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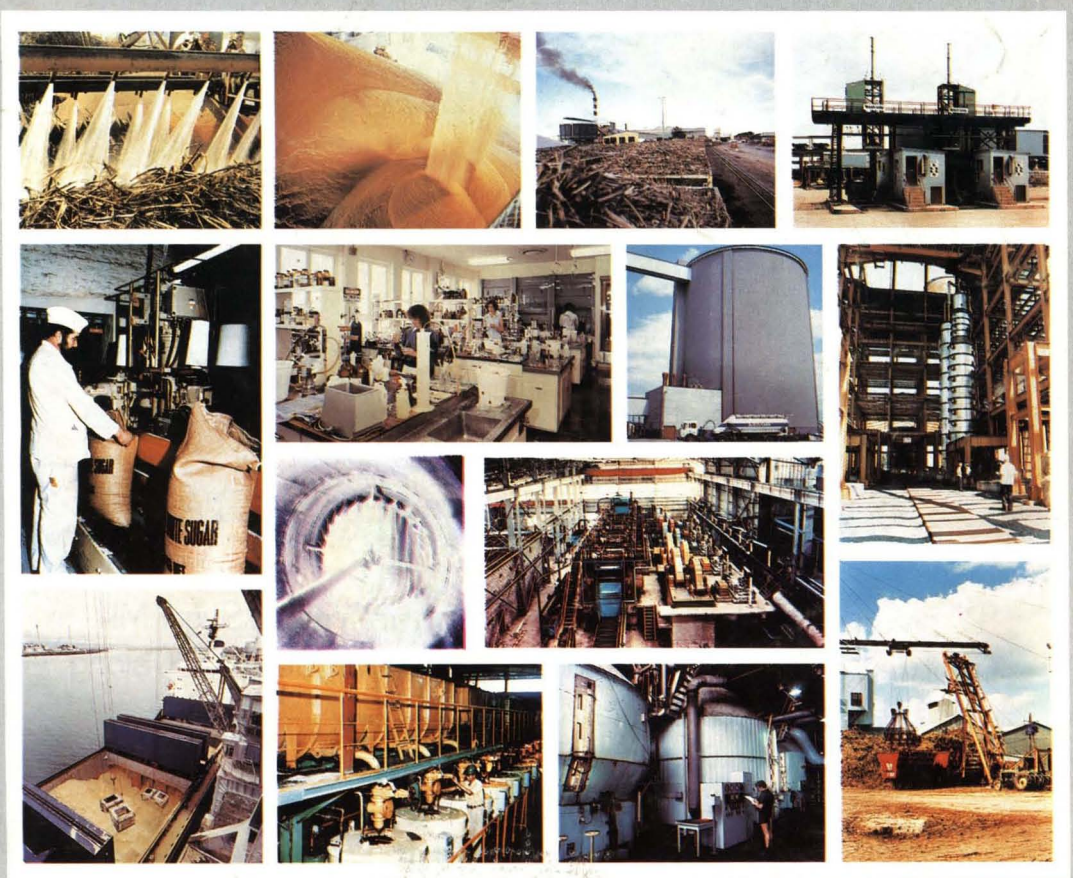

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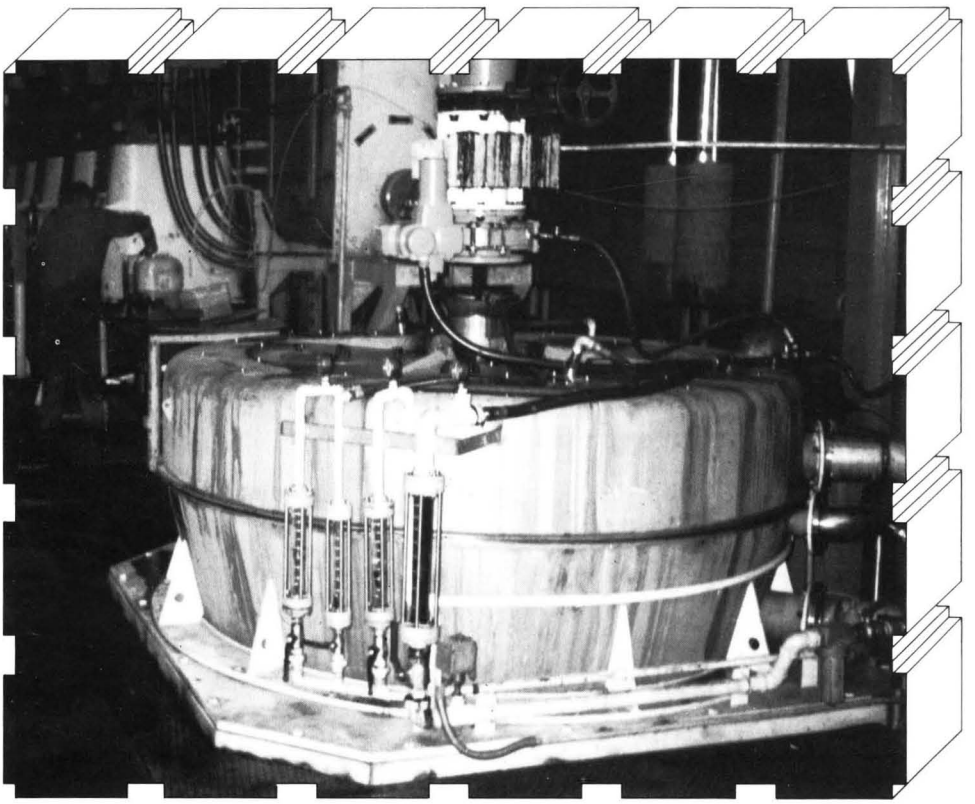

"B" product massecuite centrifugal station at an Italian Sugar Mill. Front view of the new Bosco continuous centrifugal BC-1500 along with a battery of Bosco batch centrifugals "B7".

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INTERNATIONAL SUGAR JOURNAL

UK ISSN 0020-8841
Volume 92
Issue No. 1098
June 1990

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Published by

International Media Ltd.

P.O. Box 26, Port Talbot, West Glamorgan SA13 1NX, U.K.
Telephone: +44-639-887498 *Telex:* 21792 REF 869 *Telefax:* +44-639-899830
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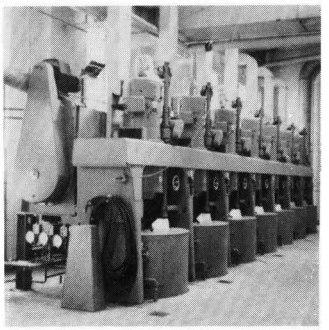

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News and views

World sugar stocks and prices[1]

It is generally accepted that the level of stocks related to consumption is the most important determinant of world sugar prices. The stock/consumption ratio is only a global measure or general indicator, while a more powerful tool is probably the concept of surplus stocks which was developed at the International Sugar Organization in the mid-1980's because this method allows identification of those countries or areas in which a surplus or deficit exists and whether it is raw or white sugar.

A recent survey by F. O. Licht GmbH has shown surplus stocks only in Africa and Oceania, amounting to 386,000 and 141,000 tonnes, raw value, respectively, while stocks in other areas are below normal requirements for consumption, exports and pipeline needs. These deficits amount to 57,000 tonnes for Western Europe, 452,000 tonnes for Eastern Europe, 208,000 tonnes for North and Central America, 726,000 tonnes for South America and 999,000 tonnes for Asia. The overall picture is of a deficit of 1,915,000 tonnes below normal stock levels.

This situation is worse than it was in 1980/81, at the time of the last major boom in world sugar prices, and many analysts were expecting prices to rise to more than 20 cents/lb. However, this has not yet happened and a number of explanations have been offered. The first and obvious possibility is that stocks are actually higher than indicated. In fact, the trade confirms that there is hardly any sugar left and that the situation could get out of hand if production does not improve in 1990/91.

Another explanation is that stock-holding policies or requirements have changed since the early 1980's. The ISO said recently that this could result from more efficient transport systems, more efficient management of inputs at factories making sugar-containing products, more efficient warehousing, etc. The ISO also thought it possible that during the mid-1980's importers had become used to exporters holding stocks on their behalf. Even though the situation has become much tighter, and exporters no longer hold large stocks, importers have not reverted to holding larger stocks themselves. This may be due to a reluctance of importers to do so; they buy sugar as and when they need it, so all the competition is for nearby sugar.

Another argument is that the price behaviour in 1980/81 was irrational as the stocks in 1980 and again a year later were far larger than those which had led to earlier booms. In the ISO'swords , the 1980/81 boom was a phantom boom and stocks were not really at a critical level, but just perceived to be so by speculators and panicking final buyers.

Yet another explanation is that macro-economic factors are behind the failure of prices to rise to a higher level. It is argued that high real interest rates have made it costly to hold surplus stocks, thus reducing overall import demand. The low rate of inflation that has prevailed in recent years is also said to have held down world sugar prices since commodities become a less attractive store of value when inflation is low and interest rates high.

The list of countries with the highest negative surplus stocks provides ample evidence that quite a number of developing countries with a fairly large potential import demand simply cannot afford to bid prices higher. China, India and the USSR would certainly import more if they had the financial means. As developing countries now account for more than 50% of total imports, this is most likely the main reason why the hopes of the bulls have not been fulfilled.

However, the danger us not over yet and any major production shortfall in 1990/91 could create chaotic conditions. The economic reforms in Brazil have made 1990/91 more than usually unpredictable. The government's anti-inflationary strategy could reduce both sugar and alcohol demand, freeing sugar for export. Brazil could produce more than 10 million tonnes and the expected stagnation in domestic consumption should enable it to export some 3 million tonnes in 1990/91, 2 million tonnes more than this season. This could keep prices in check; on the other hand, a significant drop in world sugar prices next year is only a remote possibility as stocks are too low and the industry will have to struggle to bring inventories back to normal.

South African sugar prospects[2]

Final sugar production in the 1988/89 season was little changed from the previous two seasons despite the disappointing climatic conditions during the growing season. Early expectations were for an above average crop but estimates declined steadily owing to poorly distributed rains and widespread abnormal flowering at the beginning of the harvest. The sucrose content in cane and the cane: sugar ratio showed an improvement over the previous season, resulting in the similar sugar production, reported earlier at 2,469,855 tonnes, raw value[3], from a lower cane crop.

Rainfall below the long-term average in most cane growing regions during the 1988/89 summer was reflected in the first estimates of production for 1989/90. This trend continued through the winter months, resulting in long periods of stress in many areas. Production estimates have consequently shown a steady decline throughout the crushing season. The lower cane crop, grown on an area reduced by 5000 hectares, has been partially offset by an improved cane:sugar ratio of 8.73 (9.16 in 1988/89) and a higher sucrose content (13.14% *vs.* 12.61%).

Eldana borer remains a problem, particularly along the coastal belt. Levels of infestation have been successfully contained by harvesting at an earlier age. The industry's bio-control centre, inaugurated in August 1988, has released prospective parasitoids in the field but it remains to be seen if the numbers available for release are sufficient to make an economically significant impact.

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 211 - 214.
2 *S. African Sugar J.*, 1990, **74**, 72 - 76.
3 *I.S.J.*, 1989, **91**, 162.

Government and the industry have been under continuous pressure from existing and potential cane growers to expand production. The major areas of expansion are in KwaZulu, the eastern Transvaal and KaNgwane where a new sugar factory is planned. Although development of new areas will take time, 30,000 additional hectares of land could be planted to cane, to be used for production of sugar and also a proposed fuel alcohol plant which would require a minimum of 100,000 tonnes of sugar.

European beet areas, 1990

F. O. Licht GmbH have recently published[4] their second estimate of areas planted to beet this year. The first estimate[5] showed more modest increases than the market had expected and it was thought that upward revisions were likely when sowings were complete. In fact, the second estimate shows a different story and the total is now set at 7,039,000 hectares, down from the previous total of 7,141,000 ha and little more than the 7,016,000 ha of 1989. Even the new estimate could prove to be too high if Turkey fails to achieve its target of 400,000 hectares.

The total for the EEC has been raised from 1,885,000 ha to 1,913,000 ha (1,853,000 ha in 1989), as a consequence of increases in the figures for Belgium, France, West Germany, Italy and Spain, but a 5000 ha reduction in the UK. Elsewhere in Western Europe there are also reductions totalling 10,000 ha. Reductions in the estimates for Eastern Europe total 130,000 ha and include 13,000 ha in Bulgaria, 1000 ha in Czechoslovakia, 10,000 ha in east Germany, 9000 ha in Hungary, and no less than 105,000 ha in Rumania. The 1990/91 season got off to a good start, with sowings in most countries completed earlier than usual, which should have a positive effect on yields. However, as these were quite good last year, European sugar production is not likely to show much of an increase in 1990/91. As always, it will be the weather which will determine the fate of the 1990 crop.

Possible US conversion of quotas to tariff system

The Bush Administration is reported[6] to be close to announcing a decision on how it will change the US sugar program to comply with the 1989 GATT ruling that the current import quota violates trade rules. Administration officials have been briefing congressional committees and commodity groups, telling them that they are leaning toward replacing the current import quota system with a series of import tariffs. Low tariffs could be set up to a certain level with higher tariffs placed on sugar above the set annual amount. The tariff quota could be implemented on a country-by-country basis as is the present US quota. A tariff-based system would thus control the supply of sugar in much the same way as the existing system. However, the Administration would derive two benefits: first, the move would put the US in the forefront of the search for improvement in global trade which is the goal of the GATT negotiations for reduction of agricultural supports. Second, Congressional jurisdiction of the sugar import program would change from the Agricultural Committee to the House Ways-and-Means and Senate Finance Committees; this is very significant as the latter committees are viewed as more averse to the existing sugar program and inclined to free market operations for agriculture and international trade.

India sugar policy

In 1988/89 India produced a record of 204.6 million tonnes of cane[7]. First indications were that a record level of white sugar would be produced by the factories, up to 11 million tonnes. However, the manufacturers of open-pan sugars (gur and khandsari), who are largely outside the tax and levy system, were able to offer better prices for cane, particularly towards the end of the crushing season. The final outturn was 9.5 million tonnes, compared with 9.9 million tonnes in 1987/88. The result was high prices for sugar in the third quarter of 1989 and a requirement to import for the first time since the first half of 1988.

For the 1989/90 crop year, the government took steps to prevent the same occurring again. The statutory minimum price of cane was increased by 13% to 22 rupees per quintal and the proportion of free market sugar the millers could sell was raised to 80% from 55% (the balance must be sold at a fixed price for the so-called levy sales) for the first two months of the new campaign (October and November), in order to encourage an early start which could help to meet the emerging deficit and moderate prices. This policy seems to have achieved an increase in sugar production in the early months; outturn in the period October - December 1989 was 3.1 million tonnes, up almost 500,000 tonnes from the equivalent quarter of the previous year.

The Indian Sugar Mills Association called for total decontrol of sugar while retaining the system of regulated monthly sugar releases[8]. After receiving a detailed memorandum on the subject from the ISMA, the government decided to seek the opinion of sugar producers not covered by the Association. It approached the National Federation of Cooperative Sugar Factories which represents the cooperatives producing 57% of India's sugar. The Federation was opposed to complete decontrol, arguing that the current system had worked smoothly. The government decided to maintain the status quo and rejected the ISMA's demand. It has conceived a plan for diversification of the industry, however, which, if accepted at cabinet level, could promote output of paper, alcohol, cattle feed, furfural and particle board in addition to sugar. The concept is part of an official strategy to bring about diversification of traditional sugar factories and ensure their economic viability during the 8th Plan period.

4 *Int. Sugar Rpt.*, 1990, **122**, 229 - 231.
5 *I.S.J.*, 1990, **92**, 57.
6 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 185, 204.
7 *ISO MECAS Review of the Market Situation*, March 19, 1990, pp. 7-8.
8 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 208.

Rheological studies of massecuites and molasses

By R. Broadfoot and K. F. Miller
(Sugar Research Institute, Mackay, Queensland, Australia)

Introduction

There are several areas in raw sugar processing where the rheology of massecuites and molasses is of prime importance. These include crystallizer design and operation, the design of pipe-flow systems for transferring massecuite and molasses and in crystal-molasses separation in centrifugal machines.

In this paper results of studies using a pipeline viscometer to investigate the rheology of massecuites and molasses are given. Tubes of different length were used to assess the pressure losses associated with tube entrance and exit and a procedure is proposed to correct for these effects. Viscosities of the samples were also measured using a Brookfield rotating cylinder viscometer and the results obtained using the two methods are compared.

Model of rheological behaviour

The flow behaviour of a material under a shear force is generally presented as a plot of log shear stress against log shear rate (the flow curve). For the usual practical range of shear rate for pipeline flow in factories (typically 0.1 to 10 s^{-1}), massecuites and molasses generally show pseudoplastic flow behaviour, i.e. the viscosity decreases with increasing shear rate. This non-Newtonian flow behaviour can be adequately described by the "Power Law" model[1,2] as follows.

$$\tau = K \gamma_{corr}^{n}$$

and $$\mu = \tau/\gamma_{corr} = K \gamma_{corr}^{n-1}$$

where τ = shear stress at the interface of the fluid and the shear producing element (Pa), μ = viscosity of the material (Pa.s), γ_{corr} = corrected shear rate at the interface (s^{-1}), and K = consistency (Ns^nm^{-2}) (The higher the value of K the more viscous the material). n = flow index (dimensionless); this is a measure of the degree of the non-Newtonian behaviour. For pseudoplastic fluids, the flow index n lies between zero and unity with values further removed from unity indicating a more pronounced non-Newtonian behaviour.

R. Broadfoot

K. F. Miller

The rheological description of such non-Newtonian solutions requires that the range of shear rates and the parameters K and n of the model are specified. It also requires that the viscosity determinations should be made at the shear rate of interest for the process and, if extrapolation of viscosity data to a different shear range is necessary for design or process calculations, care should be exercised to ensure that significant errors are not introduced.

The viscometers and their application

A brief description of each of the viscometers used in this study is given below. The procedures used in each case to calculate the consistency and flow index of the material are summarized in Table I. Details of the mathematical derivations are available in Skelland[3].

The Brookfield RVT rotating cylinder viscometer

Brookfield rotating cylinder viscometers are widely applied in the sugar industry[2,4]. For a single test sample the Brookfield viscometer model RVT can be operated at three or four speeds of rotation, allowing measurement over a four-fold range of shear rate. The shear stress and shear rate are determined from the primary measurements of torque, speed of rotation and geometry of the system.

At the Sugar Research Institute in Australia two measuring systems are used with the Brookfield viscometer:

(1) *Rotating cylinder in an "infinite" medium*

This procedure is used mainly for measuring the viscosity of massecuites. In this system a cylindrical spindle (No. 7) of 3.15 mm diameter is immersed to a depth of 55 mm in the sample contained in a water-jacketed stainless steel vessel of 90 mm diameter and is rotated at constant speed. The walls of the vessel exert negligible influence on the shearing movement of the fluid owing to the large diameter of the vessel relative to the diameter of the spindle.

(2) *Small sample adapter (SSA) and coaxial rotating cylinder*

The small sample adapter fitted to the Brookfield viscometer comprises a water-jacketed stationary reservoir (Model SC4-13R) of 19 mm internal diameter. Two cylindrical spindles of 11.8 mm and 7.6 mm diameter (Nos. 27 and 29 spindles, respectively) are available and these combinations are designated SC4-27/13R and SC4-29/13R, respectively. Because of the very narrow annulus between the coaxial cylinders this method is not suitable for massecuites but is used for molasses, including pressure filtered molasses samples. The coaxial rotating cylinder viscometer has been adopted as an Official ICUMSA Method for measuring the viscosity of molasses[5].

Pipeline viscometer

The components of a pipeline viscometer and its operation have been described previously by Ness[6] while details of Sugar Research Institute's combination crystallizer pipeline viscometer have been given by Broadfoot & Miller[7]. Several water-jacketed tubes have been used with the latter unit to study the effect of L/D ratio of the tubes on the viscosity values. The dimensions of these tubes are given in Table II. Each tube has a rounded entrance to assist the development of the laminar velocity profile and to minimize

1 Tiu *et al.*: *Chem Eng. in Australia*, 1982, **4**, 27 - 35.
2 Ness: *Proc. 18th Congr. ISSCT*, 1983, 1295 - 1303.
3 "Non-Newtonian flow and heat transfer" (Wiley, New York), 1967.
4 Durgueil: *Proc. S. African Sugar Tech. Assoc.*, 1987, 32 - 39.
5 Moritsugu: *Proc. 17th Session ICUMSA*, 1978, 370 - 385.
6 *Proc. Australian Soc. Sugar Cane Tech.*, 1980, 195 - 200.
7 *ibid.*, 1984, 287 - 292.

Table I. Procedures for calculating the consistency and flow index for a "Power Law" fluid

Parameter	Viscosity measuring system: *Brookfield viscometer with rotating cylinder in an "infinite" medium*	*Brookfield viscometer with small sample adapter and rotating cylinder*	*Pipeline viscometer*
(i) Shear stress at the interface between the shear inducing element and the liquid, τ	$\tau = T/2\pi R^2L$ where T = torque required to rotate the cylinder, R = radius of cylinder, and L = length of cylinder	$\tau = T/2\pi R^2L_e$ where L_e = equivalent length of the cylinder	$\tau = D\Delta P/4L$ where ΔP = total pressure differential across the tube, D = internal diameter of the tube, and L = length of the tube
(ii) Uncorrected shear rate, i.e. shear rate induced in the liquid if it behaved as a Newtonian solution, γ_{uncorr}	$\gamma_{uncorr} = 4\pi N$ where N = rotational speed, rev/s	$\gamma_{uncorr} = 4\pi N/(1 - S^{-2})$ where S = ratio of the diameter of the reservoir to that of the cylinder	$\gamma_{uncorr} = 8V/D$ where V = average velocity of the fluid through the tube
(iii) Corrected shear rate at the interface, i.e. (ii) corrected for change in velocity gradient owing to non-Newtonian flow behaviour, γ_{corr}	$\gamma_{corr} = 4\pi N/n$ where n = flow index of the "Power Law" fluid	$\gamma_{corr} = 4\pi NC_R/(1 - S^{-2})$ where C_R = factor to correct for changes in the shear rate at the surface due to the non-Newtonian nature of the fluid = function (S, n); see Skelland[3]	$\gamma_{corr} = (3n + 1)\ 8V/4nD$
(iv) The consistency and flow index for a "Power Law" fluid, K and n, are derived as shown	$\tau = K(4\pi N/n)^n$ $\log \tau = \log (K/n^n) +$ $n \log (4\pi N)$ Prepare log-log plot of τ versus $4\pi N$ ($= \gamma_{uncorr}$)	$\tau = K[4\pi NC_R/(1 - S^{-2})]^n$ $\log \tau = \log (KC_R^n) +$ $n \log [4\pi N/(1 - S^{-2})]$ Prepare log-log plot of τ versus $4\pi N/(1 - S^{-2})$ ($= \gamma_{uncorr}$)	$\tau = K\ [(3n + 1)\ 8V/4nD]^n$ $\log \tau = \log$ $\{K[(3n + 1)/4n]^n\}$ $+ n \log (8V/D)$ Prepare log-log plot of τ versus $8V/D$ ($= \gamma_{uncorr}$)

entrance pressure losses. Each tube exit is cut square.

In the operation of the pipeline viscometer, between five and seven measurements of the efflux rate from the tube at different applied pressures are obtained on each sample. The shear stress and shear rate at the wall of the tube can then be calculated from the total pressure differential, the tube dimensions, and the average velocity of the fluid through the tube. The density of the material influences the estimate of the average velocity in the tube and must be determined independently for each test.

Interpretation of flow curve data

Based on the assumption that the molasses or massecuite sample behaves as a "Power Law" fluid the flow curve data obtained with each type of viscometer are used to determine the value K and n by regression analysis (see Table I). An example of a flow curve obtained for a molasses sample using the pipeline viscometer is shown in Figure 1.

For the analysis of the data from each type of viscometer the flow curve should be plotted to check that a single regression line is appropriate. Two straight-line portions of slightly different slopes or a single outlier point among the data (which would have a strong influence on the final values of K and n) could be evident, even though a correlation coefficient very close to unity (e.g. greater than 0.9995) may be indicated.

Rheological measurements on low purity molasses

A large supply of final molasses of 43.5 true purity was composited and used as the base material for a series of rheological studies. Measurements were performed using both the Brookfield RVT viscometer (with small sample adapter) and the pipeline viscometer employing tubes S1, S2, S3 and S4. The studies were conducted on

(a) the bulk supply, as obtained from the factory,

(b) subsamples, after degassing and at different solids content, and

(c) a sample having a high content of entrapped gas.

For all samples studied the "Power Law" model provided a good fit to the flow curve data.

Determinations of dry substance

Table II. Dimensions of the pipeflow tubes used in this study

Tube	Internal diameter D, mm	Length L, mm	Ratio, L/D
S1	4.91	103.8	21.1
S2	4.86	174.0	35.9
S3	4.88	324.8	66.5
S4	4.83	725.2	150.1
L1	15.96	174.0	10.9
L2	15.95	374.8	23.5
L3	16.00	726.0	45.4

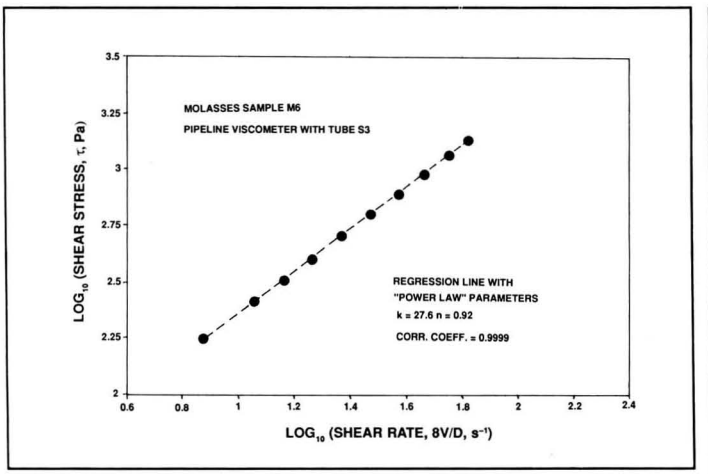


Fig. 1. Flow curve for a molasses sample using the pipeline viscometer

and sucrose by double polarimetry were made using the standard procedures of the Australian sugar industry[8].

Viscosity of factory final molasses

The gas content of the bulk molasses supply was measured at 4.5% by volume on gas-free molasses using the method described by Black & White[9]. Values of the "Power Law" parameters for measurements on two separate bulk samples (collected at the same time) are given in Table III. In general the range of shear rates used with the pipeline viscometer was wider and higher than for the rotating cylinder viscometer.

To assess the precision of the Brookfield viscometer a total of seven viscosity measurements were conducted on separate subsamples obtained from the same bulk supply of final molasses (F1). All measurements were performed by the same operator. Table III shows the mean value and standard deviation of the consistency and flow index values obtained from the measurements. For both parameters, K and n, the 95% confidence interval is within 5% of the mean value.

For each set of test conditions measurements with the pipeline viscometer were conducted on a single subsample and no estimate of the precision of the method could be determined.

The final molasses samples exhibited pseudoplastic behaviour with the Brookfield measurements showing lower flow index values than the corresponding pipeline measurements. For the Brookfield viscometer the flow index decreased as the temperature increased but for the pipeline measurements the flow index was largely

8 Anon: "Laboratory manual for Queensland sugar mills" 5th Edn. (Bureau of Sugar Experiment Stations, Brisbane), 1970.

9 *Proc. Queensland Soc. Sugar Cane Tech.*, 1977, **44**, 185 - 188.

Table III. "Power Law" parameters for final molasses samples

Sample (Dry substance)	Temperature of measurement, °C	Brookfield viscometer SC4-27/13R K, $Ns^n m^{-2}$ Mean	K Std. dev.	n Mean	n Std. dev.	Shear rate* range, s^{-1}	Pipeline viscometer Tube	K, $Ns^n m^{-2}$	n	Shear rate* range, s^{-1}
F1+	30	16.6	0.25	0.93	0.017	1-3	S4	16.7	0.88	9-30
(78.1)	40	7.6	0.20	0.87	0.018	2-7	S4	6.2	0.90	18-85
	50	4.1	0.08	0.84	0.007	3-17	S1	6.0	0.84	188-882
							S2	4.0	0.89	266-706
							S3	4.2	0.87	71-384
							S4	2.8	0.89	46-219
	60	2.5	0.09	0.80	0.011	7-34	S4	1.4	0.90	98-376
F2++	30	17.7	–	0.89	–	1-3				
(78.2)	40	7.5	–	0.85	–	2-7				
	50	3.9	–	0.84	–	3-34	S1	4.2	0.86	16-388
							S2	3.4	0.89	13-391
							S3	2.0	1.03	18-47
								3.0	0.91	47-223
	60	2.5	–	0.79	–	7-34				

Note: Final molasses of 43.5 purity contained 4.5% v/v gas on gas-free molasses

* Uncorrected shear rate

\+ Measurements with Brookfield RVT viscometer on seven subsamples by a single operator

++ Measurements with Brookfield RVT viscometer on a single subsample

unchanged by the temperature. Consistency values were found to give approximately a straight-line dependence with temperature when plotted according to the Pidoux formula[10], *viz.* log K *vs.* $(T - 273.16)T^{-2}$ with T being the absolute temperature in degrees Kelvin.

Pipelines measurements with one sample (F1) were undertaken at 50°C using the four tubes of different length. Flow curves for these measurements are given in Figure 2. It is apparent that pressure losses for the entrance and exit of the tubes have a proportionately greater influence with the shorter tubes, resulting in a higher value of consistency. Corrections for the pressure loss associated with the entrance and exit are discussed in a later section. Flow index values appear slightly lower for measurements with tubes of lower L/D ratio. Similar observations of the effect of the tube L/D ratio on the consistency and flow index values have been reported by Akoglu[11].

The flow curve for the rotating cylinder viscometer shows a similar relationship to the pipeline data, although measurements were only possible at a lower range of shear rate.

Effect of solids content on the viscosity of molasses

Molasses samples were prepared from the original bulk supply by evaporating a diluted sample under vacuum in a laboratory pan. These samples were then substantially free of entrapped gas. The results of the rheological measurements with the Brookfield RVT-SSA and pipeline viscometers, in terms of the "Power Law" parameters, are given in Table IV.

For the Brookfield measurements the consistency values are plotted in Figure 3 as a function of the Pidoux temperature term, providing a nearly linear relationship for each molasses sample. The slopes of the lines increase with increasing dry solids content, indicating that the sensitivity of the viscosity to a change in temperature was greater for molasses of higher solids content. This phenomenon has been

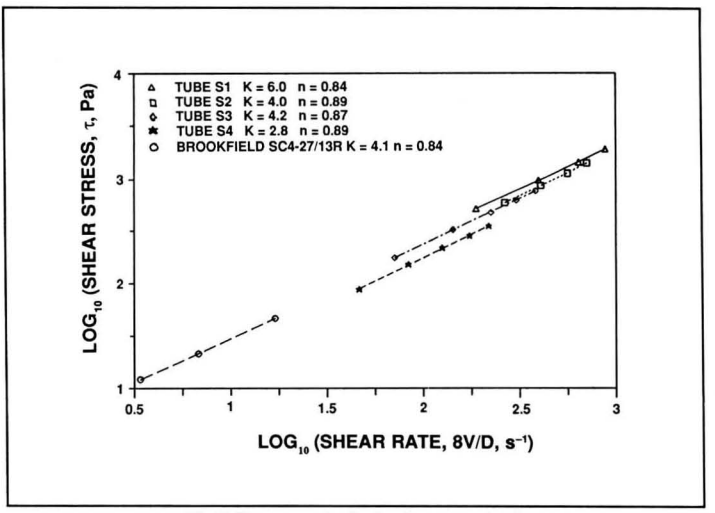


Fig. 2. Flow curves for final molasses sample F1

reported previously[12]. For the test molasses a sample of 76 dry substance at 50°C showed a doubling of viscosity for a 8.5°C drop in temperature while at 87 dry substance the same relative change resulted from a 4.2°C drop in temperature. The consistency values show an excellent fit (correlation coefficient 0.995) to the dry substance-temperature function proposed by Broadfoot & Steindl[12] and this is plotted in Figure 4.

For degassed molasses the non-Newtonian flow behaviour was inde-

10 "Sugar analysis. Official and tentative methods recommended by ICUMSA" (ICUMSA, Peterborough, England), 1979.

11 Private communication (Sugar Institute, Turkey), 1988.

12 Broadfoot & Steindl: *Proc. 17th Congr. ISSCT*, 1980, 2557 - 2581.

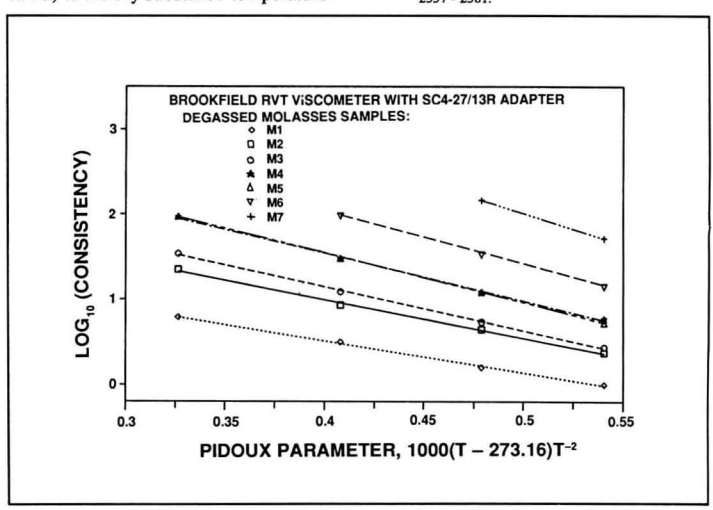


Fig. 3. Consistency of degassed molasses samples at different solids content and temperature (Pidoux parameter)

Table IV. "Power Law" parameters for degassed molasses

Sample (Dry substance)	Temperature of measurement, °C	Brookfield viscometer SC4-27/13R K, Ns^nm^{-2}	n	Shear rate* range, s^{-1}	Pipeline viscometer Tube	K, Ns^nm^{-2}	n	Shear rate* range, s^{-1}
M1 (76.6)	30	6.2	0.96	2-7				
	40	3.2	0.90	3-17				
	50	1.6	0.89	7-34				
	60	1.0	0.86	17-34				
M2 (79.3)	30	21.9	0.97	0.8-3				
	40	8.6	0.94	2-7				
	50	4.5	0.87	3-17				
	60	2.4	0.85	7-34				
M3 (80.1)	30	33.7	0.95	0.3-2				
	40	12.2	0.93	0.8-7				
	50	5.5	0.90	2-17	S1	5.3	0.92	73-280
					S2	4.9	0.93	17-294
					S3	4.3	0.96	27-157
	60	2.8	0.88	3-34				
M4 (82.0)	30	91.7	0.97	0.2-2				
	40	29.4	0.96	1-5				
	50	12.0	0.91	2-12				
	60	6.0	0.87	5-25				
M5 (82.2)	30	93.1	0.96	0.2-0.8				
	40	29.8	0.95	0.3-2				
	50	12.2	0.88	0.8-3	S1	16.5	0.87	133-464
					S2	10.4	0.91	105-281
					S3	11.1	0.89	54-174
	60	5.4	0.89	2-17				
M6 (83.7)	40	94.2	0.94	0.2-0.8				
		(93.7)**	(0.82)	0.2-1				
	50	32.9	0.88	0.3-2	S1	22.2	1.00	18-59
		(38.7)	(0.87)	0.6-5		37.3	0.88	59-140
					S2	23.8	0.97	24-68
					S3	27.6	0.92	7-66
	60	13.9	0.85	0.8-7				
		(16.7)	(0.85)	1-12				
M7 (86.7)	50	(146.0)	(0.87)	0.1-1	S1	138.3	0.93	4-57
					S2	130.0	0.94	4-33
					S3	116.9	0.95	2-19
	60	51.2	0.77	0.2-0.8				
		(53.1)	(0.84)	0.6-5				
M8 (90.4)	50	Viscosity exceeds range of instrument			S1	2239	1.04	2-3
					S2	2267	1.06	1-2
					S3	2058	1.04	0.7-1

* Uncorrected shear rate
** Data in brackets are for Brookfield viscometer SC4-29/13R

pendent of the level of solids content. As observed for the final molasses samples containing entrapped gas, the flow index values from the Brookfield viscometer tended to be lower at higher temperatures. All the pipeline measurements were undertaken at 50°C.

Generally the divergence of the individual flow curves for the different pipeline tubes (of differing L/D ratio) was not as pronounced as for the molasses samples containing gas. Nevertheless, the effects of pressure losses associated with the tube entrance and exit were still evident. In agreement with the observations on the final molasses samples containing 4.5% by volume of entrapped gas the flow index values tended to be slightly lower, on average, for the tubes of lower L/D ratio.

Effect of entrapped gas on molasses viscosity

The viscosity of a molasses sample (dry substance 78.9) containing 13.5% entrapped gas (by volume on gas-free molasses) was measured with the Brookfield RVT viscometer SC4-27/13R. These results are given in Figures 5 and 6 and are compared with results for molasses samples of similar solids

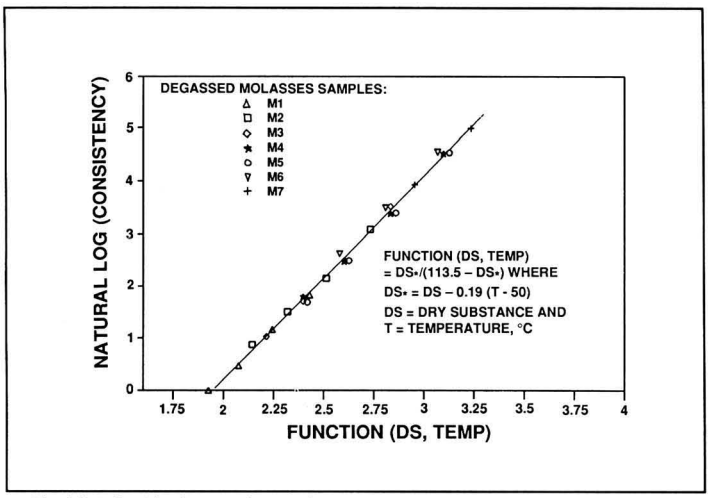


Fig. 4. Relationship of the consistency of degassed molasses samples to the dry substance and temperature function, according to Broadfoot & Steindl[12]

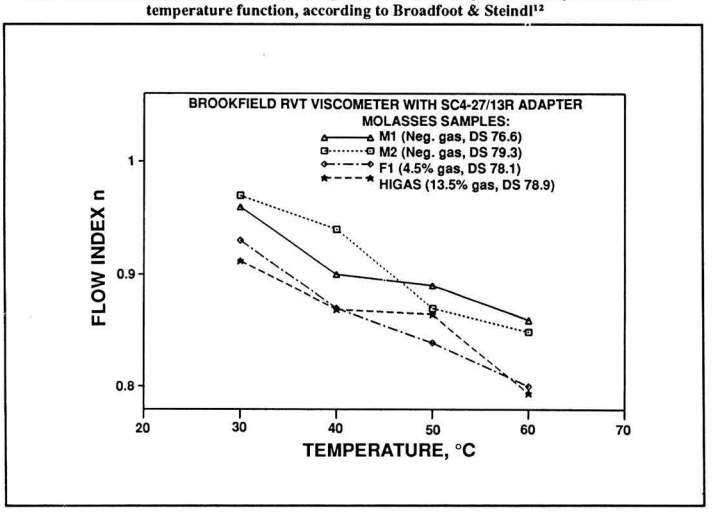


Fig. 5. Effect of gas content and temperature on the flow index of molasses samples

content, viz. degassed samples M1 and M2 and final molasses sample F1. The effect of the entrapped gas is to increase the pseudoplastic flow behaviour (lower value of n) and to increase the consistency. The results show the viscosity is about 40% greater for the molasses containing 13.5% gas compared with gas-free molasses of similar dry substance. This compares with a 25% increase predicted by the correlation given by Black & White[9].

Comparison of molasses viscosity measurements by the rotating cylinder and pipeline techniques

It was possible to compare the rheological properties, measured by both the rotating cylinder and pipeline viscometers, for six molasses samples of different dry solids levels (see Tables III and IV, samples F1, F2, M3, M5, M6 and M7). Although the measurements for the Brookfield viscometer were undertaken at a lower range of shear rate, for each comparison the data appeared to belong to a similar flow curve.

The differences between consistency values obtained with the rotating cylinder and pipeline viscometers were not statistically significant (at the 5% level), though some large individual differences were recorded. The closest agreement was obtained with the shortest tube (S1) which had a L/D ratio of 21.1.

The flow indexes determined by the pipeline and Brookfield techniques were also compared for the six molasses samples. The closest agreement was again obtained with the shortest tube (S1) with the differences obtained not being of statistical significance at the 5% level. By contrast, the other two tubes (S2 and S3) gave significantly and consistently higher values, with mean flow indexes approximately 0.05 units higher than those determined using the Brookfield viscometer.

For most practical applications of rheological data for molasses the pipeline technique is more appropriate to the application, e.g. for the design of pipe transfer systems, than the rotating cylinder method. The comparison of the data obtained for the two measuring systems indicates that the Brookfield rotating cylinder viscometer provides a good estimate of the pipeline flow behaviour though, as a general rule, the Brookfield viscometer tends to overestimate K and underestimate n relative to the pipeline method. This is particularly so when pipelines of larger L/D ratio are used or when the pressure losses associated with the pipe ends are allowed for in the data analysis.

Nevertheless, for most rheological studies on molasses, the Brookfield-SSA viscometer is favoured over the pipeline method owing to the convenience and

continued on page 115

ICUMSA News

Editor: R. Pieck

Message from the President

As advised in the last issue. Mr. Bob McCowage has been appointed General Secretary for the remainder of the 20th Session following Dr. Whayman's resignation owing to ill-health. Together we have considered the matters raised in the two letters to the editor published last issue[1]. While we would encourage further discussion of the issues raised, we tender the following views as our first reaction to a few topics

Objective of ICUMSA

Although the objective of ICUMSA has not been raised specifically, we believe that a prerequisite for the proper consideration of any major issue is a clear definition of the organization's purpose. If the object is well defined, and accepted, then it can be used as a benchmark for the assessment of issues. If the objective is not clear, nor universally accepted, then the debate on issues is likely to be confused and result in conflict.

Four objectives of ICUMSA are, of course, stated in the Constitution. The most definitive is objective 4 :

"To agree upon and to publish international recommendations for uniform methods of sugar analysis".

While this would appear to be a simple statement, there is undeniably some difference of opinion as to the meaning and intent of the word "uniform". The Oxford Dictionary provides the following definition "not varying with time or place; conforming to the same standard or rule". However, to obtain clarification of intent, we need to turn to the origins of the Commission, its raison d'être if you like.

The Commission grew out of the recognised need for uniform methods of sampling and analysis to facilitate dealings between buyers and sellers of sugars. This was the major focus of the early work of the organization and significantly early successes were the agreements for the analysis of :

- sucrose by polarimetry
- water by oven drying
- ash by incineration with sulphuric acid, and
- invert sugar by the Herzfeld method.

In other words, single methods were agreed for the determination of particular constituents of importance to the trade in sugars. Indeed, had the focus not been on single agreed methods for particular criteria, then it is difficult to understand just what the Commission could have claimed to have achieved in respect of the requirements of those trading in sugars whose needs were supposedly being addressed.

Against that background, it is our firm belief that the main objective of ICUMSA is to agree upon and promote internationally the use of a specific method for a particular constituent or property which, at any time, or at any place, will have a high degree of integrity and will be directly comparable.

Single versus *Multiple methods*

If the major objective of the organization is agreed to be as stated above, then the answer to this question is obvious. ICUMSA must resolve the merits of competing methods of analysis for particular purposes and select one method as the Official method.

If the objective of the organization are not as stated, if it is believed that ICUMSA has no role in ensuring uniformity of analysis for trade or legislative or other purposes, then the Commission should become a method validating body and drop the word "uniform" from its title. In considering the above, it is suggested that thought be given to where the real values of an organization like ICUMSA lies.

Speed of response

It has been suggested that the time taken by ICUMSA to adopt Official methods is too long. Traditionally, the status of methods has only been reviewed at four-yearly plenary sessions and it can take from eight to twelve years for a method to attain Official status.

This criticism is accepted. The Constitution already allows for recommendation to be effected by letter ballot. This process can, and should, be activated for improving the speed of response in high priority areas.

We think that, in general, ICUMSA has been slow in achieving its goals. This probably has more to do with the will to get the job done rather than the bureaucratic mechanisms of the Commission. We are highly motivated to have all methods with international ramifications properly tested and published in booklet form during the 21st Session. We have produced for approval at Colorado Springs the method for measuring the pol of raw sugar, written up in ISO format and presented in sample booklet form. If this format is agreed to, then we will expect General Referees and their Associates to produce similar drafts for all the methods within their subjects as soon as possible. The Publications Committee will edit and publish these methods and offer them for sale.

Steering Committee

A case has been made to have a steering committee allocate working arising out of Recommendations approved at a Session. We agree that there is a significant task in defining the jobs to be done and the priorities to be imposed if scarce resources are to be properly utilized. It seems to us, however, that employing the steering committee to do this allocating, puts it into the hands of people who do not have responsibility for executing the work. We believe that Referees need to take a responsible view of how recommended work is to be achieved before putting up a recommendation. If this is done beforehand, the Session's approval becomes the first step in the execution process.

One of the main reasons for establishing General Refereeships in the recent re-organization of subjects was to provide each major area of products analysis with a manager who has a working knowledge of the end user's needs as well as being qualified scientifically to undertake the method testing and documentation.

1 *I.S.J.*, 1990, **92**, 31 - 32.

We do not rule a future role for a steering committee but we think that such a committee should solve extraordinary problems rather than becoming a part of the normal management process.

Murray Player
May 1990

HPLC, a possible alternative to pol analysis for factory and molasses?

By K. J. Schäffler

Single pol measurement is probably the most frequently used and familiar analytical method applied in the sugar industry. Pol measurements have been in use for well over 100 years and can be viewed as one of the first instrumental analytical methods available to the sugar technologist. Consequently, the importance of pol is well established (even entrenched) and well known to everybody from the grower in the field and the operator in the factory to the buyer or seller in the commercial market. This universal acceptance has led to pol being adopted as a synonym for sucrose. This assumption can give rise to much misunderstanding when comparisons are made with more recent instrumental techniques. This point will be discussed later in some detail. Pol has the following strengths and weaknesses:

Historical acceptance: Pol is employed for paying sugar farmers for their crop as well as for assessing the sugar factory's routine performance. Sales of raw sugar are also based on pol. A procedure with this sort of tradition is not going to be replaced overnight no matter how appealing the advantages of any new technique may be. Even if it can be shown that pol can produce gross inaccuracies, it is often very difficult to alter legislation governing contracts especially if certain parties stand to lose financially.

Precision: Pol is an extremely precise determination; for example, the inter-laboratory reproducibility has been shown to be about 0.05 units for a 98.5 VHP sugar[2]. This makes it an ideal procedure when buying and selling raw sugar.

Calibration: The polarimeter can be independently calibrated using highly accurate quartz control plates. Thus pol calibration is not influenced by the purity of sucrose standards.

Cost effectiveness: Pol analysis is relatively inexpensive, the only consumables being filter paper and lead acetate solution. This in turn makes it an ideal payment method for beet and cane juices. This is especially true if the factory throughput is high or if the laboratory has to deal with a large number of consignments from different growers.

Ease of operation: The procedure is extremely simple to perform and with modern digital polarimeters, relatively unskilled staff can produce repeatable results.

Simple sample preparation: A simple sample dilution, followed by clarification and filtration, is all that is required prior to measuring the pol of the sugar solution.

This last point leads on to one of the most serious drawbacks of the pol determination. The need to clarify the solution so that a clear filtrate is presented to the instrument leads to problems on at least two counts:

(i) Clarification can remove or modify some pol-positive compounds (especially fructose and amino-acids), leading to inaccuracies.

(ii) Clarification agents (e.g. lead acetate) are generally toxic and are coming increasingly under fire in today's pollution-conscious environment. The search for alternative non-toxic substitutes is complicated by the unknown effects of these salts on non-sucrose constituents.

These last two points indicate that, although pol is clearly extremely precise, it is not necessarily accurate and is readily influenced by optically active compounds in the mixture. This limitation is obviously linked to the purity of the products being analysed. Technologists have been aware of pol inaccuracies but convenience and simplicity have overridden these reservations until now. Increasing legislation, forcing the abandonment of traditional lead acetate clarification, is perhaps the impetus required for the adoption of high performance liquid chromatography (HPLC) techniques for juices, syrups and molasses products[3].

As alternative clarification agents are going to bias the current pol determination anyway, HPLC offers many advantages to the factory technologist:

Accuracy: Sugar samples subjected to HPLC are separated on an analytical column. Polysaccharides, oligosaccharides and monosaccharides are all separated from each other and from non-sugar constituents. This fractionation prior to quantitative measurement results in a far more accurate estimate of sucrose, especially in low purity products. Even in relatively high purity cane juice, detailed comparisons[4] have shown that polarimetry nearly always underestimates sucrose, the difference varying from one factory to another, from month to month and from season to season. These differences are even more significant in low purity products where the pol/sucrose ratio can vary from 0.8 to 1.05. HPLC would avoid these inaccuracies which not only affect payment to growers but also bias factory control data and produce anomalous results in the fermentation industry.

Precision: For factory juices and mol-

2 Mellet *et al.: Proc. S. African Sugar Tech. Assoc.*, 1982, 55.
3 *Proc. 19th Session ICUMSA*, 1986, 149 - 163.
4 Schäffler & Morel du Boil: *Sugar Tech. Rev.*, 1988, 11, 95 - 185.

asses samples the precision of HPLC is similar to pol'[5]. The repeatability of the technique can only improve with the fairly recent introduction of computer-controlled autosamplers, pumps and detectors.

Additional information: Because HPLC first separates components and then measures their concentration, it is capable of yielding more information than direct polarimetry. In cane products, sucrose, fructose and glucose can all be determined with adequate precision. Accurate determination of glucose and fructose is useful for estimating inversion in factory front-end juices. In addition, it is possible to obtain an estimate of the total trisaccharide present[5]. It is also possible to determine the betaine content of beet molasses[6]. Ethanol and glycerol can also be estimated, which is especially important for distilleries[7]. HPLC can also be used to measure low levels of ethanol in juices to determine delays between cane cutting and crushing[8].

Non-toxicity: HPLC of sugars on cation exchange columns is a non-toxic procedure as water is used as the mobile phase.

Automation: HPLC lends itself to automation. After sample weighing and dilution, a tiny quantity is filtered into a vial. Sample injection, separation and measurement are all carried out automatically. Large runs can be initiated and left to run unattended.

Trace sugars: With modern refractive index detectors, and especially with the new pulsed amperometric detector, sugar losses due to entrainment or spillage can easily be monitored.

At the 19th ICUMSA Session in Cannes, two different HPLC techniques were subjected to an inter-laboratory test in conjunction with a gas chromatographic (GC) method for the determination of sucrose in beet and cane molasses. The GC procedure became an official ICUMSA method, whilst the two HPLC methods produced very promising results (no significant difference between GC and HPLC results). Both HPLC procedures received tentative status[5]. During the current session, the main objective of Subject 9, HPLC, is the simultaneous determination of sucrose, glucose and fructose in cane molasses using a cation exchange HPLC procedure. Collaborators have been asked to analyse six cane molasses samples for sucrose, glucose and fructose by HPLC. The molasses samples are diluted to 1%, passes through a membrane filter and chromatographed.

A large number of associate referees agreed to participate. To date response has been most encouraging. Results have been received from Czechoslovakia, Japan, Hungary, France, South Africa, Italy, the United States and the United Kingdom. Once all the results have been received, the repeatability and reproducibility of the procedure will be tested statistically. An official ICUMSA HPLC procedure would be most useful, especially for trading of cane molasses. The method would also be useful for comparing the technical performance of individual sugar factories.

HPLC has a definite future in both the beet and cane sugar industries. The polarimeter will still be required for the analysis of raw or technical sugar where sample dilution prior to HPLC can lead to unacceptable scatter. The success of HPLC for routine analysis will depend on reducing running costs as well as training of laboratory staff. Effective utilization of the additional information will also be of key importance to HPLC's success.

5 *Proc. 19th Session ICUMSA*, 1986, 94 - 148.
6 Rajakyla & Paloposkim: *J. Chromat.*, 1983, **282**, 595 - 602.
7 Clarke: *Sugar y Azúcar*, 1985, **80**, (8), 21 - 25.
8 Lionnet & Pillay: *Proc. S. African Sugar Tech. Assoc.*, 1988, 9 - 11.

Rheological studies of massecuites and molasses

continued from page 112

speed of undertaking a measurement and the small volume of sample required. This is particularly important when studying pressure-filtered molasses samples. *(To be continued)*

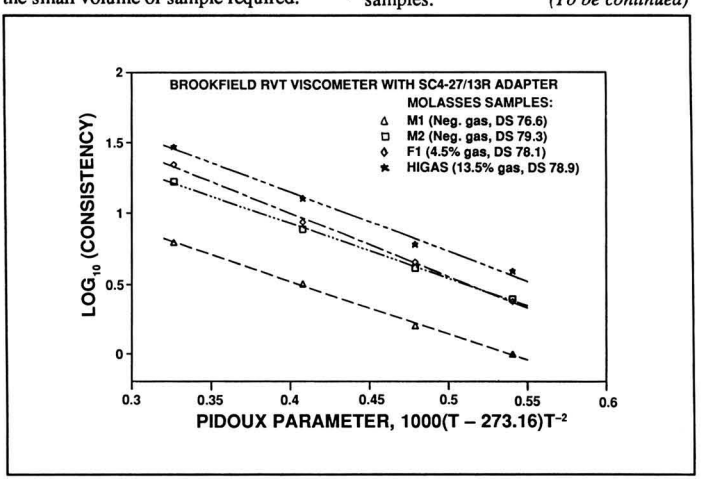


Fig. 6. Effect of gas content and temperature on the consistency of molasses samples

New Egyptian sugar refinery finance[1]

The Saudi Arabian Minister of finance has announced a loan to Egypt for the construction of a new sugar refinery. The size of the loan and location of the refinery were not disclosed.

1 *SPA (Saudi Arabia) news agency report*, March 14, 1990.

Sugar decolorization by ion-exchange resins with regenerant recovery

By Luis San Miguel Bento
(RAR Refinarias de Açúcar Reunidas S.A., Oporto, Portugal)

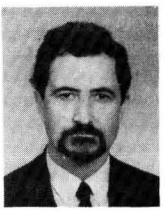
Introduction

The acidic nature of a great many sugar colorants[1] make anionic sorbents good sugar decolorizing tools. In the first application of ion exchange resins as sugar decolorizers their use was limited to polishing liquors after char or granular carbons. In the 1970's we saw an extension of the application of ion exchange resins as the main decolorizer in sugar refineries. This change was due mainly to the appearance on the market of new types of resins[2], *viz.* macro-reticular resins in the 1960's and acrylic resins in the 1970's. These resins can sustain higher colour loads and have a higher physical resistance than the earlier gel-type resins. Many technical papers have been presented referring to the advantages and disadvantages of the use of resins for sugar decolorization. One of the most pointed disadvantages is the waste disposal problem. In fact, during salt regeneration of resins, 6 to 9 m^3 of highly coloured effluent is produced per 100 tonnes of white sugar refined. The high salt concentration of this effluent makes it one of the most difficult to treat in the sugar industry[3,4].

Different methods to overcome this problem have been tested; these include decolorizing the effluent with granular carbon[5]; oxidizing the colorants with sodium or calcium hypochlorite[6,7], chlorine[6], or ozone[6,7]; separating the organic matter by ultra-filtration/reverse osmosis[6,8] or electro-dialysis[9]; salt crystallization[10]; using the salty effluent for beet pulp preservation, avoiding the growth of butyric and lactic bacteria[4,11]; and using powder resins on a once-through basis[12].

Since the first use of resins as the main sugar liquor decolorizer at RAR's Oporto refinery in 1975, we have been concerned with this waste disposal problem. To overcome this problem we have developed a regeneration process that reduces the quantity of coloured effluent and its salt content.

The experiments that were carried out on a laboratory scale and their results are the subject of this paper.



L. S. M. Bento

The regeneration effluent from a decolorizing resin

At RAR raw cane sugar of different origins are refined. The Oporto refinery has a capacity of 400 tonnes/day of standard white sugar and 50 tonnes/day of yellow areado sugar[13].

After carbonatation the liquor is decolorized by ion-exchange resins before concentration and crystallization. The filtered liquor is fed into two resin systems with two columns in series, each charged with 6 cubic metres of resin. A third system allows washing and resin regeneration without losing decolorization capacity. Each column, 2.2 m in diameter and 4 m high, is constructed in mild steel lined with butyl rubber. All columns are filled with the same type of resin, a macro-reticular polystyrene/divinyl benzene resin with quaternary ammonium groups (Amberlite IRA 900 C or Lewatit MP 500 A).

At the end of the resin's life the first column is emptied and refilled with new resin. The liquor feed is then changed to the second column and the new resin functions as a polishing resin.

The carbonatated liquor (65°Bx, 700 I.C.U. average) is fed down-flow through the columns at 2 bed volumes (BV) per hr at 70°C. Depending on liquor colour, the length of cycles varies from 40 to 60 BV.

After exhaustion, the resin is sweetened-off, back-washed and prepared for regeneration with salt. Before regeneration, part of the water is removed from the columns. The classical regeneration consists of 3 BV (one column) of 110 g/l sodium chloride solution, not made alkaline, at 2 BV/hr down-flow from the second to the first column. Every twenty cycles the resin is treated with hydrochloric acid/salt solution of pH 3, followed by a caustic soda regeneration (10°Bé).

To study the classical regeneration, salt effluent samples from the refinery column (System I/Cycle 1600 with IRA 900 C resin) were taken for analysis. The resin life was 122 cycles and the decolorization was 66% (413 I.C.U. in feed liquor). This was the 10th cycle after the special acid/alkaline regeneration.

Sodium chloride concentration in the different samples and colour, expressed as attenuation* at pH 9 and 420 nm, are presented in Figure 1. Attenuations were measured in a 1 cm cell with a Perkin-Elmer LC-55 spectrophotometer and pH with an Orion Research meter. Chloride content was determined by the Mohr titration method. From these curves we may see that a large part of the coloured compounds was desorbed from the resins even at a low salt concentration. (10% of salt removes more than 50% of colorants from the resin).

Another test was carried out which consisted of adding calcium hydroxide (5% v/v of a 100 g/l slurry) to the effluent samples, with agitation at 60°C. In these experiments we observe that the last part of the effluent had compounds which react with calcium to form a bulky precipitate. However, the

Paper presented to Sugar Industry Technologists, 1989.

* Attenuation = (Absorbance × 1000)/Cell length, cm

1 Chou & Rizzuto: *Proc. Tech. Session Cane Sugar Refining Research*, 1972, 8 - 20.
2 Fries & Walker: *ibid.*, 1980, 171 - 181.
3 Glabsky: *Gaz. Cukr.*, 1986, **94,** 45 - 46; *I.S.J.*, 1987, **89,** 50A.
4 Wolski: *ibid.*, 1984, **92,** 247 - 249; *S.I.A.*, 1985, **47,** (4), 144.
5 Delanay *et al.*: *Proc. Sugar Industry Tech.*, 1978, 67 - 87.
6 Cox: *Proc. Tech. Session Cane Sugar Refining Research.*, 1980, 212 - 221.
7 Fries & Walker: *Proc. Sugar Industry Tech.*, 1982, 1 - 13.
8 Kishihara: *Maku*, 1986, **11,** 159 - 167; *S.I.A.*, 1987, **49,** (4), 121.
9 Stepanishcheva *et al.*: *Teor. Prak. Sorb. Prot.*, 1983, **16,** 92 - 95; *S.I.A.*, 1985, **47,** (4), 134.
10 Solovets: *Sakhar. Prom.*, 1985, (7), 20 - 22; *S.I.A.*, 1984, **87,** 40A.
11 Januszewicz: *Gaz. Cukr.*, 1982, **90,** 52 - 53; *I.S.J.*, 1983, **85,** 220.
12 Kunin & Tavares: *Proc. Tech. Session Cane Sugar Refining Research.*, 1980, 163 - 170.
13 Bento: *Proc. Sugar Industry Tech.*, 1983, 222 - 241.

ISJ Abstracts

Cane sugar manufacture

First experiences with bagasse-fired automatic step grate boiler

T. M. Scheutzlich and H. C. C. Bourzutschky. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 267 - 282.

A cane separation project was started in Jamaica in 1985. In order to make the process plant commercially viable, as much as possible of the material from the stalks had to be converted into marketable products, of which charcoal made from the extracted pith and separated rind was a prime example. However, the fuel consumption had to be as low as possible so as to provide enough raw material, and a fire-tube boiler having a 5-stage step grate furnace with automatic feeding and ash removal was installed which was capable of burning pith at a high efficiency. The fuel, at about 50% moisture content, is pre-dried in the boiler with recycled flue gas in specially designed drying arches. Details are given of the boiler which, during 9 months, operated at an efficiency generally higher than 82%.

Computer-based analysis of evaporator performance

W. A. Mellowes and S. Thomas. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 287 - 303.

A computer-based simulation of evaporation was compared with the results obtained by other authors and an equation developed which defines the relationship between the temperature of the input steam and the heat transfer coefficient in the 1st effect. Modification of the Dessin equation for calculation of the evaporation coefficient gave exit Brix and steam consumption figures that were closer to true values as against much higher values given by the original Dessin equation.

Computer Aided Production. I. Pan floor material balance and management. II. Manufacturing and laboratory reports generation

R. E. O'Neal, J. S. Abdul and E. B. Ramkissoom. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 304 - 325.

The Computer Aided Production (CAP) system is an aid to simulation and optimization aimed at an achievable sugar yield per tonne of cane for a given quantity and quality of syrup Brix in an allocated time period, for which the sugar content is separated into various streams. Use of the system to draw up a cane mill and pan station material balance and a factory pol balance as well as generate laboratory reports is described.

The telecommunications network of Azúcar S.A. de C.V., Mexico

I. Rodriguez. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 326 - 339.

Azúcar S.A. de C.V. is the organization which controls sugar production and marketing in Mexico. Details are given of the telecommunications network set up for data transmission within the industry.

Expansion of a 1250 tcd standard plant to 2500 tcd with economy and efficiency

A. P. Chinnaswamy, K. Theerthamalai and S. Viswanathan. *Indian Sugar*, 1989, **39**, 371 - 401.

Whereas 1250 tcd was considered the commercially optimum size for a sugar factory in 1973 (when the Indian authorities published standard specifications for such a crushing capacity), in 1987 the optimum was 2500 tcd and the government released new specifications. Various aspects of expansion to the new crushing rate are discussed, including steam generation requirements, new equipment needed and its layout, and economic factors.

A practical report on a sieve plate scrubber for a bagasse boiler in sugar factories

C. J. Chang and J. T. Lee. *Taiwan Sugar*, 1989, **36**, (5), 9 - 11.

In pilot plant tests, trials of two full-scale double sieve plate scrubbers and normal operation of 15 sets of the scrubbers at seven factories during an entire period of 3 years, an efficiency greater than 99% was achieved in the treatment of bagasse boiler flue gas, with a reduction in dust load from 6000 to an eventual maximum of 150 mg/m^3; pressure drop across the unit was <130 mm w.g. A further 15 sets have been built at another seven factories, and it is expected that the dust loads will be reduced to 70 mg/m^3 to comply with official regulations for 1993. Details are given of the scrubber and its performance.

Evaluation of polyacrylamide for the sugar industry

C. S. Ting and Y. C. Hsiao. *Taiwan Sugar*, 1989, **36**, (5), 24 - 27.

See *I.S.J.*, 1989, **91**, 116A.

Prospects of applying magnetic treatment to aqueous solutions to combat scale formation in sugar factory heat exchangers. I. Theoretical fundamentals

R. Dunand C. *ATAC*, 1986, **45**, (5), 14 - 20 *(Spanish)*.

The literature on the principles of juice treatment in a magnetic field to prevent scale formation in juice heaters and evaporators is reviewed (24 references). It is shown that there are a number of theories put forward to explain the effect of the treatment on the properties of Ca salt-saturated juice and on the structure of the complex formed between Ca and water when the water is subjected to electrical dissociation.

Analysis of process behaviour from information on the distribution of samples of its main variables. Its application to raw sugar manufacture

T. Díaz B. and O. Torriente C. *ATAC*, 1986, **45**, (5), 35 - 39 *(Spanish)*.

The application of frequency distribution and histogram plotting to analysis of

process behaviour is discussed with *A*-massecuite boiling used as an example.

Economic aspects on the ICINAZ bagasse dryer

M. Salermo and O. Santana. *ATAC*, 1986, **45**, (5), 44 - 49 *(Spanish)*.

The ICINAZ bagasse dryer uses flue gas to reduce the moisture content to below 35% at a rate of 8 tonnes/hr in a pneumatic conveyor system, the gas and bagasse being separated in a cyclone from which the bagasse is conveyed to the furnace. An analysis of the costs shows a pay-back period of 0.37 seasons, with the added advantage that the equipment does not have to be imported.

International handling and transportation of sugar

E. Blanco D. *ATAC*, 1986, **45**, (5), 50 - 54 *(Spanish)*.

The advantages and disadvantages of bulk handling and transport of raw and refined sugar are discussed and handling and storage installations in various countries mentioned.

S.A. Coruripe Açúcar e Alcool

Anon. *STAB*, **5**, (2), 4 - 6, 8 - 10 *(Portuguese)*.

A detailed account is given of the title enterprise with information on the edaphoclimatic conditions, varieties, soil preparation, fertilizers, biological control of pests, harvesting, loading and transport of the 1,500,000 tonnes of cane processed per season, as well as the sugar factory and distillery equipment and processes employed. Some two-thirds of the cane crushed in the 1985/86 season was for the production of both white and raw sugar as well as high-test molasses, and the balance for the production of anhydrous alcohol.

Problems with decantation × varieties

A. R. P. de Andrade. *STAB*, **5**, (2), 38, 40 - 42 *(Portuguese)*.

At Usina São José juice is clarified by a sulphitation method if intended for sugar manufacture and by a simpler lime-heating method if it is to go to the distillery, both processes being followed by settling in conventional decanters. In July-September, over a period of years, problems had arisen with turbidity in the sulphitation juices and turbid juices were sent to the distillery. The problem was found to be associated with milling of high proportions of two particular varieties – SP 70-1143 and IAC 48-65 – and measures were taken to reduce them to a maxiumum of 10%. In addition, to provide the longer time needed for settling, additional clarifier capacity was installed, as well as DSM screens to remove bagacillo from the juice. A program of research has been drawn up, concerned with screen perforations, filter cloths, syrup filtration and centrifugation, different types of clarifier, laboratory control and use of rotary screens, with the object of improving sugar quality.

Bagasse drying technology

M. A. Boizán J., G. A. R. Alarcón. and J. A. Tabío R. *Centro Azúcar*, 1986, **13**, (4), 3 - 8 *(Spanish)*.

Various systems for bagasse drying with boiler flue gas are described, including a rotary dryer, a pneumatic scheme and a vertical column with central deflector plates in which free-falling bagasse particles come into contact with the gas stream.

The current situation regarding bagasse drying

M. A. Boizán, G. A. R. Alarcón and A. Fernández P. *Centro Azúcar*, 1986, **13**, (4), 9 - 14 *(Spanish)*.

The literature on bagasse drying is reviewed (with 42 references).

Effect of Tensol surfactant on boiling at Jesus Suárez Gayol sugar factory

R. García L., J. A. Bordón, J. A. León J. and R. Almanza. *Centro Azúcar*, 1986, **13**, (4), 15 - 19 *(Spanish)*.

Addition of Tensol surfactant at 50, 150 and 250 ppm to low-grade massecuite brought about a number of improvements, including an increase in the crystallization rate, crystal yield, Brix, pol and purity and reduction in sugar colour and reducing sugars content as well as molasses purity; however, the ash content of the sugar increased.

Assessment of juice clarification at Central Brasil with simple and combined liming

J. Artíles S., E. González E. and I. Mena G. *Centro Azúcar*, 1986, **13**, (4), 23 - 26 *(Spanish)*.

Replacement of some of the Ca hydroxide used in clarification with Na carbonate gave a higher settling rate and a smaller quantity of mud which was more compact than in conventional clarification, while there was a greater fall in the Ca and Mg content from raw to clear juice and the phosphate content in the clear juice was lower than with the conventional process.

Study of granulometric factors in raw sugar production using a surfactant

M. L. de la Cruz A., A. B. Sarmientos E., J. A. Bordón C. and L. Carrazana R. *Centro Azúcar*, 1986, **13**, (4), 27 - 33 *(Spanish)*.

Comparative tests were conducted on Pan-Aid (at 100, 150 and 200 ppm) and Tensol (at 100, 150, 200 and 250 ppm) as massecuite additives. Results were similar, namely higher massecuite purity and lower *A*-molasses purity, increase in crystal yield but also in colour (which was greater with Tensol than with Pan-Aid) and reduced crystal elongation. Tensol caused increased crystal size distribution but failed to increase the crystallization rate except at 250 ppm, and then only slightly.

Electronic control of imbibition

water flow in mill tandems

H. del Castillo S. *Centro Azúcar*, 1986, **13**, (4), 34 - 40 *(Spanish)*.

The system described is based on comparison of a signal proportional to the fibre:water ratio with a reference value based on the price ratio between sugar and fuel. The signal generated by the difference is employed indirectly to control the amount of imbibition water.

System of measurement and control of mill tandem operation by microprocessor

G. J. G. Ortega and R. V. Rodríguez. *Centro Azúcar*, 1986, **13**, (4), 41 - 48 *(Spanish)*.

A microprocessor system is described which measures the crushing rate every minute and transmits a signal for control of the cane elevator speed and hence cane feed to the mill.

Study of a mill in a tandem with the aim of automation

R. Ballesteros R. and A. González S. *Centro Azúcar*, 1986, **13**, (4), 49 - 52 *(Spanish)*.

Optimum values of mill settings, pressure and speed were determined for a given crushing rate with the aim of automatic control. Analysis of variation in extraction with the depth of the cane mat at the entrance to the mill with and without the optimum values shows that mill speed has greatest effect on the height of the cane mat and hence is the one factor that needs to be automatically controlled to accord with the cane mat at any given moment.

Introduction of physical modelling in evaporation equipment in the sugar industry

A. Fonte, R. González E. and E. Martínez. *Centro Azúcar*, 1986, **13**, (4), 53 - 56 *(Spanish)*.

A mathematical model was developed for evaporation based on operational and technological data obtained from various sources, including three sugar factories. The basic parameters of an evaporator design based on the calculations are presented.

Evaluation of a filtered juice clarifier by settling

G. M. Peña, J. G. Ortíz, E. M. Rodríguez and J. P. Avila. *Centro Azúcar*, 1986, **13**, (4), 63 - 66 *(Spanish)*.

Tests on the use of Magnafloc as flocculant at 7 - 8 ppm in a newly designed clarifier showed that colour rose and Brix, pol and purity fell, although the insolubles content was reduced. The poor results were blamed on the high temperature of the juice (90 - 95°C) and on its low pH. The clarifier is considered unsuitable for the task of providing a juice of sufficient quality for evaporation.

Comparative study on liming agents in the clarification of model juices

E. González G., N. V. Aguilar, E. Valdes B., N. S. Olazábal and W. Burgos G. *Centro Azúcar*, 1986, **13**, (4), 67 - 70 *(Spanish)*.

The effects of lime, NaOH and a lime-sodium carbonate mixture on clarification of model juices were determined. pH of the clarification aids was an important factor, and settling rate increased and mud volume decreased with fall in the value. Best results were given by lime and poorest results by NaOH, although the difference between the performances of NaOH and the lime-Na carbonate narrowed with time. The Ca concentration in the clear juice fell significantly when NaOH and the lime-Na carbonate mixture were used, while the Na and K contents did not alter substantially during the process.

Physico-chemical behaviour of different flocculants in cane juices with and without treatment

S. Morales M. and R. F. García. *Centro Azúcar*, 1986, **13**, (4), 71 - 77 *(Spanish)*.

The performances of four flocculants (referred to as A, B, C and D in tabulated data) in clarification are discussed.

Study of flow patterns in an industrial clarifier

C. Díaz R., T. D. Alemu and R. Santana M. *Centro Azúcar*, 1986, **13**, (4), 85 - 92 *(Spanish)*.

NaCl was used as tracer in a study of flow characteristics in a clarifier. The results obtained are analysed.

Effect of moisture on storage stability of plantation white sugar

F. A. S. de Mancilha and R. F. Grosso. *Bol. Técn. Copersucar*, 1987, (Special Edn.), 3 - 15 *(Portuguese)*.

Studies were made of the storage and stability of white sugar of 99.8 pol under laboratory and commercial conditions. When a small quantity of moist sugar (0.1 to 0.5% water) was stored in the presence of a large quantity of dry sugar, the former was dried before any inversion took place and the only noticeable effect was the caking of the formerly moist sugar. The stability of the sugar depends on its water activity or equilibrium relative humidity and not on its moisture content. Below 40% RH no liquid film forms on the crystals and no inversion takes place so no further moisture adsorption takes place. Most of the plantation white sugar in São Paulo state is produced at below 40% RH and is stable for long periods if stored under sealed conditions; hermetic conditions are necessary because ambient RH can exceed 60% for long periods. Even with sealing, there may be moderate caking of the stored sugar, however, where steep temperature gradients occur. Under partially hermetic storage conditions, the rate of increase in moisture content of the sugar is directly proportional to the outside RH and to the rate of air exchange with the outside, and inversely proportional to the amount of sugar in storage. In large piles of initially dry sugar, the effect of high atmospheric RH is first seen as a slight

increase of moisture content at the surface and inversion of some of the dissolved sucrose. The invert sugar absorbs moisture at a lower RH than almost pure sugar and so the layer intercepts diffusing water vapour and thus protects the bulk of the sugar. This phenomenon is frequently seen in storage facilities at sugar factories where dry sugar may be stored close to highly inverted moist sugar; the latter acts as a desiccant and protects the dry sugar from moisture influence. The rates of increase of invert sugar and moisture content were four times greater for sugar with an initial pH of 6.5 than that of pH 7.3, which might explain why sugar from different origins deteriorate at different rates. For better stability the sugar should be produced at pH 7.3 or slightly higher.

Fundamentals of methods for eliminating high molecular weight compounds

M. de los A. García, I. F. Bugaenko and J. R. Pérez R. *CubaAzúcar*, 1986 (Oct./Dec.), 7 - 12 *(Spanish)*.

A study is reported on the effectiveness of liming + phosphatation, carbonatation and powdered active carbon in regard to removal of high MW compounds from a 15% sugar solution to which had been added the impurities precipitated from molasses. Results showed carbonatation to be the best method, although a combination of methods is recommended.

Continuous boiling and its effect on the energy economy

R. C. del Rey, D. U. Leal S. and R. Rodríguez N. *CubaAzúcar*, 1986 (Oct./Dec.), 13 - 17 *(Spanish)*.

The basic advantages of continuous boiling are described, particularly the beneficial effect on factory energy consumption; comparison with batch boiling indicates both a fall in steam consumption and the possibility of increasing electricity generation while allowing a surplus of bagasse for other uses.

Component phases and organic substances in scale

R. González Q., N. Vega S. and C. R. González. *CubaAzúcar*, 1986 (Oct./Dec.), 36 - 41 *(Spanish)*.

Results are given of a physico-chemical analysis of scale and its formation in the first and final effects of a quintuple-effect evaporator. The predominant crystalline and amorphous phases and their relationship to the scale formation process are indicated as well as the presence of polymer-type organic matter.

Characterization of corrosive wear in the presence of cane juice

T. Ll. Ortega, R. M. González, E. A. Acosta and J. F. Queral. *ATAC*, 1986, **45**, (6), 22 - 26 *(Spanish)*.

A study showed that the rate of cane mill erosion and corrosion was a function of the content of solid particles (mainly bagacillo) in the juice and depended mainly on the flow rate of the juice in contact with metal surfaces.

A rapid method for determining insulation thicknesses

G. González, R. Monduí and C. Vázquez. *ATAC*, 1986, **45**, (6), 27 - 33 *(Spanish)*.

A method and nomogram are presented for calculation of the thickness of insulation necessary for vertical and horizontal steam pipes.

Evaluation of an anti-scale agent

R. Rodríguez, E. León and X. Aguilar. *ATAC*, 1986, **45**, (6), 34 - 40 *(Spanish)*.

The effectiveness of a Cuban polyphosphate anti-scale agent was demonstrated in evaporator tests, results of which are discussed.

Introduction into factory practice of a ICINAZ pneumatic dryer of 20 tonnes/hr

A. Arrascaeta, P. Friedman, B. Aguila and H. Alvarez. *ATAC*, 1986, **45**, (6), 41- 44 *(Spanish)*.

A bagasse dryer operating on boiler flue gas reduced the moisture content from 48 to 21% at an average throughput of 22 tonnes/ha (maximum of 31 tonnes/hr) at a power consumption of 6.4 kWh per tonne of bagasse processed or 18.6 kWh per tonne of water evaporated, thus permitting the factory in question to save enough bagasse (10,400 tonnes in a season of 150 days) to make it self-sufficient rather than bring in supplies from neighbouring factories as before.

Prospects of utilizing magnetic treatment of aqueous solutions to combat scale formation in sugar factory heat exchangers. II. Practical use of magnetic treatment

R. D. Castellanos and V. A. Karpenko. *ATAC*, 1986, **45**, (6), 45 - 56 *(Spanish)*.

A review is presented of the literature on magnetic treatment of juice as a means of preventing scale formation and thus increasing heat transfer and reducing stoppages for cleaning. Diagrams and schemes of various systems are presented.

Calculation of hydraulic resistance coefficients in baffled pipes

T. Prieto F. and A. Márquez S. *Centro Azúcar*, 1987, **14**, (1), 16 - 20 *(Spanish)*.

A method for calculating flow resistance in baffled pipes is described which permits determination of the optimum number of baffles. The method is considered particularly applicable to the design of hot liming systems.

Preliminary studies on the surface active mechanism of a new chemical additive in the sugar industry

N. Martínez A., P. Fabregat P. and M. Martínez C. *Centro Azúcar*, 1987, **14**, (1), 21 - 25 *(Spanish)*.

Clarification tests are reported in which spraying of filtered juice on the surface of the untreated mixed juice increased the settling rate and clear juice quality. The added juice acted as a surfactant.

Beet sugar manufacture

Monitoring production on the basis of the calcium and magnesium ion contents in solutions

L. D. Pis'mennyi and P. F. Ol'khovich. *Sakhar. Svekla*, 1989, (6), 43 - 45 *(Russian)*.

Since excessive Ca and Mg in beet juices and factory waters can have adverse effects on processing, including foam formation and scaling, their determination as well as analysis of water and factory products for total hardness and of scale for carbonates may be used to monitor the situation throughout the factory. Beet leaf trash and soil provide considerable quantities of Ca and Mg which may enter the diffusion water, while untreated boiler feedwater will also cause problems. Replacement of water with filtrate to sweeten-off disc filters was found at one factory to reduce the amount of Ca and Mg and other salts entering subsequent process stations. Ammonia in condensate contributes to a much greater salting-out of Ca and Mg salts than takes place in distilled water and should be removed.

Some problems with efficient heat usage

A. P. Ponomarenko. *Sakhar. Svekla*, 1989, (6), 47 - 50 *(Russian)*.

While reductions in fuel consumption in Soviet sugar factories in the 15 years up to 1982 were obtained mainly as a result of installing high-performance boilers, converting to more efficient forms of fuel, cutting the campaign time and reducing raw juice draft, efforts to reduce the specific heat consumption in processing have met with some difficulties; a number of these problems are analysed in some detail on the basis of investigations conducted at various sugar factories.

Condensate from secondary steam - a sugar extractant

N. A. Gusyatinskaya, V. M. Taran, A. A. Lipets and Yu. B. Navreotskii. *Sakhar. Svekla*, 1989, (6), 53 *(Russian)*.

Experiments are reported on stripping of ammonia from condensate for use in diffusion by passage down a plate column against an ascending air stream. Best results (a reduction from 210 - 230 to 50 - 60 mg/litre) were obtained at a liquid load of 1.7 - 2.8 kg/sec and an air flow rate of 0.45 - 0.70 m/sec. Steam fed in the lower section of the column reduced the fall in temperature of the condensate (which was discharged at 55 - 60°C) and increased ammonia separation.

Determination of the density of sugar syrups

A. A. Gotsun, V. I. Strel'nikov, A. A. Slavyanskii and S. S. Chervyakov. *Sakhar. Svekla*, 1989, (6), 54 - 55 *(Russian)*.

A description is given of a Brix measuring system involving a differential manometer and deceleration tube used to monitor thick juice leaving an evaporator.

An economically justified pipeline diameter and thermal insulation thickness

P. Slugocki. *Gaz. Cukr.*, 1989, **97**, 145 - 147 *(Polish)*.

A universal method for calculating optimum inside diameters of sugar factory pipelines and thickness of insulation cladding at which performance is unimpaired and costs are minimal is explained. The value of a computer to solve the various equations and demonstrate the effects of changes in parameters in the form of numerical data or graphs is indicated.

The mechanism and requirements of waste water fermentation

B. Polec. *Gaz. Cukr.*, 1989, **97**, 155 - 159 *(Polish)*.

The biochemical reactions that take place in anaerobic treatment of waste water are explained and information given on the genera and species of micro-organisms used and their functions. The effects of pH, temperature, redox potential and other factors on treatment are discussed including the inhibitory action of N and S salts and compounds. 52 references are given to the literature.

The kinetics of waste water treatment by methane fermentation

B. Polec. *Gaz. Cukr.*, 1989, **97**, 159 - 163 *(Polish)*.

Steps in the calculation of the major kinetic factors involved in anaerobic treatment of waste water are set out, including equations relating to the rates of impurity removal and COD and BOD_5 reduction, biomass accumulation and biogas generation. The literature on the subject is also summarized.

Modification of a thin juice demineralization process to save chemicals and solve the effluent problem

F. Perschak. *Zuckerind.*, 1989, **114**, 971 - 975 *(German)*.

In tests on modification of the ion exchange demineralization process used for thin juice at Hohenau, the juice was passed in the first stage through a weakly acid cation exchange resin in H^+ form without prior softening by neutral ion exchange and was then treated with strongly acidic cation exchanger in H^+ form; subsequent treatment with a weakly basic anion exchange resin was also abolished. The cation exchanger in the modified 1st stage treatment was regenerated with all of the spent sulphuric acid (diluted to 0.7%) from the 2nd stage strongly acidic cation exchanger, thus removing all of the sulphate and reducing the consumption of sulphuric acid and NaCl as well as the amount of effluent. Adoption of the modified scheme led to 40% decolorization of the entire thin juice (although only 45% of the total amount is demineralized) and permitted two white sugar strikes to be boiled in succession. Sugar losses through inversion are about 20% lower because of the shorter time of contact

with the strongly acid resin. Treatment of the 2nd stage resin with ammonia before every 2nd regeneration (to desorb nitrogenous compounds such as amino-acids, peptides and betaine) has reduced the COD as a result of the smaller amount of organic matter in the sulphuric acid fraction used to regenerate the 1st stage resin; however, the overall effect is diminished by the fact that all the sulphuric acid fractions are used for regeneration.

Reducing losses of sugar

V. S. Shterman, E. V. Ivchenko, A. G. Sapronov, G. A. Vovk and M. S. Zhigalov. *Pishch. Prom.*, 1989, (9), 44 - 45; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (2), Abs. 2 R1452.

The effect on the diffusion process of Ca bisulphite prepared in the factory by sulphitation of diluted milk-of-lime with gaseous or liquid SO_2 was investigated. Two-stage sweetening-off of filter cake reduced the sugar losses by 50 - 60% by comparison with the conventional one-stage sweetening-off scheme.

Theoretical bases and practical experience in projection and design of modern evaporators in the sugar industry

P. Hoffman. *Listy Cukr.*, 1989, **105**, 269 - 286 *(Czech)*.

The advantages and disadvantages of Robert and of falling-film evaporators are discussed and comparison made between average heat transfer and temperature conditions in a quadruple-effect station of both types, demonstrating the superiority of the film evaporator in all but the 1st effect; the best arrangement is considered to be a quintuple-effect evaporator in which the first two effects are Robert type and the last three are falling-film units. The values for the Robert type, obtained from a number of factories during 1980/88, were lower than results outside Czechoslovakia because of poor quality juice, a juice level below optimum and inadequate incondensable gas withdrawal; these aspects are discussed. Tests on falling-film evaporators are reported and the results obtained are compared with those of other authors; a number of recommendations are made on suitable evaporator arrangement and on tube construction from stainless steel. The question of entrainment separation is also discussed. A computer program is presented for calculation of the parameters of an evaporator (with or without pre-evaporator and with or without 1st or 2nd effect vapour compression) of given heat surface area or for given temperature conditions.

Continuous boiling control with the evapo-crystallization tower as example

K. E. Austmeyer, D. Schliephake, R. Hempelmann and T. Frankenfeld. *Zuckerind.*, 1990, **115**, 15 - 18 *(German)*.

Experiences with the evapo-crystallization tower (ECT), in which Brix is maintained at a required level by syrup drinks and the throughput is adjusted by means of steam pressure, showed that a process refractometer gave measurements of mother liquor Brix that were adequate for determination of supersaturation, but regular rinsing was needed to prevent incrustation, while determination of supersaturation on the basis of boiling point elevation calls for a very high measuring accuracy. The possibility of process control on the basis of a compiled mass, material and heat balance compiled at regular intervals was investigated and tested with a process refractometer. A mathematical process was developed which allowed simulation of steady-state conditions for prediction of process variables. Correlation was established between crystal growth rate and supersaturation for balanced operational conditions from which iterative calculation of the supersaturation was possible; satisfactory agreement between calculated and true values was obtained from which it was concluded that direct measurement was possible in at least one chamber with only slight deviations over a given period of time. Future possible trends in control of the process are discussed.

Purification of waste water in sugar factories - anaerobic and aerobic treatment and N elimination

C. Nähle. *Zuckerind.*, 1990, **115**, 27 - 32.

See *I.S.J.*, 1990, **92**, 43 - 48.

New Babbini Type PB pulp presses

Anon. *Zuckerind.*, 1990, **115**, 53 - 56.

Details are given of the Babbini Type PB high-performance, twin-screw pulp presses. Means of overcoming back-mixing and reduced forward feed (caused by rotation of the pulp with the spindle when the rotary speed exceeds the axial resultant as a consequence of change in the friction between spindle and outer perforated screen when e.g. pulp quality and spindle speed alter) and of preventing unstable conditions caused by increased friction between the perforated spindle and pulp are described. Over a number of campaigns at a West German factory, a PB 32 press gave an average pulp dry solids content of 34.7% at 2731 tonnes/day throughput by comparison with 34.2% at 1307 tonnes/day with an earlier P 24 press of different screw geometry.

Distribution of air volume and effect of direction of boundary flow in sugar beet ventilation

B. Senge, E. Manzke and P. V. Schmidt. *Lebensmittelind.*, 1990, **37**, (1), 32 - 37 *(German)*.

Investigations were conducted on forced ventilation of stored beet at four East German sugar factories to examine the distribution of air flow along the ventilation ducts and the effect of boundary flow (the direction of air flow in the boundary zone between the mouth of the duct and the beet). Results showed that the distribution of air volume was directly dependent on the ratio A of the geom-

etric surface area of the air current to the cross-section area of the duct; it was more uniform with a smaller ratio and in concrete than in steel ducting (a consequence of greater velocity load on the steel ducting and of associated conversion of dynamic to static pressure). However, a fairly uniform temperature distribution within the beet pile indicated that the distribution of air volume was of minor significance provided there was minimum pressure loss and maximum possible air flow through the pile. Surprisingly, at values of ratio A up to a critical level, the air flow velocity and total pressure were virtually unimpaired by the ratio between the volume of air leaving the duct and the amount of stored beet. Reasons for this are discussed.

Effect of sugar beet quality and qualitative parameters on sugar factory performance

B. Tichá. *Listy Cukr.*, 1990, **106**, 6 - 7 *(Czech)*.

The adverse effects on beet storage, processing and sugar yield and waste water BOD_5 of beet trash, mechanical injury and frost are discussed. Investigations over a number of years at two factories showed molasses losses and consumption of energy and process chemicals were higher and there was need for reboiling to maintain sugar quality where the beets had been topped too high (so that leaves and petioles remained) by comparison with beets topped at an optimum height. Beets in which more than 10% of the root dry matter is affected by frost are considered unsuitable for processing because of the secretion of polysaccharides, dextran and levan which caused filtration problems and because of the greater quantity of reducing sugars and non-sugars. The undesirability of high concentrations of Na and K salts and of nitrogenous compounds is discussed and the extent to which non-sugars are removed in the various processes examined. While beets of higher sugar content will attract greater payments to the farmer, they will also ensure that the factory is working at about its design capacity.

Plant for biological treatment of waste water at sugar factories. III. Model tests

L. Budicek, J. Rejsek, J. Tinl, M. Kubin, I. Navratilova, K. Hartig and Z. Hala. *Listy Cukr.*, 1990, **106**, 25 - 35 *(Czech)*.

Laboratory tests on the UASB process applied to waste water of 4220 mg/litre initial COD gave 75% mean COD reduction at 24 hr retention; these experiments were followed by trials of a packed column of 1 m^3 effective volume and 170 m^2 effective surface area in which the average COD was reduced by 88% from 3550 mg/litre at a mean hold-up time of 30.6 hr. Finally, in 1986 and 1987 a 2 m^3 stirred reactor was used in tests to determine optimum conditions for treatment of water of 3000 mg/litre average COD (found to be 37°C, pH 7 and a load of 0.7 kg COD/kg organic matter/day at which average COD reduction was 95%) and to study the instability of the process. It was found that increase in the organic load was accompanied by a fall in purification efficiency and increased generation of biogas which, however, underwent changes in composition, but there was no evidence of change in pH or in the activated sludge properties. A short period of overloading of the reactor did not impair methanization, although prolonged operation at high organic load could cause a major fall in efficiency and pH with changes in gas composition and mud properties.

Raising the efficiency of heat treatment of beet cossettes

L. A. Verkhola, V. G. Yarmalko and L. M. Osadchii. *Puti Intensif. Protsessov Sveklosakh. Proizv.*, 1989, 7 - 14; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1443.

Examination of the basic parameters of heat exchange in diffusers showed that the most intense scalding of cossettes was attained in those models where raw juice was sprayed over a bed of them and that the heat exchange efficiency rose with the number of spraying stages. Results of factory-scale trials of an experimental model of a single-stage belt scalder having a daily capacity of 3000 tonnes of beet indicated high heat exchange efficiency. A decrease in the heating time caused a considerable reduction in unknown sugar losses in diffusion and improved the technological parameters of the unit.

Intensification of preliming

L. I. Pankin, V. F. Shutka, V. M. Leshchenko, A. S. Belinskii, A. R. Sapronov and A. M. Gavrilov. *Puti Intensif. Protsessov Sveklosakh. Proizv.*, 1989, 44 - 52; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1448.

Examination of methods of intensifying preliming demonstrtated the unsuitability of raising the temperature. A method of counter-current preliming using a supplementary circulation circuit is proposed; the results are given of comparative tests in which the conventional preliming process was carried out in a horizontal counter-current unit. The advantage of the experimental process was especially apparent with reduced 1st carbonatation juice recycling.

A refinement of the massecuite boiling process using porous elements

V. O. Shtangeev, I. M. Grinchuk and V. D. Novoseletskii. *Puti Intensif. Protsessov Sveklosakh. Proizv.*, 1989, 166 - 171; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1463.

A method is presented for intensifying massecuite crystallization in batch vacuum pans using devices with porous metalloceramic elements to blow steam into the circulating massecuite. An analysis of their performance has shown that they increase the mean bulk steam content in the massecuite and intensify natural circulation. Results are presented of factory-scale trials with batch pans equipped with the porous elements.

Sugar refining

Another regeneration method for anion exchange resin

M. V. Rozhkova, G. A. Chikin, V. I. Tyagunova and V. A. Kashirskii. *Sakhar. Svekla*, 1989, (5), 55 - 57 *(Russian)*.

An improved method for regeneration of AV-17-2P anion exchange resin as used for refinery liquor decolorization is described. Contact is maintained for a day between 1 volume of spent resin and 2 volumes of 18% NaCl + 0.36% NaOH preheated to 50°C, while once a season it is recommended to treat the resin with 1 mol/litre HCl preheated to 50°C at a ratio of 7 volumes acid to 1 volume resin followed by reactivation with 0.05% NaOH solution at 1.5 volumes to 1 volume of resin. The HCl was found in tests to desorb Fe^{+++} to a far greater extent than the NaCl-NaOH mixture but was less effective in colorant desorption.

Moisture problems in the shipment of refined sugar in containers

T. L. Excell and V. C. Stone. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 68 - 72.

See *I.S.J.*, 1990, **92**, 34A.

The effect of sugar temperature on the operating performance of a conditioning silo

R. R. Ramphal. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 64 - 67.

The intention to cool refined sugar before prepacking at Hulett Refineries Ltd. prompted an investigation into the effect that sugar cooled to 32°C would have on the performance of the conditioning silo. Two pilot conditioning silos were arranged in parallel and assembled so that the conditioning air and silo temperature could be changed and accurately maintained. During each of a number of batch tests, the sugar and conditioning air temperatures and moisture profiles were monitored and the conditioning times determined for various combinations of sugar and air temperatures. Results showed that, for sugar and air of the same temperature, conditioning time was extended by 25%, whereas conditioning cooled sugar at a higher air temperature caused caking within the silo. It was concluded that both sugar and air conditioning temperatures of at least 40°C were needed to achieve an optimum conditioning time of 72 hr. Caking can be prevented by avoiding large temperature differences between sugar and conditioning air.

Choice of an optimum scheme for white sugar production from raw sugar by means of ion exchange decolorization. II

M. Delgado, P. Anzardo and N. López. *ATAC*, 1986, **45**, (5), 21 - 25 *(Spanish)*.

Simple and double defecosulphitation and simple carbonatation, all of them followed by decolorization with basic anion exchange resin in Cl^- form, were used to treat 97.8 pol raw sugar of low colour content as an aqueous remelt. While simple defecosulphitation + decolorization gave only 92% decolorization as against 95% with the other two systems, it was the easiest to use and, like the others, would allow replacement of active carbon with resin.

Materials balance of permanent and variable components from clarified juice to refined sugar. III. Method for control of crystallization and centrifugation of refinery massecuites

D. Fernández A., O. Janigova and J. Burianek. *CubaAzúcar*, 1986 (Oct./Dec.), 30 - 35 *(Spanish)*.

The crystal fraction in *A*-massecuite at two refineries was calculated in terms of the ash:pol ratio; by determining the fraction as a function of boiling time, it is possible to establish the optimum Brix for the completion of the strike at which the fraction is maximum. It is also possible to find the proportion of sugar in the syrup film surrounding the crystal after centrifugalling and thereby allow control of wash water addition.

The evaporative capacity of sugar syrups

V. P. Andrushchenko and A. N. Kashurin. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 47 - 49 *(Russian)*.

Investigations at 25 - 250°C of the evaporative capacity of a 79°Bx syrup containing 51.4% sugar, 15.6% invert sugar and 2.2% raffinose by weight as well as a 41°Bx and a 20.6°Bx syrup intended for use as a dry product in the baking and confectionery industry are reported. Results showed that, since the evaporative capacity falls with increase in Brix, it is advisable for the initial syrup to be of 20 - 40°Bx and drying to be carried out at 90 - 100°C which will provide quickest evaporation and required thermal stability. An end-product of desirable moisture content may be obtained by spray drying at a temperature in this range.

An improved scheme for raw sugar processing

A. R. Sapronov, Yu. I. Sidorenko, A. V. Vetokhin, Yu. V. Ogol'tsova, A. K. Gladchenko and T. A. Derevyanko. *Sakhar. Svekla*, 1989, (6), 37 - 38 *(Russian)*.

Cane raw sugar contains up to 1% reducing matter; most of this and the other non-sugars are in the outer layer of the crystal. The rate at which crystals dissolve in remelting is governed by pH as shown by an empirical equation. By adding 1.2 - 1.7% lime on weight of raw sugar and melting at 80 - 85°C at pH_{20} 8.6, reducing sugars degradation was raised to 94% as against 74.5% in normal remelting and the colour of the remelt liquor was 13.5% lower; purity and Brix also rose.

Non-sugars: extraneous matter in raw and refined sugar

D. S. Martin and J. E. Somner. *Sugar J.*, 1989, **52**, (5), 9 - 12.

See *I.S.J.*, 1989, **91**, 125A.

By-products

Coordination of waste treatment processes with the fertility improvement of agricultural lands

P. Nigam. *Bharatiya Sugar*, 1989, **14**, (11), 23 - 28.

Methods of treating vinasse are outlined, including land irrigation with it, recovery of potassium from it for use as fertilizer and processing it to provide a compound liquid fertilizer.

Investigation of the mechanism of hardening of a mixture of filter cake and lime with the aim of calcining it in vertical kilns

L. G. Belostotskii, L. I. Tanashchuk, V. A. Lagoda, T. V. Gutnichenko, N. P. Moklyak, N. V. Raskina, L. S. Zaets and V. F. Skripnik. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 96 *(Abstract only)*.

The possibilities of obtaining a stone-like material from filter cake by using unslaked lime as binder were investigated. It was found that the hardening process may be affected by the quality and granulometry of the lime, the temperature of the mixture and the ratio of filter cake to lime. An artificial stone of maximum strength was obtained by using a finely dispersed quick-slaking lime at 10% by weight of filter cake.

Alcoholic fermentation by membrane bioreactor: high cell density and process efficiencies

P. Perlot, F. Daujat and J. Mazellier. *Ind. Alim. Agric.*, 1989, **106**, 855 - 860 *(French)*.

A laboratory-scale continuous process developed by Béghin-Say S.A. in collaboration with SPEICHIM is described. Tests were conducted in which a *Saccharomyces cerevisiae* culture was maintained on beet molasses, green syrup or glucose syrup in a single fermenter; yeast retention by tangential microfiltration provided a high cell concentration (>100 g/litre dry weight) and greatly reduced the fermentation time, while bleeding of yeast from the fermenter ensured a sufficient concentration of viable biomass to give the desired alcohol yield. With beet molasses as substrate, liquid retention time was 4 hr as against 20 hr for conventional fermentation with 50% yeast recycle and the 7.5°GL alcohol yield was 90% of theoretical; 20% vinasse recycle would be possible. With green syrup, 2.5 hr fermentation yield 8.5°GL alcohol which again was 90% of the theoretical.

Tablopan bagasse board plant in Venezuela

F. Cordovez. *GEPLACEA Bull.*, 1989, **6**, (12), 2 pp.

Information is given on the bagasse board plant adjacent to El Palmar sugar factory which supplies the depithed bagasse. The plant started operations with one production line in 1964, while a second line was installed in 1977. The dry process is used because of its flexibility and local water shortage. Details are given of the major properties of the two types of board which are used in the manufacture of furniture. The plant is provided with a laminating section for coating of the boards with paper or plastic.

Energy savings by evaporative drying of pressed pulp

A. S. Jensen. *Zuckerind.*, 1989, **114**, 964 - 969 *(German)*.

Details are given of modifications and improvements to the DDS fluidized-bed beet pulp dryer at Stege sugar factory which was described earlier[1]. They include: the direct use of the vapour from the dryer in one of two film evaporators used as 1st effects for normal juice concentration instead of condensing the vapour in a heat exchanger to create pure steam for the evaporator; alteration to the inter-cell guide rail feed system to reduce the residence time of the smaller particles and increase that of the larger particles so as to provide uniform drying and slightly raise throughput; pretreatment of the pulp in the screw conveyor with steam that unavoidably escapes during feeding or discharge of the material (thereby preventing any of the steam leaving the actual dryer and creating an unpleasant odour); and redesign of the perforated bottom plate through which steam passes into the dryer. The potential savings in steam made possible by the dryer are indicated and a steam system is described which would generate sufficient electricity for use by the factory. Other advantages of pulp drying with steam are noted.

Effect of surfactant addition on the synthesis of a sucroglyceride without use of a solvent

P. L. Gutiérrez M. and L. R. de la Nuez F. *ATAC*, 1986, **45**, (5), 40 - 43 *(Spanish)*.

Tallow was reacted with sucrose and potassium carbonate at 125°C with vigorous stirring in the presence and absence of a surfactant (sucroglyceride obtained from the same reaction carried out earlier) but without any solvent; normally, the second (transesterification) stage of the reaction is characterized by abundant foam formation and a sharp rise in viscosity. Results showed that addition of the surfactant reduced the induction period and allowed equilibrium to be established within 8 hr, which was not possible after even 12 hr in its absence. The sucroglycerides obtained in both cases contained the same components but in different proportion.

Location and removal of secondary products from the rectification column for the production of ethyl alcohol

J. I. de Moraes, S. E. L. de Araujo and M. S. Cardoso. *STAB*, 1986, **5**, (2), 35 - 37 *(Portuguese)*.

Analyses were made of the contents of a rectification column at 15 of the trays and the results are tabulated as well as provided in the form of graphs of the contents of ethanol, n-propanol, iso-butanol, n-butanol and iso-amyl alcohol. The intention is to provide a means of

1 Jensen *et al.*: *I.S.J.*, 1987, **89**, 105.

obtaining distillates of higher quality by elimination of the fractions with greater proportions of the higher alcohol impurities.

Hydrolysed cane bagasse now used on a large scale in feed lots

M. C. G. Lacôrte, R. Burgi and A. J. F. Lacôrte. *STAB*, 1986, **5**, (2), 43, 46, 48, 50 - 52 *(Portuguese)*.

In 1986 a number of sugar factories and distilleries started to produce hydrolysed bagasse for cattle feed. Batch and continuous processes are employed and the bagasse is subjected to heat and pressure by the admission of steam into the reaction vessel. Acetic acid is liberated from the hemicellulose and this promotes the latter's hydrolysis to give hexoses and pentoses. An account is given of the process and the quality of the product as an animal fodder, weight gains, economics, etc.

New method for production of high-fructose syrups from sucrose

E. Duarte P. *ATAC*, 1986, **45**, (5), 30 - 34 *(Spanish)*.

Laboratory tests are reported in which *Saccharomyces cerevisiae* immobilized on bagasse was used to invert sucrose of up to 2.0 mol concentration passed at 1 and 2 SV (substrate:volume) and pH 3.6 and 4.0 through columns of 30, 50 and 90 cm^3. Results showed no significant effect of pH on the degree of inversion which did alter markedly with sucrose concentration, a maximum of 97.3% being achieved at 0.7 mol, pH 3.6 and a flow rate of 1 SV (90 ml/hr) in the biggest of the three columns. Trials on a larger scale were conducted with 50 - 56% solutions passed through three columns totalling 900 cm^3 at 55 ± 2°C at 500 - 600 ml/hr (0.6 SV). More than 90% inversion was achieved, and the fructose content of the invert syrup was greater than a 42% fructose syrup obtained by glucose isomerization. Enzymatic inversion does not need as high a temperature and retention time as acid inversion so that it does not carry the same risk of increase in colour and formation of hydroxymethyl furfural.

Agricultural use of mud from the production of biogas from filter cake. I. Chemical properties

F. J. Arcia, A. G. Núñez, Y. Amoros and L. A. Mustelier. *CubaAzúcar*, 1986 (Oct./Dec.), 3 - 6 *(Spanish)*.

Experiments are reported in which mud from filter cake fermentation as well as filter cake itself were applied to soil in pots in which sorgum was grown; the materials were both added on their own and combined with NK, PK and NPK. Results indicated that both materials caused a marked increase in yield over the control as well as increases in soil P (which were very substantial when the mud was applied) and K.

Criteria for alcohol production in a distillery integrated with a sugar factory. I. Basic concept, selection of suitable sugar factory and operational control of the complex

A. Suzarte and G. D. Iglesias. *CubaAzúcar*, 1986 (Oct./Dec.), 49 - 55 *(Spanish)*.

The fundamentals of a distillery/sugar factory complex are outlined; the proposed scheme assumes that all the secondary juice leaving the last mills is fermented to alcohol together with primary juice from the first two mills (thus decreasing sugar production by about 84%) or with molasses (cutting sugar production by 41%) to give sufficient reducing sugars for fermentation. The mathematics involved in operational control of such a complex are set out; computer programs have been developed to correlate the optimum capacities of the factory and distillery.

Development of increasing hydrogen producing bacteria on cane vinasse

S. V. Ferreira, E. F. C. Sérvulo, I. M. da Silva and H. L. Martelli. *Brasil Açuc.*, 1986, **104**, (3/4), 30 - 31 *(Portuguese)*.

Two bacterial cultures (*Enterobacter agglomerans* and *Citrobacter freundii*) isolated from vinasse biodigesters were anaerobically cultured in a medium comprising vinasse enriched with 0.5 g/litre of sucrose. When the vinasse was from an n-butanol fermentation, the biogas produced by the two micro-organisms contained 57.76% and 40.87% H_2, respectively. When the vinasse was from ethanol fermentation, these figures were 58.62% and 57.85%, respectively. With ethanol vinasse the gas produced totalled 900 and 360 ml, the quantity of hydrogen 47.11 and 18.59 mg and the number of cells produced after 18 hours was 2.13×10^{10} and 1.1×10^{10}, respectively, for the two cultures, per litre of medium. *E. agglomerans* was chosen for future experiments on biodigestion of vinasse.

Probable production of sugar and alcohol as a function of frost intensity

F. A. Fogliata. *Ind. Azuc.*, 1987, **92**, (1038), 5 - 8 *(Spanish)*.

Analyses of juice samples taken from cane growing in three regions of Argentina where it was exposed to subzero temperatures as well as frostless conditions showed that a mild frost (– 3°C) had little effect on the fermentation properties of the juice and on alcohol yield, whereas a severe frost (between – 6° and – 8°C) caused a marked fall in alcohol yield.

Organic waste from cane sugar factories and alcohol distilleries as saline soil ameliorants. II. Changes in the organic fraction and biological activity

M. Mena, A. Martínez C. and A. Noa. *Cienc. Agric.*, 1986, (29), 122 - 127 *(Spanish)*.

Application of vinasse to soil increased the total N, C and organic matter contents, modified the C:N and humic acid: fulvic acid ratios and considerably raised the dehydrogenase activity (a measure of

biological activity) as well as the bacterial, fungal and Actinomycetes populations; sugar factory filter cake diluted with waste water increased the *Azotobacter* population but was less effective than vinasse with regard to the other soil parameters, while waste water gave the poorest results which were nevertheless better than for the untreated control or than results given by merely irrigating with normal water.

Stubble digester

E. Nuñez. *Ind. Azuc.*, 1987, **93**, (1039), 4 - 7 *(Spanish)*.

Enzymatic treatment of filter cake in a Stubble Digester Plus of Cytozyme Laboratories is described. After 60 days' processing, the product is suitable for application to soil at 3 tonnes/ha. Details are given of the nutrient content of the treated cake and of the process economics.

Influence of filter cake on phosphorus uptake from fertilizers by sugar cane

E. Angarica, A. Cabrera, M. López and A. Vantour. ATAC, 1986, 45, (6), 10 - 16 (Spanish).

The uptake by cane of P in filter cake applied to soil was greater than when P was applied as inorganic fertilizer, so that filter cake is seen as a suitable substitute.

Vinasse: alternative source of fodder biomass

M. F. Alves. *STAB*, 1987, **5**, (3), 43, 46, 48 *(Portuguese)*.

The yeast *Candida utilis*, ATCC 9226, was grown on vinasse as extracted from the lower part of an alcohol distillery column and supplemented with nutrient – potassium phosphate, ammonium sulphate and ammonium phosphate. The aerobic fermentation reduced the BOD of the vinasse in all cases, from 34.35% in the case of the "natural" vinasse to 76.8% where it was supplemented with both N and P. The nutrients raised the protein production from 1.1 g/litre to 4.1 g/litre in the case of the highest amount of amonium phosphate added (4.42 g/litre). Such treatment increases the value of the vinasse in that it produces an animal fodder of value while reducing the cost of treatment to bring down the BOD.

Study of the viability of extending the sugar cane harvest period for the production of ethanol

A. Mendes, R. M. del Giúdice, N. Marciano, J. T. L. Thièbaut, J. M. Vieira and F. F. F. Teles. *STAB*, 1987, **5**, (3), 50 - 53 *(Portuguese)*.

Cane of varieties CB 45-3 and NA 56-79 were planted in January and February, respectively and sampled fortnightly between 11 and 21 months and between 10 and 22 months, respectively. The samples were analysed for calculation of total sugars, recoverable sugars and ethanol production potential. The results showed that the two varieties could be harvested 1.5 and 2 months earlier than usual, the former offering less recoverable sugar but a higher yield of alcohol per hectare.

Influence of filter cake application on potato yield and incidence of *Fusarium* and *Erwinia* pathogens

M. S. Martín, M. A. Lorenzo C., N. Cruz Q., A. I. Fernández R. and A. González D. *Centro Agric.*, 1987, **14**, (1), 50 - 54 *(Spanish)*.

Application of up to 90 tonnes/ha filter cake to soil increased the potato yield and increased resistance to *E. carotovora* but had no effect on the reaction to *F. oxysporum*.

Direct contact heating and flash cooling in the treatment of juice for alcohol manufacture

W. Pizaia, D. T. Oliveira and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1987, (37), 8 - 13 *(Portuguese)*.

Two processes have been developed for juice heating and cooling. The first raises it from 54° to 105°C in three stages using exhaust steam and vapour from two flash tanks; the hot juice is decanted before cooling in the flash tanks to 60°C. In the second four flash tanks are used and cool the juice to 30°C. The first operated successfully at one factory in 1985 and the second was being evaluated at two factories of 200 and 300 tch, respectively, in 1986/87.

Options for the total utilization of fermentation tank bottoms

J. N. de Vasconcelos, A. F. M. da Silva and A. F. de Oliveira. *Brasil Açuc.*, 1987, **105**, (1), 17 - 25 *(Portuguese)*.

The fermentation bottoms are the residues in the tank after removal of the liquor for distillation. This material has been considered worthless but nearly 3000 tests at a distillery annexed to a sugar factory in Brazil have been made to obtain analyses and these indicate its high microbiological quality which can provide a noticeable diminution in fermentation time or increase in the fermentation efficiency.

Biotechnological and chemical pathways to intermediate synthesis products from sucrose

K. Buchholz and M. Kunz. *Zuckerind.*, 1990, **115**, 20 - 24 *(German)*.

Selective oxidation of sucrose or other disaccharides by *Agrobacterium tumefaciens* introduces a keto-group which may be used in further reactions to yield e.g. tensides. This biosynthesis can be followed by chemical synthesis processes to yield other products e.g. diamines (of application in condensation products such as polyurethanes) obtainable from sugars derived from sucrose. The application of dextransucrase to catalyse dextran synthesis from sucrose is also described; in a side-reaction, the glucose moiety can be converted to other sugars (acceptors) and high yields of oligosaccharides can be eventually obtained starting with fructose as acceptor. The fields of application of polysaccharides and tensides are indicated.

samples from the beginning of the regeneration did not precipitate.

During regeneration, as the salt penetrates the resin and its concentration increases, the chloride ions displace the colorants fixed to the resin and those of higher affinity to the resin which, in turn, displace the colorants of lower affinity toward the end of the resin bed. These successive adsorption-desorption mechanisms cause the separation of colorants according to their affinity to the resin. The first group of colorants, removed at low salt concentration at the beginning of regeneration, comprise the anionic colorants of low charge, sorbed on the resin matrix. In the last part of the regeneration, a group of colorants with higher affinity leaves the resin at higher salt concentration; this group comprises the anionic colorants of higher charge.

By pre-regeneration at a low salt concentration before normal regeneration it is possible to obtain better separation between these two colorant groups. This was tested in a refinery column (System I, Cycle 1604) with a pre-regeneration of 2 BV at 30 g/l of sodium chloride, at 60°C and 2 BV/hr, followed by a normal regeneration (3 BV at 110 g/l).

The resulting values of attenuation, salt concentration, Indicator Value[14] (I.V.)† and lime precipitation are presented in Figures 2, 3 and 4. Lime precipitation efficiency is presented here as L.V. (Lime Value) which is related to the decolorization obtained by the colorants precipitation with lime in standard conditions (see the Appendix). This parameter gives an idea of the colorant's anionic charge. The I.V. and L.V. increase from the beginning to the end of regeneration, indicating a high concentration of pH sensitive and

† I.V. = (Attenuation at pH 9/Attenuation at pH 4) both measured at 420 nm.

14 Clarke *et al.*: *Proc. CITS*, 1987, 67 - 81.

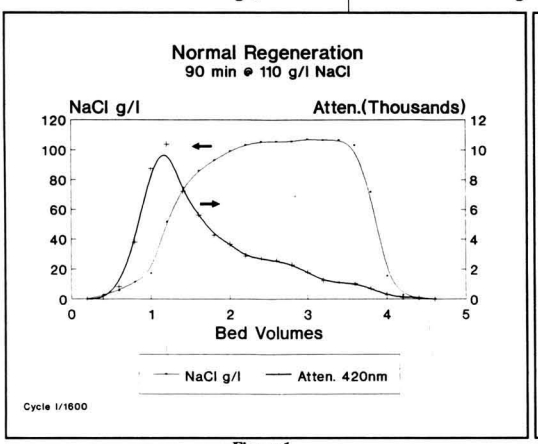


Figure 1

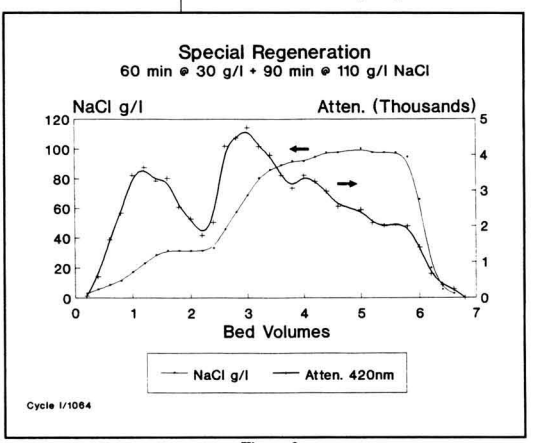


Figure 2

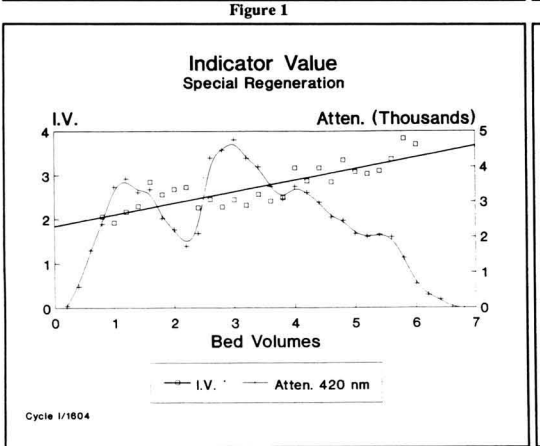


Figure 3

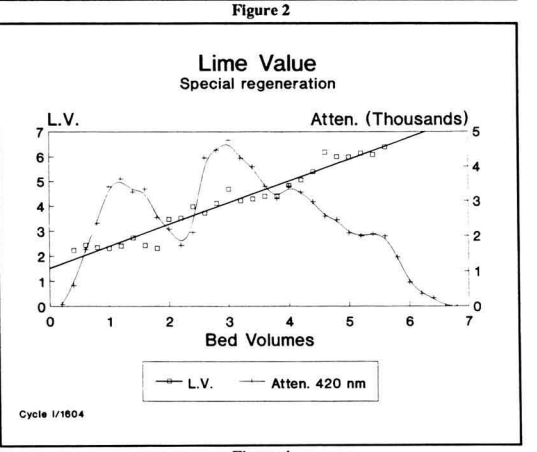


Figure 4

anionic charged compounds in the last part of the effluent.

Observing these curves we noted a better separation between low and high affinity colorants from the resin. Although the effluent colour intensity (Attenuation) is lower than in the first curve (Fig. 1), the quantity of coloured material released from the resin is higher than in the normal regeneration. In fact, integrating the two curves (Figures 1 and 2) we observe an increase of 30% in colorants removal during the second regeneration process (assuming a direct relationship between attenuation and colorants concentration).

The process

The separation of the ionic colorants by selective desorption during regeneration and their precipitation with lime, allowing the re-use of the salt solution, is the basic idea behind the process we have developed. In this new process the regeneration is carried out in two steps: the first at a low salt concentration – the pre-regeneration – and the second at the normal salt concentration – the regeneration.

In the pre-regeneration we use the low-concentration salt solution from the salt washes of the previous regeneration, made alkaline with soda or ammonia. The high pH increases the removal of the mechanically sorbed colorants[15]. Also, the low salt concentration maintains the resin in a swollen state, which facilitates the removal of the large organic molecules.

The anionic colorants with high affinity for the resin are removed in the regeneration stage with a higher salt concentration. The effluent resulting from this part of the regeneration is then treated with calcium hydroxide. After the precipitation of the colorants and other organic matter, the calcium ions remaining in solution are removed using an appropriate scavenger. The final pH of the filtrate solution is then adjusted.

This process was first tested on a laboratory scale with a water-jacketed Pharmacia K26/40 column of 2.6 × 40 cm charged with 100 ml of IRA 900 C resin, of 19 cm bed height, supported on 4 cm of silex (2.2 mm). In the jacket of the column warm water at 50°C was circulated using a peristaltic pump.

Carbonatated liquor from Oporto refinery, diluted and heated to 50°C, was passed down-flow through the column using a dosing meter pump at 2 BV/hr‡. During the summer shut-down of the refinery we used carbonatated liquor from RAR's Matosinhos refinery. At the end of each cycle (30 to 50 BV) the resins was washed and back-washed under the same conditions as used in the refinery.

Resin regeneration was performed in the following way (Figures 5 and 6):

(i) Pre-regeneration with 0.5 to 1.0 BV of low density regenerant (LDR, 30 to 50 g/l of NaCl) adjusted to pH 12 at a flow rate of 2 BV/hr.

(ii) Regeneration with 3.0 BV of high density regenerant (HDR, 70 to 110 g/l of NaCl) at a flow rate of 2 BV/hr.

(iii) Washing with hot water in the normal way.

The coloured effluents were separated into the following quantities:

(a) 1.0 BV of high colour and low salt content effluent to be rejected – the rejected effluent (RE),

(b) 3.0 BV of high colour and high salt content effluent to be treated with lime – the high density effluent (HDE), and

(c) 1.0 BV of low colour and low salt content effluent (LDE – low density effluent) to be used in the pre-regeneration after addition of NaOH or NH_3 as necessary.

The main regeneration was performed with the salt solution recovered from the chemical treatment of high salt content effluent (HDE). For the first cycle one normal regeneration was done.

The colorants were precipitated with lime slurry [100 g/l $Ca(OH)_2$], with slow agitation and heating to 60°C.

‡ Liquor volumes mentioned refer to the original liquor concentration.

15 Cookson *et al.: Proc. Tech. Session Cane Sugar Refining Research.*, 1970, 103 - 124.

	IN	OUT	TREAT.	RECIRC.	WASTE
PRE REGEN.	LDR 40 g/l	WATER		WATER	
		H Col. L Salt			RE
REGEN.	HDR 70 g/l	H Col. H Salt	LIME + X	HDR	
					MUD
WASH.	WATER	L Col. L Salt		LDR	
		WATER		WATER	

Figure 5

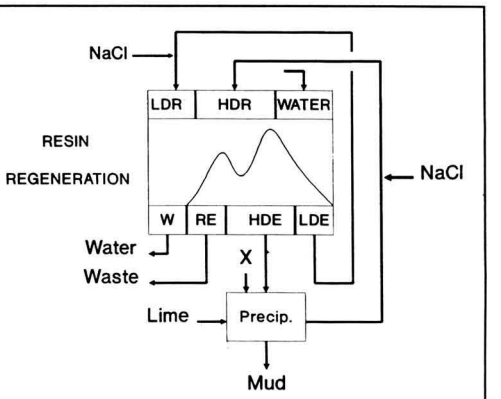


Figure 6

Different quantities of lime slurry were used and the attenuations of the filtrates were measured at 420 nm and pH 9. The appropriate lime quantity to be used for maximum colour removal from the salt effluent was determined as being between 5 and 10% v/v (Figure 7).

The calcium in solution was removed as calcium carbonate by precipitation with sodium carbonate or carbon dioxide. Precipitation as calcium phosphate was also tried using trisodium phosphate or phosphoric acid. The precipitation was complete when the residual calcium in solution reached values lower than 0.1 g/l (Figure 8). Calcium in solution was determined by a complexometric method using EDTA with Eriochrome Black T as indicator.

In the test with carbon dioxide we used the flue gas from the refinery carbonatation until a final pH of 8.5 was reached. The precipitates formed were removed from the solutions by vacuum filtration through Whatman filter paper No. 42. Results of the experiments with different precipitation methods are given in Table I.

Although a high pH is beneficial to colorant removal from the resin, we adjusted the effluent pH to 12 ± 0.5 with HCl or an alkali, when necessary, as we observed that a higher pH was harmful to the precipitation process.

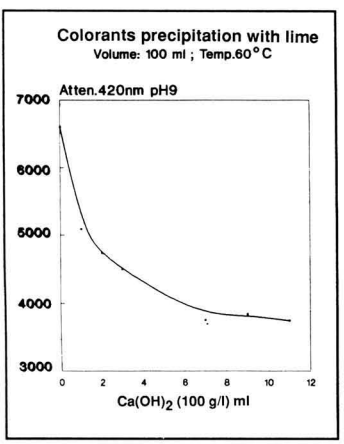


Figure 7

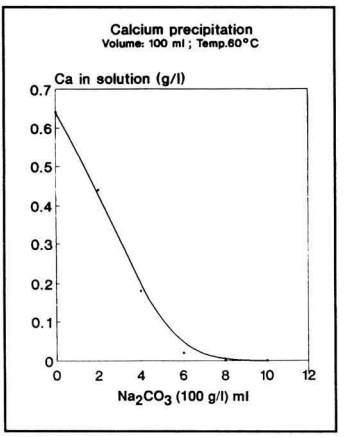


Figure 8

At the beginning of the development of the process, an extra precipitation with sodium silicate (100 - 300 ppm) was tried, giving additional colour removal. This process was abandoned owing to the difficulties of removing precipitated silicate and to avoid possible silicate leakage into the liquor through the resin.

Removal of colorants from the salt effluent by chemical precipitation, as described, is easier than from the sugar solutions, because the viscosity of the effluent is lower and the colorant concentration is more than 10 times that in the sugar liquors. Extreme conditions (pH, temperature, chemical) can also be used without causing sugar losses.

Over a year, we performed 200 cycles re-using the effluent after the chemical treatment. Special acid and alkaline regeneration with fresh salt were performed every twenty cycles. In order to maintain its concentration, a sodium chloride make-up was made using solid salt directly or diluted in the lime slurry, to avoid salt dilution. The total salt make-up in the pre- and main regeneration was 44 g/l of resin per cycle (representing 80% of salt recovery). This make-up compensates for the salt lost in the rejected effluent, in the wet precipitate, in the resin wash, for the salt consumed in the ion-exchange process, etc. The total salt consumption, including the special regenerations and the salt make-up during effluent treatments, was 77 g/l of resin per cycle, or 1.8 kg of salt per tonne of dry solids, which is lower than for classical regeneration[16].

The results of the 200 cycles are indicated in Table II and summarized here:

Resin:	100 ml (IRA 900 C)
Liquor in:	9153 BV 46 BV/cycle 65.2°Brix 7.8 tonnes d.s./litre of resin 39 kg d.s./litre of resin/cycle 669 ICUMSA colour (Method 2) 5267 total colour charge units (C.C.U.)[§] 26.3 C.C.U./cycle 8.6 pH
Liquor out:	180 ICUMSA colour 73.1% decolorization 7.7 pH

Figure 9 represents liquor decolorization obtained through the 200 cycles. Figure 10 represents % decolorization related to the cumulative colour charge. In this figure the regression line indicates a reduction of 3.3% on decolorization per 1000 C.C.U. which is a low value[17].

After the 200 cycles of service the resin presented a storage-base capacity of 0.58 meq/ml. During the 200 cycles, different treatment conditions and chemical quantities were tried. These conditions vary with the quantity and quality of the coloured material. As an indication, for an average resin salt effluent from a cane sugar carbonatation refinery, the salt and other chemical consumptions, per m^3 of resin, may be:

§ C.C.U. (colour charge unit) = Tonnes of dry solids × ICUMSA colour units per litre of resin.

16 Ramm-Schmidt *et al.: Proc. Sugar Industry Tech.*, 1988, 161 - 179.

17 Hindefelt & Lilja: *ibid.*, 1986, 1 - 21.

Table I. Coloured effluent treatment (Average of five cycles)

	High density effluent			After treatment			
Cycles	NaCl, g/l	Colour*	pH	Treatment	Colour*	Decolorization, %	NaCl make-up, g/l/cycle **
1-5	98	1.73	9.3	Silicate	0.77	55.5	170
6-10	93	2.52	9.2	"	1.12	55.6	128
11-15	87	3.56	9.5	"	1.64	53.9	79
16-20	61	7.12	9.2	"	5.34	25.0	50
21-25	103	10.74	9.5	"	5.89	45.2	24
26-30	60	12.95	9.4	"	8.81	32.0	48
31-35	61	12.63	9.4	H_3PO_4	8.44	33.2	16
36-40	36	9.90	9.5	"	6.88	30.5	35
41-45	59	12.80	8.9	"	7.02	45.2	20
46-50	40	6.34	8.9	"	3.84	39.4	36
51-55	59	8.52	8.7	"	3.42	59.9	22
56-60	40	8.27	9.0	"	5.12	38.1	49
61-65	35	6.42	9.9	"	3.84	40.2	25
66-70	26	6.24	10.0	"	4.88	21.8	30
71-75	53	8.15	10.6	"	4.11	49.6	20
76-80	35	7.42	11.1	"	5.57	24.9	39
81-85	58	13.32	10.4	"	6.74	49.4	29
86-90	51	13.30	10.9	"	8.91	33.0	53
91-95	78	11.36	11.4	"	6.55	42.3	36
96-100	56	12.36	10.9	"	8.36	32.4	54
101-105	64	15.05	10.4	"	10.76	28.5	64
106-110	63	18.60	11.4	"	12.83	31.0	62
111-115	76	11.82	11.0	Na_3PO_4	7.50	36.5	45
116-120	64	10.31	10.8	"	5.89	42.9	46
121-125	68	11.02	11.0	"	5.89	46.6	51
126-130	69	12.72	10.8	"	6.98	45.1	53
131-135	79	9.83	10.9	Na_2CO_3	5.66	42.4	36
136-140	68	11.58	9.7	"	7.25	37.4	59
141-145	66	11.46	10.0	"	6.85	40.2	44
146-150	67	15.11	7.9	"	9.62	36.3	34
151-155	78	10.85	10.1	CO_2	6.49	40.2	8
156-160	66	14.00	10.9	"	10.99	21.5	35
161-165	70	17.34	10.3	"	12.77	26.4	35
166-170	70	17.20	10.3	"	13.63	20.8	33
171-175	77	13.08	10.0	Na_2CO_3	8.24	37.0	9
176-180	68	21.68	10.3	"	14.12	34.9	37
181-185	70	20.34	10.3	"	12.50	38.5	36
186-190	70	22.58	12.2	"	14.20	37.1	36
191-195	76	10.09	9.8	"	6.20	38.6	31
196-200	67	7.14	8.9	"	3.91	45.2	27
Average	65	11.44	10.1		7.24	38.4	44

* (Attenuation at pH 9 and 420 nm)/1000

** Salt consumption per litre of resin per normal cycle (excluding special acid/alkali regenerations)

	Calcium precipitation processes				
	Classic	Na_2CO_3	CO_2	Na_3PO_4	H_3PO_4
NaCl	250 kg	44 kg	44 kg	44 kg	44 kg
NaOH	5 kg				
$Ca(OH)_2$		22 kg	22 kg	22 kg	22 kg
Na_2CO_3		16 kg			
Na_3PO_4				16 kg	
H_3PO_4					13 kg
NH_3			3 kg		3 kg

The consumption for special acid/alkaline regenerations are not included here.

The total decolorization obtained with the different effluent treatments were 38% when using Na_2CO_3, 26% with CO_2, 43% with Na_3PO_4 and 37% with H_3PO_4.

During these experiments we observed that the colorants which

Table II. Liquor decolorization by ion-exchange with regeneration recovery (Average of five cycles)

Cycles		Liquor in				Liquor out		Colour
	BV	Brix	Colour, I.C.U.	C.C.U.*	pH	Colour, I.C.U.	pH	decrease, %
1-5	30	65.7	728	18.9	8.6	114	7.6	84.3
6-10	30	65.4	517	13.4	8.4	84	7.4	83.8
11-15	30	64.4	681	17.3	8.8	99	7.5	85.5
16-20	50	63.8	688	28.7	8.9	114	7.2	83.4
21-25	48	65.9	635	26.6	8.9	102	7.8	83.9
26-30	44	64.4	906	33.7	9.2	159	7.7	82.5
31-35	43	64.2	884	32.0	8.8	146	7.5	83.5
36-40	36	63.9	958	28.9	9.2	195	8.5	79.6
41-45	38	62.5	871	26.9	8.8	142	8.4	83.7
46-50	48	65.8	570	23.8	8.2	147	7.4	74.2
51-55	44	65.3	805	32.1	8.8	155	7.7	80.7
56-60	51	66.9	655	29.7	8.3	178	8.5	72.8
61-65	48	65.6	772	32.1	8.3	256	7.1	66.8
66-70	38	65.8	933	30.8	8.3	303	6.7	67.5
71-75	44	66.5	783	30.4	8.3	221	7.6	71.8
76-80	46	65.0	738	29.0	8.5	223	7.9	69.8
81-85	50	66.2	715	31.3	8.2	210	7.7	70.6
86-90	48	65.8	733	30.6	8.5	227	6.4	69.0
91-95	46	67.7	765	31.8	8.6	196	8.3	74.4
96-100	46	67.0	807	33.0	8.2	242	7.6	70.0
101-105	50	65.4	719	31.0	9.1	189	6.7	73.7
106-110	47	67.7	715	30.3	8.6	191	7.7	73.3
111-115	44	66.5	737	28.6	8.2	211	7.7	71.4
116-120	50	63.7	636	26.5	8.4	206	7.2	67.6
121-125	38	66.5	775	26.0	8.2	239	7.3	69.2
126-130	42	63.3	835	29.0	8.3	246	7.3	70.5
131-135	50	65.8	519	22.6	9.1	149	7.2	71.3
136-140	50	64.2	616	25.9	8.4	183	6.8	70.3
141-145	50	66.3	564	24.8	8.8	143	7.2	74.6
146-150	50	64.6	524	22.2	8.5	157	6.9	70.0
151-155	50	65.4	465	20.1	8.8	143	8.0	69.2
156-160	50	63.8	544	22.7	9.5	126	8.2	76.8
161-165	50	64.9	518	22.1	8.7	164	7.7	68.3
166-170	50	64.2	506	21.3	8.8	173	8.1	65.8
171-175	50	63.8	508	21.2	8.9	175	9.2	65.6
176-180	50	67.1	593	26.4	8.8	189	9.2	68.1
181-185	50	63.4	543	22.5	8.4	167	9.0	69.2
186-190	50	64.2	562	23.7	8.7	194	9.2	65.5
191-195	51	64.2	523	22.5	8.5	179	8.4	65.8
196-200	50	64.2	550	23.2	8.4	214	7.1	61.1
Average	46	65.2	669	26.3	8.6	180	7.7	73.1

* C.C.U. (colour charge units) = Tonnes of Dry Solids × I.C.U./litre of resin

remained in the treated effluent did not greatly interfere with the chemical ion-exchange regeneration. In fact, these compounds, not reacting with the lime, do not have a high anionic charge and consequently do not compete with the chloride ions during the ion exchange process.

The total waste in the form of rejected effluent and solid mud was the following:

Liquid:	Volume	1.0 litre/litre of resin
	NaCl conc.	23 g/litre
	Attenuation pH 9, 420 nm	8600
	pH	9.6
Solid:	Weight (dry)	39 g/litre of resin

This method of recirculating the coloured effluent after chemical treatment was also tested in a similar laboratory column with an acrylic strongly basic anionic resin (IRA 458). The results were:

Number of cycles	5
Feed colour 628 I.C.U.	
Liquor decolorization	81%
Effluent attenuation	10,000
Chemical treatment	7% $Ca(OH)_2$ + 5% Na_2CO_3
Effluent decolorization	40%

Another test was made in three

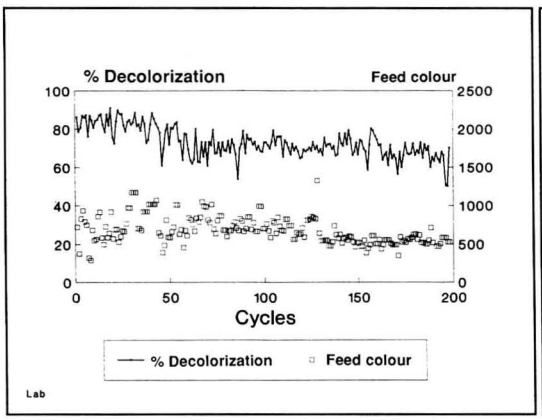


Figure 9

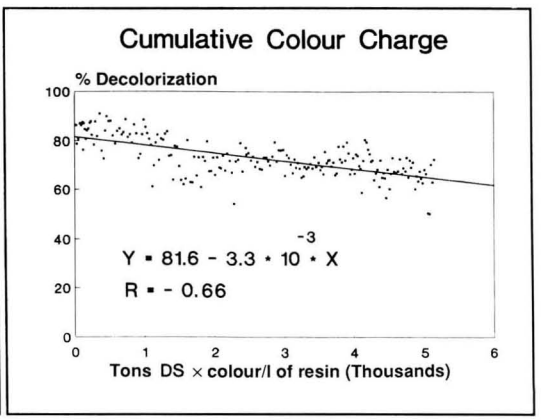


Figure 10

identical Pharmacia K26/40 columns with 100 ml of IRA 900 C, to compare this new process with the classic regeneration process using alkaline salt. Precipitation as carbonate and as phosphate were tested separately. The decolorization results of these experiments are presented in Figure 11 and summarized here:

Classical regeneration	75%
New process (phosphate)	70%
" " (carbonate)	69%

Salt concentration in the classical process was 110 g/l and in the new process was 80 g/l, which may explain the difference observed. This difference can be overcome by reducing the length of the cycles or increasing the salt level. However, the advantages of the new process compensate for these modifications.

Discussion

Treatment of the coloured effluent with the re-use of the salt solution, as described above, presents great advantages when compared with the classical regeneration using alkaline salt solution:

(i) Reduction of coloured waste effluents

With the new system we have 1 BV of coloured effluent which represents 3 m^3 per 100 tonnes of refined white sugar, that is one-third of the classical effluent volume. The salt concentration of this liquid waste is 23 g/litre which is one-fourth of the salt concentration in the classical regeneration effluent. As a result, its biodegradability is greater and biological treatment is easier, so that with the new process the environmental impact is reduced. Also, when ammonia is used for pH adjustment in the diluted salt solutions, the rejected effluent, after mixing with molasses, can be used as a nitrogen source for ruminant feeding[18,19].

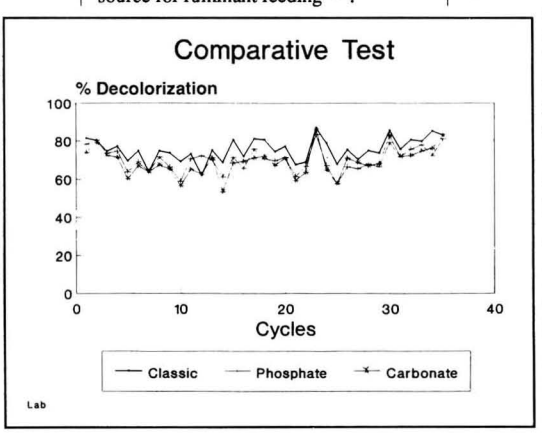


Figure 11

(ii) Reduction of chemical and utilities cost

Based on the consumptions indicated earlier, the chemical cost per tonne of dry solids, at local prices, compared with the classical regeneration are (in $US):

Classical	$0.35
Na_2CO_3	$0.18
CO_2	$0.13
Na_2PO_4	$0.26
H_3PO_4	$0.36

Costs of salt and chemicals for special acid/alkaline regenerations every 20 cycles are not considered here as they are used in both the classical and the new process.

When using soda ash as a calcium scavenger, there is a reduction of 48% on chemical costs. A higher reduction of 63% is obtained when using carbon dioxide. The use of phosphate precipitation is less attractive (at local prices). Using trisodium phosphate we have a reduction of 26% in chemical costs and using phosphoric acid the chemical costs are similar to the classical

18 Kirk-Othmer: "Encyclopedia of chemical technology. Vol. 2", 1978, pp. 470 - 516.

19 Rader & Anderson: *Proc. Tech. Session Cane Sugar Refining Research.*, 1970, 114 - 124.

regeneration process.

The use of carbon dioxide from an existing carbonatation plant is the most economical of these processes. The quantity of lime to be neutralized is only 5% of the total lime consumed in the main liquor carbonatation so that gas from an existing plant can probably be used without any change in the existing equipment.

The next most economical choice is the sodium carbonate process. This is a very convenient system for refineries which do not employ the carbonatation process. Phosphoric acid or trisodium phosphate usage may be of interest to phosphatation refineries, depending on chemical prices. As the regenerant chemical cost represents the major cost for the resin process[20] this saving is important for the decolorizing process economy.

Reduction in operating costs due to less hot water consumption and for waste treatment are not considered here.

(iii) The possibility of increasing the salt level without increasing salt consumption

As the salt solution is recirculated for the next regeneration we can increase the salt level without extra salt consumption. Using 4 BV of salt solution (80 g/l) for the resin regeneration instead of 3 BV we increase the salt level from 240 g/l resin/cycle to 320 g/l resin/cycle, with approximately the same salt consumption. The other chemicals used when passing from 3 to 4 BV do not increase in the same proportion, as the quantity of colorants removed from the resin does not increase accordingly. This is important as increasing the salt level is beneficial in extending the life of the resins.

(iv) The chemical treatment produces alkaline solutions

After the precipitation of the colorants with calcium hydroxide and after the calcium precipitation with a sodium salt, the remaining solution has a high pH which is beneficial to the resin regeneration. Moreover, the diluted alkaline salt solutions are a good regenerant for weakly basic anionic resins.

The salt effluent treatment adapted to a two-resins system

It is well known that weakly basic resins remove efficiently large organic molecules and other colorants such as caramels and alkaline degradation products[19]. By installing this kind of resin before the strongly basic anionic resin, a protection against chemical fouling can be achieved.

The effluent treatment previously described was adapted to a two-resins system in separate laboratory columns using a weakly basic anionic resin (Lewatit MP 62) in the first column and a strongly basic anionic resin (IRA 900 C) in the second column.

For the regeneration of the second column a salt (NaCl) solution was used and the coloured effluent recirculated after chemical treatment with $Ca(OH)_2$ and Na_2CO_3 as described above. The diluted alkaline solutions resulting from the resin wash at the end of the regeneration was used to regenerate the weakly basic anionic resin, after pH adjustment to 13 with NH_3 or NaOH.

As the large organic and non-anionic molecules are sorbed into the weakly basic anionic resin, the pre-regeneration step was eliminated and no waste effluent was rejected from the second column (Figure 12).

A special regeneration (2 BV at 30 g/l NaCl + 3 BV at 110 g/l NaCl) was carried out on the strong base anionic resin and a low peak of the first group of colorants out of the resin was observed (Figure 13). This confirms the retention of colorants with low affinity to the strong resin by the weak base anionic resin.

This two-resins process was tried on a laboratory scale with two 100 ml water-jacketed Pharmacia K26/40

20 Burke: "Use of ion exchange resin systems for cane sugar refining", (Illinois Water Treatment Co., Rockford.) 1980.

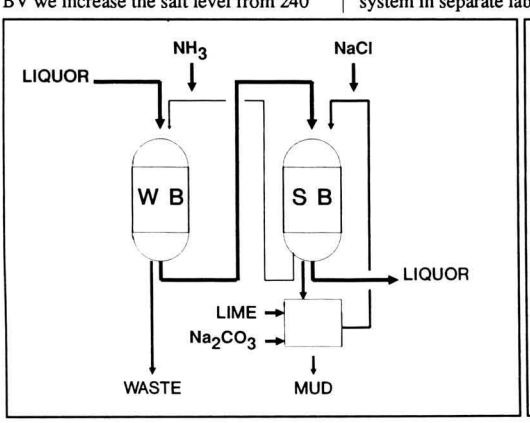


Figure 12

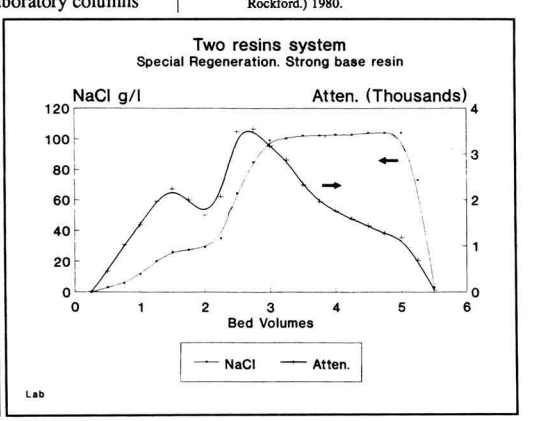


Figure 13

columns with a dosing pump for liquor transfer between the two columns.

The feed liquor colour and the decolorization obtained are presented in Table III and Figure 14. The results of the effluent treatment are presented in Table IV. The average decolorization during 30 cycles was 86% from a feed liquor colour of 557 I.C.U. With the weakly basic anionic resin a decolorization of 50% was obtained.

During these tests a lower decolorization by the lime treatment of the salt effluent was observed as some anionic colorants are removed in the first column. An increase in the pH was also observed between the feed and the final liquor. It was also observed that the strong base resin maintains its original appearance, indicating low resin fouling.

The pilot plant

As a result of these laboratory-scale experiments it was decided to install a pilot plant for salt effluent treatment with a capacity of 1 m^3/hr (Figure 15). The plant installed consists

Table III. Liquor decolorization by ion-exchange with regeneration recovery (Two-resins system: weakly basic + strongly basic anionic resin – average of five cycles)

Cycles		Liquor in				Liquor out		Colour
	BV	Brix	Colour, I.C.U.	C.C.U.*	pH	Colour, I.C.U.	pH	decrease, %
1-5	50	63.5	485	20.1	9.2	59	9.4	87.8
6-10	50	65.5	541	23.4	8.8	74	8.9	86.3
11-15	50	65.6	588	25.4	8.5	87	8.9	85.2
16-20	50	63.2	552	22.8	8.6	85	8.9	84.6
21-25	50	61.8	550	22.0	8.5	87	9.0	84.2
26-30	50	63.0	624	25.6	8.5	75	8.6	88.0
Average	50	63.8	557	23.2	8.7	78	9.0	86.0

* C.C.U. (colour charge units) = Tonnes of dry solids × I.C.U./litre of resin

Table IV. Coloured effluent treatment (Two resins system: weakly basic + strongly basic anionic resin – average of five cycles)

Cycles	High density effluent NaCl, g/l	Colour*	pH	Treatment	After treatment Colour*	Decolorization	NaCl make-up, g/l/cycle **
1-5	86	2.52	11.8	Na_2CO_3	1.27	49.6	84
6-10	75	7.05	12.6	"	4.35	38.3	41
11-15	76	8.89	11.7	"	7.19	19.1	52
16-20	76	10.90	12.7	"	8.15	25.2	49
21-25	74	6.31	11.7	"	4.69	25.7	29
26-30	69	7.80	12.8	"	6.66	14.6	47
Average	76	7.25	12.2		5.39	28.8	50

* (Attenuation at pH 9 and 420 nm)/1000

** Salt consumption per litre of resin per cycle (excluding special acid/alkaline regeneration)

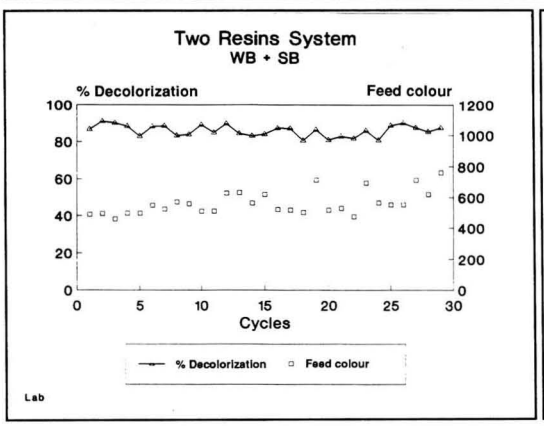


Figure 14

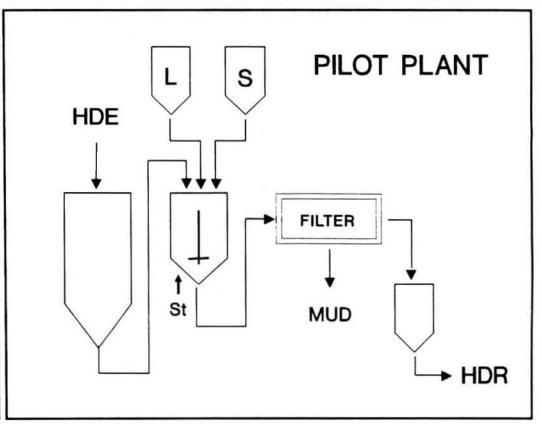


Figure 15

of two 1 m^3 stainless steel reaction tanks with stirrers, heated by direct steam. One of these tanks receives the coloured effluent from the refinery columns, plus the lime and other chemicals. The treated effluent is then pumped by a 50 l/min centrifugal pump into the filter press. This filter has a capacity of 40 llitres of mud and a total filtration area of 2 m^2 with 8 plates and 9 frames, all in polypropylene, supporting the polypropylene monofilament cloths. The filtrate is treated in the second stirred tank for pH correction and is then stored in an existing concrete tank, which is lined with fibre glass and usually used for the special alkaline regenerations.

Results from the first trials with the pilot plant confirm the laboratory tests. After setting the operation conditions the treated salt effluent produced will be used directly in the refinery columns.

Conclusion

Sugar colorants comprise a great variety of compounds of different origin and chemical nature. A great many of these compounds can be fixed to strongly basic anionic resins by different mechanisms: by physical sorption into the resin matrix, by chemical bond with the fixed ion in the resin active group[21,22], or by an "amplified ionic binding"[22] with both mechanisms acting on the same colorant molecule. The colorants fixed to the resin are removed with salt solutions in a reverse order of their affinity to the resin. By pre-regeneration with a low salt concentration, the colorants with low affinity are separated, in the eluted effluent, from the anionic colorants with higher affinity for the resin. Strong base anionic resins are elastic sorbents, shrinking with increases of the salt concentration[23]. Therefore during the pre-regeneration, using an alkaline solution of low salt concentration, the resin is maintained in a swollen state which facilitates the removal of the physically sorbed colorants. The anionic colorants remaining in the resin are then removed at a high salt concentration. The first group of low affinity colorants are removed from the system in a waste effluent with a low salt concentration. The anionic colorants from the last part of the regenerant effluent are precipitated with lime and removed from the system in a solid waste. The filtered solution is employed as resin regenerant for subsequent cycles. The non-anionic colorants that remain in this solution do not compete with the counter ion during the chemical regeneration. Resulting diluted alkaline solutions from the resin regeneration can be used as regenerants of weakly basic anionic resins installed before the strongly basic resin, protecting this resin from fouling by large organic molecules.

This new process, for which a patent has been applied, of re-using the salt effluent after chemical treatment can be a useful tool for a more economical and less polluting use of ion exchange resins in the sugar industry.

Acknowledgement

The author wishes to thank all the people who helped him during the development of his work, especially João Machado Santos for his enthusiastic assistance in the laboratory and Maria Emília Pereira and Dr. Manuel Mota for their valuable collaboration. Also Paula Cardoso and Laura Correia, who carried out the analysis for almost 300 resin cycles and to Rohm & Haas (Portugal) and Bayer (Portugal) for the resin samples supplied. Finally the author thanks RAR Administration and all RAR workers, to whom he dedicates this paper.

Appendix

Lime Test: – For coloured salt effluent from decolorization of ion exchange resins with an attenuation (at 240 nm pH 9) higher than 500.

Take 200 ml of coloured effluent solution and adjust to pH 9 with NaOH or HCl. Measure the attenuation of this solution. Make the necessary dilution to give an attenuation of 500 ± 50. Take two 100 ml portions of this solution and heat in a water bath to 60°C. To one of the portions (A) add 3 ml of a calcium hydroxide slurry [100 g/l of $Ca(OH)_2$] and to the second portion (B) add 3 ml of distilled water. Heat both solutions for 5 minutes at 60°C with gentle agitation. Remove the precipitate in (A) by vacuum filtration through Whatman filter paper No. 42. Adjust both samples to pH 9 again and measure the attenuation at 420 nm. Calculate the Lime Value (L.V.) as: L.V. = [(Attenuation B – Attenuation A)/Attenuation B] × 10.

21 Fujii *et al.: I.S.J.*, 1980, **82**, 199 - 203.
22 Williams & Bhardwaj: *Paper presented to S.P.R.I.. Conf.*, 1988.
23 McGarvey: "Ion exchange technology", Eds. Naden & Streat. (Reinhold, New York), 1984, pp. 295 - 303.

Facts and figures

Thailand sugar exports[1]

	1989	1988
	tonnes, tel quel	
Algeria	12,467	0
Bangladesh	21,964	27,554
Brunei	105	1,657
China	410,437	849,163
EEC	43,361	0
Egypt	20,182	0
Hong Kong	6,651	17,051
India	24,080	0
Indonesia	135,780	28,202
Iran	43,648	0
Japan	544,869	488,640
Korea, South	440,084	363,446
Laos	2,154	2,443
Malaysia	228,568	38,383
Mexico	12,981	0
Morocco	161,075	0
New Zealand	20,718	1,370
Pakistan	22,603	0
Philippines	0	53,261
Singapore	3,220	15,399
Sri Lanka	163,372	35,725
Syria	25,008	0
USA	14,767	12,828
USSR	694,206	0
Vietnam	2,235	3,490
Yemen, North	12,276	0
Total	3,067,160	1,942,338
Total, raw value	3,105,215	1,961,223

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S133.

CITS Scientific Committee Meeting

A Workshop of the CITS (Commission Internationale Technique de Sucrerie) Scientific Committee was held on April 10, 1990 in Neu Offstein, Germany. We give below summaries of the papers presented.

Chemical pretreatment and pressing of exhausted cossettes

K. M. Bliesener, D. Miehe and K. Buchholz *(Braunschweig Technical University, Germany)*

Chemical pressing aids have contributed considerably to the significant increase in the dry substance content of pressed pulp which has been observed over recent years. Need to bring down the costs of the drying, as well as constraints related to environmental protection require further improvement of the mechanical dewatering. Experimental work has been done on the pilot scale on the alkaline pretreatment of the cossettes. We wanted to evaluate whether and to what extent such pretreatment would enable us to rationalize and optimize the technical processes of juice extraction and juice clarification. We were particularly interested in size reduction of the required apparatus and by fuel economy. It is well known that alkaline pretreatment of the fresh cossettes with a saccharate solution allows avoidance of the transfer into the raw juice of colloidal material. This would make the preliming unnecessary and would reduce considerably the equipment required for filtration. We examined the possibility of replacing the diffusion by a single or multiple pressing of the treated cossettes. We believed such a method to be feasible since the pretreatment results into a significant improvement of the dewatering characteristics of the cossettes. The following criteria were used for evaluating the possible yields of juice extraction along those principles: the yield of sugar; the amount of press juice (draft); the quality of the press juice; the characteristics of the juice during the clarification; and the dry matter content of the pulp. We examined the following variable process parameters in order to optimize the results: the change in alkalinity during the pretreatment; the change of temperature; the amount and the repartition of the water for soaking the cossettes; and the type of press (twin screw press, piston, screen belt press and spindle press). The results which we obtained with a pilot plant proved the process to be attractive: 50% water content in pressed pulp, 98% raw juice on beet, 86.6% raw juice purity and 98-99% sugar yield.

Utilization of N.I.R. for nitrogen determination in raw juice

G. Vaccari, G. Mantovani and G. Sgualdino *(University of Ferrara, Italy)*

In the beet sugar factory, organic nitrogen, which enters the raw juice during the extraction step, unfavourably affects the processing. The Kjeldhal method is rather laborious and time consuming so that usually analysis is only occasionally carried out. The possibility of having at our disposal a rapid method which, in real time, can give the raw juice nitrogen content could allow us to evaluate better the technological quality of juice entering the process. Based on our experience of using the NIR technique for analysing various process products, calibration curves have been set up with comparative analyses by traditional methods of a certain number of raw juice samples during the 1989 campaign.

Stripping of ammonia at the Offstein factory

A. Reinefeld, C. Nähle and E. Ellerich *(Südzucker AG, Germany)*

In sugar factory waste water most of the ammoniacal nitrogen comes from the condensate. During juice purification and in the evaporators, glutamine is saponified, yielding ammonia and pyrrolidone carboxylic acid. Ammonia is stripped off with the vapours and then appears in the condensate. In a sugar factory, ammonia can be removed at the source before it appears in the waste water. This can be done by stripping of dissolved ammonia from the condensate. We carried out trials in the 1985 campaign with a pilot plant using air as the entrainment gas. The stripping efficiency depends upon the pH, the temperature and the air/water volume ratio. In the 1989 campaign a stripping plant went on-stream at the Offstein factory. The plant is designed for a flow rate of 400 m^3/hr condensate and an ammonia content of about 150 mg N per litre. Ammonia-stripping technology can be an option for the activated sludge process in a sugar factory to maintain a limited ammonia content in the treated waste water. Stripping technology would permit continuance of the aerobic treatment of the waste water by lagooning.

Extraction of sucrose and non-sugars under laboratory conditions

K. Lisik, K. Szwajcowska and H. Zaorska *(Lodz Polytechnic, Poland)*

During the extraction process, easily soluble components as well as sucrose pass from cossettes into the raw juice. It is well known that there are many factors controlling the passage of non-sugars into the raw juice. The aim of our investigation was to determine the effect of extraction time on the diffusion of sucrose and non-sugars from the cossettes into the raw juice. Extraction was carried out in a laboratory apparatus under conditions as identical as possible, except for the time, which varied from 30 to 100 minutes. It was found that after 30 minutes of cossettes extraction, 97 to 98% of the sucrose and about 90% of the total non-sugars (including 83 to 85% of potassium, 71 to 79% of sodium and almost the total amount of amino acids) passed into the raw juice. During sucrose extraction from good quality beets and within an optimal time (i.e. 60 to 70 minutes), a significant juice purification took place; the elimination efficiency was nearly 20%. In the case of beets of a poorer technological value, this efficiency was much lower and reached only about 10%.

Further experiences with plate evaporators

G. Witte *(Südzucker AG, Germany)*

Results of thermal and technological investigations which were carried out during the 1987/88 and 1988/89 campaigns at Waghäusel sugar factory of Südzucker using different plate designs were recently published[1]. Further trial runs were carried out at Waghäusel during the 1989/90 campaign using plate designs specially developed for the evaporators in the sugar industry. Essential features of the new plates are gasket-less, laser-welded steam chambers, open juice/vapour outlets and plate patterns better suited to evaporation purposes. The plate evaporator, working parallel to a Robert-type evaporator, was charged with the juice from the 5th effect (pre-evaporator). The results of our measurements are presented. The heat transfer behaviour of the plate evaporator is considerably better by comparison with the Robert-type evaporator. The increase of juice colour was clearly lower in the plate type than in the conventional evaporator.

Use of sodium bisulphite between first and second carbonatations

G. Vaccari, G. Mantovani and G. Sgualdino *(University of Ferrara, Italy)*

Unlike the technological characteristics of beet grown in the countries of Northern Europe, those in Italy generally include low purity values of juice. In particular very high colour and low alkalinity are found in thick juice. The lack of alkalinity requires the addition of large amounts of sodium hydroxide so as to maintain a sufficiently high pH value. Consequently, the use of sulphur dioxide for thin juice decolorization is very limited since more would require a further increase in the already high addition of sodium hydroxide. The possibility of adding sodium bisulphite between first and second carbonatation has been studied. By adopting this solution, it was possible to add higher amounts of sulphur dioxide as bisulphite ion. This allowed an appreciable decrease of the juice colour without increasing the sodium hydroxide consumption.

Further comments on cane sugar crystal morphology

G. Vaccari, G. Mantovani and G. Sgualdino *(University of Ferrara, Italy)*

The morphology of the cane sugar crystal and, in particular, its elongation along the c-axis have been the subject of research for many years and the role of dextrans has been pointed out. We have recently considered the influence exerted on sucrose crystal morphology by two other impurities, viz. glucose and fructose, normally present in significant amounts in cane sugar processing. With the aim of verifying a possible synergistic effect, the morphology of crystals from *A*-, *B*-and *C*-massecuites has been related to the concentration of the three impurities quoted above.

High molecular weight sugar colorant

M. A. Clarke and M. A. Godshall *(Sugar Processing Research Inc., U.S.A.)*

The importance of high molecular weight colorant (above 10,000 daltons), and its relationship to polysaccharides, have become evident in research work. Developments in studies on the nature and structure of these colorants are reported. Their origins, whether in the growing cane or beet plant, or in reactions in factory processes, are discussed.

Colour formation in white sugar during storage

R F. Madsen *(De Danske Sukkerfabrikker, Denmark)*

Sugar entering the silos at a Danish factory normally entered at a colour of around 20 ICUMSA units and was withdrawn at below 32 units. In March 1988 sugar from one silo was withdrawn at 39 - 60 ICUMSA units whereas that from another silo, filled at the same time from the same factory, was withdrawn at 25 units. Both silos were provided with air ventilation but this had been stopped in the high-colour silo, which sugar had entered at around 43°C. This was higher than in 1987 (38°C) owing to a change in the washing system in the centrifugals. Tests have been carried out on the effect of eliminating, wholly and by half, of the thin juice sulphitation. Sugar colour increased from 19 units to 30 units with halved sulphitation and to 38 without sulphitation. Examination at 100 and 160 days showed that colour increase had stabilized by 100 days, reaching around 50 units. Potassium, ash and SO_2 content of the sugar were all reduced, perhaps owing to the presence of potassium imidodisulphonate in sugar from sulphited thin juice. The sugar produced without sulphitation is not so white but is of virtually unchanged EEC points quality because of lower ash and might be suitable for a few customers although most need very low colour.

1 *Zuckerind.*, 1989, **114**, 785 - 798.

Continuous crushing introduction in Australia[2]

Up to 9 Queensland sugar factories will adopt continuous crushing in 1990 following agreement between cane growers and mill operators in the Herbert River district. Five have already converted and four more are due to by the start of the new season in June. Limitations on milling capacity are a barrier to expanded production while extending the season reduces growers incomes. In the absence of capital investment to raise milling capacity, the extra production can most easily be achieved by changing from 5-day to 7-day working.

Fiji sugar exports, 1989[3]

	1989	1988
	tonnes, raw value	
China	0	51,682
EEC	181,363	192,343
Japan	48,939	32,560
Korea, South	14,501	0
Malaysia	111,916	68,868
New Zealand	22,393	60,417
USA	25,514	8,434
Total	404,626	414,304

2 *Australian Canegrower*, 1990, **12**, (4), 6.
3 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S134.

Facts and figures

US sugar imports, 1989[1]

	1989	1988
	tonnes, tel quel	
Argentina	112,441	23,500
Australia	118,075	74,539
Barbados	7,191	7,409
Belgium	16	3,008
Belize	13,560	25,833
Bolivia	3,337	12,883
Brazil	55,991	131,078
Canada	12,785	12,567
Colombia	315,294	77,425
Congo	0	7,502
Costa Rica	16,841	19,986
Dominican Republic	286,560	197,295
Ecuador	14,248	7,214
Fiji	9,340	8,523
Gabon	396	7,503
Germany, West	108	2,065
Guatemala	59,266	71,132
Guyana	4,572	0
Haiti	7,147	7,297
Honduras	21,632	13,663
India	7,929	7,145
Ivory Coast	6,999	7,464
Jamaica	15,991	10,638
Madagascar	6,650	5,278
Malawi	9,988	9,112
Mauritius	19,228	10,532
Mexico	136,237	163,512
Mozambique	13,717	11,625
Papua-New Guinea	7,013	7,511
Paraguay	7,041	12,778
Peru	32,380	43,692
Philippines	206,950	135,581
St. Kitts	6,751	6,597
El Salvador	19,300	38,913
Swaziland	43,428	14,419
Taiwan	12,227	10,810
Thailand	15,211	8,896
Trinidad	7,200	7,791
Uruguay	8,583	5,114
Zimbabwe	21,548	10,974
Other countries	9,865	15,627
Total	1,673,130	1,259,299
Total, raw value	1,675,608	1,262,049

Fiji sugar expansion prospects[2]

The Fiji Finance Minister recently said that sugar production was estimated to increase by 28% to 465,000 tonnes in 1989 and to 500,000 tonnes in 1990.

Switzerland sugar imports, 1989[3]

Switzerland imported a total of 121,180 tonnes, raw value, of sugar in 1989, of which 3806 tonnes was raw sugar and 107,984 tonnes was white sugar. Cuba supplied 2298 tonnes of raw sugar and Mauritius 1087 tonnes, with the balance from other countries. Most of the white sugar (88,656 tonnes) came from West Germany, while France supplied 18,366 tonnes and the balance was from other suppliers.

Another reprieve for Brazilian Sugar Institute[4]

The Brazilian Sugar and Alcohol Institute (IAA) is to remain in operation for as long as six months, in spite of a decree calling for its abolition as part of the incoming government's emergency reform package. The reprieve is intended to ease unrest on commodity markets. On March 15, President Fernando Collor de Melo ordered the immediate closure of 23 government agencies, including the IAA and the Brazilian Coffee Institute. When markets reopened after a three-day bank holiday, operations were paralysed because traders lacked detailed information on how business should proceed in the absence of the two institutes. The government is to announce soon which department is to assume the IAA's present functions.

New Indonesian sugar factory[5]

A new sugar factory is to be established at Paguyaman, Gorontalo, in North Sulawesi. The factory, which will have a capacity of 4000 t.c.d., will begin its first milling season in June 1992 with an area of 3500 hectares of cane; this area is to be expanded to 7000 hectares in 1993 and approximately 10,500 ha in 1994.

Increased Peru sugar imports possible[6]

Peru plans to import 231,000 tonnes of sugar this year, but the figure could rise if drought continues in its main sugar-producing regions. Despite rising imports, Peru still has healthy stocks and guarantees it will fill its 1990 US sugar quota of 74,200 tonnes. The imports of 231,000 were calculated on normal weather conditions but the drought since early January has hurt crops in most of Peru's main sugar areas, especially in northern coastal departments of Piura and Lambayeque near the Ecuadorean border. In 1989 imports of 150,000 tonnes had been planned but strong domestic production had permitted a reduction to 117,000 tonnes.

Turkey sugar production, 1989/90[7]

Sugar production from the 1989/90 campaign was lower than anticipated owing to the worst drought for more than 30 years. Output fell to 1,270,000 tonnes, white value, 33,000 tonnes less than 1988/89, and if final stocks are to be maintained at the end of the year as at the beginning, the country will have to import up to 300,000 tonnes, raw value, of sugar. The government has decontrolled sugar supplies by allowing private companies to import.

Brazilian sugar cane technology for Iran[8]

In exchange for oil, Brazil is to provide farm and industrial machinery to Iran, together with equipment for cultivating sugar cane. The project, to be developed on a large scale, will be implemented in the province of Kurdistan.

China sugar crops reduction[9]

The sugar beet crop in China dropped in 1989 to 9.36 million tonnes, against 13.3 million tonnes in 1988. Although disappointingly low, the final figure was above earlier estimates of 7.88 million tonnes. The decline in the sugar cane crop was less pronounced, with a total of 48.57 million tonnes harvested in 1989 against 49.10 million tonnes in 1988. Cane sugar output totalled 4.96 million tonnes, an increase of 7.6% on 1988, however[10].

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S127 - S128.
2 *S. African Sugar J.*, 1990, **74**, 2.
3 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S.99.
4 *Financial Times*, March 21, 1990.
5 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 135.
6 *Public Ledger*, February 24, 1990.
7 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 144.
8 *Alcool & Açúcar*, Nov./Dec. 1989; through *GEPLACEA Bull.*, 1990, **7**, (2), Sugar Inf.-1.
9 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 148 - 149.
10 *Xinhua (China) news agency report*, March 5, 1990.

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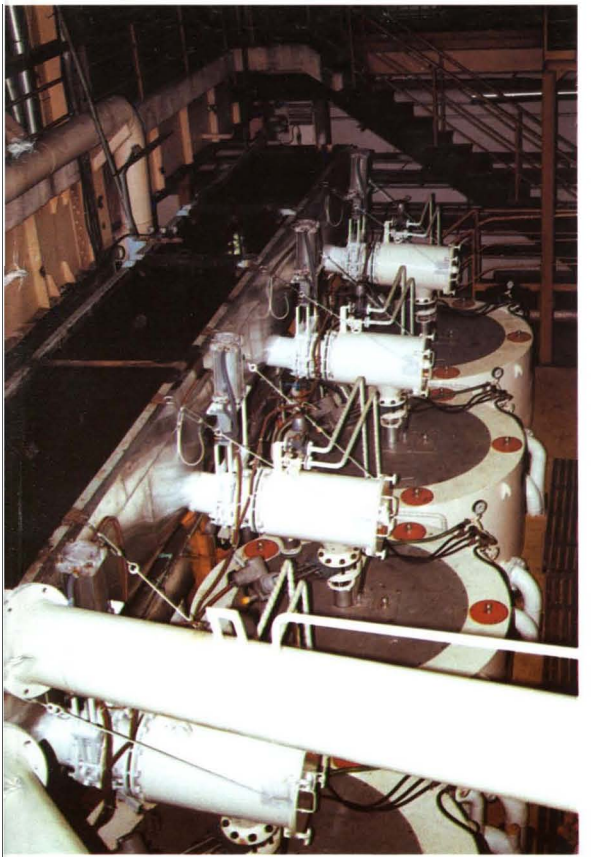

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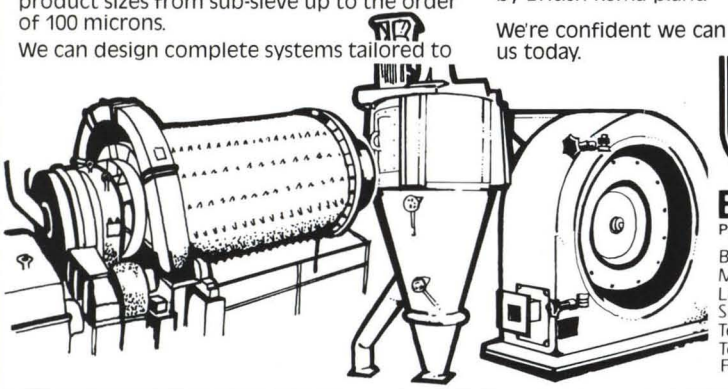

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Above photo shows

4 modern —Putsch Candle Filters

for juice thickening purposes in a sugar factory with 6.500 t/d capacity.
Each filter has a filter surface of 205 m².
Modern PUTSCH Candle Filters come in sizes between 205 m² and 255 m².

- High operating capacity
- Fully automatic operation
- Quick change device for candles

For more details ask —Putsch – an international group:

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