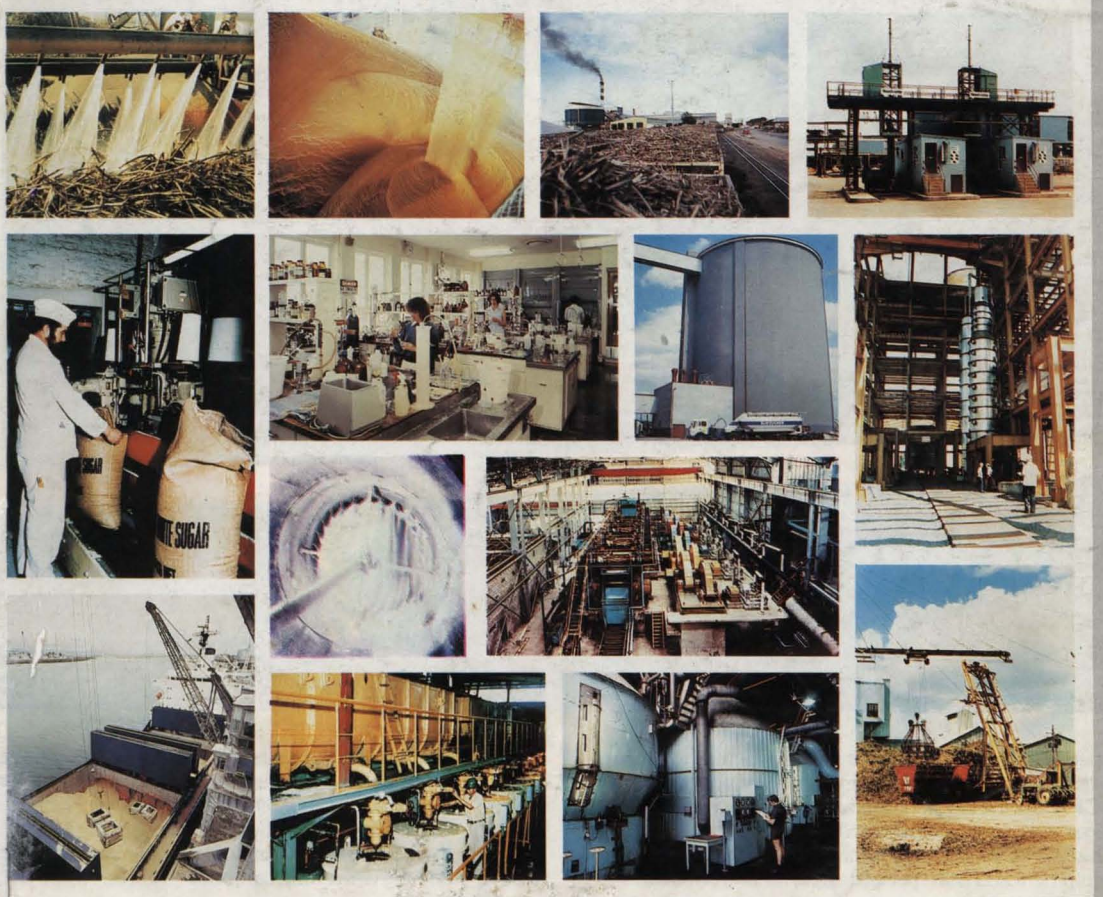
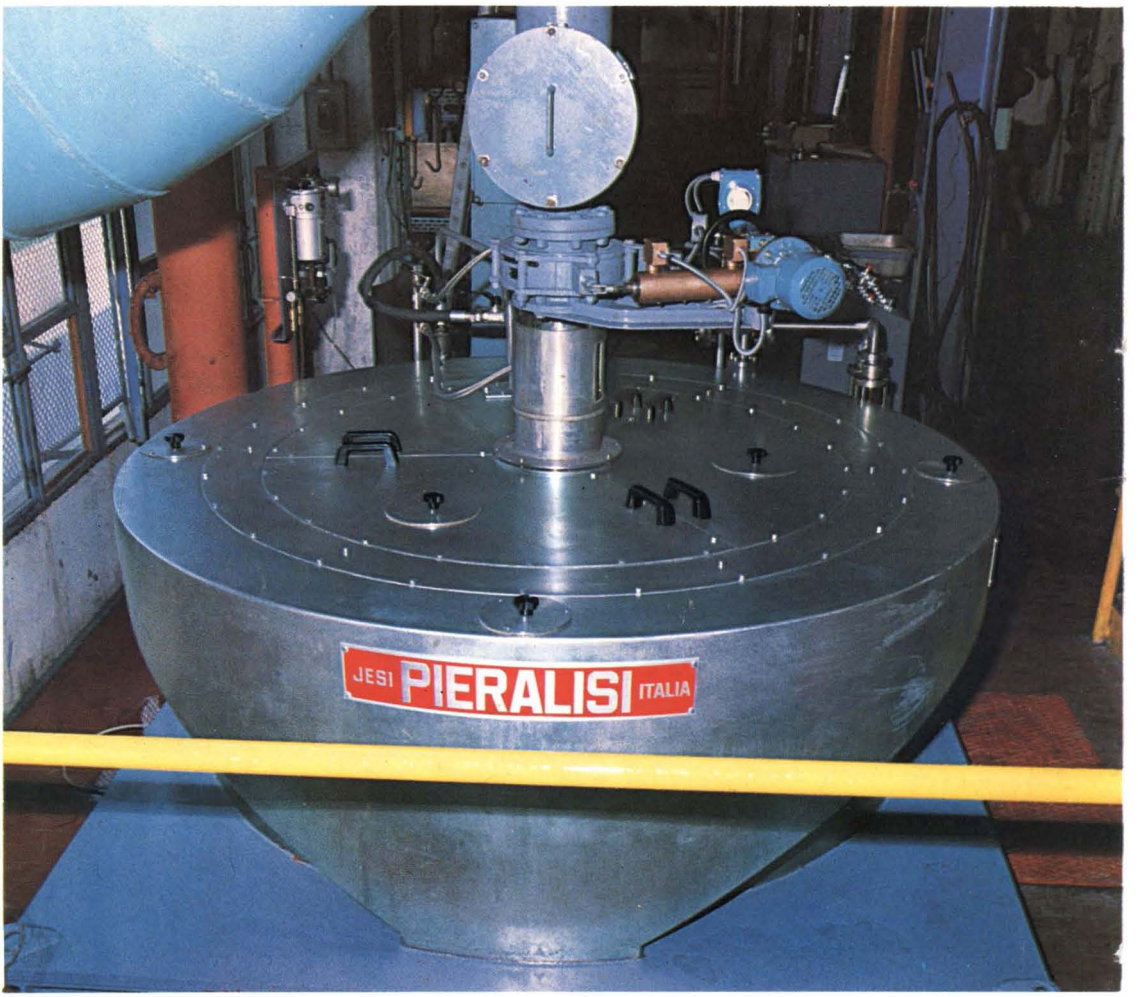
INTERNATIONAL SUGAR JOURNAL



VOLUME LXXVIII/ISSUE No. 1045 JANUARY 1986

PIERALISI
CONTINUOUS CENTRIFUGES



Specially designed for a sugar refinery wanting to step up production and cut running and maintenance costs, the **SCP-C5** is the biggest continuous centrifuge for treating sugar massecuite available today.
The **SCP-C5** is equipped with programmable logic control equipment and with special devices for the formation of magma in the centrifuge and of Bx-controlled syrup. The machine body and the basket are made entirely of stainless steel. The oil-mist system is used for lubrication. The **SCP-C5** – a truly great machine – has joined the Pieralisi family of centrifuges for the treatment of beet floating waters and carbonation juices.

NUOVA M.A.I.P. MACCHINE AGRICOLE INDUSTRIALI
PIERALISI
Società per Azioni
Viale Cavallotti, 30 - 60035 JESI - Italia - Tel. (0731) 58244 - Telex 560033

INTERNATIONAL SUGAR JOURNAL

Volume 88
Issue No. 1045

CONTENTS January 1986

UK ISSN 0020-8841

Annual Subscription:
£50.00 post free

Single Copies
£5.00 post free

Airmail: £24 extra

Claims for missing issues will not be allowed if received more than two months from date of mailing, plus time normally required for postal delivery of journal and claim.

Published by
International Media Ltd.,
P.O. Box 26, Port Talbot,
West Glamorgan SA13 1NX, U.K.
Tel: 0639-887498 *Telex:* 21792 REF 869

Printed by Adams & Sons (Printers) Ltd.,
Blueschool Street, Hereford.
Telephone: 0432 54123.

Published by

International Media Ltd.

P.O. Box 26, Port Talbot, West Glamorgan SA13 1NX, U.K.

Telephone: 0639-887498 *Telex:* 21792 REF 869

US Office: P.O. Box 143773, Coral Gables Station, FL 33114-3773.

Inquiries regarding advertising should be addressed to the above offices or to the appropriate representative:

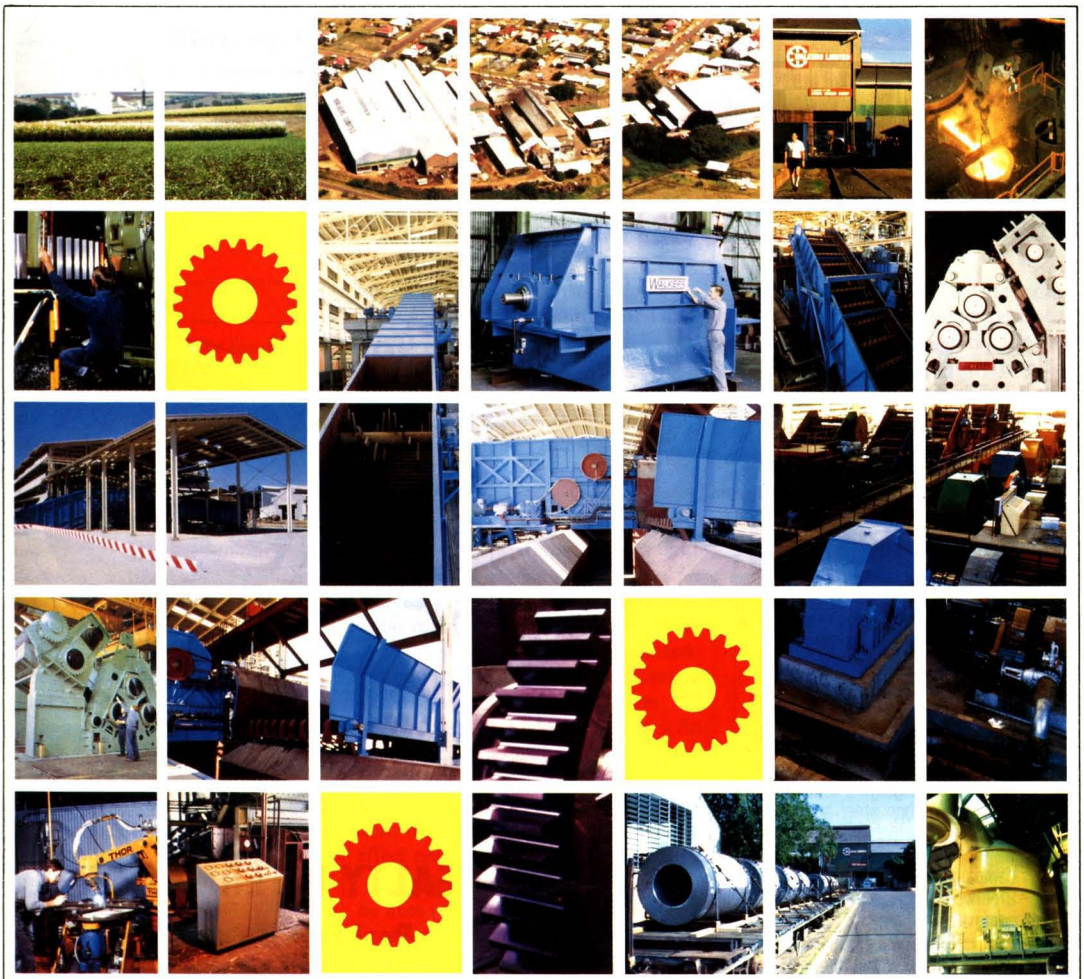
UK: T. G. Scott & Son Ltd.,
30-32 Southampton Street, London WC2E 7HR
Tel: 01-240 2032. *Telex:* 299181.

France: MaG-Watt International,
6 rue des Acacias, Vert-le-Grand, 91810 Essonne.
Tel: (6) 456-00.15.

Belgium, Holland and West Germany: G. Arnold Teesing B.V.,
Prof. Tulpstraat 17, 1018 GZ Amsterdam.
Tel: 020-263615. *Telex:* 13133.

Japan: Shinano International,
Akasaka Kyowa Bldg., 6-14 Akasaka 1-chome, Minato-ku, Tokyo 107.
Tel: (03) 584-6420. *Telex:* J27850 Sinanoco.

Latin America: Mr. Mario A. Mascaró,
7321 S.W. 82nd Street No. 2, Miami, FL, U.S.A. 33143.
Tel: (305) 667-1724.



Cane sugar Engineered Systems

Walkers Limited's healthy involvement in most corners of the cane sugar world has resulted in a unique blend of International and Australian Milling expertise which Walkers Engineers have reflected in their milling designs.

By being constantly in tune with todays sugar industry needs, Walkers are able to assist clients to plan for the most practical and proven factory equipment to suit their development objectives and financial constraints.

Write for our complete brochure on Cane sugar Engineered Systems.

- **Cane Handling**
  Tippers, Feeder Tables and Cane Carriers
- **Cane Preparation**
  Cane Kickers and Knives, Reverse Fiberizors, and Shredders
- **Cane Mills**
  3, 4, 5 and 6 Roller Mills in Brass and Roller Bearing including the Constant Ratio Type. Pressure Feeders of Medium, Heavy and Toothed
- **Mill Drives**
  Intermediate and Low speed reduction gears.

WALKERS LIMITED

Head Office and Works:
23 Bowen Street,
Maryborough,
Queensland, Australia

Mailing Address:
P.O. Box 211,
Maryborough, 4650.
Queensland, Australia.

Telephone:
National (071) 21 8100
International
61-71-21 8100

FAX
61-71-22 4400
Telex AA49718
Cables "ITOLZAK"

M&A

Notes and comments

World sugar prices

After rising from $143 per tonne on November 1 to $147.50 on November 6 the London Daily Price of raw sugar started to slide on reports that the drought in Brazil would hit alcohol production rather than sugar and that the Soviet Union's campaign was proceeding better than had been expected. There were also rumours, since denied, of sales by Brazil which country was supposed to be out of the market in 1985. The LDP dipped to reach a low of $131.50 on November 18 but rose to $141.50 on November 22 as reports came in of damage to the Cuban cane crop by hurricane Kate. Thereafter, the influence of further reports of improvement in European beet sugar crops exerted a downward trend on sugar prices and the LDP finished the month at $138.50.

By contrast, the white sugar market remained fairly steady throughout the month, although it followed raw sugar price movements to a limited extent. Thus, the LDP(W) began the month at $176 per tonne, rose to $181 on November 6 and fell to $172.50 on November 18, rose again to a peak of $180.50 on November 22 and ended the month at $175.

EEC sugar production quotas

An overall reduction in the European Economic Community's sugar surplus as a result of enlargement from ten to twelve countries, and the prospect of increased use of sugar by the chemical industry, are given by the EEC Commission as reasons for not reducing sugar production quotas in spite of great over-capacity both in the Community and elsewhere. A-quotas for the 12 members total 10,485,000 tonnes, and B-quotas 2,283,000 tonnes, giving a total of 12,768,000 tonnes of quota sugar. Of this production in 1985/86 is expected to reach 10,225,000 tonnes of A-quota and 1,914,000 tonnes of B-quota sugar, or 12,139,000 tonnes in all, while consumption is estimated at 10,730,000 tonnes. Thus a surplus of quota sugar is set at 1,409,000 tonnes. If the average C-sugar production for 1980/84 is added, i.e. 1,786,000 tonnes, the total surplus is calculated to be 3,196,000 tonnes.

Agra Europe, quoted by F. O. Licht GmbH[1], disputes these figures and claims that C-sugar production is nearly double the Commission's figure, at 3.2 million tonnes giving a total surplus of 4.6 million tonnes. The C-sugar must be exported on the world market without subsidy but financed by the high returns from quota sugar. The proposed change in taxes on quota sugar, to reduce the huge deficit from subsidizing export sales, may well help to reduce over-production but decisions on the proposals have not yet been made, although they are to take effect next July.

In order for the chemical industry to be able to use sugar as a raw material, its price would have to be not more than 25% of the intervention price, and the Commission apparently agrees with the demands of some member countries that legislation should be introduced to allow a subsidy to permit this.

British Sugar plc, the sole UK beet processor, has complained that the Commission's proposal to leave quotas unchanged is discriminatory[2]. Alone in the EEC, the UK's production quota is insufficient to meet consumption needs, even after allowing for imports from the ACP countries, and there would certainly not be sufficient to supply the new biotechnology industries which are expected to being emerging shortly. This, it is claimed, will discourage the new industries from being established in the UK which would still, through production levies, have to help subsidize them when they appeared elsewhere in the Community.

C. Czarnikow Ltd. comments: "There is no doubt that the UK producers have a case. Much of the new technology is British but, if the raw material cannot be readily available in this country, the industries will be established elsewhere. But this has to be measured against the fact that there is already a surplus of sugar in the Community which has to be disposed of one way or another at less than production costs and increased quotas would only serve to worsen the situation."

New proposals for the EEC sugar regime[5]

The EEC Commission has scrapped its plan to raise substantially the levies on sugar producers, substituting a proposal to impose a new additional tax on output modulated to account for each country's average production over the past five years. The scheme represents a marked departure from the original call for an increase in production levies (from 2 to 2.5% on A-quota and from 37.5 to 47% on B-quota).

As such it is likely to meet a more favourable response from member states which had strongly resisted the first plan as inequitable. It appears unlikely, however, that the new levy, averaging 1.3% on guaranteed intervention prices, will harness output. Under the new proposal, the Commission has calculated the level of tax for each country based on their last five years' performance. This ranges from 0.6% for Italy, whose small production incurs little cost in export subsidies, to 1.6% for France and West Germany whose larger tonnages cost more to the farm budget.

The Commission aims to use the funds raised to pay off, over a period of five years, the 400 million e.c.u. debt that the supposedly self-financing sugar regime has built up over the recent past. Soundings from member states suggest that the revised plan stands a substantially better chance than its predecessor of winning the approval of farm ministers. Officials were anxious that the question should be resolved

1 *Int. Sugar Rpt.*, 1985, **117**, 573-574.
2 C. Czarnikow Ltd., *Sugar Review*, 1985, (1742), 134.
3 *Financial Times*, November 29, 1985.

when the Farm Council met in December as further delays could disrupt their planning for farm prices in 1986.

The original proposals were aimed at raising revenue to balance the books on sugar export financing by the Community but in a way which would discourage the production of B-quota sugar, the main part of such exports. The new proposal may raise the revenue but its impact on surplus sugar production is likely to be negligible.

Hurricane damage in Cuba[4]

Hurricane Kate, which swept across Cuba on November 18-19 did damage to many of the country's cane plantations and sugar factories, although officials feel the overall effect may not become apparent for weeks or even months. Thousands of acres of cane were toppled, low-lying areas were flooded and roofs and warehouses at factories and other facilities were destroyed.

The harvest had begun a week earlier against the background of a nationwide drought which looked certain to cut production by 12% according to President Castro in a September broadcast. The rains and floods caused by the hurricane could cause a drop in cane sugar content, and the bent or toppled stalks will mean that the target of 65% mechanical harvesting is unlikely to be met this season. Planting for next year is also likely to have been disrupted. Industry sources say that it is too early to assess damage but feel that targets for the crop may have to be cut.

Opposition to EEC price for ACP sugar[5]

The plan to improve the guaranteed price paid by the EEC to sugar producing members of the 65-nation African, Caribbean and Pacific (ACP) trading bloc looks set to be withdrawn after objections from several community countries at a meeting of the EEC Council of Agriculture Ministers in Luxembourg. The European Commission had proposed to raise prices for the 1.3 million tonnes of ACP sugar imported yearly by the EEC from the 1.15% agreed in June to 1.3%[6]. The improvement was made after leaders of the ACP rejected the initial offer as inadequate to sustain their industries in the current climate of depressed prices.

The effect of the proposal was to pay for ACP raw sugar at the rate reserved in the EEC for white sugar support. Several Farm ministers voiced their opposition to the plan at the meeting. The objections were led by the UK and West German ministers who pointed out that such a move, while not adding to farm budget costs, would penalise cane sugar refineries, reduce their profit margins and possibly put plants in jeopardy.

An alternative plan to aid the ACP producer countries by reducing the damaging effect of fluctuating currencies on their receipts is now to be examined by officials.

US Farm Bill

After much wheeling and dealing in the US Senate, a compromise bill proposed by Senator Dole, the Majority Leader, was passed by a 56 to 41 vote on November 19. The bill provides a range of options for different commodities while, in the case of sugar, the sugar loan rate would be frozen for four years at 18 cents/lb while as a concession to win the votes of senators from cane growing states, a provision is included whereby the sugar program is to operate at no cost to the treasury other than administrative costs[7]. This is considered to require a smaller quota for imported sugar, in order to keep supplies tight and prices high enough so that domestic producers would not forfeit their sugar to the CCC in lieu of repaying their loans. This could be a major political embarrassment to the Administration since it chose to provide an import quota larger than US needs as part of political support for friendly nations in the Caribbean and Latin America, and would not relish having to reduce such quotas.

It should be mentioned that the Senate Bill and the House Bill, passed in September, were due to be considered by a joint House-Senate Conference Committee and, while the original Administration proposals to reduce the loan rate are unlikely to be reinstated, the final form of the Bill sent to the President remained a matter for negotiation among the politicians concerned.

World sugar production, 1985/86

F. O. Licht GmbH recently published their first estimate of world sugar production in the current season[3], September 1985 — August 1986. Total output is forecast at 97,677,000 tonnes, raw value, against the 1984/85 total of 100,949,000 tonnes. The estimate is some 400,000 tonnes higher than that published by C. Czarnikow Ltd. some weeks earlier[4], and good weather in the interim has contributed to the expectation of higher crops in Europe. Licht notes that in some exporting countries, cost-cutting measures are starting to emerge as the burden of financing export production becomes excessive, while production is expected to fall mainly in the major sugar exporting nations. "However, it would be fatal if exporters were to see the projected decline in sugar output this season as a signal to return to the disastrous course of unrestrained production policy that has led the market into its worst crisis ever . . . It would be premature to say that the crisis is over; much remains to be done to lead the market out of its current depression."

4 *Public Ledger's Commodity Week*, November 23, 1985.
5 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 549.
6 See *I.S.J.*, 1985, **87**, 162.
7 *Dyergram*, 1985, (39-85), 3.
8 *Int. Sugar Rpt.*, 1985, **117**, 561-569.
9 *I.S.J.*, 1985, **87**, 217.

Analysis of sugar boiling and its technical consequences*

Part I. Supersaturation, crystal growth and the footing process

By K. E. Austmeyer

(Institut für landwirtschaftliche Technologie und Zuckerindustrie an der TU Braunschweig, Germany)

Introduction

The conventional pattern of discontinuous sugar crystallization is characterized in Figure 1a. Undersaturated solution is drawn in until the level L is such that the floating calandria is covered. It is evaporated until a supersaturation y of about 1.15 is reached, when seeding with slurry takes place. The median size of these very fine-grained seed crystals is about 10 μm. By bubble evaporation at the heating surface and injection of fresh undersaturated solution the vacuum pan is loaded to its maximum charge (level L_{max}). In the last stage of the process (Brixing-up), the strike is thickened without charging until the desired crystal content w_c is reached. Crystal growth from median grain size to product size (d'_c=0.7 mm) is also shown in Figure 1a.

It is known that, for the usual operating method, the calandria in the normal design of vacuum pan is too large during the stage of crystal growth. This becomes clear from the course of the supersaturation y. During the initial stage of the process a disparity exists between crystal surface $A_{c,tot}$ and the mass Δm_S able to crystallize. This is the reason why the metastable range is often exceeded during conventional operation with slurry as seed. In the last stage of the process this situation is reversed; here, the evaporation is insufficient to maintain the desired concentration gradient in the solution at the now greatly increased crystal surface[1].

The beginning of the stage where the rate of process is no longer determined by mass transfer but by heat transfer is characterized by the maximum in the curve of the supersaturation y.

In Figure 1b it is shown that the ratio δ of crystal surface $A_{c,tot}$ to the sucrose mass Δm_S able to crystallize out at the given temperature has reached a value of about 100 m^2/kg at the end of the stage, here called crystal formation. The end of this stage is reached when the curve of supersaturation y passes through a point of inflection.

For comparison, the ratio δ after feeding of slurry has a value of only ca. 0.05 m^2/kg, a reduction by more than 10^3. In particular, in the stage of crystalline growth δ changes considerably more[2] than the half crystal distance λ, also shown in Figure 1b.

The ratio δ illustrates that controlling the first stage of growth of the slurry-seeding crystal in the conventional vacuum pan poses a considerable problem in view of the high water evaporation rate given by bubble boiling. Dissolving in undersaturated zones and the occurrence of conglomeration at the same time, mainly in zones of too high supersaturation, are undesirable effects which are hardly avoidable. The following has to be said about these effects: At the inner surface of the seeding tubes significant temperature

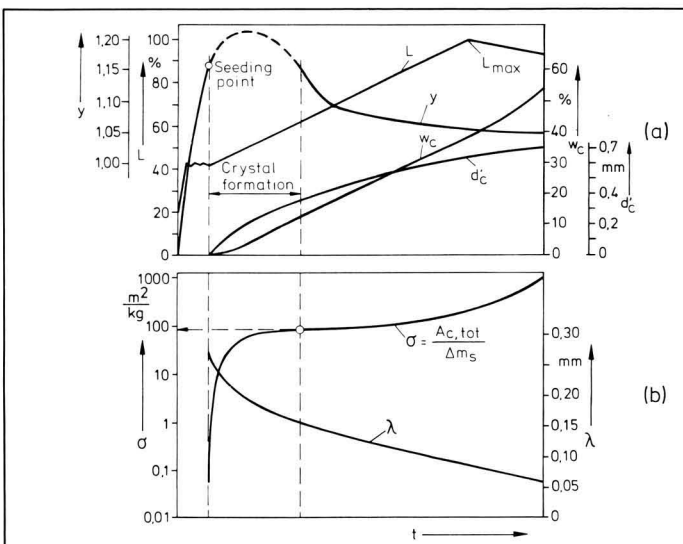


Fig. 1. Pattern of some characteristic values during discontinuous white sugar crystallization by evaporation. Key: y = supersaturation, L = level of syrup or massecuite, w_c = crystal content, d'_c = mean crystal size, λ = ratio of half crystal distance, and δ = total crystal surface related to sugar mass in solution able to crystallize at the given temperature

K. E. Austmeyer

*Extended version of a paper presented to the 27th Technical Conference of British Sugar plc, June 1984.

1 Schliephake & Austmeyer: *Zucker*, 1976, **29**, 293.

2 Genie: *Zeitsch. Zuckerind.*, 1962, **87**, 557; Vogeler: *Zucker*, 1977, **30**, 676.

Symbols and indices used in this series

Symbols

A_c	m^2	crystal surface
A_h	m^2	heating surface
a	m^2/sec	temperature conductivity
C	—	coefficient
c_p	J/(kg °K)	specific heating capacity under constant pressure
d	m	diameter
dn_{con}/dt	sec^{-1}	conglomeration velocity
d_c	m	crystal size
d'_c	m	characteristic crystal size of RRSB-distribution
dv/ds	sec^{-1}	shearing gradient
E_R	kJ/mol	surface reaction activation energy
g	m/sec^2	acceleration due to gravity
$\dot{H}$	W	enthalpy flow
h	J/kg	specific enthalpy
k	$W/(m^2\ °K)$	overall coefficient of heat transfer
k*	$W/(m^2\ °K)$	apparent overall coefficient of heat transfer
k_D	m/sec	velocity coefficient of material transport
k_R	m/sec	surface reaction rate constant
L	m	level
l	m	characteristic length contained in the identification numbers
m	kg; tonne	mass
$\dot{m}$	kg/sec; tonnes/hr	mass flow
Ne	—	Newton number
Nu	—	Nusselt number
n	sec^{-1}	frequency of rotation
P	W	power
Pr	—	Prandtl number
p	bar	pressure
$\dot{Q}$	W	heat flux
Q_3	%	mass amount distribution
q	—	purity of a sugar solution
$\dot{q}$	W/m^2	heat flux density
$q_{S/W}$	—	sugar/water ratio of a solution
R	%	residual amounts distribution
R	$m^2\ °K/W$	heat transfer resistance
R_D	sec/m	transport resistance
R_{tot}	sec/m	growth process resistance
R_R	—	surface reaction resistance
R	kJ/(mol °K)	universal gas constant
Re	—	Reynolds number
r	J/kg	evaporation enthalpy
s	m	thickness of wall
T	°K	absolute temperature
t	min	time
t_r	min	residence time
th	m	thickness of wall
V	m^3	volume
v	m/sec	characteristic speed contained in the identification values
w	—	content
x	m	axial coordinate
y	—	supersaturation number $[q_{S/W}/q_{S/W,sat}(\vartheta_{Sol})]$
α	$W/(m^2\ °K)$	heat transfer coefficient
η	Pas	dynamic viscosity
ϑ	°C	temperature
$\Delta\vartheta$	°K	temperature difference
$(\Delta\vartheta)^*$	°K	apparent temperature gradient
Δc	kg/m^3	driving concentration gradient
λ	W/(m °K)	thermal conductivity coefficient
ρ	kg/m^3	density
σ	N/m	surface tension

Indices

afc	above floating calandria
B	vapour bubble
c	crystal
cf	crystal foot
cof	condensate film
ds	dry substance
eff	effective
fc	fractional component
fs	feed solution
gt	guiding tube
hs	heating surface
hsco	heating steam condensate
hst	(heating-) steam
i	inside
j	running parameter
lo	loss
Ma	magma
N.N.	Non-Newtonian fluid
o	outside
p	product
S	sugar
s	state of boiling
sat	saturation
sol	solution
st	stirrer
th	thickness
tot	total
tw	tube wall
Va	vapour
W	water

profiles are present because of relatively low heat transfer coefficients on the magma side[3]. Also, while the solution at the magma level is supersaturated, a considerable amount of slurry particle melting will take place in the undersaturated zones which are close to the wall[4].

Apart from these undersaturated zones there are also regions of unacceptably high supersaturation, particularly at the surface of the massecuite, owing to the temperature gradient in the boiling apparatus. Besides secondary nucleation, formation of conglomerates is also to be expected in these zones. Mainly still very small crystals ($d_c < 100$ μm) are involved in conglomeration[5,6], which adversely affects the crystal quality. The mechanism of formation of conglomerates cannot yet be defined clearly.

This undesired effect sets in especially when small crystals with a high rate of growth and energetically favourable arrangement of the facing surfaces reside for too long at very short distances apart, because of too low a shearing gradient. This can be concluded from the measured relationships. Exceptionally good conditions for conglomeration occur during the reconstruction stage, i.e. when damage to crystals in the slurry is being repaired (high energy of crystal surfaces and high growth velocity). Conglomeration combined with secondary nucleation is also conceivable. Though there are still some questions, the general conclusion can already be reached that conglomeration can be modified if the rate of growth of the very small crystals is reduced and the shearing rate in the suspension is increased and, above all, made uniform.

Figure 2 shows a general view of dependence of the conglomeration rate dn_{con}/dt on rate of growth $d(d_c)/dt$ ($\sim dm \times dt \cdot 1/A_c$) and shearing gradient dv/ds. Thus, conglomeration decreases, as expected, with decreasing rate of growth and increasing shearing gradient. To avoid conglomeration of slurry seeding particles for instance, it is necessary to attempt to work in the left-hand bottom corner of the diagram in Figure 2.

Further, the average (half) crystal distance is of importance (here: $\bar{\lambda} = 25 \times 10^{-6}$ m). As it is not possible to realize the special requirements in formation of the seed particles in a conventional vacuum pan, it is suggested that this process section should be incorporated in a convenient system. Crystallization by evaporation in conventional vacuum pans should not be started before $\delta \approx 100$ m²/kg (see Fig. 1) is reached.

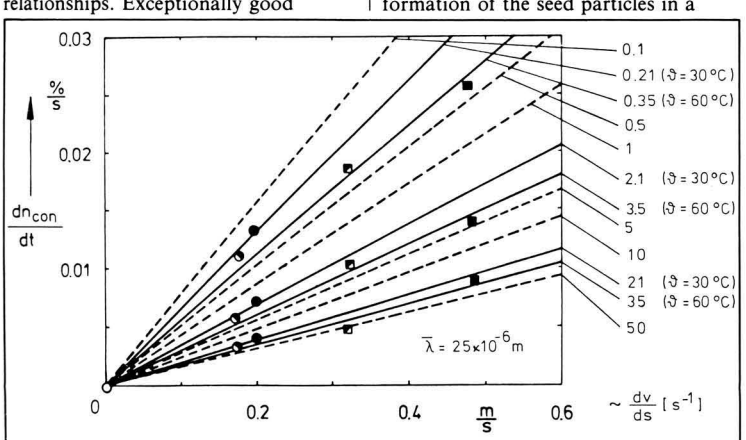


Fig. 2. Conglomeration velocity dn_{con}/dt and dependence[7] on linear nucleation rate $d(d_c)/dt$ and laminar shearing gradient dv/ds at an average (half) crystal distance $\bar{\lambda}$

Footing apparatus

A low working temperature should be chosen to reduce the rate of growth if the easily measurable and adjustable supersaturation value of $y = 1.1$ is to be maintained. This fact is illustrated in Figure 3, which shows the temperature dependence of the rate of growth $dm/dt \times 1/A_c$.

When $R_D/R_{tot} = 0$, the transport resistance R_D disappears ($Re \to \infty$) and only the surface reaction resistance R_R, dependent on the temperature, has to be surmounted. Figure 3 shows the wedge-shaped scatter of measured values obtained by various authors as well as the foundation of growth of very small crystals (the dashed curve where $d_c = 10^{-6}$m)[1].

If the diagram for diffusively determined growth of undisturbed particles ($Sh = 2$) is taken as a basis, rates of growth outside the normal field of scatter result, owing to the high material transport coefficient k_D.

The dashed curve (valid for $d_c = 10^{-6}$m, $Sh = 2$) is close to the line $R_D/R_{tot} = 0$, which shows the maximum rate of growth dependent on the temperature only.

Reduction of the temperature, as mentioned above, is necessary for slowing the rate of growth of the slurry particles at an unchanged supersaturation number ($y = 1.1$). During cooling crystallization, as suggested by the Braunschweig Institute, the slurry is added to a solution with low degree of supersaturation ($y = 1.1$). Subsequently

3 Austmeyer & Schliephake: *Zuckerind.*, 1981, **106**, 421.
4 Idem: *I.S.J.*, 1983, **85**, 328.
5 Kamoda & Yamane: *Proc. Japan Sugar Refineries' Tech.*, 1959, **8**, 123.
6 Kuijvenhoven *et al.*: *I.S.J.*, 1983, **85**, 201.
7 Schulze: *Diploma Thesis* (TU Braunschweig), 1980; Reinefeld: *Zuckerind.*, 1982, **107**, 369.

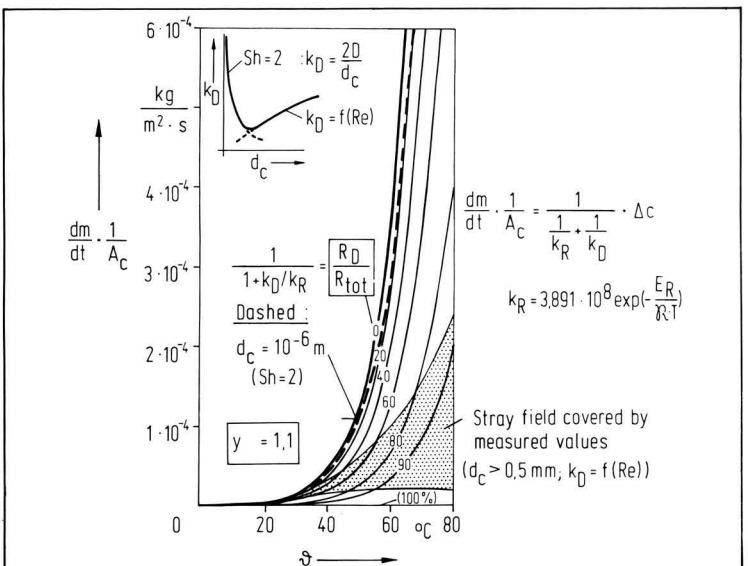


Fig. 3. Rate of growth of very small ($d_c = 10^{-6}$m) sucrose crystals in pure solution

the suspension is cooled at a rate $d\vartheta/dt$ of about 8°K/hr. Figure 4 shows a system employing this apparatus which was developed for the purpose. The changes of level with time in the three main parts of the system (denoted by 1.1, 1.2 and 2 in Fig. 4) are shown in Figure 5.

A solution of high purity (dry substance content: $0.74 \leqslant w_{ds} \leqslant 0.75$) is seeded with slurry at a super-saturation y of 1.1 in a stirred vessel (1.1)(dissipated power demand $P_{st}/V \geqslant 2$ kW/m³). The solution is then cooled to approximately 22°C (obtainable crystal content w_c about 0.18).

The portion of solution needed for cooling crystallization is bled from the footing vacuum pan (2) when the desired dry substance content (0.74-0.75) is reached. The solution has then to be held temporarily in vessel 1.2.

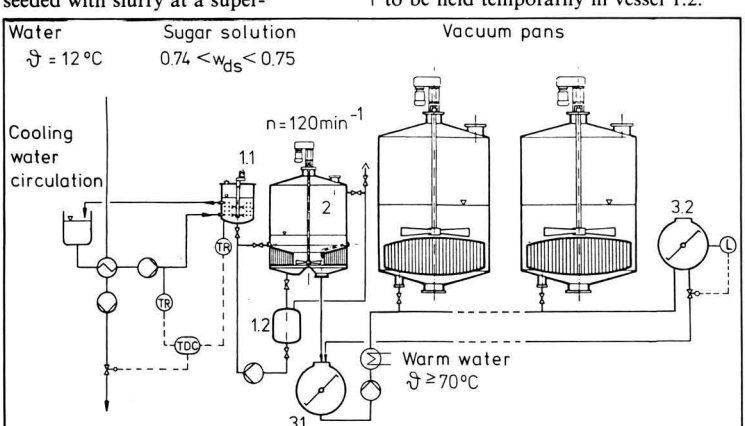


Fig. 4. Scheme of the crystal footing plant (Braunschweig Institute system)

After discharging the stirred vessel 1.1 on seeding the footing vacuum pan 2, the contents of vessel 1.2 are transferred to the stirred vessel 1.1. After the solution has cooled to the desired supersaturation the already mentioned cooling crystallization starts in vessel 1.1.

When this process has finished, the crystal footing produced in vessel 1.1 is added to the low supersaturation solution in crysallizer 2 (see Fig. 6). In this vacuum pan, which is also provided with a high-shearing stirrer, the crystals grow from an average grain size d_c' of about 0.1 mm to about 0.35 mm. The crystal content w_c at the end of the boiling process in vessel 2 amounts to about 0.5.

After the end of the batch, the magma is discharged into the crystallizer 3.1, from which it is pumped through a ring conduit, passing the footing crystallizers, into the level-controlled crystallizer 3.2.

Mixing of the "cold" suspension from the cooling crystallizer with the "warm" solution in the footing vacuum pan creates no problems as the h,w_{ds}-diagram of Figure 6 shows.

Starting with the mother liquor of the suspension obtained by cooling crystallization at low supersaturation (state 1, $\vartheta = 22$°C), the mixing point 3 ($\vartheta = 61$°C) is attained when the suspension is added to the footing crystallizer (solution state 2, $\vartheta = 65$°C) in the mixing ratio used in this example.

Owing to the almost linear nature of the curves (y is constant), nearly all conceivable mixing points in the range of interest lie on the same supersaturation curve. In the present example, solution equilibrium is finally reached when the mixed suspension (3) is heated to boiling state (4). Thus the footing sugar boiling process starts with saturated solution.

With the aid of the method of operation introduced here, a distinct improvement in crystal quality has been gained in practice because of

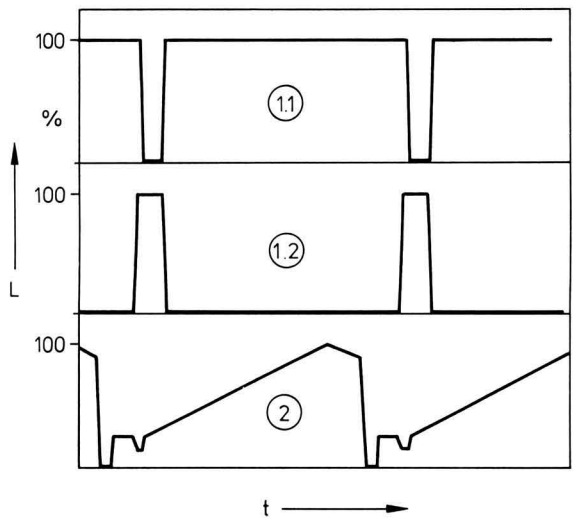


Fig. 5. Change in the level with time in the parts of the plant indicated as 1.1, 1.2 and 2 in Fig. 4

allowance for the special requirements of crystal formation.

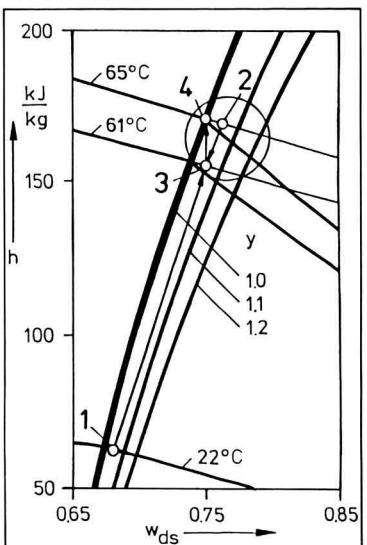


Fig. 6. Blending of "cold" mother liquor from the cooling crystallization with "warm" suspension in the footing vacuum pan

Sucrose crystal habit in a refinery

By P. G. Morel du Boil

(Sugar Milling Research Institute, Durban, Natal, South Africa)

Introduction

The shape or appearance of a crystal is called the crystal habit. Although crystals of a given substance may be very different in shape the angles between the faces are characteristic and constant. The general outward appearance of the crystal is governed by conditions during growth which can affect the relative growth rates of the different crystal faces. Several factors can influence these growth rates, including supersaturation, temperature variations and the concentration and

P. G. Morel du Boil

nature of impurities. The shape of a crystal grown in the presence of impurities is largely controlled by the faces most retarded by adsorption of the impurities. It is generally conceded that the most profound influence can be attributed to the types of impurities present. Other factors will have considerably less effect on the ultimate crystal shape. There is a distinction between crystallographically elongated crystals and long crystals. If two specified linear dimensions of the crystal are used to measure shape then the natural shape of a pure sucrose crystal grown in water is about twice as long in the b-direction (y) as in the c-direction (z). This can be deduced from the basic rate data published by

Paper presented to the South African Technologists' Association, 1985

Vernon[1] and by Smythe[2] and recently highlighted by Vane[3]. Hence crystals with y/z ratios of about 2 are normal, ratios less than 2 indicate c-axis elongation and ratios greater than 2 imply b-axis elongation.

The classical study by Smythe[2,4,5] showed that the effects of oligosaccharides were the result of highly stereo-specific adsorption. Mantovani[6–9] and his school have also focused on the mechanisms of added impurities, particularly raffinose which is of importance in the beet industry. Observations in the factory environment have tended to link needle grain with polysaccharides, especially when processing deteriorated juices or low quality syrups.

The Australians have been very active in this area. Keniry *et al.*[10] postulated dextran as a promising quantitative indicator of the processing quality of cane on the basis of correlations between dextran and molasses purity or crystal elongation. Sutherland[11], Sutherland & Paton[12] as well as Leonard & Richards[13] separated refractory syrups into polysaccharide and oligosaccharide fractions and concluded that the predominant causative agent in crystal elongation was polymeric and that oligosaccharides were not an important primary cause of elongation. However, these workers all assumed that the almost square shape normally observed in massecuites was ideal. Such crystals are in fact already significantly elongated in the c-direction. Later work by Day[14] and by Covacevich *et al.*[15] demonstrated the effect on elongation of temperature, dextran molecular weight, concentration and structure, but also overlooked the fact that the major elongating properties were already present in the base medium. This is presumably why so many authors have commented on the relatively slight elongation obtained with dextrans in pure solutions even at unrealistically high concentrations — by using an elongated (although square) crystal as the reference point the small additional influence caused by dextran is noticed more quickly. That dextran is not usually a major crystal habit modifier can also be inferred from the work of Hidi & Staker[16]. These authors demonstrated significant enzymatic dextran removal under factory trial conditions, but an insignificant improvement in crystal elongation (e.g. decreasing the dextran in the incoming juice from about 1700 ppm to less than 100 ppm only improved the y/z ratio from 0.75 to 0.90). In one instance, by reducing the level from 2300 ppm to 150 ppm in *B*-molasses, the crystal shape for *C*-sugar improved from 0.35 to 0.65 which is still extensively elongated crystal. In a third trial where the average dextran level in *C*-massecuite (4300 ppm) was decreased by 60% the crystal shape only improved from 0.45 to 0.50. By contrast, Inkerman[17] reported a marked reduction in the percentage of elongated crystals after "complete" enzymatic removal of dextran.

Saska & Polack[18] investigated the effects of dextrans and partially hydrolysed dextrans on sucrose crystal habit and found decreasing elongation effects as the molecular weight decreased — implying that these oligosaccharides were less significant than polysaccharides. Cremata *et al.*[19] contend that low molecular weight polysaccharides accumulated between cutting and milling and caused c-axis elongation.

In the West Indies Tilbury[20] could find no statistically significant correlation between dextran content and crystal elongation in *C*-massecuite during a period when high dextran levels were entering the factory. However all samples showed marked crystal elongation. Mantovani *et al.*[21] and Shah & Delavier[22] observed "cubic" crystals in the presence of added dextran. This cubic tendency implies that growth has been retarded in both the b- and c- directions. Kamoda *et al.*[23] have separated a polysaccharide and an oligosaccharide fraction from refinery final molasses and added this to sugar solutions in a laboratory vacuum pan. Kamoda found that oligosaccharides were the major causative factor. More recently Montenegro[24] has confirmed these findings by concluding that the compounds exerting more influence on the elongation of sucrose crystals were the oligosaccharides rather than the polysaccharides and that micro-organisms present in juices produce oligosaccharides capable of causing c-axis elongation.

Many refiners have become convinced that elongated crystals are due to the presence of dextran. As a result there has been a general resurgence of interest, particularly in connexion with raw sugar penalty schemes, although much of the evidence linking dextran and needle grain is circumstantial and uncorroborated.

Despite the questionable evidence that sucrose crystal elongation is directly attributable to dextran, the other processing problems associated with polysaccharides or dextrans should not be underestimated. These processing problems will directly affect throughput and exhaustion and are

1 "The velocity of crystallization of sucrose" (Ph.D. Thesis, Univ. of London), 1938.
2 *Australian J. Chem.*, 1967, **20,** 1087-1095.
3 *Sugar Ind. Tech.*, 1981, 95-102.
4 *Australian J. Chem.*, 1967, **20,** 1097-1114.
5 *ibid.*, 1115-1131.
6 Mantovani & Fagioli: *Zeitsch. Zuckerind.*, 1964, **89,** 202-205.
7 Idem: *ibid.*, 1965, **90,** 690-692.
8 Mantovani *et al.*: *Zucker*, 1967, **20,** 663-668.
9 Idem: *ibid.*, 1973, **26,** 513-518.
10 *I.S.J.*, 1967, **69,** 330-333.
11 *ibid.*, 1968, **70,** 355-358.
12 Sutherland & Paton: *ibid.*, 1969, **71,** 131-135.
13 *ibid.*, 1969, **71,** 263-267.
14 "The habit modification of sucrose crystals grown in the presence of dextran" (M.Sc. Thesis, Univ. of Queensland), 1971.
15 *Proc. 16th Congr. ISSCT*, 1977, 2493-2507.
16 *Proc. Queensland Soc. Sugar Cane Tech.*, 1975, **42,** 331-334.
17 *Proc. 17th Congr. ISSCT*, 1980, 2411-2427.
18 *Zuckerind.*, 1982, **107,** 941-943.
19 *Proc. 18th Congr. ISSCT*, 1983, (3), 433-454.
20 *Proc. 14th Congr. ISSCT*, 1971, 1444-1458.
21 *Compt. Rend. CITS*, 1975, **15,** 399-405.
22 *Zeitsch. Zuckerind.*, 1974, **99,** 27-31.
23 *Proc. 13th Congr. ISSCT*, 1968, 362-373.
24 *Proc. 18th Congr. ISSCT*, 1983, (3), 477-505.

probably of more importance than crystal shape implications.

South African raw sugars usually show negligible dextran levels using the haze technique but are generally c-axis elongated, with the problem occasionally becoming more severe. The associated decrease in throughput is probably the most troublesome aspect. It is interesting to note that Vane[3] classified South African raws as behaving well in the refinery despite y/z ratios of 0.8. Although the Sugar Milling Research Institute has investigated the problem on several occasions no formalized findings have been published. This paper summarizes the results of our recent re-investigation of the problem with particular emphasis on refining. Clearly the findings are not conclusive but represent the current status of what is an on-going project.

Experimental Procedure

Crystallization apparatus

The laboratory crystallizer consisted of glass tubes (130×30 mm with B29 stoppers and holding about 50 ml solution) attached to a motor-driven wheel (diameter 280 mm). The speed of rotation could be varied electronically and could be monitored electro-mechanically. In most experiments this speed was about 20 rpm. The entire apparatus was placed in an electronically thermostatted oven operated at 60-61°C.

Preparation, curing and equilibration of solutions

Sugar solutions were prepared by weighing first refinery boilings, impure factory products and water to give a sucrose:water ratio (S/W) of 3.075 (i.e. a degree of supersaturation of 1.06 for pure sucrose at 60.5°C based on the data of Charles[25]) and the desired non-sucrose/water level (NSW/W). For most experiments the NS/W ratio was equivalent to 0.1 on molasses. The components were dissolved at 70°C in a rotating flask and the clear solutions were cured for several hours in an oven held at 70°C. The cured solutions were transferred to the crystallization tubes and equilibrated overnight at the working temperature (60-61°C).

Crystallization procedure

A single-crystal technique was used to measure crystal growth rates whilst a multi-crystal approach was used for shape applications. In the former case single crystals (grown from selected coffee crystals to about 75 to 100 mg at 1.04 degree of supersaturation) were tied to stainless wire formers using single filament nylon (diameter 0.15 mm). The tied crystals were pre-warmed in the oven for 10 to 15 minutes before being placed in the hot sugar solution. In the latter case one drop of factory-prepared ball-mill slurry (between 0.5 and 1.5 mg sucrose) was placed on the surface of the solution. The stoppered glass tubes were placed on the wheel with minimum delay.

After 5 hours the single crystals were removed from the solutions, excess syrup was wiped off with soft tissue and the crystals were weighed. Shape runs lasted 48 hours. The crystal-syrup mixture was poured into small perspex baskets (30 mm i.d. ×55 mm) fitted with wire mesh (0.35 mm aperture), centrifuged at about 3000 rpm for about 5 minutes, washed with methanol and recentrifuged. The washing step was repeated once more and the crystals were air-dried.

Crystal measurement

The large crystals were weighed for rate determination before and after the run and the following formula was used to calculate the growth rate ($kg.m^{-2}.sec^{-1}$):

$$R = \frac{202.266 \times (M_F - M_I) \times 10^{-5}}{t \times (M_I^{2/3} + M_I^{1/3} \times M_F^{1/3} + M_F^{2/3})}$$

where M_I = initial mass (g), M_F = final mass (g), t = time (hr).

The ratio of the crystal length in the b-axis direction (y) to that in the c-axis direction (z) was used as the shape parameter. Between 200 and 250 crystals were crystallographically identified and the crystal lengths measured using a manual image analyser (Kontron MOP-Videoplan). The average y/z ratio indicates the crystal elongation. Commercial boilings were usually dispersed in glycerol (saturated with sucrose) before measuring and the shape expressed as $\bar{y}/\bar{z}$.

Isolation of fractions

Refinery exhaust molasses (200 g) was diluted to 20°Bx and centrifuged at 10,000 rpm for 20 minutes at 15°C. The sediment (0.4 g) was discarded. High molecular weight material was precipitated by adding 3.5 volumes of absolute ethanol to 1 volume of supernatant. After standing overnight the sediment was removed by centrifuging. The sediment was dissolved in warm water (400 ml) and reprecipitated by adding ethanol (1400 ml) and standing overnight. The suspension was centrifuged. The sediment was dissolved in warm water (300 ml) and ultrafiltered (Amicon CH-4A concentrator with 5000 molecular weight cut-off) using a washout technique with 1000 ml water, to remove completely any low molecular weight material. The retentate was freeze-dried (fraction A — yield 3.4 g).

The combined supernatants from the alcohol precipitations were concentrated under vacuum at 40°C (fraction B — yield 188 g).

A carbon-Celite column was prepared by packing a glass column (5×100 cm) with a 1:1 slurry of Darco G-60 and Celite 545 in 50% ethanol. The column was washed with water (2-3 litres) before use. Water (50 ml) was added to a portion of fraction B (110 g) and the solution loaded onto the carbon-Celite column at about 1 ml/min.

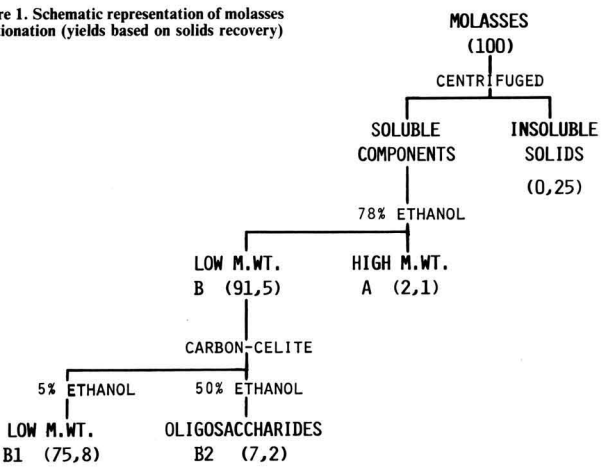
After collecting 150 ml the solvent was changed to 5% ethanol (2100 ml) and then to 50% ethanol. Fractions were monitored using thin layer

25 *I.S.J.*, 1960, **62**, 126-131.

chromatography[26]. The monosaccharides, sucrose and traces of trisaccharides were eluted between 1650 and 4000 ml. This eluent was concentrated under vacuum at 40°C (fraction B1 — yield 90 g). The oligomers were eluted between 4000 and 6500 ml. This eluent was concentrated under vacuum at 40°C (fraction B2 — yield 6.9 g).

The isolation procedure is summarized schematically in Figure 1.

Figure 1. Schematic representation of molasses fractionation (yields based on solids recovery)



Crude oligosaccharide preparations

Three broad classes of oligosaccharides were prepared and subjected to the same carbon column clean-up as described above for molasses.

(a) **Isomalto-oligomers** were prepared by refluxing dextran (Sephadex T-150) (5 g) in 0.3N sulphuric acid (25 ml) for 2 hours. The solution was cooled, neutralized with sodium carbonate and freeze-dried[18].

(b) **Malto-oligomers** were obtained from a commercial glucose syrup (DE 42).

(c) **Sucrose-derived oligomers** were prepared by reacting sucrose with invertase according to the method of Gross[27].

Hydrolysis of oligosaccharides

Fraction B2 and preparation (c) were hydrolysed using invertase. The sample (0.3-0.4 g) was dissolved in 0.2M sodium acetate-acetic acid buffer of pH 4.6 (3 ml), and invertase (BDH 39020) (0.6 ml) was added. After reacting at ambient temperature for 2 hours, the enzyme was inactivated by boiling the solution for 2 minutes. The cooled solution was neutralized [Amberlite IR 45 (OH)], filtered and freeze-dried. A control was prepared in a similar way, but with the enzyme omitted.

Chemical analysis

All impure products and fractions were analysed for sucrose using a gas chromatographic technique[28] and for water by a Karl Fischer method[29].

Low molecular weight fractions, column eluents, oligosaccharide preparations and hydrolysates were monitored or profiled using tlc[26]. The solvent polarity was varied by adjusting the ethanol component (28 to 38%) and the development time varied between 1 hr and 48 hr depending on the application (i.e. fast monitoring or detailed resolution).

Results and Discussion

Data presented in Table I highlight two points. First, there is a wide range in crystal shape from one refinery to the next and, second, as boiling progresses and the impurity levels increase, the crystal shape always becomes more elongated. For example, first boilings generally lie in the range 1.0 to 1.6; second boilings in the range 0.9 to 1.4; third boilings in the range 0.6 to 1.3 whilst fourth boilings are between 0.5 and 0.9. Recovery house boilings have even lower ratios (approximately 0.3).

In view of this progressive deterioration in crystal shape with increasing impurities it was decided that exhaust molasses from a third recovery boiling would be a suitable source of concentrated elongating constituents. All further experiments were based on this molasses sample.

Under controlled laboratory

26 Schäffler & Morel du Boil: *J. Chromatogr.*, 1972, **72**, 212-216.
27 "Methods in carbohydrate chemistry", Vol. 1. (Academic Press, New York). 1962, pp. 360-364.
28 Schäffler & Morel du Boil: *Sugar Tech. Rev.*, 1984, **11**, 95-185.
29 MacGillivray & Nurok: *Proc. 47th Congr. S. African Sugar Tech. Assoc.*, 1973, 39-43.

Table I. Crystal shape ($\bar{y}/\bar{z}$) for different boilings at several refineries

Refinery	$\bar{y}/\bar{z}$ Ratio			
	Boiling 1	Boiling 2	Boiling 3	Boiling 4
A	1.05	0.90	0.55	0.55
	1.30	1.10	1.00	0.55
B	1.55	1.40	1.25	0.85
	1.35	1.15	0.85	—
C	1.45	1.15	1.20	0.60
D	1.60	1.35	0.90	0.80
	1.40	1.20	0.90	0.65
E	1.35	1.20	1.10	—

ISJ Abstracts

Cane sugar manufacture

Micro-based fuel control for cell-type furnaces

K. McGrew and R. Crum. *J. Amer. Soc. Sugar Cane Tech.*, 1985, **4**, 122 *(abstract only)*.

The authors discuss the equipment used at Sterling Sugars on a Dennis Dietrick cell-type furnace. Control was accomplished by installing a low-radiation source sensor outside the cell. This allowed a high- and low-contact point to be picked up and gave the engineers a range within which to work. The contacts were sent to a microprocessor controlling the main gates on the bagasse drag-type conveyor. A gate-opening bias was installed because of the varying fuel conditions. The microprocessor can expand as experience grows in boiler control, and is capable of complete process loop control; it can also be used for data storage and report generation.

Microbial deterioration of mixed sugar cane juice in Iraq

I. M. Mansour, Y. A. Hamdi, Z. T. Hamid and H. Toma. *Agr. Res. Rev.* (Cairo), 1979, **57**, (2), 155-166; through *Food Sci. Tech. Abs.*, 1984, **16**, (7), Abs. 7 L 428.

Mixed juice in Iraq was reported to lose 6.47% of its sucrose content during 1 hour's delay in processing. Among bacteria, yeasts and fungi found to be causes of biodeterioration, *Leuconostoc* spp. played the major role. The agent causing rind disease of sugar cane, *Pleocyta sacchari,* especially in the presence of *Candida* sp., inoculated into sterile juice caused a 95% decrease in pol and a very large increase in reducing sugars in 20 days.

Optimum conditions of cane juice purification by ultra-filtration

M. Tako, Y. Nakayama, S. Nakamura, S. Kishihara and M. Komoto. *J. Agr. Chem. Soc. Jap.*, 1984, **58**, (7), 685-690; through *Ref. Zhurn. AN SSSR (Khim.)*, 1985, (8), Abs. 8 R430.

Ultrafiltration of defecation juice was studied with the aim of determining the possibility of obtaining a better juice quality at maximum throughput. With addition of lime at 10°C and ultrafiltration at 60-67°C, highest filtration rate and highest filtrate purity were obtained at pH 8.1-8.5. The ultrafiltration rate was highest at 80°C and pH 7.8 after liming at 10, 30 or 85°C; under these conditions, purity was highest, the colour and CaO contents lowest and the P_2O_5 content optimum. When liming was carried out at 10 or 30°C, the pH of the juice fell during ultrafiltration from 8.1 and 7.8 to 7.2-7.3. Optimum pH of the defecation juice was 8.1, 7.8 and 7.0 at liming temperatures of 10, 30 and 85°C, respectively.

Bulk terminal has revolutionized exports

G. Dewey. *S. African Sugar J.*, 1985, **69**, 86-87, 90.

An outline is given of the Durban bulk sugar terminal and its operation 20 years after the first raw sugar shipment was made to Japan.

Extraneous matter as related to tons cane/tons sugar ratio

E. Shah. *Proc. 1982 Meeting West Indies Sugar Tech.*, 63-73.

Chopped and whole-stalk cane consignments were sampled in the factory yard for extraneous matter in the form of (i) tops, trash and water suckers, and (ii) roots, soil, dead or dry canes and foreign matter; an average of 7.45% was found. Since this was almost identical to a figure of 7.47% for the deviation in the tons cane:tons sugar ratio, a unit increase in extraneous matter would theoretically cause a unit rise in the ratio; however, the effect on the ratio takes no account of the decrease in juice reabsorption by bagasse and hence increase in milling extraction with the reduction (of trash) in millable cane, so that there would be an increase in available sucrose in the mixed juice. While the amount of chopped cane crushed was only one-third of the total, the levels of extraneous matter in both forms of cane caused the same variation in the tons cane:tons sugar ratio, demonstrating the much higher quantity of extraneous matter in the chopped cane.

Preliminary considerations on the fluidized bed combustion of bagasse

D. R. McGaw, W. S. Milford and A. A. Nunez. *Proc. 1982 Meeting West Indies Sugar Tech.*, 281-289.

Studies on coal combustion have demonstrated the benefits of the fluidized bed process by comparison with conventional firing, particularly in the case of low-grade fuels; the major advantages are more efficient combustion and reduced pollution. Preliminary experiments were conducted on application of the process to bagasse in a tube of $4\frac{1}{2}$ in diameter and 27 in long, at the base of which was a perforated plate. Air was blown by fan at a controlled velocity, being pre-heated to 200-250°C so as to initiate combustion. Sand was used as inert bed component. Dry bagasse (of approx. 11% moisture content) and wet bagasse (containing approx. 50% moisture) were fed batchwise by hand at 5-10 second intervals. Results showed that the process is feasible but that much further basic work is needed so as to investigate the effects of the various parameters. The temperatures were not as high as expected, but the operating conditions were stable, with a relatively even temperature distribution in the bulk of the bed and low bed temperature fluctuations with time; carryover of partially burnt material, a major problem with fixed bed combustion, was insignificant, and little or no ash was left in the bed at the end of each run.

Beet sugar manufacture

Certain questions concerning the choice of evaporator in a sugar factory

A. Laudański. *Gaz. Cukr.*, 1985, **93**, 7-10 (*Polish*).

The interlinking of the concentration requirements of juice fed to an evaporator and the vapour requirements of other process stations such as the pan station and juice heaters is discussed in relation to the size of the evaporator. Investigations at sugar factories having a quadruple-effect evaporator of 160-180 m^3 heating surface area per 100 tonnes of beet sliced per day showed that the value of 1.8-2.0 for the evaporation factor n[1] was below the nominal and practically the same as in the first two effects; the h.s. was considered inadequate and caused problems in the use of the evaporator heat. However, increasing the h.s. is only of benefit if the heat flux in the first two effects is greater than the total demands of the other vapour consumers, and it is suggested that there is a tendency to oversize evaporators. A recommended arrangement involves a triple-effect evaporator used solely to concentrate juice and characterized by a n value of 2.7-3.0. A method of calculating evaporator requirements is described, and two worked examples are given.

Some aspects of fluidized-bed dryer design

T. Klepacki. *Gaz. Cukr.*, 1985, **93**, 11-13 (*Polish*).

Snags encountered with fluidized-bed sugar dryers are discussed, including (1) the inadequate retention time of some of the crystals as a consequence of intensive mixing in the fluidized bed, and (2) problems created by variations in crystal size, whereby the smaller crystals risk being entrained from the bed, while larger crystals may sink. Equations are presented for calculation of the proportion of crystals of given size desirable for efficient drying; comparison with experimental values demonstrate the deviation of the latter from the requirements. Data are given for a vibratory fluidized-bed dryer[2] and a Dunford-Elliott dryer built under licence in Poland.

Modernization of the energy system at Gostyń sugar factory

D. Glinka, S. Jórdeczka and J. Górnikowski. *Gaz. Cukr.*, 1985, **93**, 13-15 (*Polish*).

Details are given of plans for upgrading the power plant at Gostyń, which (to all intents and purposes) has only one boiler, of 12 tonnes/hr steam output, that could be expected to operate for a further number of years, while the other boilers were installed in 1925/28 and are unreliable. Power generation depends on a Brown-Boveri turbogenerator of 2.5 MW installed in 1930. The new equipment that was to be installed under an investment program aimed at completion in 1985 is listed and some information is given on preliminary work carried out.

The steam accumulator in sugar factory thermo-technological systems

A. Laudański. *Gaz. Cukr.*, 1985, **93**, 25-27 (*Polish*).

Fluctuations in steam demand and hence in the load on sugar factory boilers are discussed, and the benefits of steam accumulators of the constant-pressure or pressure-drop type are indicated. A sample calculation of the required volumetric capacity of an accumulator based on a daily beet slice of 1200 tonnes and a maximum boiler output of 32 tonnes/hr is presented.

Testing and evaluating Antiprex for scale prevention on the heating surface of an evaporator

H. Gruszecka. *Gaz. Cukr.*, 1985, **93**, 43-44 (*Polish*).

Antiprex A, an Allied Colloids product, was tested on scale prevention and removal. Laboratory trials showed that a concentration of 75-100 ppm reduced the lime salts in juice samples without affecting juice quality. Subsequent experiments at eight sugar factories in different areas of Poland involved dosage rates in the range 4.4-33 litres/24 hours (concentration details are not given) split 20:40:30:10 for evaporator effects 1, 2, 3 and 4, respectively. Initial use of 13-33 litres/24 hours during processing of immature beet caused the disappearance of incrustation from the sight glasses within a few days. In other tests using various dosage rates (depending on the lime salts content in the juice) the deposit on the sight glasses was initially dissolved, the effective temperature difference across the evaporators was maintained practically constant throughout the test period, there were no problems with juice concentration apart from a gradual fall in Brix over the campaign, and most of the scale was easily dissolved during evaporator cleaning (which required small quantities of chemicals), although there was some residual scale that became slimy and was generally difficult to remove by mechanical means. Some information is given on the composition of scale at two factories, with an indication of the differences in component quantities between effects.

Elements of planned maintenance

F. W. Meyer. *Zuckerind.*, 1985, **110**, 275-279 (*German*).

Changes in the approach to factory maintenance have accompanied changes in sugar technology. Cost analysis has highlighted the need for a more selective approach to maintenance of specific plant based on its relative importance, conditions of use and the relative amount of time it is in operation, while other factors relate to the availability of skilled labour, to the accessibility of the manufacturer of the

1 Laudański: *I.S.J.*, 1985, **87**, 127A.
2 Gawrzyński *et al.*: *ibid.*, 1982, **84**, 153.

equipment in question and to the age of the plant, etc. The elements of a planned maintenance system based on the new thinking are explained, and the role of computerized data processing in such a system briefly examined.

Inhibition of thermophilic aerobic spore-formers from diffusion juices by antiseptic substances based on quaternary ammonium compounds

P. Brigidi, M. G. Marzola, F. Trotta, G. Vaccari and D. Matteuzzi. *Zuckerind.*, 1985, **110**, 302-304.

Of 50 strains of thermophilic *Bacillus* spp. isolated from raw juice samples obtained at different Italian sugar factories, 40 were found to be *B. stearothermophilus* and 10 *B. coagulans* (of which 7 belonged to Group A and the others to Group B). *In vitro* tests were conducted with a number of antiseptics, the most active of which (giving positive effects at dosage rates of 2-4 ppm) were Nalco D 4580 (manufactured by Nalco Italiana S.p.A.), Auxil A/l-L (made by ELMA S.a.S.) and Nalco N 7326/C; Auxil A/l-M, Nalco D 2085 and Nalco V 1152 were intermediate in having little effect at 2 ppm but proving successful at 4 ppm, while Perfect B 4 and Divo AP (manufactured by Diversey S.p.A.) were active only at 8 ppm, and Anios DIF (made by Laboratoires Anios S.A.) was active at 8 and 16 ppm. However, in tests on juice inoculated with three strains of *B. stearothermophilus,* Auxil A/l-M proved to be the most effective. On the other hand, although the results confirm the effectiveness of quaternary ammonium compounds as antiseptics, no conclusions could be drawn on the relative activities of the different products in view of the controlled nature of the tests and the number of variables that could have effect under factory conditions.

Electronic detection and measurements of the intensity of frost damage during (beet) storage

G. Alcaraz. *Sucr. Franç.*, 1985, **126**, 211-221 (*French*).

Investigations of the effect of frost on stored beet are reported. A fall in temperature causes a loss of plasticity and hence an increase in membrane pore diameter. At -6°C (near the lethal threshold for the beet tissue) there was a sharp rise in the discharge of potassium (as electrolyte); however, restoration of the initial cell permeability with rise in temperature after freezing confirmed earlier findings in the case of sucrose effusion[1]. The rate of freezing and the speed of return to positive temperatures govern the effects of frost. The change in membrane permeability is associated with a greater ionic mobility; the resultant change in electrical charge is reflected in changes in conductivity and resistivity. Reference is made to the work of a number of authors on measurement of conductivity or resistivity as a means of determining the state of health of the beet, and reasons are suggested for the unsuitability of the various methods tested. The approach of the author of the present article was to introduce a constant current into the beet tissue and measure any changes in it as a function of the condition of the cellular tissue. Preliminary results showed a progressive fall in conductivity from the crown to the tip, so that a midway point was chosen in order to obtain median values that were comparable between different roots. A good correlation was established between intensity of frost, conductivity and expected beet damage; this allowed scheduling of beet processing on the basis of the condition of the roots in particular sections of a pile 3-5 days in advance. Current density at 1 cm below the surface of the beet fell from 0.7 to 0.4 mA with a temperature fall from +10° to 0°C. At below -7°C, the current was constant at below the threshold of 0.1 mA. While the membranes became permeable and favoured ionic mobility, and the threshold resistance of the cell juice fell and thus increased conductivity, freezing caused an increase in viscosity with resistance and thus a fall in conductivity, which makes correlation between the biological behaviour of the beet and measurements of current density difficult; however, the interest lies in the deterioration that occurs with thawing. The studies showed four classes of behaviour with thawing; (1) beets in which conductivity was unaffected by thawing, (2) beets that had been exposed to temperatures lower than -4°C and in which conductivity rose with thawing; they gradually regained their original state and sometimes exhibited necrosis at the root extremities where conductivity was highest; (3) beets that had been exposed to temperatures below -6°C over a short period, and in which conductivity rose markedly with temperature rise from -3°C. There was oozing from some parts with reheating, and a large proportion of the beet showed necrosis; (4) beets which had a conductivity greater than 1 mA with rise in temperature from -1°C; the effect of thawing on conductivity was immediate, and there was rapid deterioration of the root. A scale of 0-9 was established on the basis of the conductivity *vs.* temperature relationship; up to 2 there is no risk of deterioration, from 2 to 4 there is some risk, at 4-6 there is danger of deterioration, while 6-9 represents an urgent situation. A battery-operated device developed to predict the condition of stored beet is described and illustrated. It comprises a hand-held rod carrying, at its lower end, a temperature needle probe and two electrodes. When the probe pierces the top layer of a beet, the temperature is registered as a liquid crystal digital display, and the appropriate range of values in the above-mentioned scale is then selected, after which the

1 Barbier & Nalin: *I.S.J.*, 1982, **84**, 347.

conductivity is measured. A number of the instruments have been tested and have proved satisfactory.

Conversion and extension work with modernization of Zuckerfabrik & Raffinerie Aarberg AG. I. The evaporator station and multi-energy scheme. II. General plan for the conversion and extension of Zuckerfabrik & Raffinerie Aarberg AG. III. Heat transfer coefficients, residence times and colour formation in the new evaporator system at Zuckerfabrik & Raffinerie Aarberg AG

(I) H. R. Brunner, K. Geckert, H. D. Kimmich, D. Bourée and R. Michel. *Zuckerind.*, 1985, **110**, 393-398; (II) W. Hoppe and J. Nigg. *ibid.*, 398-402; (III) S. Kurndis and W. Mauch. *ibid.*, 402-406 (*German*).

(I) The decision to increase the daily beet slice of Aarberg sugar factory/refinery in Switzerland to 8000 tonnes led to development of a multi-energy scheme aimed at minimizing steam consumption by making maximum use of the heat in condensate, optimizing energy consumption as well as capital and working costs, and allowing economical electricity generation. Pulp drying was to be eliminated and the pressed pulp spread on the land. Details are given of the modifications made to the more important processes so as to achieve energy savings, and a diagram illustrates the overall juice heating scheme based on condensate. The use of mechanical vapour compression and generation of some of the electricity used have reduced overall energy consumption by comparison with the previous system based on use of public grid electricity, and the energy consumption is very much lower than in a French sugar factory producing all of its electricity but not using vapour compression. Details are given of the evaporation scheme, which embodies a double-effect Robert pre-evaporator of 2500 and 3000 m^2 heating surface and a vapour compressor which raises the juice Brix to about 23°, followed by a quintuple-effect evaporator which raises the Brix to 68° and comprises a Robert 1st effect of 1500 m^2 h.s. and four falling-film vessels of 1700 and 3×1500 m^2 h.s.

(II) An outline is given of the different phases of the work on modernization of the sugar factory/refinery, including the initial planning, dismantling of machinery and the building work proper. The layout of the extension and of the equipment in it is briefly described.

(III) Details are given of the methods used to determine the heat transfer coefficients, juice colour and residence time distribution in the new evaporator, and the values found are discussed. The mean heat transfer coefficients fell from 3393 $W/m^2/°K$ in the 1st pre-evaporator effect to 1043 $W/m^2/°K$ in the 5th effect of the quintuple set, there was an average increase of only 5% in juice colour (from 1501 to 1575 units at 420 nm), and the average residence time throughout the entire evaporator was only 32.5 minutes. Comparison is made between the values of the three parameters and data given in the literature, demonstrating the high efficiency at Aarberg.

Pulp pressing developments

D. A. G. Brown, W. Marsden and A. J. Randall. *Zuckerind.*, 1985, **110**, 409-414.

See *I.S.J.*, 1985, **87**, 26A.

The gas turbine

P. Wertán. *Cukoripar*, 1985, **38**, 28-29 (*Hungarian*).

The role that a gas turbine plant could play in the energy economy of a sugar factory is briefly examined, with an outline description given of the component parts (air compressor, combustion chamber and the turbine proper) and comparative evaluation of a gas and a steam turbine as power generators.

The evaporator station and vapour compression

E. Otorowski. *Gaz. Cukr.*, 1985, 55-58 (*Polish*).

By means of a number of examples of evaporator station operation using vapour recompression, the author endeavours to answer those critics of compression who argue that it contributes nothing positive to the steam economy of a sugar factory. In four cases involving quintuple-effect evaporation, vapour is bled to varying degrees and the feed requirements of the 1st effect are partially met by recompressed and recycled 5th or 1st effect vapour. A diagram is presented of a scheme proposed by the author in 1978 in which a set of steam ejectors acting as thermocompressors and operating in conjunction with the pressure reducing station operate automatically as a function of juice throughput. While recompression permits increased juice throughput without the need for increased evaporator heating surface area or increased number of effects, the steam economy of a sugar factory can also benefit from use of vapour that is not used or only partly so in Polish factories, particularly pulp drying vapour. Pan vapours are used to some extent, but their recompression consumes much energy since they are under considerable vacuum and occupy a volume of approx. 7 m^3/kg.

Some observations on trough-type diffuser operation

R. Wiśniowski. *Gaz. Cukr.*, 1985, **93**, 58-60 (*Polish*).

Factors affecting diffuser performance which are discussed include the speed of rotation of the scrolls, cossettes load and quality, temperature, juice level and draft, cossettes and juice flow interference, and disinfection with formalin.

Sugar refining

Features of raw sugar processing at Gorodeya sugar combine

L. S. Alekseeva. *Sakhar. Prom.*, 1984, (3), 19-22 (*Russian*).

Details are given of modifications carried out at Gorodeya during 1983 and 1984 in order to raise its refining efficiency, and some performance data are presented. The factory processes up to 50,000 tonnes of imported raw sugar during the post-campaign period.

Computer control of white sugar refining process

D. T. Schweitzer. *Proc. Amer. Control Conf.*, 1983, **2**, 372-375; through *S.I.A.*, 1985, **47**, Abs. 85-474.

Control of vacuum pans used for 1st boilings is considered to be an ideal application for process control computers. The sequence of operations in a boiling is described: start-up, charging, concentrating, seeding, feeding, dropping the massecuite, clean out. Four major process variables must be considered: absolute pressure and mass temperature (necessary to determine the seeding point), and level and consistency, which are most important during feeding. In pans equipped with a mechanical circulator, the current load on the motor can be used as a measure of consistency. The computer can reproduce the sequencing operations for different grades of sugar in different pans, through the use of separate set point arrays. A major advantage is a decrease in the time for each boiling. Downtime is minimized, since the computer takes corrective action when necessary to avoid emergency situations.

Some incentives for improving raw sugar quality

J. B. Alexander and A. B. Ravnö. *Sugar y Azúcar*, 1985, **80**, (3), 12-14, 16.

See *I.S.J.*, 1985, **87**, 16A.

The changing world of white sugar manufacture

M. C. Bennett. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 16 pp.

The decline in cane raw sugar refining in the UK, Canada and the USA (involving the closure of 16 refineries since 1968), in the face of competition from beet white sugar, cane white sugar manufactured in "countries of origin" and HFS, is examined, and the effect of the situation on utilization of installed refinery capacity discussed. White sugar standards and specifications are compared with typical refined sugar standards in various countries, and the subjects discussed in SIT papers over the last 15 years are categorized in the form of bar charts, covering: energy; raw sugar quality; colour and decolorization; products and packaging; and computer and microcompressor control. Problems encountered in deep bed filtration of refinery liquor in the past are listed, and mention made of experimental work conducted at Tate & Lyle plc in which a correlation was established between particle size distribution and specific gravity of a number of possible filter bed materials on the one hand and the penetration of impurity particles into the bed on the other. On the basis of the investigations, a number of such filters have been constructed and installed at various locations around the world. A schematic layout of a deep bed filter installed in conjunction with a flotation clarification system is shown, in which the clarified liquor (containing traces of carry-over) is fed under pressure to the top of the filter and the impurity particles trapped throughout the entire depth of the bed, with a gradual rise in pressure differential between the top and bottom of the bed. At a pre-set pressure differential, when the bed is full of impurities, the filter automatically switches to back-flush, and a small part of the filtrate is returned to the bottom of the bed; under agitation, the bed is lifted and the trapped impurities are carried away from the top of the filter to be returned to the flotation clarifier feed. The impurities are eventually removed from the process stream in the clarifier mud. When back-flushing stops, the bed is allowed to settle, with automatic regrading, the liquor feed is resumed. No water is used in this operation, so that there is no sweet-water, nor is there any loss of the filter media. The technical specifications and performance data are given for a typical unit of 27 m^3/hr maximum feed flow. During a run lasting several weeks, one unit treated a total of 13 million US gallons of liquor at an average Brix of 63°, with a cycle time averaging 6½ hr (2-20 hr) and yielding a filtrate of constant clarity.

Crystallization symposium: white sugar operations

I. Knight. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 11 pp.

Details are given of boiling house operations at Toronto refinery in Canada, where the 3-strike system previously used for white sugar (including back-boiling of 1st run-off at up to 35% of the total syrup produced, back-boiling of some of the 3rd run-off, and passing 2nd and some 3rd run-off over char for recycle to the 3rd strike) was modified in order to counteract problems in char decolorization and throughput resulting from accelerated sugar production (the benefits of which are listed). Char treatment is now used only for fine liquor, and 3rd strike sugar (previously of 30 ICUMSA colour units but now of 45 units) is used mostly for soft sugars; since not all of it is needed for this, some of it is stored as white sugar, the colour being controlled by boiling on a 1st run-off. Problems concerning specialty sugar strikes are caused by the larger crystal size and hence longer boiling time of some of the sugars,

while soft sugars take less time to boil but more time to spin.

Crystallization symposium: remelt operations

J. W. Alberino. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 5 pp.

Details are given of the equipment and operations used in the 3-boiling remelt scheme at Savannah refinery, including pan boiling, purging in continuous centrifugals and quality control.

Vacuum pan control systems

D. L. Mackintosh. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 8 pp.

Based on his experiences at CSR Ltd., the author sets out the criteria that the boiling process must satisfy, lists instrumentation and controls provided for the more important boiling parameters, lists the nine distinct steps in a boiling cycle and then discusses full seeding as the preferred graining method. Advantages of full seeding include ease of control (with no need to reduce the vacuum and using steam flow to balance the crystallization rate while maintaining supersaturation within the metastable range, i.e. below 1.2) and the possibility of energy savings as result of the ability to boil feed of high Brix. The benefits of massecuite stirrers in regard to grain establishment are indicated; they have also permitted boiling of higher Brix feeds, improvements in pan yields and evaporation rates, allowed higher boiling levels above the calandria, and provided better control of heavying-up. In a brief reference to automatic boiling control, it is stressed that relatively simple control logic is the sole requirement for refined sugar pans, much of the boiling process being self-regulating.

Modifications to Roto-Louvre granulators

M. K. Faviell. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 12 pp.

Although three Roto-Louvre fixed-bed co-current air flow granulators dried white sugar satisfactorily, there was a considerable amount of crystal adhesion, with consequent adverse effect on sugar screening, bulk density and packaging properties. Some improvement was achieved in crystal quality by installing lifting flights from two redundant Hershey drum granulators in the initial 8 feet of the 30-ft Roto-Louvre units, and by reducing the quantity of icing sugar used as seed for massecuite boiling. Since the adhesion problem persisted, a further 8 feet of flights was installed in one of the granulators, but evaluation of the dried sugar under the microscope and by the crystal regularity index method showed no further improvement in quality. Further work involving installation of more lifting flights, the quantity of seed and temperature and flow of the air in granulators is planned.

Automatic pan boiling control using rheometer and microprocessor

H. Hashimoto, T. Kawamura, T. Chigusa and T. Satori. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 9 pp.

An automatic boiling control system based on measurement of massecuite consistency by a rheometer is described. Developed by Ensuiko Sugar Refining Co. Ltd. and Yokogawa Hokushin Electric Corporation, it incorporates a 16-bit microprocessor for monitoring, continuous control and sequential control, with inputs and outputs for each control loop being displayed by LDU which also provides manual operation ability. A colour CRT display provides monitoring of the control operations, while control programs can be modified by keyboard operation. The start of any one boiling cycle is by press button once the appropriate floppy disc is loaded; the syrup feed valve opens, followed by the steam valve, and syrup supply continues until the first rheometer set-point is reached. Five minutes before the second set-point, an audio-visual alarm informs the operator of the need to inject seed into a pot connected to the pan, and the seed is drawn into the pan at the set-point; this semi-automatic operation enables the seed sugar to be kept completely dry before introduction into the pan. After seeding, the program continues until point 11, massecuite being diluted with water or syrup every time the rheometer value reaches the preset value in the labile zone. Once tightening is complete, the bottom valve is opened and the massecuite dropped. Tabulated field test data from four cases demonstrate the advantages of the system in terms of a reduction in steam consumption, improvement in sugar quality and a decrease in boiling time, although the main feature is the energy saving associated with steam consumption. More than 100 of the systems have been installed and are operating successfully in Japanese and Korean refineries. The scheme has also been introduced into beet sugar factories, while one cane sugar factory in Japan has also adopted it after successful tests in 1984.

Construction and start-up of a coal-fired boiler and turbo-generator

J. C. Tillman. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 13 pp.

Details are given of the 300 short tons/hr Babcock & Wilcox coal-fired boiler installed at Savannah refinery to replace oil- and gas-fired units in view of rising oil and gas prices. A used 5 MW turbo-generator was also embodied in the scheme, the total capital cost of which was approx. $13 million (some $2 million below the budgeted cost).

Starch based sweeteners

Immobilized glucose isomerase in the manufacture of fructose syrups and fructose

K. Demnerova, O. Valentova, M. Marek and J. Kas. *Chemické Listy*, 1984, **78**, 199-210; through *S.I.A.*, 1985, **47**, Abs. 85-125.

A review (151 references) is given on the immobilization of free glucose isomerase and of cells with glucose isomerase activity. The references cited are tabulated according to the technique of immobilization (cells adsorption, cells flocculation, trapping cells in polymer, trapping enzyme, bonding enzyme onto substrate); supports used with each technique are indicated. The present state and prospects of using such biocatalysts for making fructose syrups are discussed.

Monosaccharides from sucrose. V. Some economic considerations of glucose and fructose manufacture

M. Kulhanek and M. Tadra. *Listy Cukr.*, 1985, **101**, 31-34 *(Czech)*.

The economics of fructose and glucose manufacture from sucrose and starch are discussed, as is the manufacture of sorbitol by hydrogenation of glucose syrup. While starch is not a suitable raw material in Czechoslovakia, both economically and technologically, sucrose is particularly suitable, especially when hydrolysed by passage through a cation exchange resin in H^+ form to give an invert sugar of high quality. A diagram illustrates the main stages in manufacture of the monosaccharides and sorbitol.

Manufacture of a glucose-fructose syrup using Imfruzim, a Soviet immobilized glucose isomerase

N. S. Golovina *et al. Sakhar. Prom.*, 1985, (3), 42-44 *(Russian)*.

Details are given of a process for preparation and immobilization of a glucose isomerase obtained from *Actinomyces albogriseolus* and of its application to preparation by glucose isomerization of a syrup containing up to 44% fructose, depending on reaction time (1-37 days) and temperature (60, 65, 70 or 75°C).

Microbial production of glucose-fructose syrups

A. Matur and N. Saglam. *Mikrobiyoloji Bulteni*, 1982, **16**, (2), 143-150; through *Food Sci. Tech. Abs.*, 1985, **17**, (1), Abs. 1 L 69.

Manufacture of glucose-fructose syrups is discussed with special reference to the use of microbial enzymes. Aspects considered include: basic principles of starch hydrolysis; glucose syrup manufacture; isomerization of glucose to fructose; microbial amylases, amyloglucosidases and glucose isomerases used in syrup production; and characteristics and required reaction conditions of these enzymes.

Analysis of the performance of a simulated counter-current chromatographic system for fructose-glucose separation

C. B. Ching and D. M. Ruthven. *Can. J. Chem. Eng.*, 1984, **62**, (3), 398-403; through *S.I.A.*, 1985, **47**, Abs. 85-412.

The adsorptive separation of fructose from glucose was carried out in a simulated counter-current chromatographic system, in which the adsorbent was Zerolit-25SCR14 ion exchange resin in Ca^{++} form. Rate and equilibrium constants were calculated from chromatographic retention time measurements. The performance of a system comprising 10 identical columns in series was investigated; the behaviour of such a system could be approximately represented by a simple McCabe-Thiele model. The height equivalent to one theoretical plate was higher than would be expected for an ideal plug-flow system, showing that axial mixing was important. The McCabe-Thiele analysis was used to obtain a preliminary assessment of the performance of a 4-section Sorbex system. Such a system, in which desorption of the extract product (fructose) is carried out continuously in an additional counter-current section, results in less dilution than does the simulated counter-current system, and would therefore be more economical.

Enhanced digital control of a mechanical recompression evaporator in a modern fructose refinery

D. Dietrich. *Starch/Stärke*, 1985, **37**, 149-154.

The use of a vapour recompression with falling-film evaporators is discussed, and difficulties encountered with fixed-speed, electrically driven compressors indicated; they are more difficult to start from cold than variable-speed, turbine-driven compressors and need more careful supervision with changes in throughput. The problems are caused by the choking action of the variable turbine inlet guide vanes which act as the main control means. There is no simple, reliable flow meter available for compressed vapour in contrast to gases or air, so that standard methods of avoiding the critical vibration area based on measured flow (surge control) are not suitable. Details are given of a two-tier hierarchical control system in which the flow, pressure, temperature and density loops are directly controlled by electronic analogues from PID controllers, while a supervisory master computer coordinates the set-points of the controllers so that all loops operate on the cascade principle. The system increases safety during start-up, allows safe and reliable reduction in throughput from maximum to one-third of maximum and decreases the need for operator supervision. A flow diagram demonstrates its application to glucose hydrolysate processing in a fructose plant.

Laboratory studies

The effect of the presence of raffinose on the representativeness of the established Polish test

K. Wagnerowski. *Gaz. Cukr.*, 1984, **92**, 206-210, 229-232 (*Polish*).

The effect of the presence of raffinose in molasses on the validity of the method of Wagnerowski (Polish test) for experimental measurement of molasses exhaustion is discussed. A raffinose coefficient is introduced as the product of the amount by which the specific rotation of raffinose exceeds that of sucrose times the ratio of the raffinose content to the apparent non-sugars content. The difference between true and calculated purity allowing and not allowing for raffinose is indicated by calculated examples. The raffinose coefficient is then used to calculate values of the constants *m* and *b*; comparison of the true and apparent parameters in the saturation function demonstrates the effect of raffinose on *m* while *b* remains unchanged; the apparent value of *m* is also shown to be a linear function of temperature. As an extension, the apparent standard molasses purity is too high in the presence of raffinose and is a positive linear function of the raffinose coefficient; however, at a raffinose content of <0.5% any change in apparent standard purity may be ignored. Equally, the effect of raffinose on low-grade massecuite supersaturation has been examined, and an empirical equation developed for calculation of the true supersaturation. Again, at temperatures below 65°C at the end of crystallization, the presence of raffinose causes the apparent supersaturation as calculated by the Polish test to be too high. Equations and nomograms presented by the author are recommended for use in correcting values where the raffinose content exceeds 0.5%.

Kinetics of sucrose crystal growth in impure solutions

A. Pérez S. *Rev. Cub. Fis.*, 1984, **4**, (1), 129-144; through *Ref. Zhurn. AN SSSR (Khim.)*, 1985, (6), Abs. 6 R468.

The effects of NaCl, Na_2CO_3, KCl, K_2CO_3 and $CaCl_2$ at cation concentrations of 0.1 and 0.8% on the growth of single sucrose crystals at 0.015-0.035 supersaturation and 50°C were investigated. The growth rate was determined by weighing the crystals every 3 hours. It was found that, while there was no change in the growth rate at cation concentrations of 0.1%, at 0.8% the salts caused a marked deceleration by comparison with pure solutions. The retarding effect depended on the anionic component, chlorides having a greater effect than carbonates. There was no correlation between the effects of the salts and changes in viscosity caused by their presence. Good agreement was found between the experimental results and calculated values obtained using an empirical equation.

Studies on the use of a non-toxic clarifying agent for polarimetry of cane sugar products

W. G. Huang. *J. Amer. Soc. Sugar Cane Tech.*, 1985, **4**, 86-96.

Experiments at the South China Institute of Technology and the Audubon Sugar Institute are reported in which a clarifying agent based on bismuth chloride proved comparable in its efficiency to lead subacetate while being non-toxic. The tests were conducted on samples of mixed juice, 2nd carbonatation and sulphitation juice, syrup, raw sugar solution and final molasses. The tabulated results are discussed. In the case of carbonatation juice, the two clarifying agents gave identical values; the results were almost identical with raw sugar solution, while the $BiCl_3$ gave lower pol values than the subacetate in the case of mixed juice, sulphitation juice and syrup, although the differences were within permissible limits. On the other hand, considerable differences occurred with molasses, and a correction factor would be needed so as to allow adjustment of the values given by the $BiCl_3$ to those obtained with subacetate. The bismuth chloride is somewhat hygroscopic and so requires storage in a tightly sealed container, preferably in moisture-proof packets.

Recent applications of colour fractionation in CSR refineries

D. H. Bardwell, J. R. Croker and N. H. Paton. *Paper presented at 44th Ann. Meeting Sugar Ind. Technol.*, 1985, 21 pp.

By measuring the HPLC response of each of five major flavonoids obtained from raw sugar factory liquor relative to apigenin and determining the increase in colour when a small amount of each compound was added to a pure sucrose solution, the contribution of each to the colour of raw and refined sugar was established. Results showed that at pH 7 and 9 the falvonoids contributed less to colour than previously thought, and it is assumed that it is most probably pH-sensitive non-flavonoid colorants formed in the factory that contribute the major part of sugar colour at pH values about neutral. Investigations of 3rd product refined sugar showed that flavonoid contribution to colour was very small and very much lower when char was used to decolorize liquor than in the case of resin, which was less efficient in removal of all flavonoids, although still fairly good at removing factory-formed colorants. Carbon was better than bone char and removed virtually all of the flavonoid colorants from raw liquor. Talofloc phosphatation had a lower capacity for flavonoid removal than carbonatation and should, it is suggested, be coupled with a carbon-based decolorizer. HPLC showed that a Canesorb bone char:carbon mixture had a flavonoid removal efficiency proportionately between that achieved with char and carbon alone.

By-products

Storing bagasse under hot and arid climatic conditions

K. Kopfmann. *Non-Wood Plant Fibre Pulping Progress Rpt.* (TAPPI), 1983, (14), 9-20; through *S.I.A.*, 1985, **47**, Abs. 85-533.

The design of a moist bulk storage system for bagasse at Misan Pulp and Paper Mill, Iraq, is described. The factory is in an area with a hot, dry climate. Results during the first season (1979) were very unsatisfactory, and the system was therefore converted to a wet bulk storage system. It was shown that, when pre-depithed bagasse containing 50% moisture was conveyed to the yard, wetted to its water-holding capacity as it was discharged onto the pile, and compacted thoroughly, an essentially anaerobic condition could be obtained. The bagasse should be pre-depithed and sent to storage as soon as possible after it leaves the mill tandem to prevent the start of uncontrolled fermentation. The pile should be monitored for temperature, pH and moisture content to maintain optimum conditions. When these measures were strictly adhered to, excellent results could be obtained, even under the climatic conditions in Iraq.

Oxygen pulping of non-wood plant fibres according to the NACO process

W. Fiala, O. Danielsson, K. G. Ryrberg and F. Nardi. *Non-Wood Plant Fibre Pulping Progress Rpt.* (TAPPI), 1983, (14), 77-86; through *S.I.A.*, 1985, **47**, Abs. 85-536.

A new pulping process which has been developed, the NACO process, is described. The aim is to make it possible to produce chemical pulp economically, even on a small scale, using locally available raw material and with minimal pollution of the environment. The NACO process involves delignification with oxygen to a low Kappa number in Na_2CO_3 solution, with NaOH as "activating" and make-up chemical. It is carried out in a special reactor, a pressurized continuous turbopulper. The importance of a suitable pretreatment is emphasized. Pilot-plant tests on wheat straw and bagasse are reported; bagasse gave pulps with good properties.

Hydrogen peroxide-alkaline pulp (PAP) prepared from non-wood raw materials

A. Mita. *Non-Wood Plant Fibre Pulping Progress Rpt.* (TAPPI), 1983, (14), 87-93; through *S.I.A.*, 1985, **47**, Abs. 85-537.

A new process, the hydrogen peroxide-alkali (PA) process, was used for pulping bagasse and other raw materials. It involved cooking with an aqueous solution of H_2O_2 + NaOH + small quantities of EDTA and anthraquinone. When bagasse was cooked with 20% alkali (as Na_2O) and 3% H_2O_2 at a liquor ratio of 10 litres/kg at 150°C for 60 minutes, the yield of screened pulp was 38.6%; the effects of cooking conditions on pulp properties are shown. One-stage NaOCl bleaching increased the brightness from 45 to 70%.

Calculation of fuel consumption in production of dried pulp

A. F. Zaborsin and V. D. Orlov. *Sakhar. Prom.*, 1985, (4), 32-34 (*Russian*).

The part played by pressing of beet pulp in determining the fuel consumption in pulp drying is discussed, as is the need for suitable means of measuring the fuel consumption (often absent where oil is used as fuel for pulp dryers). Apart from efficient use of presses and their maintenance, other factors leading to minimum fuel consumption in pulp drying include maintenance of a diffusion temperature no higher than 72°C (otherwise the pressed pulp dry solids content will fall), a pulp pH in the range of 5.5-5.8 (preferably the lower value for the sake of efficient pressing), a higher cossettes marc content without fringes, and adequate loading of the presses.

Cane sugar residues — technology perspectives

N. R. Ayyangar and J. V. Rajan. *Maharashtra Sugar*, 1984, **10**, (1), 27, 29, 31, 33, 35.

A brief survey is presented of by-products obtainable from cane, from sugar factory waste materials and from sugar.

Beef cattle in the cane fields

R. Grafton. *S. African Sugar J.*, 1985, **69**, 60-61.

Details are given of combined cane growing and raising of beef cattle by two brothers. The cattle feed on grass pasture during the summer, and then move into the cane fields for feeding largely on cane tops as the crop is harvested; since cane tops provide very little weight gain (no more than 0.2 kg/day), they are also given a protein and energy lick such as molasses with urea. The tops from each 1000 tonnes of cane harvested will support 8-10 head of cattle.

Nutrient value of distiller's waste and its effect on soil pH

S. M. Rao. *Proc. Inter-American Sugar Cane Seminar on Soil Fertility and Management*, 1983, 235-242 (*English*), 540, 543-549 (*Spanish*).

The six rum distilleries in Jamaica annually produce a total of 113 million gallons of vinasse, the use of which as K fertilizer is discussed. Research in 1949 and 1982/83 is summarized, and it is concluded that the total K_2O value of vinasse represents some 66% of the total potash requirement of the island's cane crop. Any adverse effect on soil pH has been found to be short-lived. However, the K content of vinasse is still so low that the amount needed to

be transported to the cane fields to provide a required K_2O level is much greater than the equivalent quantity of KCl fertilizer. Attempts to concentrate vinasse so as to increase the potash content per unit volume have failed for a number of reasons. However, reducing the volume by 30-40% by concentrating with excess steam and then mixing with a nitrogenous fertilizer before application to the soil could make the system more economical; use of filter cake as P source coupled with vinasse as K source would reduce the total dependence of the Jamaican sugar industry on imported fertilizers. Another means of vinasse disposal mentioned is its use as a carbon source for fodder yeast manufacture.

Influence of incorporation of sugar cane trash on yield of wheat and gram

P. B. Shinde, G. D. Jangale, S. G. Bangar, V. V. Shingte and P. L. Patil. *Maharashtra Sugar,* 1984, **10,** (2), 72-74.

Cane trash was incorporated, after crushing or chopping, at the time of tillage one month before sowing of gram and wheat; together with N-P-K application at recommended rates, the trash at 2.5 and 5.0 tonnes/ha caused a significant increase in yields of both crops, particularly gram, by comparison with the control.

From low-temperature pre-drying to low-temperature complete drying by the Turbo-Kammer modular system

G. Kammer. *Zuckerind.,* 1985, **110,** 305-307 (*German*).

Details are given of a low-temperature beet pulp dryer designed to raise the dry solids content to a required final level (e.g. 88%). Warm air flows through each end of a hollow rotary shaft housed in a stationary drum; the shaft carries paddles so designed that two carry the pulp forward while a third passes it back, thus creating turbulence. The air passes out of the shaft through two longitudinal tapered slits and mixes with the pulp in the outer drum, maintaining it constantly moist so that the discharged air is dust-free. The drum stands in a chamber, and a number of chambers can be stacked one on the other, with an air outlet at the very top of the stack. Small-scale tests were conducted at Brühl factory in 1983 and 1984, and the results compared with those given by a band dryer. They showed that, despite a snag associated with the scale of the experiments, expectations of a final dry solids greater than with a band dryer yet still using low-temperature air (generally at 55°C) were justified. Parameters for an hourly throughput of 10 tonnes per module are calculated.

Nitrogenous matter in dried beet pulp

M. Foacant, B. Allart, M. G. Gillain and M. Vanbelle. *Le Betteravier,* 1985, **197,** (19), 6, 10 (*French*).

The total nitrogenous matter and its solubility in pepsin (a protein-digesting enzyme) were determined for 135 monthly samples of dried pulp from nine Belgian sugar factories in 1979/83. The total N fluctuated from 8.6 to 13.5% on dry matter and was essentially attributable to variation in the quantities of molasses or vinasse added before pelleting, although the organic matter content and month/year of production may also affect it. Solubility was a function of the individual factory; low solubility was linked to low digestibility by sheep.

The potential for anhydrous ethanol and ethylene production in the Caribbean

D. R. McGraw and A. C. Pilgrim. *Proc. 1982 Meeting West Indies Sugar Tech.,* 404-416.

An examination of the feasibility of producing anhydrous ethanol from cane juice in Jamaica showed that a plant producing 120,000 litres/day, enough to replace 9% of the island's gasoline imports, would cost approx. US$ 23 million to build, while production costs would be $0.70 per litre based on cane at $34 per tonne. Similarly, a plant of 60,000 litres/day output to supply ethanol to replace approx. 20% of Guyana's gasoline imports would cost $14 million and the costs of production would be $0.62 per litre, based on cane at $25 per tonne. In both cases, the costs are based on projected 1984 prices and indicate that there would be a net loss in foreign exchange compared with sugar production from cane, while the pump price of gasoline would have to be raised. Investigation of the economics of ethylene production from ethanol showed that the costs would be well above the world prices current at the time the article was written.

Ethanol production from molasses using cell recycling of *Saccharomyces cerevisiae*

R. K. Sedha, G. Verma, R. P. Gupta and H. K. Tewari. *J. Ferment. Technol.,* 1984, **62,** (5), 471-476; through *Ref. Zhurn. AN SSSR (Khim.),* 1985, (8), Abs. 8 R352.

Optimum conditions were established for manufacture of alcohol by molasses fermentation with *S. cerevisiae* strains Sc 6, J1L, R1, G and HSR. For determination of alcohol tolerance, 1.4×10^6 cells/ml were added to a mixture of glucose, yeast extract and alcohol at concentrations of 8-12%; R1 had a tolerance of 9%, while all the other strains had 10% tolerance. At an initial molasses sugar concentration of 18%, the optimum fermentation temperature was 30°C. Addition of urea accelerated fermentation, and optimum dosage rates were 0.1% with strain J1L, 0.2% with R1 and HRS, and 0.3% with Sc6 and G; under these conditions, alcohol yield rose by 1.84-4.84%, and the total productivity for all recycles rose by 1.84-40.4%.

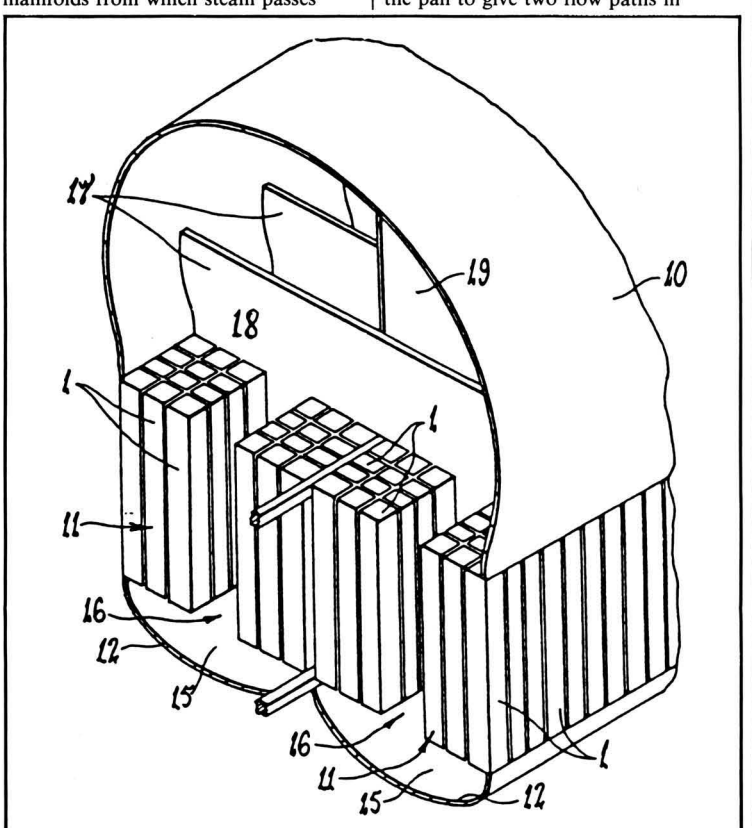
Patents

UNITED KINGDOM

Continuous vacuum pan

Racecourse Cooperative Sugar Association, of Mackay, Queensland, Australia. **2,090,653.** December 9, 1981; July 14, 1981; February 1, 1984.

The crystallizer includes a number of parallel, open-ended tubes 1 of rectangular cross-section held together vertically in rows by spacer members in the form of grids welded at both ends of the tubes. The spaces between tubes and between rows form a series of interconnected steam lanes between the tubes and are closed at the sides of the banks of tubes by flat vertical bars, while the ends of the banks have manifolds from which steam passes through the lanes, heating the entire outer surface of the tubes. The tubes are lighter and occupy less space than conventional round tubes of the same surface area. The pan comprises an upper shell 10 with an upper flow space and a lower shell 12 with two lower flow chambers 15. A downcomer compartment 16 is located between the banks of tubes 11 in each flow path, while transverse baffles 17 divide compartment 16 into a series of cells and promote a desired flow pattern. Massecuite is heated in the tubes, rises and enters cell 18; it flows down compartment 16 and below baffles 17 to below the tubes in the next cell. A vertical longitudinal baffle 19 divides the pan to give two flow paths in opposite directions along its length; the baffle ends before the last cell so that massecuite can change its direction of flow.



Purifying sugar juice

A/S De Danske Sukkerfabrikker, of Copenhagen, Denmark. **2,090,861.** January 14, 1982; July 21, 1982; March 21, 1984.

Beet juice is purified by mechanically separating undissolved components, chemically treating the juice (by oxidation or addition of a complexing agent, at 60-70°C, at pH 6.8-7.2) to convert low M.W. non-sugars into higher molecular compounds, and ultrafiltering the juice (at 80-90°C) to remove these higher molecular compounds. Water may be added to the concentrate from ultrafiltration and the diluted material subjected to a second ultrafiltration. Lime is added to the ultrafiltered juice to precipitate organic and/or inorganic acids, (heated to about 100°C) and the precipitate separated (after which the juice is treated with SO_2).

Preparation of fodder yeast and/or ethanol from plants or cellulose-containing wastes of plant origin

Orazagos Kozegeszegugyi Intezet, of Budapest, Hungary. **2,090,514.** December 23, 1980; July 14, 1982.

The starting material (75% cane waste and 25% bagasse) is pretreated [for 0.5-5 (0.5-3) hr] [at 80-100°C (90-98°C)] with [0.5-10% (0.5-4%) of] dilute mineral acid, e.g. sulphuric acid, and/or [0.5-10% (0.5-4%) of] a dilute base, e.g. soda lye, and then fermented [at 33-39°C (35-37°C)] aerobically or anaerobically [continuously or batchwise (for 16-72 hr or preferably 16-50 hr)] with a *Candida utilis* var *cellulolytica* strain to produce yeast and ethanol. The free oxygen content of the broth is 1.0-4.0 (1.5-2.5) mg O_2/litre under aerobic conditions or 0.1 mg O_2/litre under anaerobic conditions.

conditions increasing levels of this molasses were added to pure sucrose solutions so that the S/W ratio remained constant at 3.075 while the NS/W ratio increased from 0.05 to 0.60. When the $(\overline{y/z})$ ratio is plotted against NS/W the influence of increasing impurity levels can be clearly seen (Figure 2).

Hence, although physical parameters probably play some part in determining crystal shape the overriding influence is obviously the concentration of crystal habit modifiers.

Nevertheless, we chose our arbitrary laboratory crystallization temperature to be not too dissimilar from factory boiling temperatures. False grain became a problem in pure solutions at S/W ratios greater than 3.075 or when turbine-stirred vessels such as that used by Smythe[2] were tried. Although such vessels offer the advantage of being readily water-jacketed so that temperature variations are minimal we had no success with this type of vessel. This was the main reason we chose to use a rotating wheel with attached vessels. The major disadvantage when working at temperatures in the region of 60°C was the poor heat transfer properties of the air bath. Consequently, even with a rigid experimental protocol, solution temperatures initially dropped by about 5 to 6°C and, although they recovered to within 1°C of working temperature in less than 20 minutes, the final temperature recovery was of the order of 1 to $1\frac{1}{2}$ hours. This has two implications for growth rate experiments. In the first place it is impossible to measure true growth rates and only possible to compare rates under similar conditions. In the second place it is impossible to reproduce the temperature profile from one run to the next. Inevitably growth rates measured under these far from ideal conditions will show considerable variation with a tendency to overestimate rates and can only be used to indicate gross trends. The major advantage of this crystallizer is that it allows several different solutions to be compared at the same time under identical conditions.

It is generally conceded that habit modifiers retard growth in specific directions thus leading to a reduction in the overall growth rate. Hence potent habit modifiers are also probably potent growth rate retardants although rate retardants will not necessarily affect crystal habit. Growth rates are only comparable at the same degree of supersaturation. Broadfoot & Steindl[30] have indicated that solubility could affect the supersaturation by about 5% in the NS/W range used, but that with the accuracy associated with growth rate measurements it is reasonable to assume constant supersaturation for a particular molasses in this NS/W range. Rates were compared at constant S/W ratios. This means that measured rates include a solubility influence as well as a habit influence in addition to the previously mentioned temperature effect. Figure 3 illustrates the general pattern observed, i.e. as impurities increase the rate decreases. Comparison of Figures 2 and 3 indirectly confirms the observation that elongated crystals grow more slowly. For this particular combination of impurities and with equivalent conditions, boiling times would have increased about three-fold if the crystals had had a y/z ratio of 0.6.

The data displayed in Figure 2 were found to fit a linear regression of the form:

$\ln(y/z) = -1.79 - 0.632 \times \ln(NS/W)$ ($r = 0.976$).

Clearly the slope of this line will depend on the concentrations and potency of the habit modifiers present. We feel that this aspect may allow the distinction between synergistic and additive effects once responses have been established for the different components. At present, in the absence of the identity of these factors, all non-sucrose concentrations have been made equivalent to those of the original molasses by simple proportion on the basis of the yields of different component classes. Most further runs were carried out at a single NS/W level so that only direct comparisons are possible at this stage.

Overall recoveries after the various fractionations gave 90% for sucrose and 85% for non-sucrose, indicating

30 *Proc. 17th Congr. ISSCT*, 1980, 2557-2580.

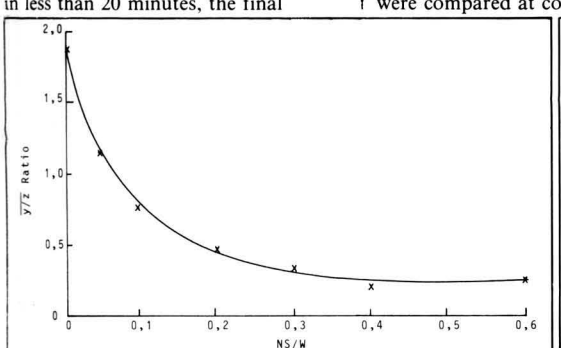


Figure 2. Effect of impurity concentration on crystal shape

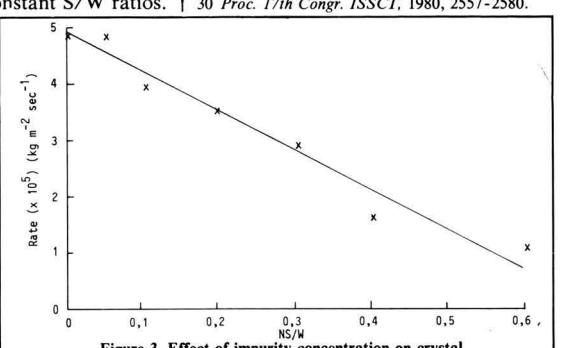


Figure 3. Effect of impurity concentration on crystal growth rate at 60°C and S/W = 3.075

the possibility of both physical and selective losses. However when the various fractions were recombined in proportion to actual yields it was obvious that there had been no significant loss of elongating properties (Table II). It should be pointed out that these rsd's represent the variation of shape within a batch of crystals. The average batch-to-batch mean with molasses impurities at NS/W = 0.1 was 0.76 ± 0.05 (rsd = 7%) for ten batches.

Table II. Crystal shape ($\overline{y/z}$) in reconstituted molasses (NS/W equivalent to 0.1 molasses impurities)

Combined fractions	$\overline{y/z}$	rsd (%)
Molasses	0.75	30
A + B	0.75	33
A + B1 + B2	0.75	32

The rate and shape measurements obtained with the individual fractions when added at levels equivalent to those in the starting molasses sample are summarized in Table III and IV.

Table III. Comparison of growth rates in various molasses fractions

Fraction	Rate ($kg.m^{-2}.sec^{-1} \times 10^5$)	
	Mean	sd
Sucrose	5.7	0.8
Molasses	3.1	0.3
A	6.5	0.4
B	4.2	0.3
B1	5.1	0.8
B2	2.2	0.3

Table IV. Comparison of crystal shape in various molasses fractions

Fraction	$\overline{y/z}$		
	Mean	sd	rsd (%)
Sucrose	1.85	0.50	27
Molasses	0.75	0.22	29
A	1.95	0.61	31
B	0.80	0.27	34
B1	1.70	0.47	28
B2	0.90	0.31	34

Clearly both the habit-modifying and rate-retarding properties are mainly in the oligosaccharide fraction with very little effect from the polysaccharides. Furthermore, the polysaccharide fraction (which contains approximately 50% dextran by the Roberts[31] method) only slightly increases the elongation to give a ($\overline{y/z}$) ratio of 1.5 when added at five times the concentration found in molasses, i.e. the elongation properties are not very powerful. This is in agreement with the relatively small extent of elongation in the presence of standard dextrans (Table V).

Table V. Comparison of elongation with molasses polysaccharide and with standard dextran

Compound	NS/W*	$\overline{y/z}$	rsd (%)
Fraction A	0.007	1.60	28
Fraction A	0.035	1.55	23
Dextran (T-40)	0.033	1.70	36

*Fraction A at NS/W = 0.007 is equivalent to using unfractionated molasses at NS/W = 0.100

The main elongating effects have been isolated in the oligosaccharide fraction. The obvious possible components of this fraction include the iso-maltose homologues (as dextran anabolic or breakdown products), the maltose homologues (as amylose anabolic or breakdown products) and the fructosyl-sucrose or glucosyl-sucrose oligomers. Crude extracts of each of these classes were added to sucrose as though fraction B2 consisted entirely of each class. The results are presented in Table VI.

Table VI. Effect of oligosaccharide classes on crystal elongation

Oligosaccharide	NS/W*	$\overline{y/z}$	
		Mean	rsd (%)
Sucrose	—	2.00	29
Fraction B2	0.013	0.90	41
Isomalto-series	0.014	1.75	33
Malto-series	0.014	1.80	30
F-S and G-S series†	0.014	2.05	32

*Fraction B2 at NS/W = 0.013 is equivalent to using unfractionated molasses at NS/W = 0.100.
†F-S = fructosyl-sucroses, G-S = glucosyl-sucroses

Only fraction B2 has any significant c-elongating effect. The shape of sucrose crystals grown in the presence of either malto- or isomalto-homologues is very little different from that of pure sucrose. The addition of oligosaccharides prepared from sucrose (probably mainly 6- and neo-kestose) causes slight b-axis elongation. Crystals grown in the presence of fraction B2 were not only extensively elongated in the c-direction, but were often small and extensively conglomerated. Moller[32], Pot[33] and Kuijvenhoven *et al.*[34] have indicated that there is probably a critical interval of small particle size in which conglomeration takes place. The observed conglomeration may be induced because of the relatively long residence time in this crystal size range as a result of the slow growth rate. Typical shapes of these crystals are illustrated in Figure 4.

Invertase hydrolysis of fraction B2 and of the kestose-preparation completely removed the elongating properties so that normal shaped crystals were obtained when sucrose solutions were spiked with these hydrolysates. The control showed minimal improvement in elongated morphology (Table VII).

Table VII. Influence of invertase hydrolysis on elongating properties

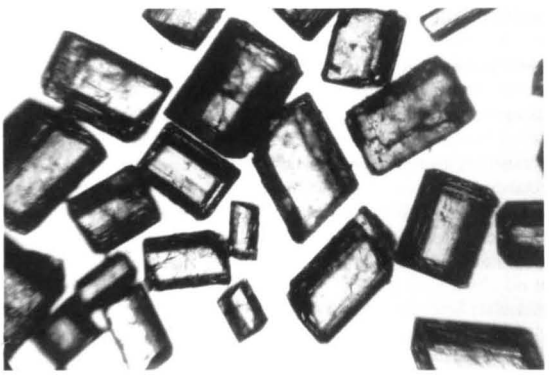
Preparation	$\overline{y/z}$	
	Mean	rsd (%)
F-S and G-S series	2.25	38
(F-S and G-S) after hydrolysis	1.80	30
B2	0.90	34
Control (B2 + buffer)	1.10	34
B2 after hydrolysis	1.95	29

Hence fructosyl-oligosaccharides were probably responsible for the extensive c-axis elongation observed in this refinery.

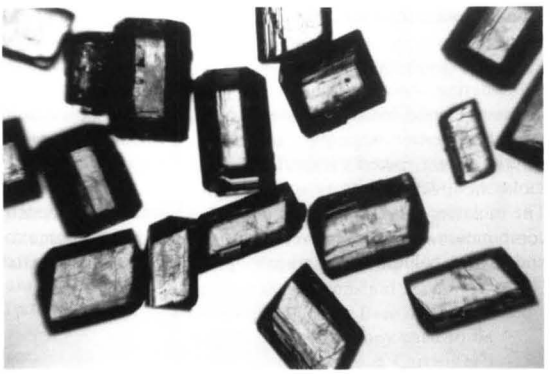
Conclusion

The extensive sucrose c-axis elongation observed in a refinery has been mainly attributed to the presence of fructose containing oligosaccharides. The polysaccharide components were

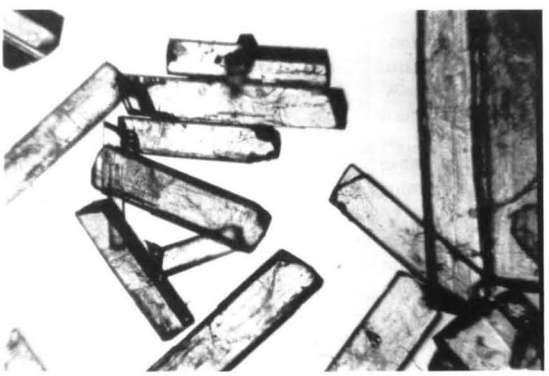
31 *I.S.J.*, 1983, **85**, 10-13.
32 *Sugar*, 1954, **49**, (11), 49-50.
33 "Industrial sucrose crystallization" (Ph.D. Thesis, Univ. Delft), 1983.
34 *I.S.J.*, 1983, **85**, 201-207.



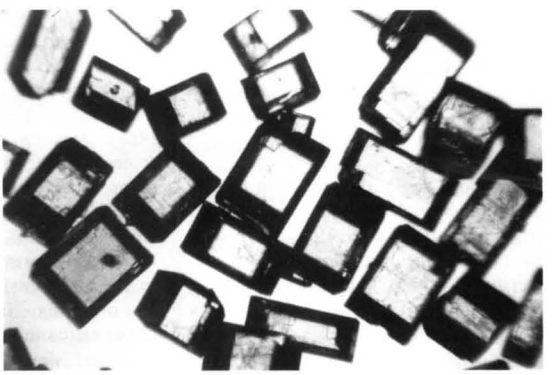
(a) Molasses at NS/W = 0.1



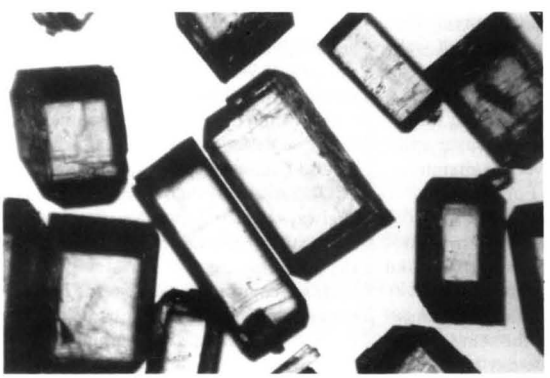
(d) Fraction B equivalent to NS/W = 0.1



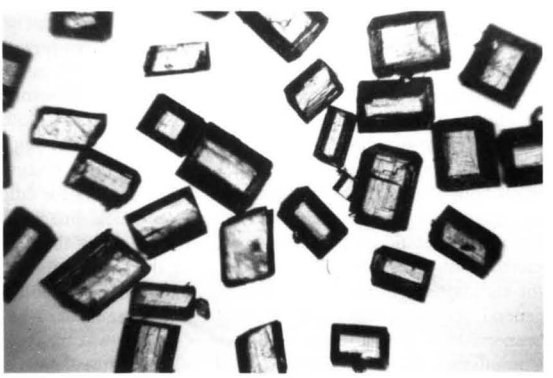
(b) Molasses at NS/W = 0.4



(e) Fraction B1 equivalent to NS/W = 0.1



(c) Fraction A equivalent to NS/W = 0.1



(f) Fraction B2 equivalent to NS/W = 0.1

Figure 4. Sucrose crystals grown in the laboratory from solutions with added molasses impurities

found to exert little influence at the concentrations encountered.

Summary

Increasing concentrations of molasses caused increasing extents of crystal elongation when pure sucrose solutions were spiked with refinery molasses under laboratory conditions. The molasses was fractionated using a combination of ethanolic precipitation and carbon column chromatography. This fractionation caused no significant loss of c-axis elongating properties. Addition of the individual fractions to sucrose solutions indicated that the major habit modifiers were in the fraction containing low molecular weight oligomers. This fraction also had the greatest rate-retarding effect. It was also demonstrated that standard dextrans, isomalto-oligosaccharides, malto-oligosaccharides and a "kestose" preparation did not induce significant c-axis elongation under similar conditions and at similar concentrations. Hydrolysis of this fraction with yeast invertase completely removed the habit-modifying properties. This implies that fructose-based oligomers were probably responsible for c-axis elongation in this refinery, with minimal contribution from the polysaccharide components.

Instrument error in measuring sugar colour

By Frank G. Carpenter

Introduction

The word "colour", as used in the sugar industry, does not mean the visual appearance to the human eye but rather it means "colorant"; specifically what requires measurement is the amount of colorant material per unit amount of sugar. Since the exact nature of this material is unknown, the relation between "colour" as observed and amount of "colorant" cannot be directly evaluated. It is, therefore, measured as an absorbancy index at a single wavelength, which is only proportional to the amount of colorant (with an unknown proportionality constant). As such it has no unique, absolute, or true value. The number obtained for sugar colour depends upon how it is measured and how it is expressed. For measurements to bear a meaningful relationship, a standard method must therefore be used, and the standards for sugar analyses in general, including sugar colour, have been established by the International Commission for Uniform Methods of Sugar Analysis (ICUMSA).

Accuracy, therefore, does not express how close the measurement comes to the absolute "true" value of the sugar colour, but rather how close it comes to the method of ICUMSA in every respect and detail.

Precision expresses only how closely the measurements can be repeated, right or wrong. The total error is the sum of errors in both precision and accuracy.

Sugar colour is a prime example of a measurement with high precision but low accuracy. Anyone who makes numerous sugar colour measurements soon learns how to repeat himself well enough, but cannot get the same colour as someone in another laboratory. Colour is a factor in the sales price of sugar, so that buyer and seller often disagree over the premium or penalty for colour. For this very practical financial reason, it is important that the source of errors in the sugar colour measurement be found and reduced to an acceptable level.

Meads[1] showed that when the same sugar was measured in the same laboratory, on the same day by the same operator using the same instrument, the error expressed as coefficient of variation was about 1%. This is the precision of the measurement. However, for measurements made on the same sugar but in different laboratories, by different operators on different instruments, the error was 14% at best and typically about 100%. For the very best refined sugar of very low colour, the error was 500%. These results were obtained in 1970, and there has been very little improvement since then. Between-laboratory and between-instrument comparisons are generally so bad that they are never published. Weber[2] in 1981 found good precision with one instrument but found differences between instruments in the same laboratory even after careful calibration. At each session of ICUMSA one of the recommendations is always something to the effect of more study on reducing the error of the measurement.

It is recognized that the error in sugar colour measurement can come from three sources: (i) sampling, (ii) preparation of the sample for measurement, and (iii) making the

1 *Proc. 15th Session ICUMSA*, 1970, 234-264.
2 *Brasil Açuc.*, 1981, **97**, 221-225.

measurement.

It is reasonable, and has been confirmed by experience, that, by proper adherence to sampling theory and practice, the sampling error can be reduced to below 1%. There are two parts to sampling error: obtaining the initial sample from the lot (shipload) sampled, and subdividing the sample. These subjects are not discussed in this paper.

The preparation of the sample for measurement is recognized as a major source of error, but is not the subject of this paper. All comparative measurements were made on the same prepared sample.

The measurement is often considered a minor source of error because expensive instruments command an aura of respect, and it is assumed that they must be right. It is the purpose of this paper to examine in detail the size of the error that can be introduced by the instrument of measurement. The standard used is optical theory, properties of commercial sugars, and every detail of the ICUMSA test procedure. The objective is to get the overall error below 1%.

Nomenclature

Sugar colour is evaluated by a light transmission measurement, and the nomenclature can be confusing. The following definitions are from ICUMSA[3].

Transmission is used in the general sense and means the fraction of the incident light that passes through a sample.

Intensity, I, is the primary measurement of light that is registered by the photodetector of the colorimeter or spectrophotometer.

Transmittance is (intensity out)/(intensity in), referred only to the sample, not including the cell. This is a rather theoretical concept that cannot be directly measured because there always has to be cell walls and reflections at surfaces. However the idea is clear that transmittance is the transmission of the sample only, not counting any cells or surfaces. For emphasis it is sometimes called "Internal Transmittance".

Transmittancy is (Transmittance of sample)/(Transmittance of solution). Solution means the solvent, blank, reference, or pure solution. In sugar colour work solution means water. This is what is actually measured when the colorimeter or spectrophotometer is zeroed (100% T) on water, and then a reading made on the sample. The cell walls and reflection effects have cancelled out.

Unfortunately all three, Transmission, Transmittance, and Transmittancy sometimes have the same symbol, T, and the words often are used interchangeably. This causes confusion but the correct meaning can usually be surmised from the context. When the reference has nearly 100% transmittance, as water does in sugar work, then all three have essentially the same value. Nevertheless, the concept is still different.

All light measuring instruments measure intensities; these are then ratioed to give transmittancies, which refer to an optical unit, the sample in the cell. This is where optics leaves off because we are not interested in the sample in the cell as a whole, but rather in a component in the sample. It can easily be shown (but will not be repeated here) that the concentration of a component is not related to the transmittancy *per se* but to its logarithm. We therefore leave optics and go to chemistry.

Absorbancy is negative base 10 logarithm of transmittancy.

$$A = -\log_{10} T$$

Absorbancy is also known as optical density and extinction coefficient. This is the other scale marked on many colorimeters and spectrophotometers and the only scale on some. The general term is *absorption.*

Absorbancy is related to concentration and cell depth by the Lambert-Beer law and the constant in this law is called *absorbancy index.*

$$a = A/bc = (-\log T)/bc$$

All the above refers only to optically clear, non-scattering solutions. All sugar solutions have some scattering, so the above terms are called *Attenuation, Attenuancy,* A*, and *Attenuancy index,* a*. Attenuancy index is measured as if it were absorbancy index, but the name is changed to emphasize that we know that it contains some scattering and that it is not necessarily constant according to the simple Lamber-Beer law. An added term for scattering may need to be included (see Reiger & Carpenter[4]).

Wavelength

Colour readings in general are usually made at a peak in the absorption *vs.* wavelength curve where there is the most to measure and, the curve being horizontal at a peak, a small wavelength error will result in little or no reading error. However, sugar colour shows no peaks. This is because the "colour", which really means colorant, comprises very many, perhaps hundreds of components. The colour curve is therefore really hundreds of curves added together so that the peaks all blend together in one perhaps slightly ragged curve. Typical curves are shown in Figure 1 (from Carpenter & Deitz[5]). Reports of peaks being found here and there have all been traced to some special mistreatment of the sugar or to some artifact in the measurement.

All ordinary sugars and sugar products, from the most highly refined sugar to molasses, show remarkably similar absorption curves with high absorption in the blue and little in the red. They differ in magnitude by many powers of 10, but have the same shape. This is the basis for having the sugar colour measured at a single wavelength. ICUMSA has chosen a wavelength of 420 nm with an

3 Meads: *ICUMSA Proc. 14th Session,* 1966, 125-132.

4 *J. Research* (Nat. Bureau Standards), 1959, **63A,** 205-211.

5 *J. Amer. Soc. Sugar Beet Tech.,* 1963, **12,** 326-347; *Proc. Sugar Ind. Tech.* 1962, 32-52.

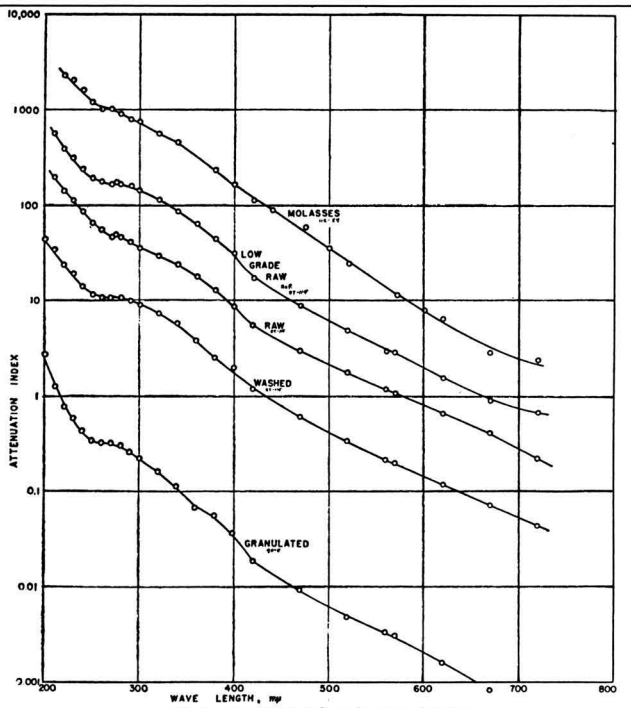


Fig. 1. Attenuation indices for typical sugars

allowable error of ±1. When plotted in a semi-log plot of log a *vs.* wavelength (w) as in Figure 1, the curves are fairly linear with a slope of about 1 log a in 141 nm.

$$\frac{d(\log a)}{dw} = \frac{-1}{141 \text{ nm}}$$

$$\frac{2.3\ d(\log a)}{dw} = \frac{-2.3}{141} = -0.0163/\text{nm}$$

$$\frac{d(\ln a)}{dw} = \frac{da}{a\ dw} = -0.0163/\text{nm} = 1.63\%/\text{nm}.$$

Thus an error of only 1 nanometer in wavelength produces an error of 1.6% in colour reading. The ICUMSA specification is if anything a little lax; it should be 420±0.6 nm.

How do actual instruments compare? It is very easy to check the wavelength scale of spectrophotometers by use of the mercury arc lines that are present in every fluorescent light source. The mercury lines are very stable, reproducible, and are secondary length standards. The line at 435.833 nm is near enough to 420. The following spectrophotometers* were found to be correct to within a few tenths of a nanometer: Beckman DU, Cary, Beckman DB, and Beckman DU-7. These are all expensive precision instruments.

A Perkin Elmer 35, which is an inexpensive instrument, was about 8 nm too high. This was less than 2 of the finest marks on the wavelength scale but alone would produce a sugar colour reading error of 13% too low.

The Talameter is a single-wavelength colorimeter, manufactured by Tate & Lyle Process Technology and designed just for measuring sugar colour. The model examined was the original "1000" series, the first model out. This instrument uses interference filters to define the wavelength. The interference filters from two of these instruments were measured in a Beckman DU-7 and the transmission peaks were at 426.1 and 421.8 nm. These are both outside the ICUMSA specs, and would produce sugar colour measuring errors of -10.0% and -2.9%. More recent models of this instrument have a more accurate wavelength.

Weber[2] recently compared a Micronal (Brazilian) instrument with a Varian 635 and a Bausch & Lomb Spectronic 88 and found the wavelengths at 420 nm to be in substantial agreement after calibration with a peak in $KMnO_4$ at 522 nm.

From the above it is evident that a sugar colorimeter should be frequently checked for wavelength, or preferably have a built-in wavelength calibration or wavelength check. As an alternative, a constant wavelength light source such as a mercury arc or stable laser could be used. This approach may require a wavelength other than 420 nm, but there is no fundamental requirement that the wavelength be exactly 420 nm. Another wavelength in the range 400 to 450 nm should be just as good. Stability of the source intensity is also a factor.

Bandwidth

Because the sugar colour depends so much on the exact wavelength, it is also important that the bandwidth be kept sufficiently narrow. ICUMSA has no specification on bandwidth. Bandwidth of a monochromator is defined as the width in nm of the transmission peak at ½ the peak height. It is the bandwidth that determines the resolution of a monochromator. Clearly, two peaks can be resolved only if the bandwidth is less than the distance between them.

However, the bandwidth is also involved in the effective wavelength response of the whole system. The output reading at any wavelength obtained in any light measuring

*Measurements made with individual samples of instruments named are not necessarily typical of that particular model or make of instrument.

instrument depends upon the following factors at that wavelength: (a) Intensity of the source, (b) Transmission of the monochromator, (c) Transmission of any cells, lenses, or other optical components, (d) Transmission of the sample, and (e) Response of the photodetector.

In the customary use of spectrophotometers and colorimeters, the sample is interchanged between knowns and unknowns, when all the other factors cancel out. However, in the measurement of sugar colour, an absolute measurement is being made, and all the other factors count.

Sources for measurements at 420 nm are usually incandescent lamps. These have an emission approximating blackbody radiation which is given by Planck's Law:

$$E=\frac{3.7403\times10^{-12}\ w^{-5}}{Exp(14384/wT)-1}$$

where w is wavelength in microns, T is absolute temperature, and E is radiant energy in watt cm^2.

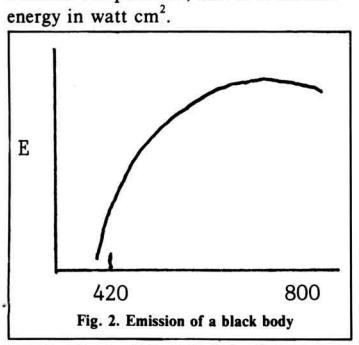


Fig. 2. Emission of a black body

The shape of the black body emission curve is shown in Figure 2. Lamps for spectrophotometers and colorimeters are usually operated at about 3000°, and at this temperature a wavelength of 420 is in the steep part of the curve. This equation was evaluated for 3000° and wavelengths in the vicinity of 420 nm and the emission was found to vary with wavelength with a slope of about 1.53%/nm. The relative emission (E) at a wavelength (w) near 420 is given by:

$$E=1+SE\times Dw$$

where SE is the slope of the emission curve and Dw is the difference in wavelength from 420.

Some colorimeters may operate at slightly different energy levels (temperatures). At twice the energy level (3180°) the slope was 1.38 and at half the energy level (2820°) the slope was 1.70. These are small differences and were found to make no difference in the final evaluation. The slope of the emission curve was therefore taken as 1.53%/nm. This is very steep and is inherent in all colorimeters. This has long been known by instrument designers but little appreciated by most users of colorimeters and spectrophotometers. The slope is in the direction of more intensity at longer wavelengths. This is in the same direction as the sugar colour and compounds the errors.

In slit *monochromators* the transmission band is a square peak whose width depends upon the width of the slit. However, the peak is well rounded off at the top and broadened at the bottom by aberrations and optical imperfections. In an interference filter the peak is approximately the same shape, but of non-adjustable width.

A typical peak was digitized in terms of relative transmission (TM) at fractions of the half-band-width (f). An abbreviation of the digitization follows:

f	TM
0	1
0.2	0.985
0.4	0.95
0.6	0.88
1.0	0.5
1.5	0.08
2.0	0

The difference in wavelength from 420 (Dw) is evaluated as: $Dw=f\times Bw/2$, where $-2<f<+2$. Small variations on the shape of this curve have negligible effect on the conclusions reached; the important variable is the band width (Bw).

The *cells, lenses, and other optical components* are all chosen for uniformly high transmission in the vicinity of 420 nm, so these introduce no error and can be dismissed.

The *transmission of the sample,* as noted previously, is strongly dependent on wavelength and so must be considered. The linear relationship shown in Figure 1 is in terms of log a. Absorbance is the way the final results must be expressed, but the light measurement is in terms of transmission, which is the reciprocal antilog of absorbance. Furthermore the factors of cell depth (b) and concentration (c) are involved, so that for any particular absorbance there is no corresponding single transmission value. The operator chooses the cell depth and concentration so that the transmission will be in the sensitive part of the scale, namely from 80% to 20%.

The slope of the absorbance curve of 1.63%/nm at 420 nm, when translated to sample transmission (ST) comes out to the following values:

ST	SS slope, %/nm
80	0.36
60	0.83
40	1.5
20	2.6

The relative transmission of the sample (TS) is evaluated as:

$$TS=1+SS\times Dw$$

Photodetectors can have any shape of response curve. However, the more useful ones have a relatively flat response. It is assumed for this calculation that the photodetector has sufficiently uniform response so that it will not make any practical difference in the results. The evaluation is therefore in terms of energy reaching the photodetector.

(to be continued)

Ghana sugar mills rehabilitation[1]

Cuba is to rehabilitate two of Ghana's sugar factories at Asutsuare and Komenda. A Cuban delegation is also to visit Accra to identify commodities which Cuba could barter with Ghana.

1 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 537.

New books

Biofuels for developing countries: promising strategy or dead end?

G. Heber, G. Schäfer, W. Teplitz, C. P. Zeitinger and G. Zieroth. Transl. G. McElhency and D. Jones. 174 pp; 14.7×21 cm. (Deutsche Gesellschaft für Technische Zusammenarbeit GmbH, Dag-Hammarskjöld-Weg 1+2, D-6236 Eschborn 1, Germany.) 1985.

The magnitude of the energy problems facing developing countries has increased dramatically over the past few years, and in a number of these countries the substitution of imported petroleum derivatives by domestically produced biomass-based fuels is currently seen as a promising strategy to eliminate energy shortages and to improve the national energy balance. This study seeks to assess the economic advisability of producing and using liquid fuels produced from sugar-, starch- and oil-bearing plants. Problems created by the use and production of bio-fuels are outlined, starting with an examination of the current state of the art in internal combustion engine design and the technology of bio-fuel production. The authors present the results of their research on such questions as: Which agricultural products might be suitable for use as feedstock? How great is the potential for bio-fuel production in view of the available raw material base? What would be the feasibility, limits and costs of expanded cultivation of energy crops? How would such changes in land use most likely affect the agricultural sector in technological, economic and structural terms, and what would be their probable impact on the ecology? An assessment is made as to whether or not the production and utilization of bio-fuels as a substitute for petroleum derivatives would be advisable in the light of current and estimated future conditions, the criterion used being that of macroeconomic profitability based on world market prices. The arguments are set out cogently with, as would be expected, much of the material based on the Brazilian experience. The authors have taken pains to ensure that the study is as objective and dispassionate as possible, and hope that the work will make a meaningful contribution to the current international discussion of the subject.

Sugar: major trade and stabilization issues in the eighties. FAO Economic and Social Development Paper 50

37 pp; 21×29.2 cm. (Food and Agricultural Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.) 1985.

This study, prepared by FAO with the cooperation of the Secretariat of the International Sugar Organization, analyses the world sugar economy and its chronic supply/demand imbalances, and suggests measures that would help to stabilize the international sugar market. It notes the combination of complex problems that characterize the world sugar economy and affect both developing and developed countries. It is stressed that, despite world production exceeding consumption in most years since 1960 with consequent depression of prices on the free market, production has continued to expand and to outpace consumption even in those countries producing largely for export. Apart from the patterns of world production and consumption, the study looks at reasons for the failures to negotiate a new International Sugar Agreement in 1983/84. The FAO experts conclude that there is little likelihood of any significant improvement in the price situation in the near future and that a sugar surplus right up to 1990 is probable; it is therefore of interest that the price has improved significantly in recent weeks and that C. Czarnikow Ltd. forecast a 3-million tonnes shortfall in the 1985/86 season. Nevertheless, market stabilization will be more easily achieved if exporting countries harmonize their policies as is suggested by the authors.

Australian sugar year book 1985

271 pp; 18×23.7 cm. (Strand Publishing, GPO Box 1185, Brisbane, Queensland 4001, Australia.) 1985. Price: $A 29.00.

Once again, this publication makes its familiar appearance as the standard annual review of the Australian sugar industry. For those readers unacquainted with the book, it contains a map of the Australian sugar industry, details of sugar industry organization, a sugar factory directory, a review of the 1984 season, industry leaders' comments, reviews of the sugar industry and of the sugar regions, details of sugar personalities, sugar industry education, reports of annual conferences and of BSES field days, extracts from the Sugar Board annual report, a review of sugar research and extracts from the annual review of the Sugar Research Institute, extracts from the BSES annual report, the background to the sugar industry and sugar industry statistics. It remains the definitive work on sugar in Australia, one of the most important producers in the world.

Zucker und Zuckerwaren (Sugar and confectionery)

H. Hoffmann, W. Mauch and W. Untze. 432 pp; 15.4×23 cm. (Verlag Paul Parey, Lindenstrasse 44-47, D-1000 Berlin 61, Germany.) 1985. Price: DM 148.00.

This paperback is No. 20 in the series of fundamentals of and advances in food research and technology. It concerns the chemistry and properties of sucrose and the extraction of sugar from beet and cane and its subsequent use in confectionery manufacture. While the bulk of the contents is devoted to confectionery, there is a modicum of information on the subject of sugar and its manufacture although too elementary for our readers.

Brevities and statistics

Mexico sugar production, 1984/85[1]

Mexican 1984/85 sugar production totalled 3,225,579 tonnes, tel quel, up 200,000 tonnes from the previous season. This includes a tradeable surplus of 160,000 tonnes which will be used in several barter deals. The cane harvested amounted to 26,297,000 tonnes. For the 1985/86 season the state sugar organization Azúcar S.A. expects 28,568,000 tonnes of cane will be harvested to yield 3.4 million tonnes of sugar. The country is once again in a position to export sugar when the price is right, according to spokesmen of UNPASA, the national union of sugar producers, who also forecast that the domestic price of sugar would rise next year. The guaranteed price paid for cane in the forthcoming season is scheduled to rise by 60% in line with inflation.

Turkey beet area reduction[2]

Owing to low government support prices, Turkish farmers reduced the area sown to beet to 320,000 hectares in 1985, against 370,000 ha in 1984; the beet crop is expected to be smaller and sugar production to decline from 1.5 to 1.4 million tonnes. If support prices for beet continue to be unsatisfactory to growers, production is likely to decline further this year.

China sugar imports, 1984[3]

	1984	1983	1982
	tonnes, raw value		
Argentina	0	0	18,249
Australia	261,697	324,474	402,281
Brazil	0	0	146,938
Colombia	0	0	49,800
Cuba	705,054	771,717	915,311
EEC	0	420,336	117,478
Fiji	20,537	44,082	43,708
Hong Kong	0	5,163	1,667
India	0	0	92,809
Japan	0	11,885	0
Malaysia	0	0	1
Philippines	67,991	0	198,776
Poland	14,777	109,061	0
Swaziland	0	0	26,657
Thailand	277,920	90,020	549,243
	1,347,976	1,776,738	2,562,918

Sri Lanka sugar expansion program[4]

Sri Lanka, which currently consumes between 260,000 and 270,000 tonnes of white sugar a year and which expects to consume 350,000 tonnes annually by 1995, plans to increase sugar output. Production is to reach 175,000 tonnes in 1995. Three private factories which are expected to begin production between 1986 and 1989 will supply 100,000 tonnes by 1995 and the government hopes to increase output at its own factories to their full capacity of 50,000 tonnes a year and produce an additional 25,000 tonnes from new facilities. The private firms are reported to be Pelwatte Sugar Company, with an annual capacity of 47,000 tonnes, Monaragala Sugar Company, which will produce 43,000 tonnes a year, and the Nakkala Sugar Company with a capacity of 10,000 tonnes a year. Sri Lanka's sugar production in 1984 was 21,000 tonnes; however, production in 1985 is expected to fall from this level because of guerilla activities in growing areas and other economic factors.

Poland beet area reduction[5]

The area planted to sugar beet in 1985 was 443,000 hectares, a drop of 6.8% compared with 1984, according to the official news agency PAP. The state of the crop varies over the country but, in general, yield and sugar content are expected to be close to those of 1984. Therefore, in 1985/86, Poland may produce less than last campaign's total of 1.97 million tonnes of sugar.

US sugar loan rate for 1985/86[6]

The US Dept. of Agriculture has announced that the national average loan rate for raw cane sugar from the 1985/86 crop will be 18 cents/lb, the minimum prescribed by law, against 17.75 cents/lb in 1984/85. The loan rate for white beet sugar will be 21.06 cents/lb, both prices being subject to adjustment for regional differentials. The Market Stabilization Price was also announced at 21.57 cents/lb (21.17 cents/lb in 1984/85); this includes average transport costs, interest charges and marketing costs and is the reference price level; if actual domestic prices are lower, the sugar placed under loan may be forfeited.

International symposium on automatic control and optimization of food processes

An international symposium on the above theme is to be held in Paris during November 12-13, 1986, with the object of bringing together food industry engineers interested in automation and optimization and automation specialists having an interest in the food industry. The dates have been chosen to coincide with an exhibition of food industry equipment and technology and is under the auspices of the European Federation of Chemical Engineering. Persons interested in presenting papers should write to Prof. J. J. Bimbenet, ENSIA-Dépt. GIA, 1 Avenue des Olympiades, 91305 Massy, France, while those wishing to attend should write for more information to Mlle. Véronique Reynaud, Salon du G.I.A., B.P. 551, 42 rue du Louvre, 75027 Paris Cedex 01, France.

New sugar economic abstracts publication

Commodity Economic Abstracts Ltd. has introduced a new quarterly entitled "Sugar and sweeteners" which contains summaries of items judged to be of value to those wishing to take a long-term view of the sugar and sweetener business world-wide. It includes sections on cane and beet agriculture, processing, industry trends and surveys, policy, non-sugar sweeteners and by-products, while the abstracts in each include a reference number, title of the paper, translated into English where necessary, the authors, their organizations, a summary of the paper, and a full reference to the source. The first issue includes 34 pages and 88 abstracts. The cost of a year's subscription, i.e. four issues, is £95 or US $140, with an additional £9.50 or $14.00 for airmail despatch. Further information is available from C.E.A. Ltd., P.O. Box 9, Hartley Wintney, Basingstoke, Hampshire RG27 0QW, England.

S.P.R.I. Science Award

Sugar Processing Research Inc. is soliciting nominations for its Science Award for 1986. This award, presented biennially in October, consists of a cash honorarium of US $1000, a plaque, and reasonable travel expenses to the award presentation, at the S.P.R.I. Conference to be held in Savannah, Georgia, USA during October 19-21, 1986. Scientists/researchers who have at least ten years of active research and development experience in sucrose science and technology, in a research environment of a university and/or research institute and/or company engaged in the business of sucrose processing and production, and have approximately ten recent, relevant sucrose and sucrose-related publications in internationally recognized textbooks, or journals which operate a referee system of selection for publication, are eligible for consideration by the Award Committee. Nominating forms may be obtained from the Managing Director, Sugar Processing Research Inc., P.O. Box 19687, New Orleans, LA 70179, U.S.A. The deadline for nominations is March 15, 1986.

A/S De Danske Sukkerfabrikker report, 1984/85

The five DDS factories processed 3.2 million tonnes of beet to yield 469,000 tonnes of sugar, more than 100,000 tonnes above the EEC quota. Early sowing, favourable weather and low incidence of pests and diseases combined to give a record yield, whereas in 1983 the disappointing harvest had produced only 293,000 tonnes of sugar. Domestic sales amounted to 195,000 tonnes while exports included those to regular markets in Iceland, Norway and the UK. An interesting phrase in the report is that "sugar produced in excess of the EEC quota and sold for export at world market prices *earned only a modest profit*" (our italics). This presumably indicates that the world prices obtained were slightly higher than the marginal cost of production with overheads and fixed costs attributed only to quota production. Sales of beet seed increased in spite of a reduction of beet area in several markets. Export of plant and machinery by DDS-Engineering and DDS-Kroyer A/S have been smaller but included beet sugar machinery for the UK, Canada and Holland, and orders have been received for mini-sugar factories for Bangladesh and the Central African Republic, as well as plant for China, India and Indonesia.

El Salvador alcohol program[7]

El Salvador's National Sugar Institute is accepting bids for five fuel alcohol facilities with a combined annual capacity of about 42 million gallons. The two largest facilities will be owned by the government and three will be owned and operated by the private sector. These plants will be in addition to a 6 million gallons/year facility near San Salvador which is already producing

fuel alcohol for sale to the US. As a beneficiary of the "Caribbean Basin Initiative", El Salvador is exempt from the normal 60 cents/gallon US import duty. Financing of the program will be provided by a $30 million loan from the Venezuelan Investment Fund; one stipulation is that a Venezuelan firm (probably CBT which built the earlier facility) shall build the plants. It is hoped that the facilities will be in operation within 12 months. The Institute will assign sugar quotas to the plants, each of which will be built adjacent to sugar factories. The price for the alcohol will be set by the world market, with the approval of the Institute which will also be charged with administering exports.

New Burundi sugar factory[8]

West Germany's Friedrich Krupp has been awarded a contract worth about DM 80 million ($27.2 million) to supply mechanical equipment for the new 1000 tonnes/day sugar factory at Rutana in the southwest. Under an agreement signed in August with the Bujumbura-based Société Sucrière du Mosso (Sosumo), Krupp is to be the sole main contractor for the project. Finance is being provided by the Arab Bank for Economic Development in Africa ($10 million), the OPEC Fund for International Development ($7 million) and the Abu Dhabi Fund for Arab Economic Development ($5.5 million).

Egypt sugar imports, 1984[9]

	1984	1983	1982
	tonnes, raw value		
Argentina	0	23,546	8,261
Brazil	315,119	135,184	364,849
Bulgaria	0	10,340	0
Congo	0	0	5,699
Cuba	137,911	230,779	190,269
Cyprus	1	2	0
Czechoslovakia	39,130	0	0
EEC	289,507	70,800	150,261
Germany, East	0	33,805	21,630
India	51,320	302,570	29,118
Ivory Coast	0	0	5,000
Poland	12,945	350	0
Portugal	11,000	0	0
Rumania	0	31,941	0
Thailand	5,943	48,125	0
US	39,218	24,290	1
	902,094	911,732	775,088

Hurricane damage in Louisiana[10]

Hurricane Juan has severely damaged the Louisiana sugar cane crop, and industry estimates set losses at 5-20% of the harvest which had been expected to produce 550,000-600,000 short tons of sugar.

Bagasse paper plant reactivation plans[11]

A Brazilian team is to submit a report on the reactivation of the bagasse paper plant at Santiago de Cao, near Trujillo, Peru, which was built in 1968 but has been closed owing to technical problems. It was intended to produce 110,000 tonnes annually of newsprint but at present only operates sporadically, producing paper for packing. Brazilian technologists are also to study the possibility of building a plant in Trujillo, a major sugar-producing area, to make fuel alcohol.

Ivory Coast sugar exports[12]

The Ivory Coast exported 42,750 tonnes of sugar in 1983/84 of which 39,600 tonnes went to Portugal and the balance to EEC countries. Exports in 1982/83 were significantly higher at 87,000 tonnes.

Jamaica distillery project[13]

Archer Daniels Midland (ADM) is believed to be actively exploring construction of a fermentation distillation sugar-fed alcohol plant in Jamaica. ADM is looking for a private-sector partner for the plant and is attempting to get funding through the US Agency for International Development (AID). If ADM cannot get AID funding, however, the firm is said to have indicated that it "may be willing to put up the funds itself". ADM officials have declined to comment on these reports.

Taiwan sugar exports reduction[14]

The Taiwan Sugar Corporation is to reduce sugar exports in 1986 by at least 35% to 110,000 tonnes from the 170,000 tonnes estimated for 1985. This is to prevent heavy losses which are estimated at $20 million, mainly resulting from the company's massive subsidization of local farmers. The sugar production target for the 1985/86 season has been set at 550,000 tonnes, tel quel, against 660,000 tonnes in 1984/85.

Iran sugar production and imports[15]

Official figures for sugar production and imports by Iran have been published and appear below. It is presumed that all figures are given in white sugar value.

	Production	*Imports*
	tonnes	
1971/72	581,371	87,551
1972/73	579,650	142,592
1973/74	607,753	286,064
1974/75	638,005	219,545
1975/76	657,335	596,497
1976/77	721,979	262,350
1977/78	632,382	447,553
1978/79	579,388	247,477
1979/80	592,503	1,269,125
1980/81	595,705	784,334
1981/82	537,607	667,000
1982/83	707,700	412,043
1983/84	662,705	654,934
1984/85	632,803	575,000

Morocco sugar imports, 1984[16]

Morocco imported 283,200 tonnes of sugar, tel quel, in 1984, compared with 247,600 tonnes in 1983.

Argentina national alcohol fuel program[17]

Argentina plans to produce both methanol and ethanol each to be added at 3-4% in its gasoline. Some of the ethanol will be produced from sorghum but Brazil is selling seven distilleries to Argentina, all of which will use sugar cane as raw material. Argentina expects to use only 285 million litres of its estimated production in 1985/86 of 345 million litres; the surplus is to be exported to the US and Japan.

Canary Islands sugar refinery proposal[18]

A five-member consortium of Spanish firms is seeking technology and capital backing to build a sugar refinery in the Canary Islands. The group, led by Jugos Canarios S.A., estimates the initial cost at 600 million pesetas for the facility, which would produce liquid sugar for industrial use. Plant site is said to be undecided, but Gran Canaria has been mentioned as the most likely location.

Thailand sugar export problems[19]

Serious problems have arisen in financing Thailand's sugar exports, which has resulted in various Thai banks seizing stocks held for export. Following intensive negotiations between the various parties involved, including the Central Bank, agreements have been reached regarding particular shipments. However, major difficulties remain which could have an impact on financing next season's crop.

Kenya-Yugoslavia barter agreement[20]

Press reports state that Yugoslavia has signed a contract with a Kenyan firm for the supply of 50,000 tonnes of refined sugar in exchange for fuel oil and some other unspecified commodities. The arrangement helps to reduce Yugoslavia's carryover stocks, now estimated at 210,000 tonnes, while providing some badly needed fuel for processing of the 1985 beet crop.

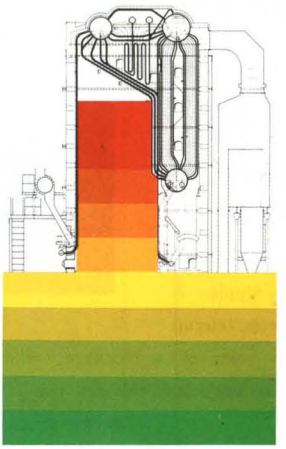
Antigua alcohol manufacturing plans[21]

Government officials and representatives of the American firm Peerless Petrochemicals have met to consider details for establishing a plant for production of alcohol.

1 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 535-536, 557.
2 *World Sugar J.*, 1985, **8**, (2), 28.
3 *I.S.O. Stat. Bull.*, 1985, **44**, (7), v.
4 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 521.
5 *Public Ledger's Commodity Week*, September 21, 1985.
6 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 577.
7 *Amerop-Westway Newsletter*, 1985, (143), 15.
8 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 582.
9 *I.S.O. Stat. Bull.*, 1985, **44**, (7), vii.
10 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 633.
11 *GEPLACEA Bulletin*, 1985, **2**, (5).
12 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 599.
13 *Amerop-Westway Newsletter*, 1985, (143), 16.
14 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 599.
15 C. Czarnikow Ltd., *Sugar Review*, 1985, (1742), 141.
16 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 616.
17 *GEPLACEA Bulletin*, 1985, **2**, (5).
18 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 596.
19 *Standard Chartered Review*, October 1985, 37.
20 F. O. Licht, *Int. Sugar Rpt.*, 1985, **117**, 632.
21 *GEPLACEA Bulletin*, 1985, **2**, (5).

Bagatex 20

CONVERTS YOUR EXCESS BAGASSE INTO ENERGY



Producers of Cane Sugar and Cane Alcohol :
After every crop, you are left with a large amount of **surplus bagasse,** generally unused, economically untransportable, quick-rotting and therefore pollutive, a fire hazard.

The **BAGATEX 20** process turns your bagasse surplus containing 50 % water into bagasse with only 20 % water, called B.20.

without any costly thermal dehydration which would use a large part of the fuel obtained,

with no other losses apart from the controlled natural evaporation of approximately 30 % of the weight of the bagasse.

With **BAGATEX 20,** a simple process the investment in which can be amortized on a very short term and which preserves your surpluses and those you will get through additional economy savings.

you will be able to produce and sell KW all year round for irrigation and the local electrical grid (civil or industrial).

you will also be able to produce alcohol, refined sugar, cattlefeed between crops.

1 ton of bagasse surplus with 50 % water turned into B.20 = 1,5 oils barrels.
Can be preserved more than 1 year in a storing area.

Bagatex 20

The process which turns **biomass** into solid fuel, renewable every year.

SUCRES ET DENREES GROUP

SUCDEN ENGINEERING

133 avenue des Champs-Elysées 75380 Paris Cedex 8
Tél. (1) 47 23 55 77 Télex 610 540/611 022/611 067/620 167

SUCDEN'S DESIGN OFFICE : SOLUTIONS/REALISATIONS 77810 Thomery - Téléphone 60 70 06 10 - Télex Solréal 692772 F

Index to Advertisers

SUGAR BOOKS

Prices given below include insurance, packing and surface mail postage. They are approximate and subject to alteration without notice owing to fluctuations in currency exchange rates. Air mail postage extra will be quoted on request. Terms are strictly cash in advance.

Check your personal library against the list of basic books given below:

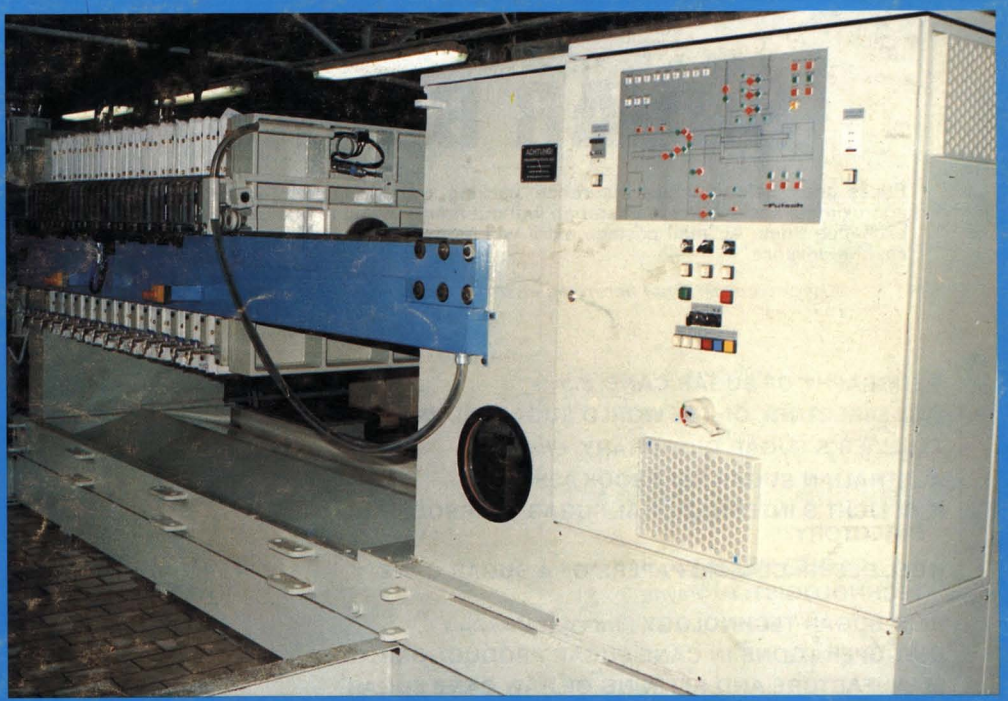
GEOGRAPHY OF SUGAR CANE: *Blume*	(1985)	**£51.50**
WSJ DIRECTORY OF THE WORLD SUGAR INDUSTRY	(1984)	**£230.00**
ELSEVIER'S SUGAR DICTIONARY: *Chaballe*	(1984)	**£55.40**
AUSTRALIAN SUGAR YEARBOOK 1984	(1984)	**£22.15**
F. O. LICHT'S INTERNATIONAL SUGAR YEARBOOK AND DIRECTORY	(1984)	**£40.70**
NOEL DEERR: CLASSIC PAPERS OF A SUGAR CANE TECHNOLOGIST: *Ed. Payne*	(1983)	**£83.25**
BEET SUGAR TECHNOLOGY (3rd ed.): *McGinnis*	(1982)	**£40.50**
UNIT OPERATIONS IN CANE SUGAR PRODUCTIONS: *Payne*	(1982)	**£34.00**
MANUFACTURE AND REFINING OF RAW CANE SUGAR (2nd ed.): *Baikow*	(1982)	**£98.30**
BY-PRODUCTS OF THE CANE SUGAR INDUSTRY (3rd ed.): *Paturau*	(1981)	**£48.80**
STANDARD FABRICATION PRACTICES FOR CANE SUGAR MILLS: *Delden*	(1981)	**£38.85**
THE EFFICIENT USE OF STEAM: *Ed. Goodall*	(1980)	**£49.65**
SUGAR ANALYSIS: ICUMSA METHODS: *Schneider*	(1979)	**£13.75**
CANE SUGAR HANDBOOK (11th ed.): *Meade-Chen*	(1977)	**£143.00**
PHYSICS AND CHEMISTRY OF SUGAR BEET IN SUGAR MANUFACTURE: *Vukov*	(1977)	**£68.00**
SUGAR BEET NUTRITION: *Draycott*	(1972)	**£27.25**
HANDBOOK OF CANE SUGAR ENGINEERING: *Hugot,* transl. *Jenkins*	(1972)	**£144.00**
PROCEEDINGS 16th (1974) SESSION ICUMSA	(1975)	**£8.50**
,, **17th (1978)** ,, ,,	(1979)	**£23.65**
,, **18th (1982)** ,, ,,	(1983)	**£18.50**
ANALYTICAL METHODS USED IN SUGAR REFINING: *Plews*	(1970)	**£25.25**
SUCROSE CHEMICALS: *Kollonitsch*	(1970)	**£8.50**
INTRODUCTION TO CANE SUGAR TECHNOLOGY: *Jenkins*	(1966)	**£57.50**
TECHNOLOGY FOR SUGAR REFINERY WORKERS (3rd ed.): *Lyle*	(1957)	**£20.00**

SUGAR BOOK DEPARTMENT

International Sugar Journal Ltd.

P.O. Box 26, Port Talbot, West Glamorgan SA13 1NX, U.K.

Performance proves —Putsch Quality



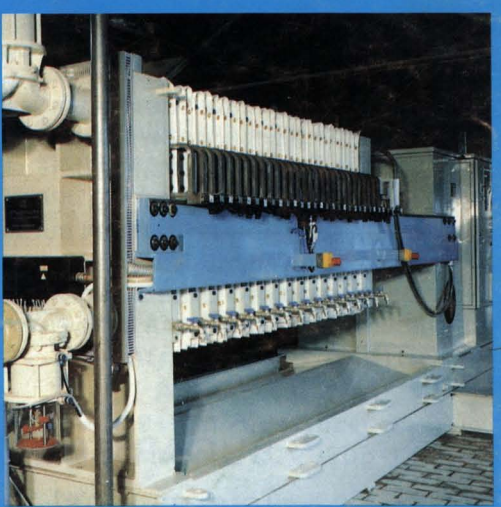
Another new —Putsch design in filters:

The new favourite in the plant!

THE MEMBRANE PRESS FILTER

Helps your plant ecology by producing 70 to 75 % dry substance in your filter cake. Excellent sweetening-off results. Fully automatic operating cycles.

For more details ask —Putsch



—Putsch

ez 104

H. PUTSCH GMBH & COMP. · Postfach 4221 · 5800 Hagen 1 · West Germany · Tel. (0 23 31) 3 10 31 · Telex 8 23 795
H. PUTSCH & COMPANY, INC. · P.O. Box 5128 · Asheville, N.C. 28803 · USA · Tel. (704) 684-0671 · Telex 577443
PUTSCH-NERVA, S.A. · Apartado 406 · Valladolid-8 · Spain · Tel. (83) 272208-12-16 · Telex 26383