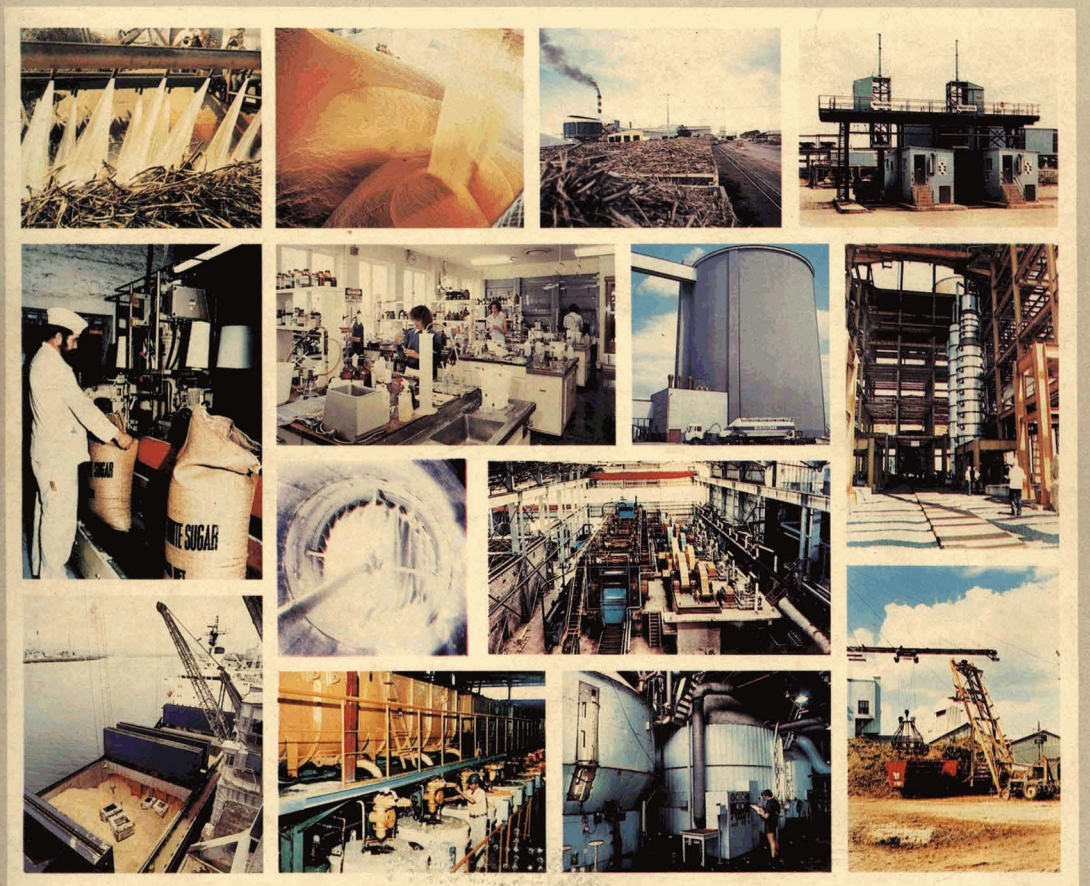
INTERNATIONAL SUGAR JOURNAL



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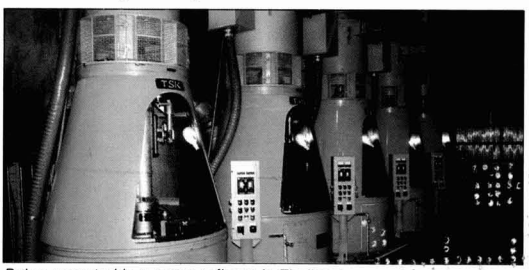

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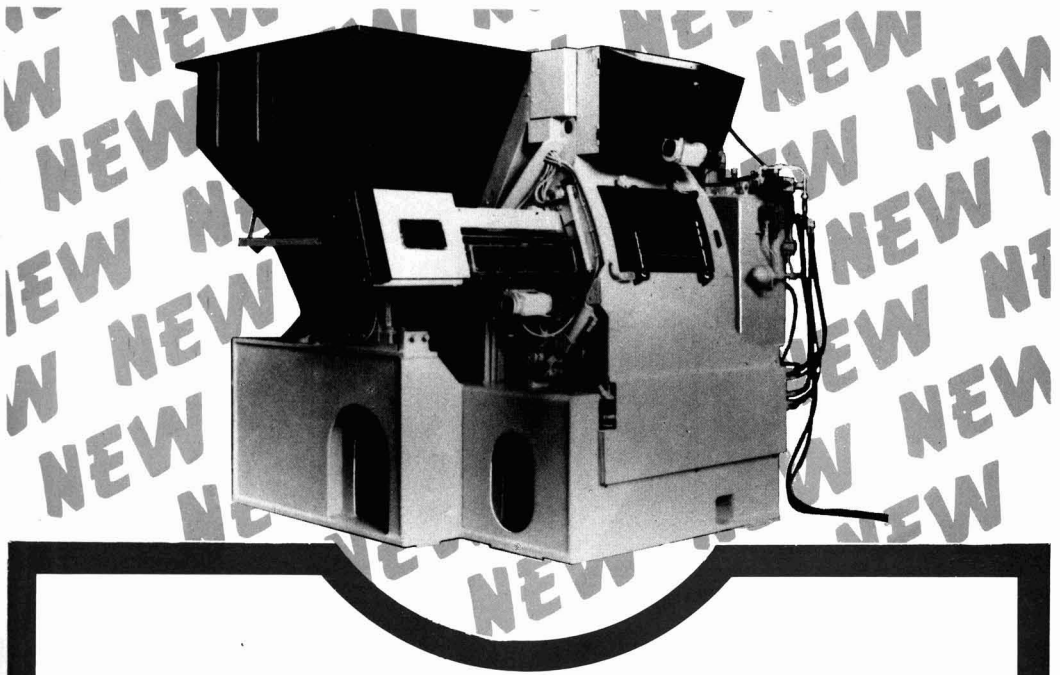

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Notes and comments

World sugar prices

The London Daily Price of raw sugar started the month of January at $98 per tonne and weakened slowly during the first week to reach $95 on January 7. It then started to recover on reports of purchases by China and the USSR. The LDP reached $117 on January 17 but the bearish influence of the statistical position reasserted itself and prices started to slide again to a low of $104 on January 23, after which more reports and rumours of sales caused a burst of confidence which carried the price of $122.50 per tonne on January 31.

White sugar values were much less volatile during the month; the LDP(W) started the month at $135 and fell to $133 but then, like the LDP, rose and reached $148 on January 16. After January 17 it also started to decline to a trough of $141 but then began to climb at the end of the month to $149.50 on January 28. Unlike the LDP which continued to climb, the LDP(W) sank to $141.50 on January 30 and it ended the month at $144.

Sugar deficit forecast by FAO[1]

According to some market observers, 1984/85 is likely to see sugar in deficit and the Food & Agriculture Organization has estimated that offtake could rise by 2 million tonnes and exceed production by 1 million tonnes. The net result would, of course, be a drawdown in world stocks of about a million tonnes, which would be a step in the right direction but would still leave them equivalent to 37% of consumption, way above what is considered to be the level needed to ensure adequate protection against potential shortfalls.

The FAO's production figure was slightly lower than earlier thought because of lower production in Brazil and Cuba, and an Indian crop much the same as that of 1983/84. However, bumper crops are expected in Australia, Fiji, Indonesia, Mexico and South Africa. Beet output should rise fractionally with bigger EEC, Japanese and US crops compensating for shortfalls in China, Turkey and the USSR.

US sugar trends[2]

Between 1975 and 1984 total caloric sweetener consumption in the US has increased by 16%, from 12,040,000 to 13,966,000 tonnes. Of these amounts, corn-based sweeteners have increased from 2,694,000 to 6,209,000 tonnes, i.e. by 130%, including a rise in usage of high-fructose syrups from 490,000 to 3,901,000 tonnes, an increase of 696%. Sugar consumption has fallen by 17%, from 9,346,000 tonnes to 7,757,000 tonnes. As a consequence, US sugar imports have fallen by just under 40%, and prospects are for a continuing decline as a consequence of the decision by Coca-Cola and Pepsico to allow use of 100% HFS instead of sugar, and the likely expansion in substitution of sugar by aspartame, the synthetic sweetener.

World Sugar Journal concludes that, if the trend continues, the US will cease to be a sugar importer by 1990, and thereafter, domestic producers may either be forced to cut production and/or export their excess production either at a financial loss or with a subsidy by taxpayers.

"Such a situation will create extreme economic pains to those countries which rely heavily on their foreign exchange earnings from sugar. First, they stand to lose more than two million tonnes equivalent of outlets within a relatively short period of five to six years and, second, as a continuation of this most undesirable development, they would face competition from exported US sugar which will most likely be subsidized."

GEPLACEA 29th Meeting

The Group of Latin American and Caribbean Cane Sugar Exporting Countries (GEPLACEA) held its 20th Meeting in San Miguel de Tucumán, Argentina, during November 5-8. The Secretary of Commerce of Argentina, Sr. Ricardo Campero, opened the session by stressing how serious is the crisis for the sugar industry at a time when most member countries are going through hard times because of their balance of foreign payments. The head of the host delegation, Sr. Eduardo Poliche, was elected President of the meeting.

One of the main subjects of the session was the present situation of the sugar industry in the face of the absence of an International Sugar Agreement, low world market prices, and the sugar policies of the USA and EEC. One of the delegates from Argentina was Sr. Jorge Zorreguieta, who had presided over the Geneva negotiations of the International Sugar Organization. He explained how they developed and how the rigid positions taken by some countries defeated an agreement. He said that the absence of a regulating agreement could mean the ruin of the sugar industry in some countries. He exhorted the attending members to ratify the Administrative Agreement in order to have a forum for the industry and the basis for a future regulatory agreement.

In a special session, Mr. Nicholas Kominus, President of the U.S. Cane Sugar Refiners Association, spoke about the present situation of the sugar market in his country, with emphasis on the shrinking of that market and the damage this will cause to the Latin American and Caribbean sugar exporting countries. After a session of questions and answers, the participants adopted a resolution to take the necessary steps to make contact with US government officials and organizations in order to defend the interests of GEPLACEA members and to work for a more equitable sugar policy in the future Farm Bill.

The assembly elected Sr. Eduardo Latorre of the Dominican Republic its

1 *Public Ledger's Commodity Week*, December 15, 1984.
2 *World Sugar J.*, 1984, 7, (4/5), 6-7.

Executive Secretary. It was not decided when and where the next session will take place. As customary, however, an estimate of the world sugar balance was released, as follows:

	1984/85	1983/84	1982/83
		tonnes, raw value	
Initial stocks	34,404,000	34,444,000	28,528,000
Production	96,858,000	95,308,000	99,636,000
	131,262,000	129,752,000	128,164,000
Consumption	96,712,000	95,348,000	93,720,000
Final stocks	34,550,000	34,404,000	34,444,000
" " % consumption	35.72%	36.08%	36.75%

International Sugar Agreement

The last meeting of the Council set up under the 1977 I.S.A. was held in January and wound up its financial affairs by agreeing the method of disposing of the remainder of the Stock Financing Fund. A new Council was elected by members of the new Agreement; sufficient countries had ratified, accepted or agreed to membership. The Executive Director and Secretary were confirmed in their posts with the International Sugar Organization, and the Council elected a Chairman and Vice-Chairman. It was agreed to extend the deadline for signing the new agreement and to arrange a more convenient method of accession for new applicants.

US sugar support cut proposals

The US Administration's new farm legislation was due to be put before Congress in early February and details were not available at the time of writing; however, a number of indications have been leaked and it seems clear that a gradual reduction in support measures for farm products is proposed with, specifically, a lowering of the loan rate for sugar by 2 cents/lb per annum over each of the next five years, which would bring it from 18 to 8 cents/lb. In order to provide a cushioning of this removal of support, a system of quotas for sugar imports would be maintained for the first few years of the program and a Market Stabilization Price would be established. The policy objective would be, however, to bring internal farm supports which reflect world market prices. This could have a traumatic effect on domestic sugar growers and processors in several areas of the USA and it is by no means certain that the proposals would get through Congress; indeed it seems likely that considerable modifications may be made in the bill before it becomes law.

Nevertheless, C. Czarnikow Ltd. comment[1], "Whatever the implications for the domestic situation in the USA, we believe that this attempt is an important development in the wider context of the world sugar trade. If, despite internal opposition, such measures were to be enacted, there would not only be potentially greater access to a major market by overseas suppliers but in the longer term the support measures in other areas of the sugar world could well be influenced and reassessed."

Mauritius sugar industry rationalization proposals[2]

The Mauritius Chamber of Agriculture has submitted its master plan to restructure the sugar sector. In this plan, the closure of six sugar factories, abolition of the sugar export tax and new investment of 678 million rupees (US $44.8 million) in the remaining 15 factories have been recommended. The plan has been submitted to the Sugar Authority which was set up to draft policy guidelines for the industry. The government was expected to publish its legislative sugar program before the end of 1984.

Closing the six heaviest loss-making estates — Solitude, Saint Antoine, Reufac, Rose Belle, Saint Felix and Bel Ombre — would entail the loss of 1175 jobs. The overall cost of the plan, including redundancy payments and expansion of the area under irrigation, is put at 1055.4 million rupees ($69.8 million).

The proposals have been coolly received by the Minister of Agriculture who has proposed a 1% annual decrease in the area of arable land for cane cultivation from 1987 and has spoken out against redundancy and abolition of the export tax. In the long term, according to the Chamber, the number of sugar factories should be reduced to seven, with cane from closed factories processed by others. The Belle-Vue factory could increase its capacity to 500,000 tonnes a year from its present average of 290,000 tonnes. The Chamber estimates that the closures could mean savings of 117 rupees ($7.70) a tonne on sugar produced. Assuming average production of 660,000 tonnes a year, annual savings could total 77 million rupees ($5,100,000).

US sugar group for sale

Hunt International Resources Corporation has said it is offering to sell its Great Western Sugar Company's stock and assets, either as a package or in parts. Great Western operates twelve beet sugar factories in the USA and also owns Godchaux-Henderson Sugar Co. Inc. with a refinery in Louisiana and the Northern Ohio Sugar Co., which also operates a beet sugar factory. It is possible that a number of the beet sugar plants will not be working in the next campaign.

1 *Sugar Review*, 1985, (1734), 2.
2 F. O. Licht, *International Sugar Rpt.*, 1985, **117**, 17-18.

Continuous centrifugal development for high-grade massecuites

By B. C. Goodacre*, H. C. Bristow* and R. Connor†

Introduction

Continuous centrifugals have virtually replaced batch machines for low-grade sugar massecuites owing to the many advantages which they offer. The capital and energy costs are only about half those of the batch counterpart. Maintenance costs are lower, the control system is simpler and electrical load surges are eliminated. Even the separation performance has been reported to be superior, particularly for fine grain and highly viscous massecuites [1].

By contrast, continuous centrifugals have not been adopted for white sugar, largely owing to the problems of crystal breakage and inferior sugar purity. Developments in machine design specifically for high-grade massecuites, however, can be expected to improve the performance significantly.

A development program has been undertaken by Smith-Mirrlees in collaboration with Tate & Lyle Group R & D and Westburn refinery, with the objective of matching batch machine performance for high-grade material ranging from white sugar massecuite to affination magma.

Literature review

Although there are a number of references to continuous centrifugals published in the literature only a few refer specifically to their use with high-grade sugars.

The possible use of continuous centrifugals with high-grade material has been discussed by Swindells & Kirby [2] and the advantages and limitations of both batch and continuous machines have been compared. *A*-massecuite was treated at the Illovo factory in South Africa [3] using an FC 1000 GCV SE 25° continuous machine, the development of which had been reported separately [4]. It was concluded that a throughput of 12 tonnes per hour was the maximum that could be achieved in order to meet the local specifications. A grain size equivalent to that obtained with the batch machine was achieved but only by using a very large (5m diameter) outer casing. It was also concluded that further development is required to overcome the problems of lump formation and high sugar moisture content. In another trial on *A*-massecuite with the same type of machine it was concluded that there was an increase in capacity and a better quality of sugar compared with a 30° machine [1].

B. C. Goodacre

H. C. Bristow

R.Connor

Reference is made to the development of continuous machines for white sugar massecuite in company literature [5, 6]. The only solution to the problems of crystal breakage mentioned in these is to use a large-diameter outer casing.

A large number of patents have been issued on the subject of continuous centrifugals. Only a minority of these contain designs intended to improve the performance of high-grade sugar machines. Most of the patents involved the use of a standard conical basket with the massecuite fed into the bottom and moving continuously along a screen to the top. An exception to this is a machine that builds up a layer of static sugar on a conical basket [7]. This is then washed and discharged by means of a scraper moving at a slightly different speed of rotation.

A large number of patents have included ideas for reducing the breakage caused by impact of the sugar on the outer casing. These ideas have included:

(i) sloping the outer casing to form a cone giving an angled impact [8].
(ii) providing a carousel of vertical vanes which can be positioned to interrupt the sugar flow and adjusted to vary the impact angle [9].
(ii) providing a rotating ring at the point of discharge which is angled so that the sugar is discharged from one part of the circumference of the basket only. The sugar can then be directed into a discharge duct [10].
(iv) using an air current to deflect the sugar and slow it down [11].

Designs to reduce the spray formed by the impact of the wash water onto the screen or to isolate it from the sugar have been patented. These have included:

(i) devices for rotating the water addition system with the basket [12].
(ii) covering the top portion of the basket so that any spray formed is deflected into a separate chamber from the sugar and discharged separately [13].

The problem of the syrup passing through the gap between the rotating basket and the static inner chamber casing has been tackled in one patent [14]. This involves using pads to entrain any

Paper presented to the 43rd Ann. Meeting, Sugar Ind. Tech., 1984.

*Tate and Lyle, Group R & D, Reading, UK.
†Smith-Mirrlees, Glasgow, UK.

1 Alam *et al.: Proc. 17th Conf. Pakistan Soc. Sugar Tech.*, 1981, 52-59.
2 *Proc. Australian Soc. Sugar Cane Tech.*, 1981, 49-54.
3 de Robillard & Journet: *Proc. S. African Sugar Tech. Assoc.*, 1980, 82-86.
4 Credoz *et al.: Sugar y Azúcar*, 1980, **75**, (2), 34-42.
5 *B.M.A. Information*, 1981, (20).
6 *Brochure* FCB21108.80 (Soc. Fives-Cail Babcock).
7 EP Patent 31,549.
8 UK Patent 1,247,279.
9 UK Patent 2,104,793A.
10 UK Patent 1,490,323.
11 UK Patent 1,293,761.
12 UK Patent 1,469,467.
13 UK Patent 2,093,364A.
14 US Patent 4,352,451.

syrup droplets, with designs for allowing this entrained syrup to fall back into the main syrup chamber.

Experimental

Description of installation and trial

The centrifugal to be tested was installed at Tate & Lyle's Westburn refinery at Greenock in Scotland. It was placed in the affination station with a special connexion which allowed white massecuite to be pumped across. Consequently it was possible to run the machine on either white massecuite or affination magma.

The performance of an existing continuous machine (Mk I) was first assessed and the observations used to improve the design and operation of the machine. Tests were then carried out on the improved designs to assess their effectiveness so that recommendations could be made for including any proven features on production models.

The data obtained from the trials included a combination of white sugar and affined sugar results. It was concluded early in the trials that the behaviour of the two massecuites within the machine was similar and it was therefore possible to carry out some trials, such as those on breakage, on affination and apply the results for development of white sugar separation.

Figures 1 to 4 show the development from the original machine (Mk I) with a 34° basket to the current Mk IV model (Rota 900). Further details of the modifications are given below.

The development has taken place over a period of 3 years. The trials on the Mk I machine concentrated mainly on white massecuite with some affination work. Trials on the Mk II model concentrated exclusively on white massecuite. The Mk III trials were run on both white massecuite and affination magma. The Mk IV trials were on affination magma only.

Performance measurements

During the trials, samples of sugar, syrup, massecuite and syrup with no wash (mother syrup) were taken for analysis. Equivalent samples corresponding to massecuite from the same pan, but separated using a batch machine, were taken for comparison. The current drawn by the machine, the speed of rotation, the wash water flow rate and the massecuite and wash water temperatures were recorded for each set of samples taken. The current drawn was related to the massecuite flow rate by means of a calibration curve. Four basic criteria, in addition to throughput, were used to assess the performance of the machines. They were the impurity level, moisture, yield and breakage.

Impurity level: The impurity level is usually measured in terms of the ash and colour of the sugar. However, these measurements are affected by the characteristics of the massecuite as well as by the performance of the machine. Corrections thus have to be made for variations in the mother syrup impurity level when results from different tests are compared. Corrections also need to be made for variations in the amount of occluded impurity within the sugar crystal.

In practice the occluded ash is so low for white sugar that corrections only need to be made in respect of syrup purity. For affination the occluded ash is significant and variable so that corrections need to be made in this respect as well as in respect of syrup purity.

Occluded colour is significant for all sugars. However, the present study has concentrated on ash as a measure of impurity with only a few colour measurements made on some white sugars.

Moisture: Sugar samples were collected in sealable containers and moisture was determined by oven drying.

Yield: The amount of crystalline sugar recovered expressed as a percentage of the total crystalline sugar in the massecuite is defined as the yield. This figure can be calculated from data on the massecuite, the mother syrup and the syrup run off. It is possible to get a measure of yield using Brix data, ash data or purity data. It has been found that yields based on the Brix give the most consistent results and these have therefore been used.

Breakage: The breakage is assessed using two criteria, based on sieve analysis:

(a) The mean aperture

(b) Fines less than 300μm

Operating parameters

During the trials a number of operating parameters were varied.

Throughput: The rate was normally 12 tonnes/hour but rates of up to 24 tonnes/hour have been employed during tests on affination magma.

Wash water rate: This is defined as the percentage by weight of the wash water divided by the massecuite flow rate. The wash water rate at Westburn refinery, on white batch machines, is typically 3% (2% nozzle wash and 1% tray wash) for the 1st boiling ('L' pan) white sugar. During the trials, rates of between 2% and 6% were tried.

Water temperature: The wash water temperature was approximately 65°C. Temperatures up to 85°C were used in some experiments.

Speed of rotation: The majority of the data were obtained with a speed of rotation of 1400 r.p.m. However some data were collected using speeds of 1000 to 1600 r.p.m. Most of these data were obtained using *B*-massecuite (3rd boiling).

Performance of the original machine (Mk I)

The initial trials were carried out on a machine with a 34° basket (Fig. 1) in order to observe how its performance compared with the batch machines.

The results of Table I showed that an average sugar moisture of approximately 1.8% was obtained at all wash rates, 0.5% higher than the average equivalent batch centrifugal results. The impurity level was reduced with increasing wash water, but it levelled out at the higher wash rates.

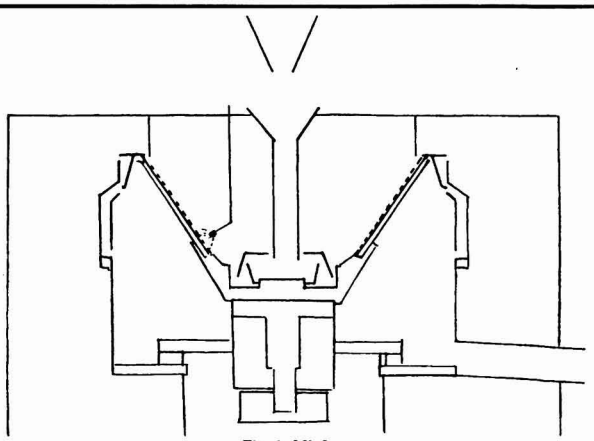


Fig. 1. Mk I

Table I. Results of Mk. I trials on white sugar massecuite

	Wash water, %		No. of readings	Sugar			
	Range	Average		Moisture, %	Ash, %	Colour, ICU	Yield, %
Continuous	<3.0	2.0	15	1.8	0.032	57	94
	3.0-4.0	3.4	8	1.7	0.022	41	93
	4.1-5.0	4.4	2	1.7	0.029	48	93
Batch		3.1		1.3	0.005	27	84*
Difference	<3.0	2.0	15	0.5	0.027	30	10
	3.0-4.0	3.4	8	0.4	0.017	14	9
	4.1-5.0	4.4	2	0.4	0.024	21	9

* The figure of 84% yield is based on 3.1% water and a massecuite with 58% crystal content. The water is assumed to dissolve sugar up to 75°Bx.

Average syrup ash 0.48%; Massecuite ash 0.20%; % Crystal 58%.

Over the 3-4% wash range an average ash of 0.022% was obtained which is 0.017% above the batch machine equivalent. The sugar colour was in all cases much higher than the batch machine equivalent. Only the yield compared favourably, with a value of 94%, which is 10% higher than the batch centrifugal equivalent.

Visual observation with a stroboscope showed that the sugar moved very rapidly along the screen. At the point of water application there was an extremely rapid acceleration which left the screen apparently empty above it.

It was further observed that spray was formed by impact of the water on the sugar and that this spray was passing over the top of the basket. It was also noted that a drier sugar was produced when the wash water was turned off (1.4% compared with 1.8% with wash water and 1.3% using the batch machine), indicating that in the absence of water the residence time on the screen is sufficiently long for the separation of syrup from sugar.

Measurement of the air flow showed that a lot of air passed from the syrup chamber to the outer sugar chamber through the gap below the basket top ring. The air carried droplets of syrup which re-contaminated the sugar and adversely affected the impurity level.

Particle size analysis showed that there was a significantly larger degree of breakage in the continuous machine than in the batch machine.

The results clearly showed that the level of impurity and moisture in the continuous machine sugar was much higher than in the batch machine sugar. Any modifcation must aim to increase the residence time of the sugar on the basket in the presence of wash water and to improve the application of wash water so that less spray is generated. Particle breakage must also be reduced.

Modifications to the basic machine

The main modifications made to the machine during the series of trials, in order to improve its performance, are described below.

Angle

In order to increase the residence time of the sugar on the basket, the basket angle was reduced. Friction tests were carried out to determine the precise angle of friction at which the sugar would not move up the screen. This was found to be approximately 20° and it was concluded that 5° difference would leave a sufficient margin of error. Consequently, a basket with a 25° angle was constructed and tested.

Wash nozzles

Modifications to the wash nozzles were carried out with the objectives of: (a) reducing the amount of impact spray and therefore the moisture of the sugar, (b) improving the application of the water so that it would not be carried along the screen by windage, and (c) allowing the position of the point or points of application to be controlled more easily and thus get more efficient washing.

Three different types of wash nozzles were used. They were high-impact flat spray ("Vee Jet"), low-impact flat spray ("Flood Jet") and solid-stream, as shown in Figure 5. The flat spray jets were positioned at right angles to

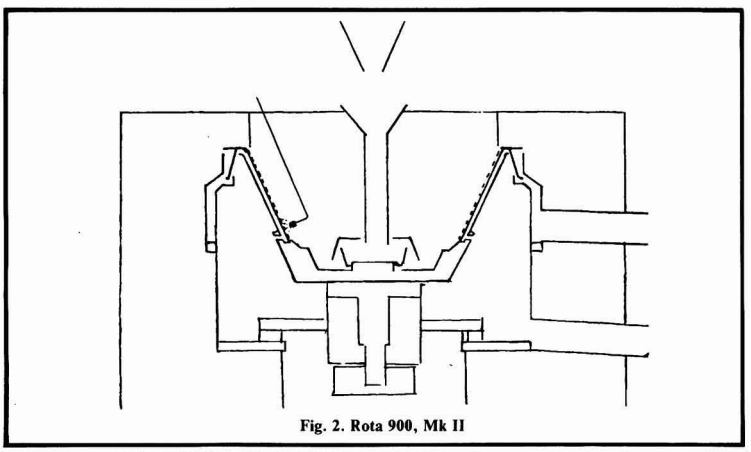


Fig. 2. Rota 900, Mk II

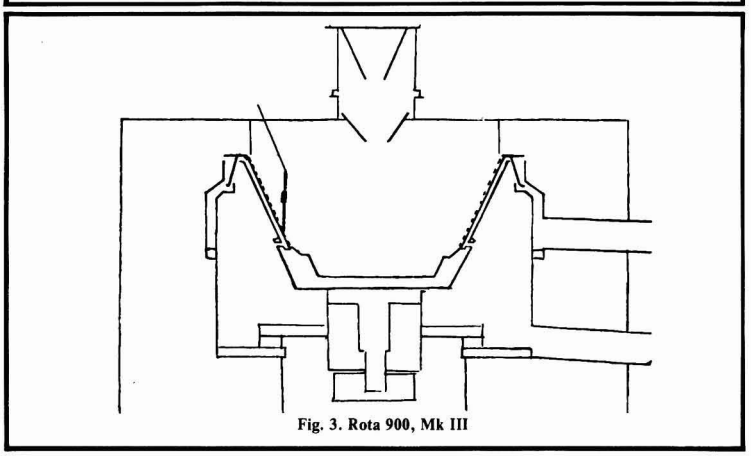


Fig. 3. Rota 900, Mk III

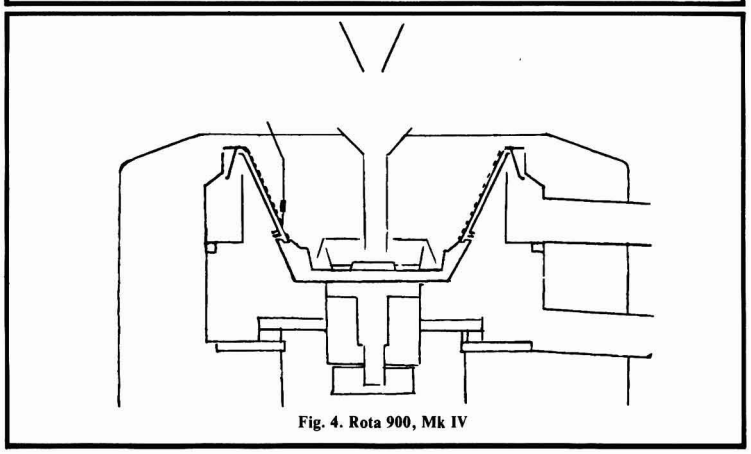


Fig. 4. Rota 900, Mk IV

the screen as in Figures 1 and 2. The solid stream was positioned vertically as in Figures 3 and 4.

Sealing the top of the basket

The top of the basket was sealed on the Mk III machine in order to prevent air being sucked in. This can be seen in Figure 3. The objective was to decrease the amount of air passing through the machine. This would reduce the amount of syrup-entrained air passing through the gap from the syrup chamber to the sugar chamber and thus reduce re-contamination of the sugar. The Mk IV machine was not sealed.

Syrup discharge pipes

The syrup discharge pipes were enlarged and angled tangentially in the direction of rotation of the basket in order to allow any internal windage generated by the basket to be discharged through these pipes. This would avoid re-contamination of sugar by the syrup-entrained air.

Basket holes

Holes were added to the base of the solid basket with the aim of (a) allowing the green syrup to run off separately from the wash syrup, (b) effecting better syrup separation from the massecuite by removing it from the gap between the screen and the basket wall so that the gap did not become overloaded and (c) reducing the inertia of the machine, therefore saving energy.

Basket base angle

The vertical accelerating section at the base of the basket was altered to a slight incline. The aim of this was to prevent the build up of massecuite lumps on this section. These lumps have led to the formation of blind patches on the screen above them and, in extreme cases, to basket vibration.

Accelerator

The acceleration cup was replaced with a flat, stabbed plate and the feed pipe removed mainly in order to

eliminate the local high windage caused by air being pulled down through the feed tube and to eliminate any air disruption caused locally by the cup. The objective was to reduce the disturbance of the wash water by high windage.

Outer casing

The outer casing of the machine was changed so that the sugar would strike a sloping conical section instead of a vertical wall (see Figure 4). The aim of this was to reduce the degree of sugar crystal breakage caused by impact.

Results from modifications

Angle

Tables I and II show a comparison of the results between the Mk I and Mk II trials. It should be noted that the average syrup ash during the Mk II trials was significantly higher than in the Mk I trials.

The flow pattern on the centrifugal screen was markedly improved by the steeper angle. An even sugar coverage was achieved at all wash water levels and, thus, a longer residence time for the sugar. There was steady reduction in ash with increasing wash water, indicating a beneficial effect over the entire range. The difference between continuous and batch sugar ash levels was significantly reduced compared with the Mk I at all wash water levels when the difference in syrup ash was corrected for by dividing the sugar ash by the syrup ash. Sugar colours were also closer to the batch equivalent. Moisture levels were still significantly higher than the batch equivalent, however, and had not been improved by the steeper angle.

Wash nozzle types

Table IV shows a comparison of the results from tests using high-impact "Vee Jet" and low-impact "Flood Jet" nozzles. The results show that, for similar overall wash water and mother syrup ash levels, the ash and colour with the low impact nozzles (0.018% ash, 32 colour against 0.023% ash, 38 colour) were significantly lower (difference statistically significant at 99.8% level). From visual observations it was clear that there was less spray from the low impact nozzles.

Solid stream nozzles were used during the Mk III trials (Table III). A comparison of the results between the Mk II and III trials shows that there was a significant reduction (95% level) in the final sugar moisture with the value not significantly different from the equivalent batch results over the 3%-5% wash water range. Additionally there was a significant reduction (98% level) in the sugar impurity. Ash levels were very close to the batch equivalent; colour levels were even closer.

From visual observations it was apparent that the solid stream nozzles caused little water spray.

Wash nozzle position and wash area

The effect of varying the height of the wash nozzles along the basket was studied using spray nozzles. The results show that the point of wash water addition was not critical within the tested range of 70-185 mm, measured from the bottom of the working screen.

Table II. Results of Mk. II trials on white sugar massecuite

Wash water, %			Rota 900			Rota 900 – Batch		
			Sugar					
Range	Average	No. of readings	Moisture, %	Ash, %	Colour, ICU	Moisture, %	Ash, %	Colour, ICU
<3.0	2.7	6	1.6	0.036	55	0.6	0.029	24
3.0-4.0	3.4	34	1.5	0.022	32	0.5	0.015	10
4.1-5.0	4.6	75	1.6	0.021	33	0.6	0.013	11
>5.0	6.2	14	2.3	0.018	31	1.3	0.011	3

Average syrup ash 0.68%; Massecuite ash 0.29%; % Crystal 51%.

Table III. Results of Mk. III trials on white sugar massecuite

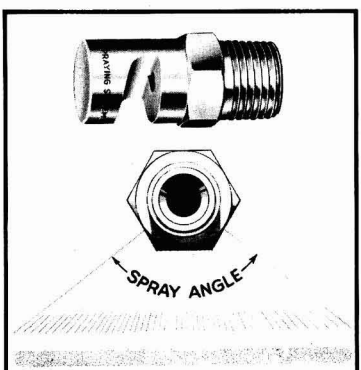
Wash water, %			Rota 900			Rota 900 – Batch		
			Sugar					
Range	Average	No. of readings	Moisture, %	Ash, %	Colour, ICU	Moisture, %	Ash, %	Colour, ICU
<3.0	1.9	12	1.3	0.018	34	0.1	0.010	4
3.0-4.0	3.3	12	1.2	0.015	30	0	0.007	3
4.1-5.0	4.6	3	1.1	0.012	25	– 0.1	0.004	0
>5.0	6.2	4	1.3	0.010	27	0.1	0.002	1

Average syrup ash 0.67%; Massecuite ash 0.29%; % Crystal 53%.

Table IV. Effect of high and low impact nozzles on white sugar (Mk. II trials: 12 tonnes massecuite/hr)

Nozzle type	Wash water, %		No. of readings	Moisture, %	Ash, %	Colour, ICU	Syrup ash, %
	Range	Actual					
High impact	<4.0	3.4	7	1.7	0.024	41	
	>4.0	4.6	10	2.0	0.023	36	
	Average	4.1	17	1.9	0.023	38	0.68
	Std. Dev.	0.7		0.4	0.007	20	0,08
Low impact	<4.0	3.3	3	2.1	0.021	36	
	>4.0	4.7	17	1.9	0.017	31	
	Average	4.5	20	1.9	0.018	32	0.67
	Std. Dev.	0.5		0.3	0.006	12	0.11

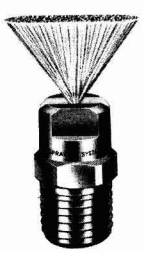
Both types of spray nozzles were tested in wide, medium and narrow types of assess the effect of varying the wash area. However, there were no detectable differences.



WIDE FLAT SPRAY PATTERN

Low impact "Floodjet"

FLAT SPRAY PATTERN



High impact "VeeJet"

Solid stream

Fig. 5. Different types of wash nozzles

Table V. Effect of varying wash temperature

Trial	Material	Wash water, %	Wash temperature, °C	Moisture, %	Ash*, %	Colour, ICU
Mk. II	White massecuite	4.5	84	1.7	0.028	27
			68	1.5	0.026	54
			65	1.6	0.028	37
			62	1.7	0.016	41
			54	–	0.016	36
			50	2.2	0.026	41
Mk. IV	Affination magma	4.0	85	1.5	0.05	
			85	1.6	0.06	
			75	1.6	0.06	
			64	1.6	0.07	
			63	2.1	0.08	
			61	1.5	0.06	
			57	1.8	0.06	

* Corrected for occluded ash in the case of affined sugar

Wash temperature

Table V shows the effect of varying the wash water temperature. The results show that over the entire range of wash water temperatures, from 50°C to 85°C, there was no detectable trend of increasing or decreasing moisture, ash or colour.

Sealing the top of the machine

The changes in air velocity within the machine by sealing the top of the machine were measured. The air flow through the basket rim gap was only reduced by 25% suggesting a large degree of air recirculation within the machine.

Discharge pipe and inner casing modifications

Enlarging the syrup discharge pipes and angling them tangentially led to a large increase in the volume of air discharged from the washings pipe (from 37 to 164 l/sec). At the same time there was a small increase in the volume sucked in through the green syrup pipe (48 to 64 l/sec). The reduction of the air flow through the basket rim gap was only 25%, however. Nevertheless, the affination tests on the Mk III and Mk IV models (Table X) showed a significant improvement (99.8% level).

On the Mk IV model tests the Rota 900 performance was not significantly different (90% level) from the batch equivalent. This indicates that the remaining syrup spray was not too serious a problem.

Basket base angle

The insert at the base of the basket prevented any lumps of sugar from sticking there.

Accelerator

The accelerator plate gave a good

Table VI. Crystal breakage before and after casing modification (1400 rpm; 12 tonnes masse/hr)

		Mean aperture, μm		Fines less than 300 μm, %	
		Actual	Decrease from masse	Actual	Increase over masse
Before modification (Mk. II) (white)	Rota 900	550	80	15.5	10.0
	Batch	620	10	7.3	1.8
	Masse	630	–	5.5	–
After modification (Mk. IV) (affined)	Rota 900	540	90	14.6	7.0
	Batch	620	10	8.0	0.4
	Masse	630	–	7.6	–

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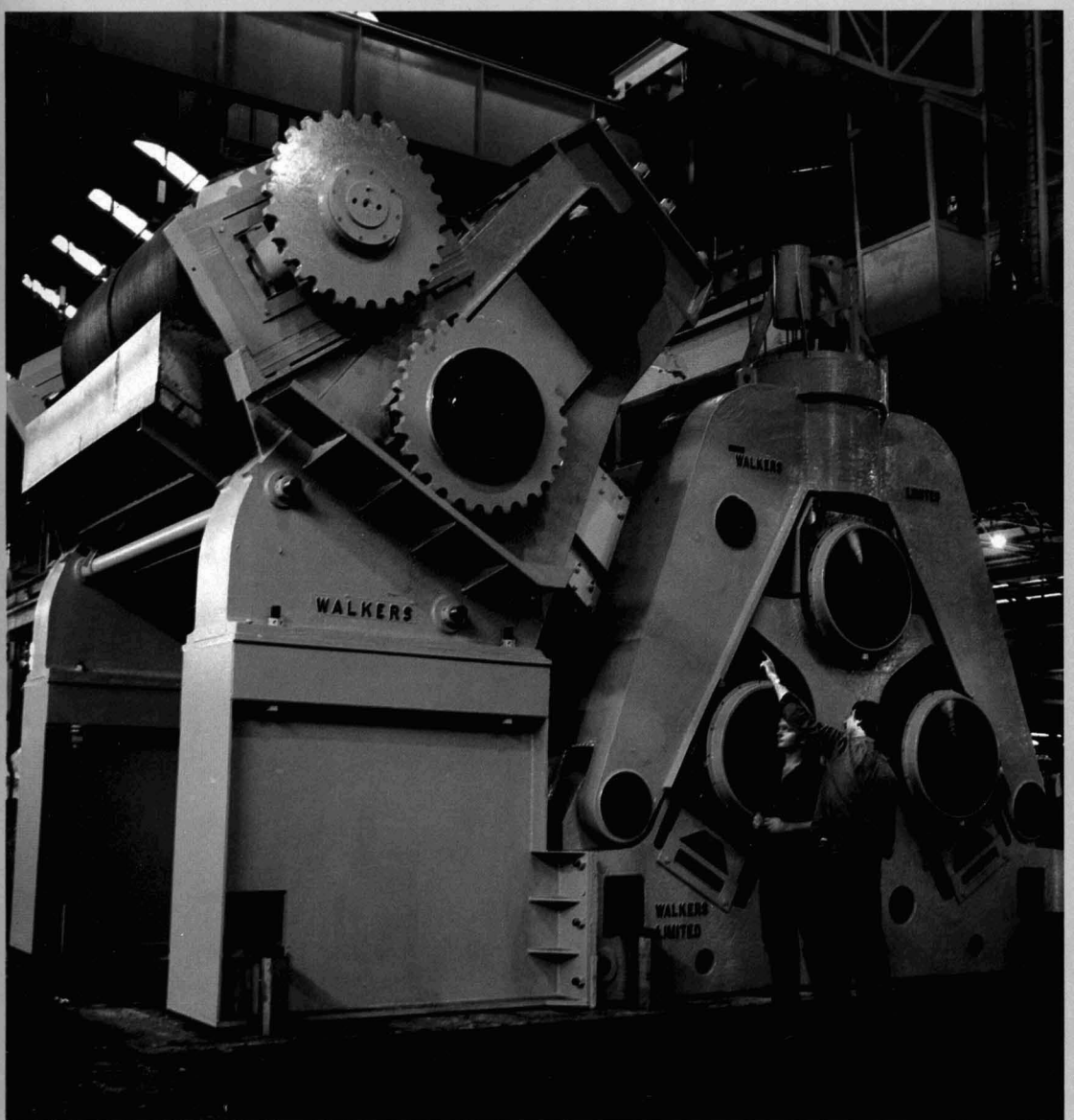

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distribution of massecuite onto the screen. It was also observed that there was less disturbance caused to the wash water within the basket compared with when a standard accelerator cup was fitted.

Outer casing

Although the sloping outer casing prevented sugar from building up, Table VI shows that there was little change in the amount of breakage as assessed by either of the two criteria used.

Results of varying the operating parameters

Throughput

Table VII shows results obtained on the Mk IV machine using affination magma. These results show that there was very little variation in the ash level of the product sugar as the throughput was increased from 12 to 24 tonnes per hour, with an average of 0.18% (0.06% higher than the occluded ash). The batch equivalent was also 0.18%.

Table VII. Ash and yield variation at different affination magma throughputs—Mk IV trials* (4% water on magma; occluded ash 0.12%)

Throughput, tonnes/hr	Ash, %		Yield, %	
	Actual	Average	Actual	Average
12	0.18	0.18	96	96
	0.19		97	
	0.17		94	
18	0.19	0.18	99	99
	0.17		98	
21	0.18	0.18	95	95
	0.18		95	
24	0.19	0.19	95	95
	0.19		95	

* With acceleration cup and feed tube removed

Figure 6 shows the variation in the two parameters used to assess the amount of crystal breakage. The results plotted are the difference between the actual results and those measured on a sample of the massecuite. The results show that the degree of breakage reduced as the throughput was increased.

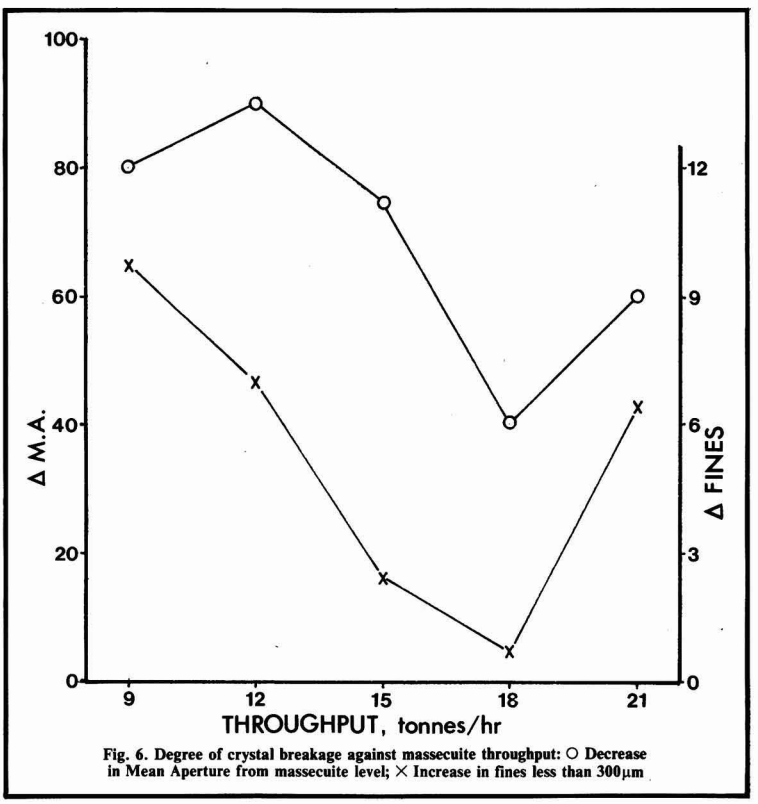


Fig. 6. Degree of crystal breakage against massecuite throughput: ○ Decrease in Mean Aperture from massecuite level; × Increase in fines less than 300μm

Table VIII. Effect of speed of rotation (Mk. II trials; 12 tonnes/hr white massecuite)

Wash water, %	Speed of rotation, rpm	Moisture, %	Ash, %	Colour, ICU	Boiling
4.5	1000	1.6	0.092	120	3rd
	1200	1.3	0.074	87	
	1400	1.3	0.066	78	
	1600	1.3	0.064	82	
4.5	1400	1.6	0.028	37	1st
	1600	1.8	0.027	42	
6.4	1400	2.6	0.017	34	1st
	1600	2.5	0.016	36	

Wash water

The effects of varying the wash water varied depending on basket angle and nozzle type as illustrated in Tables I-III.

Speed of rotation

Table VIII shows that there was a steady increase in ash and colour as the speed was reduced. However, there appears to be very little improvement from increasing the speed from 1400 rpm to 1600 rpm. The speed variation had very little effect on the moisture of the sugar.

(To be continued)

The micro-computer applied to beet reception

By R. D. Robins and P. R. Leaton

Introduction

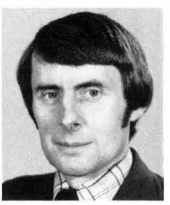
In the 27 years which have elapsed since British Sugar installed the first of its electronic beet costing data collection systems, many changes have been made. This period has seen the technology change from a punched card-based system, through paper tape equipment, to mini-computer systems collecting data on diskette.

Survey of previous systems

The changes which have taken place over the years are illustrated in Figure 1. The payment of growers for beets delivered is based on information collected from weighbridges (gross and tare weights) and the tarehouse (sample information) (See Figure 2).

This information is processed on the basis of prices ruling and the grower receives payment for the tonnes of clean beet delivered with the final value dependent on sugar content. Variations from a base level of 16% sugar content

R. D. Robins



P. R. Leaton

result in higher or lower payments.

Until 1950 purchase of beet was carried out individually by each factory. The complete operation of collecting the data and making the payment to growers was carried out manually.

During the period 1950/57 the system of payment was centralized and partly mechanized, with factories continuing with manual data collection.

Following experiments at Wissington, the first automatic data system was installed at that factory in 1957, based on punched cards manufactured by ICT (International Computers and Tabulators Ltd.). This system was installed at fourteen factories and laid the foundations of automated data capture within British Sugar.

The ICT equipment was by no means ideal for the task to which it was applied. In particular, there was scope for presentation of data in a more manageable way.

In order to reduce the amount of paper (in the form of punched cards) being shipped into the centre for processing, the decision was taken to convert to systems using paper tape. The paper tape was also considered to offer a higher degree of security. A system was installed at Bardney factory in 1964 (weighbridge and tarehouse) and at Wissington factory (weighbridge only) in 1965. These two sets of equipment formed the basis of the beet data collection machinery installed at

Paper presented to the 27th Technical Conference, British Sugar plc, 1984.

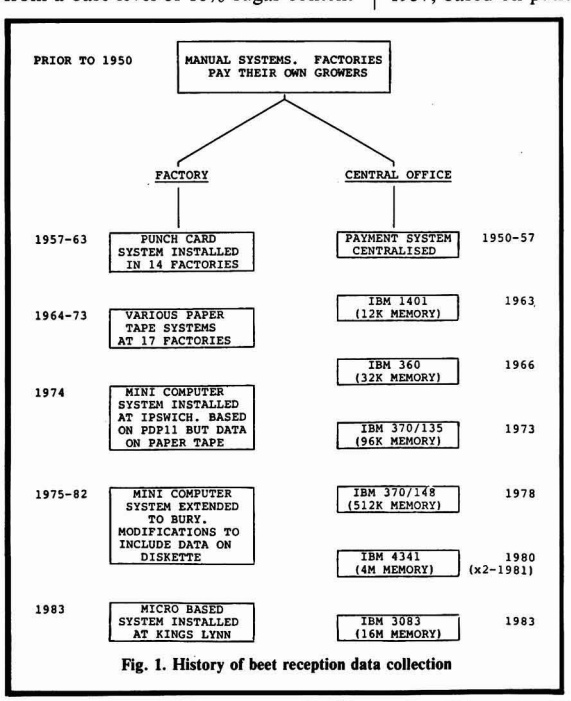


Fig. 1. History of beet reception data collection

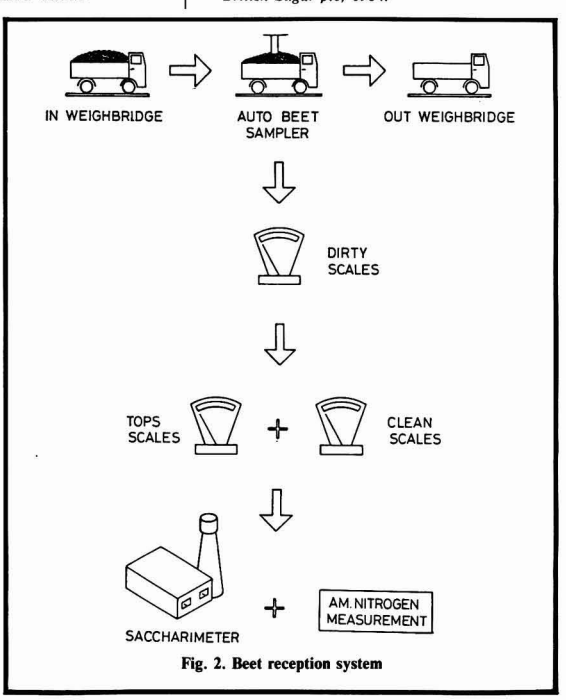


Fig. 2. Beet reception system

ISJ Abstracts

Cane sugar manufacture

Identification of the boiling process in pans

F. Herrera F. and F. Pérez R. *Centro Azúcar,* 1983, **10,** (1), 63-76 (*Spanish*).

Results of the application of a dynamic identification method to the process of crystallization in batch vacuum pans are presented. The method is based on the least squares theory; first the data are taken and the identification method applied, using a digital computer. The results are so good that they justify the use of the method in a control system for the process. A short summary of the method employed and the experimental data are presented, as is a mathematical model, based on the stochastic characteristics of the process, which may be used for its control. On analysis of the results it is concluded that the discrete dynamic identification method may be used in this case; this is justified, furthermore, by the great technical advances being made in the field of computational means, microcomputers, etc.

Digital simulation of pan control variants based on a linearized model

M. Rodríguez B. and M. García A. *Centro Azúcar,* 1983, **10,** (1), 77-88 (*Spanish*).

The results are presented of the digital simulation of different kinds of pan control, taking as the input variable the syrup flow and as the output variable the mass of the crystals, while supposing that the temperature and steam pressure were constant. The work starts from a linearized model of the pan and shows its behaviour in order to obtain desired variations in the mass of crystals with P and PD control, as well as the response to changes in steam pressure and massecuite temperature with these controls in the syrup feed loop. The effect of adding feed-forward control to the P and PD control was also considered. The types of control offering best results are identified from the curves obtained. The importance of digital simulation in the design and analysis of control systems is also emphasized.

Energy balance in a central refinery

L. Toledo, G., J. R. Taboada H., H. Pérez A., A. Toledo and J. A. Avadi. *Centro Azúcar,* 1983, **10,** (1), 103-115 (*Spanish*).

An analysis is presented of energy aspects of a combined sugar factory-refinery using design and operational data obtained during a period of two months in the 1981/82 season. This is complemented with visual analyses of the operation, showing the correspondence of these with the results obtained in the evaluation. Some factors which influence the thermal imbalance are discussed, analysing the same and proposing possible solutions for improving the energy operation of the factory.

Considerations on film evaporation in the sugar industry

M. J. Carrillo and N. Priadco. *Centro Azúcar,* 1983, **10,** (1), 117-124 (*Spanish*).

The application of film-type evaporators (mainly falling film) in the sugar industry is discussed, with the aid of a bibliography, and theoretical considerations which apply are summarized. Experimental equipment has been designed and is to be used for a rigorous economic analysis of the system.

Improvements in the design of clarifiers in Mexico and Nicaragua following the technology of the Oriente DTC clarifier

E. Díaz G. *ATAC,* 1983, **42,** (3), 45-51 (*Spanish*).

The Atlas DTC clarifier was designed in 1973 and numerous existing units in Cuban sugar factories were modified subsequently. The original design provided five chambers formed by the conical bottom of the tank and four conical partitions above, all at an inclination of 23%. A central tube was divided by vertical partitions into four channels, two of which were used to deliver juice through ports into each compartment just underneath the top of the clarifier and under each of the partitions. The other two channels also had ports into which mud passed from the top surfaces of the partitions. Angled collecting pipes at the periphery, beneath the conical partitions, received the clarified juice. The central tube carried arms with angled blades to direct the mud on the conical partitions towards the centre. The feed to the central tube was from an upper coagulation chamber with a diameter 40% of that of the clarifier. Diameter and height of the unit were equal, and 10-20 ppm of polyelectrolyte was used. Subsequent modifications in order to cope with higher milling rates involved sealing the central tube and providing a series of rectangular ports in the conical partitions, of increasing size from top to bottom, so that the mud descended through these to the sump from which it was removed. Clear juice withdrawal was through three arcuate pipes forming almost complete circles under each partition. In 1981 a Honiron clarifier at a Mexican sugar factory was modified in accordance with the DTC design; it resulted in a brilliant juice, a 2 points rise in purity and dense mud, obtained with a residence time of 15-22 minutes.

Cleaning of evaporators with acetic acid

R. Monduí G. and V. Palacio D. *ATAC,* 1983, **42,** (3), 52-58 (*Spanish*).

Comparisons were made between cleaning efficiency and corrosion caused by acetic and hydrochloric acids used at boiling temperature for scale removal from evaporators. The rate of corrosion by acetic acid (and also formic and propionic acids) was much lower than that by HCl and was reduced further by incorporation of

inhibitors, the best results being given in the presence of an unidentified "new inhibitor". Acetic acid removed 95% by weight of the scale in more than half of the samples tested.

Techniques for the support of the pan section in sugar factories

T. Díaz B. *ATAC*, 1983, **42**, (4, 5 & 6), 24-31 (*Spanish*).

Improvement in pan operation has been sought by establishing records of operational indicators, preparing control charts and applying operational strategies based on these. The system has been successful at five Cuban sugar factories.

Optimizing electrical power export by supervisory control

R. J. McIntyre. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 29-36.

Seventeen Queensland sugar factories regularly supply surplus electricity (totalling 33 GWh per year) to the state grid during the crushing season, and several others are considering the use of spare generating plant for power export in the future. The degree of control over power export levels varies widely between factories, and several have devised their own method of control, mostly based on the use of meter relays. An experiment using an Impac 80 microprocessor-based system was tested at North Eton to maximize the use of available HP steam for power export; the criterion used was the imbalance between HP and LP steam demands of the factory, i.e. the steam flow to the LP make-up valve. Details are given of the constraints to be observed, the steam balance as recorded in 1982, the schemes chosen for power control and reactive power control (the main function of the latter being maintenance of the voltage between limits prescribed by the electricity board) and their performances. Results indicated the suitability of the system, although it is expected that, in future, factories would employ less sophisticated and more economical programmable controllers for the purpose.

Preliminary measurements in the flame region of a bagasse-fired boiler

T. F. Dixon. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 165-171.

While combustion stability in bagasse furnaces is aceptable under normal milling operations when bagasse moisture levels are nominally constant, so that fully automatic operation of the boiler station is possible, recent investigations have shown that the bagasse moisture content at the furnace entry can vary by ±4 - 6% over a relatively short period during which milling performance may be considered normal, and short-term variations of this degree produce fluctuations in flame luminosity. As part of a wider investigation into bagasse combustion stability, measurements were made of gas temperature distribution, oxygen concentration distribution and carbon monoxide concentration, the aim being to characterize the furnace environment surrounding a bagasse stream from its initial entry into the furnace to the region of flaming combustion. The measurements, taken in a region adjacent to the bagasse inlet distributors, showed maximum gas temperatures approaching 1000°C, a less-than-optimum distribution of undergrate air flow to the furnace (suggesting a high degree of stratification between the high-temperature flame stream and the oxygen-rich front wall stream), and high CO concentrations across the whole of the furnace section (thought to be related to bagasse decomposition and a consequence of current bagasse firing techniques). The data demonstrated the influence of the front wall secondary air curtain on gas conditions adjacent to the bagasse stream and confirm previous findings of the limited benefit to combustion stability of this air curtain.

Milling train control at Fairymead

E. Troiani and G. N. McLucas. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 141-148.

A description is given of the programmable controller installed on the milling train at Fairymead with the object of improving performance under conditions of high and fluctuating crushing rates with vastly differing cane varieties. The scheme embodies a total of 12 loops for the control of cane feeding and preparation, mill speed, pressure feeder torque and maceration flow, while sequence control allows fully automatic starting and stopping of the train from the operator console, as well as overriding of normal loop control in the case of excessive deviations from set point. Feeder carrier speed is controlled as a function of cane height, while shredder speed depends on the variety and is so controlled as to prevent a high degree of preparation with e.g. soft-fibred cane and thereby avoid associated milling problems. The main carrier speed is set as a direct ratio to elevator speed, which in turn is controlled as a function of the cane level in the No. 1 mill chute. The speed set point for the No. 1 mill is constant and can be altered only through operator intervention, while the speed of the other mills in the train is varied by the controller to maintain an acceptable level in the feed chutes. The first and last mills each have pressure feeder tailbar torque control. Maceration has two levels of control: a basic scheme for maintenance of a fixed water flow rate regardless of fibre rate, and a higher level scheme which automatically adjusts the flow rate in order to maintain a constant maceration % fibre, the fibre rate being determined from the escribed volume and expected compaction at No. 1 mill. The overall control scheme has reduced

lost time and the final bagasse moisture content, has increased extraction and has the advantage of flexibility.

Cane diffusion control at Fairymead

R. C. Young and A. R. Teasdale. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 141-148.

In addition to the cane milling train referred to in the preceding abstract, Fairymead has two cane diffusers operating in parallel; the cane is carried to the diffusers from a shredder via a set of slides positioned above the head end of both vessels so that the flow is suitably split. Parameters controlled by a system installed in 1983 include cane feed rate via a set of hydraulically operated doors, shredder speed, diffuser bed height, maceration flow rate, dewatering mill chute height and dewatering mill torque. The programmable controller interlocks the conveyors feeding the diffusers, stops the first belt when the shredder speed is below a given preset value (whereupon the rate control doors close), stops the transport systems in the diffusers when there is no feed from the shredder and stops the feed conveyors when the cane levels in the feed chutes of both diffusers are too high, accelerates the diffuser transport systems in response to such a high level of cane, stops and starts the pumps responsible for liquid application to the cane beds in the diffusers as a function of the transport movement, and activates the press water pump and heating in accordance with chute height and dewatering mill torque. The control scheme has helped to reduce lost time and bagasse moisture, while providing slightly higher extraction and improved cane rate control as well as more consistent preparation levels.

Hierarchical control of the Fairymead extraction plant

G. D. Maclean and R. J. Swindells. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 157-164.

The hardware and software of the hierarchical control scheme installed at Fairymead for control of the cane milling and diffusion systems (see preceding two abstracts) are described. Central to the scheme is a mini-computer which communicates to five terminals, four printers and the two programmable controllers mentioned previously. With the communication system, every second the programmable controllers provide the computer with information on the status of the control relays, of the microprocessors in the controllers and of the microprocessor in each of the computer interface modules, and receive from the computer information on cane variety and crushing rate. Every minute, the computer receives process data from the programmable controllers on e.g. mill speeds, escribed volumes and tank levels; this information, together with data from the cane tracking system for juice sampling, is stored on disc. The overall control scheme supervises cane tipping as well as extraction by the mills and diffusers. The system has proved highly reliable. Future development plans are outlined.

The steam-cleaned stationary grate

P. W. Levy and D. A. Kenny. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 173-179.

The bars of a steam-cleaned stationary grate (also known as a pinhole grate) lie on a bed of spaced water tubes that are extensions of the normal steam/water circulation system of the boiler. Thus, the bars are cooled not only by the flow of combustion air but also as a result of heat conduction into the tubes supporting them. By comparison, grates used for suspension firing of bagasse are not insulated against heat radiated from the fire above, while the combustion air used to fire the bagasse has a high temperature. Details are given of the pinhole grates as installed at South Johnstone and Racecourse factories. Reference is made to the installation of a similar grate for the 1975 season at Laupahoehoe Sugar Co. in Hawaii. Advantages of the grate are discussed, and measures incorporated in the John Thompson unit at South Johnstone to prevent erosion of walls, tubes and hoppers by the jets of steam used to clear accumulated ash are described. Although detailed costing has not been carried out, the installation of a pinhole grate in an existing boiler is considered to be probably an attractive economic proposition.

Improvements in low-grade exhaustion at Pioneer mill

G. J. McGrath and M. W. Webster. *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 235-242.

Because of a steady increase in molasses losses over recent years at Pioneer, a detailed survey was conducted on the performances of the crystallizers, vacuum pans and centrifugals. The major cause was found to be poor exhaustion in the low-grade pans; however, tighter control of grain size, purity and Brix at dropping failed to give any improvement, although some success was achieved when the boiling was carried out at higher temperatures, although one disadvantage was the increase in mother liquor colour. A positive reduction in molasses losses was finally obtained by gradually lowering ("ramping") the conductivity set-point manually in three stages from a pan content of about two-thirds until Brixing-up; this improvement was sustained in the latter part of the 1982 season and continued during the entire 1983 season. The measure brought about improvement in all aspects of pan and crystallizer exhaustion, including crystal content and final molasses purity.

Beet sugar manufacture

Pulp pressing developments

D. A. G. Brown, W. Marsden and A. J. Randall. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 27 pp.

Experiments on the use of a drained spindle for beet pulp pressing are reported. The spindle, developed by Stord Bartz A/S, is so designed that the whole of the bottom surface of the flights is drilled with 1.2 mm holes which allow the press water to drain into an annular space running the entire length of the spindle. The water is collected at the wet pulp end of the press and discharged beneath the press tray. In the trials at York sugar factory, one of a battery of MS 64S variable-speed twin-scroll presses was fitted with drained spindles and its performance compared with that of an identical but unmodified press. The three parameters studied were: spindle rotary speed, dry solids of the pressed pulp and press throughput; particular importance was attached to the relationship between throughput and dry solids. An increase of 2.5-3.0% in dry solids was achieved by comparison with the standard press when fed with the same quantity of pulp; however, the capacity of the modified press fell with time for no explicable reason, although it is suggested that the metal surfaces became polished during a running-in process. Assuming a dry solids of 28% compared with 25.5% in a normal press and a wet pulp feed of 9.6% solids, a total energy saving of 5600 GJ would, it is calculated, be possible through the reduction in the quantity of water to be evaporated from pulp pressed at the rate of 20 tonnes/hr. The financial saving is estimated at £11,200, while the perforated spindles would cost an extra £20,000, or about half of the cost of a new pair of spindles. The question of spindles is discussed in regard to speed of rotation and water extraction. Observations confirmed that very little water is expressed in the final stages of the process, e.g. where the final dry solids content of the pressed pulp was 26%, dewatering to 21% solids occurred after the first seven turns of the scroll. Changes to the configuration of flight depths and pitches on a spindle have involved reducing the number of pitches, although a Babbini press has spindles carrying 21 flights. Comparison between the performances of a Stord and a Babbini press on the basis of the swept volume of the parallel sections of the spindles (after the tapered section) showed the Babbini press to have the larger volume; it was also found that pulp flow was considerably restricted by the last two turns of the scroll, a factor that is believed to be important for obtaining high dry solids content. Spindle design aims to give high water extraction at a low rotary speed; because of increasing fuel costs, it is considered economically preferable to run presses at lower speed, e.g. 2.0-2.5 rpm compared with 4.5 rpm in the case of MS 64S presses, which effectively doubles the residence time.

Sugar beet and frost damage in the Netherlands. A successful approach to prevent the delivery of frozen beet

L. H. de Nie, P. W. van der Poel and M. H. van de Velde. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 17 pp.

Waste water treatment plant in Holland has to be highly efficient to meet the requirements of the water authorities, and discharged effluent is also subject to a tax. The systems are designed to handle pollution loads equivalent to beet sugar losses of 0.1-0.2%, but frost damage can make beets susceptible to cell wall damage, even before severe deterioration, which increases the losses in the flume-wash water system and in turn can overload the effluent treatment plant. In addition, such deterioration will have an adverse effect on processing. An account is given of the procedure used by the Dutch sugar industry to control the delivery of frosted beet. Besides radio and television broadcasts giving advice on frost protection when severe frosts are forecast, clamps are inspected by sugar company staff — frozen material is declared unacceptable by the factory and has to be removed from the other beets. A further check is made in the tarehouse, where coloured photographs of model samples are used to indicate the degree of frost penetration. Three levels of damage are recognized: $<15\%$, 15-30% and $>30\%$ damage. If any deliveries include frosted beet, a fine is imposed on the farmer. Results for three campaigns up to 1983, during which the system has been in operation, are reported.

A new approach to full seeding

P. W. van der Poel, M. A. M. de Schutter, C. C. Bleyenberg and P. M. T. van Heeschvelde. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 29 pp.

In the 3-boiling scheme used as standard by CSM sugar factories in Holland, white sugar is boiled from standard liquor of about 92 apparent purity. Since the mother liquor purity is $\leqslant 85$, occlusion avoidance is necessary in order to maintain the colour and ash contents within the limits set by the soft drinks industry; no problems have arisen provided the standard liquor Brix is kept below 65°, but a higher Brix than this (up to 75°) is desirable from the energy point-of-view, and with rising Brix it becomes increasingly difficult to produce crystal of optimum uniformity. In the phase between seeding and attainment of a crystal size of approx. 200μm it has proved difficult to make rapid corrections to supersaturation so as to keep the water evaporation rate in balance with the crystallization rate, so that secondary nucleation has occurred. Details are given of a Coulter counter used in crystal growth and nucleation studies which is applicable for crystal sizes up to 300μm. Laboratory experiments were conducted on control

of crystal growth and secondary nucleation; results showed that it was impossible to achieve crystal growth without secondary nucleation, although this could be limited by reducing the volume of massecuite, while cooling was shown to be a highly effective means of establishing supersaturation. A pilot plant designed in collaboration with Süddeutsche Zucker-AG and constructed by Selwig & Lange GmbH was installed at Breda factory to produce enough seed magma for a 1st product strike of 90 tonnes. The process, controlled by the pan station computer and involving seeding with ball milled slurry, gave a crystal size of only about 100μm when cooling from 85° to approx. 75°C was used; an evaporation stage was required after cooling in order to give the requisite 200μm crystals. For this purpose, an external heat exchanger was installed. The magma was discharged to this for about 20 seconds' residence (to dissolve the fraction smaller than 2μm) and then recycled to the pan. Details are given of the stages in production of seed magma in a factory-scale plant at Halfweg factory which has operated over two campaigns, providing enough material for a daily white sugar production of 1000 tonnes. The system has contributed to energy savings, has almost completely prevented conglomeration, and has improved non-sugar elimination in the centrifugals, yielding a high-quality white sugar from a standard liquor of up to 75°Bx.

Application of numerical analyses for pan automation

P. Bonnenfant. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 30 pp.

When an increase in daily white sugar production was required without increasing the number of batch pans and using a feed of 74-76°Bx (for energy saving), it was necessary to have knowledge of the boiling times for a given white sugar M.A. and C.V. A mathemematical model of the boiling process was developed to calculate the optimum conditions. Details are given of the micro- and macro-kinetic elements included in the model, and of the operational variants involving 30 parameters. It was found that, to obtain a M.A. of 0.65, a boiling time of 3 hours 15 minutes was needed when the standard liquor Brix was 75°. Since this was too long, and steam flow after seeding was sufficiently low (2 tonnes/hr) to give problems, the possibility of using magma seeding was considered. Instead of 600 g of seed of 10μm particle size, 490 kg of 145μm seed was chosen; this represented 1.7% crystal content immediately after seeding and allowed a rapid increase in steam flow, cutting the boiling time by ½ hour. Feeding was carried out in three stages. The boiling patterns for the variants studied are plotted.

Effect of flocculants on enlargement of 1st carbonatation mud particles

T. N. Samoilova, D. Khainike and I. F. Bugaenko. *Sakhar. Prom.,* 1984, (6), 26-28 (*Russian*).

Tests to determine the effect of flocculants on carbonatation mud particle size involved addition, as 0.1% solutions, of polyacrylamide and active silicic acid, individually, to unfiltered 1st carbonatation juice at 0.005% by weight. Microscopy was then used to determine the mean particle diameter in each of the samples diluted 1:50 with distilled water. Untreated juice contained mostly particles measuring 5-25μm, while the range was mostly 40-72μm after treatment with polyacrylamide and 166-400μm with silicic acid. The major effect of the flocculants was to reduce the number of particles in the 5-10μm range, thereby providing a clear juice after 30 minutes' settling rather than a somewhat turbid juice. The form of the aggregated particles depended on the flocculant used: in the case of polyacrylamide they were extended chains, whereas use of silicic acid gave a more compact form, with lengths and widths approximately the same.

Raising the efficiency of sugar crystallization by use of magnesium sulphate

V. S. Shterman, V. I. Smagina, M. S. Zhigalov and L. S. Khodakova. *Sakhar. Prom.,* 1984, (6), 28-30 (*Russian*).

Investigations were conducted on the use of Mg sulphate to reduce sucrose solubility in molasses. The sulphate, at 1.4% on weight of molasses, was added to 100 g samples of 80, 82 and 84% dry solids together with 40% crystal sugar. After 10 hours' intensive mixing at 40°C, the artificial massecuites were centrifuged at 3000 rpm and the run-offs analysed for refractometric dry solids, sucrose, K and Mg salts and viscosity. Results showed that the run-off viscosity after Mg sulphate addition was higher and the purity approx. 3.5 units lower than for the control; sulphate treatment also reduced standard molasses viscosity by 2.6-3.3%. Further experiments to determine sucrose and Mg sulphate distribution between solid and liquid phases during crystallization involved the use of detachable, cylindrical brass vessels placed one on top of the other and separated by a metal centrifugal screen which was initially covered with a plastic film. The "massecuite" was placed in the top vessel and mixed thoroughly during 12 hours at 40°C, after which the plastic was removed and the massecuite centrifuged. The amount of run-off was found from the difference in weight of the lower vessel before and after the experiment. Similarly, the amount of crystal sugar was found by weighing the upper vessel with its contents. Calculations, allowing for the mother liquor adhering to the crystals, demonstrated the salting-out effect of Mg sulphate, which is therefore recommended as an additive for low-grade massecuite at 0.5-1.0% by weight.

Evaluation of the throughput of continuous centrifugals from basic design parameters of the basket

S. V. Danilin. *Sakhar. Prom.*, 1984, (6), 30-33 (*Russian*).

The performance data for 17 Soviet and imported continuous centrifugals were analysed statistically in order to compare their hourly massecuite throughputs. The data were collected from catalogues, experimental results and technical publications. Tabulated values for a Silver 3630, a BMA K-850, Fives Lille-Cail FC 1000, Buckau-Wolf C-1100, Hein, Lehmann Konti-10, a Bosco B5-C, a Sangerhausen machine built under licence from Bosco, and a Soviet FVIl-1061 K-2 centrifugal showed that the Bosco machine had the greatest throughput, followed by the Soviet machine and then the Sangerhausen. Design throughputs are also indicated in most cases. However, it is admitted that the intensity of the centrifugal force field will have a greater effect on throughput than will the surface area of the centrifugal screen, all other conditions being equal, so that the calculated throughputs can only be regarded as approximate, although they could be used for preliminary evaluation of centrifugal capacity. However, with a higher value of the mean field intensity, centrifugal throughput will increase, and the difference will be greater with increase in rotary speed and with changeover from handling of easily separable products such as *B*-massecuite to more difficult material such as low-grade massecuite.

Effect of sucrose crystal dimensions on its linear rate of growth and dissolution

L. I. Trebin, Yu. I. Skripko and I. G. Bazhal. *Sakhar. Prom.*, 1984, (6), 33-35 (*Russian*).

Experiments to establish the quantitative relationships between the linear dimensions of a growing or dissolving crystal and its initial size are described. The mean weight of 50 crystals measuring approx. 1 mm was determined, and a further 250 crystals measuring 1-5 mm were weighed, and all 300 crystals (weighing a total of 1.924 g) heated at a constant 70°C before being placed in a 1-litre flask together with 1 kg of saturated sugar solution. The flask was then rotated about its own longitudinal axis at 6 rpm so that the crystals remained approximately in the same position relative to one another and to the mother liquor. The temperature was allowed to fall automatically at a rate of 0.01°C per minute for 420 minutes, after which the crystals were separated from the mother liquor by vacuum filtration, washed with sugar-saturated alcohol at 70°C, dried and weighed. The size (mm) and surface area (mm^2) of the crystals were determined as a function of weight using the Kukharenko formulae. A similar series of experiments involved heating the crystals for 80 minutes instead of cooling. The results, demonstrating linearity between the initial and final crystal dimensions, are discussed. Statistical evaluation allowed for proportionality between the weights and surface areas of the crystals. Calculated values obtained by mathematical simulation of mass transfer between liquid and solid phases were in close agreement with the experimental results.

Heat calculations of vacuum pans

I. S. Gulyi, A. G. Scherbatyuk and B. V. Kuz'menko. *Sakhar. Prom.*, 1984, (6), 52-53 (*Russian*).

An earlier method developed by Popov for calculation of heat parameters in boiling was based on division of the process into n theoretical sections (comparable to the theoretical plate approach for distillation calculations) and the parameters found for each section; although increase in Brix between each section falls with increase in n, so that the heat transfer coefficient will be calculated more accurately, the method is considered cumbersome. A method is described which uses formulae, based on Popov's work, to calculate the mean integral of the heat transfer coefficient in *A*- and *B*-massecuite boiling. Use of the method is explained by means of an example concerning a five-sectioned continuous vacuum pan. Results of the calculations indicate the closeness of the pan in question to an ideal displacement vessel in which changes in concentration are sufficiently smooth to cause smooth changes in the heat transfer coefficient.

New regeneration system for softener resin in a beet sugar factory

S. Oikawa, Y. Senba and T. Muratsubaki. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1984, **33**, 43-48 (*Japanese*).

NaCl used for regeneration of ion exchange resin employed in deliming of 2nd carbonatation juice increases the pollution load of the regenerant effluent. The problem can be overcome by application of a regeneration system using NaOH dissolved in thin juice, and investigations showed that such a sucrose-NaOH system is superior in regard to regeneration efficiency, probably because of the higher calcium solubility and the complex interaction between the sugar and Ca. However, it was found that a system involving concentrated Steffen filtrate (CSF) was even better, since it was comparable in respect of regeneration efficiency while producing no waste water. CSF typically contains 6.83% K and 1.53% Na, and at a 1N (Na+K) concentration and a CSF:resin volume ratio of 3:1 regeneration efficiency exceeded 90% at 20°, 40° and 60°C. In the proposed scheme, the CSF is withdrawn from the evaporator to a feed tank, thence to the resin column (rinsings being added between the tank and column), from which the effluent is returned to the Steffen filtrate before carbonatation. The deliming resin is rinsed and sweetened-on and off as normally.

Sugar refining

Programmable control at the C and H sugar refinery

D. Mosher. *Paper presented at 43rd Ann. Meeting Sugar Ind. Technologists,* 1984, 13 pp.

Five examples of programmable controller application at Crockett refinery are described: (1) control of bone char slurry conveying from the regeneration furnace to the decolorization filters, (2) control of the warehouse palletizing system for packaged sugar (ultimately 10 programmable controllers will replace 1500 relays), (3) monitoring of power consumption throughout the refinery, (4) automation of the liquor/syrup continuous blending station, for which the programmable controller is coupled with a computer; the latter device acts as operator interface, continually selecting the blend composition and determining the flow rate for a given blend on the basis of liquor inventories, this information being transferred to the controller. The computer also generates hourly reports. (5) Use as a standby facility to control affination syrup feed to the mingler in the melt house and hence liquor density in the event of a breakdown of the computer; because of its age, the computer has been subject to failures of increasing frequency.

Supervisory control and data acquisition for process control at Imperial Sugar Company

B. Harrison and J. Ruzicka. *Paper presented at 43rd Ann. Meeting Sugar Ind. Technologists,* 1984, 17 pp.

Details are given of the distributed control systems involving programmable controllers installed in the filter-press and affination centrifugal stations at Imperial Sugar Co. Some of the equipment requirements considered prior to purchase are listed, and a layout diagram of the SCADA (Supervisory Control and Data Acquisition) control scheme is presented. The stages leading to final conversion to the new schemes are described, and the resulting benefits are indicated. During 20 months of operation of the filter station there have been no failures of the programmable controllers or production losses, while the non-filtration stage of the filter cycle has been reduced by 40%, resulting in increased throughput capability.

New resin decolorization station at Finnish Sugar Porkkala refinery

L. Ramm-Schmidt and G. Hyöky. *Paper presented at 43rd Ann. Meeting Sugar Ind. Technologists,* 1984, 19 pp.

At Porkkala, both beet and cane raws are refined, but separately because of the lower pol and higher colour content of the cane sugar, which has to be affined, carbonatated and filtered, while the beet sugar is only melted but not affined (because of its very small crystal size) nor carbonatated. Previously, both had been treated by four pressure leaf filters precoated with a kieselguhr/powdered carbon slurry, followed by decolorization with resin, but with replacement of the 6-m^3 resin columns by three pairs of 8-m^3 columns in series there is no need to treat the beet liquor with carbon, while the carbon consumption for the cane liquor has been reduced. In two of the pairs of columns, the first column is filled with acrylic resin and the second with styrene resin; in the third pair, both columns contain styrene resin. Normally, two lines are operating while the third is being regenerated or is on standby. Details and a diagram are given of the columns; these have flat bottoms which prevent the occurrence of dead spaces and of microbial growth while obviating the need for a gravel or nozzle plate. Compressed air forces the liquor down onto the resin surface before the sweetening-on and -off stages and is also used in regeneration. Advantages of the new column design, as established in trials with a test unit and as found in operation of the new station, are listed. Tabulated data show a lower colour content in each of the crystal products from the four strikes boiled from cane syrup by comparison with the previous system.

Technology, quality and uses of sugar and alcohol produced in Brazil

D. G. Quast, J. M. M. Borges and M. Sobral. *Paper presented at 43rd Ann. Meeting Sugar Ind. Technologists,* 1984, 18 pp.

A survey is presented of the types of sugar produced in Brazil, with particular mention of the main one used by the beverage and food industries, namely plantation white sugar, of which there are three grades. Some 70% of the output of sugar factories is white sugar, while a small but increasing amount of refined sugar is being produced directly at factories; advantages are lower energy costs by comparison with autonomous refineries (because of the availability of bagasse) and the convenience of using residual syrups for alcohol manufacture, while disadvantages are seasonality and smaller scale of operation than in autonomous refineries. Both "amorphous" and granulated refined sugar are produced in Brazil, the former type being the main product from the autonomous refineries. However, while its colour is lower than that of the top two grades of plantation white sugar, it is of lower pol and has a comparable conductivity ash content and a much higher moisture content. Details are given of the types of alcohol produced from cane in Brazil and of its uses, and the economics of sugar and alcohol are considered. Future developments envisaged in the Brazilian sugar industry include improvement in energy management at sugar factories and in the quality of white sugar, and bulk storage and transport of sugar (at present all white sugar in Brazil is stored and shipped in 50-kg cotton bags).

Laboratory studies

Factors affecting white sugar colour

M. Shore, N. W. Broughton, J. V. Dutton and A. Sissons. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 115 pp.

Investigations into factors affecting white sugar colour are reported. Gel permeation chromatography (GPC) was used to fractionate laboratory-prepared synthetic colorants. Melanoidin-type colorants were of relatively high molecular weight (mostly greater than 1000 but no greater than 5000), while caramel-type colorants were of significantly lower M.W. (mostly up to 1000). GPC of factory juices and sugars revealed the presence of materials having a low M.W. (<100), medium M.W. (100-1000) and a high M.W. (1000-5000). Relatively large quantities of the last category were found in raw and after-product sugar as well as molasses. The high M.W. materials found in raw and after-product sugar may be incorporated preferentially into the white sugar crystal; GPC of colour extracted from white sugar showed that colorants of high M.W. are found only inside the sugar crystals, while those of medium and low M.W. occur both inside and on the surface. Infra-red studies of colorants isolated from juices and sugars confirmed the presence of melanoidin- and caramel-type materials. Most of the colour in white sugar was found to be distributed evenly throughout most of the crystal. The colour content could be reduced by an average of 25% by dissolving 20% of the crystal, but further dissolution produced no greater improvement in colour. This applied to sugars of both high and low colour content, indicating that the "extra" colour in a sugar of high colour content is not specifically located in the surface layers but is evenly distributed throughout the crystal, so that high M.W. colorants would appear to be responsible for most of the white sugar colour. Comparison of results of GPC separation of beet sugar colorants with process juice colorants showed similarities between "outer" white sugar colorant and standard liquor and between "inner" sugar colorant and molasses, showing that the colorant material on the crystal surface results from a residual film of standard liquor, whereas the colorant materials inside the crystal are derived from the components found in the later processing stages, e.g. raw and after-product sugar, the colour of which could be reduced by up to 85% by dissolving up to 30% of the crystal. Thus, the distribution of colour in these sugars was quite different from that in white sugar. A method has been developed for determining a factory "colour balance"; it facilitates calculation of the respective contributions of reactions and process liquors and sugars to the colour of factory juices. Much colour was found to be returned to process with remelt sugars and wash syrups. HPLC studies of polyphenolic compounds in process juices have shown them to be present in raw juice only, so that colour formation from such precursors later in the process is unlikely. Raw juice treatment with SO_2 and H_2O_2 was found to improve the colour. On a factory scale, reduction in juice and white sugar colour has been brought about by raw juice aeration and application of increased oxygen levels in carbonatation. Lower juice and white sugar colours was also effected by reducing the formalin dosage in diffusion. At >30°C the colour of white sugar increased markedly during storage; sugars stored for 200 days or more at 50°C exhibited a colour increase that was at least 100%. The colour was formed throughout the crystal and not exclusively in the surface layers, since washing experiments indicated the same distribution of colour in the crystals of sugar stored at room temperature. The presence of SO_2 at about twice the current legal limit of 15 ppm would have inhibited the increase in colour.

Nitrogen fertilizer control by amino-nitrogen measurements

M. Shore, N. W. Broughton, J. V. Dutton and G. I. Bowler. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 43 pp.

Analysis of tarehouse samples of beet for amino-nitrogen as a means of assessing N fertilizer usage was introduced at two British Sugar factories during the 1981/82 campaign, since when the program has been extended. The ninhydrin method of Carruthers & Oldfield[1] had been developed by DDS into an automatic analysis system which was initially used by British Sugar, but this method gave results which were on an average 25% lower than those given by the original manual method. A modified form of the DDS procedure proved unsuitable for routine application because of its complexity, the need for manual loading of the sample and an excessive time delay before results were available. Therefore, a much simpler and more effective automatic system was developed on the basis of the Kubadinow & Wieninger modification[2] of the Stanek & Pavlas "blue number" method[3]. Laboratory comparison of the methods showed that the blue number method, using a 2:1 sample:reagent ratio and compensating for sample blank, gave a result which was on average 5-10% greater than the value given by the ninhydrin autoanalyser; this results was comparable to the relationship between the values given by the original manual ninhydrin method and those obtained by the British Sugar autoanalyser method. However, neither the ninhydrin nor the blue number method can be considered absolute, since each determines the combined colorimetric response of at least 20 different amino-acids, the individual concentrations of which vary as well as their reactivities. The amino-acids are however

1 *I.S.J.*, 1961, **63**, 103-105.
2 *ibid.*, 1972, **74**, 120.
3 *ibid.*, 1959, **61** 44-45.

sufficiently similar for their collective determination to yield a useful parameter. Although the blue number method tends to exhibit more variation than the ninhydrin method, its accuracy is more than enough for tarehouse determinations. Results of tarehouse investigations into method suitability for routine use confirmed the laboratory findings and the applicability of the blue number method, which gives an immediate results in contrast to the 10-12 minute delay with the ninhydrin method. Hence, the automated blue number method is to be used exclusively for future amino-nitrogen analyses in British Sugar tarehouses. Results obtained and their use as a guide to nitrogen fertilizer application on different soils in the UK are discussed. Tests demonstrated the relationship between amino-N and crop net value, i.e. maximum financial return, and pointed to the deleterious effect of excessive N application.

Development and utilization of quality criteria for sugar beet in Austria

G. Pollach. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 22 pp.

The author shows how, after a period of steady decline in beet quality in 1960/70, the Austrian sugar industry has become the leading European country for white sugar yield per hectare. Details are given of the beet payment system used, which is based not on actual sugar content but on the average sugar content of all Austrian beet, with a premium being paid for beet of higher quality. Beet quality assessment is based on the amino-nitrogen content and the alkalinity coefficient (molar ratio of alkalis to amino-N) as well as the purity coefficient as obtained from thick juice purity and beet Na, K and amino-N contents. From the ratio between alkalis and sucrose in molasses, formulae have been derived for calculation of molasses sugar from beet data for use where the alkalinity coefficient is <1.8 or $\geqslant 1.8$. The incentives to improve beet quality are discussed.

Sucrochemistry. XI. A simplified equation for determining the gas-liquid chromatographic response calibration value K for carbohydrates

L. Poncini. *Fiji Agr. J.,* 1982, **44,** (1), 37-40; through *Food Sci. Tech. Abs.,* 1984, **16,** (3), 3L168.

A simplified equation for determination of the GLC response calibration value K is reported, together with experimentally determined K values for common sugars. This equation is suitable for a linear calibration response up to an experimental sugar:standard sugar ratio of 5, and facilitates the reliable and rapid standardization of GLC detectors.

Simultaneous spectrophotometric determination of fructose and glucose in mixtures

D. Miljkovic, N. Kuojevic, M. Popsavin and M. Miljkovic. *Glas. Khemijsk. Drush. Beograd,* 1984, **49,** 247-250.

Known spectrophotometric procedures for determination of fructose in the presence of glucose involve complicated equipment and/or expensive reagents. Investigations to find a new method showed that the two sugars could be determined together or individually in aqueous solution of pH 10.7 by oxidation with potassium dichromate for 2 hours at 90°C in the presence of sodium carbonate, the absorbance then being measured at 370 nm. For selective determination of fructose, the solution was maintained at pH 6 with a phosphate buffer and potassium dichromate used to oxidize the fructose for 2½ hours at 90°C, after which absorbance was read at 355 nm; the dichromate did not react with glucose under these conditions. The methods were accurate to within ±2% for total sugars or ±3% for fructose.

Trace components in sugars. III. Determination of Cu, Pb and Mn by the gel co-precipitation method

S. Saito, T. Miki, H. Ito and M. Kamoda. *Proc. Research Soc. Japan Sugar Refineries' Tech.,* 1984, **33,** 38-42 (*Japanese*).

A simple and rapid method was developed for the determination of Cu, Pb and Mn in sugars. The procedure was as follows: a 15-30% sugar solution was prepared and its pH adjusted to 5.3-5.4; 25-30 ml of the solution was mixed with 2.0 ml of 6% DDTC solution and 0.3 g of silica gel. After standing for 1 hr at room temperature, the mixture was centrifuged at 17,000 rpm for 20 min at 15°C. The precipitate was dissolved in 10 ml of 15% nitric acid and then filtered through Toyo Roshi No. 7 paper, and the filtrate subjected to atomic absorption spectrophotometry. Recoveries ranged from 95.9 to 100%. Comparison was made with the dry ashing method for raw sugar, raw-grade liquid sugar, cane and refinery molasses.

Polysaccharides in cane granulated sugars removed by ultrafiltration

T. Miki. *Proc. Research Soc. Japan Sugar Refineries' Tech.,* 1984, **33,** 75-78 (*Japanese*).

The polysaccharides in cane sugar samples were removed by ultrafiltration and their component investigated. A galactomannan that contributes to acid-floc formation in carbonated beverages was removed completely from a floc-positive sugar by the ultrafiltration, which also removed polysaccharides from floc-negative sugars; these polysaccharides mainly consisted of starch and dextran present at a total content of 18-100 ppm. However, neither starch nor dextran seemed to play an important part in floc formation.

By products

Quality aspects on fodder products from beet pulp

J. Tjebbes. *Paper presented to 27th Tech. Conf. British Sugar plc,* 1984, 17 pp.

Most of the beet pulp at Swedish sugar factories is mixed with 50% molasses, dried and pelleted, providing a fodder of 25% total sugar (as invert) and 9.5% raw protein. Two major problems experienced by users of the pulp nuts of high molasses content are hardness and bridging in storage tanks. Tests were conducted on addition of 1st carbonatation mud or fat to the pulp. Addition of up to 5.7% carbonatation mud before drying had no effect on hardness but did cause appreciable increases in dust emission resulting from the lime particles. On the other hand, addition of up to 8% fat after drying reduced hardness dramatically, increased hourly throughput of the pelleting presses, reduced power consumption (since the fat was water-free, less evaporation was needed to give the same total sugar content per kg of pulp) and decreased bridging from "severe" to "reasonable". A combination of straw and fat was also found to have positive effects as additive. With both carbonatation mud and fat as additives, the pulp showed high resistance to handling.

Molasses, pulp and (beet) tops—an important reserve in deciding the production program

T. P. Khvalkovskii. *Sakhar. Prom.,* 1984, (6), 54-55 (*Russian*).

In the USSR, methods for sugar recovery from molasses and for utilization of molasses non-sugars are not used for various reasons. Molasses is used as feedstock in a number of industries and as animal fodder, but there is a need for greater study of potential uses of molasses, particularly cane molasses, on a grander scale than hitherto. The value of beet tops as animal fodder is discussed. Mention is also made of the use of refinery molasses in the confectionery and baking industries. It is pointed out that factories pay inadequate attention to the question of molasses and pulp quantities and monetary value, which can be balanced against the cost of beet, and recommendations are made on improvement in balancing and bookkeeping to allow for the by-products.

Molasses in animal feed

F. Morel d'Arleux. *Sucr. Franç.,* 1984, **125,** 209-212 (*French*).

After summarizing the chemical composition of beet and cane molasses, the author discusses the energy and nitrogen values of molasses and its use as fodder for cattle, sheep, goats and horses. The economics, storage and distribution are briefly considered.

Biotechnology: a particularly fruitful and promising area of research

B. Genesté. *Sucr. Franç.,* 1984, **125,** 213-228 (*French*).

A general survey is presented of fermentation processes in a number of industries, with an indication of end-products, raw materials and micro-organisms, yeasts and enzymes involved.

Raw materials used as fermentation substrate by the Rhône-Poulenc Group

B. Genesté. *Sucr. Franç.,* 1984, **125,** 229 (*French*).

A brief account is given of the raw materials used by Rhône-Poulenc for the manufacture of antibiotics, vitamins and vaccines. Annual consumption of sucrose equivalent is 30,000 tonnes, and half of the carbohydrate used is in the form of molasses, although starch and its derivatives can be used, the process always being based on glucose conversion by a micro-organism. Mention is also made of a process currently being developed for lysine manufacture from molasses using *Corynebacterium glutamicum* to metabolize the glucose and sucrose.

Molasses: sodium glutamate production at Orsan

C. Renaud. *Sucr. Franç.,* 1984, **125,** 231-232 (*French*).

A short account is given of the principal steps in monosodium glutamate (MSG) manufacture from beet molasses at the Nesle plant of Société Orsan. Molasses quality criteria are indicated, and it is reported that since 1976 there has been a clear fall in performance as a result of decrease in molasses total organic N, increase in unfermentable organic acids and the use of additives in sugar manufacture such as anti-foam agents, bactericides, sequestering agents and viscosity-reducing surfactants; the last have the greatest adverse effect, a fact that partly explains difficulties encountered in the use of Quentin molasses. Advantages of beet molasses as raw material are given as its good storage properties (storage is possible at ambient temperature without affecting stability), low costs and possibility of using the unfermentable residue for other purposes. Disadvantages include variability of composition between years at the same sugar factory and between factories (the company draws its supplies from 15-20 sugar factories) and tying up of money in storage of 80% of the annual requirements. There is a constant effort to find different raw materials as substrates.

Molasses: utilization at Eurolysine

J. L. Bréhant. *Sucr. Franç.,* 1984, **125,** 233-235 (*French*).

Information is given on the manufacture of lysine hydrochloride from beet molasses at Société Eurolysine, a company created as the result of a joint venture between Ajinomoto Co. and Société Orsan. The difference between "slow" and "fast" molasses is explained: slow molasses is of lower productivity but gives a good

yield, while fast molasses has a higher productivity but gives a lower yield. The negative effect of bactericides, sequestering agents, viscosity-reducing surfactants and anti-foam agents used in sugar manufacture on lysine fermentation is discussed, and mention is also made of problems associated with increased calcium in the molasses (e.g. >0.2% w/w as frequently found with the Gryllus process) and with inadequate nitrate content in Quentin molasses to inhibit the corrosive effect of Cl^- ions in multiple-effect evaporation (the typical content is only 0.1-0.15% NO_3^- w/w compared with 0.2-0.3% w/w in conventional molasses).

Citric acid production by Société Leasaffre Frères

F. Lesaffre. *Sucr. Franç.*, 1984, **125**, 237 (*French*).

The company in the title is the only citric acid manufacturer in France, where some 10-11,000 tonnes is sold each year. Production has risen progressively and is expected to reach 1500 tonnes per year in the near future; current beet molasses consumption is approximately 3200 tonnes per year. The factory uses surface fermentation to manufacture the acid in the form of monohydrate crystals.

The liquid concentrates resulting from beet molasses fermentation

G. Deleplanque and G. Maindron. *Sucr. Franç.*, 1984, **125**, 239-247 (*French*).

Flow sheets are presented showing (i) the derivation of vinasse as a waste product from molasses fermentation and (ii) its concentration and treatment. Information is given on the physico-chemical properties and chemical composition of the liquid concentrate from normal and from Quentin molasses, showing a solids content ranging from 60 to 70% but usually about 65%. The vinasse has applications as animal fodder (particular mention is made of its incorporation in beet pulp silage as protein source), as fertilizer (mainly because of its K and N content but also because of the 2-3% Na it contains), for agglomeration of various materials such as straw, paper, sawdust, etc., and for brick and tile manufacture.

Vinasse boosts straw breakdown

J. Cannstetter. *The Furrow*, 1984, **89**, (3), 20-21.

A brief account is given of trials in West Germany on use of vinasse as fertilizer and soil conditioner at the rate of 4 tonnes/ha, and mention is made of growing interest in this use of vinasse in Belgium, Italy and Austria. It is pointed out that vinasse has been used widely in French agriculture over the past 20 years.

Manufacturing conditions of melibiose

M. Maekawa, K. Sayama, T. Kawamoto and S. Oikawa. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1984, **33**, 64-71 (*Japanese*).

A pilot plant at the Research Centre of Nippon Beet Sugar Mfg. Co. Ltd. has produced about 5 tonnes of raffinose since its installation in 1979, but the market for the sugar is very small despite efforts to develop new fields of application. An investigation was therefore conducted on production of melibiose from raffinose using a yeast culture and an HPLC method with a strongly acid cation exchange resin in H^+ form. The fermentation method proved to be more practical and gave higher quality melibiose than the HPLC method. A melibiose yield of 14.2% was obtained after 6 hours. Melibiose, which sells at a higher price than raffinose, has been reported to be a successful anti-cancer agent.

Energy generation through distillery effluent treatment

S. H. Godbole. *Maharashtra Sugar*, 1984, **9**, (7), 9-12.

The composition and pollution load of vinasse are indicated, and means of treating it described. Of these, two are beneficial in reducing the pollution and at the same time providing energy, either in the form of steam from the incineration process or in the form of methane from anaerobic fermentation.

Stabilizing sugar production by total diversion of bagasse for paper manufacture

R. Srinivasan. *SISSTA Sugar J.*, 1983, **9**, (4), 7 pp.

The author calculates the economic advantages of (i) using the surplus bagasse from a factory crushing 1250 tcd to produce power for sale to the public utility (based on a crushing season of 180 days), (ii) using the surplus bagasse for pulp and paper manufacture, and (iii) burning coal instead of bagasse and using all the bagasse for pulp and paper manufacture. He shows that the extra profit over conventional factory operation is lowest and only marginal in (i), in (ii) is double that obtainable in (i), while in (iii) the extra profit is more than 7 times that in (i). Other advantages of scheme (iii) are noted.

all seventeen factories by 1973.

In the early 70's it was decided to examine the possibility of combining the weighbridge and tarehouse into one system taking advantage of the mini-computer technology which had by then become both reliable and relatively cheap.

Ipswich factory was chosen for the installation of the system (based on a Digital PDP11) in 1974. Although there were advantages, some significant problems were introduced by:

(a) the dependence upon one computer for the whole process,
(b) The complexity of software, owing to a desire to obtain many potential benefits,
(c) integrating features from the original system, in particular the documentation.

The mini-computer system, besides accepting the information from weighbridge and tarehouse, offered additional facilities to supervisory personnel. These facilities included inspection of the mini-computer database to check on collected station data and the production of a daily "beet balance" report based on a mathematics package included in the system.

By the early 80's the mini-system had been refined to include the use of micro-computers controlling the weighbridge stations and the collection of the data onto diskette. This feature had been incorporated because failures of the mini-computer had led to weighbridge traffic holdups.

The diskette was favoured by the central data processing department because of slow data input rates and general difficulties in reading the paper tapes used in beet reception systems. (It may be mentioned that paper tape reading proved significantly troublesome during the 1983/84 campaign.)

In its final form the mini-computer system at Bury and Ipswich factories was invaluable in helping to formulate the system specification for the next generation of equipment based upon micro-processors.

One of the most important areas where essential experience was gained at Bury and Ipswich concerned regulations applied by the Department of Trade (i.e. the National Weights and Measures Laboratory) to computer-based data capture from trade weighing devices.

Reasons for developing a new system

The most significant reason for needing to develop a new data collection system was the obsolescence of existing equipment.

System failures, even short-term, create unacceptable problems simultaneously in several areas. Operationally, factory yard traffic congestion occurs which can soon affect local highways. Extra beet reception personnel are required to create emergency handwritten data records. Subsequently further problems occur in the chain of data handling, in particular an increased workload for the computer services department. The potential risk of this happening simultaneously at a number of sites was considered to be unacceptable.

Agricultural personnel have been critical of the long delays that can occur in receiving management reports. This results in inefficient control of load quality.

From a company viewpoint, whilst the development of the mini-computer system had achieved its goals, a number of aspects were unsatisfactory. The reliance on one processor caused system availability problems, the long-term supply of systems and the service were suspect and there was an increasing demand that British Sugar should have complete control over the application software employed.

Development of a new system had to take the following points into account:

(a) Resilience to hardware failures should be built into the system by use of distributed micro-processors.
(b) The hardware technology should be such that first line maintenance by factory personnel would be possible to ensure system availability.
(c) A standard system had to be installed at all sites so that software maintenance problems would be minimized.
(d) Long-term availability and serviceability of hardware and software products should be realized by the chosen supplier.
(e) The developed system should be compatible with the wider company policy on computer networking and distributed data processing.

Project resourcing

The need to develop, install and replicate a system in a relatively short time had been identified. Time was of the essence both because of current obsolete plant and the need to replicate a new system with hardware the lifetime of which was not dated in a fast-moving technology area. In order to achieve that objective the "Task Force" concept was applied to the project resourcing.

Figure 3 illustrates the number of departments involved with the operation of the data collection system. Functional requirements for the new system were debated and agreed by heads of departments.

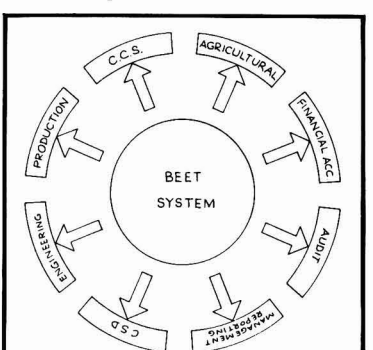


Fig. 3

A "Task Force" was created, consisting of personnel with considerable knowledge in the development of previous systems, and charged with the responsibility for developing a new system within

identified time-scales and with specified system objectives.

Documentation and peripheral equipment

Documentation

A requirement of the new system was that an automatic reading technique be employed for data entry. This was particularly important at the weighbridge station where operator fatigue, a result of large volumes of keyboard entries, had previously led to problems.

Two methods of automatic reading, *viz.* magnetics and optical bar coding, were investigated. Optical bar code reading was chosen for a number of reasons, the most significant being the ready availability on the market of low-cost bar code reader terminals that could be easily interfaced to micro-computer equipment.

Bar coded documentation also lent itself to automation of the beet delivery control scheme employed by agricultural staff at each factory which required a high level of manual effort during the campaign.

The grower delivery document used in the new system consisted of a permit card encoded with the grower's contract number and an adhesive authority-to-deliver label, as illustrated in Figure 4. The new form of sample stub cards which were issued at the weighbridge consisted of plastic encapsulated bar coded cards as per Figure 4.

The peripheral equipment

In the case of King's Lynn factory the combination of

(a) weighbridge equipment which would not pass Department of Trade tests for weighing equipment when attached to computers,
(b) the decision to replace tarehouse bench scales in parallel with the new data system, and
(c) some small changes in beet reception procedures

ensured that, with the exception of the saccharimeters, all the measuring instrumentation interfaced to the system would be new. It was decided at an early stage that the interfacing would be of the 20 mA loop type to normal industrial standards.

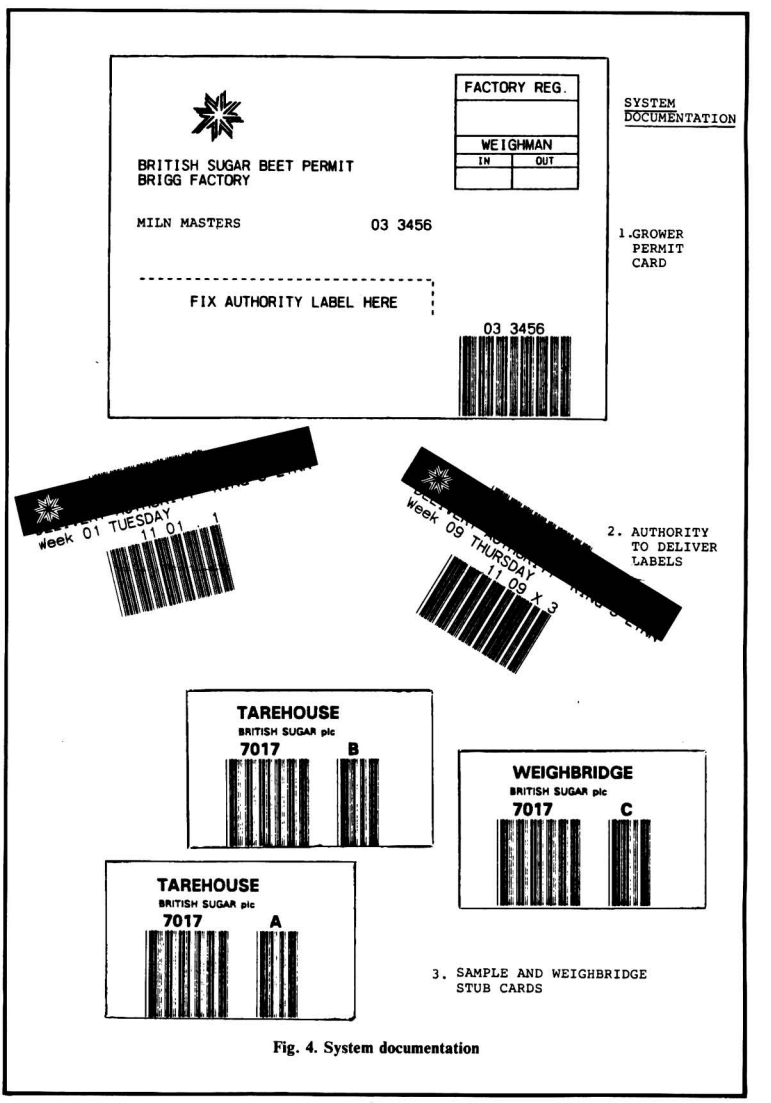


Fig. 4. System documentation

Permits/stub card readers

During the 1982/83 beet campaign realistic tests were carried out on optical bar code-reading equipment. Following encouraging results the reader (suitably modified to suit British Sugar's environmental conditions) was chosen as the "badge reader" for the system. It should be noted that the system documentation was designed so that firmware operating in the bar code reader could expect to read two complete bar codes regardless of the duty on which the reader was installed.

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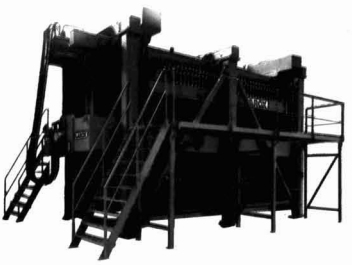

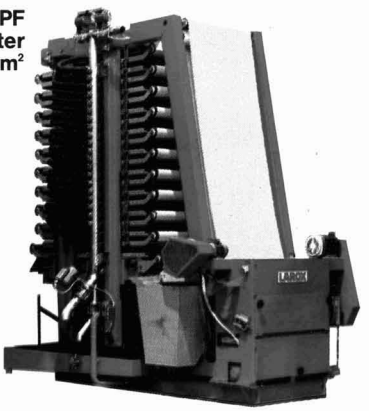

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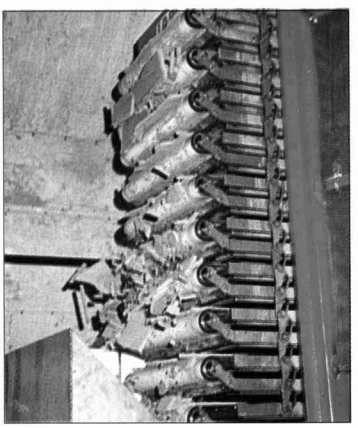

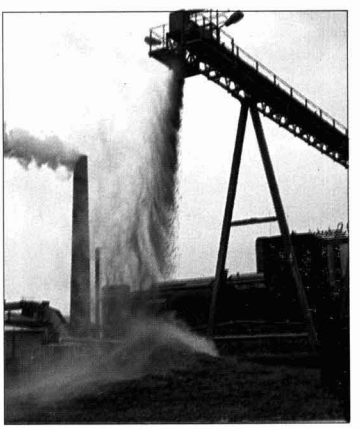

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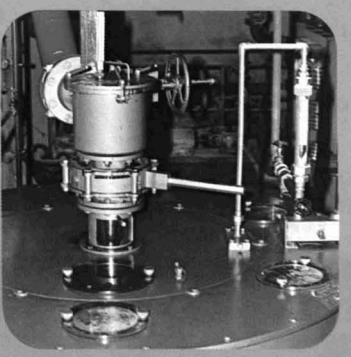

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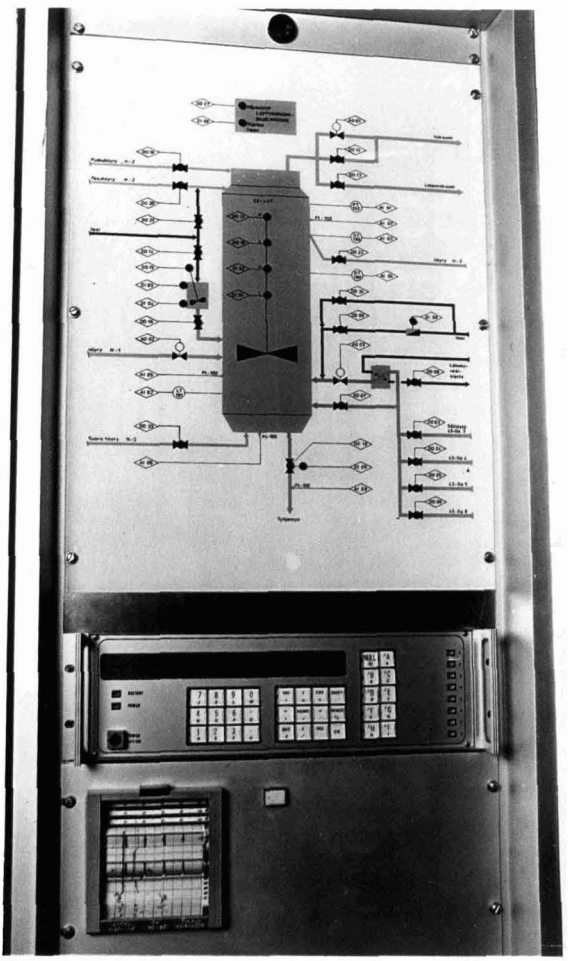

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In the data system the readers are used both externally and internally at the weighbridges (Figure 5), on each sampling unit at the sample point, and on each working station at the tarehouse.

Fig. 5. Remote document reader

Weighbridges

The weighbridges (15×3m/50000 kg capacity) used at King's Lynn were re-sited and the latest weigh-head instrumentation installed in order to satisfy Department of Trade testing standards (see Figure 6).

Fig. 6. Out-weighbridge equipment

Tarehouse scales

The bench dial scales with electrical output which have traditionally been used for weighing beet samples (plus the additional mechanical fan scales for tops weighing at the clean beet station) were replaced by electronic weighers (see Figure 7).

The instruments for the five scales at King's Lynn were identical except that those used for weighing tops had a smaller platform size than the dirty and clean beet machines.

For the 1984/85 campaign at King's Lynn the instruments will be replaced by the same units as used in the weighbridges.

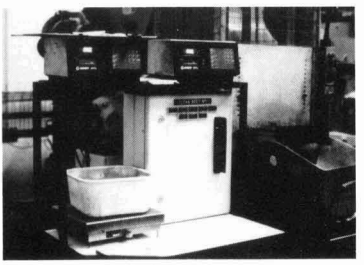


Fig. 7. Clean scale station

The use of common instrumentation on these scales was prevented at the original specification stage by a large differential in price which has since been dramatically reduced.

Saccharimeters

The existing saccharimeters were modified to include a 20 mA interface to the data equipment but were otherwise as used in previous campaigns.

Amino-nitrogen analyser

This instrument is combined with the saccharimeter to be controlled by a single micro, as illustrated in Figure 8. The equipment (a new concept in amino-nitrogen measurement) was not used at King's Lynn during the 1983/84 campaign owing to several operational problems. The problems were solved during the campaign and the instrument successfully used at other factories. During the 1984 off-season the equipment was to be installed and tested at King's Lynn ready for operation in the coming beet campaign.

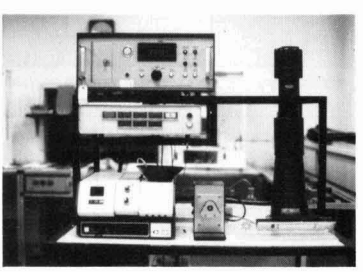


Fig. 8. Saccharimeter station with amino-nitrogen equipment

Description of the new system

Functional design

A number of requirements were identified which influenced the hardware structure of the system. Within this structure three distinct levels of functional hardware have evolved. These levels will be referred to as base level, communication level and commercial computer system level.

BASE level requirements are for

(a) a micro-computer to be installed at each of the weighbridge and tarehouse station, so that any micro failure affects data collection at only one station,
(b) the micro to be capable of operating in a stand-alone mode in the event of failure of equipment at hierarchical levels in the system and to store data on non-volatile memory,
(c) the station micro to be capable of easy replacement by factory personnel, and
(d) application software resident in EPROM memory to be selected on installing the micro in any particular location.

COMMUNICATION level requirements are for:

(a) a micro installed capable of transmitting station data between base level micros and a commercial mini computer system installed in the factory office,
(b) the micro to continue to operate in the event of failure of the commercial mini computer system or communication link, logging data to a diskette unit, and
(c) the micro also to transfer "in" weighbridge data to the "out" weighbridge.

COMMERCIAL COMPUTER SYSTEM requirements are for:

(a) data items to be assembled and loads cleared,
(b) a tarehouse logging printer function.
(c) access for Beet Clerk/Beet Receptionist to monitor and control data collection operations.
(d) a management enquiry facility.

The micro-computer applied to beet reception

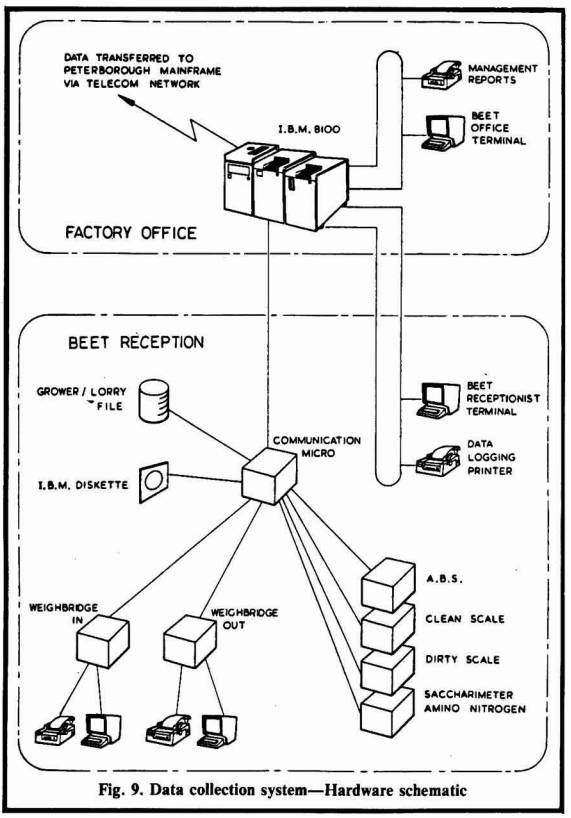


Fig. 9. Data collection system—Hardware schematic

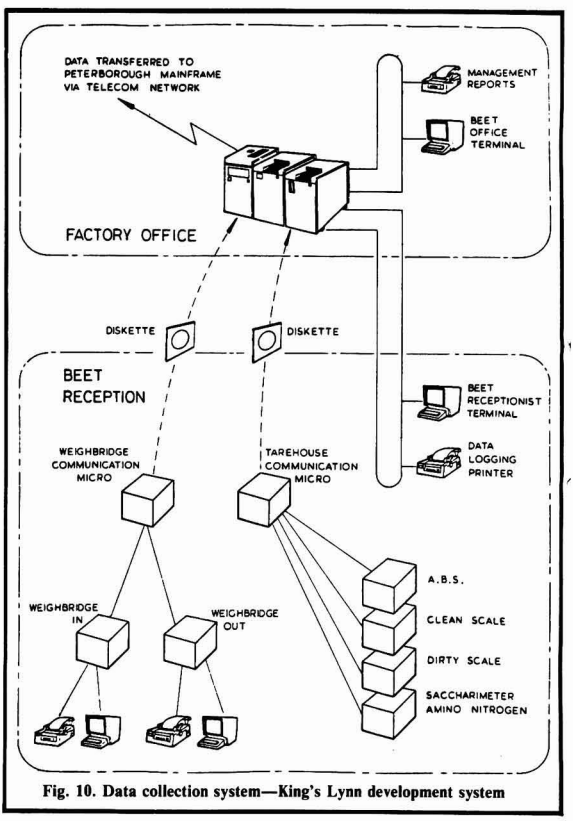


Fig. 10. Data collection system—King's Lynn development system

(e) end-of-day management reports to be produced, and
(f) data to be transmitted to Central Office at Peterborough via the public telecommunications network.

System schematic

The hardware arrangement employed to achieve identified functional requirements is illustrated in Figure 9.

The assembly of load data and management reporting facilities were provided by a commercial mini-computer system installed in the factory office.

Development system

In order to minimize the risks associated with the implementation of a new and complex system a decision was made to install distinct hardware modules for the first campaign's operation. A separate communication micro would handle weighbridge and tarehouse stations but operate under the same software.

Data transfer from the tarehouse and weighbridge micro systems to the commercial system would be achieved by the use of diskettes as time available did not permit the development of on-line data transfer. Implementation of the on-line data transfer would be a campaign activity. Thus the installed system hardware for start of operations was as Figure 10.

(To be continued)

Brevities

Zambia sugar production, 1984[1]

Zambia had a record sugar output in 1984 with 141,231 tonnes, of which 21,000 tonnes is available for export. This outturn, which is the third record in a row, was nearly 7% up on the 1983 production of 132,005 tonnes and was made from a record cane crop of 1,180,000 tonnes. Domestic sugar consumption is reported to be 120,000 tonnes. 70% of the surplus will be exported as white sugar and 5100 tonnes has been sold to Zaire and Burundi.

Bolivian distillery project[2]

A complex at San Buenaventura will produce 60,000 litres a day of fuel alcohol, starting in 1986, utilizing sugar cane grown on 2000-2400 hectares. Plant will be supplied by Codistil S.A. of Brazil and by Dedini who are also to expand the sugar factory to produce 4500-5500 tonnes/year.

1 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 676.
2 *Sugar J.*, 1984, **47**, (5), 25.

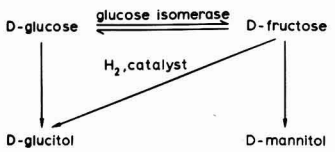
HPLC analysis of reaction mixtures containing monosaccharides and alditols

By M. Makkee, A. P. G. Kieboom, and H. van Bekkum

(Delft University of Technology, Laboratory of Organic Chemistry, Julianalaan 136, 2628 BL Delft, Holland)

Introduction

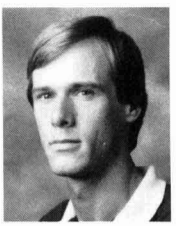
The valuable nutritive sweetener D-mannitol is manufactured commercially by high pressure hydrogenation of invert sugar with Raney nickel as the catalyst. As only D-fructose gives rise to partial D-mannitol formation the overall D-mannitol yield is less than 30%. Searching for an alternative procedure for the preparation of D-mannitol, we have studied the combined process depicted in the scheme below[1].



This combined single batch procedure involves the enzymic conversion of D-glucose to D-fructose using immobilized glucose isomerase with concomitant and preferential hydrogenation of the D-fructose using copper-on-silica as the catalyst. Up to 65% yields of D-mannitol have been obtained[1].

The investigation of the simultaneous isomerization and hydrogenation of D-glucose/D-fructose mixtures[1] required a quantitative fast analysis technique for the determination of D-glucose, D-fructose, D-mannitol and D-glucitol. In addition, it was sometimes of importance to detect the formation of possible by-products such as D-psicose, D-sorbose, D-tagatose and D-mannose.

Gas chromatography (GC) is a well-developed and accurate analytical tool for the analysis of carbohydrate mixtures. However, quantitative derivatization of the samples is required to obtain sufficient volatility of the carbohydrate components. Moreover, GC analysis shows separate peaks for the different anomeric furanose and pyranose forms of reducing sugars which complicates quantitative interpretation. Since the GC method is also rather time-consuming and cannot easily be automated because of the required derivatization step, we have chosen HPLC as the analytical tool.



M. Makkee

A. P. G. Kieboom

H. van Bekkum

During the last decade HPLC has become a sophisticated and rapid method for the analysis of carbohydrate mixtures. At present, two types of stationary phase are commonly used in the HPLC analysis of carbohydrates and related compounds:

(a) alkylamine-modified silica using acetonitrile/water as the eluent[2–5];
(b) cation exchange resin using water as the eluent[6–11].

Silica can be modified with alkylamine chemically as well as physically. A modified silica as the stationary phase is resistant to high pressure and results in good separations, especially of disaccharides, at room temperature. The carbohydrates are eluted in the order of increasing degree of polymerization: the monosaccharides first, subsequently the disaccharides and then oligosaccharides. For a routine analysis, there is the problem that both retention times and response factors are highly sensitive to small variations in the composition of the eluent acetonitrile/water and to small alterations in column temperature[5]. Furthermore, solubility problems often arise in the acetonitrile/water solvent system and the signal to noise ratio is rather poor using RI-detection. Finally, acetonitrile is expensive and toxic. The above mentioned reasons have, therefore, led us to choose cation exchange resins as the stationary phase together with water as the eluent for the present investigations, despite the fact that the pressure resistance of this system is less than that of modified silica.

Cation exchange resins in carbohydrate HPLC-analysis

The main task of the cation exchange resin is to immobilize the cation. In carbohydrate separation, resins of the sulphonated polystyrene-divinylbenzene type are most frequently used. These rigid, gel-type resins become porous on swelling, with the pore size depending on the degree of cross-linking (as indicated by the percentage of divinylbenzene in the copolymer). A resin with a lower percentage of cross-linking has a more open structure permeable to higher molecular weight substances than a higher cross-linked resin. It has, however, a lower physical resistance to shrinking and swelling. Because of high porosity and high concentration of functional groups within their chemical structure, ion exchange resins have a high effective capacity. Finally, the remarkable chemical stability of ion exchange resins makes them useful under a wide variety of conditions including temperature, organic solvents, reducing and oxidizing agents.

1 Makkee *et al.*: *J. Chem. Soc., Chem. Commun.*, 1980, 930; Kieboom & van Bekkum: *Rec. Trav. Chim. Pays-Bas*, 1984, **103**, 1.
2 Schwarzenbach: *J. Chromatogr.*, 1976, **117**, 206.
3 Conrad & Palmer: *Food Technol.*, October 1976, 84.
4 Aitzetmüller: *Chromatographia*, 1980, **13**, 432.
5 Brons & Olieman: *J. Chromatogr.*, 1983, **259**, 79.
6 Angyal *et al.*: *Carbohydr. Res.*, 1979, **73**, 9.
7 Ladisch *et al.*: *J. Chromatogr.*, 1978, **147**, 185.
8 Scobell *et al.*: *Cereal Chem.*, 1977, **54**, 905.
9 Scobell & Brobst: *J. Chromatogr.*, 1981, **212**, 51.
10 Goulding: *ibid.*, 1975, **103**, 229.
11 Gray: *The Liquid Chromatographer*, 1981, **7**, 3.

We will focus our attention on the sulphonated polystyrene-divinylbenzene cation exchange resin. The various carbohydrate-resin interactions which may play a role in the separation process have been summarized below:
Ligand exchange: based on the interaction of the carbohydrate with the cation;
Reverse-phase partitioning: based on the distribution of carbohydrates between a polar mobile phase and the non-polar resin backbone;
Normal-phase partitioning: based on the distribution of sample molecules between intra-particle ("bound") mobile phase and the bulk mobile phase;
Size exclusion: based on the physical exclusion of carbohydrates which are too large to penetrate part of the effective pore structure of the resin.
In carbohydrate analysis the *character of the cation* of the exchange resin is a major factor in determining the quality of the separation. The separation is to a large extent due to differences in coordinating ability of the carbohydrate with the cation of the resin. It has been shown by NMR and electrophoresis studies, both carried out in the presence of metal ions[6,11], that an *ax-eq-ax* sequence of three adjacent hydroxyl groups of cyclohexitol systems or in pyranose rings, or an *all-cis* arrangement of three vicinal hydroxyl groups in furanose rings gives rise to tridentate chelation with suitable metal cations (K_{ass} = 1–5 mol^{-1} in water at 25°C). The same holds for a *threo-threo* arrangement of three adjacent hydroxyls in alditols[12,13]. In general, the strength of coordination of two vicinal hydroxyl groups is much weaker (K_{ass} < 0.1 mol^{-1}). It has been reported by Gray[11] that an appropriate choice of the cation may easily result in a rapid base-line separation of a mixture of D-glucose, D-xylose, D-galactose, D-arabinose, and D-mannose.

The *degree of cross-linking* is also of importance. In particular, mixtures of oligosaccharides of different molecular weight are better separated with cation exchange resins with a lower degree of cross-linking, as the separation mechanism of size exclusion (molecular sieving) becomes of greater importance. This was shown by Scobell & Brobst[9] for the analysis of acid-hydrolysed corn syrups over four Ag(I) resins with different degrees of cross-linking. Although the effect of partial Ag(I) loading is not yet clearly understood, it provides a much better method for the separation of oligosaccharides than the use of resins in other cationic forms [Ca(II) and Pb(II)]. However, of the many cation exchange resins studied[6,10,11,14], Ca(II) exchange resin gave the best overall performance for the separation of monosaccharides, which is of most importance for the present investigation.

It should be noted that mono- and disaccharides containing an anomeric hydroxyl (e.g. reducing sugars) often show broader peaks than those without an anomeric hydroxyl, in particular at lower temperature. This is caused by the rather slow rate of mutarotation and the different strengths of coordination of the various anomers of the former under the chromatographic conditions. Angyal *et al.*[6] and Verhaar & Kuster[14] have found that the addition of 0.001M triethylamine, which catalyses the mutarotation reaction, results in an efficient separation of various carbohydrate mixtures over a resin in the Ca(II) form at 30–50°C.

On the basis of these literature data we have developed a convenient HPLC procedure for the quantitative analysis of reaction mixtures containing both monosaccharides and sugar alcohols. The effect of particle size, temperature and flow rate has been examined.

Experimental

Apparatus

The HPLC system consisted of an M 6000 A pump (Waters Associates), a Rheodyne 7125 injector or a Dupont 834 autoinjector fitted with a Rheodyne 7010 injector and an R 401 differential refractometer (Waters).

Chromatographic grade tubings (SS 316 Lichroma) 25 cm × 4.0 mm i.d. and 30 cm × 7.8 mm i.d. with the appropriate Parker Hannifin end fittings were obtained from Bio-Rad Lab. Chromatographic grade tubing Apollo (SS 316 Lichroma) 30 cm × 7.0 mm i.d. with the appropriate Valco end fittings were obtained from Betron and Chrompack, respectively.

Chromatographic conditions

Unless otherwise specified the following conditions were used throughout: Deionized and degassed water at 85°C as the eluent; column temperature of 85°C; detector temperature of 35°C; detector attenuation of 16×; recorder sensitivity of 10 mV full scale; sample concentration of 1–3% (w/w) carbohydrates in water; sample volume of 20–50 μl.

Materials

The HPLC column Aminex HPX 87 C, obtained from Bio-Rad Laboratories, had the following specifications: column (30 cm × 7.8 mm i.d.); chromatographic resin Aminex A 7 (particle size 7–11 μm) in the Ca(II) form. The chromatographic resins Aminex A 7 (particle size 7–11 μm) and Aminex A 5 (particle size 10–15 μm) were supplied by Bio-Rad in the Na(I) form and were converted into the Ca(II) form (see column preparation). The resin matrix had the following specifications: sulphonic acid; exchange capacity: 1.7 meq/ml; maximum allowable temperature: 150°C; maximum allowable pressure: 5000 psi.

D-Psicose was prepared by the oxidation of 1,2:4,5-di-O-isopropylidene-α-D-fructopyranose and the subsequent reduction of 1,2:4,5-di-O-isopropylidene-α-D-fructopyran-3-ulose[15]. The desired product was obtained by liquid

12 Kieboom *et al.*: *Rec. Trav. Chim. Pays-Bas*, 1975, **94**, 53.
13 Idem: *ibid.*, 1979, **98**, 393.
14 Verhaar & Kuster: *J. Chromatogr.*, 1981, **210**, 279.
15 Stevens: *Methods in Carbohyd. Chem.*, 1972, **6**, 123.

chromatography, using the cation exchange resin Bio-Rad AG 50 W-X8 in the Ca(II) form and water as eluent. D-Psicose was identified by ^{13}C NMR[16]. D-Xylulose was prepared by the isomerization of D-xylose using glucose isomerase, followed by liquid chromatography[17] over the anion exchange resin Bio-Rad AG 1-X8 in the bisulphite form using a 3:1 propanol:water mixture as the eluent. All other chemicals used were of analytical grade and were commercially available.

Column preparation

The procedure used for the column preparation is based on literature methods[7,14] with some modifications.

(i) A suspension of cation exchange resin Aminex A 5 or Aminex A 7 (ca. 1.5 g/ml column content) was boiled under reflux for 0.5 hr in 6 M HCl (50 ml). The resin was filtered off and the procedure was repeated. The resulting slurry was cooled to room temperature and diluted with an equal volume of deionized water. The resin was filtered off, washed with deionized water (500 ml), stirred with 0.5M calcium nitrate (100 ml) for 0.5 hr, and filtered off. This procedure was repeated three times. The resulting resin was then washed by stirring with deionized water (100 ml) and this washing repeated three times.

(ii) The analysis column was fitted with a stainless steel filter on top and a pre-column below. A filling reservoir was connected to the pre-column.

(iii) The resin was slurried in deionized water and put into the filling reservoir, which was subsequently filled with deionized water and connected to the eluent pump.

(iv) Deionized water was pumped through at a flow rate of 1.5 ml/min. After reaching a pressure drop of 50 psi per cm bed height, deionized water was pumped through for one hour in such a way as to maintain this pressure drop.

(v) The analysis column was disconnected, filled off flatly and fitted with a stainless steel filter.

Results and discussion

The influence of the particle size of the cation exchange resin

The effect of the particle size on the chromatographic efficiency has been studied by comparison of the Ca(II) cation exchange resins Aminex A 5, Aminex A 7, which differ only in particle size, and the commercially available analysis column Aminex HPX 87 C in the HPLC analysis of a mixture of D-glucose, D-fructose, D-mannitol and D-glucitol (Fig. 1 and Table I).

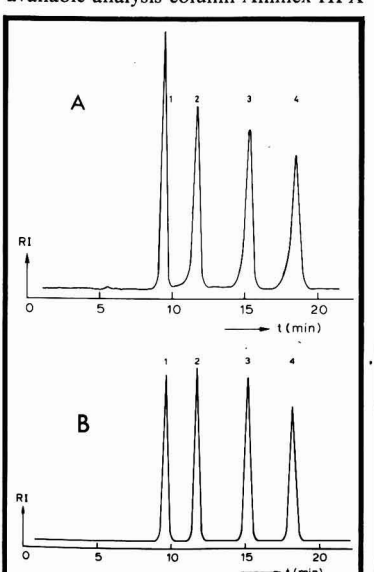


Fig. 1. Effect of particle size distribution on the efficiency of D-glucose (1), D-fructose (2), D-mannitol (3), and D-glucitol (4). Chromatographic conditions: column (30 × 7.8 mm i.d.); stationary phase: sulphonated polystyrene-divinylbenzene resin; eluent: H_2O; flow rate: 0.6 ml/min; temperature: 85°C. (A) Aminex A 5 in Ca(II) form (10-15 μm). (B) Aminex A 7 in Ca(II) form (7-11 μm).

The results clearly show the favourable effect of smaller particles on the efficiency and peak form. It may also be concluded that the efficiency of the home-prepared column is about 50% higher than that of the commercially available Aminex HPX 87 C with the same particle size distribution.

The influence of temperature and flow rate on the capacity factor and the efficiency

As mentioned, monosaccharides containing an anomeric hydroxyl often show broader peaks than those without an anomeric hydroxyl, which is due to the relatively slow rate of mutarotation of the former under the chromatographic conditions. A higher temperature has a positive effect on the efficiency since both the rate of mass transfer and the rate of mutarotation increase. On the other hand, the complexation strength of the carbohydrate with the cation will decrease at higher temperature. Therefore, the capacity factor

$$k' = \frac{t_r - t_o}{t_o}$$

in which t_r = retention time of a compound that coordinates to the cation, and t_o = retention time of an unretained compound[18], will also

16 Angyal & Bethell; *Austral. J. Chem.*, 1976, **29**, 1249.

17 Tipson & Brady: *Carbohydr. Res.*, 1969, **10**, 549.

18 Hamilton & Sewell: "Introduction to high performance liquid chromatography" (Wiley, New York) 1977, 1–36.

Table I. Effect of particle size of Ca(II) resins on the efficiency [a,b]

Ca(II) resin Particle size (μm)	Aminex A 5 10–15	Aminex A 7 7–11	Aminex HPX 87 C 7–11
D-Glucose	3600	4500	3100
D-Fructose	4900	7500	4800
D-Mannitol	6100	11000	7600
D-Glucitol	5800	10500	7300

[a] Chromatographic conditions: column dimension 30 cm × 7.8 mm i.d. eluent: H_2O; flow rate: 0.6 ml/min; temperature: 85°C

[b] Efficiency: number of theoretical plates $N = 5.54 (t_r/w_{1/2})^2$, in which t_r = retention time and $w_{1/2}$ = peak width at half height[18].

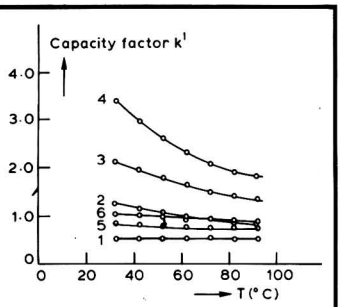


Fig. 2. The influence of the temperature on the capacity factor of D-glucose (1), D-fructose (2), D-mannitol (3), D-glucitol (4), D-mannose (5), and myo-inositol (6).
Chromatographic conditions: column (30 cm × 7.0 mm id.); eluent: H_2O; stationary phase: sulphonated polystyrene-divinylbenzene resin; Aminex A 5 in the Ca(II) form (10-15 μm), and Aminex A 7 in the Ca(II) form (7-11 μm); flow rates of 0.1, 0.3, 0.6, and 1.0 ml/min.
[Each point is a coincidence of eight measurements at different flow rates and particle size distributions (see text)].

decrease at higher temperatures. Fig. 2 illustrates the influence of the temperature on the capacity factors with various flow rates and different particle size distributions of the cation exchange resins. At each temperature identical retention volumes were observed at different flow rates (0.1–1.0 ml/min). Also the particle size distribution [Aminex A 5 (10–15 μm) and Aminex A 7 (7–11 μm)] has no effect on the retention volume.

The temperature dependency D-glucitol (4) > D-mannitol (3)> D-fructose (2) > D-glucose (1) ~ D-mannose (5) ~ myo-inositol (6) clearly parallels the order of Ca(II) complexation strengths[6, 11–13]. The decrease in capacity factor at increasing temperature will therefore be due to a decrease of Ca(II) complexation of D-glucitol, D-mannitol and D-fructose.

The effect of flow rate on the efficiency at different temperatures is shown in Fig. 3.

The behaviour of both cyclic and acyclic carbohydrates without an anomeric hydroxyl, *i.e.* myo-inositol, D-glucitol and D-mannitol, is quite different from that of D-glucose, D-mannose and D-fructose. Clearly, this difference is due to mutarotation phenomena of the latter compounds during the chromatographic separation.

(To be continued)

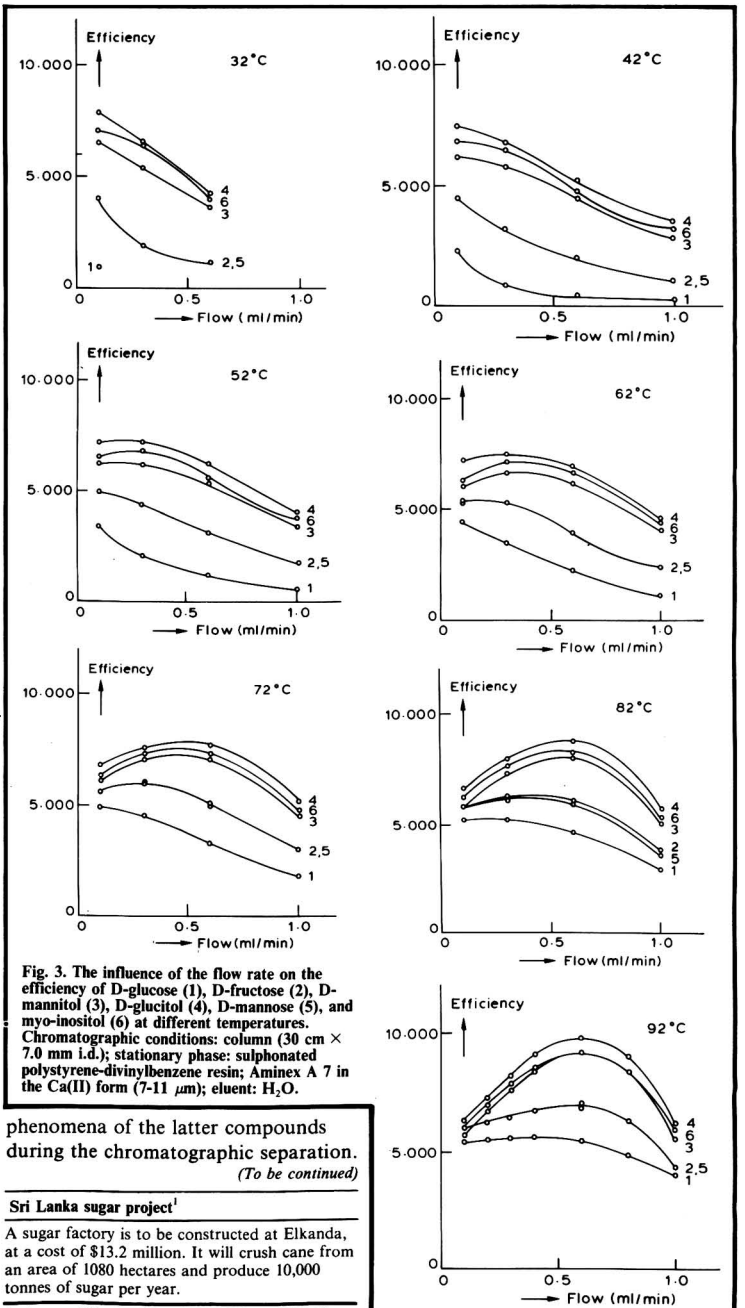


Fig. 3. The influence of the flow rate on the efficiency of D-glucose (1), D-fructose (2), D-mannitol (3), D-glucitol (4), D-mannose (5), and myo-inositol (6) at different temperatures.
Chromatographic conditions: column (30 cm × 7.0 mm i.d.); stationary phase: sulphonated polystyrene-divinylbenzene resin; Aminex A 7 in the Ca(II) form (7-11 μm); eluent: H_2O.

Sri Lanka sugar project[1]

A sugar factory is to be constructed at Elkanda, at a cost of $13.2 million. It will crush cane from an area of 1080 hectares and produce 10,000 tonnes of sugar per year.

1 *Amerop-Westway Newsletter*, 1984, (133), 12.

Brevities and statistics

Brazil sugar exports, 1985

In 1984 Brazil achieved record exports of sugar totalling 3,039,508 tonnes, raw value, including 1,377,831 tonnes of raw sugar, 1,301,990 tonnes of refined granulated sugar and the balance of non-refined special crystal and coarse grain sugar. Destinations are tabulated below:

Algeria	410,614	tonnes,	raw	value
Bangladesh	10,826	,,	,,	,,,
Canada	20,000	,,	,,	,,
Chile	66,313	,,	,,	,,
Egypt	302,045	,,	,,	,,
Ghana	32,478	,,	,,	,,
India	298,773	,,	,,	,,
Iran	152,261	,,	,,	,,
Iraq	161,606	,,	,,	,,
Jordan	15,156	,,	,,	,,
Kenya	28,581	,,	,,	,,
Madagascar	8,369	,,	,,	,,
Mexico	13,641	,,	,,	,,
Morocco	149,000	,,	,,	,,
Nigeria	11,390	,,	,,	,,
Peru	23,871	,,	,,	,,
Portugal	59,950	,,	,,	,,
Saudi Arabia	54,943	,,	,,	,,
Somalia	14,290	,,	,,	,,
Sri Lanka	38,491	,,	,,	,,
Switzerland	48,800	,,	,,	,,
Syria	58,028	,,	,,	,,
Trinidad	10,000	,,	,,	,,
Tunisia	71,626	,,	,,	,,
USA	271,917	,,	,,	,,
USSR	612,036	,,	,,	,,
Venezuela	94,500	,,	,,	,,
	3,039,508	,,	,,	,,

Control of risks in handling and storage of granular foods

An International Symposium on the above subject is to be held at the Montparnasse Park Hotel in Paris during April 24-26, 1985 under the patronage of the International Commission for Food Industries and organized by APRIA, the Association pour la Promotion Industrie Agriculture. None of the papers is specifically concerned with sugar but there are a number concerning explosion of dust/air mixtures in silos. Simultaneous English/French interpretation will be provided and two visits are proposed, one to a new silo embodying the latest security measures at the port of Rouen, and another to the research centre of the French coal industry. Details may be obtained from the offices of APRIA at 35 rue du Général-Foy, 75008 Paris, France.

Redpath Sugars diversification[1]

Redpath Industries Ltd., the Toronto-based subsidiary of Tate & Lyle Holdings PLC, has acquired Donlee Manufacturing Industries Ltd., a manufacturer of automotive drive transmissions, plastic parts and components for the nuclear and defence industries. Valued at about $Can 44 million, the acquisition is part of Redpath's policy of reducing its dependence on the sugar business.

USDA Economic Research Service publications

The USDA is to alter its outlook and situation reports series by curtailing the frequency of some, introducing commodity yearbooks and expanding its *Agricultural Outlook* magazine. The outlook and situation report on sugar and sweeteners will be changed from quarterly to twice annually and will be supported by a yearbook of historical and current data.

UK beet campaign, 1984/85

As the campaign drew to a close on February 1, British Sugar plc confirmed that it had achieved its second best result with the 13 UK factories producing 1.3 million tonnes of sugar. Although factories had operated at full capacity throughout the campaign, there had been problems; autumn rain had made harvesting difficult in many areas and snow and ice in January had impeded deliveries to some factories. The record production at British Sugar was achieved in the 1982/83 campaign when 1.4 million tonnes was made from 10 million tonnes of beet. Agreement has been reached with the National Farmers Union as to the treatment of C- or non-quota sugar from the campaign (that produced in excess of the A- plus B-quota total of 1,144,000 tonnes), which is likely to be about 150,000 tonnes. Of this, 50,000 tonnes will be carried over to 1985/86 and paid for at the quota price for next campaign, 54,000 tonnes has already been sold on the world market and the balance will be disposed of by British Sugar before January 1986 on the best possible terms.

Corrigendum

In our November 1984 issue we published an article on "Developments in the Indonesian sugar industry" but inadvertently gave the wrong name for the author. It was Mr. A. H. Budisusetija, of P. T. Agriconsult International, who presented the paper to the British Society of Sugar Cane Technologists. We apologise to him for our mistake.

Increasing diversion of cane to alcohol in Brazil[2]

The President of the I.A.A. has stated that, if world market prices continue low in 1985, Brazil will be forced to reduce its exports and to put more emphasis on producing alcohol, exports of which were projected at 1000 million litres in the 1985/86 crop year, double those of 1984/85.

Iran cane sugar expansion[3]

According to the national news agency IRNA, cane sugar production at the Haft Tappeh Project in south-west Iran will rise in 1984/85 to 80,000 tonnes. It quoted an official at the project as saying that $270 million will be spent on increasing the area under cultivation by more than a half, or 14,500 hectares, and that a 50,000 tonnes/year sugar refinery will also be built soon in the area. IRNA said that the area under cane at the nearby Karun Agro-Industry centre will rise by approximately 39% from 18,000 to 25,000 hectares. Iran imports about half of its total annual sugar consumption of 1,200,000 tonnes and most of its own production comes from sugar beet.

French state aid for Mauritius sugar industry[4]

The French state aid agency Caisse Centrale de Coopération Economique (CCCE) is to assist in restructuring the Mauritius sugar industry, according to an AED report. The amount has not yet been finalized but is expected to be discussed at the next joint economic commission meeting in Paris in early 1985. The Mauritius government, which is also meeting the World Bank, the European Investment Bank and the African Development Bank, was to announce its sugar program before the end of 1984, according to AED.

El Salvador distillery[5]

A plant for the manufacture of fuel alcohol is now operational in Sonsonate[6]. The plant and equipment, originally supplied by Venezuela, has the capability to produce 1900 cubic metres (1,900,000 litres) per month from either molasses or cane juice.

China sugar production estimates[7]

Cane sugar production in China from the 1984/85 crop is estimated at 3,160,000 tonnes, white value (3,425,000 tonnes, raw value) while beet sugar production is estimated at 840,000 tonnes, white value (913,000 tonnes, raw value). With favourable weather, 533,000 hectares of cane has done well in the south of the country; in 1983, China's main cane growing province of Guangdong was hit by severe storms. The rise in cane sugar output will be partly offset by a reduced beet sugar output which is expected to fall by about 100,000 tonnes against 1983/84, owing to cuts in area after a drop of sugar content of the beets over the past few years. Moreover, the north-east has recently suffered quite badly from drought. At the end of 1983 China had 386 cane sugar factories with a capacity of 3,680,000 tonnes and 108 beet sugar factories with a capacity of 1,070,000 tonnes.

Distillery in France[8]

Recently, the French Minister of Agriculture officially opened a 63 million francs ($6,700,000) plant at Arcis-sur-Aube belonging to Sucre Union, who own the local sugar factory. The distillery has a nominal capacity of 90,000 litres/day of alcohol and has storage capacity of 18.5 million litres. It will use sugar beets as raw material for the alcohol which will be sold as a fuel additive or as base material for chemical manufacture.

1 *Ontario Bulletin*, Dec. 1984-Jan. 1985.
2 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 675-676.
3 *World Sugar J.*, 1984, **7**, (4/5), 29.
4 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 676.
5 *Amerop-Westway Newsletter*, 1984, (133), 10,
6 See also *I.S.J.*, 1984, **86**, 294.
7 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 677.
8 *Amerop-Westway Newsletter*, 1984, (133), 10; *Reuter Sugar Newsletter*, November 15, 1984.

New Indonesian sugar factory[1]

The Sohang sugar factory, constructed by Pakistan as a turnkey project in Indonesia[2], has begun trial production.

New Zaire sugar factory[3]

Production is reported to have started at a new sugar factory near Kisangani in upper Zaire. The factory, which has an annual production capacity of 15,000 tonnes of cane sugar and 1500 tonnes of pharmaceutical alcohol, is the third in Zaire to have been built with Chinese technology.

Italy beet sugar production, 1984[4]

Italian beet sugar production in 1984 rose to 1,270,000 tonnes from 1,240,000 tonnes in 1983, according to the National Association of Sugar Beet Producers. Per hectare yield had risen from 6.8 tonnes to 7.4, while the beet area was 10,000 ha smaller at 210,000 ha. Abundant rain with sufficient drying periods had boosted sugar beet production to 11.15 million tonnes from 9.7 million tonnes in 1983, but lack of sunshine had reduced the sugar content.

Spanish sugar factory closures[5]

It has been decided recently to close the beet sugar factory at Luceni in the province of Zaragoza. There are also fears that the factory at Santa Eulalia (Teruel) may also be closed.

PERSONAL NOTES

On November 30, 1984, **Dr. Frank G. Carpenter** retired from the US Department of Agriculture, completing 36 years of active research for the sugar industry. In 1948, Carpenter joined the Bone Char Research Project in Washington, D.C., and worked at the National Bureau of Standards under Dr. Victor R. Deitz until 1963 on projects on bone char decolorization, testing, and regeneration optimization. He was particularly noted for work on sieve analyses and the excess polyvalent anion concept. In 1963, he moved to New Orleans to organize the Cane Sugar Refining Research Project at the Southern Regional Research Center, where research expanded into all sugar refining aspects, and valuable information on the chemical nature of individual sugar colorants was developed. Other C.S.R.R.P. projects emphasized minor component effects on acid beverage floc formation; analytical methods development; and, flavour and odours in sugars. Carpenter served as Director of the C.S.R.R.P. until 1981 when the group was reorganized to become Sugar Processing Research Inc. In 1981, Carpenter joined the US Department of Agriculture, whom he has served in various capacities including that of Chief of the Food Crops Laboratory. Since 1970, he has been Secretary-Treasurer for the US National Committee of ICUMSA, and was International Referee for Subject 22 (Colour) from 1971 to 1982. He has authored many technical papers, including chapters in the "Cane Sugar Handbook" and the "Encyclopedia of Chemical Technology", and is a regular contributor to the column "The Clarifier Station" in *The Sugar Journal*, published in Louisiana.

EEC sugar exports estimate for 1984/85[6]

Sugar exports from the European Economic Community for the year October 1984/September 1985 are forecast at 4.3 million tonnes, raw value, about the same as in 1983/84, according to the EEC Commission's first estimate, presented to the International Sugar Organization. This is in spite of an expected rise in output from around 12 to 13 million tonnes, resulting from better yields and weather.

Possible reduction in the 1985 beet area in France[7]

French sugar beet plantings in 1985 are expected to fall by between 5 and 10% because of the poor world sugar market situation, according to the French Sugar Beet Planters Confederation (CGB). The 1984 plantings reached 509,000 hectares, up from 466,000 ha in 1983.

Zaire sugar project[8]

Feasibility studies for the Mushie-Pentane sugar project, 32 km from Bandundu, are almost over. The heads of this project seem to be convinced that it will be profitable, provided product distribution is by waterway and the road between Bandundu and Mushie-Pentane is paved. The sugar complex must have port facilities on the Kasai river. Final studies have been assigned to SOPEX, of Belgium, who will also be in charge of finding finance for the scheme.

Yugoslavia beet area expansion[9]

Yugoslavia plans to increase its overall agricultural production in 1985 and, of the main crops, sugar beet will be sown on 182,500 hectares, 25% more than in 1984. From this area a beet crop of 8 million tonnes is expected which would permit the factories to produce 975,000 tonnes of sugar, white value. In 1984, the sugar beet crop is reported to have reached 6,280,000 tonnes.

Guyana sugar Production, 1984[10]

Strikes in the factories and cane fields, and poor weather throughout the year, led to a 7.6% decline in sugar output in Guyana last year. The two harvests yielded a total of 241,851 tonnes of raw sugar, 43,000 tonnes below the target set by the industry.

Columbia sugar exports plan for 1985[11]

The Colombian government has fixed at 300,000 tonnes the country's export quota for 1985. The National Association of Sugar Cane Growers (Asocana) estimates 1984 output at 1,180,000 tonnes, raw value, against 1,300,000 tonnes in 1983. In 1984 Colombia exported only 182,000 tonnes of its ISA quota of 304,000 tonnes.

World sugar market analysis

Following the failure of the UNCTAD sugar conference in Geneva last year, F. O. Licht GmbH commissioned articles from several participants in the negotiations and have prepared an analysis of the causes of the breakdown and the effects of the lack of international regulation on the patterns of production and trade in the next few years. The report, "World sugar market without controls: The outlook after the Geneva conference" is now available at the price of DM65.00 per copy, from F. O. Licht GmbH, Abt. I, P.O. Box 1220, D-2418 Ratzeburg, Germany.

Malawi development loan[12]

The European Investment Bank has recently granted a conditional loan of 3.5 million e.c.u. (around $4,980,000) to Malawi, part of which will be used to assist Dwangwa Sugar Corporation, which has been suffering from an acute lack of fresh capital, and also to modernize the transport facilities in the landlocked country where most of the sugar is moved by rail.

Australian cane harvest, 1984[13]

Australia's 33 sugar factories crushed a record 25.51 million tonnes of cane in the 1984 harvest which ended in December. This was well above the drought-hit 1983 crop of 24.19 million tonnes which produced 3.71 million tonnes of raw sugar (94 net titre) but fell short of earlier predictions of a 25.77 million tonnes crop. Sugar production in 1984/85 is estimated at 3.5 million tonnes, 94 N.T., slightly lower than previous forecasts. The crushing shortfall was due to late rains in south-east Queensland which prevented harvesting of some cane; this will stand over for the 1985/86 season. Official sources said, on current indications, the 1985 cane crop is likely to be around the 1984 level.

Canada beet sugar production, 1984/85[14]

The 1984/85 beet campaign in the province of Alberta came to an end in January, bringing the combined output from Alberta and Manitoba to 91,500 tonnes, white value. In Quebec the campaign closed at 12,700 tonnes, basis 98.5 pol. Total Canadian output on a 96° raw value basis was therefore of the order of 112,000 tonnes, which compared with 135,500 tonnes in 1983/84.

1 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 679.
2 See *I.S.J.*, 1984, **86**, 146.
3 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 676-677.
4 *Reuter Sugar Newsletter*, November 19, 1984.
5 F. O. Licht, *International Sugar Rpt.*, 1984, **116**, 692.
6 *Public Ledger*, November 23, 1984.
7 F. O. Licht, *International Sugar Rpt.*, 1985, **117**, 10.
8 *Amerop-Westway Newsletter*, 1984, (133), 12.
9 F. O. Licht, *International Sugar Rpt.*, 1985, **117**, 12.
10 *Financial Times*, January 24, 1985.
11 F. O. Licht, *International Sugar Rpt.*, 1985, **117**, 17.
12 C. Czarnikow Ltd., *Sugar Review*, 1985, (1734), 9.
13 F. O. Licht, *International Sugar Rpt.*, 1985, **117**, 20.
14 C. Czarnikow Ltd., *Sugar Review*, 1985, (1734), 10.

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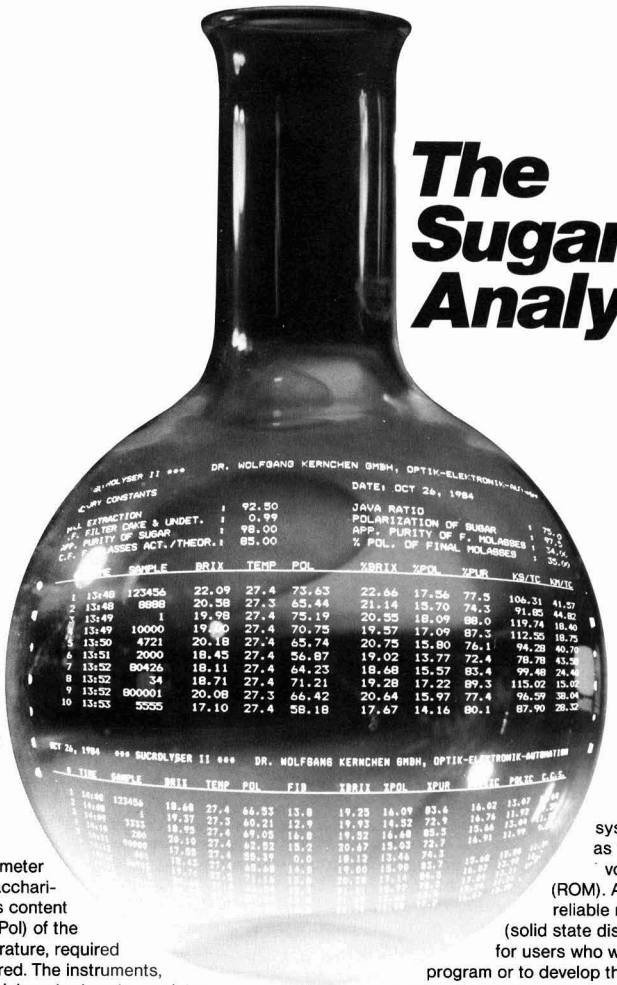

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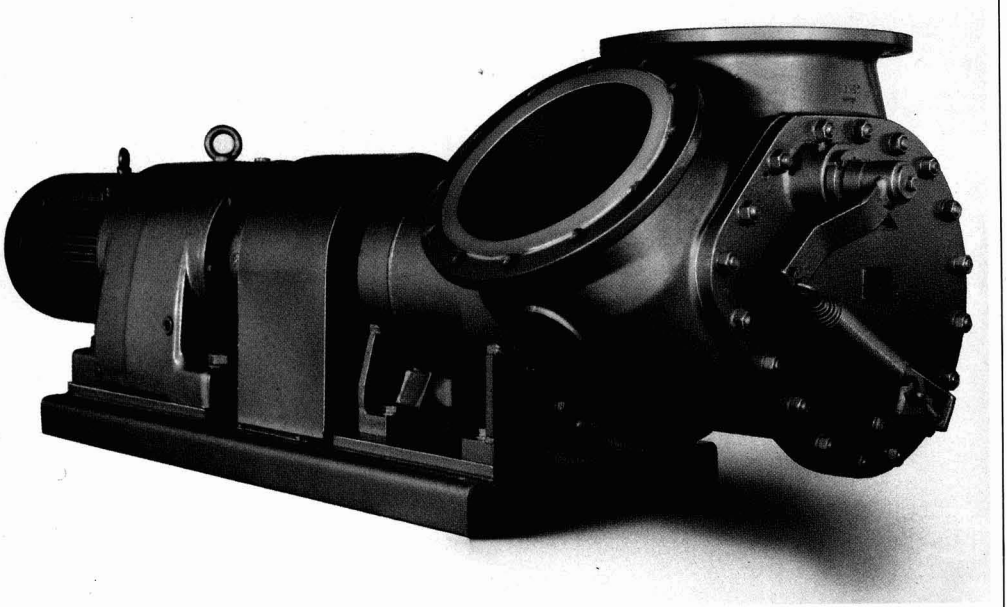

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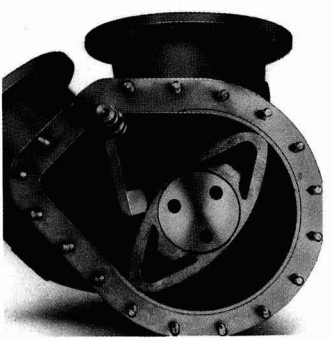

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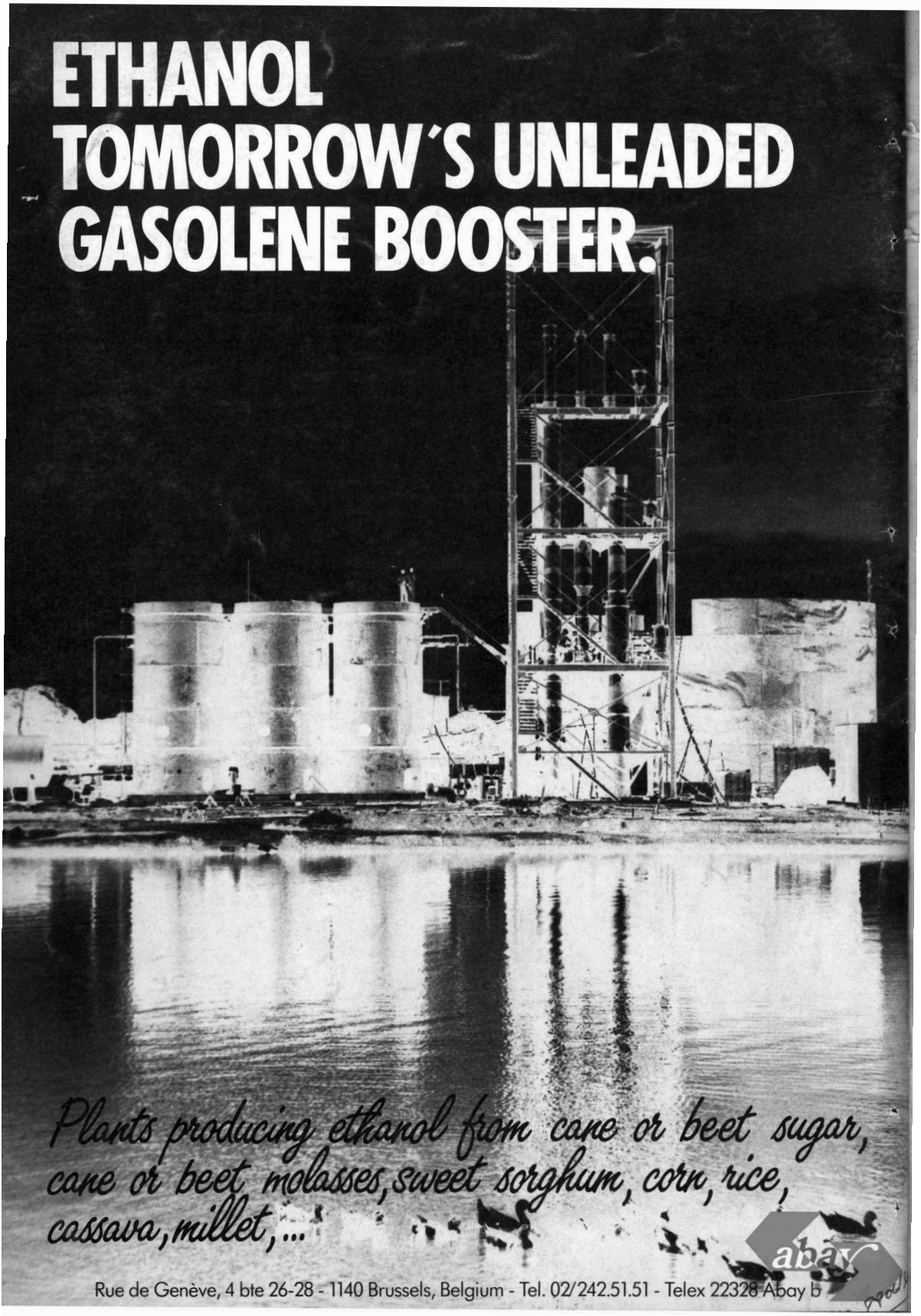
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