar*, 1987, **37**, 459 - 464.

See *I.S.J.*, 1987, **89**, 101A.

Steam consumption in Mauritius sugar factories

Anon. *Ann. Rpt. Mauritius Sugar Ind. Research Inst.*, 1986, 46 - 47.

Since 1982, steam balances have been compiled for Mauritius sugar factories; the mean results are given for the last three of the 19 factories to be examined: St. Félix, St. Antoine (equipped with a diffuser) and Médine. The project has allowed identification of inefficient steam users, assessment of steam generation efficiency and utilization and evaluation of different steam networks. From comparative data on energy consumption per tonne of fibre milled, much scope for improvement is evident, and data from the survey will serve as basis for a model aimed at optimizing energy usage.

Falling-film evaporators for the Sugar Industry Research Institute's pilot plant

H. Bourzutschky. *J.A.S.T.J.*, 1982, **43**, 106 - 115.

Details are given of a triple-effect falling-film evaporator installed at SIRI in Jamaica in order to allow investigations of steam economy and technological problems of evaporation.

The control of oil burning on bagasse-fired boilers

M. Hylton. *J.A.S.T.J.*, 1982, **43**, 115 - 120.

Aspects of burning oil as an auxiliary fuel in bagasse furnaces are discussed.

Economics and techniques of intermediate syrup production

H. Bourzutschky. *J.A.S.T.J.*, 1982, **43**, 121 - 127.

The economics of producing only syrup at a converted sugar factory for processing at a larger factory are discussed; the aim is to show how to restore viability to smaller factories in Jamaica that were due for closure but continued to operate so as to maintain agriculture and employment in a cane-growing region.

Effect of chemical components on the colour of sugar cane juice

S. Thangavelu and K. C. Rao. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, Ag.103 - Ag.108.

The colour of juice from 30 cane varieties aged 6 - 13 months was found to differ significantly with variety and stage of growth, decreasing as the age of the crop advanced. It was affected by the amino-acids, colloids, titratable acidity, Ca and S in juice from immature cane and by P, Cl, total N and polyphenols in juice from mature cane.

Juice clarification characteristics of some sugar cane genetic stocks

S. Thangavelu and K. C. Rao. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, Ag.115 - Ag.123.

Significant differences were found between mud volumes and settling times of juice from 30 cane varieties as well as between the clear juice colour, which ranged from light yellow to brownish-yellow. Mud volume had a significant positive correlation with juice starch and silicon and a negative correlation (as did settling time) with reducing sugars, titratable acidity, ash and calcium.

Microprocessor-based control system for combustion optimization of boilers

S. K. Ghosh, M. L. Agiwal and J. K. Bhatnagar. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, E.1 - E.9.

See Agiwal *et al.*: *I.S.J.*, 1987, **89**, 47A.

Adoption of closed-loop condensate system and water heater for energy conservation

H. L. Verma, M. L. Agiwal and J. K. Bhatnagar. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, E.11 - E.19.

By introducing a closed-loop system, whereby 1st condensate from the evaporator for use as boiler feed was sent directly to the deaerator instead of to the feed tank, and using flue gas to heat the water at Mawana factory, the temperature of the feed water was raised from 95°C in the previous system to 119°C and the flue gas temperature reduced from 170° to 145°C, resulting in a bagasse saving of 28 tonnes per day. The investment costs of the system were recovered within 100 days.

Siphon the juice in evaporators for steam economy and efficiency

P. Sekharaiah. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, E.21 - E.24.

The benefits of inverted siphons to feed juice from one evaporator effect to the next are discussed, particularly in the case of vessels having sealed downtakes.

Potential of steam saving in Indian sugar plants with mechanical vapour recompression (MVR)

H. K. Khattar. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, E.25 - E.43.

The advantages of MVR in reducing steam consumption in evaporation are discussed with the aid of case histories from Indian sugar factories, and advice is given on compressor installation and operation.

Milling performance - an investigation

H. N. Gupta, D. S. Misra and S. C. Nigam. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, E.45 - E.53.

From examination of three mill tandems and pol analysis it is concluded that milling efficiency is generally affected by poor cane preparation and inadequate imbibition; it is shown how improvement in these two factors could allow the number of mills in a tandem to be reduced without adversely affecting performance.

Equipment design and instrumentation system for the sugar crystallization process in continuous pans

P. Kapur, V. L. Patil, G. K. Gautam, T. R. Vasudeva and G. N. Acharya. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, M.49 - M.59.

The advantages, operating principles and design of continuous vacuum pans are discussed and outlines given of 11 systems. Requirements of continuous boiling are listed and reference made to a monitoring system based on massecuite viscosity and resistivity.

Use of DNPT as bactericide

H. K. Dubey and R. C. Tewari. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, G.1 - G.5.

See Dubey & Tewari: *I.S.J.*, 1988, **90**, 115A.

Beet sugar manufacture

Protection of equipment against corrosion

I. K. Klebanova, V. P. Zubchenko and T. A. Vishnivskaya. *Sakhar. Svekla*, 1988, (2), 49 - 53 *(Russian)*.

Investigations at Yagotin sugar factory demonstrated the combined effects of atmospheric moisture and impurities (such as SO_2, chlorides and ammonia) and the aggressive nature of the material being handled in causing corrosion of equipment constructed from St.3 as commonly used in the Soviet sugar industry. The rates of corrosive destruction of the material in specific pieces of equipment used throughout the factory from the beet flume to the crystallizers were determined for up to 90 days, and the anti-corrosion effects of specific types of protective coatings then assessed for the same equipment. Results showed that a plastic based on ethyl cellulose was best; it completely prevented corrosion in all but four cases, and in these the rate of corrosion was very low. The various types of grease used in different countries are also mentioned.

A system approach is needed

A. P. Ponomarenko. *Sakhar. Svekla*, 1988, (2), 53 - 56 *(Russian)*.

A critical appraisal is made of the article by Oleinik *et al.*[1] describing a system for cossettes prescalding with bled vapour. It is felt that the results obtained were considered only in regard to diffusion, whereas they should have been examined also in relation to other aspects of the sugar manufacturing process and should have taken account of the extra quantity of live steam involved as well as other possible negative effects, e.g. of reducing the amount of K and Na in raw juice and foam formation. As an alternative, it is shown how adoption of a system engineering approach to the problem permits increase in the cossettes temperature and reduction in pulp losses with less increase in live steam demand by comparison with the original scheme.

Rate of dissolution of sucrose crystals in thick juice

V. V. Spichak and L. I. Trebin. *Sakhar. Svekla*, 1988, (2), 57 - 60 *(Russian)*.

The rate of dissolution of sugar crystals in thick juices of 92 purity, supersaturation in the range 0.74 - 1.00 and 0 - 25% concentration was determined at 30°, 40°, 50°, 60° and 70°C. From the results, an empirical equation was derived for use in melting, boiling and massecuite cooling calculations.

Dependence of the ζ-potential of carbonatation mud on lime consumption in defecation

S. P. Olyanskaya, L. M. Khomichak and V. A. Tsekhmistrenko. *Sakhar. Svekla*, 1988, (2), 60 - 62 *(Russian)*.

Investigations showed that gassing juice containing up to 200% lime by weight of non-sugars in the presence of pectin and albumin as polyelectrolytes caused the formation of mud particles having a negative charge; this also occurred when 300% lime was used in main liming where predefecation mud was not initially separated. Under these circumstances, recycling unfiltered 1st carbonatation juice or mud to preliming would not increase adsorption of the negative-charge non-sugars; the maximum zeta-potential corresponding to greatest non-sugars adsorption was found to occur at 100 - 130% lime on non-sugars.

First on-line controlled high-stack warehouse system in the sugar industry

H. Röhr and O. Grün. *Zuckerind.*, 1988, **113**, 295 - 297*(German)*.

A fully-automatic palleted storage system is described that was installed by Noell GmbH in the dispatch warehouse at Ochsenfurt sugar factory for about 100 various products, including packeted sugars. The shelving has a run of 73 m and is about 12 m high. Details are given of the stacking and retrieval procedures.

Additives and colour formation: effects of hydrogen peroxide

C. A. Accorsi, M. Peretti and P. Fontana. *Zuckerind.*, 1988, **113**, 299 - 303 *(German)*.

See *I.S.J.*, 1987, **89**, 107.

Mathematical modelling and simulation of the sugar extraction process

A. Korgul. *Zuckerind.*, 1988, **113**, 304 - 309.

A mathematical model developed for the DDS-type inclined-trough diffuser is described. Sugar extraction is simulated by partial differential equations; interpolated and subsequently integrated concentration gradients allow the sugar concentration to be found at any one point along the diffuser. Results obtained have been found to be adequate for process control.

Mathematical modelling of the process of crystallization by cooling allowing for initial crystal sizes

A. P. Kozyavkin and I. P. Mel'nik. *Izv. Vuzov, Pishch. Tekh.*, 1988, (1), 112 *(Abstract only)*.

The effect of initial crystal size on the specific and bulk crystallization rate, cooling period and rate and molasses exhaustion rate was determined and mathematical models were derived for the relationship between crystallization rate and cooling period as a function of cooling temperature and initial crystal size.

Investigation of the effect of crystal concentration on massecuite crystallization in crystallizers by the method of mathematical experiment design

A. P. Kozyavkin and I. P. Mel'nik. *Izv. Vuzov, Pishch. Tekh.*, 1988, (1), 112 *(Abstract only)*.

The effect of initial crystal content on

1 *I.S.J.*, 1987, **89**, 104A.

low-grade massecuite cooling in crystallizers was determined and mathematical models are presented of crystallization rate and cooling period as a function of initial solid phase content. Boiling low-grade massecuite to a crystal content of 38% is suggested.

Basic problems of an energy-saving economy in sugar factories

A. Laudanski. *Gaz. Cukr.*, 1987, **95**, 169 - 172 *(Polish)*.

In an examination of the various factors to be considered in endeavouring to reduce energy consumption in a sugar factory, the author emphasizes the complexity of the problem whereby finding a solution in one quarter may create further obstacles in another; hence, the need is for consideration of all the factors as they affect one another and not each in isolation. Thus, the need to reduce steam consumption must be balanced against the need to have sufficient steam for electricity generation, while there must always be enough reserve steam capacity to allow for fluctuations in evaporator parameters so that the process stations dependent on bled vapour do not suffer.

A radiation-ozone method of treating sugar industry effluent

J. Perkowski and M. Jezierski. *Gaz. Cukr.*, 1987, **95**, 173 - 176 *(Polish)*.

Further tests on treatment of waste water by a combination of gamma-radiation, exposure to a stream of ozone-containing air and passage through a trickling filter over layers of coke are reported[2]. Best results in terms of reduction in COD and BOD_5 (up to 62% and 77.5% decrease, respectively) were obtained by 7 hours' irradiation plus 7 hours' ozone treatment and up to 130 minutes' contact in the trickling filter. However, the costs of the method are considered prohibitive, although (it is suggested) they could be lowered.

Supplementary filtration of 1st and 2nd carbonatation juices, thick juice and remelt liquor at Guzów sugar factory

S. Solczynski. *Gaz. Cukr.*, 1987, **95**, 177 *(Polish)*.

Bag filters used in most Polish sugar factories for secondary filtration of carbonatation juice and standard liquor have a number of snags. At Guzów, they were converted to low-pressure (0.04 MPa) filter-thickeners; details and a diagram are given of the conversion, which reduced labour requirements, specific filter cloth consumption and sugar losses while increasing filtrate clarity and bringing about other benefits.

A flume drum-type water separator

F. Kozaczka. *Gaz.Cukr.*, 1987, **95**, 187 - 188 *(Polish)*.

An electrically-operated flume water separator basically consisting of a perforated drum rotating at 12 rpm is described.

Disinfection of barometric water using synthetic bactericidal preparations

B. Polec. *Gaz. Cukr.*, 1988, **95**, 207 - 209 *(Polish)*.

Three disinfectants were tested for their bactericidal effects on barometric condenser water in cooling ponds; their active components were (i) chloramine-B, (ii) trichloromelamine, and (iii) a complex of trisodium phosphate and sodium hypochlorite. Their performances were assessed in terms of pH stability, stability of the condition of the water, putrescibility (determined using methylene blue) and bacterial population. Both batch and continuous dosing were evaluated. Best results were given by (i) at 100 g/m^3 added over a 1-hr period once a day or at 20 g/m^3 added continuously.

Aerobic treatment of sugar factory wastes in the light of investigations conducted at the Institute of the Sugar Industry

J. Lewandowska and B. Polec. *Gaz. Cukr.*, 1987, **95**, 210 - 212 *(Polish)*.

Results of laboratory and pilot plant scale investigations conducted over a number of years at the Institute of the Sugar Industry (IPC) in Poland are summarized. The COD and BOD_5 were reduced by 90% and >90%, from 3000 - 8000 mg/litre and 2600 - 6000 mg/litre, respectively, with activated sludge provided retention in the aeration tanks used was in the range 3 - 8 days and the respective loads were about 1 g/litre/day and 0.8 g/litre/day. Pretreatment in accumulation tanks followed by 21 hours' treatment with activated sludge in aeration tanks gave final COD and BOD_5 reductions of 92% and 96%, respectively. Two-stage activated sludge pretreatment with recycling of the sludge after each stage with an average retention of 5.6 hr in the 1st stage and 8.6 hr in the 2nd stage was followed by aerobic treatment which achieved 83% and 95% reduction of COD and BOD_5, respectively; however, increasing the total pretreatment retention time by 50% gave reductions in the pollution parameters which exceeded 99% in both cases, while 1-stage pretreatment using excessive quantities of activated sludge gave almost the same results as the original shorter 2-stage retention. Activated sludge treatment of a mixture of factory effluent and domestic sewage in a 1:2 ratio gave 88% and 95% reduction of COD and BOD_5, respectively, after only 13 hours' contact in a 2-stage system, while 9 hours' contact gave a performance that was only 10% lower; the COD : N : PO_4 ratio was 100 : 6.4 : 2.18 in the mixture and 100 : 4.2 : 0.3 in the sugar factory effluent. The benefits of this method of treatment lay in the elimination of the need for pre-fermentation and for addition of N and P.

Desolvation in sugar solutions

B. Dorocakova, M. Konecna and V. Tibensky. *Listy Cukr.*, 1988, **104**, 78 - 80 *(Czech)*.

2 See Perkowski *et al.*: *I.S.J.*, 1988, **90**, 15A.

Juice purification removes a maximum of only 40% of the non-sugars; while most are finally discharged in molasses, some (particularly colloids) can cause crystallization problems in boiling. One method of increasing non-sugars removal is based on the desolvating action of organic solvents of low polarity such as acetone. Coacervation (separation of a lyophilic colloid into two immiscible liquid phases of differing concentration as used in sewage disposal) was studied in tests on beet juices in which treatment gave 50 - 85% decolorization, 25 - 95% decolorization and 40% removal of α-amino-N; acetone was less effective in colour removal in the presence of MgO, but its action was particularly improved by addition of pectin. A 1:3.5 juice:acetone ratio was better than a 1:2 ratio v/v except in the presence of MgO.

ADAT - statistical data processing with a microcomputer

L. Budicek. *Listy Cukr.*, 1988, **104**, 81 - 88 *(Czech)*.

ADAT (Analysis of DATa) is a conversational program for one- and multi-dimensional processing and provides a means of statistical analysis of experimental results whereby regression functions are calculated by the computer or are inserted by the user. Application of the program is described with the aid of print-outs.

Notes from a thematic visit to Poland

J. Radek. *Listy Cukr.*, 1988, **104**, 88 - 91 *(Czech)*.

Accounts are given of the activities of the Sugar Industry Institute in Warsaw and of the processes used at Ropczyce and Krasnystaw sugar factories.

Some thoughts on further developments in sucrose crystallization

K. E. Austmeyer. *Zuckerind.*, 1988, **113**, 389 - 397 *(German)*.

Secondary nucleation and the problems it can cause are discussed (including the advantage of continuous boiling in regard to the relative ease with which fines formation can be prevented). The physical fundamentals of nucleation and the significance of boiling by vapour expansion are examined. Pressure and temperature profiles in batch and continuous pans are compared; reduction of the height of the massecuite column greatly eliminates fine grain formation, as does intensive mixing combined with a relatively low massecuite feed point in cooling crystallization by vapour expansion. Incrustation problems, of particular relevance to continuous boiling, are discussed in connexion with nucleation; the mechanisms of incrustation formation are examined with the aid of photographs and preventive means are indicated. Comparison of mechanical and pneumatic circulation of massecuite has shown the latter to give a higher relative velocity as a result of the gas component in the heating tubes.

Problems with beet soil in the sugar factory

E. Muhlack. *Zuckerind.*, 1988, **113**, 400 - 402 *(German)*.

At Regensburg sugar factory between 100,000 and 200,000 tonnes of soil are separated from beets per campaign; it is mixed with flume and wash water and dumped in huge concrete basins where the mud settles out and the residual water is recycled to the flume system. The thickened mud is transported to coffers (each having an area of 2.5 ha and covering a total of 40 ha) in which it is spread to a maximum depth of 2.5 m. At the end of the campaign, a pair of disc wheels is pulled over the bed of soil to form drainage grooves, followed by laying of a bed of straw and sowing of grass seed; the straw prevents odour emission when the temperatures start to rise in spring, while the grass provides the fastest possible method of obtaining a green surface while also contributing to odour prevention and water absorption. Most of the soil is sold to tenant farmers, institutions and firms (for recultivation purposes).

Kinetic studies on low-grade boiling

V. Maurandi, G. Mantovani and G. Vaccari. *Sugar Tech. Rev.*, 1988, **14**, 29 - 118.

The fundamentals of current kinetic theories of crystal growth under the effects of volume diffusion and surface reaction are discussed, followed by an examination of the physico-chemical effects of impurities, including melassigenesis and the influence of impurities on crystallization activation energy. The effects of impurities on crystal growth kinetics are investigated, including the viscosity of impure as against pure syrups; specific impurities and groups of impurities considered include raffinose, reducing sugars, other carbohydrates, various organic substances, inorganic salts and colouring matter, while the kinetic effect of total non-sucrose is also examined. Crystal growth rates in low-purity syrups are discussed under various conditions such as constant impurity:water ratios and low supersaturation. Molasses exhaustion and the chief factors affecting the exhaustion of low-grade massecuite are analysed and a technique for low-grade massecuite treatment is outlined.

Experimental investigations of the carbonatation process at elevated pressure

T. Bogumil. *Gaz. Cukr.*, 1988, **96**, 25 - 28 *(Polish)*.

Small-scale experiments were conducted on carbonatation of water and lime in a vertical column at atmospheric pressure of 0.20 - 0.35 bar with a mixture of CO_2 and compressed air containing 10 - 40% of the gas.The enthalpy change involved in raising the temperature of the liquid to the requisite level was much smaller as a result of the use of pressure than in conventional carbonatation, thus reducing the heat loss and cutting the process time by up to 25%. (See also Lekawski & Urbaniec: *I.S.J.*, 1986, **88**, 69A.)

Sugar refining

Safety instructions for sugar silos

G. Dupire. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 14 pp.

Dust explosions in sugar and grain silos in France are mentioned, followed by a discussion of various aspects of bulk storage, including: four conditions under which, if they are simultaneously satisfied, a dust explosion will occur; means of preventing or limiting the effects of explosions; precautions to take in the design and construction of silos, conveyors and elevators as well as dust extraction equipment; and precautions to take in the operation and maintenance of silo equipment, including cleaning to remove accumulations of dust; and the part played by personnel in preventing fires and explosions. A detailed description is given of a sugar elevator accompanied by diagrams of an elevator and a dust extractor.

Multiple-hearth furnace. Ten years in review

B. T. Harrison. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 16 pp.

Details and diagrams are presented of a multiple-hearth furnace installed at Imperial Sugar Co. in Texas to regenerate all the spent granular carbon used for liquor decolorization. The components of the carbon feed and discharge systems are described and problems experienced in the operation of these two systems and of the furnace itself are mentioned together with their causes and remedies. Besides operating parameters and their threshold values above or below which alarms are actuated, details are given of the gas burner settings.

The need for better supervisory control in white sugar boiling

M. Braeckman. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 15 pp.

White sugar boiling is aimed at producing crystals of highest purity, correct shape and requisite size using the minimum of energy. The author discusses how the customer requirements may be satisfied and energy consumption minimized; he examines means used to control boiling parameters (with mention of automation of the batch pans at Tirlemont refinery in Belgium) and discusses crystal size and decolorization needs. The point is made that the production capacity of a refinery is often under-utilized, that incorrect boiling will lead to problems in storage while excessive fines or dust will cause caking unless remedial action is taken; increased colour and turbidity and inadequate filtrability are often causes for customer complaints and can lead to losses if rejected sugar is recycled. Modern means of analysing test data and evaluating boiling performance to provide a database for use as an aid in optimization are discussed.

Optimizing filter aid filtration cycles

R. H. Rees. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 22 pp.

The characteristics of kieselguhr and its properties as a filter aid are described. It is of benefit for three major reasons: (1) It prevents plugging of septa by undissolved solids in the liquor being filtered; a typical septum has about 2000 pores per in^2 whereas a 1/16-in kieselguhr precoat will raise this to about 2.5 million. (2) It facilitates septum cleaning by bridging the septum pores rather than filling them and taking undissolved solid fines with it when it is removed; in the absence of kieselguhr, these fines become embedded in the mesh of the septum. (3) It permits high-quality filtrate to be obtained from the start of the cycle; many fines and compressible solids will pass through an unprotected screen. In most filtration processes, kieselguhr must be body fed (admixed) so that the filter cake permeability can be maintained and thus extend the length of the cycle. Factors affecting filtration economy include: adaptability of the filter aid to the septum and of both to the undissolved solids particle size, the sedimentation tendency of kieselguhr particles, optimum amount of body feed (the more compressible and concentrated the undissolved solids the greater will be the amount of body feed required), body feed yield rate and cake space utilization.

Statistical process control - the new wave in quality assurance

R. Priester. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 14 pp.

Guidance is given on statistical process control and its application to quality and productivity. Although the subject is treated in general terms, the author is employed as Chief Chemist at Savannah refinery and uses a table of values of sugar ash contents determined at the refinery over a 20-day period as an example of how to prepare a control chart.

Stabilization of remelt liquor flow to the purification station

Z. Hotovy. *Listy Cukr.*, 1988, **104**, 108 - 110 *(Czech)*.

Faults in the operation of the remelt carbonatation station at an experimental factory refining cane raws were attributed to marked fluctuations in liquor feed leading to imbalance in liming and hence pH. The problem was solved by installing a constant-level tank through which the liquor flowed from the melter at a rate corresponding to a retention time of 2 minutes per m^3, thus allowing for a total of 16 min for a typical quantity of half the tank capacity; a signal corresponding to the fall in pressure as the liquor left the tank was transmitted to the milk-of-lime dosing controller. The system maintained pH to within $\pm$ 0.3 units in one of two carbonatation vessels and to within $\pm$ 0.1 in the other and increased the carbonatation station handling capacity by 15%.

Laboratory studies

Prediction of molasses sugar

P. Devillers. *Sucr. Franç.*, 1988, **129**, 87 *(French)*.

While various formulae currently available for estimation of molasses sugar from beet brei analysis include K, Na and α-amino N as the major non-sugars, they represent together less than 50% of soluble non-sugars in beet and are not completely extracted with sugar; hence, by implication, the formulae are based on correlations between determined and undetermined constituents. Moreover, these correlations have changed in line with improvements in beet development, e.g. α-amino N tends to represent only 0.2 mmol % beet by comparison with 2 - 3 mmol % 10 years ago, whereas other nitrogenous components have probably not changed to the same extent. Some beet laboratories also determine glucose, which at an average 10% of total non-sugars is a major component that should be included. From determination of the melassigenic coefficients of two major categories of impurity (the salts of alkali metals and molasses nitrogenous substances) and from examination of the relationship between molasses N and beet α-amino N in 180 samples taken from different regions of France over a 6-year period, a new formula has been derived for calculation of molasses sugar Sm; it takes the form Sm = 0.14 (K + Na) + 0.25 αN + 3.3 G + 0.30, where K, Na and αN are given as mmol % beet and G = glucose % beet (w/w). Recoverable sugar is given by pol - Sm - 0.7. An alkalinity coefficient above or below 1.8 has little effect on results, so that the distinction has been abandoned. The new formulae give values in closer agreement with average results obtained in the industry than previous formulae.

Varietal tests

M. Loilier and E. Dethune. *Sucr. Franç.*, 1988, **129**, 89 - 91 *(French)*.

The formula given in the previous abstract for molasses sugar was applied to samples of 25 beet varieties; the average value was 1.40% on beet compared with 1.11% given by an earlier formula (IRIS 84). The improved precision of the new formulae is attributed to the inclusion of glucose as determined enzymatically; it proved to be a criterion of beet quality, with low values in superior varieties, which also contained little (K + Na) and α-amino N.

Determination of reducing sugars separated by high-performance liquid chromatography with post-column coloration

G. Deruy and J. P. Lescure. *Sucr. Franç.*, 1988, **129**, 117 - 124 *(French)*.

The sample was eluted by water + calcium acetate through a Bio Rad HPX 87 C column containing cation exchange resin in Ca^{++} form (preceded by a pre-column), and *p*-aminobenzoic acid hydrazide added at the column exit; in the presence of reducing sugars an intense orange colour was formed which was measured by spectrocolorimeter at 410 nm. (For detection of non-reducing polysaccharides, a Bio Rad HPX 87 H column containing cation exchange resin in H^+ form can be placed after the separation column; this hydrolyses the polysaccharides and is of particular value for determining small concentrations of sucrose in a mixture of reducing sugars.) Excellent linear correlation was obtained (whether integration or peak height was used) for fructose, glucose, galactose and lactose added in concentrations between 50 mg/litre and 2 g/litre, with sensitivity decreasing in the order given. Linearity was also obtained for sucrose up to 10 g/litre, beyond which hydrolysis was inadequate. Details are given of the procedures used and results obtained for reducing sugars in beet leaves, petioles, crowns, roots and tails, cane syrup and refinery molasses and for analysis of starch hydrolysate added to beet pulp.

The determination of total solids in molasses by freeze drying

D. Y. Byfield and E. V. E. Roberts. *J.A.S.T.J.*, 1981, **42**, 60 - 66.

A freeze-drying method is described for molasses total solids determination which compared favourably with hydrometric, refractometric and vacuum drying methods. Good correlation (r = 0.94) was found between values given by the new method and refractometric Brix.

The composition of Jamaican final molasses

D. Y. Byfield and E. V. E. Roberts. *J.A.S.T.J.*, 1981, **42**, 66 - 83.

The major components of molasses samples from Jamaican factories were analysed and the average analysis found to be similar to that in other cane sugar-producing countries. The effects of the constituents on exhaustibility are discussed and a number of formulae derived for calculation of true purity as a function of K^+, Na^+ and Cl^-, respectively; the formula involving Cl^- was found to be the most promising.

The functions of the Sugar Industry Research Institute's Central Laboratory

L. Brown and H. Bourzutschky. *J.A.S.T.J.*, 1981, **42**, 131 - 138.

Aspects of the operation of the SIRI Central Laboratory in Kingston, Jamaica, are discussed. The laboratory was set up to monitor raw sugar quality by determining pol, moisture, ash, colour, dextran and grain size. An ion exchange/enzymatic technique for determining raw sugar is described.

The effects of results of sugar analyses on the apparent production of 96° sugar

J. Jaddoo. *J.A.S.T.J.*, 1981, **42**, 138 - 140.

Some Jamaican factories consistently reported higher raw sugar pol and lower moisture contents than the values determined at the Central Laboratory; the main reasons for the discrepancies are listed and the importance of accuracy in assessing payment is stressed.

Centrifugation prior to Brix measurement

Anon. *Ann. Rpt. Mauritius Sugar Ind. Research Inst.*, 1986, 47 - 48.

Tests on the use of a centrifuge to remove suspended solids from juices and molasses before refractometric Brix measurement showed no difference in Brix between centrifuging at 17,300 and 14,130*g* using a 6 × 94 ml rotor, while centrifuging at 14,130*g* for 10 minutes gave almost the same values as filtration through Whatman 91 paper for first and last expressed juice, mixed juice and molasses, while centrifuging is preferable since it is quicker, allowing six samples to be prepared for Brix measurement within 20 min regardless of whether they come from stale or burnt cane or are slow filtering; in some cases, juice may not filter at all. Since centrifuging is carried out in closed tubes, there is no risk of evaporation as occurs in filtration.

Automatic refractometers

Anon. *Ann. Rpt. Mauritius Sugar Ind. Research Inst.*, 1986, 48.

A Schmidt & Haensch Digital Universal Refractometer (DUR) was found to have good stability at the zero point and at each of three standard Brix values (20°, 14° and 3°) and gave highly consistent readings throughout a 12-day test period despite variations in voltage between 221 and 240 V and frequency fluctuations between 49.0 and 50.1 Hz. In tests for normal routine Brix measurement of factory products, simple flushing with distilled water between series of measurements was enough to return the refractometer reading to zero; no breakdowns, erratic readings or changes in the zero point were observed and the instrument operated without any problem throughout the test period. Although suspended solids in juices and molasses samples appeared to have a smaller effect on the readings of the DUR than on those of a Bausch & Lomb instrument and the Refractomat-L, it is still recommended to remove the solids beforehand.

Electrical conductivity of sugar systems and their activation energies

M. Prasad, P. K. Jain and G. D. Nigam. *Proc. 50th Ann. Conv. Sugar Tech. Assoc. India*, 1987, G.49 - G.56.

The electrical conductivity of sucrose, commercial sugar, sulphited and unsulphited syrup and KCl solution were determined at 25° and 55°C. Plotting conductivity *vs.* Brix curves showed clear maxima that are interpreted as a result of concentration and the mobility of ionic species. The activation energies are discussed in terms of ionic and protonic hopping conductance.

A note on the hemimorphism of sucrose

A. VanHook. *Ind. Sacc. Ital.*, 1988, **81**, 7 - 10 *(Italian)*.

As a result of sucrose crystal hemimorphism, the rate of growth of the right pole exceeds that of the left pole by a factor of at least 2, a relative difference that is maintained when the crystal dissolves; raffinose retards growth and causes marked elongation by reducing the extension of the right pole to only one-third to one-fifth of that of the left pole. Studies of the effects of fructose and glucose (individually and as invert sugar) on sucrose hemimorphism showed that both hexoses caused a marked reduction in growth rate (glucose causing greater retardation) and change in the ratio of growth rate between the right and left poles in both crystal growth and dissolution, but no particular changes in habit were observed other than marked development of q faces and some elongation of b/a.

Analysis by ion chromatography in the sugar industry

B. Tungland. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 17 pp.

Ion chromatography (IC) is a highly versatile technique with numerous applications in the sugar industry; the time needed for analysis of ions is much less than required for separate analysis of components of a sample, while the detection limits approach 1 ppm for most species and the relative precision is good for many components, with a maximum relative standard deviation of ± 0.9%. High-pressure gradient IC couples the efficiency and flexibility of HPLC with the specificity and sensitivity of IC for determining a multitude of different ions in complex matrices. The author describes the procedure and equipment used in IC and presents a number of chromatograms representing analyses of cane molasses, process waters and boiler feedwater, cane refinery products and dextrin. Since IC is specific for glucose, fructose and sucrose it is more suitable than polarimetry for sucrose determination in the presence of high levels of invert sugar.

Isolation of kestoses and nystose from enzyme digests by high-performance liquid chromatography

P. C. Ivin and M. L. Clarke. *J. Chromatogr.*, 1987, **408**, 393 - 398; through *Anal. Abs.*, 1988, **50**, Abs. 6D115.

The digests (0.10 - 0.15 ml) from yeasts β-fructofuranosidase or α-amylase were analysed on a 10-μm Radial-PAK cartridge (10 cm × 5 mm), with 379:121 acetonitrile:water, containing 0.01% of SM2 (Waters Assoc. amine modifier), as mobile phase (1.15 ml/min). The oligosaccharides were detected refractometrically and appropriate fractions were combined and evaporated. The residues were dissolved in water and the solutions again chromatographed on a 5-μm C_{18} Radial-PAK cartridge (10 cm × 8 mm), with water as mobile phase (0.5 or 0.7 ml/min). The calibration graph was rectilinear up to 3.0 mg/ml and 1-kestose, 6-kestose, neokestose and nystose were separated in sufficient purity to be usable as standards in the analysis of sugar cane process materials.

By-products

Leucrose - production and use

D. Schwengers, H. Benecke and H. Giehring. *Paper presented at Ann. Meeting Sugar Ind. Technol.*, 1988, 6 pp.

Leucrose is a disaccharide which contains glucose and fructose molecules with the fructose as a 6-membered pyranose ring. It is formed as a by-product in the synthesis of dextran from sucrose. At Pfeifer & Langen in West Germany, leucrose yields up to 80% have been made possible by optimization of dextran synthesis using dextransucrase, whereby cleavage of the sucrose molecule is followed by transfer of glucose from the fructose molecule in the sucrose to another fructose molecule by an a-1,5 linkage which is quite stable to hydrolysis under normal reaction conditions. Leucrose crystallizes at <70°C with one molecule of water which can be removed by heating under vacuum to 106°C; it has a m.p. of 158°C and about half of the sweetness of sucrose but is not cariogenic. Possible applications of leucrose in the food industry and as a chemical intermediate are discussed.

Pulp drying by superheated steam and mechanical recompression of steam

F. Pouillaude, P. Ternynck, B. Marcotte and M. Roche. *Zuckerind.*, 1988, **113**, 405 - 413.

See *I.S.J.*, 1987, **89**, 110; 1988, **90**, 59A.

Concept for changing the heat economy in beet sugar factories

E. Otorowski. *Zuckerind.*, 988, **113**, 437 - 440, 442 *(German).*

Three variants of a patented scheme are analysed in which superheated vapour from the evaporator is used for pulp drying; comparison is also made with a factory where the pulp is not dried and with a scheme in which all the pressed pulp is dried to 33% dry solids using conventional hot gases. Two of the variants are based on a final pulp dry solids content of 33% and one on 40% dry solids. The total fuel oil consumption ranges from 4.20 to 4.75 tonnes/hr for a factory slicing 5000 tonnes of beet per day as against 6.5 tonnes/hr where conventional pulp drying is used; details are given of electricity generation and consumption for each variant. In addition to the heat savings, the use of superheated vapour also has the advantage of avoiding oxidation of the pulp and keeping the pulp temperature at no more than 95°C. Control of the process is based on the temperature of the vapour at discharge from the dryer. Organic components such as vitamins are not affected by the superheated vapour.

A note on the utilization of processed swills and final molasses for pregnant sows

M. Anuez and M. Patterson. *Cuban J. Agric. Sci.*, 1988, **22**, 71 - 74.

Feeding 6.72 kg of a mixture of pig swill and final molasses plus 1 kg of cereal feed during one reproductive cycle increased the gestation gain and litter weights at birth and at weaning by comparison with the controls which were fed 2 kg of cereal feed. The molasses feed also increased the percentage of sows presenting heat and cost less to produce than the control feed.

Change: the challenge of the sugar industry

N. Rivero. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 7 - 11.

Since the growing and processing of sugar cane is vital to the economies of the Caribbean and Latin America, the challenge of unfavourable market forces has to be met by developing new and different uses of cane. The subject is discussed in broad terms with particular mention of ethanol manufacture.

Diversification of the government-controlled sugar industry in the Dominican Republic

V. M. Báez. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 12 - 34.

Because of reduced revenues for sugar produced by the 12 state-owned sugar factories in the Dominican Republic, a diversification program has been formulated under which the more efficient factories will continue to process cane and produce sugar, molasses, energy from bagasse, cattle feed and probably alcohol, etc., while cane land from the other factories will be used to grow a variety of other crops. Thermo-electric plant is to be installed in the sugar factories for co-generation and sale of surplus electricity to the national grid. The economics of producing alcohol in distilleries attached to sugar factories and mixing it with gasoline for use as motor fuel on the domestic market as well as exporting it are discussed.

Availability of Venezuelan public financing for alcohol projects

L. Alberú. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 35 - 41.

A scheme for financing alcohol-manufacturing projects in the various cane-growing countries of Central America and the Caribbean is described.

The utilization of the sugar cane industry by-products in Mexico: present status and outlook

L. E. Zedillo P. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 42 - 59.

Cane by-products utilization in Mexico is surveyed and details are given of the sugar industry (as represented by 70 factories) and of measures to prevent environmental pollution. Plants that utilize some of the by-products mentioned are listed, and the future outlook for the industry is examined.

The updating of our sugar industry concerning energy and by-products

J. Fernández. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 60 - 66.

The competition between the cane sugar

and corn syrup industries in the USA is discussed and a number of possibilities for the sugar industry are examined; these include production of a cane juice beverage that could be drunk on its own or mixed with fruit juices, manufacture of a sweetener or concentrate from cane tops, and the use of cane crop residues as feed for alcohol fermentation (yielding a diesel fuel that could be mixed with vegetable oils) or for newsprint manufacture. Mention is made of the Ryder Program initiated by the University of Miami in 1979 and designed for the Florida sugar industry but which failed to come to fruition.

Cane varieties for power production

S. J. Clarke and W. Keenliside. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 102 - 115.

It is shown that minimizing sugar recovery in order to maximize power production is not viable unless the value of the electricity exceeds that of the sugar. High-fibre cane varieties are probably not viable alone but may serve to extend a crop where there is demand for both power and ethanol; they are more suitable for alcohol production, perhaps after a single strike of sugar. These results were based on a computer program for calculation of material and energy balances involved in the processing and power options of a given variety; the processing options included variations in extraction and evaporation schemes, conventional or limited sugar production and alcohol fermentation of juice or molasses. High-pressure steam maximizes the net electricity production after balancing the internal energy requirements of the factory and/or distillery. Product quantities and expected revenues are given for typical and high-fibre varieties and trends in processing options are outlined.

The National Fuel Alcohol Program of El Salvador

C. E. Escamilla. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 116, 119 - 122.

The title program is intended to minimize surpluses of sugar to be sold on the world market and instead to produce alcohol from it for use as motor fuel (initially in a blend with gasoline but ultimately on its own, for which a complementary hydrated alcohol program would be formulated). A distillation plant at El Carmen sugar factory was developed as the first step in the program (originally it had been planned for alcohol manufacture from molasses) with a production target of 20 million gallons per year. A 15% alcohol:gasoline mixture is already being marketed in the country under the name Enerhol.

Technological progress in rum production and its impact on the economy of producing countries

O. C. López. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 123 - 129.

An account is given of the developments in rum manufacture in Caribbean countries during 1940/60 and 1960/86 (with the introduction of light rums). The advantages of vacuum distillation over the atmospheric process lie in the very much lower fuel and steam consumption and virtual freedom from scale, so that production can be maintained at a constant level; flow sheets are given of both processes as well as of continuous distillation. Besides the introduction of vacuum distillation, other improvements have been in the sale of CO_2 produced during the fermentation process, the treatment of rum with active carbon and purification of rum dilution water by ion exchange. The marketing of rum and tax revenues from it are discussed.

Sugar cane molasses as an important aid in the fermentation of hydrolysates - a brief experimental summary

M. A. Suárez C. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 130 - 135.

In pilot plant experiments on continuous alcohol fermentation of acid hydrolysate obtained from wood waste, ammonium diphosphate as nutrient source became too expensive for the size of the plant and was replaced with raw molasses diluted to 10:1 or 8:1 for best saccharification. Use of 5% molasses allowed omission of multiple-effect evaporation that would have been needed to bring the hydrolysate to a required sugar concentration, while other advantages included a sufficiency of nutrients to allow a strong fermentation (vigorous fermentation neutralizing the action of toxins present in the hydrolysate); Ca and Mg in the molasses removed the need for lime or other base to adjust the pH to 4. Removal of the sulphate ash in the molasses allowed fermentation to progress much more efficiently.

Possibilities for ethanol in the Caribbean

W. A. Mellowes, C. C. Inkim, R. E. R. Lewis, A. C. Pilgrim and D. Maharaj. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 136 - 142.

A survey was carried out of potential raw materials other than cane molasses for ethanol production in the English-speaking Caribbean countries, where it has been traditionally used for rum manufacture. Fermentation of hydrolysed cane tops and Guinea grass *(Panicum maximum)* using *Fusarium oxysporum* gave an ethanol content in the fermentate of 0.30% and 0.35%, respectively, corresponding to a yield of 60 - 70 litres/tonne. Although bagasse has been found to yield 100 - 150 litres/tonne, the technology is not considered economically viable, but the hydrolysate could be added to molasses, while the possibility has also been suggested of using bagasse from high-fibre cane as fuel to produce electricity while alcohol could be produced from the juice and molasses. Of various vegetables and fruits considered as potential material for ethanol production, bananas are regarded as the most promising; biomass availabilities in the form of cane by-

products, sugar, vegetables and fruit are tabulated for 7 countries.

Mexican alcohol development from final molasses

C. S. Peck. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 143 - 152.

Data are presented on ethanol production from final molasses in Mexico as well as alcohol consumption, installed capacity, production costs and molasses availability. There are currently 35 distilleries in operation, all adjacent to sugar factories and having installed capacities ranging from 3000 to 62,000 litres/day; utilization of the total capacity was 73% in 1984 and 69% in 1985, while increase in alcohol consumption (increasing by an average of 10 million litres per year) is slow. Possible alternative uses of alcohol are considered. The question of vinasse treatment and disposal is discussed; some factories already use it as cattle fodder (the formulation is given of a ration containing vinasse, bagasse and molasses) and others apply it as fertilizer via irrigation systems, while the potential of vinasse as fuel is under study, particularly in the form of biogas from which to generate steam for use in the distillation process.

Technology of alcohol production: technical, financial and development aspects

D. Urdaneta and S. Parisca. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 163 - 175.

A process for ethanol manufacture from clarified and pasteurized cane molasses by continuous fermentation with recycling of yeast and vinasse is outlined. (In the case of *A*-molasses, clarification should be carried out in the factory without liming so as to allow separation of Ca as sulphate.) The clarification muds, containing up to 20% fermentable sugars (representing 5 - 7% of the alcohol produced), are washed and separated. Alcohol is recovered from the CO_2 produced during fermentation by extraction with molasses dilution water in a tower which also acts as an anti-scum system. The benefits of the process, including a smaller capital investment, a higher overall efficiency and a higher internal rate of return than with other systems in which vinasse is not recycled, are due mainly to the greater volumetric productivity resulting from yeast recycling and to the substantial reduction in the final amount of vinasse for treatment and disposal. Detailed analyses are given of the technology and financial aspects of three model cases.

Considerations on the process of technological development in engineering corporations of the Third World

D. Urdaneta and S. Parisca. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 176 - 182.

The value of simulation models of alcoholic fermentation of cane syrup for the development of suitable technology in developing countries is discussed with the aid of a mass and energy balance.

Utilization of bagasse for chemical recovery: furfural

R. E. English. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 185 - 190.

Steam treatment of bagasse followed by distillation of the condensed vapours and separation of the components yields 1 tonne of furfural per 14 tonnes of bone-dry bagasse plus 500 units of acetic acid and 20 units of alcohol; 95% of the initial fibre is recycled as boiler fuel. The economics of the process are discussed.

Rational utilization of bagasse and its contribution to the sugar factory economy

L. Galeazzi. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 191 - 193.

The sale of bagasse as raw material for paper manufacture in Mexico (where 30% of the cellulose consumed by the paper industry comes from bagasse) has helped maintain the sugar industry, but the author considers that much more money remains to be saved by using bagasse as raw material for other products instead of burning it as fuel. Brief mention is made of the importance of proper storage so as to avoid unnecessary bagasse losses and deterioration.

By-products from molasses and bagasse

R. Katzen. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 194 - 199.

Descriptions are given of yeast manufacture from diluted cane molasses or cane juice by continuous or batch fermentation using a culture of *Saccharomyces cerevisiae* to give a product suitable for use as animal fodder and for human consumption, and of pulp manufacture from bagasse using ethanol and water at elevated pressure and temperature to free and extract lignin and part of the hemicellulose, thereby giving a high-quality product in a final yield that is higher than with conventional kraft pulping without pollution or odour problems. Flow sheets of the processes concerned are provided.

Bagasse and molasses utilization in the formulation of complete ruminant diets

R. H. Singh, S. K. Sankat, P. O. Osuji, B. Lauckner and L. Goberdhan. *Proc. Inter-Amer. Sugar Cane Seminar*, 1986, 217 - 226, 229.

The requirements of a suitable diet for cattle are discussed against the backcloth of conditions in Trinidad and Tobago, and experiments with heifers are reported in which a high-energy diet based on treated bagasse mixed with molasses was compared with a pasture extender (treated bagasse-based fodder plus 2 kg of a dairy ration), untreated bagasse mixed with molasses in a 73:27 proportion plus 2 kg dairy ration, and chopped fresh grass. Results showed that the high-energy ration gave highest live weight gain and was economically the best.

uneconomical not only because of their high cost but also that of the required increase in lime dose. This has been observed by CEERI scientists during a number of experiments carried out in one season in a sugar factory.

Two different types of experiments carried out by CEERI, one during preliming and another during shock liming, indicate that if the initial P_2O_5 content before liming is increased from about 313 ppm to 423 ppm (i.e. by 35%) the lime doses needed to attain pH 7.5 in the preliming and shock liming stages are increased by a factor of almost 2.5 to 3. This is shown in Figures 9 and 10.

The authors, therefore, strongly recommend that the content of phosphate in mixed juice should be kept within the limits of 300 to 330 ppm.

Action of shock liming and sulphitation

It is more appropriate to consider the action of shock liming and sulphitation together, since, as already explained, the shock lime treatment has to be short-lived and the analysis of its effects can appropriately be made only after sulphitation.

Normally because in shock liming the pH increases from 7.2 to various higher values, the CaO content of the final treated juice (after SO_2 treatment) also goes up until a particular value of pH is reached, after which it comes down as the other reactions take place, i.e. formation of sulphates and other insoluble compounds. The experimental curve of CaO content of purified juice *vs.* pH indicates this (Fig. 8).

The action of SO_2 goes far beyond the simple neutralization of excess lime, which in any case will take place at high alkalinity levels attained during shock liming. It can be summarized as follows:

(i) It neutralizes excess lime to form insoluble calcium sulphite ($CaSO_3$) which can be separated by filtration. If, however, more SO_2 gas is passed, part of the calcium sulphite is converted to calcium bisulphite; this decomposes at high temperatures and releases SO_2 which corrodes pipelines. Hence high acidity through SO_2 bubbling should be avoided and juice kept almost neutral with pH around 7.

(ii) SO_2 bleaches the juice by reaction with the colouring matters.

(iii) It decreases the viscosity of juices.

(iv) It reduces to colourless compounds the ferric salts formed in the juice owing to contact with the mills.

Over-sulphitation can also have a harmful effect on the heavy precipitate of calcium phosphate which is formed earlier, thus defeating the very purpose of purification and clarification. It can be oxidized to form sulphuric acid; this

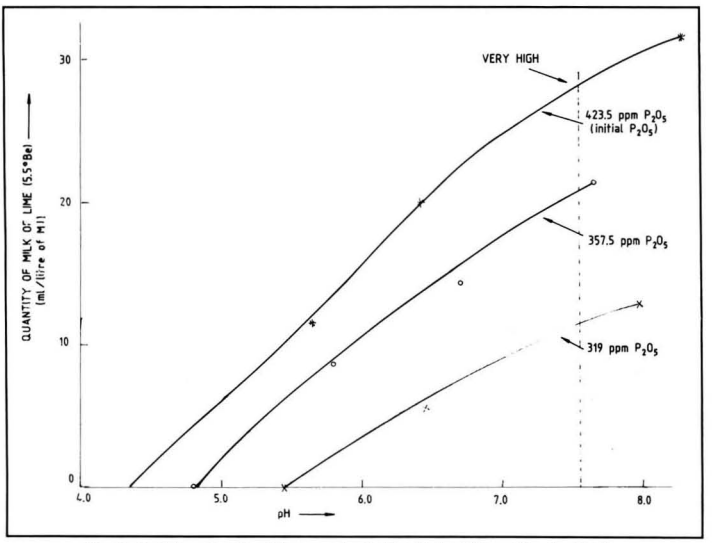

Fig. 9. Variation of milk of lime required with pH for different levels of P_2O_5

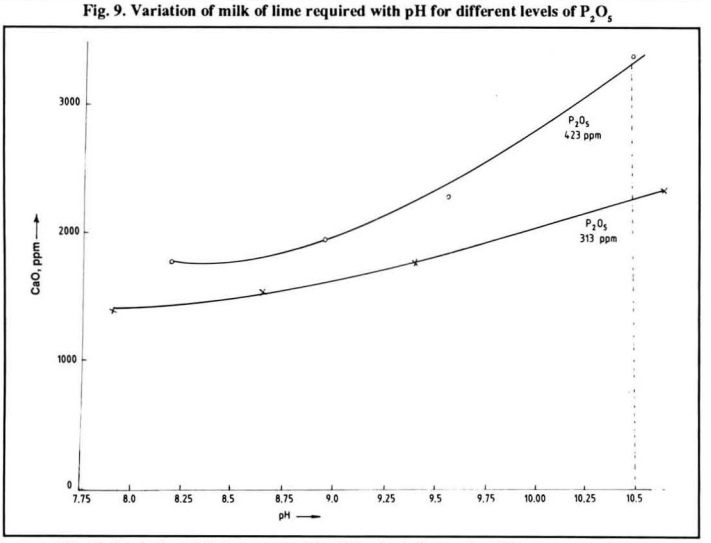

Fig.10. Variation of CaO content with pH in shock liming for different levels of P_2O_5

reacts with the tricalcium phosphate formed earlier to form a mixture of monocalcium phosphate and calcium sulphate. Both $CaSO_3$ and $CaSO_4$ have lower solubility at 70°C than at room temperature and they are precipitated along with the phosphates.

High levels of SO_2 should be avoided, which is possible if final pH is well controlled to be around 7 ± 0.1. Furthermore, once such flocs and precipitates are formed, they should not be disturbed by energetic stirring. The natural flow of juice is established in the JPMA-modified design to ensure good completion of the reactions. If a stirrer has to be used at all, its speed must be less than 60 rpm.

Scaling in evaporators

Any discussion on the purification of juice would be incomplete without giving due consideration to scaling, which depends on many factors such as the composition of raw juice, chemical composition of the water used for imbibition during extraction, the method and extent of purification, juice flow rate, etc, as discussed below.

It is now well recognised that certain impurities in the treated and clarified juice which are carried to the evaporator cause scaling of the evaporator vessels and tubes, and contribute to reduction in the heat transfer coefficient. These should be removed in the early stages of purification, or in the flash tank using some additives in the form of electrolytes. The flash tank treatment improves the flow rate also which ultimately affects the scaling rate.

The type of scales and their heat transfer coefficient are in the range indicated in Table IV. Observations published by Sonepat Sugar Mills in India are given in Table V.

From the above observations, as well as those made by many other workers, it is obvious that silicates are the scales causing greatest reduction of the heat transfer coefficient, bringing it down below 0.3. Silica scales are quite hard and look like glassy crystals.

One can see the large phosphate deposit in this and the earlier analysis. Normally this is a part of the clarification process itself, but calcium phosphate is normally an amorphous deposit and is easily removable. Calcium silicate can be troublesome and should be removed. Maximum removal of any of the above impurities occurs normally over a small range of pH values as has been observed by Honig. This is indicated in Table VI.

Table IV. Approximate analysis of evaporator scales

Type of scale	Category	Heat transfer coefficient, BTU/ft²/hour
Complex organic compounds	Amorphous	0.2 to 0.4
Organic acids	Crystalline	0.6 to 1.0
Phosphates	Microcrystalline	0.3 to 0.7
Sulphates	Crystalline	0.6 to 1.0

Table V. Effect of various scales on heat transfer coefficient

Types of scale	Category	Heat transfer coefficient BTU/ft²/hour
Phosphate (of Ca or Mg)	Microcrystalline	0.3 to 0.7
Sulphate ($CaSO_4$)	Microcrystalline	0.6 to 1
Silicic Acid (as SiO_2)	Amorphous	0.15 to 0.35
Carbonates ($CaCO_3$)	Crystalline	0.35 to 0.7
Sesquioxides ($Al_2O_3 + Fe_2O_3$)	Amorphous	0.3 to 0.55
Organic acids	Crystalline	0.6 to 1

Table VI. Approximate range of pH values corresponding to maximum removal of commonly occuring scaling compounds

Type of impurity	Range of pH values corresponding to maximum removal
Phosphate (as P_2O_5)	8 to 9
SiO_2	9 to 10.5
($Al_2O_3 + Fe_2O_3$)	9.5 to 10.5
Gums	7 to 9
MgO	9.5 to 10.5
Proteins	6 to 8
Waxy matter	7 to 9

As already discussed, quite a few of these impurities get precipitated in the shock liming stage (pH around 10) of the MAPCON system of CEERI design involving three stages.

Microprocessor-based automatic pH control system for juice purification

Discussion so far has brought out the following important considerations:

(i) Accurate measurement and control of pH values at the different stages of reaction is necessary.

(ii) The time for which the reagent remains in contact with the juice at very high or very low pH, at a given temperature, is somewhat critical and may have detrimental effects if it exceeds certain limits.

(iii) The quantity of the reagent used in the reaction has to be properly controlled so as to ensure optimum control of the process and removal of non-sugars.

Time and again it has been proved that manual control of the reagent feed to meet the above requirements is impossible and some kind of automatic control based on continuous monitoring of the pH value is the best approach for handling this problem.

Recent developments in the field of microprocessors which mainly perform the function of the Central Processing Unit (CPU) of computers have helped in achieving this goal through a dedicated Microprocessor based Automatic pH Control system. In the MAPCON system, designed and developed by CEERI, Pilani, which has been referred to earlier, there are three independent PID control loops for controlling the three pH values for optimum operations of preliming, shock liming and sulphitation. The methodology of setting the pH values with the help of a chemist has been discussed above.

A block diagram of the MAPCON system is given in Figure 11

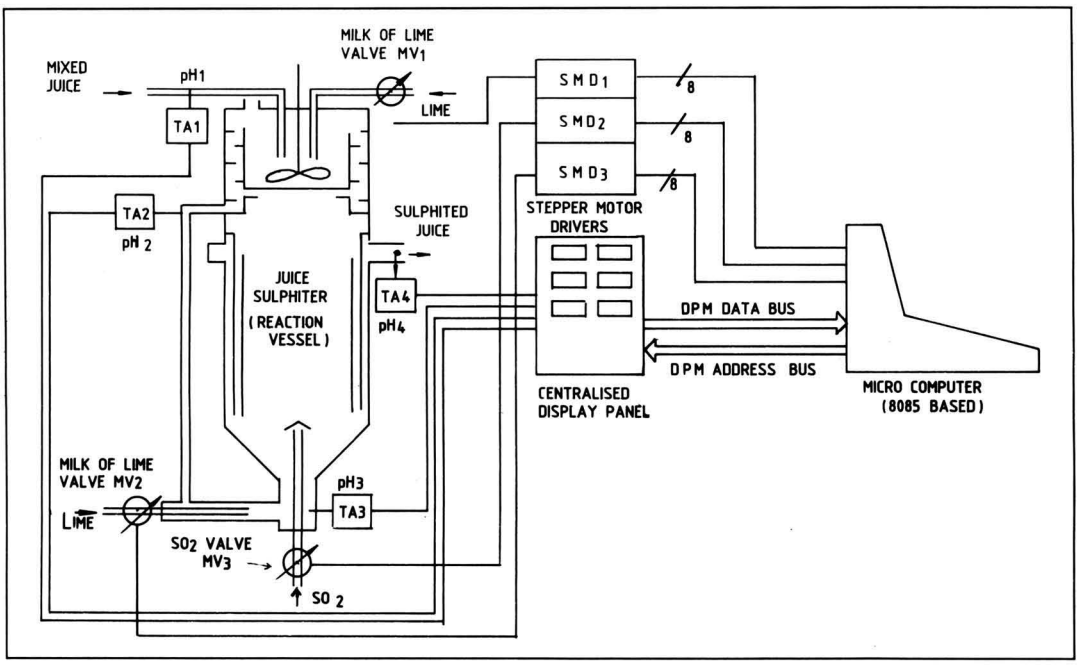

Fig. 11. Microcomputer controlled automatic pH control system (MAPCON) developed at CEERI for control of lime and sulphur dioxide in juice purification

in which the three stepper motor controllers for controlling the lime feed valves and SO_2 valve specially designed at CEERI are shown. The system uses a micro-processor in a multitasking mode and compares the three actual pH values with the corresponding set values and controls the reagent feeds to bring the pH values ultimately within ± 0.15 of the set values. Typical set values for preliming, shock liming and sulphitation are 7.2, 10.2 and 7, respectively.

A few prototypes of the system with some variations have been tried out in commercial sugar factories with good results as indicated above.

Results obtained during one season using the MAPCON system for juice purification in some factories are summarized below.

(i) Reduction in CaO content of clarified juice by 200 to 300 mg/litre compared with manual controls.

(ii) Reduction in the variation of the pH from the set value of 7 for clarified juice (± 0.25 pH compared with ± 1 pH with manual controls).

(iii) Reduction in the number of cleaning operations and also reduction in the time required for each cleaning operation (typically 37 hours compared with 60 - 65 hours required earlier in some factories).

(iv) Higher settling rate and higher mud levels indicating better precipitation of impurities.

(v) Rise in apparent purity without decomposition of invert sugars.

In the opinion of the authors, pH control with the MAPCON system, in which precipitation of impurities is done in three stages using a single microprocessor in a multitasking mode, needs to be introduced in a number of factories in India and, depending upon the results obtained in each factory, minor modifications can be made as required to suit the local conditions.

One of the modifications that is possible would be the introduction of a digital juice flow controller for on-line measurement of the juice flow to adjust the preliming dose based on proportional control and stabilize the juice flow and proportional lime flow for a fixed milk of lime density. This may help further in the juice evaporation stage and would give a coarse control of the preliming process.

Another modification would be stabilization of % SO_2 in the sulphur furnace gas mixture, enabling finer control of SO_2 feed to get the final pH value within narrow limits for good precipitation. Any modification of this dedicated microprocessor controlled system for juice purification which can maximize non-sugars removal, leading to better clarification, higher settling rate, better decolorization and higher flow rate with ultimately lower scaling of evaporators, would certainly be helpful in achieving the goal of higher productivity of good quality sugar.

One more possibility is the pre-

treatment of the Oliver filtrate before sending to the reaction vessel to improve the clarification efficiency.

Acknowledgements

The authors wish to express their gratitude to the managers and chief chemists of all the sugar factories who helped CEERI in providing the necessary field data for this paper. The authors are also grateful to the CEERI scientists, particularly Mr. M. V. Subba Rao and Mr. C. R. Thomas, who contributed to the design and development of the system and also helped in the measurements and field trials of the automatic pH control equipment in commercial sugar factories.

Summary

After a brief review of the juice purification processes practised in India for the production of direct consumption white sugar an analysis is made of the comparative merits and demerits of the three processes commonly used.

The role of pH in the removal of non-sugars and analysis of the reactions involved with the various reagents used for purification are presented. The automatic pH control system using a digital dual set-point controller and microprocessor-based three-stage controller designed and developed by the authors are discussed in brief. Results obtained with the microprocessor-based automatic pH control system introduced by the authors in Indian sugar factories are also presented.

It is concluded that the microprocessor-based controller with three different control loops for preliming, shock liming and sulphur dioxide injection is the most suitable for cane sugar production. Further modifications to such controllers for juice flow stabilization and SO_2 generation are suggested for still better results.

Automatización de la purificación del jugo de caña en la India

Después de una breve revisión de los procesos de purificación de jugo practicado en la India para la producción de azúcar para el consumo directo, se hizo un análisis de los méritos y deméritos comparativos de los tres procesos comúnmente usados. Se presenta el papel del pH en la remoción de no-azucares y el análisis de las reacciones involucradas con los diferentes reactivos usados para la purificación. Se discute también, en breve, el sistema de control automático del pH usando un doble controlador digital de punto fijo y controlador de tres etapas basado en un microprocesador diseñado y desarrollado por los autores. También se presentan los resultados obtenidos con el sistema de control automático del pH basado en un microprocesador introducido por los autores en las fábricas de azúcar de la India. Se concluye que el controlador basado en el microprocesador con tres lazos de control diferentes, para pre-calcificación, calcificación de choque e inyección de dióxido de azufre, es el más apropiado para la producción de azucar de caña. Se sugieron, para aún mejores resultados, modificaciones posteriores a tales controladores para la estabilización del flujo del jugo y para la generación del SO_2.

Automatisation en Inde de l'épuration du jus de canne

On passe brièvement en revue les processus appliqués en Inde pour l'épuration des jus en vue de la production de sucre blanc pour la consommation directe. On fait ensuite une analyse comparative des mérites et des inconvénients des trois procédés généralement utilisés. On présente le rôle du pH dans l'élimination des non-sucres et on fait une analyse des réactions qu'impliquent les différents réactifs utilisés pour l'épuration. On discute brièvement les systèmes de contrôle automatique du pH à l'aide d'un appareil digital de contrôle à deux points de référence, ainsi que d'un appareil de contrôle à trois niveaux et avec microprocesseur, conçu et développé par les auteurs. On présente les résultats obtenus avec le système automatique de contrôle du pH (basé sur microprocesseur). Ce système fut introduit par les auteurs dans des sucreries des Indes. On conclut que ce contrôleur avec microprocesseur, comprenant trois circuits différents de contrôle pour le préchaulage, le chaulage massif et pour l'injection du SO_2 est celui qui convient le mieux pour la production du sucre de canne. En vue de l'obtention de résultats encore meilleurs, on émet des suggestions pour de nouvelles modifications de ces appareils de contrôle pour la stabilisation du débit du jus et pour la génération du SO_2.

Facts and figures

Costa Rica co-generation project[1]

California's State Energy Commission has agreed to provide technical assistance to Costa Rica for the development of alternative energy projects including one for a sugar cane fuelled co-generation plant.

Mexico drought[2]

Drought in the cane growing regions of Mexico reduced sugar production to 3.6 million tonnes, against 3.7 million tonnes in 1986/87; however, no reduction is expected in domestic consumption and exports in 1988 are expected to reach 950,000 tonnes, or 400,000 tonnes more than in 1987.

New sugar factories for India[3]

Although three cooperative sugar factories in Gujarat state have been liquidated, the state government has sought permission to open four new units in South Gujarat. The new factories, proposed to be set up in Surat and Bulsar districts, will each have a crushing capacity of 1250 tcd. Justifying the proposal, the government has pointed out that South Gujarat gets heavy rain and is well irrigated from the Ukfi Kakrapur reservoir. Three more cooperative sugar factories have been approved by the Central government for the state of Haryana; they are to be set up at Bhuna in Hissar district, Kaithal in Kurukshetra district, and Maham in Rohtak district. The new factories, costing 750 million rupees, will be the biggest in the state's cooperative sector.

Dominican Republic sugar rehabilitation contract[4]

Walkers Ltd. of Australia has won contracts worth a total of $7.7 from the Dominican Republic's State Sugar Council to supply and install equipment for the sugar rehabilitation program.

1 *Amerop-Westway Newsletter*, 1988, (177), 10.
2 *GEPLACEA Bull.*, 1988, **5**, (8), Sugar Inf.-2.
3 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 464, 527.
4 *Amerop Newsletter*, 1988, (178).

Sensors for computer control of white sugar vacuum pans

By Mike Donovan
(Tate & Lyle Research & Technology, Reading, England)

Introduction

Within the Tate & Lyle Group of companies are refineries in several different countries producing white sugar to a variety of different specifications. The white sugar pans within these refineries are of different design and with different levels of control. At Tate & Lyle Research and Technology we have worked on several projects with our refineries to improve the control of white sugar pans, particularly those with computer control. We have been aiming to reduce pan boiling time, and to increase the quality of product. Several of our refineries are now trying alternative pan sensors, particularly gamma ray densitometers. The aim of this paper is to give information on our experiences with various pan sensors, including a gamma ray densitometer.

Existing control systems

Within the Group there are pans which employ most of the "usual" sensors for establishing the state of the liquor or massecuite in the pan, including temperature and pressure for Boiling Point Elevation (BPE), refractometers, rheometers, agitator power and of course, the proofstick. All of these methods have their advantages and disadvantages, and have been used for a number of years. They are all good practical techniques but, as we try to increase capacity in the pans and improve the quality of product, we see the limitations of these methods.

Boiling point elevation

One technique used to control a pan is to use boiling point elevation (BPE) to identify the seed point, and then to use agitator power to control feed to the pan, tighten the pan and indicate dropping point. The BPE method requires high accuracy of temperature and pressure measurements, and because of practical problems these are not easy to achieve on a routine basis. The reasons for this are relatively straightforward and shown in Figures 1, 2 and 3.

M. Donovan

Figure 1 shows constant pressure lines on a temperature/concentration graph. If we consider the 6-in Hg abs (200 mbar) line, the liquor will be evaporated along this line to the seed point. The temperature rises as we progress along this constant pressure line but, as can be seen from Figure 1, the temperature rise is quite small. For a 1°Bx rise in concentration, the temperature rise is only about 1°F. If we look at the supersaturation lines on the same graph we see that a difference of 1°Bx can mean a change in supersaturation from say, 1.2 to 1.25, which is quite significant. To obtain an accuracy in supersaturation of say 1.2 ± 0.02 i.e.

Paper presented to Sugar Industry Technologists, 1988.

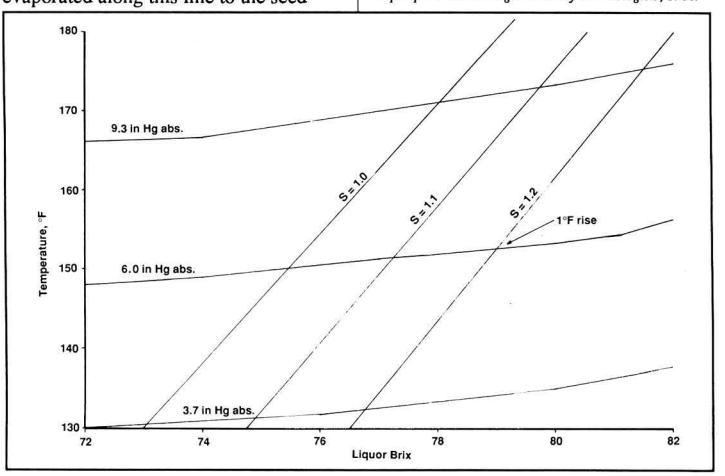

Fig. 1. Pure sucrose solubility chart

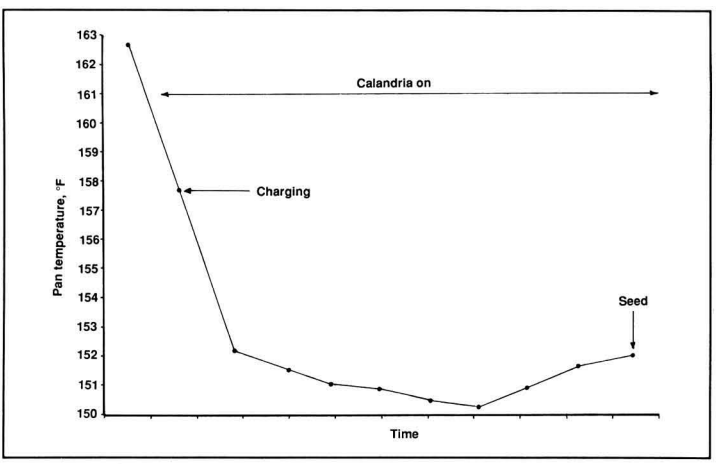

Fig. 2. Temperature trend

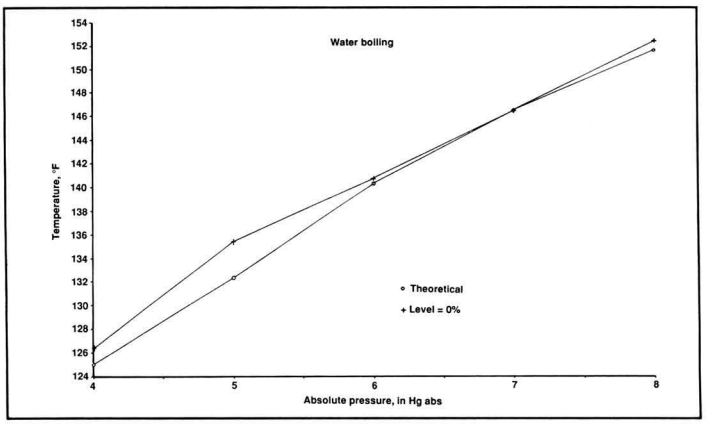

Fig. 3. Pan thermometer calibration

±10% of over saturation, we need to measure temperature to within ± 0.4°F and pressure to within ± 0.06 in Hg.

A second problem is that the liquor is not going to advance steadily along the constant pressure line. As we push evaporators to higher Brix we find that the feed will flash to perhaps only 1°Bx or so below the seed point. Thus the temperature first decreases to the constant pressure line, but this takes a period of time owing to the liquor flashing down from the feed temperature. However, since the calandria steam is put on as soon as the pan is charged, the temperature starts to rise again, although for a period of time after putting the calandria on the temperature is still decreasing. Thus the temperature decreases, reaches a minimum and increases again over a period of several minutes as shown in Figure 2. A short time after it starts to rise it reaches the designated seed temperature. It is more likely that the temperature at this point is not an equilibrium temperature, and thus is unlikely to represent an accurate value.

The third problem is the influence that a large heating mass such as a calandria can have on the liquor. Figure 3 shows the difference in temperature near the surface and above the calandria for water with steam in the calandria. In water the temperature above the calandria can be 0.5 to 3°F higher than calculated theoretically from the pressure. Prior to this test the pressure gauge had been accurately calibrated. As this degree of superheating occurs with water that has low viscosity, the amount in liquor can be expected to be higher.

Despite the problems pans can be successfully boiled using BPE, mainly because the errors are caused by dynamic factors, and in routine operations the same time-scales tend to apply.

Refractometers

The use of refractometers in pans has been questioned owing to their slow response, which is probably due to the rate of movement of liquor over the prism. We have had a recommendation from a refractometer manufacturer that the flow rate across the prism should be 1.5 metres/sec. Our calculations using typical stirrer pumping efficiences show that even the flow rate in the tubes of the calandria, probably the highest flow rate in the pan, is probably not this high. The slow response problem is compounded if there is poor mixing in the pan and doubts over whether the refractometer is "seeing" a representative sample. We have also had problems maintaining the accuracy of refractometers in pans. Again we do use refractometers regularly to identify seed point. Provided we are not looking for a fast response system, and the dynamics are similar for each strike, we can get reasonably consistent results.

Agitator power

Agitator or stirrer power is regularly use to control feed rate and identify the end-point of boiling. Limitation in its use due to lack of sensitivity; we have shown that an agitator cannot give a usable reading until there is more than 40% of crystal in the liquor, as the consistency is just not different enough from that of liquor; thus the reading cannot be used to open the feed valve until crystal content reaches this value. From this point on it seems to give good control, and it appears to be good practical technique that we regularly use.

Rheometers

We use rheometers both in white sugar pans and in recovery pans. They need to be very sensitive to measure seed point in white pans, and need a considerable amount of maintenance to keep this sensitivity. It is also possible that different crystal content/mother liquor combinations can give the same readings, leading to confusion in a control system. In one of our refineries we practise "heavy boiling", and the rheometer paddle or probe would soon be destroyed.

Gamma ray densitometers

We decided to test gamma ray densitometers to overcome some of the problems mentioned in the previous sections. We were looking for an instrument that could provide measurements of liquor and massecuite accurately, that could show a quick response to change, could measure a representative sample of material, and had low maintenance costs.

The principle of being able to measure density of liquor in order to give seed point, and density of massecuite to control feed rate, appeared to be a good one. We decided to carry out tests in a small pilot rig to obtain an idea of the likely accuracy, and establish how

to compensate for temperature. This pilot rig was a vessel in which we could carry out measurements on liquor at the required Brix and temperature, and to which we could add known quantities of crystal to provide a massecuite.

The principle of the gamma ray densitometer is that gamma rays are absorbed in proportion to the density of the material being measured. The instrument transmits a beam of rays over several inches of the material and the number of counts detected by a scintillation counter are measured. The strength of the beam detected is inversely proportional to the density as gamma ray absorption reduces at lower density. The value represents the density of the material at the measurement temperature. It does not matter whether the material being measured is liquid, solid or a mixture of the two, such as massecuite. As density is a known function of temperature for sugar liquors it is relatively straightforward to correct it back to 20°C for comparison with a Brix reading taken at this temperature in the laboratory.

Although temperature comparison is available within these instruments we preferred to use the actual density reading or, depending on the use of the reading, use the control computer to calculate Brix or density at 20°C. Bubnik *et al.*[1] give densities for sucrose solutions at dry substance levels of 65 - 82% and temperatures of 40 - 95°C, and we used their data for our temperature compensation formula.

Figure 4 shows results of our pilot tests covering liquor and massecuite at various temperatures. We measured the Brix of the liquor using laboratory refractometers and were able to calculate the density of massecuite by knowing the amount of sugar crystal added to a saturated solution. The graph shows the linear relationship of counts with actual density, for both liquid and liquid/crystal mixtures over a range of temperatures. Figure 5 shows plant data for liquor only, a linear relationship still being shown. This graph covers the range approximately 50°Bx to 74°Bx.

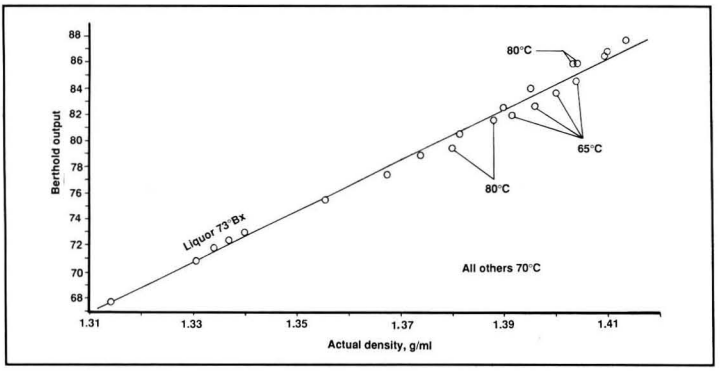

Fig. 4. Berthold output *vs.* actual density

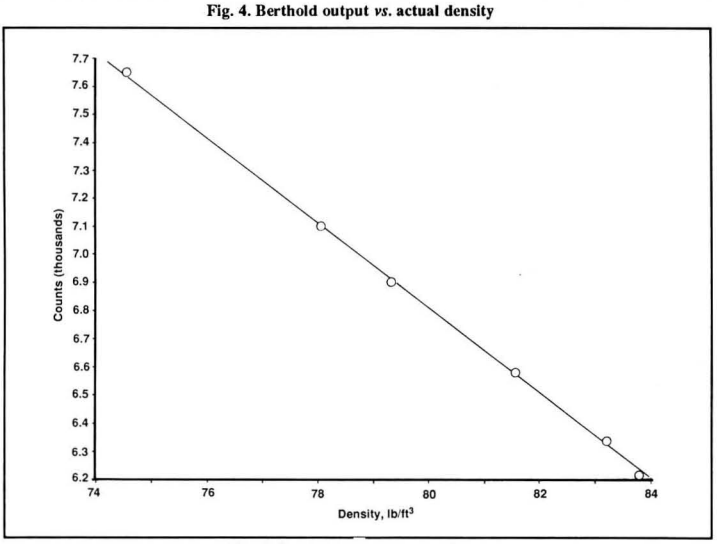

Fig. 5. Berthold counts *vs.* density

The density of massecuite is higher than normal liquor densities because the dry substance is generally higher, and also because the density of the sugar crystal is higher than the density of liquor. Finnsugar have used the latter effect as a basis of a pan control system[2]. For their control system a refractometer must be used as well as a densitometer in order to measure the Brix, and thus the density of the mother liquor. In their examples they calculate the crystal yield knowing massecuite and mother liquor densities, calculate the purity from this (in beet), and then calculate supersaturation.

Tests in a vacuum pan

The best position to install a densitometer is underneath the calandria where it is not influenced by bubbles. When using a densitometer in a pan the density can be measured accurately when Brixing-up, and then the seed Brix or density and thus the supersaturation can be determined. For a short period after seeding the crystals will not have grown sufficiently to affect the density and the supersaturation can be held at an appropriate level. Once crystals start to

1 *Sb. Vysoke Skoly Chemicko-Technol v Praze*, 1982, **E53**, 191 - 213.
2 Virtanen: *I.S.J.*, 1984, **86**, 175 - 179.

grow, the instrument detects the increase in density, and the profile of increase in density with time can be chosen to suit the pan and the characteristics of the sugar required.

Figure 6 and 7 show results using the density meter during the early stages of boiling in a white sugar pan. In Figure 6 the density a short time after charging is 86 lb/ft^3, rising on evaporation to a seed point of 86.8 lb/ft^3. After this point the density rises as crystal grows. The stirrer power reading is insensitive in this region and, although it shows a slight rise, this reading is not sufficiently reproducible to use for control of the feed valve. Hence feed does not come on until a stirrer power reading of 32% is reached, at which point the computer opens the feed valve and the level starts to rise. The densitometer would show a steady further increase from this point but this was not recorded in these tests.

In Figure 7 the density meter has been used to control the feed valve fairly soon after seeding. The liquor after charging is at 85 lb/ft^3, at seeding 86.5 lb.ft^3 and then rises as crystallization proceeds, but in this example the densitometer signals the computer to open the feed valve; this can be seen by the increase in level. The feed valve control maintains a steady increase in density and level. The stirrer power does not give a usable reading until 32%, but once it reaches this point it takes over the control of the feed valve and continues the boiling to completion.

Although not shown on the two graphs a densitometer in a pan can be used right up to the end of boiling. Experience has shown that it is best to use stirrer power to identify the actual end-point of the boiling after tightening-up as this shows a big increase at this point, whereas the densitometer indicates only a relatively small change in this region.

In our experience we have found calibration to be a straightforward procedure, once the principles are understood, and density rather than Brix is used as a measurement. We have also found that the instrument shows no drift

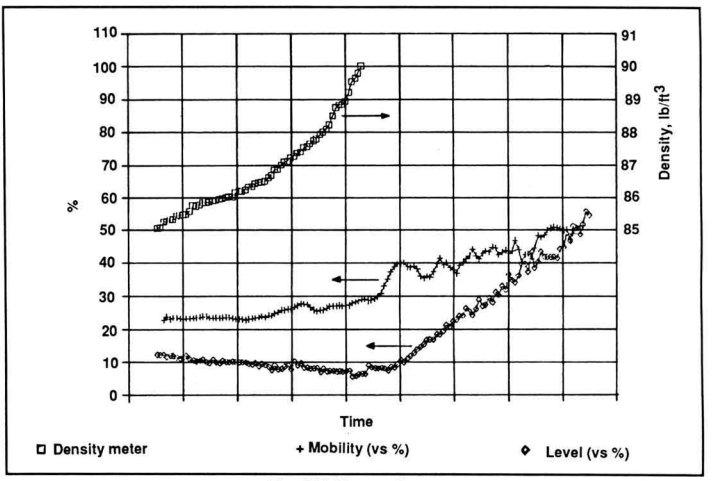

Fig. 6. Boiling profiles

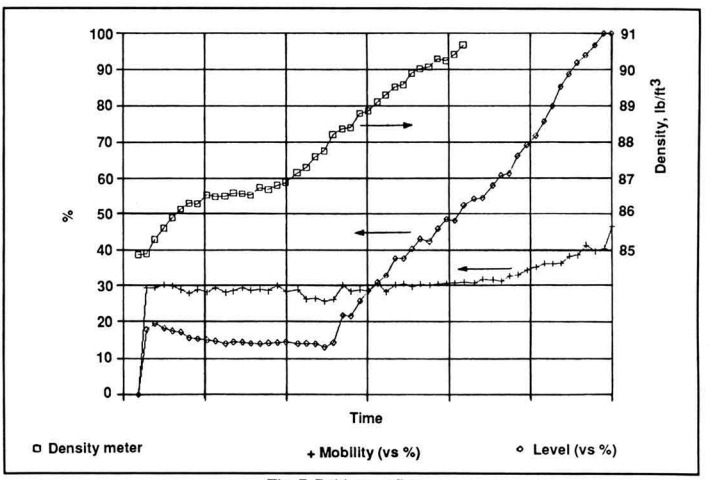

Fig. 7. Boiling profiles

and requires very low maintenance. Within our refineries we have used densitometers made by the Berthold and Texas Nuclear companies.

Safety

The units do contain radio-active materials and it is necessary to appoint a "responsible person" and display appropriate labels and notices. Secondary radiation is *not* a problem, i.e. these instruments cannot make other material radioactive.

There are two potential hazards which the design of a gamma ray density gauge must allow for. These are (i) possible leakage of radioactive material and (ii) the intensity of the radiation field outside the source housing.

The source is fully encapsulated and inside a fireproof lead-lined housing. The housing ensures that the radiation field strength at the surface of the gauge is below the legal limit in the country of use, typically 7.5 micro-

Sievert per hour. A lead shutter is also provided to cut the strength of the measurement beam to a similar safe level. It is the user's responsibility to ensure that the shutter is locked shut before the source is removed from the process plant for any reason.

The hazard presented to plant personnel by a maximum external radiation field of 7.5 μSv/hr can be understood in the context of other radiation fields to which people are exposed. A typical chest X-ray gives a gamma-ray dose of 200 μSv. A traveller by jet aircraft across the USA and back is calculated to receive a 50 μSv dose of cosmic rays. Doses from the background radioactivity in the UK from both natural and artificial sources depend on geographical region, but range from 500 to 5500 μSv per year. As the radiation field follows an inverse square-law with distance, a cage fitted around a nuclear density gauge can reduce the external radiation substantially.

Conclusion

Modern computer-based process control for white sugar pans requires more accurate and more representative sensors to indicate the state of liquor or massecuite in the pan. Our experience indicates that the gamma ray densitometer can give a linear signal with change in density regardless of whether liquor or massecuite is in the pan, and that this is a good measurement for use in controlling a white sugar vacuum pan, particularly when combined with the power reading from the agitator.

Acknowledgement

Thanks are due to Dr. Gordon Walker and Jeremy Coster for some of the data for this paper.

Facts and figures

Sweden sugar industry recovery[1]

The Swedish sugar industry now expects production in 1988/89 to reach 427,000 tonnes, raw value, which compares with 275,000 tonnes produced in the last campaign and 386,000 tonnes in 1986/87. The estimated beet harvest is 2.6 million tonnes against 1.7 million tonnes in 1987/88.

US Sweetener Producers Group name change[2]

The Group formally changed its name at its annual meeting in 1988 and has become the American Sugar Alliance.

Kenya sugar situation[3]

The closure of the Miwani and Ramisi sugar factories highlights the necessity to reorganize the entire sugar industry. Output from the two plants had waned steadily owing to gross organizational deficiencies, the cost of servicing huge foreign loans taken on to support factory modernization, and unfavourable pricing. Nor had they been helped by crossed lines with the government which did not make promised investments in agricultural development to parallel the spending on plant. The factories' problems reflect a deeper national crisis; after a brief spell of self-sufficiency in the late 1970's, sugar imports peaked at 126,200 tonnes in 1986 and could easily be as large again this year. This is all the more galling because self-sufficiency was bought dearly. Since independence, an estimated 5000 million Kenya shillings ($280 million) has been pumped into the five parastatal companies – Chemelil, Mumias, Muhuroni, Nzoia and South Nyanza. Analysts calculate that, in the unlikely event of per caput consumption remaining stable at 17 kg a year, consumption will rise to 471,000 tonnes by 1992 from just above 400,000 tonnes in 1987. If per caput consumption were to rise to 25 kg/year, total requirements would rise to 655,000 tonnes. With 1987 production hovering just above 410,000 tonnes, sweeping rationalization of existing capacity is the priority, according to industry sources. The only two profitable companies– Chemelil and Mumias – are operating close to their capacities of 55,000 and 210,000 tonnes a year, respectively. At Muhuroni, in which the India-based Mehta Group has a 16% stake, the 300 million shillings factory rehabilitation, funded by a concessionary loan from the Dutch government, is now in full swing for completion in early 1989. But shortages fuelled by 6 to 9 months delays in paying farmers meant the existing plant was working at only 30 - 40% of capacity in 1987. Muhuroni's future could well depend on whether it gets the go-ahead for a 340 million shillings agricultural development scheme to improve supplies from outgrowers. South Nyanza Sugar Company has tackled its rehabilitation from the opposite direction; since taking over management in 1986 Booker has concentrated on reviving plentiful cane supplies by clearing outgrowers payment backlogs. Cane deliveries have already exceeded forecasts and helped bring the factory back from the brink of ruin to close to break-even point. But a rehabilitation program including factory modernization and road repairs, etc. is urgently required. At Nzoia, even more than at Muhuroni, overdue payments are proving difficult to resolve and further delays may hit the reorganization scheme. Even if the plans were fully implemented, total national production would not exceed 450,000 tonnes by 1992, leaving a deficit of 33,000 tonnes in a very good crop year if per caput consumption remains stable, or of 205,000 tonnes if it rises. Kenya therefore requires at least one and possibly two major factories, to produce 90,000 - 120,000 tonnes a year. Busia is strongly tipped as the favoured site and interested companies may well be invited to submit proposals. The crucial question is whether private sources for some of the capital can be tapped since public spending cuts will prohibit an entirely state-run scheme.

Turkey sugar production, 1987/88[4]

Sugar production in Turkey in the 1987/88 campaign amounted to 1,640,950 tonnes, white value, from 11,856,000 tonnes of beet grown on 391,592 hectares. These figures correspond to an outturn of 1,300,550 tonnes of sugar from 10,043,000 tonnes of beet grown on 349,177 ha during the 1986/87 campaign.

Bangladesh cane crop increase[5]

Industry sources report a larger sugar cane crop in Bangladesh for 1988/89, owing to an increased area and higher rainfall during the year. As a consequence, prospects for sugar production are better than the moderate 1987/88 level of 189,847 tonnes, raw value, and the estimated outturn is 200,000 tonnes. Sugar imports in 1988/89 are forecast at 120,000 tonnes; imports have been minimized in recent years, mainly owing to efficient marketing of domestic sugar output by the Bangladesh Sugar and Food Industries Corporation.

Mexico sugar factory sales[6]

Financiera Nacional Azucarera S.A has announced the sale for approx. $39 million of Ingenios Atencingo and Puljitic, in Puebla and Chiapas, respectively. They are the first of 29 factories on sale by the state-owned group. Atencingo was sold to Corporativo Escorpión for $21 million and Puljitic to Operadora de Grijalva S.A. de C.V. for $18 million. Bids for a further seven factories have been received.

1 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 502.
2 *Sugar Bull.*, 1988, **66**, (24), 3.
3 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 526.
4 *Zuckerindustrie*, 1988, **113**, 837.
5 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 575.
6 *Amerop Newsletter*, 1988, (179) 12 - 13; F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 559.

ACP hopes for improved EEC subsidies[7]

The Commonwealth Club of 17 cane sugar producing developing countries hopes to win new trade subsidies from the EEC in coming months. A senior sugar official in Mauritius, which chairs the group, said he was optimistic concessions would be introduced in the current year of the joint protocol between the Club and the Community ending June 1989. He envisaged EEC aid initially to help sugar producers cope with ocean freight costs and also to improve production efficiency and diversification, with better usage of cane and sugar by-products. ACP states may export 1.3 million tonnes of sugar, white value, to the EEC each year at a guaranteed price. This price, linked to prices the EEC pays its sugar beet farmers, has been frozen for the fourth year in a row.

Madagascar sugar industry rehabilitation[8]

The rehabilitation of the Madagascar sugar industry is one of a number of projects agreed recently with French companies and which will be guaranteed by the French government.

Ferruzzi Group agro-industrial project in the USSR[9]

Italy's Ferruzzi Group is to start a farming project in the Soviet Union which is scheduled to begin production by 1990. The necessary technical studies to begin the 5000-ha project in the Ukraine should be completed by 1989 and an agreement has recently been signed for Ferruzzi to provide technology and plants for the joint venture which could eventually produce goods worth $1500 million annually. Among the agricultural goods planned for production and destined for the Soviet market are sugar and starch.

French sugar factory expansion[10]

The Erstein sugar factory in Alsace is to be expanded to a slicing capacity of 6000 tonnes/day by 1993 from its present 4000 tonnes/day. A total of 15 million francs is to be invested and new plant will include two new sugar silos, a liquid sugar station, a deliming plant, new pans and packing machinery.

Canada sugar production decline[11]

Canada's sugar production in the 1988/89 crop year is now estimated at some 100,000 tonnes, raw value, substantially down from the 147,000 tonnes of 1987/88.

South African sugar consumption increase[12]

Sugar consumption in South Africa increased by a record proportion in 1987/88, in spite of an increase in the sugar price in January 1988. Use for mineral water and confectionery rose by 26% and for canning by 13%. This reflected the success of the advertising program of the S.A.S.A. which had promoted sugar as a natural energy-giving product that improves the taste of food. Research on the results of the advertising showed that 97% of all respondents recognised it and that belief in the myth of the health issues was declining.

Cuba sugar production, 1987/88[13]

Cuba's sugar production in the 1987/88 crop year was substantially higher than assumed by most market analysts. According to ISO figures, production totalled 7,548,000 tonnes, raw value, compared with 7,220,000 tonnes in the year before. It has been reported that Cuba intends to increase its 1988/89 production by at least one million tonnes, which means a production level of some 8.5 million tonnes.

US sugar refinery sale

Tate & Lyle PLC and Redpath Industries Ltd. have announced that Refined Sugars Inc., a joint venture of the two companies, has entered into an agreement to sell its cane sugar refining operations at Yonkers, New York, to a subsidiary of Lantic Sugar Ltd. of Montreal, Canada, at a price of approximately US $105 million, compared with net assets of the business of $93.9 million. The agreement to purchase Amstar Sugar[14] and the present sale agreement are both conditional on obtaining regulatory approvals. It is believed that such approvals will be best obtained by arranging simultaneous completion of the purchase and sale agreements; filings are being made on this bases. The Board of Tate & Lyle now expect that the completion of the agreements will take place in December.

Bangladesh sugar capacity increase[15]

According to a recent agreement, Pakistan will provide Bangladesh with a soft-term supplier's credit of $13,860,000 to buy a sugar factory from Pakistan. The plant will go into operation in 1990. With this new factory and one under construction, the total number by the year 1990 will be 18, and the total centrifugal sugar production capacity will be 250,000 tonnes per year.

Australian sugar cane research program[16]

The Sugar Research Council, established in 1987 to administer the Sugar Industry Research Fund, has released details of a five-year research and development plan which includes a $Aus 1.7 million program for 1988/89. The plan caters for research priorities identified by the Council and provides researchers with a clear guide to the directions in which the industry wishes to focus its research efforts. For 1988/89 high priority has been accorded to research into irrigation, soil condition, fertilizer practices and salinity problems. The Fund will provide money to the Bureau of Sugar Experiment Stations, CSR Limited and the Sugar Research Institute with BSES getting the lion's share for work including studies on improving the yield of ratoon crops and breeding of clones with high early sugar content.

Lower sugar production for Taiwan in 1988/89[17]

From a crop of 2,450,000 tonnes of cane grown on its own farms and 3,050,000 tonnes from contracted farms, Taiwan Sugar Corporation is expected to produce 580,000 tonnes, raw value, of sugar in 1988/89, down from 625,000 tonnes produced in 1987/88 but up from the 515,000 tonnes produced in 1986/87. Sugar exports are estimated at 30,000 tonnes against an estimated 20,000 tonnes in 1987/88.

New cane cutting machine on the market[18]

A new cane cutter, originally developed by the South African Sugar Association Experiment Station is being made commercially by Howard Canequip, of New Germany, South Africa. It consists of a hydraulically driven horizontal cutting rotor mounted on the front of a tractor with pushing bars and crop dividers which lay the cane stalks forward before the base of the stalks are cut, so that the row of cane is laid down in a "sausage"-type windrow between the tractor wheels, ready for loading either manually or mechanically. Topping of the stalks is done either manually when the cane is in bundles or with a cutter bar fitted to the grab loader. The machine can cut at a rate of 50 tonnes/hour but field conditions and other factors may reduce this to around 20 tonnes/hr. The cost of the machine is 17,100 rand in South Africa.

Brazilian sugar factory for Iran

Following his visit to the Iran-Brazil Joint Economic Commission in Brasilia, the Iran Minister of Industries announced that Brazil will construct a sugar factory in Iran with a capacity of 100,000 tonnes. Further cooperation in the field of sugar production seems likely.

Argentina cane crop, 1988[19]

Sugar cane output in Argentina rose 2% to 14.8 million tonnes in 1988; however, this figure is less than the 1983/87 average of 14.9 million tonnes. Per hectare yields were slightly lower than in 1987.

Panamanian sugar for France

Panama has exported 15,000 tonnes of sugar to France instead of the United States, as a result of the economic boycott imposed against Panama by the US since last March. This news was confirmed by the Director of the state sugar company, La Victoria, who stated that Panama would continue exploring other markets because of the boycott. Panama's quota to the United States in 1987 was 26,390 short tons.

7 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 541.
8 *Czarnikow Sugar Review*, 1988, (1777), 141.
9 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 557.
10 *Zuckerindustrie*, 1988, **113,** 915.
11 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 559.
12 *S. African Sugar J.*, 1988, **72,** 308.
13 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 573.
14 *I.S.J.*, 1988, **90,** 206.
15 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 575.
16 *Australian Canegrower*, 1988, **10,** (10), 4.
17 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120,** 577.
18 *S. African Sugar J.*, 1988, **72,** 303.
19 *Public Ledger's Commodity Week*, November 5, 1988.

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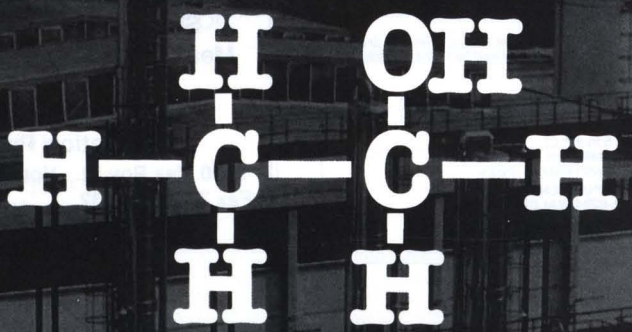

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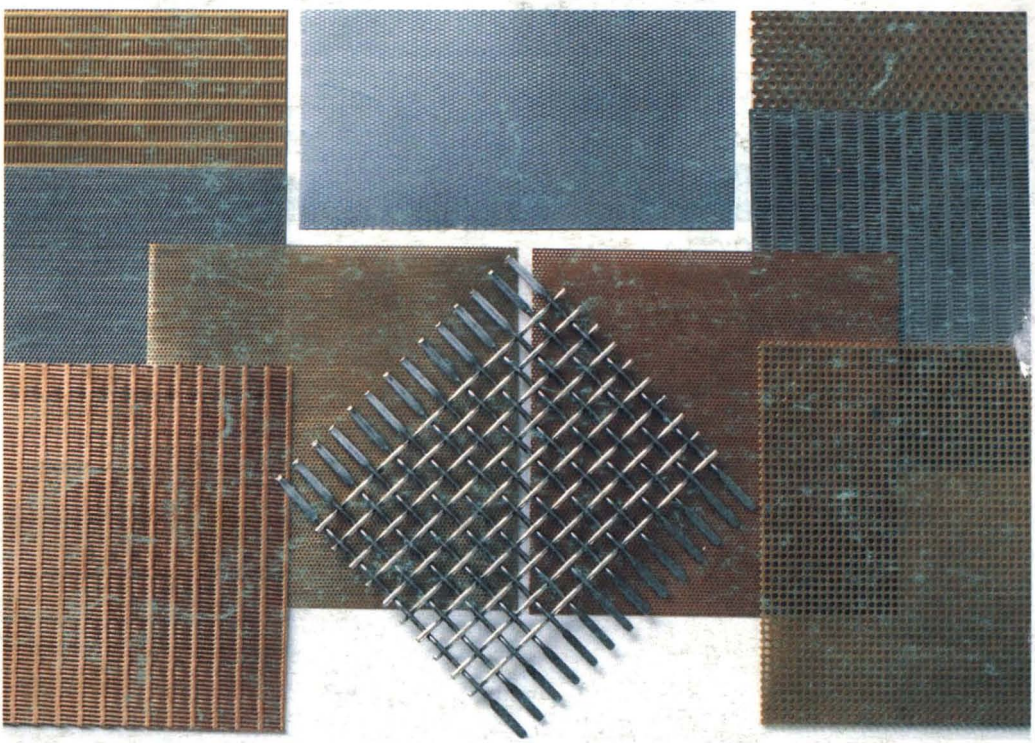

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