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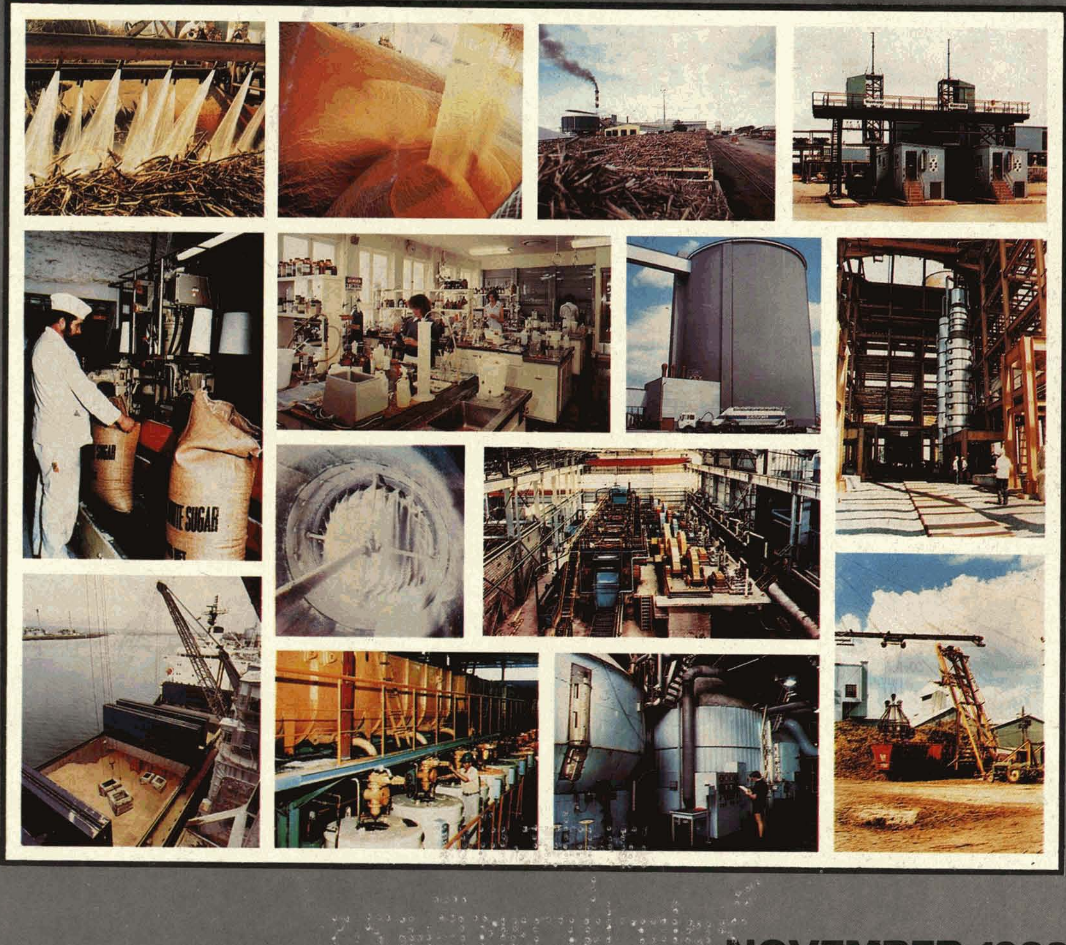

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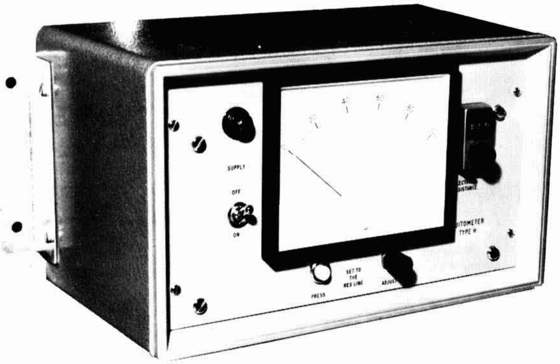

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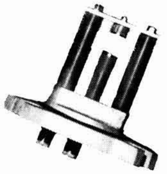

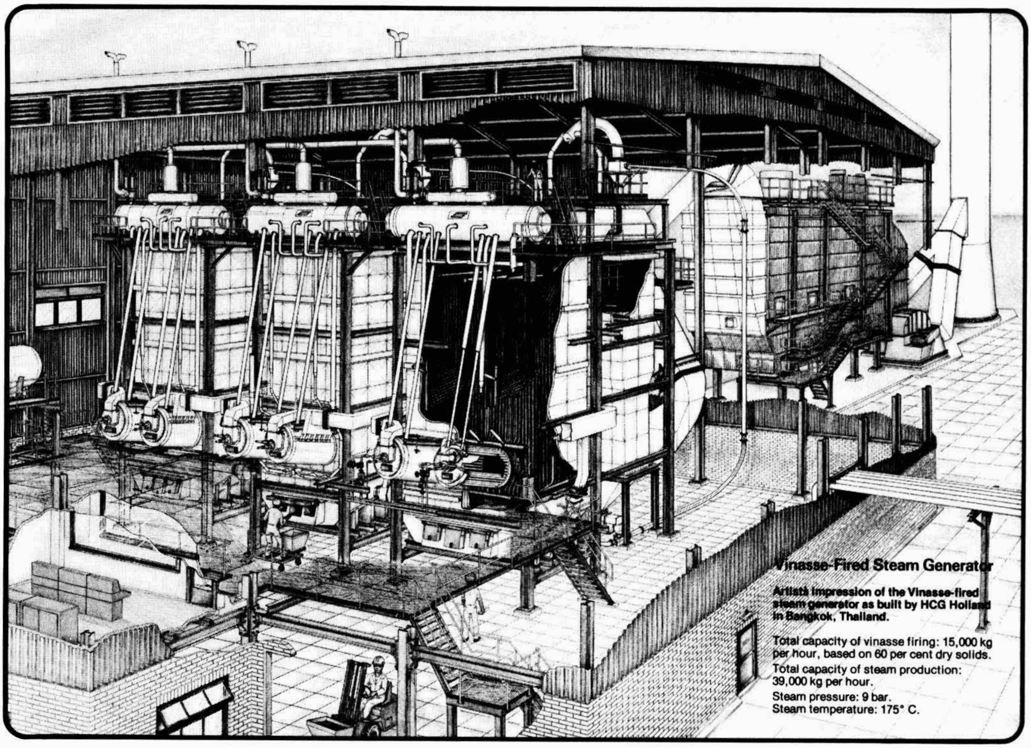

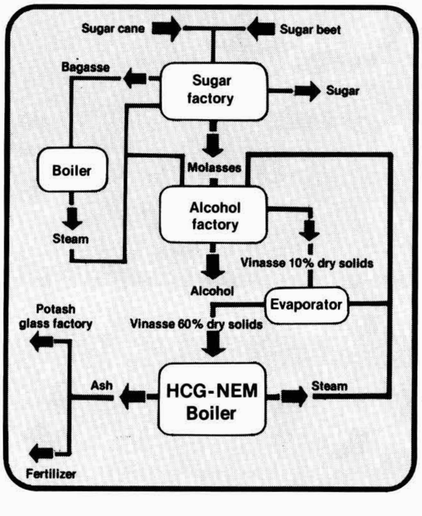
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Alcohol
Evaporator
Potash glass factory
Vinasse 60% dry solids
Ash
HCG-NEM Boiler
Steam
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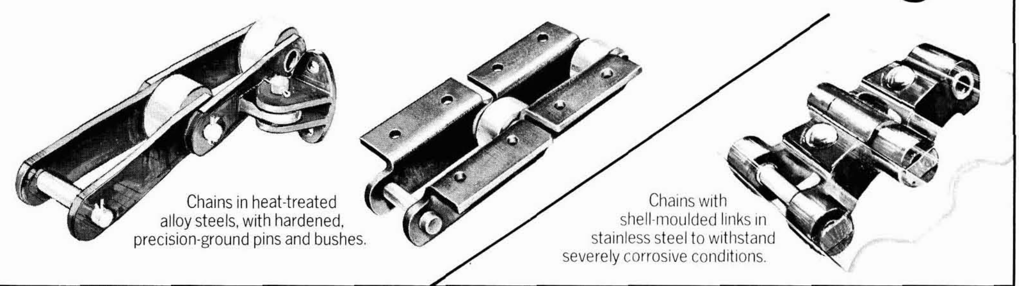

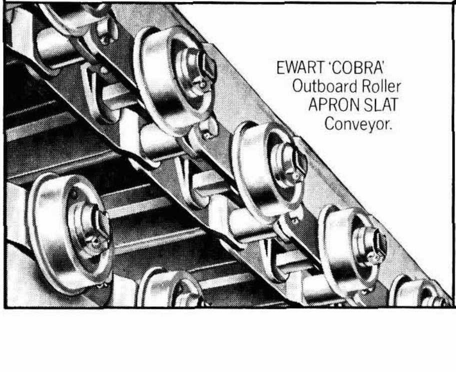

NOTES AND COMMENTS

UN sugar conference

The second phase of negotiations took the form of a a resumed UN sugar conference in Geneva during September 12-30. The Chairman, Sr. Jorge Zorreguieta, circulated a draft compromise paper at the end of July, following talks between a number of the more important exporters and it had been thought that this could provide a basis for a new Agreement since the proposals had been well received. From the start of the new meetings it became clear, however, that some of the delegations had had second thoughts in the matter and that there were numerous obstacles to agreement. The most sensitive point was the question of whether medium-sized exporters would have their supplies to the market controlled by a quota system or one based on holding of stocks. Many points of detail were agreed by the working groups set up during the conference, but agreement could not be reached on the control mechanism. Under pressure from European sugar producers organizations the EEC Commission representatives appeared to retreat away from the Chairman's compromise to its original proposals, seeking a very large stock element, (5-6 million tonnes) greater than acceptable to other exporters, and rejecting quotas. Brazil and Cuba, on the other hand, wanted the quota system to be of greater importance for controlling supplies to the market but were prepared to compromise in order to ensure EEC accession to a new agreement.

A group of six major importers introduced a compromise proposal on the role of stocks in a new agreement; all surplus stocks plus 50% of security stocks should be held as a first defence action against any decline in market prices. The amount of surplus stocks each exporter would be obliged to hold would be the amount in excess of its "Reference Export Availability" (REA). There were differences of opinion, however, as to how the REA's should be calculated, whether from historical data or from "moving averages", and the level of security stocks remained a moot point.

In the event the conference adopted a resolution requesting the Secretary-General of UNCTAD to reconvene the conference in Geneva from February 6 to 24 and requesting the Chairman to undertake further consultations. Delegations left Geneva, some blaming others for the failure of the conference to produce a new ISA. The next meeting of the International Sugar Council is set for November 14 and Sr. Zorreguieta will be consulting with delegations to see whether positions held are so entrenched that a third phase of negotiations is not worthwhile.

World sugar prices

The London Daily Price of raw sugar rose from £160.50 on September 1 by £3.00 but then started to slide, partly owing to nervousness about the reliability of Brazil's avowed intention to keep out of the market after selling its ISA quota, and later by a series of beet tests from Western European countries indicating that the good autumn weather was having a beneficial effect on the sugar content of the beet. In addition, the Soviet beet crop was progressing well ahead of schedule. The size of the combined open positions in the October deliveries of London and New York was also a feature, while Licht's reassessment of the world sugar balance for the year August 1983 was more pessimistic than his previous estimate in May. Negotiations for a new ISA seemed to be deadlocked, and the price sank to a low of £140.50 on September 22.

A recovery then set in, aided by reports of Russian buying from Poland and elsewhere, a Polish declaration of withdrawal from the market and purchases by Saudi Arabia, so that within a week the LDP reached £162 before falling again to £156.

The London Daily Price for white sugar followed the price for raws fairly closely during the month and the premium of whites over raws was generally between £19 and £24. Occasionally, however, there would be a delay between a change in the LDP and that of the LDP(W) so that the premium widened on one day to £28 and towards the end of the month fell to £16, although it ended the month at £19. As a consequence, the LDP(W), £181.50 on September 1, ranged between £162 and £185 but ended the month at £175 per tonne.

World sugar balance, 1982/83

F. O. Licht GmbH recently published their fourth estimate of the world sugar balance for the crop year September 1982/August 1983 together with country-by-country information and a summary[1]. The overall figures are reproduced below and show a lower total initial stock but production higher by 800,000 tonnes than expected at the time of the 3rd estimate in May[2], so that total availability is set 676,000 tonnes higher. This is partly reduced by a 63,000 tonnes difference in the imports-exports balance, but consumption has not increased as expected earlier, and is now set 600,000 tonnes lower than the May estimate, producing a final stocks figure 1.2 million tonnes above that of the third estimate. Higher stocks and lower consumption raise the stocks % consumption ratio markedly, from 38.7% to 40.2%.

	1982/83	1981/82	1980/81
		tonnes, raw value	
Initial stocks	32,704,000	24,325,000	25,174,000
Production	99,852,000	100,549,000	88,077,000
Imports	28,874,000	31,773,000	28,705,000
	161,430,000	156,647,000	141,956,000
Exports	29,415,000	32,079,000	28,250,000
Consumption	94,155,000	91,864,000	89,381,000
Final stocks	37,860,000	32,704,000	24,325,000

Free market trade in raw and white sugar[3]

An analysis of individual country/requirements for 1983/84, carried out by *World Sugar Journal*, concludes that availabilities exceed requirements by 580,000 tonnes, raw value. When the figures are broken down into raw sugar and white sugar amounts, however, a different pattern emerges. Nett raw sugar requirements amount to 9,874,000 tonnes against availabilities of 12,322,000 tonnes, i.e. there is a surplus of 2,448,000 tonnes. Against white sugar requirements of 10,006,000 tonnes, however, only 8,006,000 tonnes are available, a deficit of 2,000,000 tonnes. *WSJ* concludes that, while

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[1] F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 471-477.

[2] *I.S.J.*, 1983, **85**, 194.

[3] *World Sugar J.*, 1983, **6**, (3), 18-20.

as part of the operations of the market surplus raw sugar will be refined either in the country of origin or by some importing countries (or perhaps in a third country) to meet the additional demand for white sugar, the situation suggests that white sugar will command a reasonable premium over raws all through the 1983/84 crop year.

World sugar supply and demand, 1983/84[1]

An editorial in *World Sugar Journal* relating to its first estimate of the supply and demand for sugar in 1983/84 is entitled "1983/84: The return of confidence" and explains that the prospects for sugar are much brighter. In addition to improved supply and demand, there is optimism that a new International Sugar Agreement will eventually be reached. *WSJ's* estimates show that the real surplus overhanging the free market will be reduced from over 8 million tonnes to around 2 million at the end of the 1983/84 crop year. Even though this figure will be in addition to the 2½ million tonnes of ISA special stocks, its bearish influence on the market will be much less than in recent years.

Improvement in market prospects will be enhanced if a new ISA is put into effect during the year, while the Agreement will itself have a better chance of success when supply and demand is easier to manage. *WSJ* points out that an improved sugar price will unfortunately mean a better competitive edge for sugar substitutes, which will mean even more loss of outlets. "Those who demand that all sweeteners should be brought under the umbrella of a new ISA are doing so with some foresight but in practice it is difficult to see how this could be implemented". Details of the overall world supply and demand estimates appear below:

	1983/84	1982/83	1981/82
	tonnes, raw value		
Initial stocks	26,178,000	21,813,000	15,437,000
Production	93,239,000	98,968,000	99,104,000
Imports	27,266,000	28,578,000	29,778,000
	145,683,000	149,359,000	144,319,000
Consumption	97,041,000	94,119,000	91,787,000
Exports	28,220,000	29,061,000	30,719,000
Ending stocks	21,423,000	26,178,000	21,813,000
Commercial stocks	16,982,000	16,470,000	16,063,000
ISA Special stocks	2,500,000	1,400,000	1,000,000
Real surplus	1,941,000	8,308,000	4,750,000

US sugar support prices and import quotas

At the beginning of September the Market Stabilization Price to apply in the US during the fiscal year 1983/84 was announced. This involved an increase in the Loan Support Price from 17.00 to 17.50 cents/lb, a reduction in freight and costs from 2.66 to 2.62 cents/lb, a reduction in interest charges from 0.87 to 0.85 cents/lb and an incentive unchanged at 0.20 cents/lb. The net change in the MSP was to 21.17 cents/lb against 20.73 for 1982/83.

On September 16 the US Department of Agriculture announced that the import quota for 1983/84 would be 2,952,000 short tons, raw value, an increase of 150,000 tons from 1982/83. Details were not given at first but it was announced that entries against the 1983/84 quota would be permitted from September 26 while the 1982/83 quota would remain open for deliveries up to September 30.

The individual quotas were eventually announced in the last week of September and were based on the same pro-rata basis as for 1982/83 except that the Nicaraguan quota was cut to 6000 tons and the difference reallocated between Costa Rica, Honduras and El Salvador. The quotas are as follows:

	1983/84	1982/83
	short tons, raw value	
Argentina	126,850	120,400
Australia	244,850	232,400
Barbados	20,650	19,600
Belize	32,450	30,800
Bolivia	23,600	22,400
Brazil	427,750	406,000
Canada	32,450	30,800
Colombia	70,800	67,200
Costa Rica	61,035	42,000
Dominican Republic	519,200	492,800
Ecuador	32,450	30,800
Fiji	20,650	19,600
Guatemala	141,600	134,400
Guyana	35,400	33,600
Honduras	58,594	28,000
India	23,600	22,400
Jamaica	32,450	30,800
Malawi	20,650	19,600
Mauritius	32,450	30,800
Mozambique	38,350	36,400
Nicaragua	6,000	58,800
Panama	85,550	81,200
Peru	120,950	114,800
Philippines	398,250	378,000
El Salvador	86,771	72,800
South Africa	67,850	64,400
Swaziland	47,200	44,800
Taiwan	35,400	33,600
Thailand	41,300	39,200
Trinidad	20,650	19,600
Zimbabwe	35,400	33,600
Speciality sugar quota	2,000	0
Other countries	8,850**	8,400*
	2,952,000	2,800,000

* Haiti, Ivory Coast, Madagascar, Mexico, Paraguay & St. Kitts were offered the choice of a proportionate share of 8400 tons or individual quotas of 16,500 tons; all chose the latter, raising the total quota to 2,890,600 tons.

** The same countries, plus Uruguay and Zaire are being offered a proportionate share of 8850 tons or individual quotas; if all choose the latter option, the total import quota will rise to 3,075,150 tons.

Peru sugar output drop[2]

Raw sugar production in 1983 in Peru will be at most 450,000 tonnes, compared with last year's 614,000 tonnes, according to *Latin American Commodities Report*. Without the floods, the cooperatives would have continued last year's improvement and probably produced 700,000 tonnes. Peru has had to import 210,000 tonnes of raw sugar so far in 1983 and altogether up to 250,000 tonnes will be needed, partly to fulfil Peru's US sugar quota of 114,800 short tons.

Internally, the Peruvian government freed the price of sugar earlier this year but, because of the flood damage, this measure has had little impact on the cooperatives' well-being. The main problem remains financial; the cooperatives are burdened with $130 million of debt accumulated during the years when domestic prices were held down artificially. A World Bank-backed study team is looking into ways to rehabilitate the whole sugar sector and is due to report in December.

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[1] *World Sugar J.*, 1983, **6**, (2), 4-5, 9-18.

[2] F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 506.

Replacement of lead by resin and carbon for decolorization of factory samples

By ROBERT B. LEW
(Amstar Corp., Spreckels Sugar Division,
Woodland, CA 95695, USA)

Introduction

Lead compounds have recently been classified as hazardous materials. However, lead subacetate (dry lead) and basic lead acetate solution (55°Brix lead) are used routinely in control laboratories as clarifying agents in the determination of sugar and apparent purity coefficient. The current listed price[1] for lead subacetate is $15.08 per pound when purchased in 100-lb drums, and for us in Northern California, the cost for disposal of a pound of this hazardous compound in 1982 was approximately $3.50. Excluding the expenses incurred in monitoring analysts who use dry lead, the chemical cost for a molasses apparent purity determination amounts to about $0.33. Routine use of dry lead for purity determinations has become both expensive and troublesome.

The pol value of low colour samples, such as thin juice, thick juice and standard liquor, could be measured without clarifying with lead compounds. However, tests have shown that the apparent purity coefficient obtained without clarification yields values about 0.5 unit lower than for those samples clarified with dry lead. At present, polarimetry without decolorization of highly-coloured samples, such as molasses, machine syrups, massecuite, saccharate cake and Steffen fluids is not feasible. Consequently, the use of alternative substances in place of lead compounds for laboratory decolorization was investigated.

Certain criteria must be met if the substance is to replace lead for decolorization of laboratory samples. Ideally, (1) it must not have an adverse effect on polarization of the sample; (2) it must not be hazardous to health; (3) it should decolorize the sample as effectively and as quickly as lead; (4) the substance should be readily available and relatively inexpensive, and (5) it should also be stable.

DISCUSSION

Most colorants and colour precursors found in beet sugar processing syrups are anionic, while some are neutral[2]. Nearly all of the colour species are organic and the molecular weight of these compounds ranges from a few hundred to many thousands.

Robert B. Lew

Decolorization with carbons, such as bone char, granular carbon, and powdered carbon, has been well documented[3]. The surface of activated carbon is nonpolar. Consequently, this absorbent has a high affinity for neutral and high molecular weight organic compounds. Robert Kunin has recommended the use of anion-exchange resins, either in the bead form or in powdered form, as a means of sugar decolorization[4]. Currently, sugar factories in several countries employ synthetic resins for the decolorization of juices during processing.

Classification of decolorizing substances

To determine which particular ion-exchange resin is best suited for decolorizing dilute molasses solutions, a known amount of different resins as received was added to 130 cm^3 of diluted molasses (10°Bx), mixed for 10 minutes, and filtered through a 0.45 μm membrane filter. The absorbance of the resulting filtrates was measured at 420 nm using 1-cm cells. For comparison purposes, absorbance of filtrates derived from dry lead and activated carbon treatment were included. Results are shown in Table I.

Table I. Absorbance of treated dilute molasses filtrates

Decolorizer	Type	Amount used, g	Absorbance
Lead subacetate	Inorganic	8.0	0.44
Darco G-60	Activated carbon	4.0	1.08
Diaion PA308	Strong anion, Styrene	8.0	0.60
Diaion HP20	Nonpolar polymer	8.0	2.60
Diaion WA30	Weak anion	8.0	1.31
Amberlite IRA-400	Strong anion, Styrene	8.0	0.86
Amberlite IRA-900	Strong anion, Styrene	8.0	0.79
Amberlite IRA-958	Strong anion, Acrylic	8.0	1.31
Amberlite XAD-4	Nonpolar polymer	8.0	2.02
Dowex 1X4	Strong anion, Styrene	8.0	0.67
Dowex 11	Strong anion, Styrene	8.0	0.62
Dowex 50WX4	Strong cation, Styrene	8.0	2.56
Duolite A-102D	Strong anion, Styrene	8.0	0.66
Duolite ES-143	Strong anion, Styrene	8.0	0.62
Kastel 501D	Strong anion, Styrene	8.0	0.68
Ecodex GL-21	Strong anion, Styrene	4.0	0.94

Examination of the data in Table I indicates that materials used in this experiment may be qualitatively classified according to decolorizing ability: good, average, or poor. Materials that exhibit good decolorization ability are lead subacetate and styrene-based strong anion resins. Acrylic-based strong anion (Amberlite IRA-958), weak anion resin, and activated carbon were classified as intermediate decolorizers, while nonpolar and strong cation resins were found to be poor decolorizing agents.

Paper presented to Meeting of American Society of Sugar Beet Technologists, 1983.

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[1] J. T. Baker Chemical Co., Phillipsburg, NJ 08865, USA.
[2] Madsen *et al.*: *Sugar Tech. Rev.*, 1978/79, **6**, 49-115.
[3] Joyce: "Beet Sugar Technology", 2nd Ed., Ed. McGinnis, 1971.
[4] *Amber-Hi-Lites* (Rohm & Haas Co.), (160).

Replacement of lead by resin and carbon for decolorization

Two good decolorizing resins, Diaion PA308 manufactured by Mitsubishi Chemical, and Duolite A-102D manufactured by Diamond Shamrock, were used throughout this investigation because large quantities of these resins were available at the time of the investigation. Both of these resins are made by copolymerizing styrene with 4% divinylbenzene and both resins are in the chloride form. Diaion PA308 is a Type I resin while Duolite A-102D is a Type II resin.

Decolorization with activated carbon

Several activated carbons are available commercially. To determine which carbon is best suited for this application, a 2.0 g portion of different activated carbons was added to 200 cm^3 of diluted molasses (10.8°Bx), mixed for 5 minutes, and first filtered through a RA226 filter paper, then through a 0.45 μm membrane filter. The absorbance of the filtrate was determined as previously described.

The results shown in Table II indicate that Darco G-60 is a slightly better decolorizer than the Norit carbons. In addition, a considerable amount of Norit carbon was noted on each of the corresponding membrane filters. Thus, all subsequent experiments described here were carried out with Darco G-60 carbon.

Table II. Absorbance of dilute molasses decolorized with different activated carbons

Carbon	Absorbance
(a)	1.27
Darco G-60	2.02
Norit SG-1	2.36
Norit A	2.36
Norit 211	2.33
Norit SG-Extra	2.14

(a) sample decolorized with lead subacetate

Decolorization with anion resin and activated carbon

Since most colour species existing in factory juices and syrups are neutral and anionic, and some are of high molecular weight, decolorization may best be accomplished with a combined treatment of strong anion resin and activated carbon. Preliminary results, shown in Table III, indicate that on a weight basis, a mixture of Diaion PA308 resin and Darco G-60 carbon can eliminate more colorants from a given volume of dilute molasses solution than either the resin or carbon alone. The decolorizing power of a mixture containing 4 g of Diaion PA308 and 2 g of activated carbon on dilute molasses was almost equivalent to using about 8 g of dry lead. In addition, samples treated with resin and carbon filtered faster than those clarified with dry lead.

Table III. Absorbance of dilute molasses decolorized with varying amounts of Diaion PA308 resin and Darco G-60 carbon

Resin, weight g	Carbon, weight g	Absorbance
(a)	(a)	0.46
2.0	0	0.72
3.0	0	1.35
4.0	0	1.11
5.0	0	0.93
0	2.0	1.75
0	4.0	1.12
0	6.0	0.72
2.0	1.0	1.00
3.0	1.0	0.82
4.0	1.0	0.70
5.0	1.0	0.62
2.0	2.0	0.75
3.0	2.0	0.58
4.0	2.0	0.50
5.0	2.0	0.45
2.0	3.0	0.54
3.0	3.0	0.44
4.0	3.0	0.36
5.0	3.0	0.32

(a) This sample was decolorized with 8.0 g of lead subacetate.

Effect of mixing time

When resins are added to a sample, the dissolved solutes will migrate in and out of the resin matrix. To determine the mixing time required to reach equilibrium, 4 g of Diaion PA308 resin containing 59% moisture was added to several 150 cm^3 portions of a standard sugar solution and mixed for different time intervals. Measurement of pol of the solution revealed that equilibrium was attained in less than one minute of mixing time. Since filtration of a factory sample through RA226 filter paper takes about 5-10 minutes, a mixing time of 20 seconds was subsequently adopted and found to be satisfactory.

Effect of resin moisture on the pol value

Ion exchange resins are sold wet. Diaion PA308 resin may contain 57-67% moisture and Duolite A-102D resin may contain 39-44% moisture. If the resins are too wet, the sample will be diluted by the water present in the resin, thus resulting in a decrease in sugar concentration. If the resins are completely or nearly dry, the required water for hydrating the resin will be taken from the sample solution, resulting in an increase in sugar concentration. Consequently, the effect of resin moisture on the pol value was studied.

Several large portions of Diaion PA308 resin were dried for different periods of time. Some resins were dried in an oven and some were dried under ambient conditions. The final moisture content of each batch of resin was determined by oven drying. Two grams of resin and 2.0 g of activated carbon were used for decolorizing thin juice, thick juice, and standard liquor. Diluted molasses samples were treated with 4.0 g of resin and 2.0 g of carbon. The pol of the filtrates was measured in the usual manner, and the results are summarized in Table IV.

Table IV. Effect of resin moisture on polarimetry

	Pol (°S)			
Resin moisture %	Thin juice	Diluted thick juice	Diluted standard liquor	Diluted molasses
–	43.44(a)	49.85(a)	46.85(a)	26.30(a)
60.1	43.11	49.51	46.46	26.00
22.0	43.44	49.90	46.80	26.42
15.6	43.51	49.88	46.84	26.49
8.6	43.58	50.03	46.94	26.47
0.1	43.63	50.10	46.96	26.90

(a) Values obtained using lead subacetate decolorization.

The data suggest that the optimum moisture content of Diaion PA308 resin used for decolorization of thin juice, thick juice and standard liquor is 22%, while for decolorization of molasses 30% moisture is desirable. As a compromise for general use, a resin moisture value of 25 ± 2% was temporarily adopted. The moisture content of Darco G-60 carbon used throughout this investigation ranged from 3.6 to 5.0%.

Effect of resin and carbon on sugar solutions

Preliminary tests showed that sugar contents of cold solution, cold filtrate, and Steffen filtrate clarified with 2.0 g of Duolite A-102D resin and 2.0 of Darco G-60 carbon agreed closely with those clarified with basic lead acetate solution. However, when the same quantity of resin and carbon was applied to saccharate cake samples, the results were noticeably lower. Subsequently, the effect of resin and carbon on standard sugar solutions was studied.

Aliquots of a standard sugar solution were transferred into different 200 cm^3 volumetric flasks, diluted to volume, mixed, and transferred into beakers. Different amounts of Duolite A-102D resin containing 24% moisture and Darco G-60 carbon were added to each sugar solution, mixed, and filtered. The pol values of the filtrates were measured and the results are presented in Table V. For comparison purposes, an untreated sample was used as control.

Table V. Effect of resin and carbon on sugar solution

Wt.A-102D resin, g	Wt.Darco G-60 carbon, g	Pol (°S)
0	0	29.40
2.0	0	29.51
4.0	0	29.56
6.0	0	29.60
8.0	0	29.69
0	0.5	29.31
0	1.0	29.28
0	2.0	29.06
0	3.0	28.78
0	0	30.72
2.0	0.5	30.76
4.0	0.5	30.77
6.0	0.5	30.83
8.0	0.5	30.87
2.0	1.0	30.63
4.0	1.0	30.67
6.0	1.0	30.73
8.0	1.0	30.77

The data in Table V indicate that, by comparison with the control sample, standard sugar solutions treated with Duolite A-102D resin showed a slightly higher pol value (0.05° per gram resin), while sugar solutions treated with Darco G-60 carbon showed a decrease in pol (−0.17° per gram carbon). This suggests that, in order to achieve close comparative results, a weight ratio of 4 parts of resin to 1 part of carbon should be employed for decolorization. Results of subsequent tests, also shown in Table V, confirmed the above hypothesis. In addition, the data also indicate that the ratio of resin to carbon can be as high as 8:1 without having an adverse effect on results.

RECOMMENDED PROCEDURE

Two decolorization procedures using anion-exchange resin and activated carbon were developed. One of the procedures is used for the determination of sugar content, while the other is applied for apparent purity coefficient determination. The two decolorization procedures differ in the amount of resin and carbon used. Employment of different amounts of resin and carbon is necessitated by sample size and type.

Apparatus

Rudolph Autopol IIS automatic saccharimeter with 200-mm flow-through cell or equivalent.

Carl Zeiss manual refractometer or equivalent.

Reagents

Dilute acetic acid (25% v/v).

Darco G-60 decolorizing carbon (J. T. Baker Chemical Co.).

Duolite A-102D anion-exchange resin (Diamond Shamrock Corp.).

Diaion PA308 anion-exchange resin (Mitsubishi Chemical Industries Ltd.).

Celite diatomaceous earth filter aid (Johns Manville).

Procedure

Preparation of resin to contain 25 ± 2% moisture

Determine the moisture content of the resin as received by oven drying. The moisture of the wet resin is needed for calculating the weight of resin containing 25% moisture.

Transfer 500 g of wet resin to a tared aluminum pie pan when using Method A or B, or to a tared plastic pan when using Method C and dry the resin to a precalculated weight. Removal of resin moisture may be accomplished by evaporation (A) under ambient conditions, (B) by heating in an oven maintained at 70-75°C or (C) by heating in a microwave oven.

(A) Evaporation of resin moisture under ambient conditions requires about 24-48 hours and the resin should be stirred every two hours.

(B) Evaporation of resin moisture conducted in a convection oven may require 5-7 hours and the resin should be stirred every two hours.

(C) Evaporation of resin moisture conducted in a microwave oven may require 20-30 minutes and the resin should be stirred every 5 minutes.

Weigh the resin occasionally until the weight of the resin plus the pan is within ± 4 g of the precalculated weight. Transfer the resin to a plastic container and cover when not in use.

Determination of apparent purity coefficient (APC)

Dilute massecuite, machine syrup, and molasses samples with hot water to a solids content of 9-11%. Dilute thick juice and standard liquor to a solids content of 10-15%. Mix the diluted sample thoroughly, cool to the refractometer temperature and determine the Brix of the diluted sample.

Transfer 150-160 cm^3 of diluted sample to a beaker. For massecuite, machine syrup, and molasses samples, add 4 g of the prepared resin. For thin juice, thick juice, and standard liquor samples, add 2 g of resin. Mix for about 10 seconds, then add 2 g of Darco G-60 carbon and again mix for about 10 seconds. Allow to stand for about 2 minutes and filter through RA226 filter paper with added filter aid. Measure the pol of the filtrate in a 200-mm cell. Calculate the apparent purity (APC) by using the following formula:

$$\text{APC} = \frac{(0.26 \times \text{Polarization})100}{\text{Bx} \times \text{Apparent Density at } 20^\circ\text{C}}$$

Determination of sugar content

Transfer a sample of suitable size, as listed below, to a 200-cm^3 volumetric flask. Neutralize to phenolphthalein endpoint with dilute acetic acid. Dilute to the mark with distilled water, mix thoroughly and transfer the sample into a beaker.

Add the required amount of resin, as listed below, and mix for about 10 seconds. Add the required amount of Darco G-60 carbon and again mix for about 10 seconds.

Allow the mixture to stand for about 2 minutes, filter through RA226 filter paper with added filter aid, and measure the pol of the filtrate in a 200-mm cell.

Sample	Sample size taken	Resin used (g)	Darco G-60 used (g)
Cold solution	50.0 ml	4	1
Cold filtrate	50.0 ml	4	1
Steffen filtrate	100.0 ml	4	1
Cold saccharate cake	26.00 ± 0.02 g	4	0.5
Hot saccharate cake	26.00 ± 0.02 g	6	0.5
Molasses (double-diluted)	52.00 ± 0.04 g	6	2

RESULTS

The average differences in apparent purity coefficient and sugar content resulting from resin-carbon and lead decolorization as shown in Tables VI and VII are relatively small. With the exception of Steffen filtrate, the differences in results are not significant at the 95% probability level. The noted differences of 0.01 to 0.02% sugar for the Steffen filtrate samples, although significant, are acceptable.

Table VI. Comparison of APC obtained from resin-carbon and dry lead decolorization

	Apparent purity coefficient		
Sample	Resin-carbon*	Dry lead	Δ (RC-DL)
Thin juice	90.0	90.0	0
	89.8	90.0	− 0.2
	90.0	89.8	+ 0.2
	90.1	89.8	+ 0.3
	90.1	90.0	+ 0.1
	90.2	90.2	0
	90.1	90.1	0
			Avg 0.06
Thick juice	90.0	89.9	+ 0.1
	90.1	89.9	+ 0.2
	90.2	90.2	0
	90.7	90.7	0
	90.7	90.7	0
	90.4	90.4	0
	90.5	90.4	+ 0.1
			Avg 0.06
Standard liquor	94.6	94.5	+ 0.1
	94.8	95.1	− 0.3
	94.9	95.0	− 0.1
	94.0	94.0	0
	94.3	94.4	− 0.1
	94.5	94.8	− 0.3
	94.5	94.8	− 0.3
			Avg − 0.14

* Diaion PA308 resin used.

Statistical evaluation of comparative data obtained by our factory Control Laboratories are summarized in Tables VIII and IX. The differences obtained using two different decolorizing methods for molasses, intermediate massecuite, and Steffen filtrate are significant. However, the differences are relatively small and they are acceptable for process control purposes. In addition, a significant portion of the difference was due to the large excess amount of lead which factory analysts used in clarifying molasses and massecuite samples during the months of July — November.

Table VII. Comparison of sugar content obtained from resin-carbon and lead decolorization

	% Sugar (by polarimetry)		
Sample	Resin* and carbon	Lead solution (55°Brix)	Δ (RC-Pb)
Cold solution	9.81	9.82	− 0.01
	6.52	6.53	− 0.01
	7.12	7.10	0.02
	6.95	6.95	0.00
	6.84	6.84	0.00
			Avg 0.00
Cold filtrate	0.56	0.56	0.00
	0.60	0.60	0.00
	0.54	0.55	− 0.01
	0.56	0.56	0.00
	0.51	0.52	− 0.01
			Avg 0.00
Steffen filtrate (waste)	0.17	0.18	− 0.01
	0.18	0.19	− 0.01
	0.11	0.12	− 0.01
	0.09	0.11	− 0.02
	0.12	0.12	0.00
			Avg − 0.01
Cold saccharate	13.22	13.22	0.00
	13.66	13.64	0.02
	13.66	13.68	− 0.02
	13.80	13.76	0.04
	14.06	14.06	0.00
			Avg 0.01
Hot saccharate	11.36	13.38	− 0.02
	11.34	11.32	0.02
	11.32	11.36	− 0.04
	10.68	10.70	− 0.02
	11.00	11.04	− 0.04
			Avg − 0.02
Molasses	54.82	54.72	0.10
	55.46	55.40	0.06
	55.56	55.48	0.08
	53.58	53.64	− 0.06
	57.26	57.10	0.16
			Avg 0.07

* Duolite A-102D resin used.

Table VIII. Comparative data for resin-carbon and lead decolorization (Mendota Factory)

	Molasses	Cold solution	Cold saccharate	Steffen filtrate
No. of samples (N)	26	94	92	101
Avg. % S (Resin-carbon)	54.44	8.29	14.41	0.22
Avg. % S (Lead)	53.95	8.30	14.43	0.23
Avg. Diff. (RC-Lead)	0.49	− 0.01	− 0.02	− 0.01
Std. Dev. (Avg. Diff.)	0.525	0.088	0.193	0.022
t-Value	4.76	1.10	0.99	4.57
Significance, %	>99	72	67	>99

The current estimated reagent cost for the decolorization of one sample of molasses using resin and carbon is about $0.10 which is considerably less than when lead subacetate is employed. Polystyrene divinylbenzene resin and activated carbon have not been identified as hazardous wastes[5]. Thus, special and costly waste disposal procedures of these substances are not required.

Summary

A decolorization method based on the combined use of strong anion-exchange resin and activated carbon has been developed. Pol measurements of filtrates obtained from resin-carbon decolorization agreed closely with those resulting from lead clarification. The proposed reagents decolorized factory samples as effectively and quickly as lead. Samples treated with resin and carbon filtered considerably faster than those treated with lead.

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[5] *U.S. Federal Register,* 45(98), 40 CFR Part 261.

These decolorizing reagents are readily available commercially and relatively inexpensive by comparison with lead compounds. The method is applicable for decolorization of thin juice, thick juice, standard liquor, massecuite, machine syrups, molasses, Steffen fluids, and saccharate cakes.

Table IX. Comparison of APC obtained using resin-carbon and lead decolorization

	Manteca* factory	Mendota* factory	Woodland† factory
Thin juice (N)	61	79	24
Avg. Diff. (RC-Lead)	0.34	0.03	0.13
Std. Dev. (Avg. Diff.)	0.97	0.60	0.42
t-Value	2.74	0.44	1.52
Significance, %	>99	34	85
Molasses (N)	65	78	301
Avg. Diff. (RC-Lead)	0.34	0.56	0.38
Std. Dev. (Avg. Diff.)	0.62	1.17	0.60
t-Value	4.42	4.23	10.99
Significance, %	>99	>99	>99
Intermediate massecuite (N)		77	118
Avg. Diff. (RC-Lead)		0.07	0.24
Std. Dev. (Avg. Diff.)		0.55	0.43
t-Value		1.12	6.06
Significance, %		73	>99

* Duolite A-102D resin used.
† Diaion PA308 resin used.

Le remplacement du défécant au plomb par de la résine et du charbon actif

Une méthode de décoloration basée sur l'emploi combiné d'une résine échangeuse fortement acide et de charbon actif a été élaborée. Les mesures de polarisation de filtrats obtenus par décoloration résine-charbon concordaient très bien avec celles de la clarification à la liqueur au plomb. Les réactifs proposés décolorent les échantillons d'usine aussi efficacement et aussi rapidement que les solutions au plomb. Les échantillons traités à la résine et au charbon actif filtraient beaucoup plus vite que ceux traités par la liqueur au plomb. Ces agents décolorants sont aisément disponibles dans le commerce et relativement peu coûteux par comparaison avec les composés au plomb. La méthode est applicable à la décoloration du jus léger, du jus dense, de la liqueur standard, de la masse cuite, des égouts de centrifugation, de la mélasse, des liqueurs de sucraterie et des tourteaux de saccharate.

Ersatz von basischem Bleiacetat durch Ionenaustauscherharz und Aktivkohle

Eine Entfärbungsmethode, die auf der kombinierten Verwendung eines stark-basischen Anionenaustauschers und Aktivkohle beruht, wurde entwickelt. Polarisationsmessungen von Filtraten der Austauscherharz-Aktivkohle-Entfärbung stimmten fast genau mit denen der Bleiacetat-Klärung überein. Die vorgeschlagenen Reagentien entfärbten Fabrikproben genauso schnell und effektiv wie Bleiacetat. Die über Ionenaustauscher und Aktivkohle entfärbten Proben filtrierten wesentlich schneller als die mit Bleiacetat behandelten. Diese Entfärbungsreagentien sind kommerziell leicht erhältlich und relativ billig im Vergleich zu Bleiverbindungen. Die Methode ist anwendbar für die Entfärbung von Dünnsaft, Dicksaft, Standard-Kläre, Füllmasse, Zentrifugenabläufen, Melasse, Steffen-Filtrate und Saccharat-Filterkuchen.

Sustitución de plomo por resina y carbón para descolorización de muestras en una fábrica

Un método de descolorización, basado en el uso de una combinación de resina fuerte cambiador de aniones y carbón activado, se ha desarrollado. Medidas de pol en filtrados obtenidos por descolorización con resina-carbón fueron en estrecho acuerdo con ellos que resultaron de clarificación con plomo. Los reactivos propuestos han descolorizado muestras en fabricas tan efectivamente y rápidamente como plomo. La filtraciòn de muestras tratado con resina y carbón fue notablemente más rápida que en el caso de muestras clarificado con plomo. Estos reactivos estan libremente disponible y relativamente barato por comparación con compuestos de plomo. El método puede aplicarse en la descolorización de jugos ligeros, jugos densos, licor estandard, masa cocida, mieles, melazas, fluidos del proceso Steffen, y tortas de sacarato.

Correspondence

To the Editor,
International Sugar Journal.

Dear Mr. Leighton,

Fletcher and Stewart Limited

I can report that the many rumours suggesting that this company is out of business are entirely false. FS is not only alive but is prospering at its new headquarters in Derby. The surgery which led to a drastic reduction of the workforce and the closure of part of the old Derby workshops was a necessary part of the reconstruction of the FS organization and philosophy.

Although FS retains a capability and interest in major new turnkey projects the company is concentrating its efforts in the provision of a service to the existing industry through the supply of spare parts, unit equipment and engineering of the reconstruction and modernization of factory stations. In support of this philosophy the Atlas foundry at Derby, which was totally re-built in 1977, continues to devote itself to the supply of special grades of cast iron for roller shells and other spares plus high quality brass for mill bearings. The pattern-making facility and small machine shop remain open in support of the foundry which, if required, can produce an annual output of over 3000 tonnes. FS has also kept some key specialist machines which have been relocated at the premises of a large engineering works with complementary resources and capacity.

The important spare parts business is balanced by an investment in the improvement of existing products and the search for new technology as the basis for the future of FS and its customers. The company expects to launch several new products over the next year. Meanwhile, over the past six months, considerable success has been achieved in the sale of high-technology products such as the FS/Tongaat shredder (5 sold), the FS/Polymex toothed roll pressure feeder to Amatikulu in South Africa (representing the first use of this unit on a drying mill after a diffuser) and a very large evaporator to the British Sugar Corporation. This latter contract was for five vessels ranging in diameter from 14 to 19 feet and with a total heating surface of 155,000 sq.ft.

Yours sincerely,
Barry Newton,
Managing Director.

Fletcher and Stewart Ltd.,
Norman House,
Friar Gate,
Derby DE1 1NU,
England.

Solution flow and exchange and heat transfer in a heating tube of an evaporation-crystallizer

By DR. -ING. KLAUS E. AUSTMEYER and
PROF. DR. DIETRICH SCHLIEPHAKE
(Institut für landwirtschaftliche Technologie und
Zuckerindustrie, Braunschweig, Germany)

Approach to the problem

In technical evaporation-crystallization of sucrose, a wet-milled suspension or slurry, consisting of fine-grained particles of sucrose in isopropanol, is often used as seed. The average grain size of this seed within the mass frequency distribution is about 8 μm. However, since within this distribution is an almost 50% fraction of very fine particles < 0.5 μm and in view of the non-uniformity of the supersaturation field in the crystallizer, the question is to what extent can the process be controlled using this slurry as crystal seed.

Because of solution overheating in the vicinity of the walls, under-saturated zones are to be expected (particularly in the calandria) in which the very fine slurry particles may dissolve. Moreover, it may be assumed that secondary grain will form to compensate for this dissolution.

The present work concerns the chances of survival of the slurry particles under operating conditions that are normal for evaporation-crystallization of pure sugar solutions. Prerequisite for obtaining the evidence is knowledge of:

the field of the concentration gradient acting as driving force within the calandria,

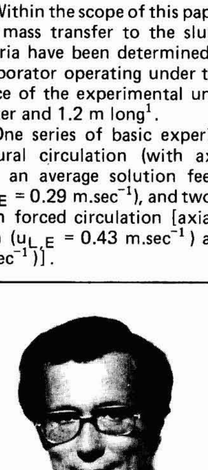
the fields of the axial flow rate and of the radial exchange rate of the solution within the calandria, and

the kinetics of mass transfer to very small sucrose particles.

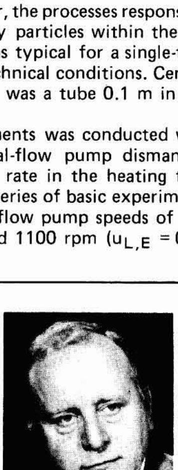
Local temperature, local static pressure, vapour bubble field and local rate of dissolution in a heating tube

Within the scope of this paper, the processes responsible for mass transfer to the slurry particles within the calandria have been determined as typical for a single-tube evaporator operating under technical conditions. Centrepiece of the experimental unit was a tube 0.1 m in diameter and 1.2 m long[1].

One series of basic experiments was conducted with natural circulation (with axial-flow pump dismantled and an average solution feed rate in the heating tube $u_{L,E} = 0.29$ m.sec^{-1}), and two series of basic experiments with forced circulation [axial-flow pump speeds of 600 rpm ($u_{L,E} = 0.43$ m.sec^{-1}) and 1100 rpm ($u_{L,E} = 0.74$ m.sec^{-1})].



K. E. Austmeyer



D. Schliephake

The temperature field of the solution within the tube was completely determined by means of a set of thermocouples, arranged axially one above the other and radially displaceable, mounted in small steel tubes. So as to be able to measure the radial temperature profiles up to the inside of the heat jacket and finally calculate the heat transfer in the heating tube, the temperature profile was also measured at a radius within the tube wall as well as the temperature of the heating steam.

Fig. 1 shows a representative selection of temperature profiles measured during natural circulation. In the radial profiles (Fig. 1a) the thickly drawn curve combines the arithmetical means of about 50 values taken per measuring point. A scatter of values was allowed for at each point. The maximum and minimum values were also joined by curves. Fig. 1a shows that already at a measuring height z = 0.1 m there is a distinct temperature profile on the tube wall. The considerable scatter of values for the wall zones (0.046 m $< r <$ 0.05 m, where r = radius) is noticeable. This suggests an intensive convective exchange of cooler solution from the core stream for heated solution at the tube wall.

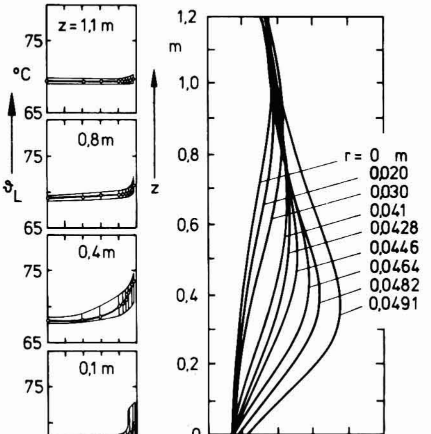


Fig. 1. Radial (a) and axial (b) temperature profiles of the solution in the heating tube during natural circulation

At a height z = 0.4 m, the effects of heat transfer have spread inwards up to a radius of 0.02 m. The effect of convection currents from the tube wall and reaching right into the tube is remarkable, particularly since, as separate measurements show, the bubble zone at this height is restricted to a small annulus of $r < 0.02$ m.

At z = 0.8 m, the heating process has reached the

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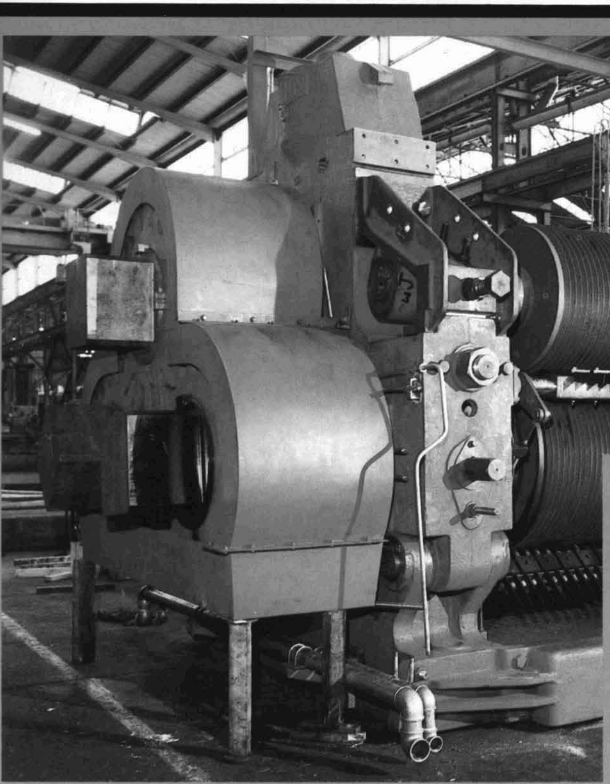
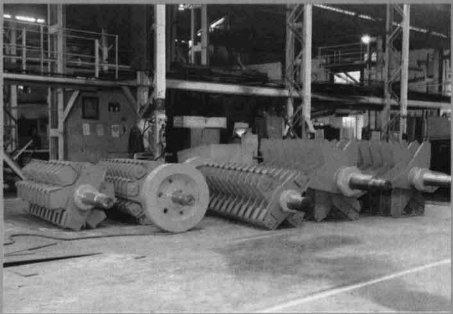
[1] Austmeyer: Dissertation (Braunschweig Technical University), 1981.



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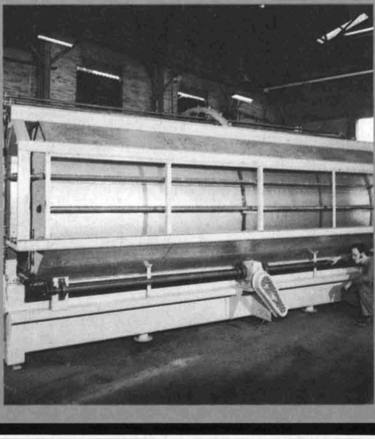

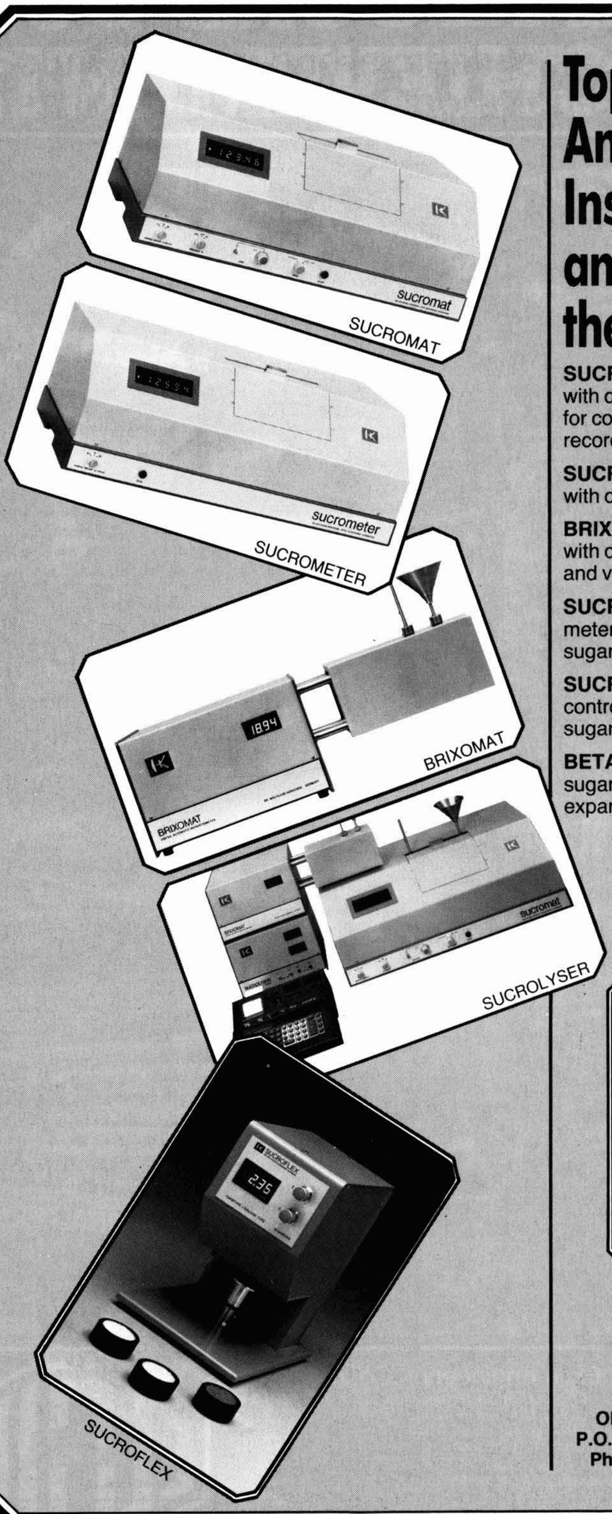
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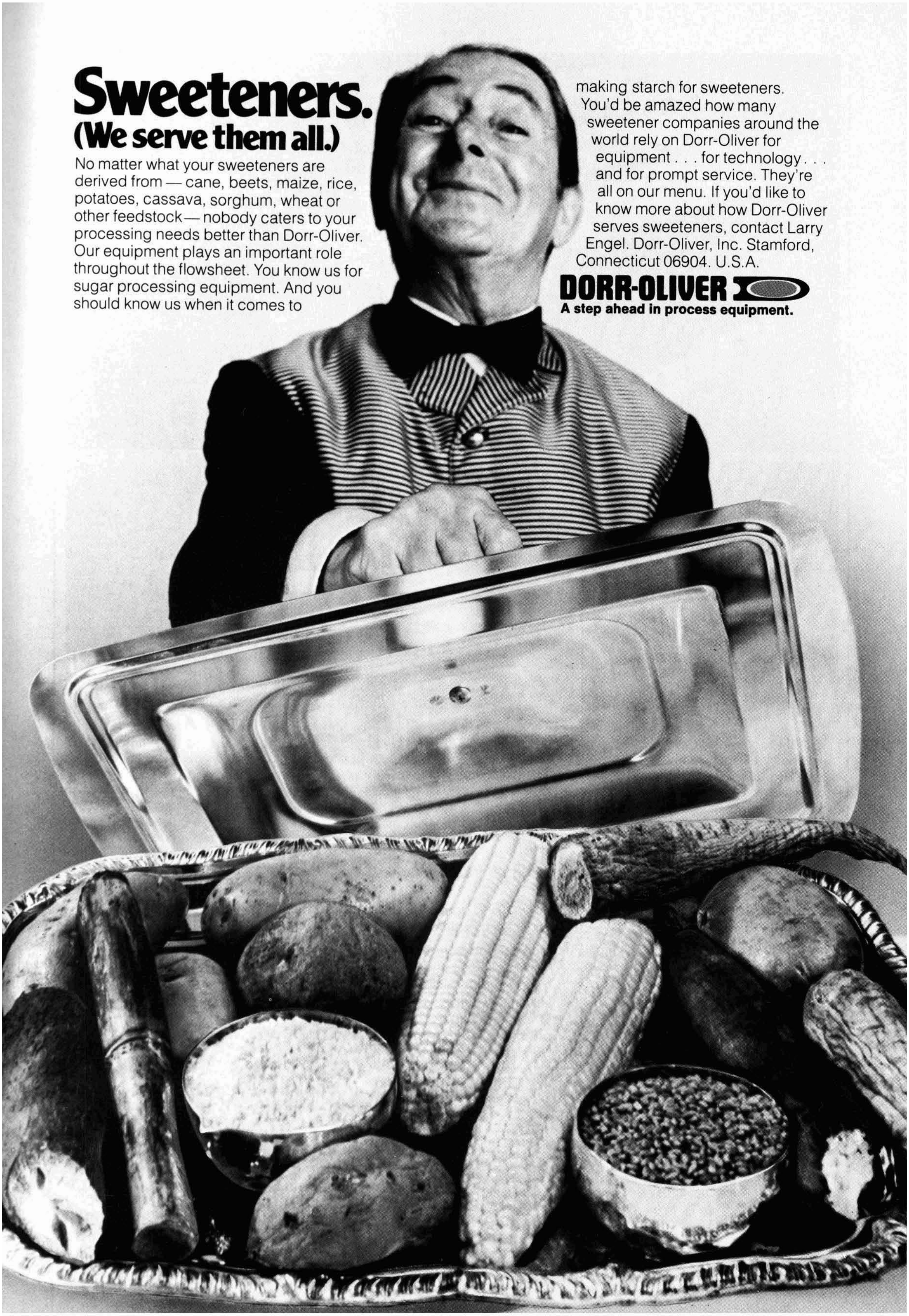

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interior of the tube. The decrease in scatter (with increase in height) in the zone affected by heat transfer illustrates the increase in homogeneity of the solution. This is also made clear by the diminishing curvature of the curve joining the arithmetical means as the height increases. This tendency continues in the radial profiles at z = 1.1 m.

Fig. 1b shows the axial temperature profiles, constructed from the arithmetical means, here reproduced for nine different radii r; their numerical values in the vicinity of the wall result from the displacement path obtained per revolution of the device used for radial movement of the thermo-couples.

It is noticeable that in the present case all the axial temperature profiles have maxima[2-9]. The occurrence of these extremes is attributable, however, to different causes, as will be shown. The particularly distinctive maxima immediately next to the wall are caused by the counteracting effects of heating by heat transfer from the tube wall on the one hand, and of cooling by convective flow of cooler solution from the core stream on the other. The temperature field for a hypothetical cylindrical annulus of radius r = 0.0491 m shows that up to a height z = 0.35 m, the heating effect is dominant, whereas above this height the effect of convective flow of cooler solution is dominant because of the increased bubble activity. To avoid any misunderstanding, let it be said that, apart from the core stream, local boiling equilibrium is still not achieved at the temperature maxima.

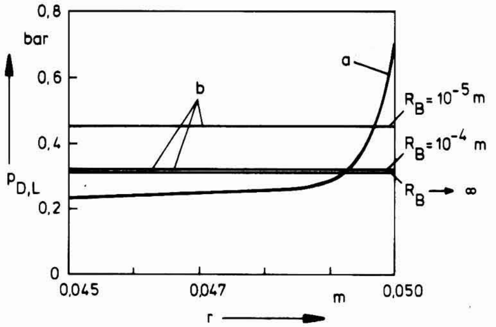

Fig. 2. Vapour pressure of solution (a) and pressure in equilibrium bubbles (b) at a measuring height z = 0.1 m

The processes taking place immediately adjacent to the tube wall are briefly discussed below. It has already been mentioned that bubbles form in the lower section of the tube. However, they recondense shortly after their release or while they are still adhering to the wall. This finding can be substantiated by looking at the thermodynamics, which will be discussed after some preliminary remarks on bubble formation. When the film of solution moistening the tube wall is sufficiently overheated, bubbles are released from the active evaporation nuclei present at the tube surface[10-12]; they leave the wall if the forces resulting from buoyancy and flow exceed the forces of adhesion.

Curve a in Fig. 2 shows the vapour pressure $p_{D,L}$ of the solution in the wall zone (0.045 m < r < 0.05 m) as determined from the measured temperature profile and the relationship between temperature θ_L, dry solids content ζ_L and vapour pressure of pure sucrose solution. The vapour pressure of the solution surrounding the equilibrium bubbles of varying radius r_B (Curve b) was determined from the the static pressure and the corresponding boiling temperature measured at this tube height.

The following formula is valid for pressure $(p_{D,L})_R$, as governed by the critical radius r_B of a hypothetical, spherical vapour bubble:

$$(p_{D,L})_R = (p_{D,L})_\infty \exp\left(-\frac{2\sigma_{L,B}}{r_B}\,\frac{V_W}{R\,T_L}\right) + \frac{2\sigma_{L,B}}{r_B}$$

where $(p_{D,L})_\infty$ is the vapour pressure on a hypothetical bubble of infinite size, V_W is the molecular volume of water, $\sigma_{L,B}$ is the interfacial tension between solution and bubble, T_L is temperature and R is the universal gas constant.

The first term, representing the Gibbs-Thomson equation, comprises the decrease in vapour pressure of a solution interfaced with a concave-surfaced bubble[12 13], where the decrease is derived from a balance of the free enthalpies with transfer from liquid to vapour phase. The expression $2\sigma_{L,B}/r_B$ represents the pressure rise within the bubbles, relative to the surroundings, as calculated from the balance of surface and volumetric forces. The decrease in vapour pressure on the concave solution annulus within the bubble may, however, be ignored in respect of the pressure rise.

If the bubbles are in equilibrium with the surrounding solution, the vapour pressure of the surroundings must exceed the saturation pressure as given, for very large bubbles, by $2\sigma_{L,B}/r_B$, i.e. the surroundings of equilibrium bubbles must always be overheated. This overheating increases with diminishing bubbles size[14-16].

The bubble radius in Fig. 2 allows for a range of 10^{-5} m $\leqslant r_B \leqslant \infty$. It is evident that only a very narrow zone in the vicinity of the wall exhibits the vapour pressure necessary for the existence of stable bubbles. We may therefore conclude that, at this height, most of the bubbles formed in the active centres of the tube surface recondense while adhering to the wall but before attaining the diameter necessary for their release, promoted by the flow of cooler solution from the interior of the tube.

Fig. 3 demonstrates the effect of the temperature field in the tube on the supersaturation of the solution (here shown only for natural circulation). It can be seen that the solution is undersaturated only in a very restricted zone in the immediate vicinity of the wall; the entire remaining section of the tube contains supersaturated solution.

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[15] Dergarabedian: *J. Appl. Mech.*, 1953, **20**, 537.
[16] Kosky: *Chem. Eng. Sci.*, 1968, **23**, 695.

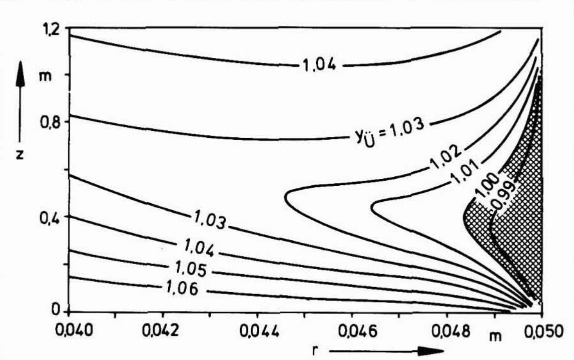

Fig. 3. Lines of equal supersaturation in the heating tube during natural circulation

With the object of verifying and completing the results obtained from temperature measurements in the bubble zones in the heating tube, we determined the static pressure p_{st} in the tube as well as the bubbles (determined conductimetrically); this is discussed in the next section. Measurements were made at three radii ($r = 0, 0.012$ and 0.034 m) and at five heights. Fig. 4 shows the measurements obtained during natural circulation. At $z = 1.3$ m (this height includes the 0.1 m high unheated tube head) the curve attains the value of the vapour pressure $p_{Br} = 0.213$ bar. Differences between the measured values of the pressure at the three radii are unsystematic. Hence, resulting cross-currents can be omitted for the measured section of the tube. The pressure p_{st} in the lower section of the tube is approximately linear for all radii. Deviations of pressure from linearity in the upper part of the tube are attributable to the presence of vapour bubbles.

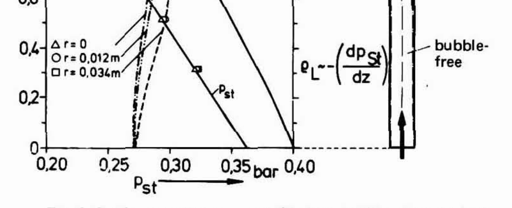

Fig. 4. Static pressure p_{st}, equilibrium boiling temperature $\theta_{L,S}$ and measured temperature θ_L in the heating tube during natural circulation

To establish the height at which the solution reaches the local vapour pressure $p_{D\infty}$, the curves of equilibrium boiling temperature $\theta_{L,S}$ corresponding to pressure distribution, and the axial temperature profiles corresponding to the tube radii were also included in the diagrams.

The boiling temperatures calculated for Fig. 4, and assigned to the local static pressures, are higher than the measured temperatures in the bubble-free heating section of the tube. Local equilibrium boiling is achieved at the points of intersection of the measured temperature profiles and the boiling temperature curves calculated from the pressure. Above these points of intersection, the curves pass through maxima which reflect the reduction in overheating caused by the bubbles, i.e. the vapour pressure of the solution corresponds at least to the equilibrium vapour pressure $(p_{D,L})_\infty$ above the maxima of the axial temperature profiles. It is noticeable that the curve of static pressure at the appropriate radius deviates from linearity below the point of intersection of the corresponding temperature curves; this clearly shows that vapour bubbles exist in this section. However, here it is mainly a question of bubbles that, after transfer to the interior of the tube, are no longer in thermodynamic equilibrium with the surrounding solution and recondense.

As mentioned above, knowledge of the fields of axial flow velocity and of the radial exchange velocity of the solution inside the tube is also a necessary prerequisite for mathematical analysis of the fate of the slurry particles. The measuring problem that arises was solved by using a probe as electrolyte detector[17].

During numerous preliminary investigations, annular electrodes coated with an electrolyte tracer solution proved highly suitable as a means of solving the above-mentioned measuring problem. When a tracer solution flows successively through two co-axially arranged electrodes, one above the other, the local axial velocity is given by the time difference between the signals transmitted during passage of the tracer. The field of local axial flow velocities and the local radial exchange velocities can be found from the distribution in the channels (arranged in one single plane) in the upper set of the mass of tracer added to the channel in the lower electrode set.

The axial velocity contours derived from the profiles of the mean axial velocity[1] for natural circulation are given in Fig. 5.

When bubbles are formed, their release from the tube wall and particularly their recondensation cause convection currents in a radial direction in the tube. The quantitative determination of these currents was the subject of a series of experiments[1], results of which will be discussed here only briefly.

Integration of the calibration curves obtained for the upper and lower electrodes interfaced with one measuring channel showed how much of the tracer in the statistical mean has left the double-cylinder system boundary between the two annular electrodes.

Investigations were also carried out, using a varied

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[17] Troino: *Izv. Vuzov, Pishch. Tekh.*, 1962, (3), 116-122.

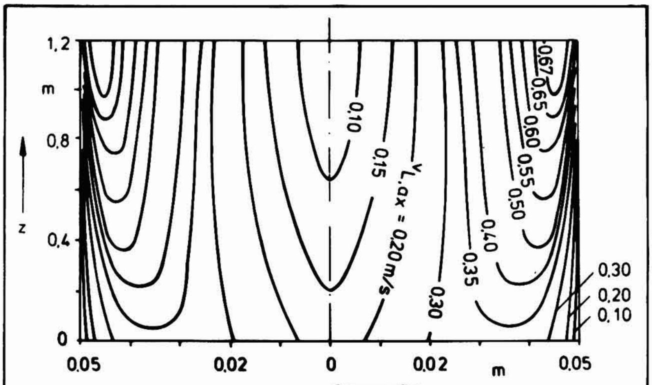

Fig. 5. Velocity contours of axial flow of solution in the heating tube during natural circulation

arrangement of the measuring channels in the upper electrode set, to determine quantitative distribution of the tracer from the feed channel in the neighbouring channels.

The simulation calculation of mass transfer to slurry particles described below on p. 332 refers back to the velocity contours of axial and radial flow of the suspension.

A balance of the system comprising tube, heat jacket, vapour space and downtake was used as basis for calculation of the solution-side heat transfer coefficients. The tube was divided into 12 axial sections of equal size. The complete axial temperature profiles for the tube were obtained, allowance being made for thermal conduction in the laminar condensate film and at the tube wall.

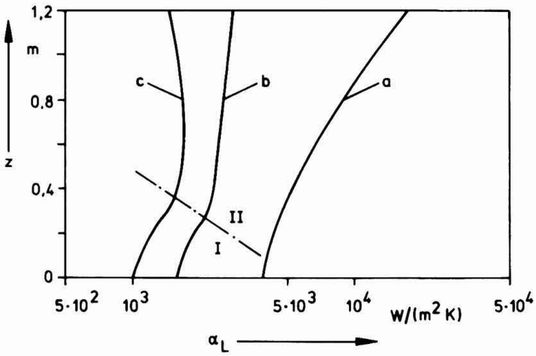

Fig. 6. Solution-side heat transfer coefficient ζ_L *vs.* tube height z
a: ζ_L = 0; b: ζ_L = 0.77; c: ζ_L = 0.84

Fig. 6 shows the heat transfer coefficients α_L determined for water, pure sugar solution and impure sugar solution of high viscosity. It is evident that the length of the preheating zone falls with reduction in viscosity of the solution. In the test using water as medium (Curve a), the axial extent of this zone cannot be determined exactly. In this case, there is comparatively vigorous local boiling because of the relatively low viscosity of the solution immediately after its entry in the tube. As measurements (not given here) show, at $z \approx 0.6$ m, the solution reached the equilibrium boiling temperature right in the core stream; hence, above this height, the possibility of recondensation of vapour bubbles can be ruled out. The gradual increase in the heat transfer coefficients with tube height is mainly attributable to convection currents created by the turbulent upflow of vapour bubbles. These convection currents increase as a result of increase in the vapour content with tube height.

In the test conducted with pure sugar solution (ζ_L = 0.77), the heat transfer coefficient α_L increased only relatively slightly above the heating zone (Curve b). This is attributable to two counteracting factors: the increase with height in the convection currents within the solution caused by the increase in the vapour component, and the reduction in micro-pulsations in local boiling (caused by bubble implosions) resulting from gradual heating of the core stream with increasing tube height.

This tendency becomes even more evident with sugar solution of higher concentration (ζ_L = 0.84) as shown by Curve c. The relatively long preheating zone at z = 0.4 m is followed by a section (0.3 m $\leqslant z \leqslant$ 1.0 m) in which the heat transfer coefficient is almost constant, while it clearly falls in the upper tube section. This pattern of α_L values can similarly be ascribed to the decreasing influence of local boiling. Moreover, the velocities of the vapour bubbles in the vicinity of the tube wall are relatively low because of the higher solution viscosity (by a factor of 5) by comparison with pure sugar solution (ζ_L = 0.77). Because of the hindered movement of bubbles away from the heating surface and the continuous formation of new bubbles, a vapour blanket forms over the heating surface in the upper tube section and has a negative effect on heat transfer.

Numerous works[18-29] concern dimensionless representation of heat transfer in ebullition. Naturally, all mathematical formulations based on experiments contain special preconditions for evaporator layout as well as the test substances used and the operating conditions. To date, no equation has been developed for heat transfer during ebullition that would allow for the numerous relevant parameters.

By means of a series of representative equations for bubble formation it has

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[18] Rohsenow: *Trans. ASME,* 1952, **74,** 969.
[19] Kirschbaum: *Chem.-Ing.-Techn.,* 1955, **27,** 248.
[20] Forster & Zuber: *A.I.Ch.E.J.,* 1955, **1,** 531.
[21] Gilmour: *Chem. Eng. Progr.,* 1958, **54,** 77.
[22] Lubunzov: *Teploenergetika,* 1960, **7,** 76.
[23] Nishikawa & Yamagata: *Int. J. Heat Mass Transfer,* 1960, **1,** 219.
[24] Ivaskevich: *Teploenergetika,* 1961, **8,** 74.
[25] Brauer: *Chem.-Ing.-Techn.,* 1963, **35,** 764.
[26] Neduzhko & Popov: *Sakhar. Prom.,* 1966, **40,** (4), 23-26.
[27] Lockhart & Martinelli: *Chem. Eng. Progr.,* 1949, **45,** 39.
[28] Guerrieri & Talty: *ibid.,* 1956, **52,** 69.
[29] Beaver & Hughmark: *A.I.Ch.E.J.,* 1968, **14,** 746.

been shown that the heat transfer to fluids exhibiting considerable overheating at the heating surface and mainly undergoing local boiling can only be satisfactorily described by a formulation based on change in bubble size with time as a function of overheating or undercooling. Such a formulation has been reported by Forster & Zuber[30].

Fig. 7 shows a graph of this equation as a thickly drawn straight line in the region investigated by the authors ($1 \leqslant Re \leqslant 10^3$). Data obtained for the average measuring height $z = 0.6$ m were used to calculate the factors from the experimental values obtained in this work. Although our experimental values are systematically below the line of the equation, they do lie on a straight line having the same slope. The low position of the values can be explained by the fact that the heat flux q in the Nusselt number at any one time refers to the overall tube height, including the preheating section. The straight line joining the measured values differs from that of the equation only in the smaller coefficients.

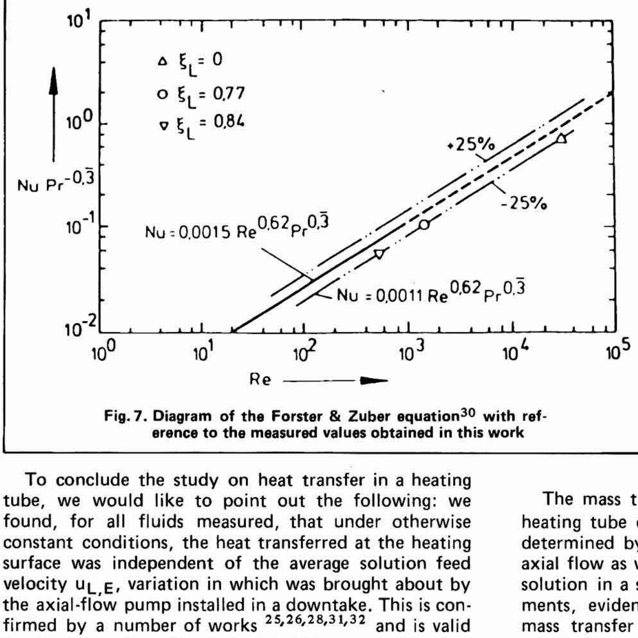

Fig. 7. Diagram of the Forster & Zuber equation[30] with reference to the measured values obtained in this work

To conclude the study on heat transfer in a heating tube, we would like to point out the following: we found, for all fluids measured, that under otherwise constant conditions, the heat transferred at the heating surface was independent of the average solution feed velocity $u_{L,E}$, variation in which was brought about by the axial-flow pump installed in a downtake. This is confirmed by a number of works [25,26,28,31,32] and is valid for heat transfer with distinct bubble evaporation but not for convective heat transfer in bubble-free flow. It again shows that the effect of free or forced convection in the fluid with respect to heat transfer is negligible by contrast with the effect of micro-pulsations produced by the vapour bubbles.

Simulation of mass transfer in a heating tube

The law of mass transfer applicable to simulation of growth and dissolution of the slurry particles in an evaporation-crystallizer was formulated from experiments in which fine-grained crystals were dissolved in a stirred vessel. Large-grained crystals were also dissolved during some of the experiments so as to provide more comprehensive evidence of mass transfer to granular particles in a stirred vessel. The mass transfer results obtained for the coarser grains were represented by an equation containing the particle number and the Reynolds number for the stirrer.

With fine-grained particles, convective transfer plays a subsidiary role; diffusion is the overriding transfer mechanism. The measured values correlated very satisfactorily with a formular derived by Nelson & Galloway[33] for diffusion of suspended particle clusters. It was found that, because of the relatively large particle spacing, the expression $Sh = 2$ was valid for diffusive mass transfer to single hypothetical, spherical, undisturbed particles under slurry seeding conditions in a technical crystallizer.

Simulation calculations of the fate of the slurry seed particles after their injection into the heating tube, divided into 100 cells, showed that, under the conditions in question, a substantial part of the seed does not survive retention in the under-saturated wall zones of the heating tube because of the high dissolution rate. Hence, in the case of natural convection, more than half of the injected particles disappeared after a period of only 4 minutes. Because of the extension of the undersaturated zone, the proportion becomes even higher with forced circulation. However, the possibility of increase in the reaction coefficient in the curing of the slurry particles had to be ignored in the simulation calculations, since to date there are no quantitative relationships for this.

Even though, in technical practice, solutions generally handled are of higher concentration than in this work, the original concept of complete survival of the injected particles associated with the slurry seed method is untenable. Reproducibility of this seed method is rendered very doubtful by the inevitable disturbances to the heating steam and particularly the vapour pressure resulting from the linking of heating steam- and vapour-side processes in technical crystallization.

Summary

The mass transfer to fine-grained seed crystals in the heating tube of a technical evaporation-crystallizer was determined by measuring the fields of temperature and axial flow as well as the radial exchange velocity of the solution in a single-tube evaporator. From the measurements, evidence required for a simulation model of mass transfer was obtained on the local state of the solution surrounding the particles as well as the local residence times of the particles. Zones of under-saturated solution were found in the immediate vicinity of the wall as a result of extremely high temperature gradients. The extent of these zones increased under the effect of reduced radial convection when forced circulation was intensified. Further investigations on static pressure within the tube confirmed findings on bubble phenomena derived from the temperature profiles. By including results obtained with the aid of a conductimetric bubble detector, evidence was obtained on bubble-free and

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[30] *J. Appl. Phys.*, 1954, **25**, 474.
[31] Fritz: *Chem.-Ing.-Techn.*, 1963, **35**, 753.
[32] Klein: *ibid.*, 1977, **49**, 757.
[33] *Chem. Eng. Sci.*, 1975, 1.

bubble-containing zones. Examination of equations for calculation of heat transfer confirmed that local (surface) boiling played a major role in the very over-heated wall zones. Because of the presence of the zones of under-saturation and high rate of seed crystal dissolution, it is concluded that the slurry seed method is of inadequate reproducibility for practical purposes.

Notation

a	–	Coefficient
c_p	$J.kg^{-1}.^\circ K^{-1}$	Specific heat capacity at constant pressure
D	$m^2.sec^{-1}$	Diffusion coefficient
d_i	m	Inside diameter
d_K	m	Particle size
k_D	$m.sec^{-1}$	Mass transfer coefficient
L	m	Characteristic length
Nu	–	Nusselt number ($= \alpha L/k$)
n	sec^{-1}	Rotary frequency
Pr	–	Prandtl number ($= \eta/(\rho a) = \eta c_p/k$
p	bar	Pressure
p_{st}	bar	Static pressure
q	$W.m^{-2}$	Heat flow density
R	$J.mole^{-1}.^\circ K^{-1}$	Universal gas constant (8.3147)
Re	–	Reynolds number ($= uL\rho/\eta$)
r	m	Radius, radial coordinate
Sh	–	Sherwood number ($= k_D L/D$)
T	$^\circ K$	Absolute temperature
u	$m.sec^{-1}$	Velocity
$u_{L,ax}$	$m.sec^{-1}$	Axial flow velocity of a solution
$u_{L,E}$	$m.sec^{-1}$	Average velocity of solution on entering heating tube
V_W	$m^3.mole^{-1}$	Molar volume of water
y_L	–	Sugar:water mass ratio in solution
y_U	–	Supersaturation coefficient ($= y_L/[y_{L,s}(\theta L)]$
$y_{L,s}$	–	Sugar:water mass ratio in a saturated solution
z	–	Height coordinate
α	$W.m^{-2}.^\circ K^{-1}$	Heat transfer coefficient
η	$Pa.sec^{-1}$	Dynamic viscosity
θ	$^\circ C$	Temperature
$\Delta\theta_{L,s}$	$^\circ K$	Boiling point elevation of a solution
k	$W.m^{-1}.^\circ K^{-1}$	Thermal conductivity coefficient
ζ	–	Dry solids content
ρ	$kg.m^{-3}$	Density
σ	$N.m^{-1}$	Interfacial tension

Indices

B	Vapour bubble	L	Solution
Br	Vapour	R	Tube
D	Heating steam	S	Boiling state

Flux de solution et échange et transfert de chaleur dans un tube de chauffe d'un évaporateur-cristalliseur

On a déterminé le transfert de masse vers des cristaux fin grain dans le tube de chauffe d'un évaporateur-cristalliseur technique. Pour cela on a mesuré les zones de température et de flux axial, ainsi que la vitesse d'échange radiale de la solution dans un évaporateur à tube unique. Ces mesures ont permis d'obtenir l'évidence nécessaire pour un modèle simulé du transfert de masse quant à l'état local de la solution autour des particules ainsi que leur temps de résidence locale. On a trouvé des zones de solution sous-saturées au voisinage immédiat de la paroi résultant de gradients de température très élevés. L'étendue de ces zones augmentait sous l'effet d'un convection radiale réduite quand la circulation forcée fut intensifiée. D'autres études au sujet de la pression statique à l'intérieur du tube confirmaient des données sur les phénomènes de bulles dérivés des profils de température. En y incorporant des résultats obtenus à l'aide d'un détecteur conductimétrique de bulles, on a obtenu des preuves quant aux zones exemptes de bulles et celles contenant des bulles. L'examen des équations pour le calcul du transfert de chaleur confirmait que le bouillissage local (en surface) jouait un rôle majeur dans les zones des parois fortement surchauffées. Suite à la présence de zones de sous-saturation et à la vitesse élevée de dissolution des cristaux-germes, on conclut que la méthode de grainage par magma n'est pas suffisamment reproductible pour la pratique.

Strömungsverlauf, Wärmeübergang und Austausch der Lösung im Siederohr eines Verdampfungs-Kristallisators

Zur Ermittlung des Stoffübergangs an feinkörnigem Saat-Kristallisat im Siederohr eines technischen Verdampfungskristallisators wurden die Felder der Temperatur und der axialen Strömungs- sowie der radialen Austauschgeschwindigkeit der Lösung innerhalb eines als repräsentativ betrachteten Siederohres mit Hilfe einer Einrohr-Verdampfanlage erarbeitet. Aus diesen Messresultaten konnten die für ein Simulationsmodell zum Stoffübergang an Saat-Partikeln erforderlichen Kenntnisse über den örtlichen Zustand der die Partikeln umgebenden Lösung sowie die örtliche Aufenthaltsdauer der Partikeln im Siederohr abgeleitet werden. Infolge sehr hoher Temperaturgradienten konnten in unmittelbarer Wandnähe Zonen untersättigter Lösung festgestellt werden. Die Ausmasse der untersättigten Bereiche nahmen auf Grund verringerter Radialkonvektion mit verstärkter Zwangsumwälzung zu. Mit Hilfe von Zusatzuntersuchungen zum statischen Druck innerhalb des Siederohres liessen sich die aus den Temperaturprofilen abgeleiteten Schlüsse zu den Blasenphänomenen im Siederohr bestätigen. Durch Hinzunahme von Messergebnissen, die mit Hilfe eines konduktometrisch arbeitenden Blasendetektors gewonnen worden waren, konnten gesicherte Aussagen über blasenfreie und blasenbehaftete Zonen im Siederohr gemacht werden. Bei der Überprüfung einiger dimensionsloser Kriteriengleichungen zum Wärmeübergang im Siederohr konnte der Befund, dass im vorliegenden Fall das örtliche Sieden in den stark überhitzten Wandzonen eine erhebliche Rolle spielt, bestätigt werden. Infolge des Entstehens von Untersättigungszone und der hohen Lösungsgeschwindigkeit des Saatkristallisats, kommt man zum Schluss, das die Slurry-Saatmethode in der Praxis unzureichend reproduzierbar ist.

Flujo y cambio de solución y transferencia de calor en un tubo calentador de un evaporador-cristalizador

La transferencia de masa a cristales-semilla de grano fino en el tubo calentador de un evaporador-cristalizador técnico se ha determinado por medición de los campos de temperatura y flujo axial así como la velocidad de intercambio radial de la solución en un evaporador con un sólo tubo. De estas mediciones se ha obtenido evidencia necesitada para hacer un modelo para simulación de transferencia de masa que describía el estado local de la solución alrededor de las partículas así como los tiempos de residencia local de las partículas. Zonas de solución subsaturada se han encontrado en la vecindad inmediata de la pared como resulta de gradientes muy altas de temperatura. El extento de estas zonas se aumentó sobre el efecto de convección radial reducida cuando se intensificó circulación forzada. Investigaciones adicionales sobre presión estática dentro del tubo han confirmado discubrimientos derivados de perfiles de temperatura respecto de fenómenos de burbujas. Por inclusión de resultados obtenidos con el ayudo de un detector conductimétrico de burbujas, se ha obtenido evidencia respecto de zonas libre de y con burbujas. Examen de ecuaciones para calcular transferencia de calor confirmó que ebulición local (superficial) hace un papel mayor en las zonas muy sobrecalentadas de la pared. A causa de la presencia de las zonas de subsaturación y alto grado de disolución de cristales de semilla, se concluye que el método de semillamiento con una pasta de cristales molidos en iso-propanol no presenta reproducibilidad adecuada para fines prácticos.

Microprocessor-based distributed control of a low-grade station at Macknade Mill

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Introduction

Macknade mill installed a new low grade centrifugal station for the 1982 crushing season, using a microcomputer-based control system. While other papers have been written on microprocessor-based control, this paper simply seeks to describe the method by which it was applied at Macknade.

The justification for the new installation was:

(i) that this station be sufficiently automated to allow a reduction in manning of one man/shift,
(ii) that the rate of the station be increased, and
(iii) that the noisy batch centrifugals be eliminated, so improving the work environment and reducing maintenance.

Previously, manning levels were: one low-grade centrifugal operator, one high-grade operator, and one dryer hand per shift. By relocating and rebuilding the low-grade centrifugal station adjacent to the high-grade machines, manning could be reduced to two operators operating as a team to run both sets of centrifugals and the dryer station.

The initial proposal and costing of the new low-grade station was based on conventional instrumentation. However, the opportunity was seen to introduce a microprocessor-based control system to control the operation of this station as well as the crystallizer station. This opportunity was taken for the following reasons:

(a) These systems have more flexibility and allow quick and easy changes to the control system by fairly simple programming.
(b) The ability of these systems to follow a series of logical instructions allowed automatic control of both batch and continuous operations.
(c) A larger control room and panels for conventional instrumentation and electrical equipment would not be necessary.
(d) Because of initially limited knowledge of this type of system, the best place to install the first of these in the mill would be on a station which was unlikely to interrupt crushing operations because of minor station stoppages. The low grade centrifugal and crystallizer station were ideal in this regard.

The system selected to control the station was the Fischer and Porter DCI 4000. This selection was made after investigation carried out by other sections of CSR where this equipment was already in use.

An estimate of costs based on conventional pneumatic instrumentation worked out a total of $A81,000. However, such a system did not readily lend itself to future supervisory computer control.

Estimated costs based on conventional electronic instrumentation, which does not have the above disadvantage, worked out at $A101,000, approximately 25% higher than the pneumatic system. In both these cases $A31,000 was attributable to extra control rooms and panels, annunciators and electrical equipment.

The total cost of the microprocessor-based control system was in excess of $A106,000 which included the training of mill personnel and upgrading of the existing control room and panel. This was approximately 5% above the conventional electrical instrumentation.

These figures indicate that the choice of a microprocessor-based control system was justified not by the basic cost of the unit but by the saving in control rooms and panels, annunciators and electrical equipment. Also, the increased capability and flexibility of such a control system allows the process engineers to change control strategies by simple software instructions rather than using extra hardware and wiring to make similar changes.

Control strategy

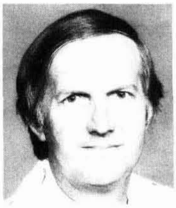
In order to specify the particular capabilities required of the system, a detailed control strategy had to be worked out.

Crystallizer station control

The control strategy chosen for the crystallizer station was based on maximum crystallizer stirrer drive load and temperature. Traditionally, Macknade has cooled *C*-massecuite at 3.5 Impurity/Water ratio to approximately 49°C. However, as the load on the crystallizer drives is considerably less than the motor full load at this temperature, it was decided that the full load of the crystallizer drives be used as the control limit for cooling of *C*-massecuites.

The Macknade crystallizer station comprises a massecuite receiver and five Burnett-type crystallizers arranged as a continuous station with feed and discharge massecuite

Paper presented to the Australian Soc. Sugar Cane Tech., 1983.



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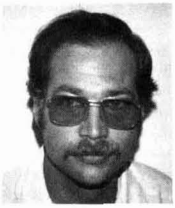

N. G. Skippen

pumps. Cooling is carried out in the first three crystallizers. Cold water is circulated through the coils of these units as long as the stirrer load is less than 85% of full load. If the load of the stirrer drive is between 85% and 95%, no water is circulated through the coils. If the stirrer load exceeds 95%, hot water is circulated through the coils to bring the load back to a safe level. By adopting this strategy, a lower end-of-cooling temperature is achieved than previously, maximizing the exhaustion achieved during crystallization. This control sequence is illustrated in Figure 1 as a flow diagram. This flow diagram was then converted to the programming language used by the Fischer and Porter system.

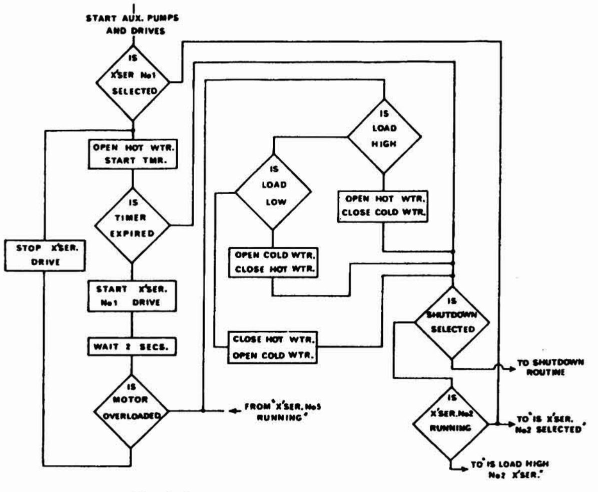

Fig. 1. Flow control diagram for No. 1 crystallizer

To condition the exhausted massecuite for centrifugalling, massecuite is reheated in the last two crystallizers of the station. Hot water at a controlled temperature of 70°C is circulated through the coils. If the massecuite temperature exceeds 60°C, hot water to the coils is shut off.

Centrifugal control

While 40 other electric motors on the station are started from the "Local Operators' Panel," the four continuous centrifugal drive motors were wired separately with individual control stations. This was done for safety reasons as it was believed that the operator should be standing by the machine when it is started.

The feed rate of massecuite to each machine is controlled by motor load, measured in kilowatts. The motor load set point can be adjusted either at the individual control station as a remote set point or from the operators' panel. The individual control stations allow all centrifugal operating parameters to be adjusted at the machine to achieve the desired rate and purging quality.

Remelt control

In the design of the new station, consideration had to be given to the handling of magma which was surplus to pan floor seed requirements. It was decided to adapt the sugar refinery melter design to suit the purpose of remelting magma to about 70°Bx for pumping direct to the syrup tank (see Fig. 2).

Magma from the magma screw is pumped into the first stage of the melter. An on/off-type Brix controller which derives its measured variable from a conductivity transmitter controls the addition of E.S.J. to this stage. The aim in this stage is to dilute to the range 70-75°Bx. The first stage overflows to the second stage which has a Brix controller operating on a 68°Bx set-point and deriving its Brix input from a sampling tower and D.P. cell arrangement. A level controller in the second stage controls the pump discharge rate.

An overall design residence time of 20 minutes, based on the total magma output, ensures that complete dissolution of crystal occurs. The Fischer and Porter system performs the analogue control functions. Also, a sequence has been programmed into the system which will automatically start-up the remelt system, run it for a desired period, and shut it down again at the expiry of the timer.

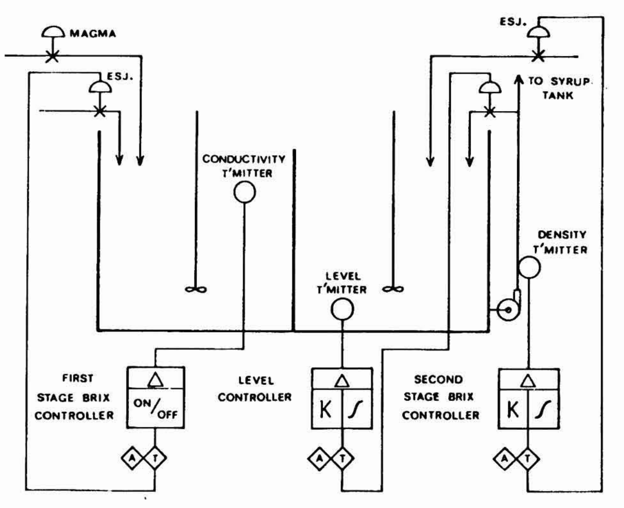

Fig. 2. Remelt system control

Other control functions

In order to minimize the operator supervision required for the station, the authors decided to automate the control of as many variables as possible. Analogue control loops were specified for the control of magma Brix, *C*-molasses Brix, *C*-molasses temperature, *C*-molasses pumping rate, reheat water temperature and massecuite flow rate through the crystallizers as well as the control loops previously discussed. In all, there were 16 P.I.D. control loops needed to perform all of these functions. The station auxiliaries (screws, pumps etc.) were started automatically using a sequence configured to start motors at three-second intervals. This allows the station to come on line quickly, without overloading the power supply.

System capability

The system supplied by Fischer and Porter was able to meet control strategy. It was supplied pre-programmed with a specified number of software modules of various types. The basic software modules were: 48 Analogue inputs, 16 Analogue outputs, 144 Contact inputs, and 128 Contact outputs, plus other software modules for controllers, timers, calculations, steps, sequences, memory and parameters. The program was configured using these modules, e.g. a controller is configured using an analogue input module, a control module and an analogue output module.

The completed program used the full available complement of sixten analogue outputs, but there was ample room for the configuration with the remaining software modules. A copy of the completed program containing the configuration and the basic module mix was stored on tape to ensure security.

Installation

The installation of the system and connexion with external hardware such as motor starters and valve actuators was straightforward. The central processor unit and system input and output relays were installed in an air-conditioned switch room. This room also contained 415 V electrical equipment associated with the centrifugal station. The operators' panel, back-up equipment and chart recorders were installed in a control room adjacent to the station and some 60 metres from the switch room.

The authors considered that a transformer-type regulated power supply was necessary for this type of equipment and all the microprocessor-based equipment was powered from this type of supply.

Commissioning

Courses were run at the mill by Fischer and Porter engineers and were attended by production, instrument and electrical staff. Later training of operators and supervisors was undertaken by mill staff involved in the system configuration. This pre-season operator training required approximately ten hours, which included instruction and practice with the equipment.

The job of software configuration was the most tedious task and, after training, mill staff made the initial attempt at this. Finally it became necessary for a Fischer and Porter engineer to assist and overcome the difficulties encountered.

Configuration of the analogue outputs and inputs was reasonably straightforward and the instrument technicians handled this.

The configuration of the flow sequences and the contact outputs and inputs proved to be more difficult. To use the minimum number of contact outputs and inputs, only one contact output was used in the motor control circuits for stop and start. An auxiliary contact on the motor starter was then used as an input for feedback to indicate that the motor was running. A sequence was then configured which constantly monitored the contact output and input status. If the two did not match, the contact output was switched off and an alarm generated. This configuration ensured that, if a motor stopped on overload, the contact output for that motor would switch off, and allow the overload to be reset without the motor immediately restarting. Other contact inputs, such as underspeed switches and limits were used for sequencing and alarms.

Configuration of the remelt and crystallizer control sequence was straightforward, once the motor control sequence was established.

System performance during 1982 season

The operators initially showed a fair degree of caution towards this new form of control. However, within two weeks of the season starting, this caution was quickly replaced by confidence in the use of the system and acceptance of its advantages.

The crystallizer control logic worked very well. End-of-cooling temperatures averaged 46°C for the season, which was 3°C below the previous target. It worked best early in the season when the RS/Ash ratio was highest (approximately 1.0) and the massecuite viscosity was lowest, and 44-45°C was averaged for the first six weeks of the season.

Automatic control of magma Brix and *C*-molasses Brix using conductivity as the measured variable was satisfactory, while the various level controllers around the station were trouble-free. The remelt system performed satisfactorily.

The main problem with the system during the season was a two-month period of hardware faults. Intermittent system crashes caused sudden shutdowns of various items of plant around the station. After prolonged attempts to locate the problem by mill personnel and by experts from the Melbourne office of Fischer and Porter, a new "Central Processor" unit was installed. There have been no system crashes since this time but there were still some minor problems to be rectified at the end of the season.

As a measure of the overall control of the station, the difference between true purity and expected purity of *C*-molasses for the season was 0.9 units at an average RS/Ash ratio of 0.75. The authors believed this good result was attributable to good pan work, and the high exhaustion achieved in the crystallizers as a result of the control strategy.

The ease of operating the whole station and the ready acceptance of the system by the operators would lead us to recommend this form of control.

Acknowledgement

The authors wish to thank CSR Management for assistance given and permission to publish this paper.

Summary

An account is given of the successful application of a microcomputer system of control in the low-grade crystallizers and centrifugals at Macknade sugar factory.

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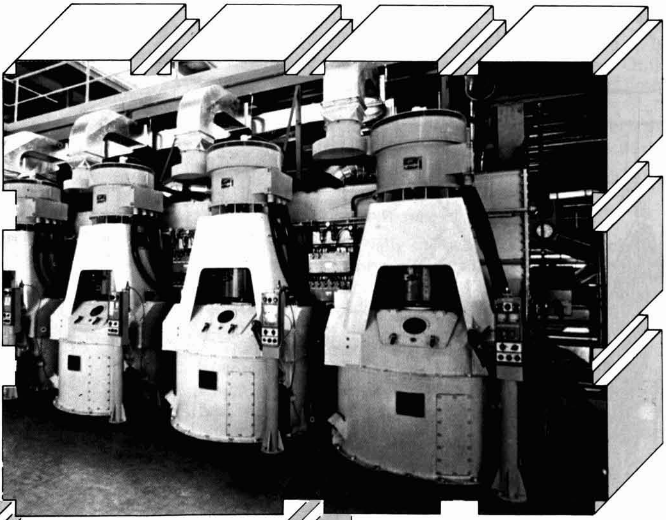
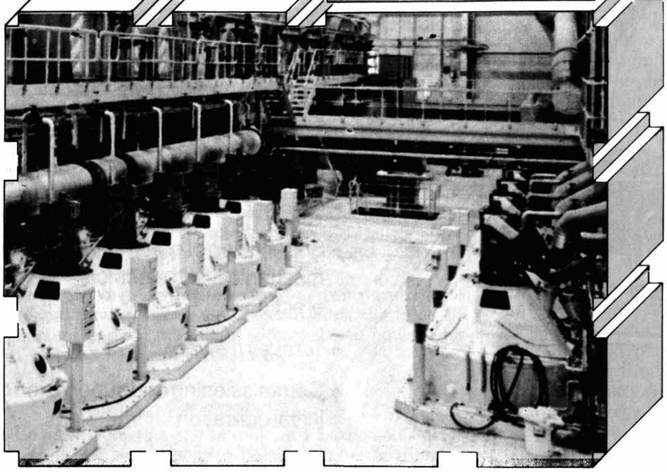
....more than 2000 high capacity, continuous and batch type Bosco centrifugals, all equipped with d.c. and a.c. motors, can now be found in operation all over the world; machines which contribute to the production activities of many of the most important cane and beet sugar-producing countries and to the industrial growth of many up coming countries. Our success lies in constant modernization, in line with the most modern manufacturing techniques and technological needs, in the high quality of the material used, in precise and accurate workmanship, in the strict internal checkings and inspections, and in the efficiency of our after-sales assistance and spare part service.





Our activities in the sugar industry include:
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— accessory equipment;
— traditional and fluid bed type plants for sugar drying and cooling;
— centrifugal separators for slurry treatment;
— vacuum pumps and compressors.

1) View of a battery of BOSCO "B7" batch type Centrifugals by 1.000 Kg. charge/cycle at an Italian Sugar Factory.
2) View of a battery of n° 10 pcs. "B5" Continuous Centrifugals for low grade and intermediate massecuites at SUIKER UNIE Factory GRONINGEN-Holland

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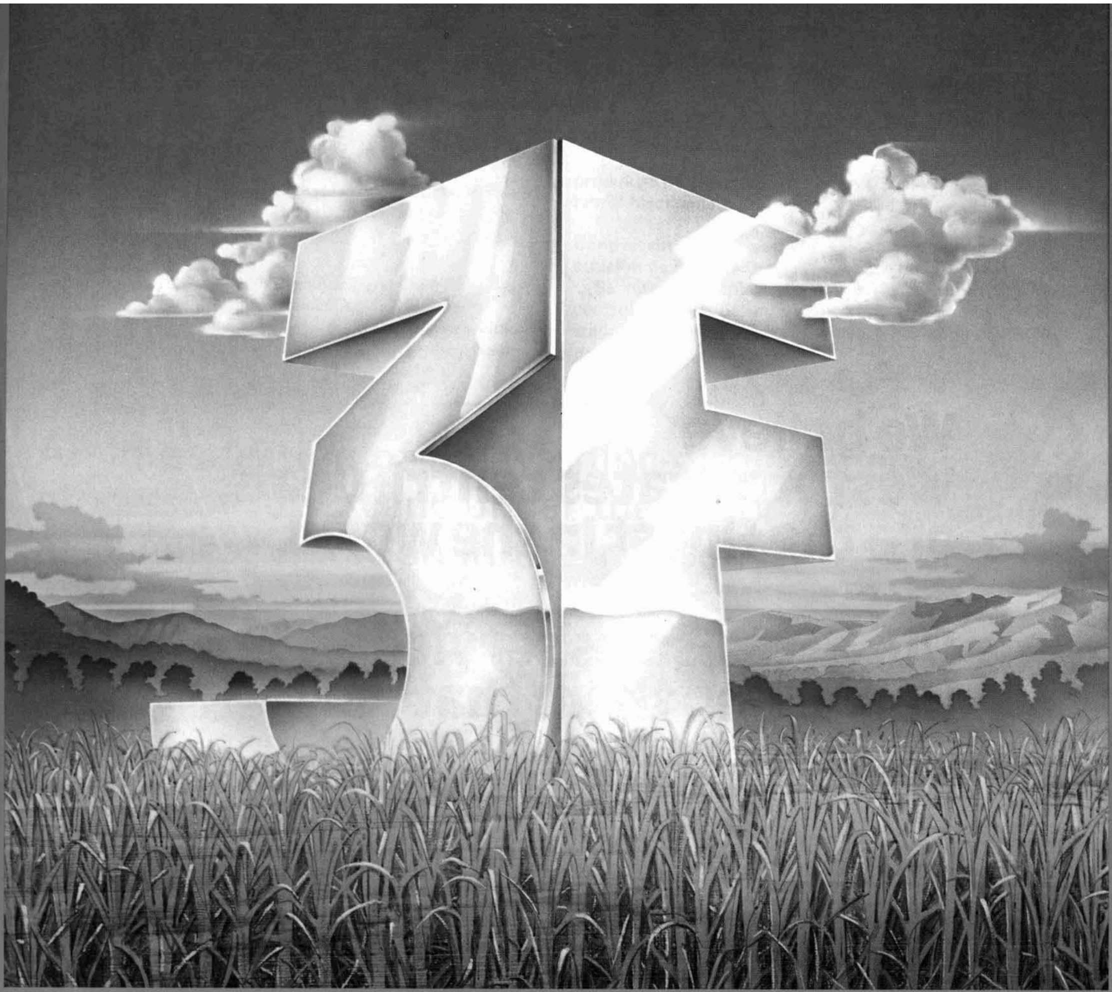
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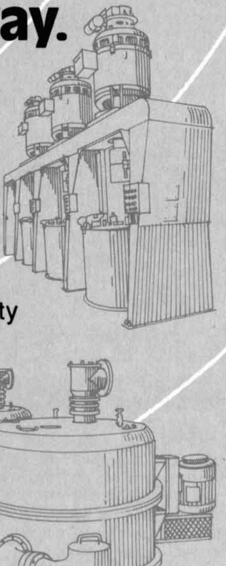

Contrôle réparti basé sur l'usage d'un microprocesseur dans la station AP de l'usine de Macknade

On rapporte l'application avec succès d'un microordinateur pour le contrôle des cristallisoirs et centrifuges AP dans l'usine de Macknade.

Auf einem Mikroprozessor basierende dezentrale Regelung der Nachproduktstation der Zuckerfabrik Macknade

Berichtet wird über den erfolgreichen Einsatz eines Mikrocomputersystems für die Regelung von Nachprodukt-Kristallisatoren und-Zentrifugen in der Zuckerfabrik Macknade.

Control distribuido, basado en un micro-procesor, del estación de bajo-grado en la azucarera de Macknade

Se discute el aplicación con éxito de un sistema de control por uso de un micro-computador de los cristalizadores y de centrífugas de bajo grado en la azucarera de Macknade.

An investigation of the washing-displacement process of sugar cane under the action of mechanical vibration in the infrasonic range

By JOSE F. GUZMAN CARMENATE and
JUAN A. GUZMAN CARMENATE
(University of Oriente, Cuba)

Introduction

Intensification of the diffusion process has been until now accomplished by increasing the flow rate of the extractive liquid. This possesses a limited potential but there are other possible ways to intensify the extraction, including the following: use of mechanical vibrations of low frequency, the injection of hot air, and use of ultrasonic radiation.

We have studied the intensification of the process of diffusion by use of mechanical vibrations and find that the process is characterized according to the different speeds of extraction that occur.

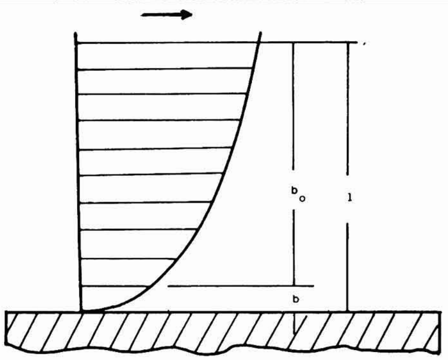

Fig. 1

During the sucrose extractive process by diffusion it is necessary to take account of the existence of two phenomena: (a) the extraction of the sucrose contained in the broken cells, and (b) the transfer of sucrose from the inside of the unbroken cells to the extractive liquid.

The first is a washing process in which the juice contained in the broken cells is displaced[1] while in the second case the extraction from the inside of the unbroken cells is accomplished by diffusion.

It is necessary to take into account that the diffusion is not directly from the intracellular juice to the extractive liquid, owing to the existence of a film in which there are the greatest gradients of concentration producing the diffusion from this boundary film.

According to Tegze[2] the thickness of this film (in the case of the beet) is a function of the flow rate of the extractive liquid and can be between 5×10^{-3} cm and 2×10^{-3} cm when the flow rate of the liquid fluctuates from 0.2 to 8.0 cm.sec^{-1}. According to Levich[3], the boundary film is composed of two layers, the hydrodynamic and the diffusive. The thickness of the diffusive layer is approximately one-tenth of the thickness of the hydrodynamic layer.

As may be seen in Figure 1, the mass transport in such a boundary film is produced by the movement of the liquid in the hydrodynamic layer, as well as the convective and molecular diffusion in the diffusive layer. It occurs in the case of laminar flow of the extractive solvent.

It can be theoretically demonstrated (see appendix) that the concentration of sucrose inside a particle of cane depends exponentially upon the coefficient of diffusion of the sucrose in water (D), on the thickness b of the diffusive layer and also on the specific surface of the particle S_v in the following way:

$$C = C_o e^{-D\frac{1}{b}S_v t}$$

where C_o is the initial concentration of sucrose inside the particle and t is the time of contact with the extractive liquid.

As the pol in cane (% P) is proportional to the concentration of sucrose (C) the above equation may be adapted to

$$\% P = \% P_o e^{-kt}, \text{ where } k = D\frac{1}{b}S_v t$$

From this equation it may be seen there are several ways to intensify the extraction by diffusion:

Paper presented to the 18th Congr. ISSCT, 1983.

[1] Rein: *Proc. 15th Congr., ISSCT,* 1974, 1523-1536.

[2] *Acta Tech. Acad. Sci. Hung.,* 1955, (3).

[3] "Gidrodinam. fisiko-khim." (Acad. Sci. USSR, Moscow), 1951.

(a) by increasing the coefficient of diffusion (the coefficient of diffusion D can be increased by raising the operating temperature),

(b) by increasing the specific surface S_v of the particles of cane (by increasing the degree of preparation of the cane subjected to the diffusion process),

(c) by decreasing the thickness b of the boundary film (by increasing the speed of the flow of the extractive liquid), and

(d) by increasing the contact time t between the prepared cane and the extractive liquid.

These four possibilities have been widely studied and exploited with greater or less success in various parts of the world. However, up to the present the possibility of intensifying the diffusion process acting over the boundary film has not been exploited and in this way it is possible to increase still more the speed of the process of diffusion, if turbulent flow is used instead of laminar flow.

In the case of turbulent flow the boundary film becomes more complex and the existence of three sub-layers[4] (see Figure 2) may be pointed out.

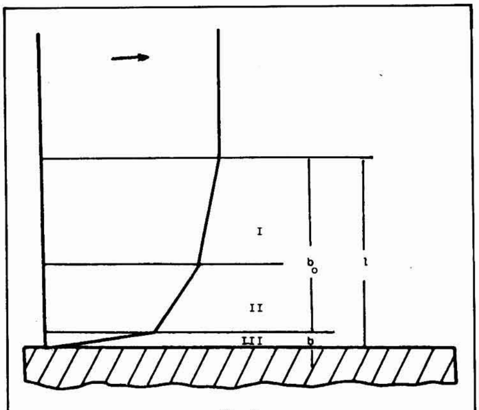

Fig. 2

In the first sub-layer of developed turbulence neither the viscosity nor molecular diffusion plays an appreciable role and the transportation of the substance through this sub-layer is determined by "turbulent pulsations".

In the second, viscous sub-layer there is a decrease of turbulent pulsations; in spite of this, in this sub-layer the diminished pulsations transport a greater quantity of substance than molecular diffusion.

In the third diffusive sub-layer only the process of molecular diffusion occurs.

As has been mentioned, the intensification of the diffusion process can be obtained by application of energy to the viscous sub-layer to generate turbulent pulsations to the greatest possible extent. Such action can be obtained through the action of the water shock produced by the mechanical vibrations of low frequency. These vibrations can be efficiently produced by means of an eccentric vibrator. It can be demonstrated that there will be an optimal transference of the energy of the vibrator to the extraction mass[4] if

$$M = 39.44\ m$$

where M is the extraction mass (cane + water) and m is the mass of the vibrator. This formula is the condition for an optimal coupling of the radiation impedance of the vibrator and the accoustic impedance of the extraction mass.

For the preparation of the cane an experimental unit was used which uses as cutting element oscillatory hammers providing a variable degree of preparation.

For quantifying the degree of preparation the displaceability index (DI) of Payne[5] was used, which expresses the relation of the number of broken cells to the total in the sample.

The method used to select the sample was as follows: the cane to be processed in the quantity of 28 kilograms was cut in pieces of approximately 8 cm and placed in the feeding chute of the MTM-1 preparation unit. The process of preparation lasts approximately 60 seconds, and at the beginning, in the middle, and at the end of the process 3 samples are taken, each of 2 kg of prepared cane. After each sample is homogenized, a portion of 1 kg is taken from each; these portions are mixed, homogenized again and finally there is taken a portion of 1 kg which is the sample selected as a representative for determining the degree of preparation of the cane, as a function of the displaceability index, measured as indicated[5].

The prepared cane was treated in the experimental installation for diffusion using mechanical vibrations, (see Figure 3) which comprised: a diffuser tank, an eccentric vibrator, a collecting receptacle, a flow meter, and a centrifugal pump.

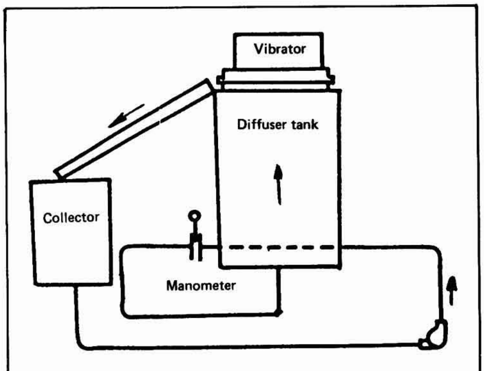

Fig. 3

The diffuser tank is 980 mm high and has a diameter of 500 mm with a capacity of 30 kg of prepared cane. It is thermally insulated with glass wool in order to maintain a high and steady temperature during the process. A 5 kW electrical heater is provided in the collecting receptacle. The water is constantly circulated, with a flow of 0.44 litre.sec^{-1}.

The eccentric vibrator is positioned over the diffuser tank, but isolated from it by means of springs which avoid the direct transmission of the vibrations to the structure of the diffuser tank. The transmission of the vibrations to the place where the diffusion is accomplished, is obtained by means of a circular plate rigidly joined to the vibrator.

Samples of cane were taken during the extraction process and the concentration of sucrose in the juice contained in the whole of the cells of the cane determined according to Bliss' method. The rate of sampling was determined by the speed of extraction of the process studied.

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[4] Burenkov: Personal communication, 1971.

[5] *Rpts. 19th Meeting Hawaiian Sugar Tech.*, 1960, 107-113.

Results

It is known that the extraction of the sucrose contained in the broken cells is brought about by the process of displacement washing which is characterized by a relatively high speed of extraction[1]; this ensures that the duration of the process is relatively short. The experimental determination of the equation that rules the process of extraction under normal operating conditions, that is, at high temperatures (approximately 80°C) is difficult. Another factor affecting the determination of the equation is that displacement-washing occurs in the first stage while, in the same stage, extraction also occurs by molecular diffusion which can partially mask the fundamental process in the first stage.

In order to reduce the negative effect of these factors during the study of the process of washing by displacement, this was carried out at a temperature of approximately 35°C[6]. In spite of the reduction of the operating temperature, the speed of extraction is still relatively high so that the samples had to be taken at 1-minute intervals in order to study in detail the process and to ensure that the experimental information obtained in this way was representative of the process studied.

There were programmed and executed two experimental runs using vibration frequencies of 900 and 1000 r.p.m. Experimental results are shown in Figures 4 and 5.

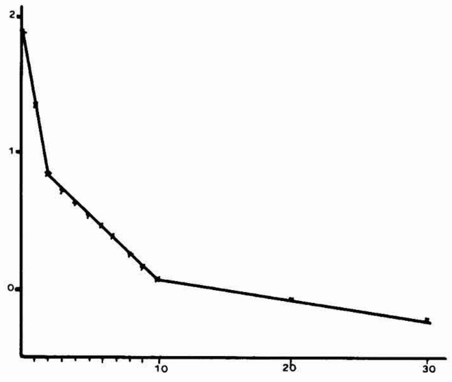

Fig. 4

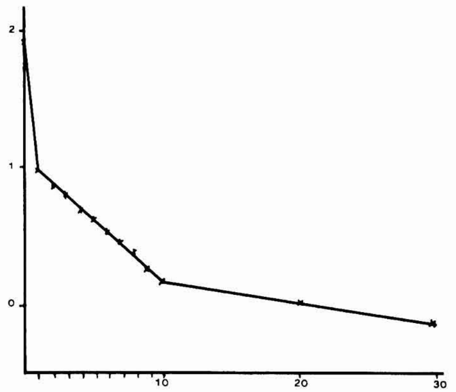

Fig. 5

Discussion

From the analysis of the curves it is deduced that there are three zones characterized by different rates of extraction of sucrose. Each has a constant coefficient of extraction, so it may be concluded that in the three zones different processes of extraction occur that depend exponentially on the time.

Linear regression analysis was used as a criterion for delimitation of the zones and as a method to prove the existence of the different processes of extraction in each. This was demonstrated by means of correlation coefficients, which were never under 0.997 so that each of the zones represents different processes of extraction characterized by different coefficients of extraction.

The first zone is determined by a displacement process during which, by the flowing action of the extractive liquid, is carried away the juice contained in the broken cells.

The second zone is determined by the extraction of the juice contained in the partially broken cells in which the process of extraction could be explained if we suppose that in such cells the extractive liquid can neither displace nor sweep away the juice contained in them. Over its surface is formed a hydrodynamic film[7] through which the sucrose contained in such cells would be diffused.

In such a case it is necessary to keep in mind that the diffusion is freely accomplished through a boundary film, directly from the inside of the partially broken cells without the obstacle represented by the intracellular walls, the coefficient of extraction reaching high values.

The third zone is determined by the molecular diffusion of the sucrose from the inside of the unbroken cells, which in such a case is hindered by the cellular walls that exist on the surface of the cane films and among the cells that constitute such particles; owing to this fact, the coefficient of extraction is low.

From the comparative analysis of the two runs it may be appreciated that the duration of the first two zones depends to a certain extent on the operating frequency, but in no case did the process of displacement exceed two minutes, the process of extraction of the sucrose contained in the broken or partially broken cells being complete in ten minutes. This establishes a certain relationship between the sucrose extracted at the beginning of the experiment and the amount of sucrose extracted after ten minutes. As was expected, it coincided with the displaceability index which is none other than the relation between the number of broken cells and the total number of cells.

Conclusions

1. The extraction of sucrose from cane, intensified by low-frequency mechanical vibrations, is shown to occur in three stages, clearly differentiated, and not two as reported in the literature; they are determined by the displaceability processes, washing and molecular diffusion in which the sucrose is extracted from the broken, partially broken and unbroken cells, respectively.
2. The three processes of extraction determined are intensified by the action of the mechanical vibrations of low frequency.
3. The process of extraction by displaceability is completed within 2 minutes or less, the whole of

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[6] Brüniche-Olsen: *Sugar Technol. Rev.,* 1969, 3-42.
[7] Freund: *Proc. 13th Congr. ISSCT.,* 133-141.

the sucrose contained in the broken cells being removed in that time.

4. The process of extraction by washing is extended fundamentally from the second to the tenth minute of the process, all the sucrose contained in the partially broken cells being extracted during that period.

Appendix

In order to develop an expression that relates the concentration of the sucrose (C) inside a particle of cane we will make the following assumptions:

1. The concentration C inside the particle is steady.
2. The thickness 1 of the diffusion sample is constant and invariable.
3. The concentration of sucrose in the extractive liquid may be disregarded.
4. The volume of the particle is constant.

Where:

N — total numbers of molecules
n — concentration of molecules
Mo — molecular diffused mass
m — mass of the diffused substance existing at time t inside the particle
b — diffusive layer thickness

Applying the equation of the continuity and the definition of diffusion:

$$\frac{dN}{dt} = - \int Dds$$

BUT

$$\text{Mon} = C, \ \text{MoN} = m, \ dm = VdC, \text{ and grad } C = \frac{C}{b},$$

SO:

$$\frac{dC}{C} = - D\frac{s}{V} \cdot \frac{1}{b}\, dt$$

$$\frac{S}{V} = S_V \text{ (Specific Surface)}$$

FINALLY:

$$C = C_O e^{-kt}, \text{ where } k = D\, S_V \frac{1}{b}$$

As the % of pol in cane (% P) is proportional to the concentration of sucrose (C) it follows that:

$$\%P = \%P_O e^{-kt}$$

Summary

Mechanical vibrations of low frequency are a means of exerting energetic action over the boundary films that surround cane particles and of intensifying the sugar cane diffusion process. This work reports investigation into the washing-displacement process under the action of mechanical vibrations of low frequency. The existence is shown experimentally of three clearly differentiated extraction zones (and not two as reported in the literature) which, in accordance with the predominant process that occurs in each, are named the (a) displacement zone, the (b) washing zone, and the (c) diffusing zone. It is demonstrated that during the displacement process, which has an approximate duration of two minutes, 85% of the sucrose contained in the broken cells is extracted, while completion of extraction of the sucrose contained in the mechanically damaged cells occurs during the washing process which occupies an approximate duration of eight minutes.

Recherche sur le procédé de lavage-déplacement de la canne à sucre sous l'action des vibrations mécaniques dans le spectre infrasonore

Les vibrations mécaniques à basse fréquence exercent une action énergétique sur la pellicule qui enveloppe les particules de la canne, tout en intensifiant le processus de diffusion. Cet exposé se penche sur le procédé de lavage-déplacement sous l'action des vibrations mécaniques à basse fréquence. Les expériences faites montrent l'existence de trois zones d'extraction nettement définies (et non de deux, comme on pensait jusqu'à présent) qui, selon le processus prédominant dans chacune d'elles, sont dénommées: (a) Zone de déplacement, (b) Zone de lavage, (c) Zone de diffusion. Les auteurs ont constaté que 85% du saccharose contenu dans les cellules brisées est extrait au cours du processus de déplacement, qui dure environ deux minutes, et que ce n'est que pendant le lavage, dont la durée se situe autour de huit minutes, que l'extraction est assurée à 100%.

Eine Untersuchung über das Wasch-Verdrängungsverfahren für Zuckerrohr unter dem Einfluß mechanischer Vibrationen im Infraschallbereich

Mechanische Vibrationen geringer Frequenz sind Mittel, um energetischen Einfluß auf Grenzfilme, die Rohrpartikel umhüllen, auszuüben, und den Zuckerrohrextraktionsprozeß zu intensivieren. Diese Arbeit berichtet über Untersuchungen am Waschverdrängungsprozeß unter Einwirkung mechanischer Vibrationen geringer Frequenz. Experimentell wird die Existenz von drei klar differenzierten Extraktionszonen (und nicht zwei, wie in der Literatur angegeben) gezeigt, die in Übereinstimmung mit dem vorherrschenen Prozeß stehen, der in jeder Zone abläuft und die a) Verdrängungszone, b) Waschzone und c) Diffusionszone genannt werden. Es wird gezeigt, daß beim Verdrängungsprozeß, der eine ungefähre Dauer von 2 min hat, 85% der in den aufgebrochenen Zellen enthaltenen Saccharose extrahiert wird, während der Abschluß der Extraktion, der in den mechanisch beschädigten Zellen beim Waschprozeß erfolgt, ungefähr acht Minuten dauert.

Investigación sobre el proceso de desplazamiento por lavado de la caña de azúcar bajo la acción de las vibraciones mecánicas en el rango infrasónico.

Las vibraciones de baja frecuencia mecánicas constituyen un medio de actuar enérgicamente sobre las capas límites que rodean las células de la caña y de intensificar el proceso de difusión de la caña de azúcar. En el presente trabajo se investiga el proceso de desplazamiento por lavado bajo la acción de las vibraciones mecánicas de baja frecuencia. Se demuestra experimentalmente la existencia de tres zonas de extracción claramente diferenciadas (en lugar de dos como reportado en la literatura), las cuales, según el proceso predominante que tiene lugar en cada una, se denominan: (a) zona de desplazamiento; (b) zona de lavado; y (c) zona de difusión. Se demuestra que durante el proceso de desplazamiento, que dura aproximadamente dos minutos, se extrae el 85% de la sacarosa contenida en las células rotas, completándose el 100% de la sacarosa contenida en las células mecánicamente dañadas durante el proceso de lavado que dura aproximadamente ocho minutos.

CANE SUGAR MANUFACTURE

Computer-aided design of energy-efficient evaporator stations. P. Friedman, A. Valdés and D. V. Leal. *Paper presented to the 18th Congr. ISSCT,* 1983, 26 pp. Details are given of the quintuple-effect evaporator of 1321 m^2 total heating surface at Pablo Noriega factory in Cuba which replaced the earlier quadruple-effect evaporator plus pre-evaporator of 1023 m^2 h.s. Vapour is bled from the first three effects of the new evaporator. The aims of the modification (which included installation of a new 1st effect) were to increase the crushing capacity from 863 to 1000 tcd and reduce the total process steam and hence oil consumption. A SIMEVA program for evaporator design was used to study different possible arrangements. The new arrangement uses 20% less steam than the previous one, while Brix of the syrup has been raised from 67.6° to 74.6°.

Energy production from sugar and by-product industries waste waters. A. García, E. Valdés, M. C. Obaya, A. Reyes, O. L. León and D. Betancourt. *Paper presented to the 18th Congr. ISSCT,* 1983, 27 pp. — The advantages of the UASB (Upflow Anaerobic Sludge Blanket) process for treatment of effluent from sugar factories, fodder yeast plants and distilleries are demonstrated by results of trials conducted on a laboratory scale. Details are given of the performance of the 1-litre reactor used, and the economics are discussed, including the fuel value of the methane obtainable within the sugar and by-products industries of Cuba.

A guide to economical insulation thickness in the sugar industry. C. R. Chang. *Taiwan Sugar,* 1982, **29,** 211-215. A graphical method of estimating the costs of thermal insulation is explained, and factors to consider in the selection of insulation materials are listed. The thermal conductivity of various materials is indicated, and factors affecting the total costs of insulation are briefly discussed.

Sugar production in Cuba. E. David. *Sugar y Azúcar,* 1983, **78,** (2), 100-108. — A survey is presented of the Cuban sugar industry, with production figures for 1965-82, information on processes and equipment, refining, and research and development work at the five centres established for the industry.

A system for the removal of sand, mud, bagacillo and trash. G. Ortiz P. *Sugar y Azúcar,* 1983, **78,** (2), 178-179. — A system is described in which mixed juice passes through a strainer to a tank from which it is pumped to vibratory spreaders and thence to the juice weigher. Tramp iron is collected at the end of the milling tandem by a magnetized plate, while the extraneous matter removed by the juice strainer is returned by a bagasse elevator to the start of the tandem. Impurities such as bagacillo, mud and sand removed by the vibratory spreader are elevated to a tank in which water from the maceration system is added, and the mixture then passed through another vibratory spreader. The liquid is then re-introduced as maceration between e.g. Nos. 3 and 4 mills, while the rejected material is deposited in a bin to be returned to the field. Advantages of the scheme, based on use of Eriez equipment, are listed.

Introduction of five-roller mills — first time in Indian sugar industry at Madhi sugar factory (Gujarat state). D. S. Patil. *Maharashtra Sugar,* 1983, **8,** (3), 9, 11-14. Details are given of a 6-mill tandem in which the 1st and 6th mills have five rollers and are supplied by heavy-duty pressure-feed system including Donnelly chutes (a Donnelly chute also being used for the light-duty feed system on the 2nd mill). Some performance data are given. The system was designed to increase the daily crushing rate without sacrificing efficiency.

H.P. requirement of a high-slip slip-ring induction motor for the cane leveller/cutter drive of a standard 1250 tcd plant expandable to 2000 tcd. B. K. Chaturvedi. *Maharashtra Sugar,* 1983, **8,** (3), 15. — The author calculates the power rating of a slip-ring motor for installation on a cane leveller/cutter in a factory of 2000 tcd crushing capacity, and shows that a drive rated at 132 kW/180 hp would be suitable.

Sugar cane trash — its effects on factory operations and efficiency. A review. K. R. R. Mani. *Maharashtra Sugar,* 1983, **8,** (3), 39-42. — The views of various authors on the adverse effects of trash on milling, clarification, molasses and total losses, boiling house and overall recovery, sugar quality and process economics are presented and the need for correct cane topping so as to minimize the amount of trash delivered to the factory is stressed.

Viscosity in sugar milling. J. N. Ness. *BSES Bull.,* 1983, (1), 4-5, 7. — Reference is made to an extensive investigation conducted by BSES (Bureau of Sugar Experiment Stations) mill technologists in recent years on the effects of viscosity on process streams in the sugar factory, especially low-grade molasses and massecuites. Three types of viscometer used are indicated: the falling-ball viscometer (used principally for juices and syrups), the rotary viscometer (generally used for molasses and massecuites, although not entirely successful with the latter material) and the pipeline viscometer, devised particularly for massecuite measurements. Advantages of the Brookfield spindle viscometer for molasses measurement are outlined, and the high sensitivity of molasses viscosity to temperature and dry solids indicated. The complex flow behaviour of massecuite is also briefly discussed. While viscosity is a significant parameter in selection of pumps, pipes, valves and other processing equipment, it is a crucial factor in boiling, and this is explained.

BSES engineers in electric power development. R. J. McIntyre. *BSES Bull.,* 1983, (1), 6. — It is pointed out that BSES factory technologists have provided much of the engineering expertise for the development of increased power generation in Queensland sugar factories. The work has involved feasibility studies, the design of circuits and equipment, and advice on selection of plant to meet specific needs. Apart from the installation of high-voltage generation equipment and associated distribution plant (all but eight factories now generate power at high voltages), a major activity has been the interconnexion of factories with the public grid for purchase of power for both normal and emergency requirements, and for the sale to the utility of surplus factory power. The most recent projects have been investigation of the use of a micro-processor control system to regulate the amount of power exported in accordance with the factory steam balance, and the study and design of a new high-voltage installation for Moreton sugar factory.

Trials provide juice screen design data. G. A. Brotherton and A. G. Noble. *BSES Bull.*, 1983, (1), 6-7. – Since cane juice leaving the milling train generally contains 1.0-1.5% fibre, depending on cane variety and level of preparation, it must be screened. The choice between the two types of screen used in the sugar industry (static and rotary) is largely governed by economic factors, the headroom above the milling train and available floor area. Hitherto, selection has been chiefly a matter of rule of thumb; however, the need for a more accurate method of selection arises with the advent of improved cane preparation and consequent higher fibre loadings. A series of trials was carried out on juice screens at a number of factories, while further (limited) work was conducted on rotary screens at two factories; at Millaquin, the effect of rotary speed on performance was studied over the range 2-12 rpm. The main conclusions were (1) that fibre removal efficiency fell slightly as the drum speed increased, although the fibre content of screened juice remained at an acceptably low level in all cases; (2) that, as the drum speed was reduced, the "flooding point" was exceeded and unscreened juice was returned to the mill. At a crushing rate of 330 tch, this happened if the drum speed fell below about 8 rpm, but it would depend on the angle of inclination of the drum (currently 5°). When flooding took place, feeding problems were observed at No. 3 mill. (3) The quantity of fibre held up in the drum increased with rotary speed, but in no case was it sufficient to cause structural problems. Trials at Farleigh to assess the performance of a Contra-shear system showed that it was a robust, well-finished unit; however, the screen aperture (0.8 mm) was too large, resulting in a high fibre level (0.35%) in screened juice and confirming the BSES recommendation of 0.5 mm apertures.

R155 m factory on schedule. Anon. *S. African Sugar J.*, 1983, **67**, 61, 63. – Information is provided on the new Felixton II factory under construction in Zululand. Designed for an initial crushing capacity of 600 tch, expandable to 900 tch, the factory will be provided with a novel cane handling system in which cane delivered by road or rail will be stored on wheels for surge storage capacity and then fed directly as short billets via a surge bin to the shredders. Extraction will be by two cane diffusers, the largest so far constructed. Bagasse drying will be by heavy-duty pressure-fed mills developed by Hulett Sugar in cooperation with Smith-Mirrlees. Quintuple-effect evaporation will be used with 2nd effect vapour bleed for heating and pan boiling; allowance has been made for addition of mechanical vapour recompression. Continuous vacuum pans, vertical crystallizers and evaporation equipment will be manufactured by Hulett Engineering, the major equipment from outside South Africa being Broadbent batch centrifugals, BMA continuous centrifugals and APE-Allen turbines. A completely centralized microprocessor-based instrumentation and control system, using distributive control loops, will be incorporated. Use of a 1:25 scale model of the factory has enabled the project team to interpret their designs accurately into three dimensions as the work progresses.

What is the future of process control in the sugar factory? P. Olsen. *Rev. Agric. Sucr. Maurice,* **1982**, **61**, 68-70 + 4 pp *(French)*. – The author explains the fundamentals of automatic process control and indicates general types of application and means of control, and then lists the advantages of the system based on a central computer. Reference is made to the benefits of distributed control in offering all the advantages of the central computer without any of the disadvantages; with this system, local controllers provided with micro-processors are located at various points in the factory instead of a large number of cables connecting the central computer to each sensor, valve, etc. Process stations in Mauritius sugar factories that are currently controlled by micro-processors are listed, and it is stated that the intention is to connect local controllers to a central supervisory computer. Interchange of information between sugar factories and the MSIRI (research institute) in Réduit by a computerized system as a means of helping to increase factory efficiency is also mentioned. Diagrams illustrate the various points made in the article.

Continuous weighing of sugar as it is conveyed to the warehouse. Anon. *Sugar y Azúcar,* 1983, **78**, (3), 27. A system is described that monitors the flow of raw sugar to the warehouse at Enterprise sugar factory in Louisiana. It embodies a weighbridge (mounted in place of a regular idler beneath the belt conveyor carrying the sugar), a speed transducer and a digital electronic integrator. The speed of the belt and the weight of the sugar are transmitted to the integrator, which multiplies the two factors together and displays the product on the front of the control panel as tonnes of sugar and rate of flow.

A discussion on the saving of boiler fuel in a sugar factory. C. H. Chen. *Taiwan Sugar,* 1983, **30**, 10-19. In a discussion of ways in which to reduce fuel consumption, the author examines means of increasing boiler efficiency (by improving the operation of an existing arrangement and/or by modernizing the plant) and means of reducing steam consumption. A case study of a factory having a daily crushing capacity of 3600 tonnes of cane is used as example of how to achieve a substantial reduction in bagasse fuel consumption.

The De Smet extraction process for cane sugar. P. H. Adam. *STAB,* 1982, **1**, (2), 37-39 *(Portuguese)*. – A brief history is given of the De Smet cane diffuser from its origin in 1964 as a device for vegetable oil recovery, and the disadvantages of milling as a cane juice extraction method are listed. The mathematical principle of extraction is indicated, and the parameters influencing it are discussed with a note of values of these found to be optimum in practice. The design of the De Smet diffuser is described and results obtained by units in operation in Brazil and elsewhere are summarized.

The pioneering experience of Confab in the diffusion of cane. D. Carletti. *STAB,* 1982, **1**, (2), 41-46 *(Portuguese)*. Confab Industrial S/A, a Brazilian engineering company without previous links with the sugar industry, built a 20 tcd pilot-plant diffuser to the patented design of James Cargill, a director of the Tongaat-Hulett Group, and installed it at Usina Jacarezinho, in Paraná. The unit operated successfully in the 1981 and 1982 seasons and a control data sheet for October 29, 1982 is reproduced, showing an extraction of 96.88% with water usage of 284.1% on fibre. The diffuser is a ring-type unit, operating with two or more levels on which blankets of prepared cane are rotated beneath a sequence of radial sprays supplied by pumps with juice draining through sections of the blanket nearer the tail. pH control is by milk-of-lime addition, and a temperature of 80°C is maintained by steam injection. Characteristics of the diffuser, advantages and means of expansion of capacity are indicated.

Methods of steam economy in the pans. E. David. *ATAC,* 1980, **39**, (3), 16-19 *(Spanish).* — Steam usage in vacuum pans is a function of the water to be evaporated and is greater with recirculation of intermediate molasses. It is suggested that the two-boiling system as used in Mauritius and South Africa could be used to save steam. The *A*-massecuite is cooled under carefully controlled conditions in a water-cooled crystallizer so as to avoid false grain formation, and the *A*-molasses, of lower purity than otherwise, is then boiled directly as a final massecuite.

Evaluation of mud filtrate under different treatments. S. Morales. *ATAC,* 1980, **39**, (3), 42-47 *(Spanish).* Rotary vacuum filtrate was treated in the laboratory with milk-of-lime to bring the pH to values in the range 7.5-8.5 in the presence and absence of 2-8 ppm of an unnamed hydrolysed anionic flocculant. The purity and insoluble matter content of the treated filtrate was examined, and it was found that liming to above pH 7.5 produced no additional benefit, while less than 8 ppm of flocculant resulted in unacceptable levels of insolubles. Best results were obtained by liming to pH 7.5 in the presence of 8 ppm of flocculant.

Mathematical modelling of syrup concentration during the sugar crystallization process. A. Marquez S. and V. Y. Tregub. *ATAC,* 1981, **40**, (1), 40-46 *(Spanish).* A series of equations are developed which describe mathematically the first of three stages in vacuum pan operation, viz. the evaporation of water from syrup feed. They are to be simplified for use in computer calculations in a later article.

Polyethylene piping in the juice feed lines. J. C. Bango. *ATAC,* 1981, **40**, (2), 4-6 *(Spanish).* — Trials with polyethylene piping for juice at temperatures below 80°C were carried out at Pablo Noriega sugar factory in 1976/77, 1977/78 and 1978/79, and the loss of piping material calculated from weight measurements. With both mixed and limed juices, the loss amounted to an erosion of 0.112 mm from the wall in the first year and nil during the second year, against losses of 0.345 and 0.265 mm for steel piping. In the third year, there was again no loss with limed juice and a loss of 0.011 mm with mixed juice for the polyethylene piping, but a further loss of 0.292 mm from the steel piping. The minimum wall thickness necessary for juice piping is calculated from an equation involving pressure, diameter, tensile strength, etc. as 5.92 mm for polyethylene and 1.11 mm for steel, so that for an initial thickness of 12 mm the polyethylene piping would have a life six times as long as steel of 10 mm wall thickness.

The modified Predco sedimenter. S. Morales M. *ATAC,* 1981, **40**, (2), 40-44 *(Spanish).* — The title equipment comprises a closed 1.14 m^3 cylindrical tank with a lower conical section and an exit pipe at the bottom of this. Within the tank is a bell-shaped baffle occupying most of the upper section of the tank, and with an exit pipe from its apex. A perforated pipe introduces rotary vacuum filtrate into the top of the tank outside the baffle. Experiments were carried out in which the filtrate was untreated or treated with milk-of-lime and/or an anionic polyelectrolyte as flocculant, and the fractions withdrawn from the upper and lower exit pipes measured for flow and solids content. The unit had only a low solids separation efficiency (1-4%).

Operation data in the analysis of pan section efficiency. I. Martínez Y. and T. Díaz B. *ATAC,* 1981, **40**, (2), 56-65 *(Spanish).* — Data on boiling times; strike volumes, Brix and purities; Brix, pol and purities of syrup and molasses were collected from four Cuban sugar factories during the 1979/80 season and analysed statistically; average values and typical deviations are tabulated. The Brix of *A*-, *B*- and *C*-massecuites were in increasing order in all cases, as is usual, but values for individual strikes from different factories were relatively similar. Brix also showed smallest deviations from the means. Purities fell from *A*- to *B*- to *C*-massecuite, but more so in the case of one factory where crystallization and centrifugalling conditions were better. Boiling times were good in one factory but were longer than desirable in the other three, carrying the additional effect of higher than normal sugar loss. Variations in molasses Brix indicate excessive dilution water use at one factory and higher-purity inadequate exhaustion at another. Conclusions are drawn as to the usefulness of statistical analysis of daily chemical control data in operational control of the boiling house.

Observations on the continuous vacuum pan in Réunion. V. Baillet. *Sugar J.,* 1983, **45**, (10), 23-25. — The design of the Langreney continuous vacuum pan is outlined and its operational advantages in boiling *A*- and *B*-sugar from a *C*-magma are discussed; these include increased capacity, reduced sugar losses and improved energy economy.

Losses of sugar by infection of the tandem. E. Duarte. *ATAC,* 1982, **41**, (1), 26-28 *(Spanish).* — The method proposed for detection of infection and measurement of sugar loss is based on dextran analysis in mixed and crusher juice. The difference in dextran % Brix is a measure of the dextran formed, from which can be calculated the sugar lost on a basis of 4 g of sucrose yielding 1 g of dextran. The need for careful preservation and handling of samples for a 24-hour composite is emphasized and it is pointed out that the direct sugar loss is compounded by the additional molasses loss, difficulties and extended times for (and so sugar loss during) boiling, poor crystal quality, etc.

Development of equipment for the Cuban sugar industry. M. M. Consuegra. *ATAC,* 1982, **41**, (2), 4-13 *(Spanish).* An account is given of the stages in development of a manufacturing and design base for re-equipment of the Cuban sugar factories which were equipped with old plant and for which spare parts were no longer available from the US after the revolution. Subsequently individual pieces of new equipment are described, including automatic control cabinets, bagasse boilers, bagged and bulk sugar loading equipment, winches, a cane defibrator, four-roller feeders, etc.

Precision in sugar accounting. M. Wong and J. Rodríguez. *ATAC,* 1982, **41**, (2), 17-20 *(Spanish).* — The nature of errors in direct and indirect measurements is discussed and a table presented of relative errors in a number of items forming part of a sugar factory balance, e.g.

weights of cane, bagasse, sugar, molasses, etc. and the quantities of pol involved in such errors. A second table estimates the error in another group of parameters – imbibition % cane, pol extraction, etc. and the importance of these is discussed relative to the overall balance.

Colloids in cane sugar production. M. Darias, L. D. Bobrovnik, C. Hernández and I. Valentín. *ATAC,* 1982, **41**, (2), 21-25 *(Spanish).* – Samples of screened mixed and clear juices, syrup, *A*- and *B*-sugars and molasses were diluted to 12°Bx with distilled water, centrifuged at 4500 rpm for 20 min and the polysaccharide, protein and colloid contents separated from the supernatant by use of gel chromatography on a calibrated Sephadex G-50 column. The amounts of each were analysed by standard methods and the changes in each, as a proportion of Brix, from one juice to the next, from *A*- to *B*-sugar and from *A*- to *B*- to *C*-molasses are illustrated in graphs and discussed. The three products were not always reduced between mixed and clear juice, while polysaccharides and proteins could increase or decrease between clear juice and syrup, depending on the reactions occurring in clarification and evaporation. Colloids increased from clear juice to syrup, and the substances not eliminated in clarification were concentrated in later stages, highest proportions occurring in molasses. The contents in sugars were in relation to the corresponding molasses.

Automatic control of crystallization. G. R. Moller. *ATAC,* 1982, **41**, (2), 28-35 *(Spanish).* – A brief account is given of development of boiling control and of the advantages resulting from automatic regulation of supersaturation. The DDS system, in which control is exercised by a micro-computer, is described and illustrated. It has reduced conglomerate formation in the Danish sugar factories from 60% to <5% and crystal colour from 0.3°St to 0.2°St. Crystal uniformity is improved as is centrifugal operation. Only two recovery strikes are boiled instead of three, thus saving steam.

Evaluation of different evaporation schemes. I. Technical aspect. M. Salermo and C. Vázquez. *ATAC,* 1982, **41**, (2), 36-40 *(Spanish).* – Calculations of heat requirements are made for a number of evaporator schemes applied to a common factory juice throughput. It is concluded that a steam saving of 15% may be attained with a pressure system in which vapour leaves the first effect at 8 psig.

Microflora in the intermediate stages of the raw sugar manufacturing process. T. Sais H. *ATAC,* 1982, **41**, (2), 44-50 *(Spanish).* – Microbial counts were made of samples of syrup, massecuites and molasses as well as the air in different parts of the sugar factory; the results are tabulated. It is concluded that syrup contains fewer microorganisms than the other products, that air in the mill house contains more than in the rest of the factory, that air is an effective vehicle for transfer of microorganisms from sources of infection to tanks, conveyors, etc. for intermediate products. The major micro-organisms in these products are: Gram-positive sporogenic bacteria, particularly *Bacillus* spp., moulds (particularly *Aspergillus* spp.) and *Microccus* spp. and *Staphylococcus* spp. bacteria.

Dextran – a new concern. J. A. Polack. *Sugar Bull.,* 1983, **61**, (14), 8. – The author expresses concern at the introduction of a dextran penalty in some raw sugar purchase agreements in the USA, whereby the basic price paid is reduced by 0.005% for every unit of dextran above 250 ppm. It is thought that the major problem is the difficulty of measuring the dextran content with sufficient precision; the method described by Roberts[1] is considered too involved, although it is much more reproducible than the method used hitherto. However, since it gives values that are higher than those given by the previous method, the author feels that a higher level of acceptable dextran content would have to be defined if the method were adopted generally. Recent penalties incurred in Louisiana have not been associated with stale cane or the formation of needle-type grain, and studies are to be carried out to determine whether the dextrans in the raw sugar emanate from the cane or are formed during processing.

Steam usage in mills. R. J. McIntyre. *BSES Bull.,* 1983, (2), 18-20. – Engineers of the Bureau of Sugar Experiment Stations in Queensland have been monitoring the use of steam in a number of sugar factories during the past three seasons. The author outlines the purpose of these investigations and the work involved in carrying them out. The details of a project at North Eton factory are used as illustration. An orifice plate was installed at each of eight locations and connected to a differential pressure transmitter. The central recording system receiving a signal from this transmitter comprised an electronic data logger which provided a regular listing of all the data; these were also recorded on magnetic tape and later transferred to a computer disc file for further processing before being plotted on a graphics device to show the low-pressure steam consumption of the evaporators, seed pans and juice heaters. Subtraction of the total consumption from the boiler feedwater quantity provides a measure of boiler steam flow; the difference (imbalance) represents the amount of make-up steam required, which should be no more than 10-20% of the total steam output of the boiler in a well-designed system. Chart sections are reproduced showing the steam balance over a 24-hour period as well as the low- and high-pressure steam demand and imbalance. Possible variations in operation of steam plant to accord with processing parameters such as the crushing rate of the mills while maintaining a balance between bagasse supply and steam demand are discussed. The arrangement used will also determine the steam consumption, which is about ½ tonne per tonne of cane.

"Fingerprinting" factory scale deposits. R. A. Johnson. *BSES Bull.,* 1983, (2), 20. – Since factory personnel are sometimes uncertain about the composition of scale and hence method to use for its removal, BSES staff are undertaking a program intended to facilitate rapid analysis of scale deposits using infra-red spectroscopy; each type of scale absorbs i.f. light at certain discrete frequencies, and the resultant spectrum serves as a "fingerprint" for matching with scale of known composition. Advantages of the i.f. technique include the requirement of minimal sample preparation, rapidity, and its ability to distinguish between a mixture of simple salts and a complex salt of the same elemental composition – the former gives a spectrum comprising a number of superimposed "fingerprints" while the latter gives one having only one characteristic "fingerprint"; this is of considerable importance where ash concentrations and temperatures often favour complex salt deposition. However, no i.f. data are available on uncommon complex salts, for which the more conventional methods of scale analysis are suitable.

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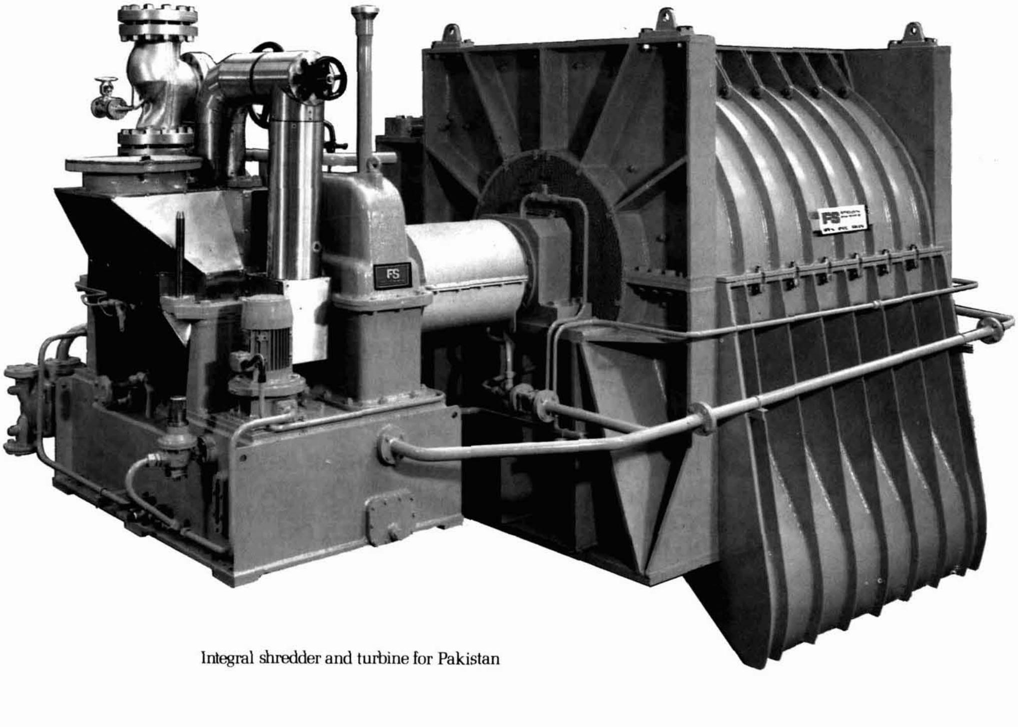
[1] *I.S.J.,* 1983, **85**, 10-13.



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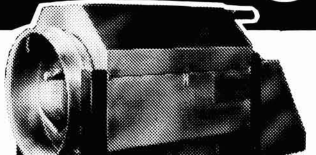

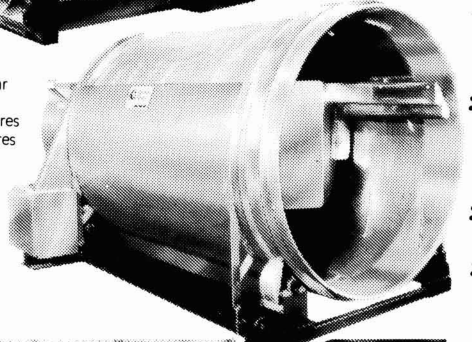

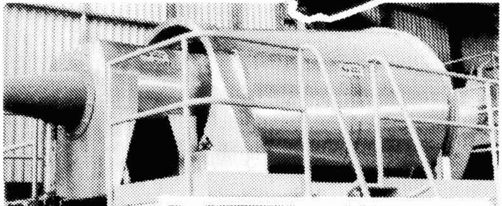

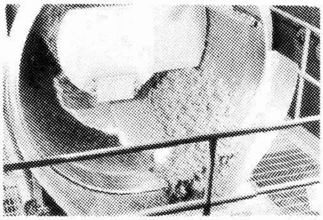

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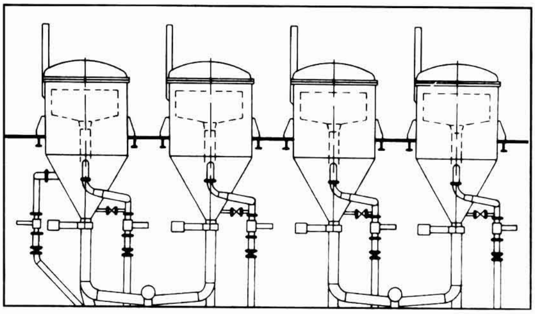

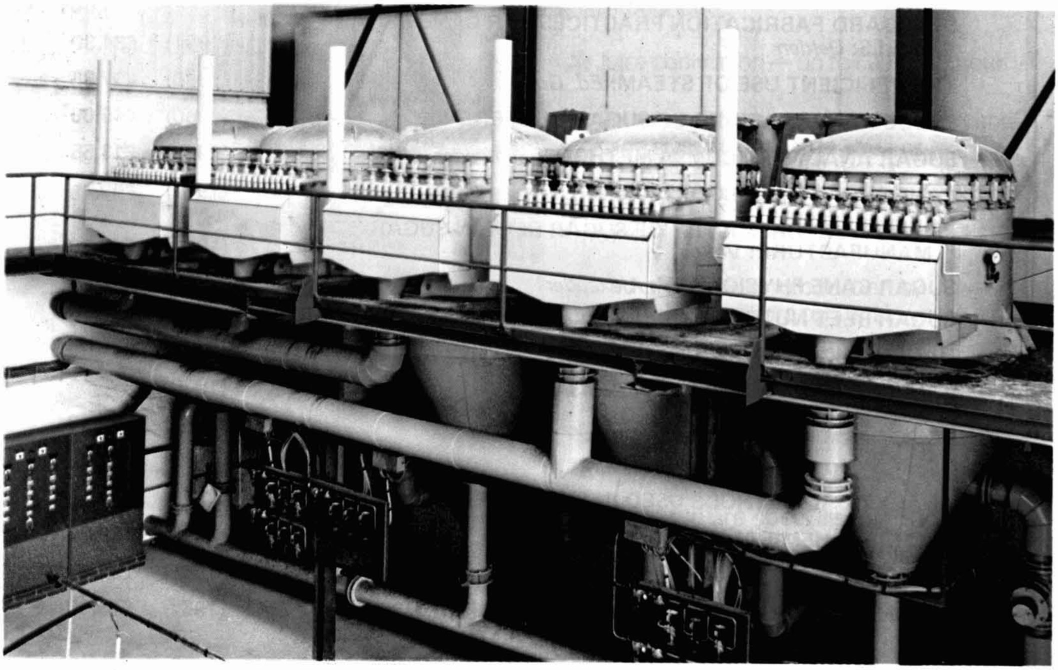

BEET SUGAR MANUFACTURE

Application of the IRIS automation process to the RT diffuser. G. Windal and D. Maes. *Sucr. Franç.,* 1983, **124,** 139-141 *(French).* — While automatic control of diffusion based on the water:cossettes ratio as a function of exhaustion and involving continuous measurement of Brix by a fixed refractometer has been applied to a De Smet diffuser and a tower diffuser, for RT diffusers it is considered that problems could arise with continuous Brix measurement (although Raffinerie Tirlemontoise S.A. have installed a somewhat sophisticated system in one diffuser), including difficulties in feeding and transmission of information. It was therefore decided to adopt an alternative, which involved discontinuous sampling for refractometric measurement (one sample per drum rotation). Details are given of an automatic sampler, which incorporates a cam located directly beneath the drum; this opens a valve in the drum and allows juice to flow into a gutter and from there to a continuous refractometer via a "preparation device" which ensures that the sample is in a suitable condition for Brix measurement, e.g. with no pulp particles, homogeneous and of the correct temperature. The Brix measurement is transmitted to the water:cossettes ratio computer for comparison with the laboratory analysis; the computer also receives the cossettes flow signal from the feed conveyor, and the output from the calculator is transmitted to the automatic control. The system has worked satisfactorily on a RT4 diffuser, giving much greater exhaustion uniformity.

The Cleopatra system for universal data handling. Application to the sugar factory laboratory. G. Windal. *Sucr. Franç.,* 1983, **124,** 149-152 *(French).* — Details are given of the Cleopatra data handling system developed by IRIS around a Solar 16-40 computer. The structured program is written in BASIC, while a shared-time system is used, so that a number of operators can use it simultaneously. The six major functions of the system are indicated, and its performance during the last campaign is appraised.

Treatment of nitrogenous pollution. J. P. Lescure and P. Bourlet. *Sucr. Franç.,* 1983, **124,** 153-160 *(French).* Experiments were conducted on effluent treatment by nitrification, using auto-seeding with laboratory-prepared beds of developing bacteria or with soil (a natural source of nitrifying bacteria) or mass injection of dairy or sugar factory muds. Auto-seeding proved too slow and consumed too much energy, whereas mass injections gave a rapid start to nitrification, but the mud structure improved only very slowly, so that it would be important to find a means of conserving the mud throughout a campaign. A continuous method, in which a mixture of lagooned water and ammoniacal condensate was treated with a fixed bed of inoculum in an ascending stream during 6 hours' residence, gave results comparable to bacterial beds or rotary discs (as aerators) in terms of COD reduction, but its use would depend on the savings in investment costs compared with the conventional method of extended aeration. Denitrification of a vinasse that had already been treated anaerobically and then by nitrification gave very good results in terms of BOD_5, NO_3 and NO_2 but was less effective in terms of COD, while there was almost no change in total Kjeldahl N and ammoniacal N contents. Untreated vinasse was used as carbon substrate in this experiment, whereas flume wash water was used as organic C source in another test aimed at improving on the performance of untreated vinasse. Tabulated results show that denitrification was excellent and that final results were better than with the vinasse; no nutrient salts were required, and the pH in the reaction vessel was in the range 8.5-8.9. However, since the muds formed became rapidly frothy and tended to overflow from the vessel, the ascending-stream technique could not be used on an industrial scale but would have to be replaced with a fixed bed system.

The 1982 campaign. E. Reinefeld. *Zuckerind.,* 1983, **108,** 307-319 *(German).* — A survey is presented of the 1982/83 campaign in West Germany, covering both beet agronomy and factory processing. Microbial infection has presented some problems at the beet end, and the importance of removing as much water as possible after the washer is stressed. The use of a fresh water spray rinse after washing is advocated, possibly combined with addition of a disinfectant. Even at relatively high flow rates in pipelines, increased infection in raw juice between the prescalder and juice purification has been found in the form of lactic acid and bacterial counts. Maintenance of average diffusion temperatures only slightly above 60°C at some factories, aimed at improving pulp pressability, has led to unsatisfactory microbiological conditions even with economical use of disinfectant. Mention is made of the installation of larger diffusers — the intention is not only to increase throughput but also to extend diffusion times and reduce juice draft. (Reference is made to a BMA tower diffuser at Vierverlaten factory in Holland, which has a daily throughput of 8000 tonnes of beet and during commissioning trials had losses clearly below the guaranteed maximum of 0.22% pol at 108% draft.) Mechanical pulp dewatering received much attention — new additional presses have been installed, and the average dry solids content for 20 factories has gradually risen from 19.60% (17.0-22.2%) in 1976 to 24.29% (20.1-30.3%) in 1982. With greater pressing, the amount of pulp in the press water has increased, but in some factories the press water is recycled to tower diffusers without depulping or heating; at 7.5% on beet (7% dry solids), this means that in a day some 375 tonnes of pulp will pass through the diffuser of a factory processing 5000 tonnes of beet daily. There is a trend towards use of calcium sulphate as aid to pulp pressing; various methods of preparing the additive solution are used, but optimum conditions have not yet been established for its use. Low-temperature drying is to be used in two factories in 1983/84, with pan vapours and preliminary condensate used as heating medium for the fresh air. Examination of causes of excessive colour formation during purification in some factories has led to a number of explanations, and the major causes are listed. Particularly mentioned is the contribution of phenolics to formation of additional browning products. In connexion with invert sugar determination in thin and thick juice, it is stressed that enzymatic methods will give only half the values found by methods based on reducing sugars, so that the method used must be stated alongside any values; thus, the tolerable limit in thick juice of 0.08% invert sugar on dry solids is reduced to about 0.04% when measured enzymatically. The importance of thick juice chest design to prevent retention of stagnating juice and possible considerable extra coloration is emphasized. There is a tendency to take 1st carbonatation to a higher end-point than that corresponding to the visually established flocculation point; advantages of this include the elimination of more silicate (and hence prevention of scaling) and removal of more anions, particularly sulphate, the content of which is greater when $CaSO_4$ is used as pulp pressing aid. However, the practice has not shown any expected improvement in juice colour, while the higher end-point leads to a worsening in filtration properties; moreover, the risk of scale formation by silicate can be reduced by omitting liming before 2nd carbonatation. However, while there may be practical arguments for slightly raising the end-point of 1st carbonatation, these cannot be extended to preliming – the final pH should not exceed 11.2, since excessive alkalinity coupled with higher or fluctuating temperatures will affect colloid precipitation and possibly lead to filtration problems. Investigations of boiling house operations have been aimed particularly at reducing production costs through economies in primary energy. Studies on heat transfer during heavying-up of a low-grade massecuite at Plattling are described; the aim was to establish the effect of massecuite level above the calandria on the heat transfer coefficient at various heat steam pressures; results showed that the coefficient reached a definite maximum corresponding to a massecuite level of about 0.8 m in a pan of 80 tonnes capacity, so that it is to be expected that there is a minimum level required for good circulation – if this level is exceeded, the column of massecuite will cause unfavourable circulation and adversely affect the heat transfer coefficient. These findings are of particular significance for continuous boiling. Details are given of a 3-massecuite boiling scheme used at Düren since 1980/81 for manufacture of only one sugar (white sugar 2). The standard liquor is made up of thick juice in which the low-grade sugar is melted, while all the *B*-sugar is affined and then melted in thin juice for use as footing. Both of the intermediate products are subjected to double centrifugalling. Trials on production of footing for white sugar boiling, using cooling instead of conventional evaporation-boiling, gave an almost agglomerate-free product; when the footing was used, the white sugar massecuite attained a crystal content of 8-10% at graining and thus avoided formation of conglomerate crystals. Investigations were carried out on the possible application of radiometric measurement of Brix (using ^{137}Cs) to boiling control. Curves show the pattern of both Brix and viscosity/consistency under the effects of supersaturation and crystal content; however, viscosity covers a much wider measurement range than Brix, which covers a range of only 1330-1460 $kg.m^{-3}$, so that it must be measured very accurately, in which case response at the start of boiling will be high. However, there is also need for temperature correction, in contrast to viscosity measurement. White sugar washing with clairce in a batch centrifugal, using two spray nozzles at different heights (since one emitting a spray at an angle of 120° was insufficient to cover the entire height of the sugar mat on the basket screen), gave a lower ash content than washing with water; a third nozzle, covering the area around the floor of the basket, would give even further improvement, but it was not possible to arrange this during the time of the trial. The method also increased crystal recovery from 40 to 51% and gave a sugar moisture of 0.7%. The significance of the treatment for boiling house operations is indicated. Other boiling house processes mentioned include continuous low-grade boiling at Lage sugar factory, a continuing investigation on massecuite mixers located above the calandria, and anaerobic treatment of effluent. For various reasons, all but one of the Biothane units installed met with operational problems; because of these, the advisability of adding lime to flume water was questioned, but it is pointed out that omitting it would lead to increase in flume-wash water microbes, that water partially treated anaerobically would undergo a temperature rise when recycled, leading to an increase in anaerobic bacteria in the flume water and a subsequent increase in infection in diffusion using the cold raw juice method, as well as considerable problems in the storage of washed beet. Denitrification of low-load waste waters is discussed.

Progress with process automation in the sugar industry using the DCI-4000 process control system. H. Kemter. *Zuckerind.*, 1983, **108**, 323-332 *(German)*. – Advantages of distributed hierarchical control systems are indicated, and the various components of the Fischer & Porter DCI-4000 system described. Various aspects of the use of the system are discussed, including configuration and programming, compatibility, reliability and maintenance. Potential applications of the system in the sugar industry are mentioned; it is stated that it has far exceeded expectations at nine West German sugar factories.

Modernization of the heat economy in sugar factories. W. Lekawski and K. Urbaniec. *Zuckerind.*, 1983, **108**, 338-343 *(German)*. – While there have been considerable improvements in sugar factory heat economies in recent years, there are factories where the boiler plant is in need of modernization and steam raising efficiency is low. Although modernization of such plant is very costly, it is stressed that it is still possible to bring about improvements in the heat economy through greater efficiency in energy use. Calculation of the heat balance of a factory is briefly discussed, and a balance given for an old factory employing a 3-massecuite scheme for white sugar manufacture. Means of reducing energy consumption and making maximum use of available heat are described, and the balance achieved is then compared with that of the factory mentioned above, showing a one-third fall in steam consumption as a result of using carbonatation gas enthalpy, reducing the amount of water to be evaporated during boiling (by evaporating thick juice to a higher Brix), raising the juice and run-off heating efficiency, utilizing pan vapour for heating and condensate for heating/moistening carbonatation gas, preheating air for use in the granulator and heating centrifugal wash water as well as raw juice.

Possibilities of utilizing the heat output of sugar factories. G. Lippold. *Lebensmittelind.*, 1983, **30**, 159-164 *(German)*. – While the major part of the enthalpy introduced in a sugar factory with the fuel is recorded as heat loss, the remaining 41% occurs as low-temperature heat such as pan vapour, pulp dryer vapour and boiler flue gas, of which only a small fraction (8%) is re-usable. A Sankey diagram for a white sugar factory having a daily slice of 1000 tonnes of beet is compared with an exergy diagram for the same factory – while the former gives only a quantitative statement on heat flows, the latter indicates their energy values. The question of how best to make use of recycled heat is discussed in the case of boiler air pre-heating, the recirculation of pulp dryer vapours to the dryer, utilizing pan and dryer vapours to heat greenhouses in the vicinity of a sugar factory, and heating living accommodation and workrooms.

LABORATORY STUDIES

Density of sugar solutions. P. Kadlec, Z. Bubnik and A. Dandar. *Sucr. Belge,* 1982, **101**, 359-368. – See Bubnik & Kadlec: *I.S.J.*, 1983, **85**, 281.

Application of high-performance liquid chromatography in beet agriculture and the sugar industry. I. Analysis of organic acids. P. Vratny, H. Mertova and D. Chadimova. *Listy Cukr.*, 1983, **99**, 56-63 *(Czech).* – Comparison was made between three HPLC techniques used to separate organic acids in beet extract, raw juice and molasses, viz. ion exchange chromatography, ion exclusion and reversed-phase chromatography, in terms of sensitivity, selectivity and resolution. Details are given of the retention of 23 acids separated from a standard mixture, and results of the separations of the other above-mentioned solutions are reported. The question of choice of detector is briefly discussed, and a description given of sample purification by passage through a cation exchange resin in H^+ form. This eliminates the impurities that otherwise block the exchange groups in the resin used for ion exclusion, found to be the most suitable of the three techniques. Detection by U.V. spectrophotometry at 210 or 215 nm was found to be more suitable than use of a differential refractometer.

Sugar extraction from beet cossettes in an electric field. I. G. Bazhal, M. P. Kupchik, I. S. Gulyi, I. M. Katrokha and V. A. Zaets. *Sakhar. Prom.*, 1983, (3), 28-30 *(Russian).* – Laboratory tests were conducted on the use of a D.C. current of 5 $V.cm^{-1}$ to extract sugar from 1 kg of cossettes in two electro-diffusers connected in series, in which distilled water was fed at 40 $ml.min^{-1}$, 50°C and pH 6.4; 200-ml samples of diffusion juice were taken from the second diffuser at 5-min intervals and analysed. Comparison was then made with juice obtained without application of electric current. Results showed that sugar extraction was faster and to a greater degree, while the colour was lower than in the control.

A column-adsorption method of purifying extracts for determination of toxic chemicals in sugar factory products. A. Z. Usmentseva. *Sakhar. Prom.*, 1983, (3), 54-56 *(Russian).* – Comparative tests were conducted on various adsorbents for removal of interfering substances, particularly colouring matter, from sugar factory products before application of thin-layer or gas-liquid chromatography to determine trace quantities of pesticides. Tabulated results are discussed; they showed that use of gel permeation chromatography with various gels in the Sephadex series as well as modified silica gels, and application of ion exchange resins and active carbons removed large quantities of co-extractives, particularly colorants, while pesticide loss did not exceed 13% of the initial content in many cases. Florisil was comparable to Soviet-produced Magnesil as regards colorant removal and low degree of irreversible adsorption of pesticide. A chromatogram is reproduced showing the clarity of spots of organo-chlorines after pre-treatment with the various adsorbents by comparison with an untreated mixture of standards.

Analyses. R. Detavernier, J. P. Ducatillon and J. Roger. *Sucr. Franç.*, 1983, **124**, 129-132 *(French).* – Brief notes are presented on the various analyses conducted in French sugar factories during the 1982/83 campaign: enzymatic determination of sucrose in raw juice and molasses, determination of calcium in juice before and after evaporation as an indication of the amount of scale formed, determination of iron in juice before and after evaporation as an indication of the amount of corrosion, determination of the bacterial counts in stored thick juice, and determination of the bacterial counts in white sugar. The results are summarized.

Determination of organic acids by gas and liquid chromatography. R. Detavernier, J. P. Ducatillon and G. Deruy. *Sucr. Franç.*, 1983, **124**, 133-137 *(French).* For C_2-C_5 fatty acid separation by GLC, a column of Porapak N is used; for lactic acid, a column of OV_1 is applied. A flame ionization detector is used in both cases. For the fatty acids, monocarboxylic acid standards are prepared directly in water, with pivalic acid as internal standard. For sugar factory products, particularly raw juice, pre-treatment with cation- followed by anion-exchange resin is necessary to remove sugar; raw juice must also be pre-treated with zinc sulphate and potassium ferrocyanide. Where lactic acid is determined in raw juice, the acid must be volatilized. Formic acid can be determined by the GLC method described, but only with the aid of a catharometer. Since, for a complete balance of raw juice organic acids, at least two chromatograms are required and pre-treatment of the sample is necessary, attention has been directed towards liquid chromatography as an alternative technique. Different analyses were carried out with a Lirec chromatograph connected to a U.V. spectrophotometer measuring at 205 nm. The acids were separated on a column of Hypersil C_{18}, a 50 mM phosphate buffer of pH 2.6 being used as mobile phase. Raw juice needed pre-treatment to remove interfering substances and prevent fouling of the column. Chromatograms are presented of a mixture of mono- and dibasic acids and of formic, lactic, acetic, propionic and isobutyric acids in raw juice.

Rapid analysis of sucrose fatty acid esters by thin-layer chromatography. H. T. Cheng, L. S. Leu and C. S. Ting. *Rpt. Taiwan Sugar Research Inst.*, 1982, (97), 57-64 *(Chinese).* – A rapid method for separation and identification of the components of sucrose fatty acid esters has been developed in which 15-150 μg samples are spotted on a silica gel layer and developed with 10:80:8:2 methanol:chloroform:acetic acid:water. $R_f \times 100$ values of 14-18, 47-61, 69-75 and 83-94 were obtained for mono-, di-, tri- and polyesters of fatty acids, respectively. Separated spots were observed distinctly after spraying with anthrone solution and heating at 110°C for 6 minutes. A high-speed scanner was used for quantitative analysis at 440 nm; the concentrations of the components were directly calculated by the external standard method of two-point calibration. The new method was used to determine the composition of products from different synthesis methods.

Dextran in the development of the sucrose crystal. E. Duarte. *ATAC,* 1981, **40**, (1), 34-39 *(Spanish).* – Examination of crystal samples from a number of Cuban sugar factories, of dextran content between 0 and 2000 ppm, showed that the *a:c* axis ratio was directly affected by the dextran content as was the content of conglomerates. With more than 500 ppm of dextran, the granulometry was sufficiently irregular to facilitate microbial deterioration.

Measurement errors in the sugar factory. E. Aguilera, C. de Armas and L. Rostgaard. *ATAC,* 1981, **40**, (2), 31-38 *(Spanish).* — An investigation was made into the errors arising in analysis of cane juice, syrup, *A*-massecuite and bagasse, and in sampling of syrup and concentrated sweet-water. Values for Brix, pol and purity of the different materials, obtained by different workers in separate shifts, are tabulated and were subjected to statistical analysis. The error was less than 1% in the cases of juice, syrup and *A*-massecuite but the purity of residual juice in bagasse could be $>$20% in error. Continuous samplers operated correctly, but the numbers of analyses were insufficient to judge sampling errors and further work is to be done.

Determination of raw sugar colour. J. A. Urrutia, J. Rodríguez, A. Alamo and R. Linares. *ATAC,* 1981, **40**, (2), 45-55 *(Spanish).* — The photocolorimetric method proposed by the Sugar Ministry National Laboratory in Cuba was examined in respect of interference by turbidity, solution pH and concentration, and wavelength, in order to reduce errors and establish a relationship between results obtained and those of the Horne and ICUMSA No. 4 methods. It was found that, under specified conditions, filtration through asbestos was quicker and equivalent to filtration through a 0.45 μm membrane. The pH should be adjusted to 7.0 ± 0.1, when measurements are made with a C.V. of less than 3%. Colour may be measured within a Brix range of 5-20° without any need to adjust to 10 ± 0.2°Bx provided the Brix is taken into consideration in the calculations and a C.V. of 5% is acceptable. The use of 436 nm permits the use of simpler and less costly instruments without increasing experimental error; it is possible to measure colour at 436 nm and express the results as at 420 nm by means of regression equations.

Filtration and centrifugation in the ICUMSA polarization method. J. A. Urrutia, J. Rodríguez and A. Leon. *ATAC,* 1982, **41**, (1), 47-52 *(Spanish).* — Tabulated results are presented of comparative pol measurements on 156 raw sugars where the samples were prepared for polarimetry by centrifuging (at 100, 2000, 3000 and 4000 *g* for 20 min) and by the standard filtration technique. The median difference was 0.017°S with a variance of 0.0064 ($t = 2.67$).

Comparison of techniques for determination of polysaccharides. J. Hormaza M. and A. Leon G. *ATAC,* 1982, **41**, (1), 53-59 *(Spanish).* — The methods of Nicholson & Horsley[1], as modified by Keniry *et al.*[2] and Hidi *et al.*[3], and of Leal & Kara-Murza[4] for dextran and total polysaccharides determination, respectively, have been compared. Details are given of the two techniques used on 32 mixed juice samples and of the results obtained with regard to interference by colour, ash and proteins, preservation with mercuric chloride, repeatability and recovery, etc. The turbidity produced in the Nicholson & Horsley method became stable between 20 and 45 minutes from its formation, when readings should be made. Juice colour was about 50% of the opalescence and should therefore be eliminated. Use of ion exchange resin was a satisfactory method of removing ash, while preservation of samples with $HgCl_2$ did not interfere with the turbidity measurement. The Nicholson & Horsley method was found to give a standard deviation of 0.016 polysaccharides % Brix and a coefficient of variation of 5.76%, which is acceptable. Corresponding figures for the Leal & Kara-Murza method were 0.0126% and 7.03%. Recovery for the Nicholson & Horsley method was 92.6% for 3 mg added to 60 ml, 94.4% for 6 mg added and 73.8% for 12 mg added; for the Leal & Kara-Murza method the recovery was 102% for 50 ppm added and 107% for 100 ppm. There was a significant difference, but an acceptable correlation, between measurements by the two methods. The Nicholson & Horsley method is applicable to measurement of dextran, particularly at low levels, and this is related to total polysaccharides. The Leal & Kara-Murza method is not affected by proteins and determines total polysaccharides, increase in which is largely due to dextran, so that the method gives a measure of its formation through infection in the field and during milling.

Equilibrium of the sucrose-lime-water system. A. R. Sapronov, D. V. Ozerov, N. E. Karaulov, V. N. Fishchenko and V. P. Yan'shin. *Sakhar. Prom.,* 1983, (5), 37-39 *(Russian).* — An attempt is made to explain the interaction of sucrose and lime under the effect of concentration and temperature. Increase in sucrose concentration once equilibrium is established leads to the formation of calcium mono- and disaccharates with a resultant increase in lime solubility. Reduction in sucrose concentration or rise in temperature causes hydrolysis of the saccharates and a fall in lime solubility. With gradual addition of lime in the presence of an excess of sucrose, some lime particles dissolve while others undergo surface damage; the consequence is a $Ca(OH)_2$ concentration in the surface layer of lime particles which is greater than the volumetric concentration of the solution, despite the solution-mud equilibrium. Penetration of the surface layer of lime particles by sucrose leads to formation of stable complexes between 4 parts sucrose and 1 part calcium, unlike the unstable mono- and disaccharates mentioned above. A fall in pH causes dissociation of all the complexes. These findings were confirmed experimentally at 25° and 50°C.

Sugar mill sucrose analysis by liquid chromatography. P. C. Ivin, P. C. Atkins and R. Russ. *Proc. Australian Soc. Sugar Cane Tech.,* 1983, 187-194. — Details are given of the equipment used in high-performance liquid chromatographic investigations at Pleystowe factory. The system used embodied Dextro-PAK cartridges packed with uniformly sized silica particles having long-chain C_{18} aliphatic groups bonded to their surface and intended for oligosaccharide separation. Results showed that the chromatograph performed satisfactorily over a 5-week period, although instability in the factory power supply caused some operational problems with the microprocessor-controlled data module integrator. Materials analysed included mixed juice, clarified juice, filtrate, evaporator supply juice, diluted massecuite and final molasses. Relative standard deviation for molasses was about ± 0.9%. The difference between pol and sucrose found by HPLC in clarifier juice was insignificant, whereas a 1.2 unit difference between double polarization values and HPLC for final molasses was highly significant. The HPLC technique required less analyst time than required for double polarization and was more specific; it can be recommended for laboratories where relatively large numbers of true purity determinations are required for low-grade materials.

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[1] *J. Agric. Food Chem.,* 1959, **8**, 640-643.
[2] *I.S.J.,* 1969, **71**, 228-233.
[3] *Proc. 15th Congr. ISSCT,* 1974, 1255-1265.
[4] *Rev. ICIDCA,* 1972, **6**, (2), 25-30.

BY-PRODUCTS

Digestion of final molasses carbohydrates in the small intestine of pre-ruminant calves. B. Chongo and P. Thivend. *Cuban J. Agric. Sci.,* 1982, **16**, 285-292. Because of the high cost of milk and increase in the amount consumed by humans in certain regions of the world, studies have been conducted on possible substitutes for milk, but any carbohydrates included must be easily digestible by the calf. Investigations were carried out in which calves received milk twice daily and infusions of final molasses, hydrolysed molasses and a glucose-fructose mixture, respectively; the glucose and fructose contents in the mixture were comparable to the quantities in given weights of molasses. Carbohydrate absorption varied with the type and quantity of material infused; the disappearance of sucrose was poor and unrelated to the amount infused, whereas glucose disappearance was satisfactory in all cases with one unexplained exception, while fructose absorption increased with infusion but disproportionately. There was a linear relationship between the amount of water excreted and of sucrose infused. The results indicate limitations in final molasses digestion in the small intestine of a calf, and suggest that sucrose hydrolysis is beneficial for reducing losses caused by water excretion.

Presence of growth regulatory substances in sugar cane bagasse. E. B. Famoso and O. K. Bautista. *Philippine Agriculturist,* 1982, **65**, 147-151; through *Crystallizer,* 1982, **5**, (6), 14. — Seedbox and petri dish tests were conducted to determine the cause of chlorosis and stunting of tomato seedlings mulched with bagasse that was between 1 and 5 months old. The study indicated that the disorders were due to inhibitory substances leached from the bagasse. The petri dish test proved that these substances were water-extractable and gradually lost their activity as the bagasse aged. Thus, after 6-8 months the bagasse stimulated growth of the seedlings.

Utilization of vinasse from molasses yeast fermentation. A. I. Skirstymonskii, P. V. Rudnitskii, M. S. Sushii, D. G. Yuditskii and M. S. Bal'shin. *Izv. Vuzov, Pishch. Tekh.,* 1983, (1), 20-22 *(Russian).* — Details are given of a method developed for production of a granular complex fertilizer (containing N, P, K, Na, sulphates and traces of Mg) from vinasse.

Utilization of albumin concentrate from sugar beet leaves in food for humans. M. S. Dudkin, L. V. Kaprel'yants, I. V. Belokon' and R. V. Levchishina. *Izv. Vuzov, Pishch. Tekh.,* 1983, (1), 100-101 *(Russian).* — Albumin concentrate obtained from beet leaves contains about 44% protein and 41% carotene, and includes a number of essential amino-acids. Tests were conducted on its inclusion in a minced meat product. Results showed that replacement of 19% force-meat with the concentrate gave a product that was as digestible as Class II beef and was richer in essential amino-acids.

Utilization of wastes from citric acid manufacture at Gyrbovsk sugar combine in Moldavia. O. I. Yurasov, V. F. Shestoperov and Z. S. Shaposhnik. *Sakhar. Prom.,* 1983, (4), 43-44 *(Russian).* — Investigations are reported on the use of by-products from citric acid fermentation of beet molasses with *Aspergillus niger.* The by-products include mycelium and calcium citrate filtrate (both tested as animal fodder) and gypsum formed by reaction of sulphuric acid with the calcium salt of citric acid and usable as a substitute for putty in the building industry.

Citric acid from beet and cane molasses. H. Kampf. *Zuckerind.,* 1983, **108**, 234-235 *(German).* — See *I.S.J.,* 1983, **85**, 284.

Bagasse — a promising raw material for the paper industry. P. J. M. Rao. *Maharashtra Sugar,* 1983, **8**, (4), 9, 11-15, 19-21, 23, 25-28. — The advantages and disadvantages of bagasse as raw material for paper manufacture are discussed, and descriptions given of bagasse handling and storage methods, depithing, pulp manufacture and bleaching, and the production of newsprint. Details are given of the processes in bagasse paper mills in a number of countries.

Fermentation vat bottoms: a factor in industrial efficiency. J. P. Stupiello and J. Horii. *STAB,* 1982, **1**, (1), 34-36 *(Portuguese).* — A review is presented of various systems for treatment and recycling of yeast cells in the fermentation bottoms, with and without centrifuging. Total separation of the bottoms results in a yeast fraction comprising mostly dead cells and partial separation is preferred, with acid treatment to pH 2.0-2.5 before mixing with yeast milk separated in a centrifuge from the fermented must.

Cane bagasse: biomass alternative to oil. N. P. Perez. *STAB,* 1982, **1**, (1), 37-38, 40-41 *(Portuguese).* — Aspects of improving bagasse combustion efficiency are discussed, including the effect of moisture content and its reduction, and bagasse drying, baling and storage.

Reduction in the volume of vinasse. F. Zarpelon. *STAB,* 1982, **1**, (2), 28-32, 34-35 *(Portuguese).* — A number of options are available for the reduction of vinasse volume, including phlegm separation, use of a higher alcohol content in the fermentate, and recycling of vinasse. The use of these, with and without an evaporation stage, is discussed.

Single-cell protein. I. The micro-organisms utilized. M. A. Otero, G. Bernal and O. Almazan. *ATAC,* 1980, **39**, (3), 22-27 *(Spanish).* — Although suggestions that microbially produced protein might be usable to meet a deficiency in world nutritional needs became public in the 1950's, algae have been collected and used as food by the Aztecs and by tribal communities near Lake Chad since remote times. Their digestibility is good and the conditions required for commercial production (as successfully practised in Algeria and Mexico) are noted. Fungi are used mainly for production of pharmaceuticals — antibiotics, etc. — and, while they have some attractive features, the disadvantages of low growth rate, ease of contamination, high effluent BOD, etc. make them less suitable as food. Much work has been done on cultivation of bacteria *(Bacillus, Hydrogenomonas, Matamonas, Methylomonas* and *Cellulomonas* spp.) which have high growth rates, 70-80% protein content and good yields. However, these also require large volumes of oxygen, aseptic cultivation, refrigeration to disperse the heat produced, and costly separation processes. Yeasts are the most widely used microorganisms, particularly *Candida, Rhodotorula* and *Saccharomyces* spp., the first two for producing animal fodder, and the last for human food. They contain proteins which possess amino-acid profiles (tabulated) that are comparable to whole eggs, and are well balanced, if somewhat deficient in thio-amino-acids.

Cane sugar and alcohol. E. David. *ATAC,* 1981, **40,** (1), 4-7 *(Spanish).* — The storage of solar energy by photosynthesis is briefly described and the efforts of Brazil, the US and South Africa to recover some of that energy by manufacturing alcohol from cane are mentioned. Aspects of alcohol fermentation of sugar by yeast are touched on, and alternative methods of vinasse disposal indicated. A table shows the quantities and steam balance for production of sugar and alcohol, and of alcohol alone, from a hectare of cane.

Single-cell protein. II. Sources of carbon and energy utilized. M. A. Otero, G. Bernal and O. Almazan. *ATAC,* 1981, **40,** (1), 8-14 *(Spanish).* — A review, with 23 references, is given of the production of single-cell protein from a number of substrates including natural gas and methane, agricultural wastes, final molasses, hydrocarbons, lower alcohols, etc.

Ethanol from bagasse. A. Herrera G. *ATAC,* 1981, **40,** (1), 22-27 *(Spanish).* — A summary is presented of the nature of bagasse and its suitability for conversion to alcohol by preliminary hydrolysis of the cellulose content, followed by fermentation of the sugars produced.

Hydrolysis of pith with dilute sulphuric acid in a stationary system. A. I. Nápoles, O. Torres, R. Lopez and C. Ramos. *ATAC,* 1982, **41,** (1), 60-65 *(Spanish).* Bagasse pith was mixed with dilute sulphuric acid and charged into a reaction vessel, the remainder of the acid needed to achieve the required pith:acid ratio was added, the reactor closed and direct-heated with steam to the required temperature (whereby inert gases were expelled). After the prehydrolysis, the solution was removed by filtration and further acid and water added. After this second stage, the residual lignin was washed to remove sugars, and the hydrolysates analysed. Trials were carried out in which prehydrolysis conditions were varied, viz. temperature (135-145°C), digestion time (15-25 min), acid concentration (0.25-0.5%), acid:pith ratio (8-12:1), heating time (12-24 min) and filtration time (20-30 min). After the best prehydrolysis conditions had been defined (140°C, 12:1 ratio, 0.5% acid, 12 min heating, 15 min digestion and 20 min filtration), those of the second hydrolysis stage were varied, including temperature (150-160°C), acid concentration (0.3-0.7%) and reaction time (20-40 min). There were four repetitions. A further trial, using 170°C, acid:pith ratio of 8:1, 0.75% acid and 25 min hydrolysis time after standard prehydrolysis, confirmed the need for a third stage to increase yield above 40% on dry pith weight. The best conditions for the second stage were 0.75% acid, 155°C, 15 min digestion at 8:1 ratio and 15 min filtration time. For the third stage they were 1.0% acid, 165°C, 15 min digestion at 8:1 ratio and 25 min filtration time; this gave a yield of 38.4%. Trials were conducted on cultivation of yeasts on the sugar solution obtained and feeding of the products to chickens; results were sufficiently good to suggest that pith hydrolysis should be practised on a national scale.

Sugar cane alcohol production in Brazil. J. E. Irvine. *Sugar J.,* 1983, **45,** (10), 15. — A short account is given of alcohol manufacture from sugar cane in Brazil, with mention of its use as motor fuel and the work being undertaken to expand this field of application. While almost 3 million ha of land is under cane in Brazil, a further 2 million ha is required to meet the increased alcohol requirement. In 1981, 84% of the entire alcohol production was manufactured in the south-central region, and it is here that the greatest expansion in cane area is expected; however, since all suitable land is already under cultivation, any expansion will have to be in areas of pasture or where the soil *(cerrado)* is so poor that growth of vegetation is stunted. Problems that are expected to occur are briefly examined. The benefits of continuous fermentation in regard to the reduction in quantity of vinasse and in its water content are mentioned; this promises to reduce vinasse transportation costs and make available a valuable source of organic matter and potassium for *cerrado* soil.

Fermentation system cuts BOD 90%, converts sugar wastes to ethanol. C. Rainwater and R. J. Swientek. *Food Process* (Chicago), 1982, **43,** (10), 74-76; through *S.I.A.,* 1983, **45,** Abs. 83-429. — A new system for treating sugar-containing wastes was installed in 1981 at Hygiea Coca-Cola Bottling Co., Pensacola, Florida. Waste liquids of 6°Bx or above are collected; the combined waste, averaging 950 gal/day at 10-12°Bx, is fermented batchwise to ethanol. Distillation gives a product containing 96.8% ethanol, which is mixed with petrol 1:9 to give a fuel for the firm's road vehicles. The wastes sent to fermentation contain 90% of all the BOD discharged from the plant, and the process gives a 90% decrease in BOD. The resulting effluent is mixed with low-BOD effluent and sent to the municipal treatment plant.

Ethanol production by coupled saccharification and fermentation of sugar cane bagasse. S. Blanco, A. Gamarra, C. Cuevas and G. Ellenrieder. *Biotechnology Letters,* 1982, **4,** (10), 661-666; through *S.I.A.,* 1983, **45,** Abs. 83-452; — Ethanol was obtained by enzymic saccharification of bagasse in a column at 50°C, fermentation of the eluate with fast-decanting yeast at 35°C and recycling of the fermentate through the column. Ethanol yield from this system after 24 or 48 hours was about 15% greater than that from simultaneous saccharification and fermentation in agitated flasks at 40°C.

Effect of nutritional factors on cellulase enzyme and microbial protein production by *Aspergillus terreus* and its evaluation. S. K. Garg and S. Neelakantan. *Biotechnol. Bioeng.,* 1982, **24,** (1), 109-125; through *S.I.A.,* 1983, **45,** Abs. 83-469. — *A. terreus* GN1 was grown in media containing 0.5-4.0% w/v alkali-treated bagasse. Effects of the type and concentration of N source on cellulolytic activity, biomass yield and protein content were tested; data are tabulated and graphed. Corn steep liquor gave the best results. Fermentation for 72 hours gave 16.9 g protein per 100 g bagasse and 69.8% bagasse cellulose utilization; during further fermentation, protein production was slower, reaching 20.1 g/100 g bagasse after 7 days.

Raw materials for the production of ethyl alcohol and their comparative economics. P. J. M. Rao. *Maharashtra Sugar,* 1983, **8,** (6), 21-25, 27-28, 30-31, 33-35, 37, 39, 41-42, 44-45. — The economics of alcohol manufacture from various raw materials are discussed; included are beet and cane juice and beet and cane molasses.

BREVITIES

UK beet sugar campaign start. — The 1983/84 campaign started on October 3, about a week later than normal, with two factories in operation, and all factories were working by the middle of October. Because of the delayed drilling — the result of the wet spring — and prolonged dry conditions during the summer, it was decided to delay the start of the campaign to allow time for additional growth in the better conditions of late September. The same procedure has been adopted in a number of European countries; with reduced beet areas and smaller crops, the delayed start would not result in extension of the campaigns beyond normal finishing dates. It has been reported[1] that British Sugar and the National Farmers Union have signed a new long-term agreement to establish a framework for the future relationship between growers and buyers of sugar beet in the UK. The agreement took effect with the start of the 1983/84 campaign and covers production, delivery of the annual crop, and payments to growers.

Finnish Sugar Co. Ltd., Annual Report, 1982. — In 1982 the Finnish Sugar Co. Ltd. bought a majority shareholding in Vaasamills Ltd., a leading cereal products and animal feed producer. Thereby Group turnover and number of employees were doubled, and the amalgamation has greatly enhanced the Goup's standing in the Finnish foodstuffs industry while also reducing dependency on sugar, which will nevertheless remain the leading segment of the business. Although the start of the 1982 growing season was unpromising, conditions improved and harvesting conditions were excellent. The sugar content of the beet rose to 16.4% against the ten-year average of 15.7% so that the 789,900 tonnes of beets grown on 32,365 hectares were sliced to yield 106,400 tonnes of sugar. This compares with a production in the previous campaign of 91,070 tonnes of sugar from 676,000 tonnes of beet grown on 31,552 ha. Imports of 257,731 tonnes of raw sugar were processed in the Porkkala and Vaasa refineries, 142,967 tonnes for use in Finland and the balance of 114,764 tonnes for export. In addition 21,468 tonnes of French and Dutch beet molasses was imported as raw material for the Naantali sugar recovery plant, destined for export. Altogether, nearly 9000 tonnes of fructose, glucose, sorbitol and xylitol were sold, about 2000 tonnes less than in 1981, the change corresponding roughly to the reduction in fructose exports to the USSR. Net sales of the fine chemicals division doubled during the year; two new enzymes went onto the market and glucose isomerase will be added in the current year. Output of molassed beet pulp rose 20% on the previous year, to 46,000 tonnes.

Pakistan beet sugar crop, 1983. — The beet campaign in Pakistan for 1983 lasted 43 days. Beets were grown on an area of 7500 hectares, a 42% drop from the 12,856 hectares for 1982. The total crop amounted to 205,872 tonnes, against 359,945 tonnes last year, and beet sugar outturn was 17,967 tonnes against 30,726 tonnes in 1982. The fall in plantings is attributed to the fact that farmers are not happy with the beet price (Rs. 267.90 or £13.28 per tonne); there is a considerable surplus of sugar. The beet yield in 1983 was slightly higher at 28.00 tonnes/hectare against 27.45 last year. Sugar beet in Pakistan is processed in four factories which also crush cane. Beet sugar production capacity is very small compared with cane sugar, however, and the 1983 outturn represents only 1.62% of cane sugar production of 1,110,575 tonnes in the 1983 season.

Süddeutsche Zucker-AG Annual Report, 1982/83. — Details are given of the results of the 1982/83 campaign in the factories of the Südzucker group, the basic data having been published earlier[2]. A separate, illustrated account is given of a pilot plant project at the Ochsenfurt factory of Zuckerfabrik Franken GmbH for the manufacture of alcohol and methane from beet, grains and potatoes, the sugar and starch-containing raw materials being fermented to alcohol and the wastes being subjected to anaerobic fermentation to yield methane which can provide the energy necessary for the alcohol recovery by distillation. One of the factories of the group, at Gross-Gerau, celebrated its centenary during the year.

Chile sugar imports and exports, 1982[3]

	1982	1981	1980
	tonnes, raw value		
Imports			
Argentna	58,226	47,649	129,230
Bolivia	6,760	0	62,672
Brazil	72,968	8,120	48,376
Colombia	0	5,163	107,309
EEC	67,264	5,989	2,250
Peru	0	0	13,522
USA	10	19,081	69,149
	205,228	86,002	432,508
Exports			
EEC	0	0	61
Mexico	0	0	38,294
Peru	0	12,000	0
	0	12,000	38,355

A/S De Danske Sukkerfabrikker Annual Report, 1982/83. — In the 1982/83 financial and campaign year, DDS produced 457,000 tonnes of sugar from 3,140,000 tonnes of beet, supplied by 16,000 farms at a cost of 1147 million Danish Kroner. The five factories also produced 45,000 of pelleted beet pulp for animal fodder. Sales in the year amounted to 421,000 tonnes of sugar, of which 226,000 tonnes was exported. 14,125 tonnes of sugar from the C-quota has been carried over to 1983/84 and will become A-quota sugar; the beet area in 1983 was reduced by about 4%. Because of reduced beet areas in a number of countries, beet seed sales fell, while plant and machinery orders have also slowed down. A cane sugar factory under construction in Vietnam is expected to be ready for operation on January 1984. DDS juice purification and automatic filtration systems have succeeded in penetrating the North American sugar industry and positive developments are expected when the current recession has passed.

Peru sugar project study[4]. — Tate & Lyle is to conduct a feasibility study for a sugar complex in Selva, covering the production of 80,000 tonnes of sugar a year and the construction of a sugar factory.

Reduced Guyana sugar crop forecast[5]. — Sugar production in 1983 is now expected to be 280,000 long tons, according to the Chairman of the state-owned Guyana Sugar Corporation, against an earlier estimate of 300,000 tons. The Spring crop yielded 86,085 tons, against an original target of 100,070 tons and production of 86,855 tons in 1982 when total annual production amounted to 288,488 tons.

New Kenya sugar factory[6]. — Construction is under way for the medium-size Opapo sugar factory in Gem Location, in Kenya's Nyanza Province. The new factory will cost 160 million shillings ($12,300,000) and will provide employment for 600 people.

Mauritius drought[7]. — A very serious drought has been prevailing since February and has adversely affected cane growth in Mauritius. As a consequence, the 1983 crop will be much below normal expectations and is now estimated at about 610,000 tonnes, tel quel (647,000 tonnes, raw value), against 687,940 tonnes, tel quel (728,597 tonnes, raw value), in 1982.

Chile sugar beet area, 1983[8]. — The state-owned sugar company IANSA announced beet prices for the 1983/84 season in May, a month earlier than usual, to encourage production. The total area sown to beet in 1983 is estimated at 50,000 hectares, compared with 36,000 hectares in 1982.

Indian irrigation project finance[9]. — The International Fund for Agricultural Development has said it has granted a $35,300,000 loan for an irrigation project in Uttar Pradesh, in northern India. The UN Agency said the scheme would result in an increase in crop production of around 300,000 tonnes of food grains, 10,000 tonnes of oilseeds and 370,000 tonnes of sugar cane.

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[1] *Public Ledger's Commodity Week,* October 8, 1983.
[2] *I.S.J.,* 1983, **85**, 255.
[3] *I.S.O. Stat. Bull.,* 1983, **42**, (6), IV.
[4] *Amerop Newsletter,* 1983, (117), 19.
[5] *Reuter Sugar Newsletter,* July 15, 1983.
[6] *African Business,* July 1983.
[7] *Mauritius Sugar News Bull.,* 1983, (7).
[8] *Bank of London & S. America Review,* 1983, **17**, 67.
[9] *Amerop Newsletter,* 1983, (117), 19.

BREVITIES

Honduras sugar problems[1]. — The sugar industry in Honduras has experienced difficulties because of low world prices and high interest rates. During 1982, 87,107 tonnes of sugar, out of a total production of 216,722 tonnes, were exported, a 6.5% increase over 1981 levels, but the low sugar price resulted in a 55.1% decline in export earnings to $21 million. A reduction is expected in 1983 as a result of the US imposing a quota of 28,000 tonnes; in 1982 the US imported 66,984 tonnes. The sugar industry is now believed to be operating at less than 60% capacity and the main sugar company has been assisted by a $20 million credit from the Banco Central.

New Egyptian beet sugar factories[2]. — The Egyptian government has decided to build 15 new beet sugar factories in the next seventeen years. A study has shown that beets are superior to other crops, particularly sugar cane. A working group from the Ministries of Agriculture, Industry and Economy is to deal with the encouragement of cultivation and processing of sugar beets. Egypt has so far only one beet sugar factory, the Delta Sugar Company, which started its first campaign in 1981/82. Beet sugar production in the 1982/83 campaign is estimated at 33,000 tonnes, raw value. Most Egyptian sugar at present is produced from cane, and output in 1982/83 is estimated at 731,000 tonnes.

Indian sugar exports limitation[3]. — An official of the Indian State Trading Corporation told Reuters that the government will not permit exports over and above the International Sugar Organization quota of 650,000 tonnes, white value, for 1983. This followed reports from the Food Ministry in New Delhi that the government had cleared exports of 900,000 tonnes and that a quota of one million tonnes had been sought. An STC official in London said that around 500,000 tonnes had been sold under quota by the beginning of August. Tenders for the remaining 100,000 tonnes or so had not been fixed. Less than a quarter of that sold had been shipped because of a shortage of 50-kg bags, the preferred size, and a lack of suitable port facilities. Indian output is at last down to below that of a year ago, 8.23 million tonnes being produced by June 30 against 8.25 million tonnes a year earlier. This will bring little cheer to the industry, however, which faces ending stocks of 5.61 million tonnes this season, more than the output of the 1980/81 season.

Sudan sugar factory rehabilitation[4]. — The Arab Fund for Economic and Social Development is providing $47 million finance for the renovation of the Melut sugar factory, the equipment of which is of Belgian origin. Further funds are expected from the German Kreditanstalt für Wiederaufbau and perhaps the World Bank, for the modernization of the Assalaya, Guneid, Khashm-El-Girba and Sennar factories.

Fiji sugar production decline[5]. — Fiji can expect a sharp drop in production to between 250,000 and 280,000 tonnes from last year's record 487,000 tonnes. The decline reflects damage to the crop from cyclone Oscar in March and a severe drought in the main cane growing areas. Meanwhile, Fiji is to supply Malaysia with a total of 210,000 tonnes of raw sugar in the years 1985-87 under a newly concluded agreement and will soon begin renegotiating its 60,000 long ton supply agreement with New Zealand.

US beet sugar crop forecasts. — The USDA has estimated 1983/84 beet sugar production at about 2,700,000 short tons, raw value, compared with 2,717,800 tons in 1982/83. McKeany-Favell Co. Inc. have recently issued[6] a detailed estimate, based on state-by-state evaluations and forecast a slightly higher production of 2,771,300 tons. The MF figure represents a partial recovery from a 1982/83 figure which was the lowest outturn for many years but is still lower than in any of the other years since 1975/76. Production in that year was 4,019,000 tons and declined to 2,879,000 tons in 1979/80 with a fall in the beet crop from 29.7 to 22.1 million tons. A recovery over the next two campaigns brought outturn to 3,166,000 tons from 27.5 million tons of beet in 1981/82, after which came the recent contraction of the industry.

Malaysia sugar imports, 1982[7]

	1982	1981	1980
	tonnes, raw value		
Australia	247,871	278,573	328,659
Brazil	0	0	10,160
Cuba	41,999	74,550	24,731
Fiji	31,900	49,808	50,570
Philippines	11,550	16,750	20,674
Swaziland	0	0	13,517
Taiwan	0	0	12,100
Thailand	99,618	43,984	49,197
Other countries	0	10	5
	432,938	463,675	509,613

Barbados sugar production increase[8]. — Sugar production in Barbados in the 1983/84 season is expected to be between 115,000 and 130,000 tonnes, after cane fires reduced production to 85,000 tonnes in 1982/83, according to industry sources. If rains continue for four or five more months, the coming crop could top the 130,000 tonnes mark for the first time since 1980, but cane fires will have to be kept to a minimum and emphasis continue to be placed on incentives for green cane reaping.

French sugar refinery closure[9]. — Beghin-Say have closed their sugar refinery at Bordeaux. Like the Nantes refinery it had a capacity of 350 tonnes of raw sugar per day. Besides Nantes, there are now only three true refineries left, two in Marseilles and the sugar conditioning installation in Sermaize, which operate as autonomous refineries; the refinery at Nassandres is part of a sugar factory complex.

New Zaire sugar project[10]. — Construction of the Yawenda-Lotokila sugar project in upper Zaire is continuing with Chinese cooperation and the factory should be complete by the end of 1984. The complex will produce annually 15,000 tonnes of sugar and 1200 tonnes of alcohol.

Turkey campaign results, 1982/83[11]. — From a beet area of 372,312 ha in 1982/83 (358,230 ha in 1981/82), was obtained a crop of 12,109,000 tonnes of beet (10,596,000 tonnes). Sugar content was 17.08% and sugar recovery 14.13%, giving a production of 1,610,828 tonnes of white sugar (1,397,262 tonnes).

Thailand sugar production, 1982/83[12]. — The 1982/83 cane crushing season started in September 1982 and lasted until the first week of June 1983. In June 1983 only 94,430 tonnes of cane was crushed whereas 457,127 tonnes was crushed in the same month a year earlier. On average, the 36 sugar factories operated for 172 days against 214 days in 1981/82. Sugar cane was harvested from 889,500 hectares against 946,700 hectares in the previous season; owing to this reduced area, cane production fell from 36 million tonnes in 1981/82 to 32 million tonnes in 1982/83. The total cane crushed in the factories was similarly lower at 12,511,427 tonnes in 1982/83 against 14,591,482 tonnes the previous season, a drop of more than 14%. However, sugar recovery rose from 8.68 to 8.87% and total cane sugar production reached 1,110,700 tonnes, white value, against 1,269,950 tonnes in 1981/82, a decrease of some 13%.

Egyptian sugar factory fire[13]. — A large fire at the Kom Ombo sugar factory in Egypt destroyed 31,000 tonnes of sugar, one third of its production and valued at three million pounds.

New Vietnam sugar factory[14]. — A sugar factory being erected at Song Be with aid from the Danish government is now nearing completion. It will produce 200 tonnes of raw sugar a day from 2000 tonnes of cane and is expected to commence operations during the last quarter of 1983, according to the official Vietnamese News Agency.

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[1] *Bank of London & S. America Review,* 1983, **17**, 71.
[2] F. O. Licht, *International Sugar Rpt.,* 1983, **115**, 421.
[3] *Public Ledger's Commodity Week,* August 6, 1983.
[4] F. O. Licht, *International Sugar Rpt.,* 1983, **115**, 421.
[5] *Public Ledger's Commodity Week,* August 20, 1983.
[6] *MF Sweetener News,* September 12, 1983.
[7] *I.S.O. Stat. Bull.,* 1983, **42**, (5), 26-27.
[8] F. O. Licht, *International Sugar Rpt.,* 1983, **115**, 436.
[9] *Zuckerindustrie,* 1983, **108**, 806.
[10] F. O. Licht, *International Sugar Rpt.,* 1983, **115**, 421.
[11] *Zuckerindustrie,* 1983, **108**, 806, 808.
[12] F. O. Licht, *International Sugar Rpt.,* 1983, **115**, 439.
[13] *Zuckerindustrie,* 1983, **108**, 808.
[14] C. Czarnikow Ltd., *Sugar Review,* 1983, (1663), 156.

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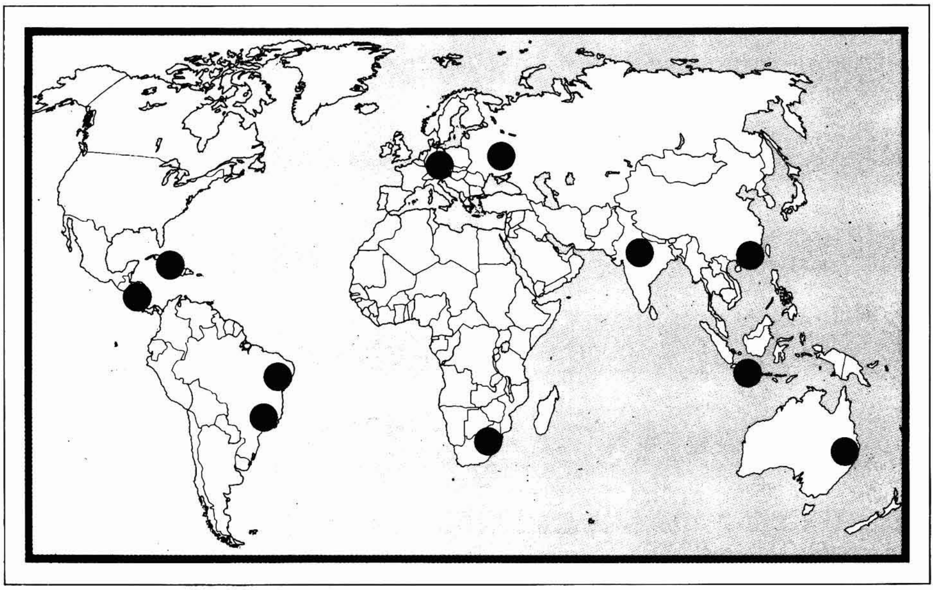

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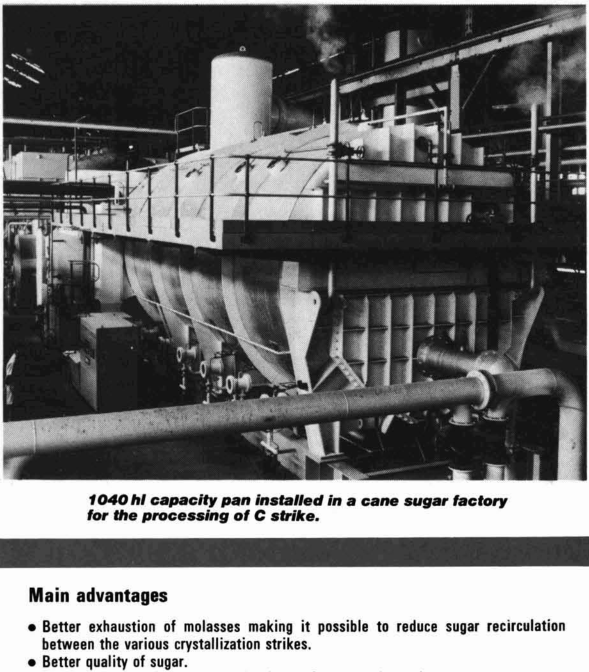

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