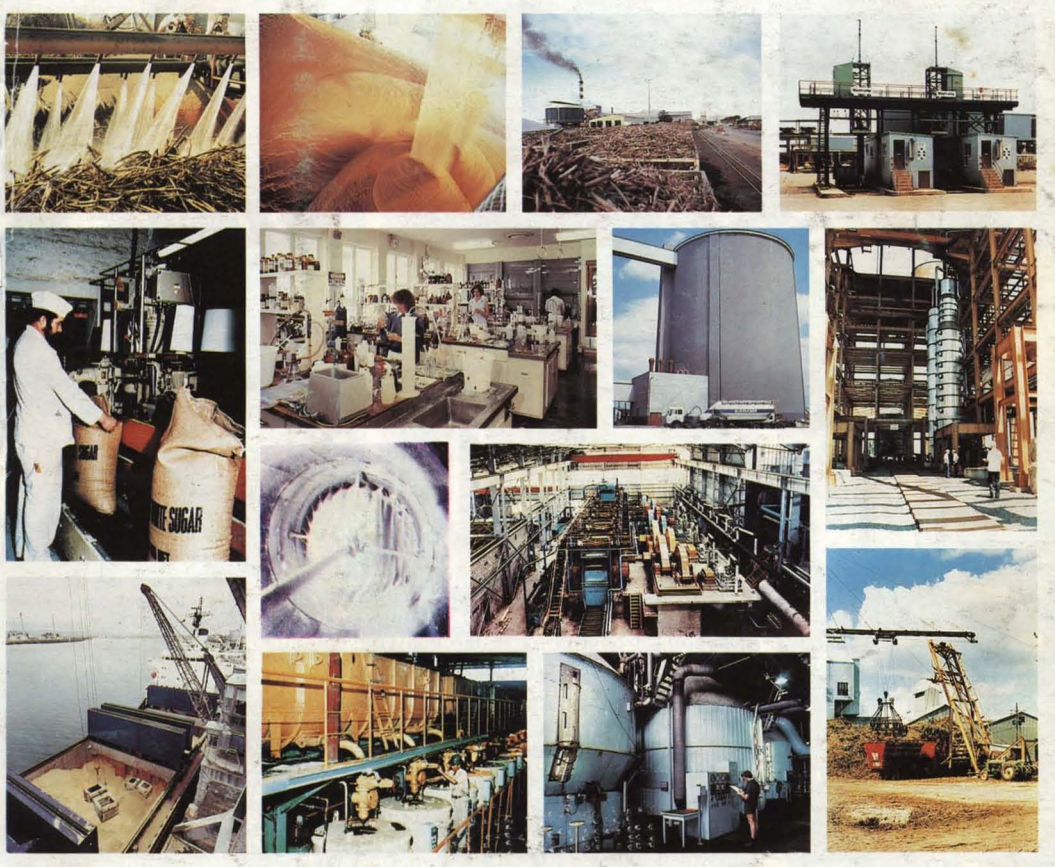
INTERNATIONAL SUGAR JOURNAL



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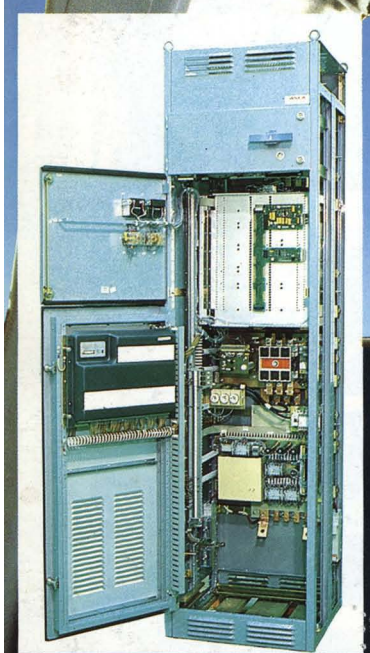

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News and views

World sugar prices

Although there were some negative effects during the first part of November owing to sales by speculators and commission houses, the bullish tendency of October continued and was aided by purchases by China and by Bulgaria as well as a continuation of the shortage of sugar in the Far East. The need for sugar in the Philippines strengthened the market, as did uncertainty over Brazil's sugar policy in the wake of changes at the Sugar and Alcohol Institute. The London Daily Price for raw sugar rose from $189 per tonne on November 2 to reach $204.60 on November 30, while that for white sugar rose from $193 to $210.50. The market seemed buoyant in spite of news of sugar rationing in China, which might mean lower imports than expected, and a lack of imports by the USSR and India which are expected to require substantial supplies.

E. D. & F. Man expect the buoyancy to continue as the forecast supply tightness has escalated[1]. Nevertheless, it is not envisaged to appear until the second half of next year and they point out that the recent world price movement has been restricted to dollar values. The ebullience of market conditions in 1974 or 1980 is unlikely to be repeated; with developing countries now accounting for the lion's share of total world imports the optimistic outlook is marred by lack of purchasing power. "It is due to this and the substitution of sugar by alternative sweeteners that consumption advances of recent years have been subdued. The process of adjustment in the sugar market therefore has been a long and arduous one. However, the market finally appears to be in balance, with the surpluses of the previous few years eradicated as production advances have been kept at bay in many of the exporting countries."

Alternative markets sought for Latin American sugar

A meeting of GEPLACEA, the Group of Latin American and Caribbean sugar exporting countries, was held in Havana during October 12 - 15 to review the current world sugar situation. José A. Cerro of Argentina was elected Executive Secretary in succession to Eduardo Latorre whose term had expired. The new secretary was enjoined to pcounter the loss of exports to the US, and diversification of the industry was also advocated. Mr. Cerro said the Group would maintain efforts to convert the current International Sugar Agreement into one with economic terms and the meeting called for a prompt resumption of negotiations by the "Big Four" exporters – Australia, Brazil, Cuba and the EEC – to this end.

EEC budget deadlock

Despite extending meetings and negotiations, the Council of Ministers was unable to agree a budget for 1988 by the October 5 deadline specified in the Treaty of Rome. The problem lies in the refusal by Greece, Spain and the UK to agree to increasing from 1.4% to 1.6% the proportion of national V.A.T. revenues contributed by member countries in the absence of progress on the reduction of the subsidies of the Common Agricultural Policy (C.A.P.) which have led to the building-up of huge surpluses which cost a great deal to export and to store, with the cost borne by consumers and taxpayers in member states.

In September the Commission introduced proposals designed to curb the spiralling costs of the C.A.P. Very few changes were proposed in respect of sugar, largely because it makes only a small call on Community's budget. This is because of the levies which are made on quota sugar (2% on A-sugar and up to 39.5% on B-sugar) to meet the cost of subsidies on EEC-produced exports. The C.A.P. bears the cost of re-exporting at world price refined sugar produced from 1.3 million tonnes of raw sugar imported at a high price from the ACP countries. In 1985 a further levy was introduced, to raise sufficient over the five years to 1990 to wipe out an accumulated deficit which had arisen because the other levies were not enough to cover the difference between high internal prices and very low world market prices. The Commission has now proposed a further levy to deal with estimated deficits in the years ahead. The new levy would vary depending on the world price and is proposed to be retrospective to 1986/87. This has met with strong opposition from sugar producers, especially in Germany and France who, as the biggest surplus producers, would pay the largest share of the new levy while the UK as a deficit country would pay only a small proportion. In fact the West German Sugar Association has called on its members not to pay the levy and Süddeutsche Zucker-AG has said it is to take legal action against the levy by challenging in the courts the West German tax authority responsible for collecting it.

World sugar balance, 1987/88

The statistical position for sugar appears to be undergoing a radical change and, sooner than expected, world sugar stocks are heading towards the critical area of 25 - 30% consumption. If the projections by F. O. Licht GmbH[2] are borne out, there will be at the end of the current year very little surplus sugar left to meet possible crop failures.

The production figures for the balance are on a calendar basis whereas Licht's recently published production estimates are on a basis of crops starting within the period concerned; hence the apparent discrepancy.

	1987/88	1986/87
	tonnes, raw value	
Initial stocks	37,069,000	37,910,000
Production	103,507,000	103,905,000
Imports	27,378,000	28,288,000
	167,954,000	170,103,000
Consumption	105,431,000	103,924,000
Exports	27,877,000	29,110,000
Final stocks	34,646,000	37,069,000
" "		
% Consumption	32.86	35.67

Stock statistics in many countries cannot be more than a guess and, while

1 *The Sugar Situation*, 1987, (439).
2 *Int. Sugar Rpt.*, 1987, **119**, 501 - 509.

the order of magnitude is important, absolute accuracy is not only unnecessary but impossible to achieve. What is important to see is the direction and roughly the extent of any stock change. Whatever the actual size of stocks may be, Licht's estimate suggests that the period of heavy stocks is over. Further, it is the size of surplus stocks in exporting countries which ultimately determines prices as it is this part of the surplus which will come onto the market if prices rise.

Exporters' surplus stocks have fallen from nearly 6 million tonnes four years ago to 2.6 million tonnes at the beginning of 1987/88 and are predicted to fall further to 1.7 million tonnes this year. Thus surplus stocks in exporting countries are approaching a critical level and are hardly high enough for a series of weather-induced production shortfalls. Another bad crop in 1988/89 could have a dramatic effect on prices which will certainly not be to the benefit of the world sugar industry. The long-term adverse consequences of a price boom should indeed provide a compelling reason for sugar producers to move quickly to establish an International Sugar Agreement able to influence the statistical position.

Outlook for the US sugar support program

The US Secretary of Agriculture, Richard Lyng, acknowledged recently[3] that sugar imports, down from 5.8 million short tons in 1977 to 1.8 million tons in 1986 and 1.1 million tons in 1987, will continue to come under pressure from rising domestic production, falling consumption and substitution by alternative sweeteners. He said "Perhaps we will reach the stage in the not too distant future where we will have no imports and we will have to eliminate the quota". The three factors named arise from a high support rate of 18 cents/lb for domestic producers which has encouraged greater output and has provided an umbrella for HFS producers who have undercut sugar suppliers in the soft drink market. Imports are expected to be reduced to between 600,000 and 800,000 tons in 1988 and, if the quota were eventually eliminated, it might be necessary to institute controls on domestic production in order to keep it a no-cost program.

A bill to cut the loan rate to 12 cents/lb was to be introduced in November by Representative Thomas Downey of New York[4]; a similar idea was proposed by the Reagan Administration in the fiscal 1988 budget but this failed to get Congressional support.

Thailand sugar dispute settlement

Up to 1982, demonstrations by cane growers in Bangkok were a regular feature of protests against exploitation. In that year the Thailand Cane and Sugar Corporation (TCSC) was set up with ownership split equally between growers, sugar producers and the government. It was formed to handle three 5-year contracts totalling 600,000 tonnes/year of sugar and secured $78 million in loans to support the domestic industry. The proceeds from sales were to be shared 70% by growers and the balance to producers. Low world market prices since 1982 meant, however, that the returns from export sales have been meagre; growers and producers have suffered financially and, since the TCSC had been unable to service its loans, its capital debt has grown to around $125 million.

No agreement had been reached on the future of the arrangements after 1987. The sugar producers wanted the 30:70 split amended in their favour, claiming that they frequently received less than 30% of the proceeds. They opposed a government ruling that 600,000 tonnes be made available for export from the 1987/88 crop and also wanted to handle export sales themselves, eliminating the TCSC. The cane growers wanted more say in the marketing of exports and also a share in the proceeds from molasses sales.

A compromise was reached on November 9 under which the TCSC is to remain in existence but the producer's commitments to it are reduced by half. The revenue sharing ratio will be unchanged for the time being but molasses proceeds will also be shared. The producers are also contributing 1620 million Baht to a Cane and Sugar Fund which has taken over the debts of the TCSC; this amount is claimed to be a saving to the producers as a result of exemption from export duty and other government taxes. However, until the revenue sharing ratio is worked out – it is supposed to be fixed within three months – the agreement will not be signed and marketing of Thailand sugar will be held up.

Indian sugar situation

The 1987/88 crushing season began on October 1, following the worst drought of the century which is estimated to reduce cane yields by about 10%[5]. On the other hand, the area under cane has risen by about 5% because remunerative cane prices were announced and because payments were made promptly and regularly. In some irrigated areas where the drought hit, growers have continued watering the crop longer than usual and the recoverable sugar content is likely to be lower. Another danger is of frost in northern states should winter rains fail.

These factors indicate that output from the new crop will not reach the approximately 8.5 million tonnes, white value, produced in 1986/87 and the current estimate is, in fact, slightly more than 8.0 million. Sugar consumption rose by more than 600,000 tonnes to about 8.9 million tonnes in 1987/88 and, even if no further increase took place in the current season, there would appear to be a shortfall of more than 800,000 tonnes. A similar increase in consumption as last season, would bring the shortfall to 1.4 million tonnes.

Imports in 1986/87 reached nearly 1,000,000 tonnes, however, because of an earlier low production forecast, and stocks rose over the season by about half this amount. Consequently, if stocks were to fall to their October 1985 level, some 900,000 tonnes of white sugar would be required.

3 *Public Ledger's Commodity Week*, October, 24, 1987.
4 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 517.
5 *ibid.*, 568 - 569.

Product news

New ASEA-Weibull batch centrifugals

A new product range of batch centrifugals has been developed during 1987 by ASEA AB and Nils Weibull AB. The available sizes are from 650 kg charge to 1500 kg. Special consideration regarding white sugar production has been taken in the centrifugal design work.

In the Swedish sugar factory at Köpingebro seven of these ASEA-Weibull centrifugals with a charge size of 1350 kg each were installed during the summer of 1987.

The following requirements were specified for the centrifugals:

- The charging of the basket should have the same thickness and the charging time should be the same, irrespective of the massecuite consistency.
- Wash water should be minimized relative to the quality of sugar processed.
- The discharger should clean the screen completely without causing wear.
- The drive system should be reliable and have a low and even energy consumption.
- Faults should be displayed in words for fast and simple fault-finding. The centrifugal must be easy to optimize and adjust both for the centrifugal operator and maintenance personnel.

These criteria were met by the machine's design features. The appearance of the new ASEA-Weibull batch centrifugal is traditional but it incorporates many unique features. An earlier design of charge indicator has been extensively developed and in conjunction with the main gate, which from fully open closes extremely quickly, gives very precise charging of the basket. Another feature of the main gate is that it prevents caking of sugar when closed for long periods and thus gives proper charging immediately when opened.

The wash pipe is designed for uniform water distribution over the complete sugar surface. This maximizes the wash efficiency and minimizes water consumption. The discharger is equipped with a specially designed plough blade that cleans the screen completely without touching it. This also minimizes the screen wear.

The ASEA-Weibull batch centrifugal is equipped with a new control system called ASEA Master Piece 200/1. This powerful system carries out both overall control of the battery and individual centrifugal control. It is also capable of controlling other equipment in the sugar house. This system can be connected with other systems by means of a bus. All parameter settings, fault indications and supervision of the centrifugals are carried out from a keyboard with screen. It is also possible to control the centrifugals directly from an operator's panel. Individual settings or common parameter values can be set for the centrifugals. When a fault occurs it is displayed on the screen in words. A printer is connected for documentation.

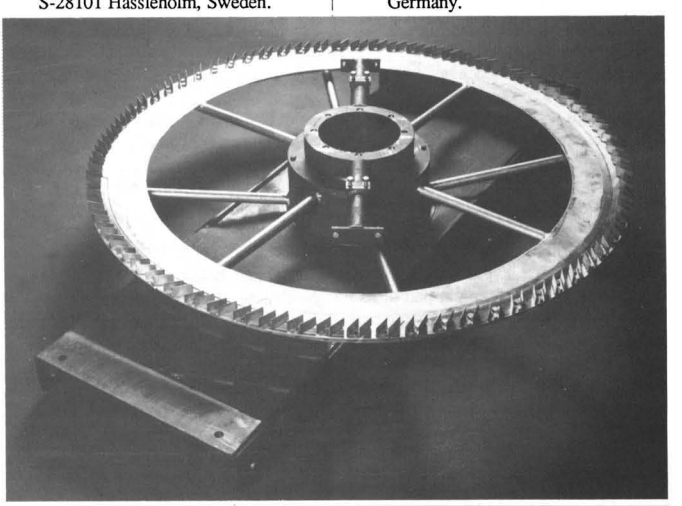
The drive system used on this battery of ASEA-Weibull centrifugals is multidrive type with frequency control. The advantages of this system are very low losses and little disturbance of the electrical system of the factory. The drive motors of the centrifugals are standard squirrel cage 3-phase motors.

Further details:
ASEA-Weibull,
Box 194,
S-28101 Hässleholm, Sweden.

Reducing crystal damage in continuous centrifugals

The crystal rotor is one of BMA's latest developments and helps reduce crystal breakage which occurs in continuous centrifugals when the crystals hit the housing wall. It is virtually a spoked wheel fitted with metal plates which is rotatably carried in the cover of the centrifugal housing and is operated at a speed below that of the basket. The percentage of broken cystals is limited by stepwise reduction of their kinetic energy between the basket and centrifugal housing. The rotor has been fitted primarily on continuous centrifugals used as foreworkers and for the production of seed magma. Even mixer-type centrifugals have been fitted with a crystal rotor which, in this case, not only prevents crystal breakage but also provides for magmatizing the spun sugar. This means that homogeneous and lump-free magma containing almost no broken crystals may be produced in a single machine.

Further details:
Braunschweigische Maschinenbauanstalt AG,
P.O. Box 3225,
D-3300 Braunschweig,
Germany.



Factors influencing the selection of centrifugal machines

By G. H. Walsh
(Techserve C.C., Durban, Natal, South Africa)

From the basic suspended centrifugal invented in the USA by Weston in 1867 and driven by a pulley to reach the centrifugal force necessary to separate the sugar cystal from its mother liquor, the centrifugal has evolved over 120 years from a simple machine to become a very sophisticated piece of equipment. From a labour-intensive unit it is now one of the most automated items of machinery in the process house.

The successful development of the continuous centrifugal, which was first introduced to cure the low-purity massecuite of the raw sugar process, has enabled it to make impressive inroads into the field which was once dominated by the batch centrifugal.

The progress made in the combined field of engineering and technology has improved the capacity and cost of production per tonne of sugar for both types of centrifugal.

The selection of centrifugal machines for any given duty has become incredibly difficult. The increase in the sizes of continuous machines and the innovative features now offered complement the continuing increase in the speeds and basket capacities of batch machines and the range of electric drives and process control systems available for them.

There are so many factors to be considered in selecting a centrifugal machine, and the duties for which continuous and batch machines are employed nowadays overlap to such an extent, that it is suggested each of the aspects referred to in these notes which require to be taken into the consideration should be evaluated in turn acording to their importance in the particular circumstances in order to evaluate machines on offer and assist in making a final selection. The investment criteria of a central refinery buying in part of its power requirements at a kWh charge plus a maximum kVA demand charge will place a different value on the true power consumption of a centrifugal machine in comparison with the value placed on this aspect by, for instance, a raw sugar factory which does not generate power for external supply.

It is not proposed to deal in this article with the treatment of massecuite or magma prior to curing, it being assumed that the product to be cured is a homogenous mixture which is at the optimum temperature. However, it is correctly said that good performance in the centrifugals originates in the vacuum pan and, for low grade sugars especially, it is continued in the crystallizers. With very high boiling house recoveries, the final massecuite viscosities will be very high so that reheating becomes critical to centrifugal performance and dilution of massecuites by adding a lubricant may be necessary. To achieve good performance with continuous machines, consistency of grain size is desirable and, in this regard, the increasing employment of continuous vacuum pans, although presenting some problems at present through the widely divergent grain sizes produced, will doubtless ultimately prove beneficial as the coefficient of grain size distribution improves through the introduction of increasingly sophisticated automatic feed control systems and the improvement of circulation throughout the continuous boiling process.

Because there is a difference in the sugar cured in the two types of machine, the use to which it will be put is usually the determining factor as to whether continuous or batch machines are selected.

For both types of machine, a reasonable period of amortization would be over some 60,000 hours operation although taxation benefits through investment allowances and accelerated depreciation may influence the cost benefit calculations.

Continuous centrifugals

Duties now commonly handled by continuous machines include:

(1) affination of raw sugar before melting and refining – an operation in decreasing use as raw sugar producers strive to increase the pol and decrease the ash content of their product.

(2) curing of *A*-sugar for melting and refining.

(3) curing of *A*- and *B*-sugars for sale as export raws.

(4) curing of *B*-sugars for magma as pan footings and for remelting, and

(5) curing of low-grade sugars for magma as pan footings and for remelting.

All of these duties were once handled only by batch machines but the advantages of continuous machines by way of reduced capital cost (of machines, structures, foundations), reduced power consumption, the fact that their operation requires virtually no labour and the ever-improving quality of the cured sugar through continuous technical innovation have ensured their increasing acceptance in the industry.

Crystal degradation has hitherto been the main drawback of continuous centrifugals causing more fines in the sugar and dull crystals in comparison with batch machines. However, the employment of mechanical decelerators and oversize outer casings have brought about marked improvements in the sugar quality by minimizing crystal degradation from high speed contact with the outer casing and more effective sealing arrangements between the basket lip and molasses compartment have reduced the molasses purities. The dullness of the crystal is of particular importance only in the case of speciality direct-consumption sugars.

Raw (export) sugar produced on continuous machines is likely to contain about 2% more fines than that produced from the same massecuite on batch machines. Furthermore, screening after drying may be expected to remove some 2% of the sugar in the form of lumps formed around droplets of molasses and water in the sugar produced on continuous machines.

The purities of molasses from continuous and batch machines dealing with the same massecuite will be about equal although the moisture content of sugar from the former will be higher.

Points to consider in the selection of continuous centrifugals

Apart from the obvious differences in basket design, diameters, angles and speeds, the selection of which will be

determined by the duty in relation to the quality required in the product, the following points should be considered:

(a) outer casing: this should provide ease of access for maintenance of the drive and of the anti-vibration mountings,

(b) basket material and construction: material is to be resistant to stress corrosion,

(c) basket sealing: there should be an adequate seal between molasses and sugar compartments – the method of basket mounting relative to the casing can affect effectiveness of the seal,

(d) basket drilling: it should preferably be fully drilled for effective drainage - this also reduces power consumption,

(e) screen: important characteristics are the method of fixing, backing and expected screen life,

(f) bearing lubrication: grease seems now to be preferred and costs less than oil in operation,

(g) drive belts: a constant tension arrangement will prevent belt slip and increase belt and pulley life,

(h) feed system: a choice must be made between centre *versus* side feed,

(i) steam and wash: distribution and control must be satisfactory,

(j) feed valve: the iris type is preferred with centre feed, otherwise the pinch or slide types are also acceptable,

(k) power monitoring: this can be used to control feed,

(l) installed cost: this includes ancilliaries, supporting structures and working floors, cabling, foundations, etc.

(m) operating cost: utilities and labour must be taken into account,

(n) maintenance cost: this is mainly for screens and drive belts.

Batch centrifugals

With some 1600 mm (63-inch) batch machines now capable of handling as much as 1750 kg of massecuite per charge at 20 cycles per hour, the effect of a single machine handling over 35 tonnes of massecuite per hour being out of service has to be considered in deciding upon the basket size. The same production is achieved by some 1372 mm (54-inch) machines which achieve up to 30 cycles per hour. Consideration of this aspect will ensure that 1067 mm (42-inch) diameter machines, which are small by current standards, will be in demand for a good many years to come.

When most machines were driven by pole-changing motors, the speed was determined by the frequency of the power supply. With DC motors and with some forms of AC drive now available, there is no such limitation.

The most important factors affecting the quality of sugar produced from a given massecuite are:

(i) maximum spin speed which, together with basket diameter, determines the separational force or gravity factor – there is an economic limit as the returns from higher gravity factors rapidly diminish above an optimum value;

(ii) spin time at top speed – there is little to be gained by extending this beyond 15 seconds; and

Table I. Typical duties for batch machines of various sizes

Basket size	Electric supply frequency	Max. speed, rpm	Gravity factor	Massecuite capacity, kg	Application
42 × 30 in	50 Hz	1000	597	520	Refined, White, *A*- & *B*-sugars
(1067 × 762 mm)	50 Hz	1500	1343	520	*A*- and *B*-sugars
	50 Hz	1500	1343	520	Low-grade sugars
	60 Hz	1200	860	520	Refined, White, *A*- & *B*-sugars
	60 Hz	1800	1934	520	Low-grade sugars
48 × 30 in	50 Hz	1000	683	740	Refined, White, *A*- & *B*-sugars
(1220 × 762 mm)	50 Hz	1500	1536	740	*A*- and *B*-sugars
	50 Hz	1500	1536	600	Low-grade sugars
	60 Hz	1200	983	740	Refined, White, *A*- & *B*-sugars
	60 Hz	1800	2212	600	Low-grade sugars
48 × 36 in	50 Hz	1000	683	880	Refined, White, *A*- & *B*-sugars
(1220 × 914 mm)	50 Hz	1500	1536	880	*A*- and *B*-sugars
	50 Hz	1500	1536	720	Low-grade sugars
	60 Hz	1200	983	880	Refined, White, *A*- & *B*-sugars
	60 Hz	1800	2212	720	Low-grade sugars
54 × 36 in	50 Hz	1000	768	1200	Refined, White, *A* & *B*-sugars
(1372 × 914 mm)	50 Hz	1400	1505	1200	*A*- and *B*-sugars
	50 Hz	1500	1727	1200	*A*- and *B*-sugrs
	60 Hz	1200	1105	1200	Refined, White, *A*- & *B*-sugars
54 × 42 in	50 Hz	1000	768	1400	Refined, White, *A* & *B*-sugars
(1372 × 1067 mm)	50 Hz	1400	1505	1400	*A*- and *B*-sugars
	50 Hz	1500	1727	1400	*A*- and *B*-sugrs
	60 Hz	1200	1105	1400	Refined, White, *A*- & *B*-sugars
63 × 43 in	50 Hz	1000	895	1750	Refined, White, *A*- & *B*-sugars
(1600 × 1100 mm)					

(iii) massecuite layer thickness – for purposes of comparison this should be taken as 150 mm (6 inches) in 42-inch machines, 180 mm (7 inches) in 48-inch machines and 200 mm (8 inches) in 54-inch machines. The benefit of thicker layers is questionable.

Safety features which should be included are: a basket load limiter (to prevent over-charging), an out-of-balance switch, a plough interlock, an emergency stop, monitor case covers, thermistors in the motor windings, and basket reinforcing hoops.

Many users prefer a "trailing" plough which will not "dig in" to the sugar wall under any circumstances (notwithstanding electrical interlocks intended to prevent such an occurrence). The amount of sugar left in the basket after ploughing is a most important factor to consider. The molasses purity rise across the machine must be kept to a minimum. The cost of the expected rise for each machine considered should be carefully calculated as this can be a dominating factor in machine selection.

Most machines now offered are equipped with a Programmable Logic Controller (PLC) which permits the operator to change certain process parameters such as wash time, steaming time, molasses classification time, Brix, dilution time, spin time, etc., and permit a key-holder (Engineer or Supervisor) to change such settings as feed speed, top speed, plough speed, etc. These Controllers have a digital display and retain entered data in their memories in the event of power failure.

Typical duties for batch machines of various sizes are given in Table I which also shows the gravity factor calculated at the basket wall.

Automatic recycling and automatic sequencing of machines are now virtually a standard feature facilitating optimization of efficient power usage. The electric current consumption of individual machines is influenced mainly by the acceleration rate and the characteristics of the drive motor. The power consumed is further influenced by the power factor of the machine, the values of which are often not readily available. Typical values for the power factor (cos ϕ) of various centrifugal drives are:

DC thyristor controlled	0.4
AC pole-changing	0.6
AC inverter (voltage fed)	0.9
AC inverter (current fed)	0.7

All of these systems incorporate regeneration of power during deceleration, the AC pole-changing drives to a lesser percentage of the power absorbed over the full cycle as they do not regenerate down to much below half speed. They also consume more power per tonne of sugar processed than DC or inverter fed AC drives.

A significant factor in the selection of drives nowadays will be the noise level which is highest for AC pole-changing motors.

Points to be considered in the selection of batch centrifugals

(a) outer casing: this should provide cleanliness and ease of access for maintenance,

(b) basket material: the material is to be resistant to stress corrosion,

(c) basket construction: important factors are the drilling pattern and number, size and material of reinforcing hoops,

(d) suspension: this must dampen out-of-balance forces and allow the basket to find its own centre of rotation,

(e) plough: safety considerations are important but particularly so is cleanliness of the basket after ploughing,

(f) discharge valve: important features are the method of opening, cleanliness and windage,

(g) feed valve: adjustment, a suitable face material and an automatic drip tray are essential,

(h) safety features: these should be as listed earlier,

(i) automatic recycling and sequencing: this is necessary to optimize capacity and minimize power consumption,

(j) cycle timer: this should have PLC features,

(k) wash system: superheated wash water is preferable to separate washing and steaming,

(l) power consumption: the criterion is nett kVAh after deducting power recovered through regeneration while motor cooling air requirements should be taken into consideration,

(m) installed cost: this includes ancilliaries, supporting structures and working floors, switchgear rooms, cabling, foundations, etc.

(n) operating cost: this includes utilities and labour,

(o) maintenance cost: the braking system, flexible coupling between motor and basket spindle and screens are the costliest maintenance areas.

Finally, despite all of the technical and commercial advantages a centrifugal machine might have, it is only as good as the back-up service available from the manufacturer or from his agent in the area where it is to be used.

Facts and figures

EEC supply quotas for ACP sugar[1]

In 1986/87 Kenya was once again unable to fill her ACP supply quota to the EEC and this has been reallocated among other supplying countries. In view of the fact that this reallocation is thought to be permanent, details of revised quotas are given below:

	tonnes, white value
Barbados	50,312.4
Belize	40,348.8
Congo	10,186.1
Fiji	165,348.3
Guyana	159,410.1
Ivory Coast	10,186.1
Jamaica	118,696.0
Madagascar	10,760.0
Malawi	20,824.4
Mauritius	491,030.5
St. Kitts	15,590.9
Swaziland	117,844.5
Tanzania	10,186.1
Trinidad	43,751.0
Zimbabwe	30,224.8
	1,294,700.0
India*	10,000.0
	1,304,700.0

* Although not an ACP country India has a supply entitlement

1 *Czarnikow Sugar Review*, 1987, (1766), 156.

The batch centrifugal of tomorrow: general view on future performance and design

By Åke Sjöblom
(Asea Drives, Sweden)

It is not probable at present that a demand for further improvement of sugar quality will have any significant effect on the development of the centrifugal of tomorrow. However, the production of maximum quality sugar from massecuite with varying characteristics, at a minimum cost, will remain of the interest to all producers.

The following is an analysis of the factors which we consider will influence the development of tomorrow's centrifugal.

Maximum quality

"Maximum quality" sugar is defined here as sugar of highest purity and dryness, produced on a long-term basis. This requirement is to be met irrespective of variations in massecuite consistency between different factories and between different boilings within the same factory.

For one centrifugal to be able to provide a satisfactory solution in all of the above situations, it must be sufficiently flexible with respect to speed setting and washing capabilities. It must be possible to preset digitally the operational speed to *any* value between 0 and 1300 rpm. By adjusting the speed characteristics, the operator should be able, on the basis of the properties of the massecuite, to control and optimize both operational economy and moisture content of the product.

The purity of the processed sugar is determined largely by the washing capabilities available and the routines used. However, the conflict inherent in gaining purer sugar by use of more washing water in the centrifugal at the expense of a reduction in operational economy makes the selection of optimum procedures a recurrent problem.

How much operational economy is lost with uncontrolled and superfluous spraying of water into the centrifugal? What is the cost of removing water/steam from the syrup? How many cycles/hour are lost in centrifugalling washing water out of the sugar? These are important questions in the operation of batch centrifugals.

The centrifugal of the future should thus offer the possibility of washing the sugar to a maximum purity, economically and without unnecessary damage to the sugar crystals. This will be achieved by using the "right quantity" of the "right medium" at the "right time". In this context, the medium can be water, steam or dilute syrup.

The parameters concerned are to be simply and digitally adjustable and variable by the operator on the basis of the sugar product. It will also be of economic interest in the future for signals derived from on-line moisture and purity measuring instuments to control directly the washing in the centrifugal. The mechanics of the washing in the centrifugal will certainly be developed and refined as serious attention is increasingly drawn to the economic aspects of the washing procedure.

Minimum production cost

Production cost can generally be divided into raw material costs, investment costs and operating costs.

The costs of raw material are of little interest to the supplier of centrifugals. For the user, however, this applies only if the centrifugal itself is sufficiently adaptable to variations in the quality of the massecuite. The massecuite must perhaps otherwise be adapted to the centrifugal with resultant extra raw material costs.

The investment costs are a function of the purchase price plus the installation costs. The purchase price is always too high from the purchaser's point of view. However, the purchase price is, in fact, a negligible proportion of the total costs of production during its service life. As cost analysis is increasingly applied, responsible purchasers will be more ready to pay a "little extra" for details which can result in "much lower" operational costs in the long run.

Particularly interesting questions associated with investments are always "how many?" and "how large?" machines are to be purchased. There is already a current trend, particularly in Europe, towards larger machines, thus reducing the number installed. This development will however be limited in the future, as today, by a reluctance to accept the consequences of failure of a single machine, and by the risk of higher maintenance costs per machine because of the higher dynamic loads to which they are subjected.

Operational costs, which in the long run are the major part of the production costs, consist of energy costs, personnel cost and maintenance costs.

The importance of energy costs varies in different parts of the world but awareness of their importance is growing. In many cane-growing countries in which bagasse is used as a fuel, the alternative value of the bagasse when used as a raw material for paper and board is becoming appreciated to a higher degree. This will result in a demand for greater economy in the use of energy.

In most developing countries, the costs of labour are increasing. This results in a demand for rationalization and automation and the requirement of maximum machine productivity when the personnel are active.

Tomorrow's machinery and centrifugals in particular, must therefore:

(i) be automatic to a high degree and require a minimum of personnel,

(ii) be operationally reliable and not stop unnecessarily,

(iii) be equipped with an automatic supervisory system which, in the event of a stop, gives a fast and certain fault analysis, and

(iv) be service-friendly to minimize down-time.

The costs of maintaining equipment are largely dependent on its physical design. Thus machines with low maintenance costs must be designed in accordance with the following guidelines. They must be:

(a) built with standardized modules and components, easy to replace on site and suitable for storage as spares,

(b) using well-proven and reliable components,

(c) provided with a supervision system for rapid error diagnosis, and

(d) documented, on delivery, to a level permitting local maintenance per-

sonnel to perform corrective procedures in most operational situations.

Summary

From the above, the following contours of "tomorrow's batch centrifugal" emerge, designed for "maximum sugar quality at a minimum cost".

(1) The average machine capacity, will be only slightly larger than today.

(2) The drive equipment should be electrical with either an A.C. or a D.C. motor. Complete speed control and maximum regeneration of energy with retardation are absolute requirements.

(3) The control equipment should be programmable and PC-based and provide: (a) possibilities of central supervision and control of a battery of centrifugals,

(b) complete fault analysis,

(c) the possibility of connecting a viscosity meter in the massecuite for control of the size of the inlet chute opening.

(4) Mechanical details and controllability of the washing equipment will be developed to improve operational economy.

(5) Technical devices for sugar removal will be refined to achieve maximum yield.

(6) Serviceability will be improved.

(7) The risks of personal injury will be minimized.

The ambition of ASEA-Weibull, as during the past 25 years, will be to remain at the forefront of the technical develpment of batch centrifugals to achieve an optimal solution of the problem of obtaining "maximum sugar quality at minimum production costs".

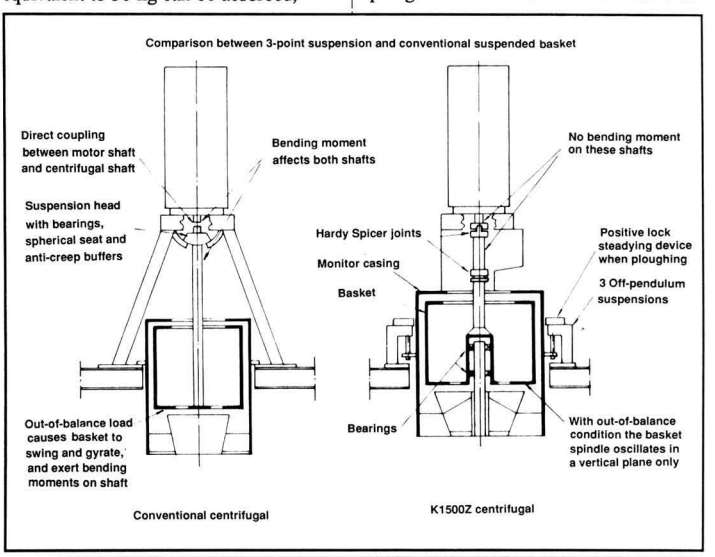
Sugar centrifugal design for the future

By Bob Clark
(Smith Mirrlees, Glasgow, Scotland)

The key requirements of sugar centrifugal design remain what they have always been: maximum output and product quality, complete reliability, stability and safety and minimum operating costs. Smith Mirrlees, who until recently have concentrated on continuous centrifugals, have joined with Selwig & Lange of Germany to market worldwide a three-point suspension batch centrifugal to meet these criteria.

The K1500Z machine has a capacity of 1500 kg of massecuite per charge and a motor rating of 25 charges per hour. The 1600 mm diameter by 1000 mm deep basket is driven by either an AC or DC motor and torque is transmitted through two Hardy Spicer universal couplings which prevents bending moments in the drive shaft. The basket rotates on a shaft rigidly mounted in the monitor casing and the casing is supported by a unique 3-point suspension system attached to a base plate. The diagram illustrates the main design features compared with conventional machines.

The unique benefits of the 3-point suspension system are that the machine is inherently stable and will operate with large out-of-balance loads in the basket resulting from poor quality massecuite or foreign matter. An imbalance equivalent to 50 kg can be absorbed, although vibration sensors prevent the machine attaining full speed with an imbalance exceeding 14 kg until the load has redistributed to eliminate the out-of-balance condition. The discharging plough is mounted on the main frame of



ONE LUMP OR NONE?

The quality of sugar processed through a Smith Mirrlees ROTA Continuous Centrifugal is by any standards, exceptional.

Sugar, virtually free of lumps and processed to a 'plantation white' quality *proves* the design and engineering excellence of the machine and its unrivalled leadership, *throughout the world.* If you are preparing to make a capital purchase as important as this one, check our benefits, our performance and our reputation.

* A better quality end product
* Competitively priced
* Guaranteed throughput of *all* grades of product
* Full range of sizes and basket angles
* Unique integral reheater for low grade products
* Finely engineered to give long, reliable service
* Low centre of gravity giving maximum stability

. . . and with all these benefits, if you want one now, you can have one *now*!

Smith Mirrlees ROTA Continuous Centrifugal sample

Competitors sugar sample

Smith Mirrlees
Eglinton Works Cook Street Glasgow G5 8JW Scotland
Tel 041 429 5441 Telex 77137 Fax 041 429 0820
A division of Tate & Lyle Industries Ltd

Western States at Thames Refinery

For the new Process Block at their Thames Refinery in London, England, Tate and Lyle Sugars chose proven efficiency, minimum maintenance, and long life.

The new Affination Station includes 14 Western States 1200 RPM, 54″ x 40″ x 7″ Automatic Centrifugals.

Each machine is driven by a thyristor-controlled d.c. motor. Each has automatic cycle control and machine diagnostics through its own single board computer. And each incorporates such proven Western States features as the ring-reinforced basket and the "Roller Wedge" massecuite feed gate.

This Affination Station was designed specifically to meet the needs of Thames Refinery's one million tonnes per annum sugar refining capacity, through close cooperation between Tate and Lyle and Western States engineers.

Tate and Lyle chose a company with proven technology, expertise, and a worldwide presence. Can you afford any less? Contact Western States or our representative for your next centrifugal requirement.

THE WESTERN STATES MACHINE COMPANY
P.O. Box 327, Hamilton, Ohio 45012 U.S.A.
Phone: 513/863-4758
Telex: (WUD) 21-4577 and (RCA) 21-2057
Telefax: 513/863-3846

Each of the 14 Western States centrifugals at Thames Refinery is d.c driven and includes programmable control and diagnostics.

the centrifugal, free from vibration and the basket and casing are automatically locked in a central position during the discharging operation which allows the tip of the plough to be set close to the screen to ensure maximum sugar discharge without the risk of screen damage.

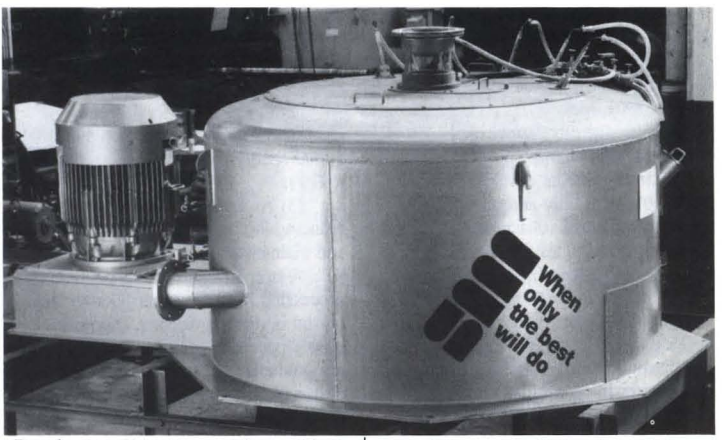
To eliminate contamination from drips, both the feed chute and steam/water wash pipes retract after use. No discharge valve is necessary as, during the charging operation, massecuite is fed via a deflector cone directly onto the rotating basket. Consequently, massecuite cannot normally discharge through the bottom of the machine and in the event of a power failure an automatic diverter operates to deflect massecuite away from the sugar conveyor.

In the European beet sugar industry, machines are running with virtually no off-crop maintenance, apart from normal wear and tear replacement, for periods of up to five years. Many features of the design make this possible. In particular, the automatic oil lubrication operates intermittently whilst the machine is shut down and vibration sensors permit the condition of the bearings to be checked without removal. Also the basket may be balanced without removing it from the machine using the installed vibration sensors. Where repairs are necessary, virtually all components can be removed without completely dismantling the machine.

From the brief description given, it can be seen that the K1500Z batch centrifugal offers many advantages over conventional suspended basket machines and is a design for the future.

Tomorrow's continuous centrifugals will be designed to allow simplicity of construction, maximum stability, long life and high capacity, with minimization of crystal damage.

The Smith Mirrlees range of Rota continuous centrifugals, manufactured in three sizes covering a capacity range of 2 to 50 tons of massecuite per hour have been evolved over 20 years with the aim of meeting these requirements, aided by Tate & Lyle's Research and



Development Department. The machines are simple in construction and the low centre of gravity gives maximum stability.

Optimum capacity is achieved by use of a re-heater to raise the massecuite temperature during charging without dissolving the sugar crystals. Special features within the accelerator ensure that the massecuite is fed onto the rotating basket to completely cover the screen. The holes in the screen are tapered to speed separation and minimize blinding, while the backing screen, with a 50% open area, facilitates molasses flow.

The basket is spun from a single piece of stainless steel without welds and other design details minimize stress concentrations and ensure long life. The upper part of the machine casing is curved so that crystals leaving the top of the basket are progressively decelerated around the curve which reduces damage and prevents sugar build-up.

Further developments are in hand, including the use of plastics to improve performance and reduce weight. A new basket design will permit syrup classification between the pure mother liquor and wash syrups and a variable speed facility will enable performance to be maximized. The simplicity of the basket design yields a smooth outer surface. This feature, together with the large volume of the molasses chamber, minimizes disturbance of the air and prevents the molasses recombining with the sugar after separation.

The Rota continuous centrifugals are currently being tested in a number of industries other than sugar, and the experience gained will produce further advance in the equipment design to ensure its suitability for the 21st Century.

Facts and figures

New Pakistan sugar factories[1]

Al Asif Sugar Mill, the 42nd sugar factory in Pakistan, went on stream on October 16 and is expected to produce 30,000 tonnes of sugar, white value, in a normal season of 150 days. It is a plant with a daily cane crushing capacity of 2000 tonnes, with provision for expansion to 3500 tonnes. Two other new units are near completion and are expected to undergo trial runs this season; they are the Sanghar Sugar Mills at Sanghar and Dewan Sugar Mills at Buddho Talpur, both in Sind Province. Each has an installed capacity of 2000 t.c.d.

Indian sugar factory closure

The Kodinar sugar factory of Shree Bileshwar Khand Udyog Khedut Sahakari Mandli Ltd. in the Amreli District of Gujarat State in India has been closed indefinitely.

1 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 538.

The status quo and trends in sugar centrifugal development

By Dr. P. Franzen
(Krupp Industrietechnik GmbH, Germany)

More than in other fields of solid-liquid separation, the development of centrifugals for the sugar industry has been dominated by premises of low cost, high capacity, modest demands on personnel, reliability, safety, and a low consumption of energy.

After significant developments in the 1960's, with fully automated batch-wise operation and continuously operating centrifugals for *C* and *B*-products, and after relatively minor improvements in the 1970's, the 1980's brought about a new surge in developments, leading to continuously and discontinuously operating machines with processing capacities deemed hitherto inconceivable.

The principal reasons for the new trend towards compact centrifugals of high capacity and low energy consumption have been the following:

(1) A concentration of sugar production in existing plants of high output but limited space.

(2) The demand for a balance of electric power and heat requirements with a total energy consumption significantly 11970's.

(3) An economic necessity of reducing the personnel for both operation and maintenance.

A strong trend towards continuous processing from the sugar juice to the crystal is still in evidence. Discontinuously operating centrifugals for secondary products are certainly a vestige of the past, and even in processing raw sugar the batchwise operation is being abandoned. In this stage of processing, coming years will firmly establish a twofold continuous separation in one machine.

Figure 1 shows the principle of the double-effect continuous centrifugal developed by Krupp Industrietechnik GmbH for this purpose. Primary separation, mixing with the filtrate of the preceding separation stage, secondary separation, washing, and dissolution in water or dispersion in sugar juice are the series of processing steps consecutively accompanied by this machine.

The production of white sugar and refined will continue to be in the realm of batchwise operation. The advantages of optimum adaptability to an available product and to established quality requirements, a high yield at little damage to the crystals, and finally low energy consumption will keep outweighing the drawbacks of a high cost of investment and the presumed

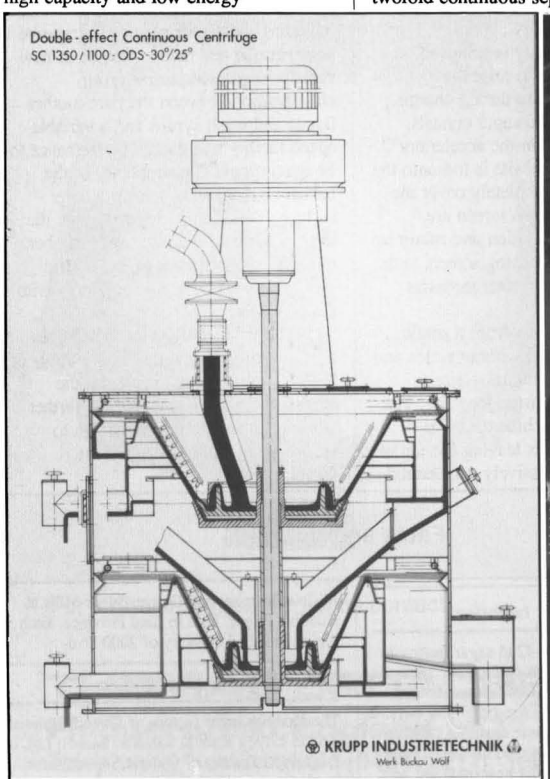


Figure 1. Double-effect continuous centrifugal

Figure. 2

ISJ Abstracts

Cane sugar manufacture

The spiral heater for mixed juice

A. Valdes and O. Gomez. *Proc. 19th Congr. ISSCT*, 1986, 859 - 865.

The performances of two Alfa-Laval spiral heaters installed in "Pablo Noriega" experimental sugar factory in Cuba to heat mixed juice from cold liming are discussed. Results indicated that the rate of scale formation was lower in the spiral units than in shell-and-tube heaters, so that the coefficient of heat transfer fell more slowly and the interval between stoppages for cleaning was longer. On the other hand, spacing studs welded to the walls of the heating surface in the spiral heaters (300 per m^2 and having a diameter of 5 mm) caused friction and a pressure drop that was higher than for two shell-and-tube units and was similar to that in a third.

The continuous low-grade pan at Tully mill

R. Broadfoot. *Proc. 19th Congr. ISSCT*, 1986, 866 - 875.

A continuous horizontal *C*-massecuite pan divided into seven compartments and having a massecuite capacity of 120 m^3 is described that was installed in Tully factory in 1982. With a nominal boiling height of 0.5 m above the top tube plate, the pan was designed to produce 34 tonnes per hr of 58 - 60 purity massecuite at a *C*-seed addition rate of 8 - 10 tonnes/hr; exhaust steam is supplied at 170 - 180 kPa. The welded calandria made up of mild steel tubes is divided into three sections located along the centre line of the pan with downtakes along each side, so that there is ample room above and below the calandria to facilitate tube replacement if necessary; the total installed heating surface area is approx. 1200 m^2. Details are given of the mode of operation of the unit and of the process variables that are automatically controlled. At a massecuite Brix of about 93°, exhaustion has been consistently high, with good circulation at low steam consumption; no serious short-circuiting of massecuite has been found, and the residence-time distribution approximates to that required for an acceptable crystal size distribution.

Some experiences of in-crop maintenance of sugar mill boilers in Cuba

R. E. Munoz L. *Proc. 19th Congr. ISSCT*, 1986, 876 - 883.

In most Cuban sugar factories, the boiler exit flue gas temperature is used as a criterion in deciding when to carry out a major cleaning operation; when the temperature exceeds by 20°C (after about 45 days of continuous operation) a minimum value established for each type of boiler, the unit is shut down within the subsequent 2 - 3 days and a cleaning procedure followed which should not take more than 60 hours, including the cooling time. Practical considerations of the system and results (including energy savings) are discussed.

Application of different membrane treatments for desalting molasses

Y. Kurniawan and M. Mochtar. *Proc. 19th Congr. ISSCT*, 1986, 984 - 995.

Electrodialysis and counter diffusion using hollow fibre membranes were tested as means of removing inorganic salts from cane molasses. Results for molasses samples from a defecation-sulphitation, a sulphitation and a carbonatation factory in Indonesia showed that both treatments removed approx. 60% of the total cations and more than 70% of the K^+ content. No sugar loss occurred in electrodialysis, but there was a loss in counter diffusion which represented more than 30% of the K^+ removed. Components of high molecular weight and the total cation content in molasses treated by electrodialysis had a considerable effect on the desalination ratio and current efficiency. The type of molasses had no effect on counter diffusion performance, but the type of membrane, recycling and molasses flow rate had a pronounced influence on salt removal, while the water flow rate appeared to affect the separation factor. The costs of removing 60% total cations per tonne of molasses by the two processes are lower than those of ion exchange.

The possibility of improving the individual bagasse drying system

M. Saechu and S. Partowinoto. *Proc. 19th Congr. ISSCT*, 1986, 1001 - 1008.

Single- and double-column bagasse dryers were tested on a laboratory scale. Results showed a reduction in moisture content from 49.4% to 34.1% at 500 kg/hr throughput in the single-column unit and from 48.5% to 30.7% and from 52.7% to 40.8% at 500 and 800 kg/hr throughputs, respectively, in the double-column dryer. The corresponding efficiencies were 33.4%, 37.9% and 47%. The total energy consumption in the double-column dryer was lower than in the single-column unit.

Seven years' experience with bagasse dryers

L. E. Correia. *Proc. 19th Congr. ISSCT*, 1986, 1009 - 1016.

Experience in the operation of three bagasse dryers installed one each in the three boilers at Santo Antonio sugar factory in Brazil is recounted. From numerous analyses over a 7-year period, it is shown how the dryers have increased boiler efficiency and can raise the performance of older boilers to match that of more modern units and so justify continuation of their use. The efficiency of a boiler with bagasse dryer but without air heater was 75.5% net calorific value compared with 71.6% for a boiler with air heater but without dryer, while an efficiency of 83% was achieved where both a dryer and an air heater were incorporated. For bagasse moisture contents of 50%, 40% and 35%, the boiler efficiencies are given as 71%, 80% and 83%, respectively. Details are given of dryer maintenance and operation.

The cane sugar factory of the future

J. M. Paturau. *Proc. 19th Congr. ISSCT*, 1986, 1017 - 1025.

The author recommends replacing batch processes by continuous operation (particularly in the case of boiling, crystallization and centrifugalling) and improved cane preparation to enable milling to be restricted to four 3-roller units, with a significant saving in capital costs and maintenance while still providing a high extraction efficiency. Electric drives should be installed generally so as to save energy and hence reduced bagasse consumption, while the evaporation station should be re-designed to minimize steam consumption. Steam and power economy is discussed, and it is calculated that a modern continuous raw sugar factory should be able to operate on 300 kg of steam/tonne of cane and 30kW/tch.

An economic analysis of cane energy production

W. Keenliside. *Proc. 19th Congr. ISSCT*, 1986, 1026 - 1035.

Since the cane season does not normally last more than 5 months in developing countries, it is suggested that the season be extended to include two cane crops; the normal crop period would be intended for sugar manufacture as at present, while the second crop period would be devoted to production of alcohol and electricity for sale to the public utility. The technological and economic aspects of upgrading a factory for operation under the proposed scheme are analysed and the financial benefits indicated.

Energy planning of a (sugar and alcohol) factory

L. E. C. Maranhão. *STAB*, 1985, **3**, (3), 34 - 36, 38 - 39 *(Portuguese)*.

Three phases in the development of a sugar factory/distillery are described. In the first, for the 1978/79 season, oil fuel was necessary to supplement bagasse. An account is given of the modifications to plant carried out in the period to 1983/84 by which time the factory was almost completely self-sufficient in energy. Further steps are mentioned which are expected in the future to provide a surplus of bagasse for use in generating energy for irrigation or concentration of the distillery's vinasse to 20°Bx.

Optimization of the use of electrical energy in sugar and alcohol factories

I. L. Brazil. *STAB*, 1985, **3**, (3), 40 - 42, 44 - 46, 48 - 49 *(Portuguese)*.

An outline is presented of industrial power generation, transmission and distribution systems and reduction of energy costs. The effects of low plant operating power factor may include overloaded cables, transformers and generators; increased copper losses; reduced voltage level; and increased power costs where a power-factor clause is part of the rate structure. Selection of voltage is one of the most significant factors in the design of a power system for an industrial plant. It is a major factor in determining overall system cost, flexibility, and ease of future expansion. The important consideration when saving energy costs is to select the best pressures and temperatures for steam generation and the proper type and size of boilers and turbines.

Pilot scale ultrafiltration of clarified juice

O. L. Crees. *Sugar J.*, 1987, **49**, (8), 17 - 19.

See *I.S.J.*, 1987, **89**, 15A.

Personal computers as data loggers in the sugar industry

A. Wienese and K. Schäffler. *S. African Sugar J.*, 1987, **71**, 71, 74.

The ease with which personal computers can be programmed for use in data logging is mentioned and guidance given on preliminary steps that must be carried out, including signal conditioning and smoothing and calibration. Details are given of the two PC-based data logging systems developed at the Sugar Milling Research Institute to assist in research projects, and their applications to a study of colour transfer during boiling in a pilot vacuum pan, to optimization of bagasse dewatering and to fractionation of sugar colorants by gel chromatography are briefly described.

Control methods for sugar crystallization vacuum pans

D. J. Wilson, E. T. White and P. L. Lee. *PACE* (Australia), 1986, **39**, (7), 42, 44 - 45, 48, 50, 52; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (7), Abs. 7 R508.

An analysis is presented of the research program at the University of Queensland that aims to develop more accurate methods of measuring the basic variables in boiling (mother liquor supersaturation coefficient and massecuite consistency) and to establish the most efficient means of controlling the process. Investigations are conducted on a 100-litre experimental pan on which various instruments can be installed for quantitative assessment of the process variables.

Recent innovations in milling technology for reduction of losses

T. T. Oommen and R. K. Choda. *Indian Sugar*, 1986, **36**, 457 - 460.

See *I.S.J.*, 1987, **89**, 78A.

Treatment of the waste stream from a sugar mill by *Azotobacter*

Y. T. Chuang. *Taiwan Sugar*, 1987, **34**, (1), 8 - 11.

See *I.S.J.*, 1987, 100A.

Pol deviation as a quality indicator in sugar cane

C. S. Yeh. *Taiwan Sugar*, 1987, **34**, (1), 16 - 20.

See *I.S.J.*, 1987, **89**, 90A.

Microcrystalline sugar drying with a spouted bed

H. C. Tso, C. H. Chen and R. Y. Chang. *Taiwan Sugar*, 1987, **34**, (1), 21 - 24.

See *I.S.J.*, 1987, **89**, 100A.

Beet sugar manufacture

Larox pressure filters at Naantali sugar factory

K. Niskala. *Larox News*, 1987, **9**, (1), 10 - 13.

An illustrated account is given of the application of Larox PF 32 automatic pressure filters to carbonatation mud treatment at Naantali sugar factory in Finland. Each unit has a filtration area of 32 m^2, and gives a cake of 70% dry solids compared with 49% when rotary filters were previously used, while cake losses average 0.3% compared with 0.8% (although the point is made that the earlier filters were not adequately maintained and that the performances of newer rotary units would be better than indicated). Sweetening-off requires only a small amount of water – about one half of the quantity of mud to be filtered. The filtrate is used mostly for lime slaking and the filter cake is sold to farmers for use as fertilizer.

Sugar storage in silos. XII. Sorption isothermals and limiting moisture contents of selected types of sugar

V. Kavan. *Listy Cukr.*, 1987, **103**, 114 - 117 *(Czech)*.

For purposes of sugar storage in silos it is necessary to make accurate measurements of absorption isothermals as a function of granulometry and ash and reducing matter contents. Knowledge of the true limiting moisture content of the sugar is closely associated with this, and measurements were made for various sugars (including refined cane raw sugar) from seven beet sugar factories. Isotherms are reproduced and discussed. The results showed that the limiting moisture content rose with increase in crystal size and fell with greater ash content; while the reducing matter content had a crucial effect on the equilibrium moisture content of a sugar, its effect on the limiting moisture content was statistically insignificant. An approximation equation derived from statistical evaluation of the results calculates the limiting moisture content as 42.3 - 364 A + 17.3 d, where A = ash content and d = crystal size (r = 0.8784).

The sugar industry in Italy

F. Buja. *Zuckerind.*, 1987, **112**, 500 - 508 *(English, German)*.

An account is given of the history of the Italian sugar industry from the commencement of processing at a factory in Rieti in 1872. By 1930, there were 54 sugar factories (47 of them in the north of the country), but this figure rose to a peak of 73 white sugar factories, 8 raw sugar factories and five juice stations in 1961/62, but the only refinery (in Genoa) closed in 1961; the industry continued to expand after the EEC sugar marketing regulations came into force in 1968, since when the number of factories has fallen dramatically to 36 in 1987 but with increased average slicing capacity. Information is given on the current factories and sugar companies.

After-crystallization with the MET (Multistage Ebullism Tank)

O. Bia. *Zuckerind.*, 1987, **112**, 518 - 524 *(German)*.

Further information is given on the Italian MET, a continuous vertical crystallizer described earlier[1], and details are given of its performance at two sugar factories in 1985. At Molinella, 31 minutes' retention of white sugar massecuite yielded 55% sugar on massecuite compared with 40% sugar recovery without the MET. At Contarina, the white sugar yield was 52% after 29 minutes' retention compared with 39%; at the same factory, the purity of *B*-white sugar mother liquor massecuite was reduced from 78.5 to 74.0 at a residence time of 25 minutes compared with a purity of 76.5 after a residence time of 3 hr 27 min in a conventional crystallizer, and crystal yield was 68.4% compared with 63.8%. A number of diagrams are presented relating to crystallization of massecuites of 87.5 - 93.5 purity.

Performances of the Fives Cail Babcock continuous vacuum pan and new prospects

J. de Crémoux, P. Credoz and M. Pattacq. *Sucr. Franç.*, 1987, **128**, 213 - 222 *(French)*.

The thermal efficiency of the FCB continuous horizontal pan is discussed and the effects on it of massecuite purity and final Brix, vacuum and quantity of water evaporated are indicated; the vapour flow pattern and the positive effect on massecuite circulation of incondensable gas injection below the vessel are described. Automatic boiling control on the basis of conductivity is compared with the newer concept of open-loop control in which the quantity of water to be evaporated, and which is introduced in the syrup fed into each compartment, corresponds to the quantity of feed vapour, continuous measurement and control of which thus regulate the between the target and true values used to adjust the flow in the final compartment. Boiling trials with reduced quantities of magma gave excellent results with as little as 10%, in contrast to a conventional 25% magma, but difficulties arose below 10%. Analysis of the problems showed that the height of the first compartments in the pan should be reduced in order to prevent too low a crystal population; reducing the volume and heating surface area by half would approximately halve the amount of syrup for the same quantity of magma as before, doubling the crystal content and reducing the distribution of crystal residence time. A pilot unit has been installed at the same factory for production of magma by diluting massecuite from the continuous pan so as to desaturate the mother liquor followed by crushing to provide the required volume of crystal nuclei; trials have demonstrated the possibility of obtaining a magma of the correct granulometry.

Change in the cell ultrastructure of beet during diffusion under the effect of temperature and an electric field

M. P. Kupchik, A. B. Matvienko, V. V. Mank, V. D. Manuil'skii and I. M. Katrokha. *Sakhar. Prom.*, 1987, (5), 18 -

1 Maurandi *et al.*: *I.S.J.*, 1986, **88**, 114A.

21 *(Russian).*

Electron microscopy was used to investigate the changes brought about in the structure of cell membrane by 30 minutes' diffusion in an electric field at 25 V/cm and 25° and 50°C by comparison with diffusion at 25° and 75°C in the absence of applied voltage. Under normal conditions all the cell structures were damaged at 25°C, the central vacuole burst and a homogeneous cell matrix (a plasma membrane dispersion) formed, in some cases concentrating in separate sections of the cell; a temperature rise to 75°C destroyed the cell structures and caused formation of individual small structures of irregular shape as well as osmophilic conglomerates. The electric field caused the homogeneous matrix to concentrate at 25°C and vesicular formations appeared, probably from the deformed cell membranes; at 50°C these shapeless forms conglomerated and moved out to the cell periphery, the accumulation of cells from damaged membranes increased at the periphery and there was a reduction in the amount of material in the central zone of the cell. Because of these marked effects of the electric field, the amount of residual non-sugar rose in the exhausted cossettes, raising the quality of the raw juice and reducing pulp sugar losses.

Massecuite boiling with maintenance of a constant distance between crystals

V. I. Tuzhilkin, A. R. Sapronov, S. V. Grigorov and M. A. Karagodin. *Sakhar. Prom.*, 1987, (5), 27 - 30 *(Russian).*

A mathematical model of the crystal growth process during boiling was used in a study of the effects of various parameters on the optimum distance between crystals of (1 - 2) × 10^{-4} m. Under identical conditions, the inter-crystal distance was maintained optimum during 24 - 27% of the total process time when conventional boiling with nucleation was used, whereas the proportion of the total time rose to 36 - 40% when a crystal footing was used. The model was used to establish conditions under which the proportion was maximum at up to 80% for a given strike; it is emphasized that while increase in this proportion will result in a reduction in the overall boiling cycle, allowance must be made for the resultant reduction in the number of crystals.

Some chemical reactions in preliming

D. V. Ozerov, A. R. Sapronov and O. V. Suetina. *Sakhar. Prom.*, 1987, (5), 25 - 27 *(Russian).*

A study of colloid behaviour in preliming showed two distinct pH ranges that differed from each other in terms of physico-chemical changes in the non-sugars component. At pH 7.8 - 8.4 there was a rise in the Ca concentration and in the negative zeta-potential, while at pH 9.0 - 9.5 there was a fall in both parameters with a change in the structure of the colloids which became more capable of conglomeration, so that this pH range was the more important of the two as regards raw juice purification.

The effectiveness of purification by carbonatation of products at different stages in manufacture

M. I. Daishev, T. P. Trifonova, A. A. Kade and L. G. Skuina. *Sakhar. Prom.*, 1987, (5), 30 - 32 *(Russian).*

Laboratory and factory-scale investigations showed that non-sugar removal by carbonatation under constant conditions increased as the relative quality of the products fell in the order syrup > *A*-massecuite wash syrup > molasses. The effectiveness of molasses treatment was demonstrated in the case of an initial non-sugar content of 1.8% by weight of beet; use of 25% CaO on non-sugar weight reduced the level by 11.6%, while pre-treatment by deliming reduced it further by 29.8%, corresponding to falls in sugar losses of 0.25 - 0.30 and 0.60 - 0.70% on beet.

Experience in the operation of an automatic purging system for equipment in the juice purification station at Chortkovskii sugar factory

V. A. Derevyanko *et al. Sakhar. Prom.*, 1987, (5), 36 - 38 *(Russian).*

Details and advantages are given of a remote control system for evacuating mud from carbonatation, preliming and liming vessels in a programmed sequence.

Experience with centralized control of beet transportation and reception

E. D. Shmagailo, V. I. Chub, I. E. Semerik, G. D. Shevchenko and Yu. S. Erushkovskii. *Sakhar. Prom.*, 1987, (5), 39 - 41 *(Russian).*

A system for regulating beet delivery to a factory so as to avoid bottlenecks created by large numbers of vehicles travelling from several farms is described.

Distribution of beet among sugar factories

V. I. Slizkii, I. P. Pibyvanets, S. I. Reznikov and V. A. Malovichko. *Sakhar. Prom.*, 1987, (5), 41 - 43 *(Russian).*

The problem of beet distribution among factories so as to allow all factories to finish the campaign at the same time and to reduce losses caused by prolonged storage at one factory of beet that could be processed earlier at another is discussed theoretically.

Organization of beet transportation by heavy-duty road trains

A. I. Pilipchenko. *Sakhar. Prom.*, 1987, (5), 43 - 45 *(Russian).*

Experience in the USSR of using beet transporters comprising a truck towing up to two trailers having a nominal total carrying capacity of 17 - 24 tonnes is discussed.

Aim, function and experiences of a new sugar beet growing contract in Sweden

C. Sperlingsson. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 14 pp.

Details are given of a new system of beet payment, transport and seed purchase introduced in Sweden in 1985 and comparison is made with the previous system. Whereas earlier payment had been made for beet on the basis of 16% sugar content with an increase or decrease of 1/160 in price for every 0.1% increase or decrease in sugar content, respectively, under the new arrangements the basic price rises by 0.9% for every 0.1% increase in sugar content above 16%, falls by 0.9% for every 0.1% decrease in sugar content down to 14%, and then by 2% for every 0.1% decrease down to 9.9% sugar, below which no payment is made. Whereas previously growers had been able to buy pulp and molasses at concessionary rates that were so low for the pulp that in effect the farmer received the pulp free of charge, under the new contract the farmer has to buy these by-products from the Swedish Sugar Corporation (SSA) at normal market prices. SSA is responsible for all the costs involved in loading and transport of clean beet subject to certain conditions. The effects of the changes are discussed.

Packaging installation at Carlow

M. E. Buckley. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 30 pp.

Details are given of the new packaging plant at Carlow which includes two SIG Swiss Industrial Company PRD units for 1-kg packets and palletizers for parcels of 15 packets and for single packets. Results obtained in 1987 are discussed.

Technical service to industrial sugar customers

P. M. Lyons. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 50 pp.

Information is provided on bulk storage, handling and transport of sugar at Irish sugar factories for industrial customers. Whereas until 1981 all bulk sugar was delivered and stored dry, since then direct dissolving plants have gradually been installed, allowing the sugar to be transported in granular form and then discharged into the normally 50 m^3 stainless steel tanks for hot or cold dissolving and storage. A major part of the paper is devoted to sugar dust explosions and their prevention.

Improvement of massecuite exhaustion by vertical vacuum cooled crystallizers at an Italian sugar factory

C. F. Buja. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 26 pp.

The design, performance and automatic control of the MET vertical crystallizer are discussed[1,2] with the aid of diagrams of the unit.

Steam turbo-alternator developments

D. A. G. Brown. *Paper presented at Int. Sugar Tech. Conf.*, (Irish Sugar plc), 1987, 22 pp.

An account is given of the development of the steam turbine and of its application to power generation in a beet sugar factory. Among questions discussed is that of optimum steam inlet temperature (considered to be 510°C) and pressure (considered to be 63 bar); at these two optima, 88% internal efficiency available with most modern turbines will provide an exhaust steam temperature of 162°C or a superheat of just below 30°C. Descriptions are given of installations at Bury St. Edmunds factory of British Sugar plc, where 13.4 MW is generated from 103 tonnes of steam per hr, at Newark where 10 MW is generated from 65 - 70 tonnes/hr and at Cantley where it is planned to install a new turbo-alternator to generate 11 MW from 70.5 tonnes/hr of steam at 45 bar and 470°C and eventually, once an oil-fired boiler has been replaced with a larger unit, to generate 13 MW from 74 tonnes/hr. The picture is one of gradual improvement in turbine internal efficiency and of reduction in factory steam consumption.

Optimization of diffuser draft and sugar loss in pulp by means of isocost charts

K. Anderson. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 12 pp.

Expression of the relationship between diffuser losses and juice draft in the form of a characteristic plant curve, and the economic effect of increased losses and of increased draft (as a result of the cost of evaporating the extra water in the juice) are discussed. The application in Danish sugar factories of isocost charts to optimize draft and sugar loss is then described whereby the cost of sugar loss is calculated from the sales of sugar and molasses and from the purchases of beet, while the cost of juice draft is calculated from the outlay on pumping of juice and diffusion water, on lime consumption and treatment of water with SO_2 and on heating and evaporation; at all points on the resultant straight lines linking the vertical loss axis with the horizontal draft axis the total cost of the juice draft and sugar loss is constant. Superimposition of the characteristic plant curve gives the required optimum values. The method is illustrated by an example from Nakskov sugar factory using vapour recompression.

Description and comparison of three different systems of footings-magma production

H. Schiweck, M. Munir and G. Witte. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 39 pp.

Details are given of the systems used at Plattling, Gross-Gerau and Regensburg factories for crystal footing production and subsequent boiling and results obtained are discussed with the aid of diagrams. The aim of all three plants is to produce white sugar 1 and 2 from the same massecuite and to control grain size distribution in the sugar product within the range 0.25 - 0.80 mm by changing the volume of crystal footing; the conditions under which these aims may be achieved are indicated.

1 Maurandi *et al.*: *I.S.J.*, 1986, **88**, 114A.
2 Bia: *ibid.*, 1988, **90**, 3A.

Sugar refining

The use of radio frequency for the control of a white pan at Hulett Refineries – a preliminary trial

D. J. Radford, D. J. Tayfield and M. G. S. Cox. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 19 pp.

The principle of operation of an automatic boiling control system based on the relationship between massecuite physical and electrical properties (as measured at radio frequencies) is described. Tests showed very good correlation between massecuite crystal content and both series and parallel capacitance at radio frequency (RF) but less so between series capacitance and Brix of the footing (although there was sufficient sensitivity for the correlation to be used to determine the seeding point, after which sensitivity to Brix rapidly diminished with increase in crystal content, indicating the greater suitability of the series capacitance signal for the control of high purity boiling). Trials on application of the system to white sugar boiling are reported. Wide variation in mean aperture was attributed to the use of shock seeding instead of a full seeding technique with slurry. In all cases the conglomerate count was lower than in manual boiling, and the system was reliable and easy to operate once all initial instrumentation problems had been overcome. Reliability and accuracy of the system for Brix control were comparable to those of a nuclear density system but at a much lower cost. A commercial RF probe is being developed by the company in collaboration with a manufacturer.

Distributed process control systems at two CSR refineries. I. Pyrmont refinery, Sydney. II. Yarraville refinery, Melbourne

G. Weiss, V. Lawrie and P. Field. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 34 pp.

I. Details are given of the distributed control system (preferred to a centralized system because of its flexibility and capacity for low-cost development as well as greater security in the case of computer breakdown) used at Pyrmont initially for the wet end of the refinery, i.e. from raw sugar recovery to liquor evaporation, so as to avoid process stoppages that led to melt delays and energy waste. In a centralized (direct digital) system, the computer is the overriding controller and is directly linked to existing programmable logic controllers (PLC's) and local transmitters and controllers, whereas in a distributed system local microprocessor units and PLC's both acquire data and act as local controllers while feeding some data to the supervisory computer which calculates optimum process throughputs and conditions and feeds the information back to operators or supervisors or changes local controller set points. Operation of the supervisory control system and of the network is explained with the aid of diagrams, and the performance of the scheme during an initial 3 months is discussed.
II. The Toshiba Tosdic 2000 system used for the pan station at Yarraville is described. It permits four grades of massecuite to be boiled in three pans and includes a total steam flow control scheme which limits the flow set point if the pressure drops below a desired level. Benefits of the control system include a reduction in downtime per cycle (resulting in a 4% increase in station capacity) and improvement in information availability; the control unit proved exceptionally reliable in its first six months of operation.

A plant-scale decolorization comparison of bone char from fresh bones

L. A. Anhaiser and R. L. Wanger. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 24 pp.

While tradition has required that bones used for char manufacture must be derived from animals that have died naturally and must have been degreased and sun-cured, trials showed that raw sugar liquor treatment by char from fresh bones was almost as efficient as that by char from sun-dried bones and, it was expected, would have attained the same level of performance within eight complete cycles as a result of the better regeneration found by comparison with conventional char.

Remelt performance at Refined Sugars Inc.

W. A. Raiola. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 11 pp.

Because of the amount of recycling needed to achieve target purities when using a 2-boiling system in the remelt station, it was decided to replace it with a 3-boiling scheme after 4 years' operation with only marginal success. Details are given of the three stages in the new system, which has reduced the amount of recycle while improving the ability to meet lower target purities; however, recovery performance has been adversely affected by increase in the invert sugar:non-sugars ratio, which has led to increased difficulties in exhaustion. The average final purity of 55 compares with an average of 60 with the 2-boiling system.

Remelt operations at C and H Sugar Company

P. J. Langley. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 11 pp.

The remelt recovery system at Crockett refinery is described, with details of the equipment, system control, the scheme used to boil four grades of massecuite and the performance of the remelt station. While the recovery system aims to recover sucrose and eliminate non-sucrose, the latter goal is achievable in only three final products: molasses, soft sugar and refinery syrups. A relatively large amount of soft sugar is boiled and about half of the non-sucrose is eliminated in soft sugar and refinery syrups, with the remainder boiled to molasses, so that raw sugar quality and soft sugar production rates are the chief factors influencing remelt station activity.

Laboratory studies

Development of a simulation model of sugar solution concentration by reverse osmosis

G. Lombardi and M. Moresi. *Ind. Alimentari*, 1987, **25**, 205 - 215 *(Italian)*.

A mathematical model of sugar solution concentration by reverse osmosis is described; the model was developed in order to predict the permeate flux in tubular, plate-and-frame and spiral-wound batch and continuous systems and assumes that no deposit forms on the membrane. Tests with various fluids demonstrated its suitability as a means of predicting performance; since membrane permeability to water and the physical and rheological properties of the solution being concentrated are the only unknown parameters, the model is of particular value for process design optimization.

Contribution to the general discussion on chromatography at the 19th ICUMSA Conference, 1986

N. Kubadinow. *Zuckerind.*, 1987, **112**, 285 - 290 *(German, English)*.

Using analysis of sucrose, glucose and fructose as example, the author discusses in detail various aspects of GLC and HPLC, including the choice and performance of detector (e.g. refractive index detector *vs.* a reaction or derivatization detector), peak area evaluation and analysis standardization.

The effect of the mud content in molasses on the correctness of the Polish test procedure

K. Wagnerowski. *Gaz. Cukr.*, 1986, **94**, 146 - 150 *(Polish)*.

By "mud" is meant the insolubles, chiefly calcium and magnesium compounds as well as carbonates and sulphates and salts of organic acids, e.g. oxalates, plus coagulated colloids adsorbed on mud particles. It has been found that results given by the Polish test for solubility and saturation determination have given values of standard molasses purity that differed between factories as a result of variation in the mud content. For calculation of Brix and sugar content, the ratio of true to apparent Brix (Bx_{tr}:Bx_{app}) is given by (100 - 0.5 M):(100 - M), where M = mud % by weight, while for sugar the appropriate equation is S_{tr}:S_{app} = (100 - 0.026 M):(100 - M). Corresponding corrections are required for purity, non-sugars concentration, saturation coefficient and m and b in the solubility equation. A modification to the test procedure is suggested in which the mud content is determined gravimetrically and given as k, i.e. M:NS_{tr} or M:(Bx_{tr} – S_{tr}); $m_{tr} = m_{app} + 0.55\ k$, and $b_{tr} = b_{app}$.

Examination of colouring matter in white sugar

I. F. Bugaenko, M. Garcia F. and V. D. Shcherbukhin. *Sakhar. Prom.*, 1987, (4), 19 - 21 *(Russian)*.

Colouring matter separated from white sugar by anion exchange was fractionated by gel chromatography using Acrylex R-60. Most of the fractions contained substances having an average molecular weight of 21,000; drying of these fractions at 30°C yielded a black powder which was examined by IR spectroscopy, TLC, GLC and HPLC. Intensive absorption occurred at frequencies in the range 1000 - 1670/cm and at 3300/cm, corresponding to a carbohydrate component, and the relevant atomic groupings are indicated. The powder was acid hydrolysed and the hydrolysate found by TLC to contain aldo-sugars (hexoses and pentoses) but no keto-sugars such as fructose. GLC of the aldononitryl acetate derivatives of the sugars in the hydrolysate yielded mostly mannose, glucose and some galactose, with traces of rhamnose, ribose, arabinose and xylose. HPLC was applied to analysis of the amino-acid component in the powder, and the relative concentrations are tabulated of 17 amino-acids; the major ones were glutamic acid, serine, leucine, glycine, valine, lysine, alanine, threonine, phenylalanine, isoleucine and aspartic acid.

The dependence of sugar solution viscosity on temperature

L. A. Sapronova. *Sakhar. Prom.*, 1987, (4), 21 - 23 *(Russian)*.

Data in the literature and experimental values obtained by the author for refined sugar solutions were used to determine the degree of influence of temperature on viscosity; the formula of Pidoux[1] was employed for generalization of the data, and resultant rectilinear curves of log viscosity *vs.* temperature are given for concentrations of 40 - 86%. While the lines for 40 - 70% concentration converged at a given point corresponding to a temperature >100°C, those for the upper part of the concentration range converged at a different point, confirming the difference in structure between sub- and supersaturated solutions and demonstrating the small effect of temperature on viscosity of saturated solutions, particularly in the range 40 - 100°C. An equation for calculation of log viscosity takes the form:

$$\log \mu = a + b\,[(T - T_o)/T^2],$$

where T_o is absolute zero; equations are also presented for calculation of a and b, and values are given for concentrations in the range 40 - 86%.

Sucrose dissolution rate in pure sugar solutions of varying concentration

V. V. Spichak, A. S. Pakhomova, L. I. Trebin and V. O. Shtangeev. *Sakhar. Prom.*, 1987, (4), 23 - 25 *(Russian)*.

The dissolution rate of crystals obtained from screened white sugar of 0.4 - 0.5 mm particle size was determined in a laboratory horizontal stirred crystallizer into which an aqueous solution containing a known weight of sugar was introduced followed by weighed crystals that had been heated to the test temperature. The times taken for each 0.5% change in the readings of a refractometer were measured during the experiment, and the sugar content in the mother liquor measured polarimetrically at the end of the experiment was compared with the refractometer readings, with

1 *Zucker*, 1961, **14**, 523 - 532.

allowance made for temperature. Results are tabulated for initial crystal contents of 5, 10, 15, 20, 25 and 30% dissolved at 30, 40, 50, 60 and 70°C, with Brix increasing from an initial 72.4° to 73.6° and supersaturation coefficients in the range 0.74 - 0.96. The values of the specific dissolution rate K (g/m²/sec) were calculated from the experimental parameters using a formula of Kukharenko.

Growth rate of small sucrose crystals at 70°C

S. K. Heffels, E. J. de Jong and D. J. Sinke. *Zuckerind.*, 1987, **112**, 511 - 518.

The growth rate of small sucrose crystals (20 - 100 μm) in suspension at 50°C and 70°C was determined in a stirred glass vessel using a Coulter Counter to measure the crystal size distribution. Results showed that a critical supersaturation was needed for crystal growth to commence; while the small crystals grew at a much slower average rate than large crystals they required a higher supersaturation than did large crystals for growth. In investigation of the possible effect of stirring on the growth rate, the influence of large particles on the velocity of the solution around small crystals was studied by adding 1 mm glass beads; however, neither stirrer speed nor the quantity of beads added had any significant effect, demonstrating that the surface reaction was the dominant factor in growth. The importance of the role of the surface reaction was confirmed by the value of the activation energy (calculated as 57 ± 14 kJ/mol for 50 μm crystals) and by the differences in growth rate between screened crystals produced by boiling in a laboratory pan (assumed to be growth products of secondary nuclei), milled crystals and crystals formed by salting out in alcohol. The dominance of the surface reaction explains the occurrence of growth rate dispersion, with crystals of the same size growing at different rates.

Alternative methods of polarizing sugar

C. C. Chou. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 25 pp.

In view of expected prohibition of landfill disposal of untreated lead-containing waste under US legislation, a systematic program was initiated by Amstar Sugar Corp. to study and evaluate polarimetry of sugar products with and without the use of non-toxic chemical reagents. Details are given of the studies, involving various types of polarimeter. Preliminary measurements of 20 samples of raw sugar obtained using a helium neon laser polarimeter differed from values given by a conventional polarimeter by between –0.5 and +0.37°S; lead subacetate was not used with either instrument. While a laser beam has advantages over a conventional light source, the helium neon laser polarimeter has one disadvantage, viz. variation of transmitted light with the colour of the raw sugar sample, so that the photodetector/photomultiplier could be overloaded and burnt out with a constant output of high-intensity light from the laser in the case of a light-coloured sample; modulating the intensity of the laser beam in step with the transmitted light would solve the problem and provide a highly accurate polarimeter of minimal interference. The average difference between measurements given by an infrared polarimeter after membrane filtration of the sample and by a conventional polarimeter after wet lead clarification was well within experimental error but the requirement of 2 - 3 membranes to provide sufficient clear filtrate per sample makes the procedure unsuitable for daily routine analysis while kieselguhr alone failed to provide clear solutions of most refinery samples. A high angular resolution polarimeter operating on the basis of the Faraday effect was sufficiently accurate for process control with a precision of the order of 0.0001° angle of rotation. While near infrared reflectance analysis gave predicted purity values of sugar samples of known purity that were close enough to the true values to demonstrate its suitability as a replacement for conventional polarization with the advantage of removing the need for sample preparation, the technique was less satisfactory on granular raw sugar samples because of irregularity in particle sizes and its adverse effect on the amount of energy absorbed. After preliminary screening of various pairs of clarification reagents, $Ca(OH)_2$ and $AlCl_3$ were selected for treatment of factory product samples for process control purposes and for raw sugar polarimetry; results were promising, with the pol values being generally higher than obtained using wet lead clarification. Details are given of the procedure used to determine the dilution purity in conjunction with the reagents.

The vapour pressure of aqueous sucrose solutions

A. K. Buryma. *Sakhar. Prom.*, 1987, (5), 21 - 25 *(Russian).*

Experimental values of the vapour pressure of sucrose solutions found by Dunning *et al.*[1] for the concentration range 60 - 90% at 5% intervals and at temperatures in the range 60 - 95°C at 5°C intervals were used to develop formulae for calculation of vapour pressure over the same concentration and temperature ranges but at concentration intervals of 1%. The derivation processes used are shown and the calculated vapour pressure values tabulated.

Identification and micro-determination of residual impurities in sugar products using modern methods

A. Z. Usmentseva, L. D. Lokantsova and I. Yu. Tsaryuk. *Sakhar. Prom.*, 1987, (5), 32 - 36 *(Russian).*

An atomic absorption spectrophotometric method is described which is suitable for determination of metals in sugar, molasses and beet pulp, while details are given of GLC and TLC methods for determination of agrochemical residues in the same three products. A regression equation is also presented for calculation of R_f values as a function of temperature, moisture content, adsorbent grain size and length of run.

1 *J. Chem. Soc.*, 1951, 2363 - 2372.

By-products

Studies on the fermentative production of L-lysine. IV. Optimization of culture conditions for L-lysine fermentation of cane molasses

Y. T. Liu. *Rpt. Taiwan Sugar Research Inst.*, 1986, (114), 45 - 62.

Optimum conditions of cane molasses fermentation with *Brevibacterium* sp. HA92Y to yield L-lysine were found to be: 50 ml of 6% molasses medium (as total sugar), 2% ammonium sulphate, 1% calcium carbonate and 3% acid hydrolysate of defatted soybean meal. Natural crude plant and animal oil proved to be effective, long-lasting and economical as anti-foam agents, and 5 ppm penicillin or chloramphenicol did not inhibit lysine synthesis if added after sufficient growth and would be useful for control of secondary bacterial growth. The source of clarified molasses had little effect on fermentation.

Molasses composition from the 1985/86 campaign

B. Kovács and P. Deák. *Szeszipar*, 1986, **34**, (2), 48 - 52; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (4), Abs. 4 R391.

Investigations showed that the molasses from the 1985/86 campaign in Hungary was of satisfactory quality (with increased dry solids and organic non-sugars) and could be used in the manufacture of bakers' yeast.

Utilization of beet molasses in the production of lactic acid

G. A. El-Sherbiny, S. S. Rizk and G. S. Yousel. *Egypt. J. Food Sci.*, 1986, **14**, (1), 91 - 100; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (4), Abs. 4 R413.

The effects of pH (4 - 7), sugar concentration (7.02 - 15.44%), temperature (30 - 50°C) and fermentation time (2 - 8 days) on lactic acid yield and sugar conversion were investigated using *Lactobacillus delbruckii* cultivation on beet molasses. Maximum yield of the acid of 62.6% by weight of initial sugar and maximum sugar conversion of 80.7% by weight of sugar consumed were obtained at an initial sugar concentration of 12.62%, pH 6, 45°C and 8 days' fermentation. The methods used to determine the composition of the media, lactic acid yield and sugar conversion are described and details given of the chemical composition of the molasses and of the fermentation parameters as a function of experimental factors.

The use of vinasse as acid corrosion inhibitor

V. K. Suprunchuk, N. P. Romenskii, E. G. Zharova and L. V. Khorunzhaya. *Sakhar. Prom.*, 1987, (3), 35 - 38 *(Russian)*.

Laboratory tests in which molasses vinasse from a distillery proved to have very good corrosion inhibition properties in evaporator tube cleaning with HCl were confirmed by beet sugar factory trials, and adoption of the practice in more factories during the 1987/88 campaign is recommended. The optimum concentration is 1.4% vinasse + 3 - 8% HCl or 2% + 10% HCl at 20 - 100°C. Apart from its low cost and good performance, vinasse had a number of advantages over industrial inhibitors.

The use of boiler flue gases in the (beet) pulp drying section at Orzhitskii sugar factory

V. S. Mokhort and V. N. Chikirisov. *Sakhar. Prom.*, 1987, (3), 41 - 44 *(Russian)*.

Details are given of the reconstruction of the pulp drying section at the title factory to allow boiler flue gas to be used as drying medium for what is regarded as a valuable animal fodder.

Effect of molasses composition on ethanol fermentation

S. S. Dhamija, D. S. Dahiya and P. Tauro. *J. Food Sci. Technol.*, 1986, **23**, (3), 162 - 164; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (5), Abs. 5 R360.

Laboratory investigations were carried out to determine the effect on ethanol yield and fermentation time of the composition of cane molasses and addition to it of urea (0.2%) and H_3PO_4 (0.02%) separately or together. Fermentation was conducted at 30°C, pH 5 and a sugar concentration of 14 - 15%; the yeast used was *Saccharomyces cerevisiae* HAV-1. It was found that the addition of urea and orthophosphoric acid accelerated fermentation to a certain degree and increased ethanol yield for most of the molasses samples. Details are given of the contents of total and fermentable sugars, ash, N and P in the molasses samples, and of the pH and ethanol concentration of the worts after 24 and 48 hours' fermentation.

The effect of insulin on the performance traits of pigs fed maize or final molasses

M. Castro and J. Ly. *Cuban J. Agric. Sci.*, 1986, **20**, 161 - 166.

Insulin injected intramuscularly into pigs every 10 days failed to increase the consumption of final molasses and reduced feed conversion by 13.9% compared with the controls; these findings were in contrast to the results for pigs fed on maize.

High efficiency carbohydrate fermentation to ethanol at temperatures above 40°C by *Kluyveromyces marxianus* var. *marxianus* isolated from sugar mills

P. J. Anderson, K. McNeil and K. Watson. *Appl. and Environmental Microbiol.*, 1986, **51**, 1314 - 1320; through *S.I.A.*, 1987, **49**, Abs. 87-180.

Of 35 strains of this organism tested for fermentation of 15% glucose w/v at high temperature (45°C), 14 produced >5.5% ethanol w/v in 24 hr. These strains were tested for their ability to ferment 16°, 19° and 22°Bx cane syrup at temperatures from 39 to 47°C. Ethanol output decreased with increasing temperature; cells remained viable up to 12 hr, but after 16 hr viability rapidly decreased. Several strains met the criteria of the ability to ferment sugars at >40°C with

rapid production of ethanol (>6% w/v after 12 hr) concurrent with >80% retention of cell viability; these criteria are considered crucial for the commercial development of tropical fermentation technology. Prospects for obtaining further improvements are discussed.

Improving the technological properties of molasses by enzymolysis

T. V. Ostrovskaya, S. T. Oliinichuk, A. D. Kovalenko, L. G. Tikhonevich and E. P. Krasun. *Ferment. i Spirt. Prom.*, 1986, (6), 25 - 27; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (7), Abs. 7 R376.

Results are given of an investigation on treatment of different molasses samples with complex enzyme preparations cytorosemin Pkh and cellokoningin P10kh with the aim of hydrolysing the polysaccharides contained in them. It was found that, as a result of formation of an additional quantity of fermentable sugars, the alcohol yield per unit raw material rose by 3.3 - 12.1 litres per tonne of nominal starch.

Ethanol separation from molasses-based fermentation broth by reverse osmosis

J. P. Choudhury and P. Ghosh. *Biotechnol. Lett.*, 1986, **8**, 731 - 734; through *Ref. Zhurn. An SSSR (Khim.).*, 1987, (7), Abs, 7 R380.

The effectiveness of reverse osmosis in separating alcohol from a molasses broth modified with cellulose acetate was studied. The alcohol concentration in the broth was raised to 5 - 20% with water or alcohol and reverse osmosis applied at 28 ± 2°C and a pressure of 56 - 98 kg/cm^2. It was found that the elution rate and alcohol separation efficiency rose from 0.69 to 1.19 litres/m^2/hr and from 80 to 89% of the initial with increase in pressure from 56 to 98 kg/cm^2, respectively, and fell with increase in alcohol concentration in the broth. Graphs are given of the change in process parameters as a function of alcohol concentration and pressure.

Production of glucose-fructose syrups using ion exchangers

L. D. Bobrovnik, G. P. Voloshanenko, G. A. Lezenko, O. P. Nazarov and T. K. Panchuk. *Teoriya i Prakt. Sorbts. Protsessov*, 1986, (18), 103 - 106; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (7), Abs. 7 R533.

An investigation was conducted on sucrose hydrolysis using strongly acidic KU-2-8 cation exchange resin as catalyst and on continuous isomerization of glucose at constant temperature in columns filled with AV-17-8 anion exchange resin in borate form. The effects of initial concentration, temperature and reaction rate on the degree of hydrolysis were studied. The syrups obtained by sucrose inversion could be used in the food industry without further treatment. It was found that the glucose isomerization in an alkaline solution was sufficiently simple and economical but was complicated by the need for supplementary purification of the syrups obtained.

Increasing the value of beet co-products: one way of improving beet profitability

J. P. Vandergeten. *Le Betteravier*, 1987, **21**, (219), 26 - 27 *(French)*.

The animal feed value of pressed pulp (with or without additives such as molasses, urea and minerals), dried pulp and beet leaves and the potential as fertilizer of beet leaves and filter-cake are discussed.

A review of some aspects of distillery spent wash (vinasse) utilization in sugar cane

J. D. Patil, S. V. Arbatti and D. G. Hapase. *Bharatiya Sugar*, 1987, **12**, (7), 9 - 11, 13, 15.

The composition and properties of vinasse and the upper permissible limits set by the Indian Standards Institution for suspended and dissolved solids, pH, temperature, BOD and COD of discharged industrial effluents such as vinasse are tabulated and briefly discussed, and the literature on application of vinasse as a fertilizer in cane crops is reviewed.

Effluent treatment processes for distillery spent wash

K. K. Johri. *Bharatiya Sugar*, 1987, **12**, (7), 23 - 25, 27 - 28.

While lagooning is the commonest method used by Indian distilleries for the treatment of vinasse, it gives rise to strong odours and causes pollution of ground water through seepage and overflow in the rainy seasons. Descriptions and diagrams are given of two other methods of treatment, namely biogas generation by fermentation followed by aerobic processing to bring the BOD down to an acceptable level, and incineration. While the methane in the biogas can be used as an additional source of energy, the generation process itself consumes electrical energy, and the quantity of effluent from the treatment greatly exceeds the vinasse input, so that it eventually poses a disposal problem. In contrast, incineration can make the distillery self-sufficient in steam and power while causing no difficulties in handling of the effluent, which may be recycled to fermenters, while the solid waste contains sufficient K_2O to be of value as a fertilizer.

Evaluation of the activation energy of yeast growth during batch cultivation

A. A. Arzamastsev. *Ferment. i Spirt. Prom.*, 1987, (1), 37 - 39; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (9), Abs. 9 R412.

The activation energy of yeasts grown under batch conditions was evaluated by studies of a mixed culture of yeasts with yeast-like fungi *Candida utilis* (L-35), *Torulopsis pinus* (L-30) and *Trichosporon cutanecum* (L-52) of high productivity when cultivated on a molasses vinasse substrate. The tests were conducted in a 10-litre fermenter with 5.5 litres of medium; aeration was effected through the shaft of the fermenter mixer, and cultivation was carried out at 24.5°C and 30°C and pH 4.0 - 5.5. Curves were plotted of increase in yeast biomass

concentration and of reduction in substrate concentration as a function of BOD, and equations are given for calculation of the maximum specific growth rate of the micro-organisms and of the activation energy.

Anaerobic fermentation of molasses wort at high temperatures

L. V. Levandovskii, V. K. Yanchevskii and A. D. Kovalenko. *Ferment. i Spirt. Prom.*, 1987, (1), 30 - 32; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (9), Abs. 9 R421.

The effect of temperature on fermentation of molasses wort of 22% dry solids concentration with varying quantities of seed yeast was investigated at 38°, 40° and 42°C; the tests were conducted in a 200-ml vessel into which 0.15% $(NH_4)_2HPO_4$ and 0.1N H_2SO_4 were introduced in quantities sufficient to maintain the pH of the medium at 5.0 - 5.1. Results showed that the economically optimum temperature was 38°C (at which the quantity of unfermented sugars and alcohol yield reached their theoretical norms at a high initial yeast biomass concentration and a corresponding reduction in overall process time). Higher temperatures were accompanied by a considerable increase in degradation of yeast cell structure, in the quantity of unfermented sugars and in the amount of secondary fermentation products (glycerol and aldehydes) and by a fall in ethanol formation. However, use of higher yeast concentrations at high temperatures intensified the fermentation process and increased the tendency for alcohol formation together with accelerated catabolism of the sugars.

Frost influence on sugar cane quality. A further study of its effects on cane destined for alcohol production

F. A. Fogliata, H. G. Ayala, E. Moreno, S. López and C. Torné. *Sugar y Azúcar*, 1987, **82**, (6), 42, 44 - 46.

Samples of NA 56-79 cane were taken from three different zones in Tucumán (Argentina) during 1985; the three zones were characterized by absence of frost, moderate frost (from 0°C to –3°C) and severe frost (from –6°C to –8°C). Predicted alcohol yield was calculated by multiplying the reduced total sugars by 0.6475. Results showed that moderate frosts did not have any apparent negative effect on juice quality, fermentation and probable yield of alcohol (litres/tonne of cane), whereas severe frosts severely affected both fermentation rate and yield and hence alcohol production.

Biological pretreatment of molasses vinasse

M. I. Koshel', T. I. Shmatko, Yu. A. Karanov, O. V. Fomkina and N. B. Chaban. *Pishch. Prom.*, 1987, (1), 30 - 32; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (10), Abs. 10 R418.

A recommended method of biological pretreatment of vinasse using a specially selected mixture of bacterial cultures was investigated. The technique involves microbial destruction of high concentrations of organic contaminants without water dilution; maximum use is made of conventional equipment as used for dry fodder yeast production. A scheme is presented for single-stage continuous pretreatment with removal of all biomass formed. The biomass is rich in protein, amino-acids, macro- and micro-elements and B-vitamins and has a well-balanced amino-acid composition.

Get it right with sugar factory lime

M. Armstrong and W. Woodwark. *British Sugar Beet Rev.*, 1987, **55**, (2), 44 - 46.

The advantages of filter-cake as a liming material for adjustment of soil pH and as a fertilizer are discussed and advice is given on the amount to apply and when.

Ten tonnes of sugar per hectare

N. Wyke. *British Sugar Beet Rev.*, 1987, **55**, (2), 46 - 47.

Reference is made to the beet and sugar yields on a UK farm where the grower applies 12 - 22 tonnes/ha of filter-cake to adjust the pH; possible reduction in Mg and P availability as a result of the rise in pH is balanced by the contents of these two elements in the filter-cake.

Performance traits of lambs fed integral rations and levels of sugar cane straw treated with NH_3

J. R. Stuart and F. S. Monteagudo. *Cuban J. Agric. Sci.*, 1987, **21**, 17 -21.

The daily and final weight gains of lambs fed ammonia-treated cane trash fell with increase in its proportion and decrease in the percentage of maize in the overall ration; at 75% trash and no maize the final weight was only 5.5 kg up on the initial weight compared with 15.9 kg when the ration contained 30% trash and 45% maize.

Effect of the form of supplying final molasses on the performance of fattening pigs

M. Castro and A. Elías. *Cuban J. Agric. Sci.*, 1987, **21**, 57 - 62.

Trials in which pigs were fed on molasses showed that, for purposes of daily weight gain and conversion, protein supplement should be incorporated in the molasses and not added separately; the poorer performance with the separate addition was attributed to the failure to maintain the balance between the protein and the main energy source.

Digestibility of final molasses diets supplemented with two levels of sugar cane filter-cake mud oil for pregnant sows

J. Díaz and R. A. Rodríguez. *Cuban J. Agric. Sci.*, 1987, **21**, 63 - 67.

Addition of 100 and 200 g of filter-cake oil to a ration containing 1.5 kg of final molasses had an adverse effect by reducing the energy digestibility; this was attributed to the high proportion of impurities (mainly waxes) in the oil.

inherent disadvantages of batchwise operation.

Figure 2 depicts the type BW 1750 K batchwise operating centrifugal developed by Krupp Industrietechnik GmbH for a processing capacity of approximately 35 tonnes of massecuite per hour. In spite of its high centrifugal acceleration of 1250*g*, this machine requires a mere 1.9 kW per tonne of sugar. Owing to a favorable mass-to-volume ratio of the basket, the given throughput can be attained by a motor having a normal rating of no more than 250 kW.

In the years to come, centrifugals for batch operation are expected to feature feed capacities between 1300 and 2000 kg per batch, variable feed and drainage speeds to suit the product quality, nominal drive ratings below 8 kW per tonne of massecuite per hour, processing capacities between 30 and 40 tonnes per hour, and a power consumption below 2 kW per tonne of white sugar.

At Krupp Industrietechnik GmbH, the future development of centrifugals will be characterized by an equal priority for continuous and discontinuous operation. For both types of machines, emphasis will be placed on availability, ease of maintenance, automation, control, and improvements in drive technology.

PROCESS MANAGEMENT

Kinetics and equilibria in cane pulp/water systems*

By G. R. E. Lionnet
(Sugar Milling Research Institute, Durban, South Africa)

Introduction

Rein[1] in 1972 developed a mathematical model defining the extraction of Brix from first mill bagasse. The model proposes that the extraction occurs via two first order processes. The first is a diffusive transfer of Brix from within unbroken cane cells to outside the cells, followed by a convective dispersal of this Brix. The diffusive transfer is much slower and is thus the rate limiting step. The second process is the convective mechanical removal of the Brix adhering to broken cane cells. This model was found to fit experimental data very satisfactorily.

Spiro[2-4], working with tea and coffee, showed that the extractions of soluble constituents follow basically first order kinetics. He developed models to describe the rates of extractions and the equilibrium conditions, the latter also yielding the concentrations of various constituents in the original tea leaf or coffee bean.

These two approaches were combined to yield two mathematical models. The first deals with the rates at

G. R. E. Lionnet

which soluble constituents are extracted from the cane pulp while the second describes equilibrium conditions and yields the concentrations of the soluble constituents in the cane itself.

Theory

1. *Kinetics of extraction*†

A mass W of cane pulp, containing a fraction X_0 of a given constituent, is immersed at time t = 0 in a volume V of water, the system being kept at a constant temperature. The mixture is well stirred and the aqueous solution is analysed at various times for the concentration C_t of the particular constituent.

Immersion has two main consequences:–

(i) the cane pulp absorbs water

(ii) various soluble constituents are extracted into the liquid.

At equilibrium, the volume of liquid, of density ρ_w, taken up by unit mass of pulp is V_n and Y is the mass of soluble constituents extracted per unit mass of cane. Then, the mass of swollen pulp, W_s, is

$$W_s = W(1 + V_n \rho_w) - YW \quad \ldots\ldots (1)$$

Two assumptions are now required:–

(i) swelling of the pulp is essentially complete before significant solute extraction has occurred, and

(ii) the mass of the swollen pulp is constant throughout the extraction process.

These assumptions were found to be valid with tea leaves and ground coffee. Both these materials are drier than cane and would thus absorb more water. It is therefore concluded that the assumptions are also valid for the cane/water system.

* Part of M.Sc. Thesis (University of Natal), 1985.
† Nomenclature is given on page 16.

1 Ph.D. Thesis (University of Natal), 1972.
2 *J. Sci. Food Agric.*, 1981, **32**, 1027 - 1139.
3 *J. Chem. Soc., Faraday Trans.*, 1982, **178**, 295 - 305.
4 *J. Sci. Food Agric.*, 1984, **35**, 915 - 930.

At time t, the concentration of the given constituent in the swollen pulp, C_s, is

$$C_s = [WX_o - C_t(V - V_nW)]/[W(1 + V_n\rho_w) - YW]$$

The back-reaction, namely the re-absorption into the pulp, is assumed to be first-order with respect to the constituent in solution.

Both rates are proportional to the interfacial area A. Thus, at any time t,

$$dC/dt = k'_1.A\{[WX_o - C_tV + C_tWV_n]/[W(1 + V_n\rho_w) - YW]\} - k'_{-1}AC_t \quad ...(2)$$

For a given set of conditions, equation 2 may be written for observed rate constants k_1 and k_{-1} as

$$dC/dt = k_1 - k_{-1}C_t \quad ..... \quad (3)$$

where k_1 is an effective zero order rate constant and k_{-1} an effective first order rate constant. As $t \rightarrow \infty$, $dC/dt \rightarrow 0$ and $C_t \rightarrow C_\infty$. Thus, from (3),

$$k_1 = k_{-1}C_\infty \quad ..... \quad (4)$$

and $dC/dt = k_{-1}(C_\infty - C_t)$.

On integration, using $C = 0$ when $t = 0$, this gives:

$$\ln[C_\infty/(C_\infty - C_t)] = k_{-1}t \quad ..... \quad (5)$$

Equation 5 shows that a plot of $\ln [C_\infty/(C_\infty - C_t)]$ versus time gives a straight line with slope equal to k_{-1} and which passes through the origin.

This approach requires the value of the concentration of the constituent at equilibrium. Long retention times are required to reach equilibrium, particularly with coarsely prepared cane. These long retention times could result in excessive chemical and/or biological changes and should therefore be avoided. An approach developed by Guggenheim[5] was used to obtain equation 6.

$$\ln(C_{t+\Delta t} - C_t) = \ln C_\infty(1 - e^{-k_{-1}\Delta t}) - k_{-1}t \quad (6)$$

where Δt is a constant time interval. Equation 6 shows that a plot of $\ln (C_{t+\Delta t} - C_t)$ versus t yields a straight line with slope $-k_{-1}$.

2. *Equilibrium conditions*

The mass of the swollen pulp, at equilibrium, is given by equation 1, namely:

$$W_s = W(1 + V_n\rho_w) - YW$$

The mass of a given constituent in the extract at equilibrium, W_a, is

$$W_a = C_\infty(V - WV_n)$$

But the total mass of that constituent is WX_o. Thus, the mass of the constituent in the pulp, W_p, is

$$W_p = WX_o - C_\infty(V - WV_n)$$

and the concentration of that constituent in the pulp is then

$$C_s = [WX_o - C_\infty(V - WV_n)]/[(W + V_n\rho_w - YW)].$$

The concentration of the constituent is the extract is C_∞/ρ_s.

A partition coefficient, K, may be defined by

K = (concentration of constituent in extract)/(concentration of constituent in pulp)

Then,

$$K = C_\infty/\rho_sC_s = (W + WV_n\rho_w - YW)/\rho_s[WX_o - C_\infty(V - WV_n)] \quad ... \quad (7)$$

Equation 7 may be rearranged to give:–

$$1/C_\infty = V/X_oW + [(1 + V_n\rho_w - Y)/K\rho_s - V_n]/X_o \quad ..... \quad (8)$$

Equation 8 shows a plot of $1/C_\infty$ versus 1/W should yield a straight line with slope equal to V/X_o and intercept equal to $1/X_o[(1 + V_n\rho_w - Y)/K\rho_s - V_n]$

X_o, the mass fraction of the constituent in the cane, may thus be obtained. K may then be calculated if the quantities V_n, ρ_w, Y and ρ_s are known. Of these, only V_n is not available but may be obtained through the following procedure:

A mass of cane W is mixed with a mass of water, W_w. The mixture is allowed to stand for about five minutes and then sieved to allow the free liquid only to run off. The run off mass, W_r, is obtained.

This is represented by the material balance

$$W_w + W = W_s + W_r \quad ..... \quad (9)$$

or

$$W_w = (W_s - W) + W_r$$

$$W_w = W_h + W_r \quad ..... \quad (10)$$

where W_h is the water held by the cane. Equation 10 cannot be used directly because the soluble solids balance shown in equation 11 must also be satisfied:-

$$WB_c/100 = W_sB_s/100 + W_rB_r/100 \quad ... \quad (11)$$

If cane sub-samples of known, equal masses are used and different known masses of water added to each, equation 10 shows that a plot of W_w versus W_r should give a straight line. The value of W_w when $W_r = 0$ gives W_h, the amount of water held by the cane, when there is no run-off. Then,

$$V_n = W_h/W \quad ..... \quad (12)$$

Experimental

Laboratory equipment

This consists of five stainless steel, jacketed vessels, each of 6 litres capacity. A variable speed stirrer is used to ensure good mixing between the cane pulp and water. Samples of extract may be withdrawn when required. Temperature and pH may be measured directly in the vessel. One such vessel is shown in Figure 1.

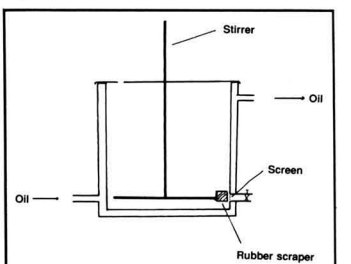


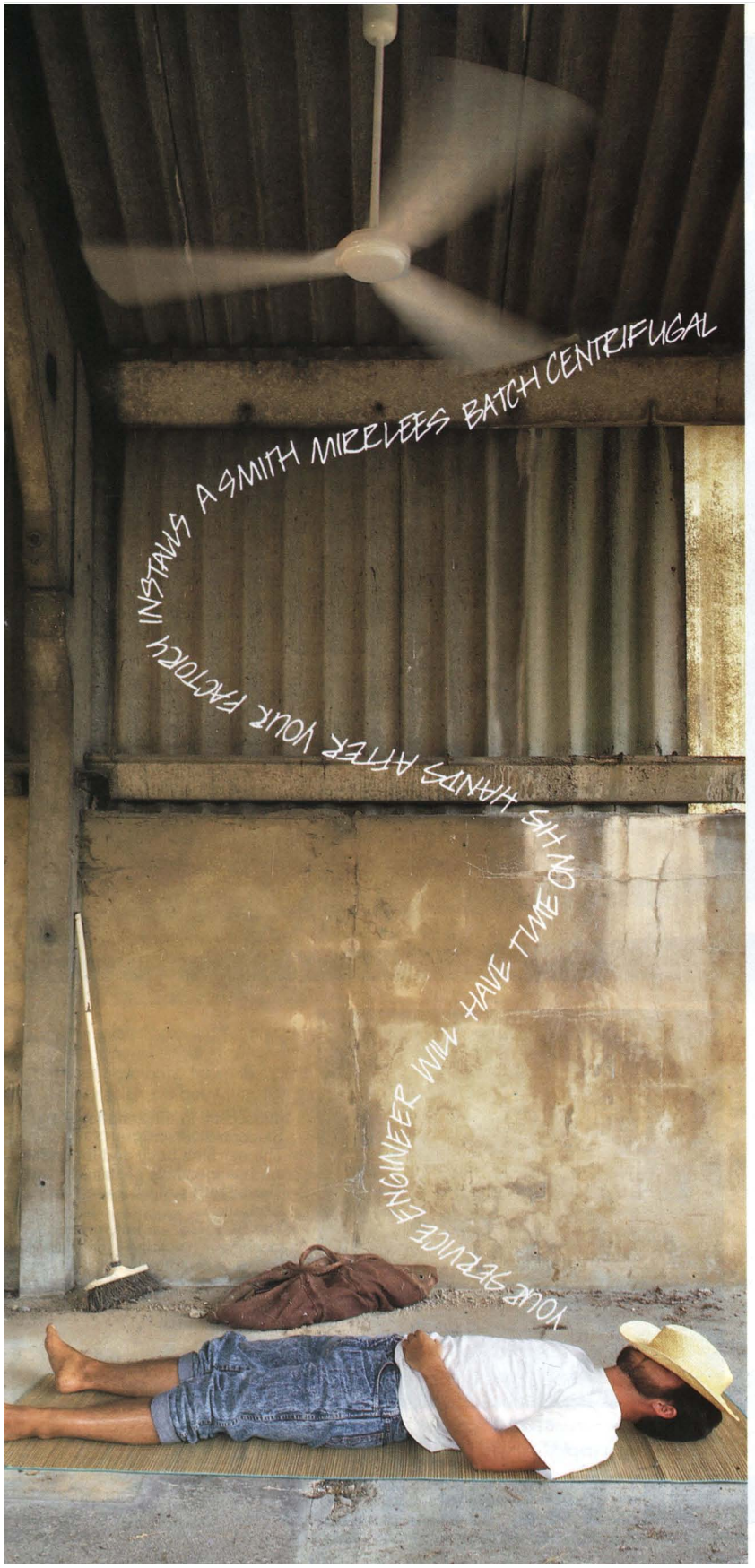
Fig. 1. Schematic diagram of one of the five laboratory diffusers

A stainless steel screen is used in front of the sampling pipe to prevent choking by fibre. The rubber scraper increases the flow of the extract during sample removal. The dead volume in the sample line is kept at a minimum and the valve is of the quick-opening ball type. All metal parts in contact with the cane/water mixtures are made of stainless steel since some of the cane colour bodies react with iron to form brown coloration. All external surfaces, pipes, etc., are well lagged.

The speed of rotation of the stirers may be varied. The lowest speed, however, is about 75 rpm, which already results in fairly vigorous mixing. The selected stirrer speed was 150 rpm, which was set on the stirrers and checked using a hand tachometer.

The temperature at which the experiment is to take place is set by using the thermostatically controlled oil

5 "Comprehensive chemical kinetics", Vol 2, Eds. Bamford & Tipper, 1969.



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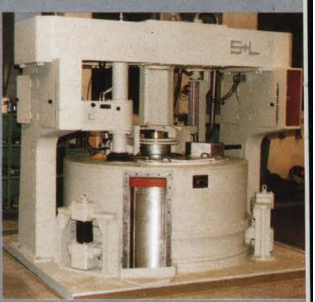

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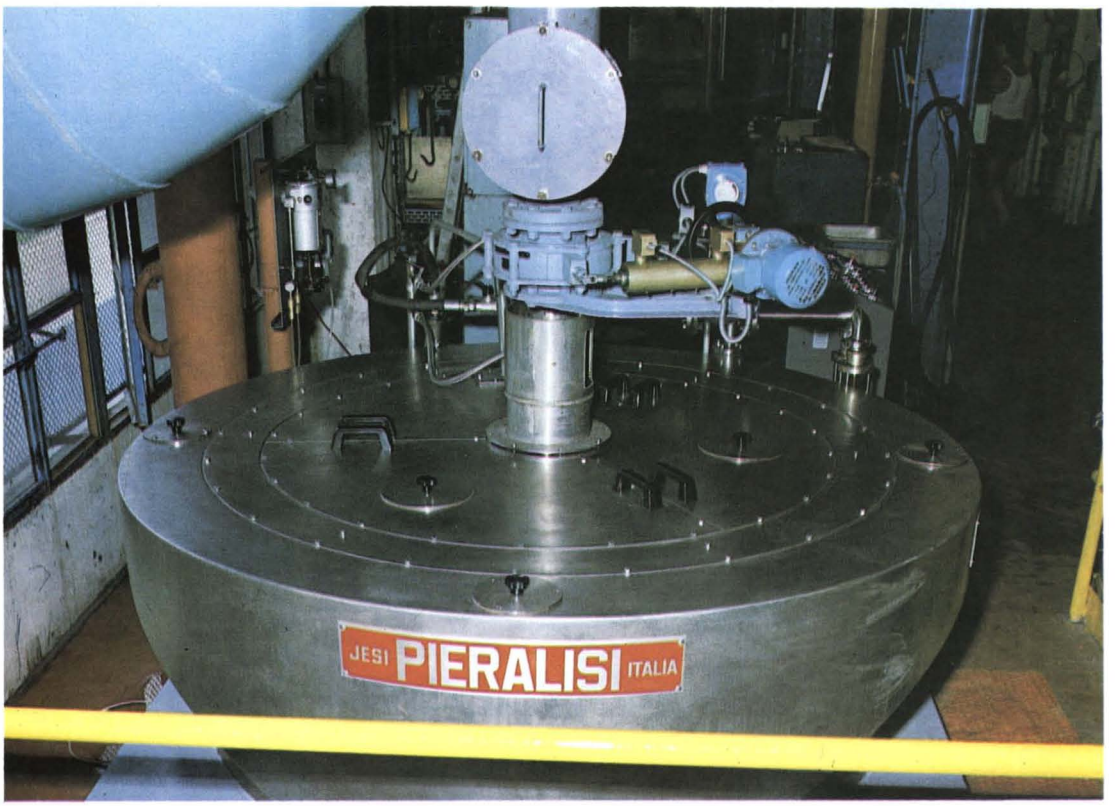

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bath. The system is designed to keep the five reaction vessels at the set temperature. It does not react rapidly to changes in temperature (which do not occur) and maintains the cane pulp/water mixture at a temperature found to be within ± 0.5°C of the set point.

Since the cane is at room temperature, a drop in temperature is unavoidable when it is added to the water. The procedure adopted has been to preheat the water, using an immersion heater, to a temperature which drops to the set point when all the cane has been added. This higher temperature was found by trial and error for various sets of conditions and then used during the tests.

Control of pH is achieved by adding a calcium hydroxide slurry [5 g $Ca(OH)_2$ in 200 cm^3 water] first to the water in the vessel and then to the cane/water mixture as the extraction proceeds.

The initial amount of slurry was established, by trial and error, to give the required pH after the cane has mixed with the water. Thereafter, as more soluble components are extracted, 1 cm^3 amounts of the slurry are added to keep the pH at the required level. The pH is measured throughout the extraction by removing samples of extract and reading the pH at the extract temperature.

Analytical

Brix has been used extensively not only to investigate the extraction processes but also to check the validity of the models because it can be determined quickly and very precisely.

The following constituents were selected for analysis:–

- Pol and Brix % cane which also allow comparison with the Direct Analysis of Cane (DAC) results;
- Total phenols by the Folin-Ciocalteu methods, since phenols are a class of compounds which has been associated with colour problems in juices and sugar;
- Amino nitrogen by the ninhydrin method. Amino nitrogen is involved in Maillard-type reactions which can cause colour problems;
- Optical absorbance in the visible region of the spectrum (420 nm) which gives a direct indication of colour. Two pH levels were used, namely 4 and 9, to allow the calculation of Indicator Value (IV). Australian workers[6] have shown that plant pigments have IV levels of 7 - 13 while enzymatic and other colorants have IV levels of 1 - 5.
- Optical absorbance at 280 nm was also measured since a number of colour bodies and colour precursors absorb in the ultraviolet spectrum.

The analytical results are reported as follows:–

Absorbance: Absorbance units on cane or extract given by Absorbance × Dilution factor/Cell length (cm)

Total phenols: ppm caffeic acid on cane or extract

Amino nitrogen : ppm amino nitrogen on cane or extract.

Cane used

All the cane used was fresh and consisted of hand-cleaned stalks (NCo 376), free of extraneous matter. The sampling techniques have been described in detail elsewhere[7].

Two levels of cane preparation were used, one similar to that found industrially and the other yielding very finely prepared cane corresponding to an ultimate level unlikely to be reached industrially.

Results

Validity of the models

The two models, represented by equations 6 and 8, require the relevant plots to be linear. Correlation coefficients for simple linear regressions for typical results are given in Table I.

Rate constants for the diffusive and convective processes were obtained from the relevant plots by numerical and graphical techniques[7], using a microcomputer. Partition coefficients and concentrations in the cane were obtained from equations 8 and 12.

Whenever possible, calculated concentrations were compared with measured ones; the agreements were always satisfactory. Based on these results, it could be concluded[7] that the fits were very satisfactory, as could be expected from the results of Rein[1] and Spiro[2-4].

Effects of temperature

Increasing the temperature increases the overall rate of extraction. This is shown in Figure 2 where sub-samples of the same coarsely prepared cane were extracted at 60 and 80°C, under otherwise identical conditions. Another cane subsample was shredded further, to the finer preparation, and extracted at 60°C.

These results show the effect of a 20°C rise in temperature. It is evident, however, that the major effect is that of preparation. This is similar to the conclusions obtained by Rein[1], using bagasse, and will be discussed later.

Temperature has been found to have a positive effect on both the diffusion and the convective rate constants of all the selected components. Generally, the precision achieved in the measurement of equilibrium concentrations was better than that for rate constants.

Furthermore, the effect of temperature has also been obtained through the equilibrium runs. These runs yield the equilibrium concentrations in the extracts and the concentrations in the cane itself. Percentage increases in concentrations, resulting from a 20°C temperature increase from 60 to 80°C, are given in Table II.

Although the above results were obtained with cane from the same field, the experiments used different approaches

6 Smith *et al.: Proc. Australian Soc. Sugar Cane Tech.*, 1981, 71 - 80.

7 Lionnet: M.Sc. Thesis (University of Natal), 1985.

Table I. Correlation coefficients for linearity checks of the models

Analysis	Kinetics (Equation 6)		Equilibrium (Equation 8)	
	Correlation coefficients	Number of observations	Correlation coefficients	Number of observations
Brix	0.999	16	0.999	5
Absorbance (pH 4, 420 nm)	0.992	15	0.942	5

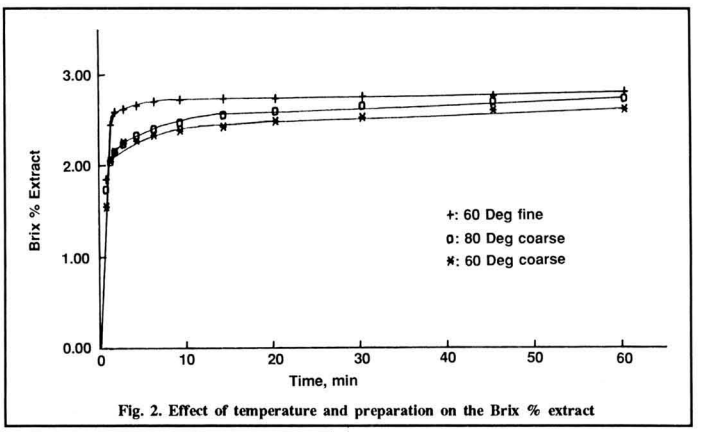

Fig. 2. Effect of temperature and preparation on the Brix % extract

Table II. Effect of a 20°C rise in temperature expressed as % concentration in cane

Analysis	% Increase	
	Kinetic runs	Equilibrium runs
Brix	+4	+6
Pol	-	+4
Total phenols	+20	+13
Amino nitrogen	+2	+4
Absorbance in the visible	+20	+24
Absorbance in the UV	+20	+30

and were done about 30 days apart. The equilibrium tests involved clean cane, clean cane + tops and clean cane + trash, separately. It can be seen, however, that the % increases obtained by the two approaches agree fairly well. Some generalization is thus possible.

The effect of temperature is about five times greater on absorbances as it is on Brix. This is not unexpected since 85% of the Brix has been obtained by the washing mechanism, leaving a small proportion on which temperature could have an effect. This is not the case with absorbances where 30% of the concentrations are obtained through diffusion and are thus affected by temperature.

Temperature does not significantly increase the amino nitrogen concentration. In fact, increasing the temperature lowers the concentration of that constituent owing to the precipitation of proteins by heat. Overall, however, no significant changes were measured.

In view of the importance of the temperature effect and because temperatures around 90°C have been used in industry, equilibrium runs were done with sub-samples of the same cane but at 60, 78 and 88°C. The results obtained are given in Table III.

Table III. Effect of temperature on concentrations

Analysis	Concentrations at		
	60°C	78°C	88°C
Brix % cane	12.7	13.6	14.0
Pol % cane	11.0	11.4	11.4
Total phenols (on extract)	193	213	238
Amino nitrogen (on extract)	40.3	46.4	44.0
Absorbance in the visible (on extract)	0.24	0.26	0.30
Absorbance in the UV (on extract)	0.20	0.22	0.27

The increases obtained here are similar to those shown in Table II, although different cane was used.

Effect of pH

Effects due to pH, in the range 5.7 to 7.2, were found to be much less evident than was the case with temperature. No significant change could be found as far as the rate constants were concerned. The only measurable effects were on the levels of the absorbances, which increased by about 10% and on that of the amino nitrogen which dropped by about 5% for an increase in pH from 5.7 to 7.2.

Effect of cane preparation

The effect of cane preparation have been measured by using the quantity α, defined as follows:–

α = (Concentration of component due to the diffusion process)/(Concentration of component due to the washing process).

It is expected that α will decrease as the preparation gets finer. The average values of α for the fine and coarse preparations are shown in Table IV.

Table IV. Mean values of α for the finely and coarsely prepared cane

Analysis	α	
	Fine	Coarse
Brix	0.08	0.14
Amino nitrogen	0.09	0.16
Total phenols	0.20	0.33
Absorbance, visible region	0.21	0.24

The difference between the mean value for the fine and coarse preparation was statistically significant in the case of Brix and of total phenols. In the case of Brix, the fine preparation results in more than 90% of the material being available through the washing mechanism during the first 4 to 5 minutes of the 60-minute extraction. Amino nitrogen shows a similar trend but it must be noted that the number of observations was small for that constituent. As far as total phenols and the absorbance are concerned, α now ranges from 0.2 to 0.3, showing that diffusion has more importance which is probably due to charge and size effects of the bigger molecules.

Effects of tops and trash

Under South African conditions, Scott[8] and Lionnet[9] have shown

8 *Proc. S. African Sugar Tech. Assoc.*, 1978, **52**, 51 - 53.
9 *Tech. Rpt. SMRI*, 1981, (1265).

that tops and trash lower juice purities by 0.3 to 0.4% for every 1% addition by mass. This investigation shows corresponding values of 0.3 to 0.5%, which agree well with the previous findings.

Tops and trash have very different compositions and are best compared by using their dry matter contents as reference. Thus, on a dry matter basis, 1% tops or trash reduces the pol % cane by 0.6 and 0.4%, respectively. It is now evident that, on a comparable basis, tops are worse than trash.

The results obtained show that these materials have adverse effects with respect to all the constituents. The findings are summarized in Table V which shows the effect of adding 1% tops or trash on dry matter to clean cane, expressed as a percentage of the clean cane value.

Table V. Effect of tops and trash on clean cane

Analysis	Differences as a % of the clean cane value due to the addition of 1% on dry matter of	
	Tops	Trash
Brix % cane	–0.3	–0.2
Pol % cane	–0.6	–0.4
Total phenols	+1	+2
Amino nitrogen	+0.3	+0.6
Absorbance in the visible	+5	+2
Absorbance in the UV	+3	+2

Lamusse[10] gives average levels of 2.0% and 4.4% for tops and trash, on a mass basis, in the South African industry. Using the results found in this study, this total quantity of extraneous matter has reduced the pol in cane by nearly 5% and has increased absorbances by around 20%. The effect of tops and trash is thus not negligible and this is an area where cane quality improvements could be achieved.

Partition coefficients

The Direct Analysis of Cane (DAC) yields values for pol and Brix % cane from extract analyses. The calculations are mass balances which assume that, at equilibrium, the concentrations in the extract and in the swollen pulp are equal.

Spiro[2-4] has found that this is not always the case with tea leaves and ground coffee beans. Values of Spiro's partition coefficient K, given by

K = (Concentration of constituent in extract)/(Concentration of constituent in pulp)

for cane pulp/water systems were found to depend on the constituent.

For Brix and pol, K was equal to unity, confirming the validity of the DAC method. K was significantly different from unity for all the other parameters, the values ranging from 0.7 to 0.8. This indicates that, at equilibrium, the concentrations are larger in the pulp than those in the aqueous solution. Spiro found similar results with tea and coffee where the values of K ranged from 0.1 to 0.7. These effects are thus more pronounced in tea but still significant with cane.

The results also show that the DAC method is not suitable for the determinations of total phenols, amino nitrogen and absorbances. The DAC method would underestimate the concentrations.

Indicator values (IV) and UV ratios (UVR)

The agreement between the IV and UVR values obtained in this study and those quoted in the literature for plant pigments was excellent.

UVR values have been found to be independent of extraction time, pH, temperature and the presence of tops and trash. They ranged from 0.5 to 0.7, indicating the presence of flavonoid-type plant pigments.

IV values, on the other hand, were dependent on pH, temperature and extraction time, as shown in Figure 3. The range, however, fell well within that given in the literature for plant pigments, namely 5 - 20.

10 *Proc. S. African Sugar Tech. Assoc.*, 1983, **57**, 10 - 29.

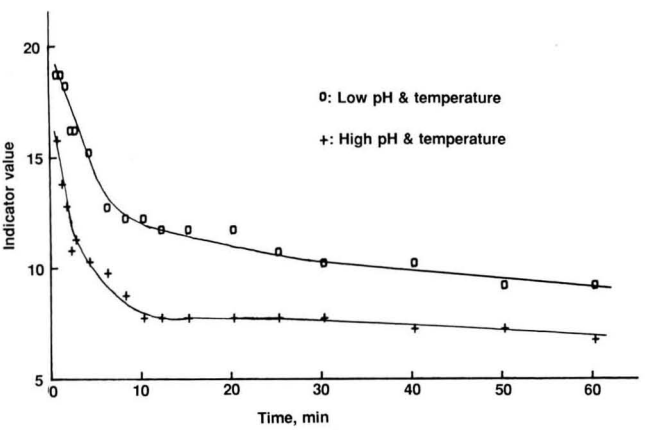

Fig. 3. Change in IV with pH, temperature and extraction time

Table VI. Change in temperature, pH, tops and trash required to increase each concentration by 1%

Analysis	Temperature °C	pH (units)	Trash (% on dry matter)	Tops (% on dry matter)
Brix	+4	-	–3	–5
Pol	+5	-	–2	–2
Total phenols	+1.2	+0.4	+1	+0.5
Absorbance in the visible	+0.9	+0.2	+0.2	+0.5
Absorbance in the UV	+0.8	+0.2	+0.3	+0.5

Conclusion

The relative importance of pH, temperature, tops and trash may be obtained by calculating the amount by which each of these factors must be changed to alter the concentrations by +1%. The results are in Table VI where the change in temperature, pH, tops and trash content (as % dry matter) required to increase each concentration by 1% have been calculated.

As may be seen from Table VI, temperature is the most important operational factor. A 10°C rise for example will increase the Brix extract by 2 - 3% but will result in the absorbances increasing by approximately 12%.

Tops and trash need to be changed by about 0.5% to achieve a similar effect on the concentrations and relatively large pH changes are required.

Although temperature is the most important factor, reduced colour levels in the industrial case can only be achieved by controlling all the above factors, as far as possible.

Finally, the approaches developed in this study have been used to investigate cane deterioration[11] and to study the effects of such factors as drought and burning on the impurity content of cane[12].

Summary

The cane pulp/water system is described in terms of two mathematical models, the first dealing with rates of extraction and the second covering equilibrium conditions. These models have been used to investigate the effects of cane quality and operational conditions on the cane diffusion process. The models have also been useful in the study of cane deterioration and of other processes requiring the determination of impurities, such as colour bodies, which are present in cane at the ppm level.

11 *ibid.*, 1986, **60**, 52 - 57.
12 *ibid.*, 62 - 65.

NOMENCLATURE

A	Interfacial area, cm^2	t	Time, min
B_c	Brix % cane, g/100g	V	Volume, cm^3
B_s	Brix % swollen pulp, g/100g	V_n	Volume of liquid taken up by unit mass of cane, cm^3/g
B_r	Brix % run off, g/100g	W	Mass of cane, g
C_s	Concentration in swollen pulp, g/cm^3	W_a	Mass of a given constituent, g
C_t	Concentration at time t in extract, g/cm^3	W_c	Mass of water in cane, g
C_∞	Concentration at infinite time in extract, $/cm^3$	W_r	Mass of run-off liquid, g
K	Partition coefficient	W_s	Mass of swollen cane pulp, g
k'_1	First order rate constant forward diffusion	W_w	Mass of water, g
k'_{-1}	First order rate constant, back diffusion	W_h	Mass of water held by cane, g
k_1	Observed rate constant, forward diffusion, $g/cm^3/min$	X_o	Mass fraction of constituent in cane, g/g
k_{-1}	Observed rate constant, back diffusion, min^{-1}	Y	Mass of soluble solids extracted per unit mass of cane, g/g
		α	Fraction of constituent obtained by diffusion
		ρ_w	Density of water, g/cm^3
		ρ_s	Density of extract, g/cm^3

CHEMISTRY

Phenolic content of maturing sugar cane

By M. A. Godshall* and B. L. Legendre**

Phenolic acids have been isolated from plant cell wall polysaccharides, especially pentosans and hemicelluloses, and play a role in cementing cell walls[1-4]. The sugar cane plant is rich in phenolic compounds, including phenolic acids[5,6] and glycosides[7], flavonoids[8,9], lignin[10,11] and anthocyanins[12]. Tannins and leucoanthocyanins have been reported in roots of sugar cane plants[13].

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1 Smith & Hartley: *Carb. Res.*, 1983, **118**, 65 - 80.
2 Ishii: *Plant Physiol.*, 1984, **76**, 959 - 961.
3 Azuma *et al.*: *Agric. Biol. Chem.*, 1985, **49**, 2661 - 2669.
4 Yamamoto & Towers: *J. Plant Physiol.*, 1985, **117**, 431 - 440.
5 Farber & Carpenter: *I.S.J.*, 1971, **73**, 99, *Proc. 1972 Tech. Session Cane Sugar Refining Res.*, 1975, 23 - 30.
6 Stevens: *I.S.J.*, 1959, **61**, 199.
7 Palla: *J. Agric. Food Chem.*, 1982, **30**, 764 - 766; 1983, **31**, 545 - 548.
8 Williams *et al.*: *Phytochem.*, 1974, **13**, 1141 - 1149.
9 Mabry *et al.*: *J. Nat. Prod.*, 1984, **47**, 127 - 130.
10 DeStevens & Nord: *J. Amer. Chem Soc.*, 1953, **75**, 305 - 309.
11 Ito *et al.*: *I.S.J.*, 1977, **79**, 250 - 253.
12 Smith & Hall: *Proc. 14th Congr. ISSCT*, 1971, 1139 - 1146.
13 Bate-Smith & Lerner: *Biochem. J.*, 1954, **58**, 126 - 132.

Phenolics are important from a processing standpoint because of their reactivity with metals and ability to produce highly coloured reaction products. As much as two-thirds of the colour in cane juice may be due to enzymatic browning of phenolic acids[14]. Phenolic compounds undergo non-enzymatic reactions including oxidation and self-polymerization into dark brown pigments, reaction with proteins and amino acids to produce brown to black melanin pigments, and reactions with aldehydes to produce red condensation products in the presence of acids.

Research has shown that the phenolic content of raw sugar colorant can be used in conjunction with several other tests, as an indicator of refining quality (i.e., ease of colour removal) of a raw sugar[15]. Because of their ability to change colour with pH, the presence of phenolic compounds in raw sugar can strongly affect colour measurement.

Plant phenolic concentration has been correlated with fungal, bacterial, and insect resistance[16,17]. Many fungal diseases of sugar cane, notably red rot, but also *Fusarium* wilts and rots, *Helminthosporium* eye spot, and others, induce the sugar cane plant to produce red phenolic pigments[18]. In addition, mechanical and chemical injury, borer damage, and bacterial and viral disease induce tissue reddening, and it is possible that an increase in phenolic concentration may also be a general stress response in sugar cane[19].

Phenolics are distributed throughout the plant. The majority are found in vacuoles[20], but some are also bound to cellulose and other cell wall polysaccharides or as a polymerized network of several different phenolic acids, in the cell wall lignin.

Two methods of cane preparation exist for the extraction of cane juice. In conventional milling, the juice is obtained by crushing the cane stalks between grooved mills. In diffusion, the cane is shredded, causing maximum disruption of the plant cells. It has not been established if the forms of cane preparation influence the concentration of phenolics in the juice.

The objectives of this study were to determine if phenolic concentration increased in sugar cane with maturity and if the method of extracting the juice from stalks, by conventional milling or with a press after shredding of cane tissue, influenced the extraction of phenolics.

Materials and methods

Studies designed to measure relative changes in juice quality (maturity) are conducted on a continuing basis at the U.S. Sugarcane Field Laboratory, Houma, Louisiana, on first stubble (ratoon) cane. From 8 to 15 varieties are planted each autumn. For the purpose of this study four varieties were selected, viz. CP 65-357, CP 70-321, CP 74-383, and NCo 310.

Planting was done on raised ridges, the rows 1.8 m apart; variety plots were 12 m long and 3 rows wide. The experimental design was a randomized block with 4 replications. Planting and cultivation were done acording to plantation practices. Weeds were controlled with a pre-emergence herbicide, the cane borer was controlled as needed with an insecticide, and the cane was fertilized with ammonia at approximately 90 kg N/ha.

At harvest, 15 stalks of each variety were randomly selected from the first two replications begining in mid-September and continuing at monthly intervals until mid-December. Stalks were topped approximately 10 cm below the terminal bud, stripped of all leafy material and delivered to the juice quality laboratory for immediate analysis.

The 15-stalk samples were subdivided into two sub-samples, one of 5 stalks and the other of 10 stalks. The 5-stalk samples were shredded through a Jeffco cutter-grinder from which a 1000 g sub-sample was removed and pressed for 1 minute at 1406 kg/cm^2. From the extracted juice (approximately 70% by weight of sample) approximately 175 ml was removed immediately and placed in a freezer at –18°C. The 10-stalk samples were crushed once through a 3-roller sample mill (approximately 50% extraction by weight of sample) and, after thorough mixing, approximately 175 ml was removed and placed in the freezer. Frozen samples were subsequently transported to Sugar Processing Research Inc. in New Orleans for analysis.

Prior to analysis, the frozen juice was thawed and allowed to reach room temperature gradually. It was mixed with a small amount of Celite† analytical filter aid and filtered under vacuum on Whatman No. 4 filter paper. The refractometer solids were determined with an Abbé Brix refractometer. An aliquot of the juice was diluted 1:50 with water and analysed for total phenolics using the Folin-Ciocalteu phenol reagent[21], using a modification of the method of Singleton & Rossi[22]. Results were reported as caffeic acid equivalents in µg/ml of juice.

High molecular weight phenolics were determined by dialysing 50 ml of juice for 100 hours against flowing toluene-saturated deionized water in a dialysis bag with 3500 molecular weight cut-off. The test for phenolics was performed on the material retained in the dialysis bag.

The indicator value of the juices was measured by determining the ratio of absorption at 420 nm of diluted, filtered juice at pH 4 and 9.

Data were analysed statistically using the Analysis of Variance procedure and General Linear Model procedure (GLM) using SAS software. Means were separated using the Duncan multiple range test.

† Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

14 Goodacre & Coombs: *I.S.J.*, 1978, **80**, 323 - 326.
15 Clarke *et al.: Proc. 1984 Sugar Processing Research Conf.*, 285 - 303.
16 Cruikshank & Perrin: in "Biochemistry of phenolic compounds" Ed. Harborne (Academic Press, London) 1964, pp. 511 - 544.
17 Friend: in "Recent advances in phytochemistry, Vol. 12, Biochemistry of plant phenolics" Eds. Swain, Harborne & van Sumere (Plenum Press, New York), 1979, pp. 557 - 588.
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19 Hokama: *Sci. Bull. Coll. Agric. Univ. Ryukyus* (Okinawa), 1973, (20), 37 - 93.
20 Bidwell: "Plant physiology" 2nd Ed., (Macmillan, New York), 1979, 726 pp.
21 Godshall & Roberts: *Proc. 1982 Sugar Processing Research Conf.*, 47 - 72.
22 *Amer. J. Enol. Viticult.*, 1965, **16**, 144 - 158.

Results and discussion

Table I summarizes the phenolic concentrations of the varieties tested, and shows that the phenolic concentration increased as the canes matured. The analysis of variance showed that there was no overall difference in the amount of phenolics extracted by the two methods of obtaining the juice (Table II). There were two instances of divergent values; in October, milling extracted almost twice as much phenolics from CP 65-357 as did the press method, and in November, milling extracted only one-third of the quantity of phenolics from CP 70-321 obtained using the press method. In both cases, the milling results would seem to be anomalous although the replication was very good. Milling also extracted a slightly higher concentration of phenolics from NCo 310 in September and from CP 74-383 in December.

Table II. Comparison of milling and pressing on the average phenolic content in cane varieties over a 4-month period

Variety	*Mean caffeic acid equivalents (μg/ml juice)* Milling	Press
CP 65-357	744*	626
CP 70-321	335	450
CP 74-383	543	542
NCo 310	517	483
Average of all varieties	535	525

* Means for milling and press values showed no significance difference at P = 0.05 for any varieties

The varieties differed from one another in phenolic content over the course of the study, with some within-month overlap (Table I). If the seasonal averages are calculated, the varieties differed significantly from one another in the amount of phenolics they contained, with CP 65-375 having the highest overall levels and CP 70-321 the lowest levels.

Although the extraction methods did not extract significantly different concentrations of phenolics into the juice, milling did extract slightly higher solids content in November and December than the press method, as determined by Brix refractometer. However, although these differences were statistically significant, from a practical viewpoint they may be considered insignificant, particularly the December results. The seasonally averaged data are summarized in Table III. As expected, the Brix increased throughout the season.

Table I. Concentration of phenolics in cane varieties in Louisiana at different harvest dates

Variety	*Mean caffeic acid equivalents (μg/ml juice)* September M	P	October M	P	November M	P	December M	P	Mean M&P
CP 65-357	479a	452a	816a	454ab	653a	645a	1027a	951a	686a
CP 70-321	296c	259b	262c	366c	155c	531b	628c	645c	393d
CP 74-383	368bc	310b	459b	537a	539b	606ab	807b	714bc	542b
NCo 310	430ab	306b	360c	350c	456b	515b	820b	760b	499c
Average of all varieties	393	332	474	427	451	574	820	767	

Key: M = Milled juice; P = Press juice
Means followed by the same letter within a column were not significantly different at the P ≤ 0.05 level, according to the Duncan multiple range test

Table III. Brix refractometer solids in cane juice obtained by two extraction methods, averaged over four varieties, each value representing the mean for all four varieties

Date	*Brix solids* Milled	Pressed
September	12.54a*	12.58a
October	15.75b	15.74b
November	18.87d	18.17c
December	19.69f	19.44e
Average	16.71	16.48

* Means followed by the same letter were not significantly different at P ≤ 0.05, according to Duncan's multiple range test

If the concentration of phenolics is determined on the basis of refractometer solids (μg phenolics/g solids) instead of on the basis of juice, as shown in Table I (μg phenolics/ml juice), the concentration of phenolics in December is seen to account for as much as 0.46% of the refractometer solids. The varieties retain their relative positions, CP 70-321 being the lowest in phenolics (0.29% of solids), CP 65-357 the highest (0.46% of solids), and NCo 310 (0.39% of solids) and CP 74-383 (0.37% of solids) intermediate. The phenolics concentration did not correlate with the solids content.

Many phenolic acids are colourless or slightly coloured at low pH and more highly coloured at high pH. This characteristic has important implications during processing and for colour determination of raw sugars. One measure of the influence of phenolics on colour of cane juice or sugar is its indicator value[23] (I.V.), which is the ratio of absorbance at 420 nm at pH 9 to that at pH 4.

Table IV shows the changes in juices I.V. that occurred between October and December. The I.V. tended to increase with maturity, and milled juices often had higher I.V. than press juices. The increase in I.V. with maturity suggests that a change occurred in the type of phenolic compounds in the juice, probably with the development of more

23 Smith & Gregory: *Proc. 14th Congr. I.S.S.C.T.*, 1971, 1415 - 1425.

Table IV. Indicator value (I.V. = Ratio of absorbance of juice at 420 nm at pH 9 to that at pH 4) of cane juice in Louisiana during maturation period as a function of varieties and methods of extraction

Variety	*Milled juice* Oct.	Nov.	Dec.	*Pressed juice* Oct.	Nov.	Dec.
CP 65-357	5.11	6.05	5.80	5.07	4.80	4.01
CP 70-321	5.26	6.00	6.27	3.48	4.41	4.44
CP 74-383	6.83	5.77	7.08	5.35	2.83	7.84
NCo 310	4.45	4.42	7.31	3.75	5.29	5.69

highly conjugated systems. The differences between extraction methods suggests that the phenolic compounds that affect the I.V. most may not be as accessible to extraction by the press method. The differences between solids extracted was less than 4%, and thus could not account for the differences in I.V. between extraction methods.

The change in I.V. that occurred with maturity is accounted for in part by the fact that absorbance at pH 4 was constant or decreased slightly while absorbance at pH 10 increased with maturity.

The proportion of phenolics in the cane juice fraction with molecular weight greater than 3500 was determined for juices obtained in October. These results showed that a significant proportion of the total phenolics were bound to high molecular weight components of the juice. CP 70-321 had the highest proportion (31%), while NCo 310 had 22%, CP 65-357 had 13% and CP 74-383 had 11%.

In conclusion, sugar cane varieties differ in phenolic content, but all varieties showed an increase in juice phenolics as they matured. These juices may produce raw sugars with higher concentrations of phenolic compounds, which can cause higher colours and larger indicator values (I.V.) later in the season. The method of obtaining the juice had no statistically significant effect on juice phenolics or colour, but milling did produce juices with slighter higher I.V., on average, than did the press method of cane juice extraction.

The press method used to obtain juice samples in this study simulated only the first step of cane diffusion. The heat and countercurrent flow used in diffusion would be expected to extract additional materials, as would maceration in cane milling. This study has shown that the variety of cane and its level of maturity are major contributing factors in the concentration of phenolics in the juice.

Summary

A study was conducted in 1983 to determine the phenolic content of cane juice of four varieties – CP 65-357, CP 70-321, CP 74-383 and NCo 310 – on four harvest dates from mid-September to mid-December, using two methods of extraction, conventional milling and a press. There was a significant increase in the phenolic content of each variety, regardless of the method of extraction, as the cane matured from the first to the last harvest date. There was also a significant difference in the phenolic content among varieties with CP 70-321 having the lowest total phenolic content and CP 65-357 the highest. However, CP 70-321 had the highest proportion (31%) of total phenolics associated with juice constituents of molecular weight above 3500. It appeared that the method of extraction had no effect on the level of phenolic compounds in the juice. In this study, phenolic constituents accounted for as much as 0.4% of refractometer solids.

Make a date.....

When?	Who?	Where?
February 4/5, 1988	American Society of Sugar Cane Technologists, Knapp Hall, Louisiana State University, Baton Rouge, LA 70803, U.S.A.	Bellemont Motor Hotel Baton Rouge, Louisiana.
April 17/22, 1988	West Indies Sugar Technologists, c/o Barbados Sugar Industry Ltd., P.O. Box 719C, Bridgetown, Barbados.	Barbados.
April 26/29, 1988	Australian Society of Sugar Cane Technologists, GPO Box 608, Queensland, Australia 4001.	Cairns, Queensland.
May 8/11, 1988	Sugar Industry Technologists Inc., P.O. Box 632, Ste. Therese de Blainville, Quebec, Canada J7E 4K3.	Hyatt Regency Hotel, Savannah, GA, U.S.A.
June 6/9, 1988	South African Sugar Technologists Association, c/o S.A.S.A. Experiment Station, Mount Edgecombe, Natal, South Africa 4300.	Marine Parade Holiday Inn, Durban, Natal, South Africa.
June 15/17	American Society of Sugar Cane Technologists, Knapp Hall, Louisiana State University, Baton Rouge, LA 70803, U.S.A.	Holiday Inn - Surfside, Clearwater, Florida.
August 1988	Philippines Sugar Technologists, Room 308, Doña Salud Building, San Juan Street, Bacolod City, Philippines.	
October 1988	ARTAS Réunion Society of Agricultural & Sugar Technologists, c/o C.E.R.F., B.P. 315, 97490 Ste.-Clotilde, Réunion.	Réunion.
September 23/29, 1989	International Society of Sugar Cane Technologists, c/o STAB, C.P. 532, Piracicaba, SP, Brazil 13400.	São Paulo, Brazil.

Facts and figures

Farm subsidy reform[1]

The Reagan Adminstration's proposal, presented in July last at the meeting of GATT, the General Agreement on Tariffs and Trade, is unrealistic, according to a new study which considers a compromise between free markets and government involvement would be a better approach. The analysis, written by former US Agriculture Undersecretary Dale Hathaway for the Institute for International Economics, is the most detailed response published since the proposal was presented. Hathway says that the plan, which calls for an end to farm subsidies in ten years, is unrealistic because it would be opposed by politically-powerful farm groups in many countries that know they would lose from free trade. Even though this approach would be the simplest, it is unlikely to be acceptable to farm producers groups in many countries. Producers in a number of countries know they would not be competitive in (free) world markets, Hathaway said. He identifies two alternatives to the Reagan approach – managed trade/market sharing agreements, and a compromise between free trade and wholesale government intervention. The history of failure of many commodity agreements is proof that managed trade is not a realistic option, he considers, and suggest a compromise under which farmers would be subsidized only on the portion of output used domestically. The US, for example, could bolster producer income by making deficiency payments on domestic portions of output, while the EEC could shift its export subsidies to direct payments to producers for the portion of their crops used domestically; the Community could also levy a co-responsibility tax on the portion of production for export to bring returns to farmers down to world market levels. Production beyond that used domestically should not be subsidized and the aim of the policies would be to restrict subsidies that encourage farmers to produce more than needed domestically.

Florida sugar crop, 1986/87[2]

In the 1986/87 crop the Florida sugar industry produced 1,476,000 short tons of raw sugar from 13,713,000 tons of cane grown on 384,359 acres. It was the first crop for several years unaffected by frost damage and compared with 1,413,000 tons of sugar produced from a cane area of 383,400 acres in 1985/86.

India sugar industry expansion[3]

Licences have been granted for the construction of four new sugar factories at Kumbakanam, Sivgiri, Periakulam and Sivaganga, all in Tamil Nadu. The crushing capacity of each will be 2500 t.c.d. Two sugar factories in the private sector in Bihar have been modernized and expanded; the Harinagar factory has gone from 3000 to 5000 t.c.d. capacity, while that at Mahajubia has been expanded from 2000 to 2500 t.c.d. Five more factories in Bihar are seeking assistance through the Sugar Development Fund and plan to modernize their old plants. Four new factories, each with a crushing capacity of about 2500 t.c.d., are to be set up at Ajnala, Jagraon, Budhladha and Faridkot in the Punjab at the cost of about 1000 million rupees (£44 million)[4].

Meeting of US and Caribbean sugar producers

In November last, representatives of the US beet sugar industry met sugar producers from the Caribbean and Latin American countries at La Romana in the Dominican Republic. The US group included officers from four companies and the cane sugar representatives included some from the Dominican Republic and Guatemala and their Washington, D.C. representatives. The US group was led by David Carter, President of the US Beet Sugar Association. The Vice President of the Dominican Republic, Carlos Morales, participated; he has been a sugar producer in private life and is currently head of the Consejo del Azúcar, a government-owned corporation which runs 11 sugar factories and also helps coordinate operations of other segements of the sugar industry in the Dominican Republic. The meeting was one of frank and open discussion of mutual situations affecting the sugar industry as a whole and, in particular, diminishing US sugar consumption.

South African sugar cane mechanization exhibition[5]

On August 5 and 6 the annual Sugarmech exhibition took place at the La Mercy farm of the South African Sugar Association Experiment Station, where more than 2500 visitors saw demonstrations of both established and new agricultural implements and techniques, with stands and displays mounted by more than 50 participants. Among the machines featured were a Marauder track unit designed to harvest burnt cane, a disc harrow, and a double-furrow cane planter developed at the Experiment Station.

Taiwan sugar refineries[6]

To satisfy the needs of domestic markets, Taiwan Sugar Corporation (TSC) has invested 1000 million NT dollars (US $30 million) to erect one sugar refinery in Hualien and one in Peiking, each with a daily capacity of 800 tonnes of refined sugar. These refineries, to be erected by TSC's engineers, are scheduled to be completed by the end of December 1988.

US refinery automated materials handling[7]

California & Hawaiian Sugar Company (C & H) has awarded Litton Industries' Industrial Automation System Group a contract for a $17 million automated material handling system at the company's refinery at Crockett, California. The system will govern automatically the movement, storage, management and control of C & H's product from the time the sugar is packaged until shipment.

Austrian sugar industry rationalization[8]

Sugana Zuckergesellschaft and Tullner Zuckerfabrik are to merge. After the fusion of the two companies the two sugar factories at Enns and Siegendorf[9] are to be closed. The reason is the stagnation of domestic demand in Austria which is below 270,000 tonnes and which has afforded no success for marketing measures. Since sugar in neighbouring countries is less expensive, considerable amounts of the commodity flow into Austria.

Ethiopia sugar situation[10]

Despite the effects of the recent drought, sugar production in Ethiopia is being roughly maintained, according to statistics published by the International Sugar Organization. From 200,000 tonnes, raw value, in 1984 it fell marginally to 191,000 tonnes in 1985 and reached 193,000 tonnes last year. Exports ranged from 38,000 tonnes in 1984 down to 24,000 tonnes last year. No details of imports under the international aid program are given in the published statistics of the ISO.

US sugar refinery closure rumour[11]

The Boston sugar refinery, the smallest of the Amstar group, is rumoured to be about to close, according to a *Dyergram* report. Amstar's total annual capacity, including the Boston facility, is estimated at 2,225,000 short tons, raw value, or more than twice the level of the 1987 import quota. The expected 1988 import quota announcement in mid-December and the trade bill stalemate in Washington will both presumably influence Amstar's decision.

China sugar shortage[12]

China's shortages of sugar are worsening and imports will continue at a high level, the official press and western diplomats said, giving as the cause the failure of the country to aim at self-sufficiency. Press reports say output is down in all major growing areas, causing shortages of white sugar in many provinces. Even steady production in Guangxi has not prevented shortages there, because 63% of its sugar has been shipped out to feed other areas. A western diplomat said China had decided not to aim for self-sufficiency in sugar, the only major crop for which it had taken such a decision, as a consequence of deciding to make the best use of a limited land area.

Virgin Islands distillery[13]

Chemical Fuel Corporation, a subsidiary of Biocom International of Australia, is spending US $16 million on a plant in the US Virgin Islands which will initially dehydrate imported alcohol to produce anhydrous ethanol for the US market. Fermentation and distillation facilities are to be added next year when the plant is expected to reach full capacity, using 350,000 tonnes of fermentable sugar to produce 50 million gallons of ethanol per year.

1 *Public Ledger*, September 15, 1987.
2 *Sugar J.*, 1987, **50**, (3), 31.
3 *Sugar Scene*, 1987, **5**, (6/7), 18.
4 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 482, 537.
5 *S. African Sugar J.*, 1987, **71**, 277.
6 *Taiwan Sugar*, 1987, **34**, (4), 30.
7 *Amerop-Westway Newsletter*, 1987, (167), 15.
8 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 479.
9 *Zuckerind.*, 1987, **112**, 917.
10 *Czarnikow Sugar Review*, 1987, (1766), 156.
11 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 535.
12 *Public Ledger's Commodity Week*, October 17, 1987.
13 *Financial Times*, October 29, 1987.

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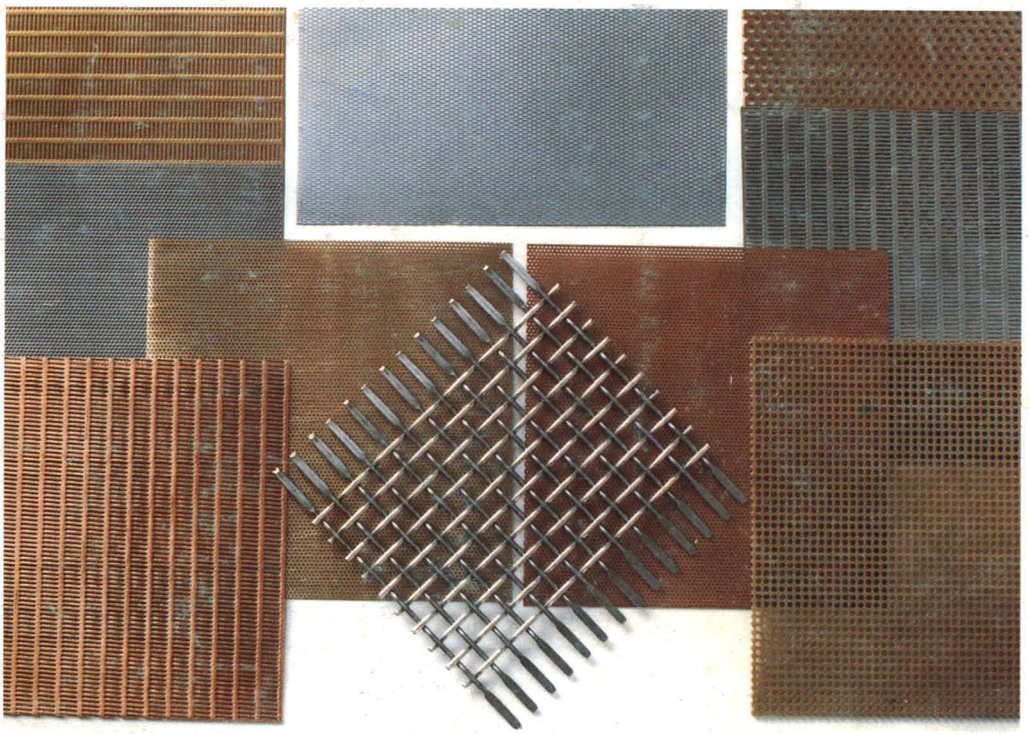

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