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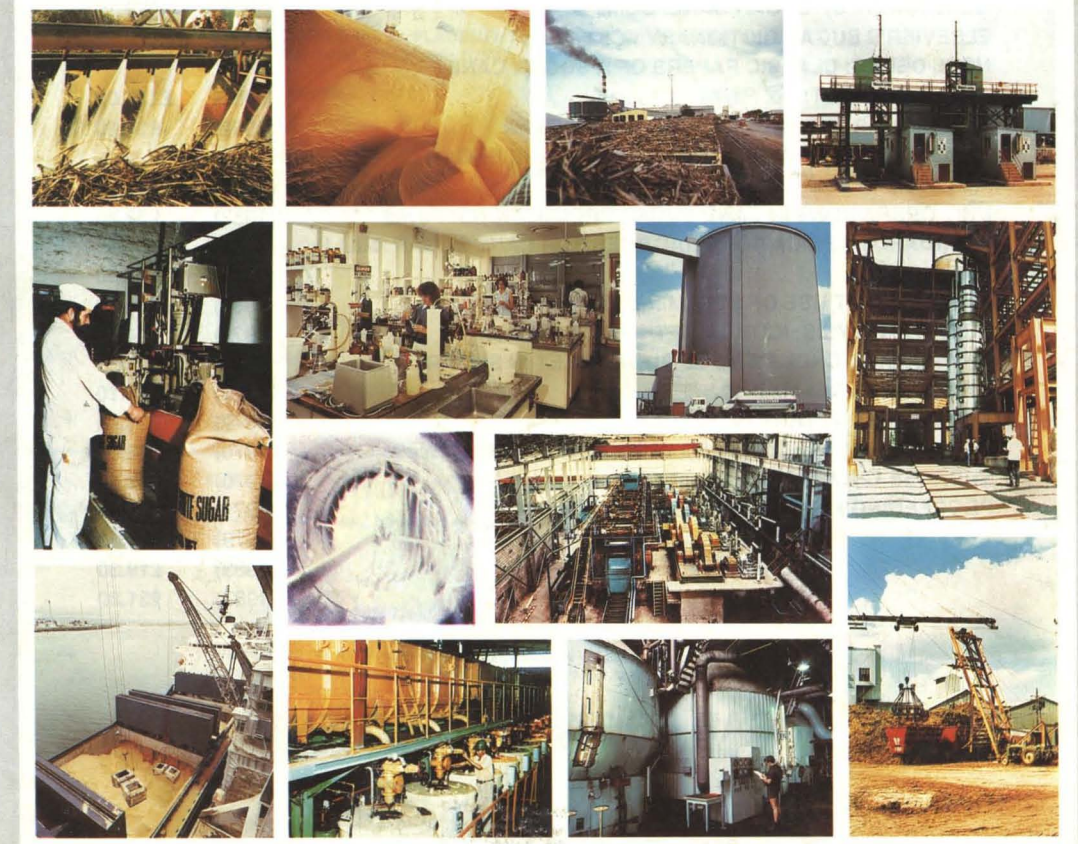

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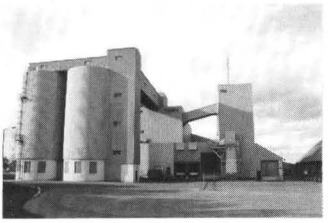

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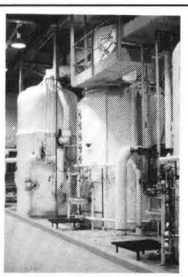

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News and views

Thailand's booming sugar industry[1]

The most striking performer among the major sugar exporters during the 1980's has been Thailand, which has nearly tripled its exports during the decade and was the world's third largest exporter in 1988/89. With a formidable combination of area expansion and yield improvements, Thai sugar cane growers and millers have more than doubled sugar production during the decade from 19.9 tonnes of cane yielding 1.7 million tonnes of sugar in 1980/81 to a record 36.0 million tonnes of cane and 4.0 million tonnes of sugar in 1988/89. Domestic sugar use for the Thai population of 55 million is around 850,000 tonnes, with a rising but still relatively low 15 kg per caput.

Thailand exported about 3 million tonnes in 1988/89, more than all countries except Cuba and the EEC. Thailand has found a growing regional market for its sugar exports, with China, Japan and South Korea taking over 90% in 1988. Recent trade reports indicate that the USSR have purchased a record 600,000 tonnes of raw sugar from Thailand in 1989. Thailand mostly exports raw sugar, but around 200,000 tonnes of white sugar goes annually to markets in East and South Asia, such as Hong Kong, Bangladesh and Sri Lanka.

The Thai sugar industry has traditionally been highly concentrated in the Central Plains. Some of the recent expansion, however, has been in the north and north-east regions of the country, spurred by investment in new milling facilities, by a revenue-sharing scheme between growers and factories, and by the government's regional development policies. The government also sets production quotas to keep supply and demand in balance and maintains relatively high domestic wholesale and retail prices to support the local sugar industry. Tax incentives are used to encourage growth of exports of sugar and sugar-containing products.

Thai sugar production and exports for 1989/90 are forecast at 3.4 million and 2.6 million, respectively, exceeded only by the phenomenal 1988/89 crop. As in 1988/89, Thailand's sugar production is likely to be an important moderating factor to a potential surge in world sugar prices. Since Thai farmers traditionally replant cane after only one or two ratoons, they can respond rapidly to higher prices. Moreover, with low production costs – 421 baht or $168 per tonne (7.6 cents/lb) last year according to the US Agricultural Attaché in Bangkok – Thai farmers have found world prices averaging more than 10 cents a pound over the past year lucrative enough to expand the cane area to a new high of 640,000 hectares in 1989/90, up 10,000 ha from last season's record.

Indian sugar production, 1988/89[2]

The 1988/89 Indian sugar season ended with a production of 8,752,000 tonnes, white value, some 360,000 tonnes down from the 9,112,000 tonnes of the previous season. However, final stocks at the end of the crop year in September, amounting to 1.2 million tonnes, were only half as much as at the same date in 1988. Sugar consumption totalled 9,936,000 tonnes, up from 9,385,000 tonnes in 1987/88. The decrease in production had been expected since March 1989, when for the first time it was noticed that the yield of plant cane was lower by 15-20%, causing large-scale diversion of the crop to gur and khandsari manufacture.

In view of the tight supply situation, the government encouraged sugar factories to start early in the current season by announcing an incentive scheme which provided for higher free sale entitlements (80% *vs.* the normal 55%) on additional production achieved up to November 15 above the average output of the corresponding period in preceding seasons. The scheme was not very effective, however, partly because factories were unable to start because of bad weather, particularly late rains. It was thought that production in the period might have reached 550,000 tonnes against 295,000 tonnes in 1988.

The area under sugar cane is reported to be 3-4% up on the previous crop and it is hoped that the sudden decline in cane yield will not be repeated in 1990. With normal conditions, the cane crop could reach 210 million tonnes against 198 million tonnes in 1988/89. The sugar outturn will depend largely on the amount of diversion of cane to gur and khandsari but is initially placed at about 9 million tonnes, white value, marginally higher than 1988/89. If this were reached, India would still require to import about one million tonnes to meet consumption even if there were no rise in consumption. To provide a reasonable carryover stock would require imports to reach 1.5 million tonnes.

Pakistan sugar expansion policy[3]

During the seventh five-year plan period in Pakistan (1988/93), demand has been projected to increase at some 6% per annum which, if borne out, would result in internal demand reaching some 2.5 million tonnes in white sugar terms by the end of the plan. A high population growth of 3% per annum is expected to combine with increasing urbanization, changes in the eating habits of the rural population, rising industrial usage and a government policy of maintaining relatively free availability of supply.

To meet this expected additional requirement of some 700,000 tonnes over the next five years, the government in Pakistan has made provision to establish a fund of 700 million rupees ($33.2 million). There is also a program of research in various experiment stations in different regions to improve cane yields and extraction rates although there has been criticism that the knowledge gained has not been communicated effectively to farmers.

There is also a government excise duty charged on sugar production at Rs. 2.15 per kilo. In past seasons new sugar

1 *USDA Sugar and Sweetener Situation and Outlook Rpt.*, September 1989, 6.
2 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 543 - 544.
3 *Czarnikow Sugar Review*, 1989, (1791), 165.

factories have been exempted from half of this charge. A shift in emphasis has been initiated in the 1989/90 budget, however. The 50% exemption for new factories in the first two years of operation has been withdrawn and instead all factories will benefit from a complete exemption of excise duty for that portion of their production which exceeds the average performance in the two preceding financial years.

Since the industry is deregulated there are no restrictions on setting up new sugar factories, although there is some concern that without demarcation and distance limits the building of new factories too close to existing operations would damage the efficiency of established facilities. There has been a policy of encouraging local industry to supply equipment and machinery for sugar factories and some 70% is supplied from local sources. There is a concessional rate of 6% from the banks for financing locally manufactured machinery, and the financial sector has been directed by the Government to continue financing, both for the expansion of existing factories and also for building of new factories at the prevailing debt:equity ratio of 60:40.

Eastern Europe and the sugar market

The pace of political change in Eastern Europe over the past year has been breathtaking and has the potential for considerable effect on the structure of the world sugar market. So many countries have up to now had their agriculture and industry subjected to central planning which has proved highly inefficient; the introduction of market economics is certain to bring about benefits in production of goods for which the population have called, including sugar, while Western nations have shown alacrity in seeking to provide expertise in management and modern equipment.

The consequence could be a marked change in production patterns in Eastern Europe and much less reliance on, for instance, imports from Cuba as well as the world market. The USSR could even become an exporter of sugar, were its full potential as a sugar producer to be realised. Cuba might have to seek other outlets for its sugar as would countries which have been selling to the USSR. Of course, this will not happen overnight, but observers will no doubt watch closely developments over the next few years.

EEC sugar industry development prospects[4]

While the completion of the Common Market by 1992/93 may lead to regional shifts in sugar demand, the overall market is not likely to expand or diminish as there is very little incentive to increase production capacity within the European Community. Since 1981/82 total daily slicing capacity has remained almost unchanged at 1.3 million tonnes; what has changed is the size of the typical sugar factory. While in 1973, when total slicing capacity was around 950,000 tonnes/day, 76% of all factories had a slicing capacity of less than 5000 tonnes per day, in 1988/89 that figure was down to 29%.

As capital investment for sugar production is very high and returns depend upon market conditions, energy costs, etc., with little chance of utilizing this equipment for other purposes, the flexibility in sugar production capacity is determined by the length of the production campaign. In 1981/82 the Community produced 15.0 million tonnes of sugar while in the following 1982/83 campaign production was down to 13.9 million tonnes. In other words, currently installed production capacities can easily put out an additional 1 to 2 million tonnes.

In the most important areas of sugar production, factories are up to current technical standards so that rationalization reserves may not be very large. In fact, tighter environmental legislation may very well affect production capacity negatively. But, overall, European sugar production, given the necessary beet area, can and will run between 12 and 14 million tonnes for the next few years.

The exact level will obviously depend to some extent on the predictions for world market prices as well as on the eventualities of a good or a bad crop year. But even a continuation of high world market prices is not very likely to stimulate additional plant investment or a significant increase in beet area. For the farmers, the most important factor for deciding whether or not to plant sugar beet will be the price expectations for other agricultural products.

Future Cuban sugar production[5]

The Cuban President, Fidel Castro, has said that Cuba could produce up to 11 million tonnes of sugar annually within the next five years, as compared with the present production of about 8 million tonnes, raw value. According to a report on Cuban television, Castro said that this increase in production would be achieved as a result of increasing the area under irrigation. In 1989, irrigation was applied to 20,000 hectares under sugar cane, leading to an increase in sugar output of 80,000 tonnes, while in 1990, irrigation will be used on 60,000 hectares, thereby yielding an additional 240,000 tonnes.

Castro added that the extension of irrigation to the entire area under sugar cane would produce 2.5 million more tonnes of sugar annually. He also referred to the desirability of achieving a yield of 85 tonnes per hectare, which would realise annual sugar production of 13.5 to 14 million tonnes.

However, the Cuban President noted a number of problems within the sugar industry. In particular, when Cuba was expanding and developing its sugar factories and refineries, there was hardly any building of irrigation systems. This had meant that Cuba was not meeting its full potential as a sugar producer, said Castro. He also referred to a lack of spare parts in the industry, as well as the severe drought during the last crop.

4 Fleck: F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 565 - 568.

5 *Prensa Latina*, December 22, 1989.

Optimization of low-grade crystallizer performance

By Michael Saska
(Audubon Sugar Institute, Louisiana Agricultural Experiment Station,
Louisiana State University Agricultural Centre, Baton Rouge, LA 70803, USA)

Introduction

The introduction in the sugar industry of new types of crystallizers, most notably those of vertical design with high-efficiency cooling systems[1-6] represents a new challenge to develop guidelines for their most efficient use. Among their advantages are[1]: (a) small floor space requirements and a possibility of outdoor installation, (b) high efficiency of cooling, (c) ease of automatic control, (d) good flow patterns with little or no dead volume and short-circuiting, (e) capability to handle high-viscosity massecuites and (f) low cost. As to the practice of low-grade cooling, in the words of Culp[7] "many 'rules of thumb' have been published by our better known technologists with very little scientific work done up to date". In particular, questions remain concerning the optimum massecuite composition at the crystallizer inlet, in terms of Brix and purity (i.e. two variables that can easily be manipulated in the vacuum pans), the rate of cooling in the crystallizers, final temperature of the massecuite, etc.

The rate of cooling especially has been a subject of frequent and contradictory statements. Payne[8] recommends cooling as rapidly as physically possible, quoting experience with cooling at 3°C/hr in a crystallizer with 1 m^2/m^3 heat transfer area that did not present any danger of nucleation. This was supported by Foster *et al.*[9] but contradicted recently[1] by Hugot arguing for cooling not faster than 1°C/hr with an initial period of 1 to 2 hours of no water cooling at all. Despite the well known differences in composition, it is interesting to note the recommendations of beet sugar technologists. Thus, Wagnerowski[10] on theoretical grounds and Nielsen & Klein[2] from practical experience on full-scale equipment recommend initial rapid cooling (5 and 3°C/hr, respectively) followed by cooling at an exponentially declining rate[10]. Pilot-plant trials at DDS[2] showed that no nucleation occurred even at a rate of 10°C/hr.

It has been recognised for some

M. Saska

time that the basis for optimizing the process must be knowledge of the kinetics of sucrose crystallization under conditions of low purity. It is well documented that, for sucrose, because of its high solubility and the high viscosity of its aqueous solutions, the crystallization rate R first increases with rising supersaturation σ, reaches a maximum and then declines at even higher levels of supersaturation. While in high-purity sucrose solutions the values of supersaturation corresponding to the maxima are unattainable since nucleation sets in long before, at high impurity levels the R maxima occur at moderate values of σ and are of practical importance in the industry.

The concept of optimum cooling, where the temperature T(t) is a locus of the maxima of a series of R(T) curves of descending C_s values has been frequently invoked in the literature[11-14] but its full implementation has been hindered by lack of reliable kinetics data that would cover the full range of conditions encountered. This is a prerequisite since any extrapolation of the data beyond the experimental range is questionable owing to the highly non-linear character of the solution viscosity and growth rate kinetics functions.

We have recently[15] measured the crystallization rate of sucrose from impure cane sugar solutions up to the C_{imp} values of 4.8 and a growth rate equation (Figure 1)

$$R(\mu/min) = 52.7\ v^{-(4.74/Cimp)\sigma} \qquad (1)$$

was found to fit adequately the data as

1 Hugot: "Handbook of cane sugar engineering" (Elsevier, Amsterdam) 1986, p. 752.
2 Nielsen & Klein: *Proc. 17th Gen. Assembly CITS*, 1983, 649 - 670.
3 Genotelle *et al.*: *I.S.J.*, 1977, **79,** 64 - 67, 96 - 100.
4 Austmeyer: *Zuckerind.*, 1985, **110,** 875 - 883.
5 Dunker: *ibid.*, 1982, **107,** 296.
6 Matusch: *ibid.*, 1987, **112,** 274.
7 *Proc. Sugar Processing Research Conf.*, 1982, 87.
8 in "Principles of sugar technology" Vol. II, Ed. Honig. (Elsevier, Amsterdam) 1959, p. 503.
9 *Proc. 25th Conf. Queensland Soc. Sugar Cane Tech.*, 1958, 179.
10 *Ind. Alim. Agric.*, 1983, **100,** 463.
11 Maurandi & Mantovani: *Sucr. Belge*, 1979, **83,** 389.
12 Schliephake: *Zucker*, 1966, **19,** 219.
13 Maudarbocus & White: *Proc. Australian Soc. Sugar Cane Tech.*, 1978, 45.
14 Saska: in "Industrial crystallization '87". Eds. Nyvlt & Zacek (North-Holland, Amsterdam), in press.
15 Saska & Oubrahim: *I.S.J.*, 1989, **91,** 109 - 116.

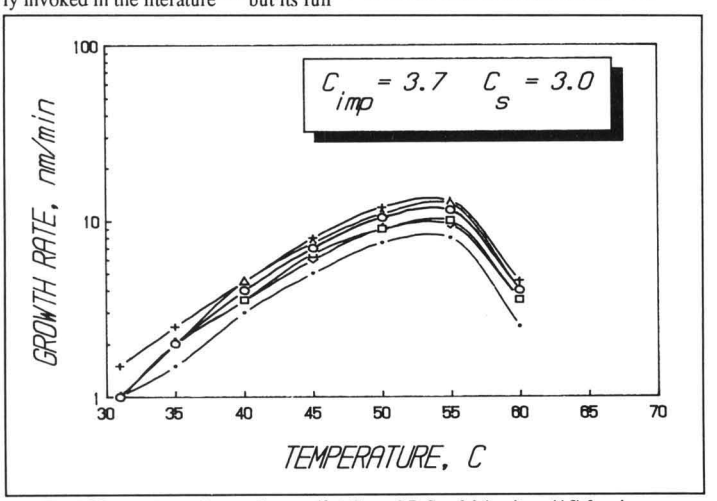

Fig. 1. Measured growth rate of sucrose[15] at C_{imp} = 3.7, C_s = 3.0 (purity = 44.8) for nine experimental runs; saturation temperature approx. 61°C

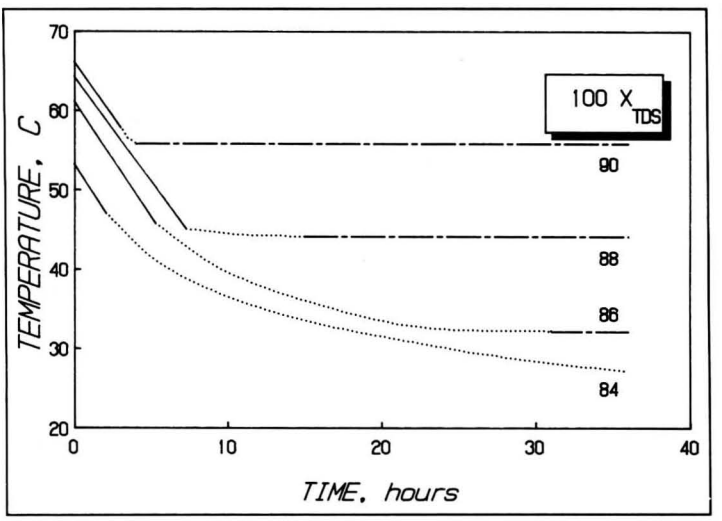

Fig. 2. Calculated constrained optimum cooling (COC) profiles for four massecuites of X_{TDSo} = 0.84, 0.86, 0.88 and 0.90. (C_s/C_{TDSo} = 0.46. All other parameters are in Table I.) COC cooling calls first for cooling at the maximum rate (cooling rate control region), then cooling is carried out such that the crystal growth rate R is at its maximum (crystallization rate control) followed by nearly constant temperature when the viscosity controls. Solid line = cooling rate control, dotted line = growth rate control, dashed line = viscosity control

well as our previous measurements[16] done at medium purities (C_{imp} from 2 to 3). Considering the sparsity of published data, equation 1 is believed to be the most reliable and also sufficiently accurate and general to cover the whole range of purities encountered in low-grade cane sugar crystallization.

In this communication we wish to illustrate the use of the crystallization kinetics data in modelling the performance of low-grade crystallizers as well as in determination of process parameters that lead to maximum molasses exhaustion. We will first review the concept of optimum cooling and the use of mass balance to describe the crystallizer operation. Equation 1 is then used to solve numerically the appropriate set of equations, subject to realistic limitations, that describe the system. The results are used to identify the operational parameters that maximize the crystallizer performance as well as to comment on some design aspects of the crystallizers. The manipulable parameters that are investigated are the massecuite Brix and purity, and its crystal content. While Brix value can easily be manipulated in the vacuum pan, its purity has to be considered in conjunction with the overall boiling scheme. Even though the data used, i.e. the crystallization kinetics equation, solubility and viscosity were either derived or at least verified under Louisiana conditions, it is believed that the conclusions are of general nature.

Mathematical description of the crystallizers: Optimum cooling

The mass balance on sucrose in a batch crystallizer with feed and solvent removal (water evaporation or dilution) leads to a first-order non-linear differential equation

$$(d/dt)\,[m_w(C_s + W)] = fX_w' C_s' \qquad (2)$$

that can be solved numerically for a given set of initial conditions and a set

16 Saska & Garandet: *AIChE Symposium Series*, 1987, 42.
17 Awang & White: *Proc. 43rd Conf. Queensland Soc. Sugar Cane Tech.*, 1976, 263.
18 Broadfoot: *Proc. Australian Soc. Sugar Cane Tech.*, 1984, 279.
19 Brotherton *et al.*: *Proc. 17th Congr. ISSCT*, 1980, 2297.
20 Kirby & White: *Proc. 45th Conf. Queensland Soc. Sugar Cane Tech.*, 1978, 53.
21 Lionnet & Rein: *Proc. 17th Congr. ISSCT*, 1980, 2328.

Table I

Parameter	*Value*	*Reference/Comments*
F_1 (eq. 2)	$52.7\ v^{-(4.74/Cimp)}$	15
F_2 (eq. 8)	$0.25 + 0.19\ C_{imp}$	15, for $C_{imp} > 3$
F_3 (eq. 9)	$0.11\ (X_s/X_{TDS}) - 1.3\ \exp[3.7\ (X_{TDS} - 0.19)\ (T - 50)]/\{113.5 - [100X_{TDS} - 0.19\ (T - 50)]\}$	17
F_4 (eq. 10)	10^E where $E = 1.65\ v\ cr\ L^{0.15}$	17
CR_{max}	3°C/hr	2, 8, 9, 21
V_{max}	2000 Pa.s	18, 19, 20
f, e, n	zero	No feed, no evaporation, no nucleation
L_o	0.225 mm	
cc_o	35.6%	
Residence time in crystallizers 36 hours		

of complementary equations describing the system and its physical properties:

$$m_w = m_{wo} + (fX_w' - e)t \quad (3)$$

$$dW/dt = g + n = 6\alpha N\rho L^2 R + n \quad (4)$$

$$R = F_1(\sigma, T, C_{imp}, \ldots) \quad (5)$$

$$\sigma = (C_s/C_{seq}) - 1 \quad (6)$$

$$C_{seq} = -SC/(1 - 1/X^{\circ}_{seq}, \ldots) \quad (7)$$

$$SC = F_2(C_{imp}, C_{RS}/C_{ash}, \ldots) \quad (8)$$

$$v = F_3(T, X_{TDS}, C_{imp}, \ldots) \quad (9)$$

$$V = F_4(v, cc, \ldots) \quad (10)$$

$$T = F_5(t) \quad (11)$$

The design of modern crystallizers minimizes the deviations from an ideal plug-flow[2,5] so that the previous equations are equally valid for continuously operated crystallizers (at steady-state) with x(A/F) substituted for time, t. The solution gives the sucrose concentration, purity, supersaturation, etc. at all times including the end of crystallization. Optimum cooling is defined as a temperature profile T(t) for which the temperature at all times is such that the growth rate is always at its maximum (for example, at the composition in Figure 1, this temperature is 54°C). If optimum cooling is to be determined, an additional equation

$$dR/dT = 0 \quad (i)$$

arises that is used instead of equation 11. Because the growth rate R(T) is a function without a minimum (Figure 1), at least within a reasonable range of temperatures, the usual second derivative condition is not necessary here for defining a maximum. Further constraints have to be imposed on the solution of equation 2 to account for the restrictions of the crystallizers, most notably the cooling rates that are achievable and, at the same time, do not lead to spontaneous nucleation and the maximum massecuite viscosity that can still be accommodated in the process; either in the crystallizers, pumps or centrifugals,

$$-dT/dt < CR_{max} \quad (ii)$$

and

$$V < V_{max} \quad (iii)$$

Even though these limits are specific for each installation, the constraints in Table I are believed to be realistic for the equipment prevailing in the industry.

Solution

The set of equations (2) to (iii) was solved numerically with the explicit Euler-type integration where the solution $C_s(t_i + h)$ at time $t_i + h$ is approximated as

$$C_s(t_i + h) = C_s(t_i) + h\,(dC_s/dt) \quad (12)$$

and where the differential dC_s/dt, given by equation 2, is evaluated at time t_i. The accuracy and stability of the solution require a small time step h, proportional to 1/R. A time-variable step

$$hR = 0.05 \text{ micrometres} \quad (13)$$

was found to give a stable solution of sufficient accuracy while minimizing the computation requirements. At each time step the temperature is calculated iteratively such as to satisfy equation i (where the differential is calculated from equation 5) unless one or both of the other limits is violated. If so, the temperature is calculated so as to just satisfy the most restrictive condition, i.e.

$$T(t_i + h) = T(t_i) - hCR_{max} \quad (14)$$

or

$$V[T(t_i + h)] = V_{max} \quad (15)$$

Results and discussion

Three regions that correspond to the three constraints (i), (ii), and (iii) are distinguished on the calculated (constrained) optimum cooling curves (COC) in Figure 2. First, the cooling is carried out at the maximum rate (3°C/hr) for a length of time that depends on the massecuite composition. Then, a period of time exists when the growth rate is at its maximum (condition i) followed by a period of nearly constant temperature when the massecuite has reached its limiting viscosity (condition iii). Here and in the following it is assumed that crystallization starts at a temperature that gives maximum R at the given (initial) composition. This is to avoid either undersaturation or too high supersaturation at some combinations of X_{TDSo} and $(C_s/C_{TDS})_o$ (total dissolved solids and purity), that would occur if the initial temperature was taken as constant, e.g. 70°C. All other parameters used in these and consequent runs are listed in Table I. In Figures 3 - 8 the results of 400 runs are summarized where the initial parameters X_{TDSo} and $(C_s/C_{TDS})_o$ of the mother liquor at the start of cooling crystallization are plotted on the horizontal axes and a parameter of the liquor or massecuite (purity, temperature, viscosity, etc.) at the end of cooling on the vertical axes. Naturally, of immediate importance is the plot of final molasses purities (Figure 3). Here, we are looking for such composition of initial massecuite that will give us, for a given type of molasses and a given crystallizer station described by the parameters of Table I, a minimum purity of the final molasses. The minimum of $(C_s/C_{TDS})_f$ of around 0.37 occurs at X_{TDSo} of 0.855 and is only slightly dependent on the purity of the initial massecuite. This, of course, is a consequence of the retention time in, or capacity of, the crystallizers which is sufficient for the massecuite to reach near equilibrium over a large range of the initial parameters (Figure 4).

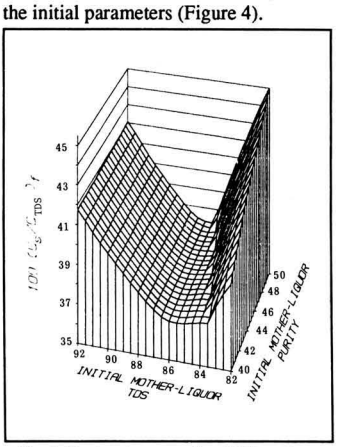

Fig. 3. Final molasses purity, COC cooling. Minimum at X_{TDSo} of about 0.855, nearly independent of the initial massecuite purity. At high X_{TDSo}, viscosity controls; at low X_{TDSo}, crystallization kinetics control

The minimum (Figure 3) of molasses purity lies between the regions of viscosity control at $X_{TDSo} > 0.86$ and a region at $X_{TDSo} < 0.84$ where the exhaustion is limited by the rate of crystalliz-

ation of sucrose. At the crystal content of 35.6% used in these calculations, X_{TDSo} of 0.855 corresponds to the TDS content of the massecuite of 90.7% or refractometric Brix of about 94.0%. Any deviation from the optimum Brix will lead to an increase in the purity of the final molasses. The slopes of the final molasses surface (Figure 3) that are nearly constant at $X_{TDSo} > 0.875$ and $X_{TDSo} < 0.855$ indicate that for each point increase in the Brix value of the initial mother-liquor (or about 0.6 points of the massecuite Brix) the final molasses purity will increase by about 1 point. For each point below optimum the final molasses purity rise will be almost twice as much (1.8).

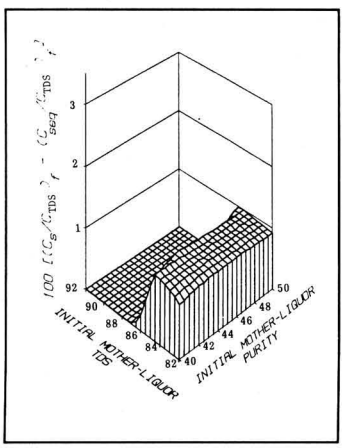

Fig. 4. Approach of the final molasses purity to equilibrium under conditions of COC cooling. Equilibrium is reached at high X_{TDSo}, where the viscosity controls. Equilibrium is not reached in the crystallization kinetics regime, at low X_{TDSo}

The approach to equilibrium is documented in Figure 4. The difference between the actual and the equilibrium molasses purity (at the same C_{imp} and T_f, the end-temperature) is plotted on the vertical axis. The equilibrium is reached in the viscosity-controlled zone where the end-temperature T_f is high (Figure 5). At the optimum value of X_{TDSo} of 0.855, the excess purity of about 0.3 corresponds to an undercooling of only about 1°C and any re-heating before the centrifugals is therefore likely to result in undersaturation. The losses may be reduced, however, by keeping the re-heating period short[9].

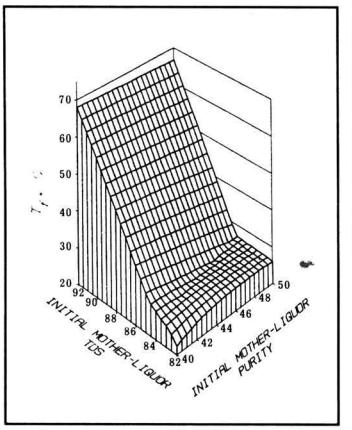

Fig. 5. End-temperatures in the crystallizers, COC cooling. Range of 28 to 33°C at the optimum X_{TDSo} of 0.855, depending on the initial magma purity

The end-temperature is a crucial parameter in molasses exhaustion and is, as expected, an increasing function of the massecuite Brix (Figure 5). With a crystal content of 35.6%, the values of X_{TDSo} of 0.82, 0.84, 0.86, 0.88, 0.90 and 0.92 correspond respectively to the approximate refractometric Brix values of the massecuite of about 91.4, 92.8, 94.2, 95.6, 96.9 and 98.2. The minimum purity that was found from Figure 3 to lie at $X_{TDSo} = 0.855$ or a massecuite Brix of around 94.0%, regardless of the initial purity, corresponds to end-temperatures between 28 and 33°C with lower values required for massecuite of higher initial purities. This range of end-temperature is considerably lower than the temperatures encountered in the industry that rarely go below 40°C. Thus this is in qualitative agreement with observations that better exhaustion correlates with lower end-temperature[22]. Occasional objections from the industry to lowering the temperature below 40°C and a frequent need in the crystallizers to dilute the massecuite is an indication that the Brix of industrial massecuite is frequently above the optimum level. The

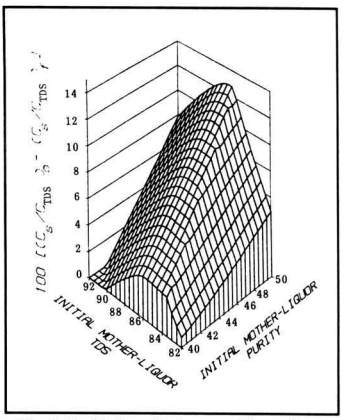

Fig. 6. Purity drop in the crystallizers, COC cooling. Maxima occur, for every initial purity, at the optimum value of X_{TDSo}, 0.855, where the utilization of the crystallizer is highest

overall purity drop in the crystallizers and the final massecuite viscosity are plotted in Figures 6 and 7, respectively. We see that, at the optimum level of X_{TDSo} of 0.855, the crystallization is carried out such that the viscosity limit just becomes active at the end of crystallization. This is also obvious from Figure 2.

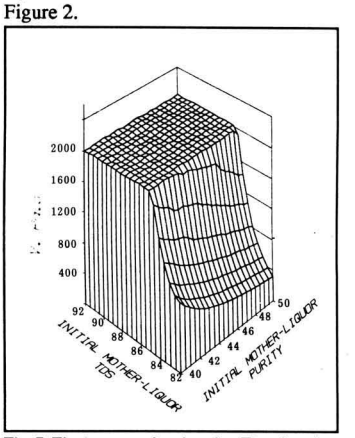

Fig. 7. Final massecuite viscosity. The viscosity constraint becomes just active at the optimum level of X_{TDSo}, 0.855

The viscosity of the mother-liquor (final molasses) compensates for the increased final crystal content and is

22 Birkett & Stein: *Proc. Audubon Sugar Institute 8th Annual Industrial Seminar*, 1988, 19.

about half (200 Pa.s) at the initial $(C_s/C_{TDS})_o$ of 0.5 as compared with $(C_s/C_{TDS})_o$ of 0.4 (Figure 8). The overall purity drop which increases almost linearly with $(C_s/C_{TDS})_o$, would be expected to level off at even higher purities, when the crystallizer capacity would become insufficient to handle the load.

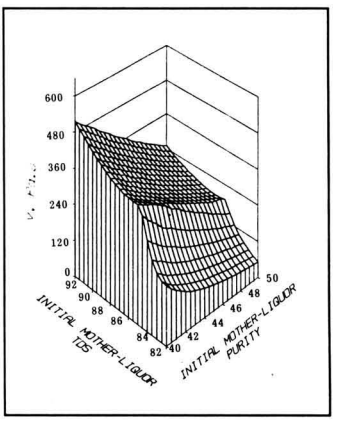

Fig. 8. Final molasses viscosity, COC cooling

The effect of crystallizer capacity is analysed in Figures 9, 10, 11 and 12. Here, the parameters from Table I were used with the exception of the retention time, which was varied between 10 and

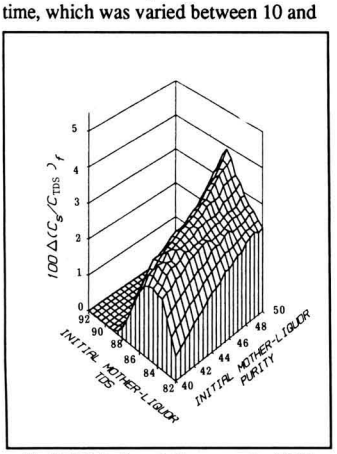

Fig. 9. Effect of crystallizer capacity, COC cooling. Final molasses purity differential in a 10-hour retention time crystallizer relative to a 50-hour retention time crystallizer. Highest loss occurs at the optimum operational parameters

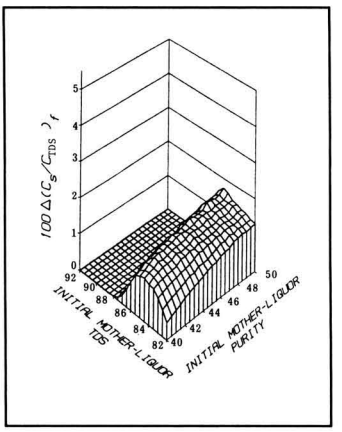

Fig. 10. Effect of crystallizer capacity, COC cooling. Final molasses purity differential in a 20-hour retention time crystallizer relative to a 50-hour retention time crystallizer

50 hours. The final molasses purity differences are plotted for retention times 10, 20, 30 and 40 hours while the 50 hour purity is taken as the basis value. It should be noted that purity loss from insufficient crystallizer capacity is highest at the optimum massecuite composition, X_{TDSo} of 0.855 or the massecuite Brix of 94.0%. This, of course, is a consequence of the fact that the utilization of the crystallizer and the

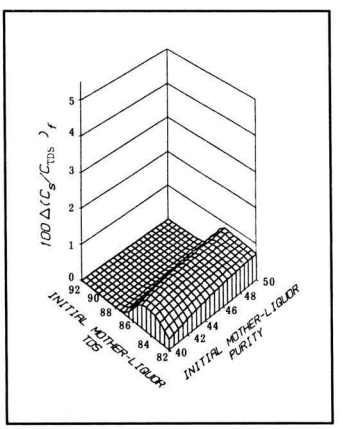

Fig. 11. Effect of crystallizer capacity, COC cooling. Final molasses purity differential in a 30-hour retention time crystallizer relative to a 50-hour retention time crystallizer

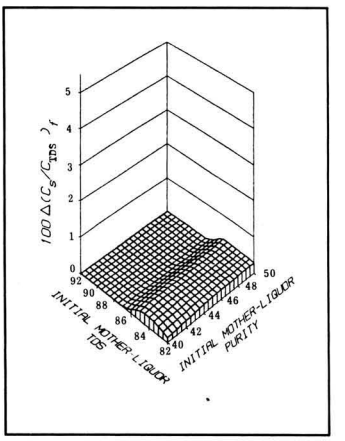

Fig. 12. Effect of crystallizer capacity, COC cooling. Final molasses purity differential in a 40-hour retention time crystallizer relative to a 50-hour retention time crystallizer

purity drop (Figure 6) are highest and that measurable exhaustion/crystallization proceeds for the longest time. For very heavy massecuites, at the high X_{TDSo} end, the (constrained) optimum end-temperature is high (Figure 5) and crystallization (and cooling) is complete within a few hours. Any expansion of the crystallizers under these circumstances will not contribute to increasing exhaustion. Even though a complete analysis must include economic aspects of the sugar production as well as the capital and operating costs of the crystallizers, it appears that little can be gained from retention times longer than 50 hours.

The crystal content of the massecuite, which can be manipulated by e.g. pre-centrifugation, effects both the viscosity [and, when its limiting value is fixed as in equation (iii), the maximum value of X_{TDSo}] as well as the overall mass crystal growth rate. One would intuitively expect that any gain that may be derived by working at lower initial crystal content and therefore at higher X_{TDSo} can only be realized when the capacity of the crystallizers is sufficient. When the purity of final molasses is plotted against the initial crystal content at such X_{TDSo} values at which it is at its

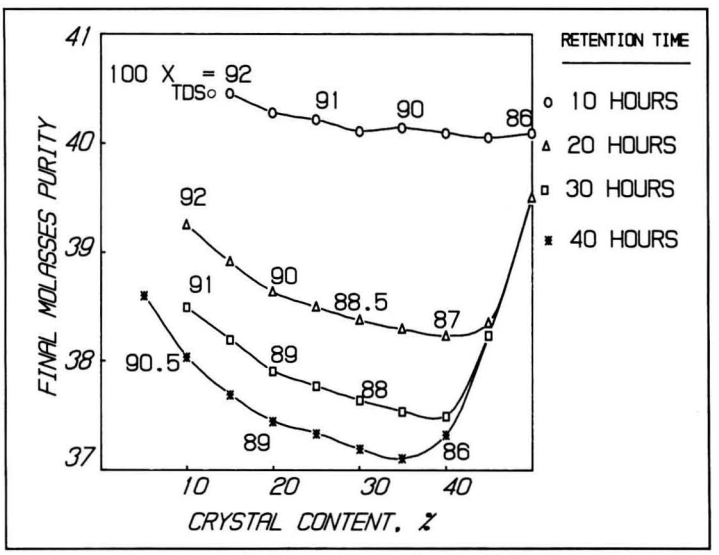

Fig. 13. Effect of crystal content, for four crystallizer holding times (10, 20, 30 and 40 hours); COC cooling. The optimum level of crystal content depends on the crystallizer capacity, and lies between 35 and 45%. The numbers at some of the points give the X_{TDSo} values resulting in the lowest final molasses purity for that particular crystal content and retention time

minimum, the lowest values are found at crystal contents between 35 and 45%, with the lower values for larger capacity crystallizers. The plot in Figure 13 corresponds to cross-sections of the surface from Figure 3 at $(C_s/C_{TDS})_o = 0.5$ (parallel to the X_{TDSo} axis) at various crystal contents and retention times.

Note

All the computer programs developed in the course of this work, which determine the constrained optimum cooling regime and simulate the crystallizer operation for a given, imposed cooling profile (equation 11) or the calculated optimum cooling are available from the author in either BASIC or FORTRAN versions for IBM-compatible mainframe or personal computers.

Acknowledgments

The continuous support of the American Sugar Cane League is gratefully acknowledged.

Nomenclature

A	free crystallizer cross-section, m^2
C	concentration, kg/kg water
cc	crystal content, kg/100 kg massecuite
cr	crystal content, m^3 crystal/m^3 mother-liquor
CR	cooling rate, °C/sec
e	evaporation rate, kg/sec
f	feed rate, kg/sec
F	volumetric flow of massecuite, m^3/sec
g	mass crystal growth rate, kg/kg water/sec
h	integration time step, sec
L	characteristic length of the crystal, m
m	mass, kg
n	nucleation rate, kg/kg water/sec
N	number of crystals, 1/kg water
R	linear crystal growth rate = 0.5 (dL/dt), m/sec
SC	solubility coefficient = C_s/C_{seq}
t	time, sec
T	temperature, °C
TDS	total dissolved solids, kg/100 kg
x	position in the crystallizer, m
X	concentration, kg/kg solution
v	mother-liquor viscosity, Pa.s
V	massecuite (suspension) viscosity, Pa.s
W	crystal content, kg/kg water
α	volume factor = 0.36
σ	supersaturation = $(C_s/C_{seq}) - 1$
ρ	crystal density; kg/m^3

Subscripts

eq	equilibrium
imp	impurity
max	maximum
o	initial
f	final
RS	reducing sugars
s	sucrose
TDS	total dissolved solids
w	water

Superscripts

o	pure water solution ($C^o_{imp} = 0$)
′	related to the feed

Summary

Constrained optimum cooling (COC) was defined as the optimum cooling limited by the cooling rate and massecuite viscosity that can be achieved and handled in the process. Although these must be evaluated for each specific installation, values believed to be representative were used to calculate the COC profiles for a wide range of massecuite parameters. It was found that at the initial mother-liquor total solids content of 85.5, corresponding to a massecuite Brix of around 94.0, the final molasses purity is at its minimum. Any deviation from the optimum massecuite Brix will result in a significant increase of the final molasses purity. It is estimated that for each 0.6% massecuite Brix above and below the optimum level, the final molasses purity will rise by about 1.0 and 1.8 points, respectively.

The final COC temperature, for optimum massecuite parameters, is around 30°C, i.e. significantly lower than the actual industrial practice. This supports industrial observations that lower end-temperatures correlate with lower final molasses purities but also,

ISJ Abstracts

Cane sugar manufacture

Expert systems - possibilities and applications in the raw sugar industry

L. J. Watson. *Proc.11th Conf. Australian Soc. Sugar Cane Tech.*, 1989, 258 - 262.

An expert system is a computer program that gives responses to particular problems similar to those which an expert would give. It works by consulting a set of rules and applying only those rules that are needed for a required solution to be reached. Possible application of expert systems to the sugar industry is demonstrated by the example of pan boiling scheduling.

Stone separation

J. F. R. Rivalland. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 80 - 88 *(French)*.

Modifications to the cane feeding system at Pente Sassy factory in Réunion are discussed. Initial alterations included adjusting the elevator slope from 60° to 40° from the horizontal and moving the carding drum more towards the 1st feeding table in order to improve cane distribution on the elevator. However, the gap between the end of the cane carrier and the cane knives was too narrow, so that cane and stones followed the same trajectory and were not adequately separated. A 2nd (short) carrier was then installed at a slope of 50° between the end of the 1st conveyor and the knives; the gap between the two carriers of 1500 mm (guide wheel centre-to-centre) was sufficiently small to allow both cane and stones to reach the second one after which the cane continued its upward path while the stones fell back and dropped through the gap. The slope of the 2nd carrier was crucial to the separation efficiency; had it been shallower more stones would have reached the knives, and had it been steeper a substantial part of the cane blanket would have been lost with the stones. A similar scheme of modifications for existing inclined carriers is suggested, and a system at Bois Rouge which is basically the same as that at Pente Sassy is described as well as a scheme at Savanna based on a Cuban arrangement.

Cleaning and densification of cane

A. Duval and I. Dufour. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 89 - 100 *(French)*.

Cane wet cleaning is not appropriate to Réunion because the extraneous matter does not contain much earth and stones and because the costs of sugar manufacture are so high that losses in washing are to be avoided. A dry cleaning station of a type used in Cuba is described that was tested at Savanna factory. The cane stalks are dumped by grapple on the feeding table at the end of which a tumbler transfers them to another table (placed at right angles to the first); a 2nd tumbler at the end of this throws the material onto two parallel conveyors (also placed at right angles to the table), the one nearer to the table receiving stones and fragments of cane (which are discharged into a chute at the end of the parallel conveyors) while the stalks (because of their greater density) are thrown to the other conveyor. Fans on each side of the conveyors at the point where the stones are discharged blow air onto the cane stalks to remove a large part of the leaf trash; the stalks continue along a single conveyor to the knives whence the 30 cm billets are conveyed to road trucks. Two more fans remove the rest of the leaf trash. The hourly capacity of the plant (which employs four operators) is 85 tonnes of cane billets. Its performance has proved satisfactory for the most part, with a maximum leaf trash content of 5% after treatment; this also removes the white grub *Hoplochelus marginalis*. It is stressed that the system is not suitable for very dirty cane.

Optimization of mill performance using Fives-Cail Babcock patented systems

R. Guyot. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 101 - 108 *(French)*.

Details are given of the FCB 4-roller self-setting mill, the large-diameter feeder roller designed to be added to a 3-roller self-setting mill, and the self-draining roller.

Reheating mixed juice by plate heat exchanger at Bois Rouge sugar factory

P. Cosson and S. Honoré. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 148 - 158 *(French)*.

In trials, vapour bled from the 3rd evaporator effect was used, at 85°C, to reheat mixed juice plus filtered juice from 40°C in a battery of three Alfa Laval plate heat exchangers. Earlier a direct-contact condenser had been used with 3rd effect vapour at 83.7°C, but the result was a marked dilution of the mixed juice and hence increase in the quantity of vapour formed during evaporation. The maximum heat transfer coefficient during the trials was 1533 instead of a theoretical 2500 kcal/m^2/°C/hr, and the juice temperature was raised by 19.3 - 30.4°C as against a required 35°C at a throughput of 279 - 379 tonnes/hr compared with a theoretical 330 tonnes/hr. Although performance was below the optimum level, evaporator performance clearly improved.

Improvement in the performance of cane preparation and milling stations at Mon Désert-Alma sugar factory

J. C. Hoareau and F. Lamport. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 159 - 167 *(French)*.

Previously, cane had been prepared by a set of 48 Smith leveller knives operated by electric motor and two turbine-driven Fletcher knife sets, each consisting of 92 knives but with one driven by a 373 kW turbine at a clearance of 150 mm and the other by a 583 kW unit at a clearance of 18 mm; the 5 mills in the tandem were

individually driven by turbine. Modifications carried out within a restricted budget to improve cane preparation included installation of a Sullivan shredder, while alterations to the milling tandem included a different reduction gear on No.1 mill, conversion of Nos.1 and 5 mills from 3- to 4-roller units with modified roller grooving, changes to the Donnelly chutes and systematic arcing of the roller teeth. The results exceeded expectation, with a 1.4 unit increase in mill extraction; conversion of the other three mills to 4-roller units was being considered for 1989 with the possibility of ultimately using only 4 mills.

Cane deterioration under South African conditions

G. R. E. Lionnet. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 168 - 176 *(French)*.

Analysis of subsamples of whole stalks of NCo 376 cane taken from a batch of samples stored on the grass showed a fall in juice purity that was exponential with time at a constant temperature, while a 10°C rise in temperature caused a 3 to 4-fold acceleration in the purity fall. Deterioration had little or no effect on the concentration of colouring matter in juice from clean, healthy cane, but caused the formation of large quantities of ethanol and lactic acid. An estimation of the delay between harvesting and processing can be made from the concentration of ethanol[1].

Continuous vacuum crystallization at Le Gol sugar factory

G. Auneau and J. Cadet. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 177 - 183 *(French)*.

A Béghin-Say continuous vacuum crystallizer to treat *A*-massecuite from four batch pans was installed at Le Gol for the 1985 season. After cooling, the massecuite is discharged to the centrifugals from which some of the green syrup is returned to the crystallizer in proportion to the quantity of massecuite feed. Initially the system operated so well that it was possible to convert from a 3- to a 2-boiling scheme, with lower molasses and total losses, increased sugar yield and greater flexibility in factory operation than previously plus various economic benefits. The massecuite is cooled from 68° to 51°C in 1 hr 45 min.

Modelling flow in the F. Langreney vacuum pan

J. M. Perrin. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 184 - 197 *(French)*.

See Perrin: *I.S.J.*, 1989, **91**, 115A.

Continuous boiling at Felixton

G. Montocchio. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 198 - 207 *(French)*.

The performances of the Tongaat-Hulett vacuum pans used at Felixton in South Africa for all three massecuites are discussed. The footing magmas are prepared in batch pans. While conductivity is used as basis for process control in the *B*- and *C*-pans, high-frequency electromagnetic electrodes are used to measure massecuite resistance and impedance, and BPE is measured in each compartment. Problems, mainly due to lack of experience and chiefly concerned with *A*-massecuite boiling, are gradually being solved; *B*- and *C*-massecuite boiling have presented no major difficulty. There is need for frequent cleaning of the *A*-pan tubes which can become dirty in less than a day under abnormal conditions such as cane harvesting under wet conditions when the ash content in the tube deposits can be considerable.

Thoughts on molasses exhaustion in Réunion

J. M. Perrin and I. Dufour. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 208 - 222 *(French)*.

A survey of molasses purities in Réunion over the 25-year period 1962/87 has shown a gradual increase. The Polish test was used to establish whether this decline in exhaustion was due to a change in target purity associated with the quality of non-sugar or whether it was a result of a drop in processing standards. Results confirmed the validity of the test for cane molasses, with values very close to theoretical exhaustion. The deterioration was attributed chiefly to greater use of mechanical harvesting and its effect on cane quality, to increased delay between harvesting and processing, to higher milling extraction, to use of processing chemicals such as MgO, flocculants and anti-scale agents and possibly to weaknesses in crystallization; increased quantities of sucrose in low-grade massecuite show the need for reducing the non-sugars:water ratio and lowering the temperature.

The production of electrical energy by burning bagasse in a cane sugar factory. The Beaufonds thermal power station (Réunion)

M. Rivière. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 223 - 234 *(French)*.

Details are given of the costs and performance of the power station built at Beaufonds to supply the 6000 tcd factory with steam and electricity (as well as selling to the grid) using a 126 tonnes/hr bagasse-fired boiler operating at 45 bar and 450°C and a 24.65 MW 9-stage reducing/condensing turbine which supplies exhaust steam at 60 tonnes/hr and 1.5 bar to a 30,000 kVA alternator. In 1986, after 3 years' operation, the total electricity supplied by the station to the public grid constituted 11.1% of the entire power consumption of the island.

Treatment of waste water from the town of Saint-Louis and from Le Gol factory

G. Auneau. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 258 - 264 *(French)*.

1 Lionnet & Pillay: *I.S.J.*, 1988, **90**, 60A; 1989, **91**, 67A.

Domestic sewage from Saint-Louis, effluent from a lemonade factory and waste water from Le Gol sugar factory are treated jointly at a station, occupying 6 ha, which comprises an aeration basin, a settling basin and a finishing tank. The plant is designed to reduce the COD from 660 to a maximum of 120 mg/litre, the BOD_5 from 330 to no more than 40 mg/litre and the suspended solids content from 260 to a maximum of 30 mg/litre. The treated water and low-pollution waste water from the sugar factory are used for canefield and forest irrigation.

Real-time management of cane supply

R. Fontaine. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 265 - 268 *(French)*.

A new computer system installed at the sugar factory of Soc. Industrielle Sucrière de Bourbon is intended to regularize cane supplies and to provide growers with an instant record of individual load weights. The system is outlined.

Electrical conductivity of industrial sugar solutions. Some aspects

M. Bharadwaj and S. Mulay. *Bharatiya Sugar*, 1989, **14**, (6), 35, 37.

From experiments, an equation is derived which expresses the conductivity of a sugar solution in terms of Brix, purity, conductivity of the sugar fraction and conductivity of the non-sugars component and which, it is claimed, could be applied to on-line indication of Brix or purity. Some values of the variables in the equation and of the ratio between non-sugar and sugar conductivity are tabulated.

Problem of scale formation in Indian sugar factories. I. Location, composition, reasons for scaling and their impact on the sugar industry

A. Kumar, S. D. Borawake, M. R. Shivde, V. S. Keskar and S. J. Jadhav. *Bharatiya Sugar*, 1989, **14**, (6), 57, 59 - 60, 65 - 66.

The causes, composition and effects of scale in juice heaters, evaporator effects and vacuum pans are discussed.

Mineral impurities - weight on the scale *versus* weight in the cost of sugar cane

J. A. B. Costa and H. J. de S. Crespo. *GEPLACEA Bull.*, 1989, **6**, (7), 10 pp.

Since the introduction of cane payment on the basis of sucrose content in the State of Rio de Janeiro (Brazil) some concern has been expressed over high contents of mineral impurities in cane supplies. Experiments were conducted on random cane samples taken from the mill yard and from which all foreign matter was removed before grinding; mineral impurities were added to provide a content of 0.5, 10, 15 and 20% by weight. Results showed no changes in juice pol and soluble solids content as a result of adding impurities, although there was a very small change in Brix, and variation in the weight of the wet ground sample was not proportional to the weight of the added impurities.

Need for pan automation

D. S. Lande and M. B. Londhe. *Indian Sugar*, 1989, **39**, 75 - 89.

Automatic boiling control based on conductivity, viscosity/consistency and boiling point rise is discussed and its advantages listed. At the Pravaranagar sugar factory of Pravara S.S.K. Ltd., *A*-massecuite boiling control is based on viscosity/consistency, while that of *B*- and *C*-massecuites uses conductivity as basis. Charts are reproduced to show the superiority of automation over manual operation in terms of pan performance; the result has been a 10 - 15% reduction in boiling time, a 2.0 - 2.5% decrease in total massecuite % cane, a fall of 2 - 3% in steam consumption and improved exhaustion and crystal content.

Sugar recovery from cane molasses by a continuous chromatographic separation process

I. Kakihana. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 11 - 17 *(Japanese)*.

A commercial HPLC plant for the recovery of sugar from cane molasses was erected at the Haneji factory of Hokubu Seito Co. Ltd. in 1984. Results of three years' operation are reviewed. At an annual average recovery of 80% at 83 purity, sugar yield % cane has been increased by 0.6%. Problems such as corrosion of equipment to concentrate the non-sugars fraction, difficulty in filtration of the highly viscous molasses and plugging of the separation medium have been overcome. The process in a second plant erected in 1986 at Showa Togyo Co. involved simplified pretreatment with elimination of molasses softening, and the separation medium was improved. During the first campaign, a sugar recovery of 91% at 91 purity was achieved. Although the process has proved commercially practical, sugar price remains the governing factor.

Steam turbines for power generation in sugar mills

R. Bowell. *Pakistan Sugar J.*, 1989, **3**, (2), 25 - 26.

In a discussion of turbine selection, design, construction (including forced lubrication), maintenance and overhaul, site conditions and future trends, the author stresses the importance for reliability of the correct specification of a turbine for power generation in a sugar factory and shows how a proper maintenance program will extend its life.

The expression and application of engineering information

S. C. Chen. *Taiwan Sugar*, 1989, **36**, (3), 17 - 18.

The author considers that all engineers in a sugar factory should have a basic knowledge of statistics and gives some examples of diagrams used in descriptive statistics to provide a clear picture of trends.

Beet sugar manufacture

A new slurry for massecuite seeding

J. Grabka. *Zuckerind.*, 1989, **114**, 467 - 468 *(German)*.

A patented method for seed slurry preparation is described in which icing sugar of about 100 μm particle size is ground in *n*-butyl or isoamyl alcohol for 6 - 8 hr in a ball mill, after which the alcohol is removed and replaced with vegetable oil which provides lubrication for the individual crystals and prevents their conglomeration; 80% of the crystals in the slurry measure 10 - 15 μm. Factory tests at Ropczyce factory in 1984/85 showed that the new slurry reduced the boiling time, gave a higher massecuite crystal content, reduced mother liquor purity and sugar colour and improved crystal M.A. and C.V. The method was adopted in more than 30 Polish factories in 1986/87, since when more than 50 sugar factories in Poland and elsewhere have used it for white sugar and low-grade massecuites.

Automatic process control of multiple-effect evaporation. I. Conditions for static and dynamic equilibrium. II. Practical realization and results

F. Rousset, Y. Saincir and M. Daclin. *Zuckerind.*, 1989, **114**, 323 - 326, 328; 470 - 476.

I. The development of an automatic evaporator control system is described, including the theoretical fundamentals of the algorithm based on static and dynamic equilibria of the unit at Roye sugar factory and interaction of the evaporator with other process stations. Optimum static conditions were determined using a computer program based on mass balances and energy parameters; steam feed to the 1st effect was calculated from the average thin juice feed and Brix, the amount of vapour bled from each effect and the proportion of thick juice stored. The dynamic balance was based on steam and juice parameters such as residence and dead times and bled vapour usage. Although the analysis is highly dependent on the individual evaporator and other factory plant, the system is easily adaptable to any arrangement and is already in use at Roye and Bray-sur-Seine factories.
II. Details are given of the components of the evaporator control systems employed at the two factories as well as a modular breakdown of the algorithms used. Results for 1987 and 1988 at Roye and for 1988 at Bray-sur-Seine indicate the advantages of the schemes, including greater control of conditions when a process station stops or when there are changes in the normal conditions such as in the beet slicing rate or thick juice handling, a saving in energy and operational flexibility. One operator can control all the processes from beet slicing to thick juice discharge from the evaporator. Diagrams show the minimum instrumentation needed for evaporator control, and flow charts demonstrate the smoothness of operation by comparison with manual control.

Microcomputer control of a DDS diffuser

P. Svarc and J. Drobny. *Listy Cukr.*, 1989, **105**, 107 - 114 *(Czech)*.

Automatic adaptive control of the Polish-built DDS diffuser at Velvary sugar factory includes a microcomputer which receives data on cossettes flow from the slicer, the levels in each of the four compartments, the water:cossettes ratio, rate of extraction (provided by continuous measurement of juice and cossettes conductivity) and press and fresh water feed. Temperature corrections and laboratory data are also input. The output from the computer is used to control the diffusion water flow, the level in the 4th compartment and hence extraction rate and draft. Trials over a 10-day period showed an estimated reduction in losses of 0.02% on beet with a 5% reduction in draft.

A thermal process for preparing boiler feed water (condensate)

E. Otorowski. *Gaz. Cukr.*, 1989, **97**, 45 - 48 *(Polish)*.

Thermal softening of prefiltered fresh water is based on the conversion at 95 - 100°C of Ca bicarbonate to carbonate and of Mg bicarbonate to hydroxide in a packed column provided with a bottom screen which retains the water-insoluble salts; some process steam or vapour from the final evaporator effect is fed to the packed column where it is gradually cooled by the water and condenses. The softened water at 100°C goes to process or is evaporated in the final evaporator effect. Variants of the scheme, which is less costly than treatment by ion exchange, are described.

Energy consumption in the world beet sugar industry in the light of statistical data

K. Urbaniec. *Gaz. Cukr.*, 1989, **97**, 48 - 49 *(Polish)*.

The relative importance of a number of European countries and the USA in terms of the amount of beet sugar produced and trends in fuel consumption are discussed.

The mean path of diffusion in cossettes of U-shaped section

P. Slugocki. *Gaz. Cukr.*, 1989, **97**, 49 - 50 *(Polish)*.

The diffusion theory of Silin concludes that the mean path of diffusion through a cossette of U-shaped section is equivalent to half of the radius. However, examination of the theory by Grabka, Dobrzycki and Wagnerowski leads to the conclusion that the mean path is equivalent to 1/3 of the radius. According to Dobrzycki, the diffusion path is a geometrical concept only, since the physical path (a disjointed movement) followed by individual molecules of sucrose is a broken line.

Modernization of Olmedo sugar factory

W. Wyganowski and W. Lekawski. *Gaz. Cukr.*, 1989, **97**, 51 - 54 *(Polish)*.

Olmedo sugar factory in Spain was

supplied by the Polish consortium Polimex-Cekop and started operations in 1975, since when it has undergone a number of stages of modernization with increase in the beet slicing rate from the original 4000 tonnes/day to 9000 tonnes/day. Details are given of the process modifications and of equipment installed, and the performance of the factory in 1987/88 is discussed. The latest changes up to 1990 include construction of 50,000-tonne concrete silos, vertical crystallizers of DDS design and new juice heaters.

Waste water treatment at Wroclaw sugar factory

T. Wolski and B. Polec. *Gaz. Cukr.*, 1989, **97**, 59 - 62 *(Polish)*.

Details are given of waste water treatment at Wroclaw. Limed flume-wash water is re-used for fluming and washing after removal of suspension in an Aquapura settling tank, the mud from which is mixed with excess waste water and mud, heated and treated anaerobically. After fermentation, the waste passes to one or two aeration tanks (possibly via a regeneration tank) and is then settled. In 1987/88, COD and BOD_5 of approx. 4500 and 3300 mg/dm^3 were reduced by 98.1 - 99.4% and 99.4 - 99.9%, respectively (fermentation being responsible for reductions of 70.9 - 72.4% and 75.2 - 86.1%, respectively) at a throughput of 2334 - 2448 m^3/day (compared with a design throughput of 2400 m^3/day.

Effect of the action of accelerated electrons on transfer of non-sugars from beet tissue to a liquid phase

A. Butwilowicz, E. Wojtczak-Lewandowska, A. Tomaszewska, K. Mossakowska-Weber and A. Chelstowska. *Gaz. Cukr.*, 1989, **97**, 63 - 64 *(Polish)*.

Preliminary experiments in which cossettes were irradiated with doses up to 10 kGy before laboratory diffusion showed that treatment had no effect on the sugar content in cossettes or raw juice but reduced the juice colloid content and the bacterial counts in the cossettes (which became completely sterile after treatment with 6 kGy). Cossettes, juice and pulp were lighter in colour after irradiation.

Continuous crystallization

R. Guyot. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 121 - 138 *(French)*.

See *I.S.J.*, 1989, **91**, 28A.

New developments in continuous crystallization. Fives-Cail Babcock integral continuous boiling at Saint Germainmont sugar factory

R. Guyot. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 139 - 147 *(French)*.

Further trials on *A*-massecuite boiling in the FCB continuous pan at Saint Germainmont are reported[1]. By dividing the first two compartments each into two, the residence time of the reduced volume of footing was made to correspond to that of a footing volume of 25%. During boiling on a magma footing volume of 3 - 4%, the syrup fed to the first two compartments was diluted with thin juice to 70 - 75°Bx so as to reduce the supersaturation and prevent the formation of fines. However, results obtained from integrated boiling with precrushing of some of the massecuite still proved unsatisfactory, although the quality of the crystals obtained, the level of exhaustion and the boiling stability were the same as obtained by boiling on the normal much greater volume of magma, and no fine crystals formed, but the average C.V. was still greater than 4.

Alkaline treatment of beet cossettes before diffusion. Pilot plant experiments

C. A. Accorsi and F. Zama. *Ind. Alimentari*, 1989, **28**, 584 - 588, 594 *(Italian)*.

Experiments are reported in which cossettes were pretreated at 20°C with a mixture of thin juice and milk-of-lime (<0.6 CaO % on beet) at pH 5.8. Results showed an increase in pressed pulp dry solids to 28 - 30% by comparison with 23% for pulp from normal untreated cossettes without any adverse effect on the properties and purification of raw juice and without the addition of a melassigenic anion, while pulp losses were comparable to those in a factory DDS diffuser; in addition, the alkaline conditions did not cause corrosion or sucrose inversion. At higher alkalinity, processing difficulties occurred and a considerable increase in cossette rigidity led to inadequate sugar extraction with a resultant 3 - 4 pol loss in pulp. The behaviour of the inorganic constituents during diffusion and their relative concentrations in the cossettes and pulp are discussed.

Processing beet grown under dry conditions

V. A. Nagornaya. *Sakhar. Svekla*, 1989, (3), 48 - 49 *(Russian)*.

In certain years, beets in the Ukraine have experienced moisture stress and high air temperatures, so that they have contained more ash, nitrogenous compounds and soluble pectin, have had a lower natural alkalinity and turgor and hence have become easily diseased and stored badly; their processing has been characterized by a fall in alkalinity, increased sucrose degradation and a greater quantity of molasses by comparison with beet grown under better conditions. Increased N application to the crop in dry years has caused greater quantities of ammonia at all process stations and in condensate, increased foaming in run-offs and massecuite, production of redd-ish low-grade massecuites, high syrup colour and spontaneous degradation of molasses. Advice on processing of such beet includes preliming to a final pH at which the juice settling rate is at least 3 cm/min and there is no turbidity in the clear juice, and minimizing the amount of recycled 1st carbonatation juice; the main liming period should be extended and the temperature raised so as to in-

1 Patacq & Journet: *I.S.J.*, 1989, **91**, 92A.

crease the degree of amide degradation and juice thermal stability, and the equipment should be modified to increase contact between juice and lime. 1st carbonatation should be carried out at higher alkalinity to reduce the amount of ammonia formed by amide degradation, while liming before 2nd carbonatation also contributes to thermal stability; measures to counter the increased foaming caused by the greater doses of lime are mentioned. Soda and trisodium phosphate should be added to help maintain 2nd carbonatation juice alkalinity above the optimum.

New beet cleaning equipment

A. E. Provolotskii. *Sakhar. Svekla*, 1989, (3), 49 - 52 *(Russian)*.

A cleaning platform described consists of a bottom continuous row of driven rollers provided with blades of a flexible material and rotating in the same direction as the flow of beet, and a number of rotary cylindrical brushes mounted above the rollers and carried by pairs of pivoting arms; the brushes rotate against the direction of beet flow at an angle which is alternately 3° and 10° to the line of the bottom roller axes. Nozzles located on the arms just above and behind the brushes direct treated flume-wash water (containing up to 20% soil and small pieces of residual debris to act as an abrasive) at the beet under pressure. The platform is designed for a daily throughput of 300 tonnes. In trials on a prototype mounted on a beet water separator, unfrozen beet were cleaned much more efficiently, and the cleaner is therefore recommended for mass production.

Optimum conditions in progressive preliming

N. I. Zharinov, V. Z. Semenenko, R. G. Zhizhina, V. V. Folomeeva and L. V. Boroda. *Sakhar. Svekla*, 1989, (3), 53 - 55 *(Russian)*.

Because of lag in changes of milk-of-lime dosage in preliming following changes in the quality of raw juice, there is need for better control of pH at its optimum for maximum non-sugars coagulation and settling rate (without peptization) and minimum mud volume. Tests in which raw juice samples of three purities were prelimed at 50°C for 20 min, limed cold at 50°C for 20 min and then hot at 85°C for 10 min, followed by 1st carbonatation, liming, 2nd carbonatation and evaporation showed that a lime dosage to give minimum juice colour provided better pH_{20} control and gave substantial improvements in settling and filtration than did pH_{20} control based on liming to provide minimum mud volume; it also gave lower thick juice colour and higher purity, leading to reduced molasses sugar.

A vertical progressive preliming vessel

A. M. Barakaev *et al. Sakhar. Svekla*, 1989, (3), 55 - 58 *(Russian)*.

The A2-PPR prelimer described is a direct-flow system consisting of three separate but interlinked vertical sections and with no moving parts, so that mixing of the juice and lime is based on hydrodynamics using the special configuration of the individual compartments. Section A comprises two identical cylindrical compartments 1 and 2, one above the other, and a top section leading to the top of the next section B; the top of compartments 1 and 2 takes the form of a narrow cone. The four compartments of section B, also one above the other, have frusto-conical bottoms, while section C is a straight narrow column from the top of which the juice flows to the first of two main limers. A diagram of an entire juice purification system shows how juice is bottom-fed via a conical section leading to compartment 1 in section A and passes eventually to compartment 3 in section B and thence to the bottom of section C. Compartments 1 in section A and 3 and 4 in section B receive unfiltered 1st carbonatation juice, while 2nd carbonatation mud is fed to compartment 2 and milk-of-lime to compartment 5 in section B and to section C. The performance of a model of the prelimer designed to handle the juice from 6000 tonnes of beet per day is summarized and technical data are given for this and other models in the range.

Heat exchange tubes with annular turbulizers

V. N. Gorokh *et al. Sakhar. Svekla*, 1989, (3), 58 - 60 *(Russian)*.

The performances of chrome-nickel steel tubes with internal annular ridges were compared with those of smooth-bore tubes in juice heaters. The pitches of the ridges ranged from 7.3 to 34.6 mm. In both types of tube, there was an initial fall in the heat transfer coefficient at juice flows of 1.45 - 1.75 m/sec as a result of scale formation. The coefficient was higher with all juices in the ridged tubes having the two lower pitches and in those having the two higher ridge pitches where carbonatation and thin juices were involved, but the coefficient was lower for the two higher pitches than in the smooth tubes when raw juice was heated at relatively high flow velocities because of the effect of eddying which spread into the bulk of the juice stream, the formation of stagnant zones between the ridges, scale formation and infiltration by condensate into the grooves on the outside of the tubes. Further tests during three campaigns with a stainless steel tube containing no nickel showed a much lower rate of scale formation than in the smooth tubes. However, the rate of wear of all the tubes tested was greater than of smooth tubes, although the absolute wear rate was still very small where chrome-nickel steel was used, and the ridges allowed a substantial reduction in the heat surface area of juice heaters.

The effect of flocculants on the electrokinetic potential of muds

N. D. Marinova and N. A. Arkhipovich. *Sakhar. Svekla*, 1989, (3), 60 - 61 *(Russian)*.

The effects of NS-1B, Fibrospan B and Magnofloc flocculants (as used in the

Bulgarian sugar industry) on the zeta-potential of $CaCO_3$ in 1st carbonatation and of the precipitated mud were investigated using model mud suspensions and laboratory-produced raw juice; the flocculants were added as 0.2% solutions at 0.001% by weight of suspension, and 0.2N $CaCl_2$ was used as control. Statistical analysis of the results indicated poor reproducibility, with errors in the range ±5 - 20%. However, the zeta-potential of pure $CaCO_3$ tended to fall (without any change in the electrical charge sign) by an average of 11 - 12 mV to levels of 28.55, 29.90 and 28.58 mV for the flocculants in the order given above; it has been shown that rapid coagulation occurs at <30 mV. The zeta-potential of the carbonatation mud was considerably lower than that of the pure $CaCO_3$, as a result of non-sugars adsorption, and the flocculants caused it to fall from an average of 2.28 mV to 1.86, 1.56 and 1.02 mV, respectively, again without any alteration of charge sign.

A follow-up on the microflora and the state of hygiene in the manufacturing chain at Sucrerie Nationale du Beht (SUNAB)

H. Essadiq, M. Belamri, M. Mardhi and A. T. Elaraki. *Sucr. Maghrebine*, 1989, (38), 11 - 17 *(French)*.

The quantitative and qualitative evolution of micro-organisms throughout a Moroccan beet sugar factory was studied and the level of microbial contamination in a diffuser determined. Results showed that press water, beet wash water, cossettes and raw juice were the most heavily infected of the test samples. Aerobic mesophiles, osmophiles, yeasts and moulds were predominant in the wash water and cossettes, but their numbers were markedly reduced during juice purification as a result of the combined effects of temperature and lime. Thermophiles were abundant in press water. In crystallization, the levels of osmophiles and heat-resistant microbes were relatively low but stable; the very high sugar concentrations favoured development of the osmophiles, while the heat-resistant organisms persisted in a sporulated form where the conditions did not favour proliferation of the bacteria. While the microbial state of the cossettes governed that in each compartment of the DDS diffuser and the juice and could be improved by washing in clean water to which active Cl has been added, press water was also found to make a marked contribution to the conditions in the diffuser and should therefore be heated to 88 - 90°C for 2 min and cooled before use. Mesophiles were by far the most abundant type of micro-organism throughout the factory.

Computer-assisted analysis of an RT2 diffuser station at a beet sugar factory. II. Possibilities of improving the performance of the station

T. Bounahmidi. *Sucr. Maghrebine*, 1988, (38), 19 - 25 *(French)*.

Results of the study showed that slicing (as expressed by the Silin number), draft and residence time were the major variables affecting performance, with slicing having a much greater effect than draft at a constant residence time. The Silin number currently used (10 m/100 g) is relatively small; one of 11.24 m/100 g would allow the draft to be reduced from 123% to 110% without increasing losses, while 12 m/100 g would cut losses to 0.2% on beet at 110% draft, but not if the residence time were increased, in which case the Silin number would have to be lower. On the other hand, it is important to operate at as high a rotary speed as is practical in order to avoid overloading the basket-shaped grids and increasing the risk of microbial infection of the juice. It is recommended that a thorough investigation be made of slicing to see how to obtain the best possible performance.

Technical aspects of the 1988/89 campaign in France. Some technical ratios

Anon. *Sucr. Franç.*, 1989, **130**, 203 - 207 *(French)*.

Diagrams compare various data from the 1988/89 campaign with results recorded during previous campaigns in France, including dirt tare and the effect on it of rain, pol in cossettes, molasses sugar loss and purity, average sugar yield, pulp dry solids (also showing the effect of added sulphuric acid), energy consumption, sugar production per ha and worker productivity. The results are discussed.

Heating molasses with water in modular liquid-liquid heat exchangers

T. Zahradnik. *Listy Cukr.*, 1989, **105**, 126 - 128 *(Czech)*.

In experiments with sections of a modular heat exchanger having a total heat exchange surface of 5.4 m^2, molasses was heated from 60 - 83° to 64 - 86°C by water at a bulk flow rate of 1.5 - 10.0 m^3/hr and a flow velocity of 0.1 - 0.65 m/sec. The pressure loss on the molasses side was 1.5 - 9.0 kPa/m. The units are considered suitable for handling high-viscosity sugar solutions.

Sugar silos - investigations, design and operation

M. Kaminski. *Zuckerind.*, 1989, **114**, 535 - 542 *(German)*.

See *I.S.J.*, 1990, **92**, 7 - 15.

Some notes on multicriterion optimization in a raw sugar factory

P. Slugocki. *Gaz. Cukr.*, 1989, **97**, 69 - 70 *(Polish)*.

The inter-relationship of process variables in regard to optimization is discussed in the cases of diffusion, juice purification and evaporation to demonstrate how, because of diametrically opposed requirements (e.g. a minimization of pulp losses but also a minimization of cossettes residence time so as to maximize throughput), a compromise solution is often sought. The author explains the mathematics of an approach to the problem.

Sugar refining

The application of ion exchange resins in cane sugar refining

M. A. Getaz. *Comm. Sugar Milling Res. Inst.*, 1988, (146), 1 - 77.

The ion exchange process and its application in sugar technology (particularly in South Africa) are outlined followed by a brief description of resin structure and classification. Decolorizing resins and their use in refining are discussed, including the nature of sugar colorants and other decolorizing agents used. The physical structure of styrene and acrylic resins, their ionic functional groups and decolorizing mechanisms, the performances of acrylic- *vs.* styrene-based resins and factors affecting decolorizing resin performance are examined and the typical ion exchange operating cycle and regeneration described. Details are given of resin assessment and test procedures and of pilot plant and laboratory column techniques. After a description of ion exchange decolorization equipment and process design, powdered ion exchange technology is briefly discussed, with a list of its benefits over conventional ion exchange decolorization. A glossary of ion exchange terms is appended as well as 64 references to the literature and a bibliography of 32 titles.

Packaging materials

L. A. Anhaiser. *Paper presented to Sugar Ind. Tech. Conf.*, 1989, 13 pp.

The types, specifications and quality of paper bags used by refineries for sugar are discussed, methods used to check the specifications described and a glossary of terms used in reference to multi-wall bags appended.

Selection of packaging equipment

J. Shpak. *Paper presented to Sugar Ind. Tech. Conf.*, 1989, 9 pp.

Criteria for the selection of packaging equipment are listed, covering operational, warehousing, marketing, distribution and consumer aspects, and a case history involving replacement of existing packaging lines with new equipment of higher speed is used as example, with a summary of the benefits that ensued.

Pilot plant tests on microfiltration of refinery syrups

P. Fontana. *Ind. Sacc. Ital.*, 1989, **82**, 96 - 98 *(Italian)*.

Tangential microfiltration of refinery syrup using permeable inorganic membranes of 0.2 - 5.0 μm porosity on an aluminium oxide support was tested in batch experiments at recycle rates of 4500 litres/hr and residence times up to 120 min. At feed and discharge pressures of 3.3 - 3.5 and 1.8 - 2.1 bar, respectively, and a temperature of 90°C, the permeate flow rate was satisfactory at 36 - 42 litres/hr and turbidity was reduced by 60 - 61%, but the filtration efficiency was disappointing. The aim was to eliminate filter cloths and filter aids.

Studies on clarification of sugar liquor by the magnesia process. III. Reburning of magnesia

K. Tasaki, K. Hamanaka, M. Kawakami, A. Tanaka, Y. Ikari and S. Yokoyama. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 1 - 9 *(Japanese)*.

Clarification of refinery liquor with MgO and perlite followed by resin demineralization and decolorization[1] has been used at Mitsui Sugar Co. Ltd. for over four years at a nominal liquor treatment of 60 tonnes/day. Advantages of the process include simplicity, improved liquor quality and reductions in initial costs, labour, liquor retention, materials consumption, energy and environmental pollution. While laboratory and pilot-scale tests had shown no differences in efficiency between MgO reactivation by oxidation and thermal decomposition of adsorbed organic matter, the full-scale kiln design was initially based on the oxidation method; however, in practice it was found impossible to maintain uniform temperature distribution in the kiln because the heat from the reaction was much greater than in the pilot plant, so that total regeneration efficiency was very low with some of the MgO over-burnt (and hence of reduced adsorption capacity) and some under-burnt; moreover, kiln temperature could not be used for temperature control as a result of considerable difference between the temperature of the air and that of the burnt matter in the kiln. However, the thermal decomposition method had disadvantages such as a slow reaction rate which resulted in a reaction time that was more than double that of the oxidation process. The problem was solved by automatic control of the oxidation process based on measurement of the temperature of the burnt substance and maintaining this at an optimum level, and by automatic control of secondary air feed by measuring the residual oxygen concentration in the kiln and again keeping this at optimum. As a consequence, the regeneration efficiency was as high as that achieved in the tests.

Electronization of the control of crystal sugar moisture during storage

L. Cerveny, R. Rehak and J. Vlach. *Listy Cukr.*, 1989, **105**, 129 - 137 *(Czech)*.

When the moisture content in the layer of syrup on a crystal sugar increases, the molecules of the various substances dissociate to cause an increase in electrical conductivity. This was used as the basis for a moisture meter incorporating a copper and an aluminium electrode in contact with the crystal surface. The instrument and its possible applications are described. Among the applications is monitoring of the moisture content of sugar as in the case of a refinery (outside Czechoslovakia) where the sugar leaving the dryers for the silos was checked and where the system proved as valid as gravimetric measurement. The probes can be inserted in stored bulk sugar or the sensors can be suspended from the ceiling at points in a bagged sugar silo. Both acoustic and electronic signals (via LED) are transmitted, and a dehumidifier automatically actuated where there is a rise in the moisture content.

1 Kaga *et al.*: *I.S.J.*, 1984, **86**, 55.

Laboratory studies

The determination of sugars by chromatography

S. Sumartini and J. Kantasubrata. *Anal. Proc.* (Roy. Soc. Chem.), 1989, **26**, Abs. PE9.

Chromatography of sugars is the only method for determining one sugar separately from others. TLC is still a popular and attractive method for sugar determination in terms of cheapness, simplicity and rapidity, and only TLC has the ability to analyse samples simultaneously. GLC is not a convenient method for determining sugars because a derivatization step is necessary for converting sugars to volatile forms. The development of the bonded column has made HPLC the newest method for determining sugars. Many chemically bonded amine columns are commercially available and have been much used for sugar separations. However, these columns tend to deteriorate with prolonged use because of the presence of Schiff bases. To avoid this phenomenon for determining sugars various methods were tried. An impregnated silica plate was used with pyridine as eluent for TLC; for HPLC, various columns were used: diol, RP-18 and silica compressed columns with *in situ* amine modifier. The results showed that the TLC method gave low precision compared with the HPLC method.

Refractometric determination of sugar content

B. Z. Zak and T. P. Khvalkovskii. *Sakhar. Svekla*, 1989, (3), 52 - 53 *(Russian)*.

The polarimetric procedure used to determine sugar in beet brei, cossettes and pulp is considered too labour-consuming and expensive, and refractometric dry solids determination is preferred, with appropriate conversion to sugar content. Investigations of variation in the apparent purity of press water showed conversion factors for Brix to sugar of 0.47 - 0.52 with an average of 0.5, indicating an almost constant level of sugar extraction in diffusion regardless of the initial sugar content in the cossettes. While a standard laboratory refractometer measured Brix to within ± 0.1 units which, on conversion, gave a pulp sugar content of 0.05% as against ± 0.03% by polarimetry, a precision or dipping refractometer gave a Brix of ± 0.03° and a corresponding sugar content of ± 0.015%. It is recommended to carry out refractometry within 20 - 30 min of pressing the pulp sample to allow the test solution to darken and allow the scale values to be easily read.

Rapid determination of the water content of sucrose solutions and of molasses by low-resolution pulsed NMR

D. le Botland, M. Guillou-Charpin and C. Tellier. *Sciences des Aliments*, 1988, **8**, 565 - 573; through *S.I.A.*, 1989, **51**, Abs. 89-0764.

The method is based on measurement of the spin echo amplitude at a time of 1 msec. The amplitude of the echo/unit mass was linearly related to the water contents of a pure sucrose solution in the range 33 - 43% sucrose and of molasses in the range 22 - 27% water. The accuracy was good (standard deviation 0.2%). This rapid method of determination (1 min) could be used in an industrial environment.

Determination of sucrose in sugar cane juice and molasses by flow-injection spectrophotometry

E. A. G. Zagatto, I. L. Mattos and A. O. Jacintho. *Anal. Chim. Acta*, 1988, **204**, 259 - 270; through *S.I.A.*, 1989, **51**, Abs. 89-0774.

An automated procedure for this determination is proposed. The diluted and filtered sample is introduced into a flow-injection analyser designed with two sample streams which merge after one of them has flowed through a heated coil in which partial and reproducible sucrose inversion is attained at controlled pH and temperature. At the confluence point, a buffered periodate stream is added to oxidize the sugar. The consumption of periodate, which mainly reflects the fructose content, is measured spectrophotometrically as a transient lowering of the iodine concentration. The two processed streams proceed sequentially to the flow cell and two peaks are recorded. The sucrose content of the sample is proportional to the difference in peak heights. The system permits analysis of about 30 cane juice samples per hour, and sample clarification is unnecessary. Results agreed well with those obtained by HPLC for cane juice samples containing 11 - 14% sucrose w/v. Modifications for analysis of molasses (16 - 52% sucrose by weight) are described.

Gas chromatography (GC) of sugars

M. R. Shivde, A. Kumar and S. J. Jadhav. *Bharatiya Sugar*, 1989, **14**, (6), 49, 51 - 52.

The fundamentals of gas-liquid chromatography are explained and its application to sugars analysis indicated in a number of methods described in the literature.

Modern developments in polarimetry and refractometry and their application in the sugar industry

M. Kuchejda. *Zuckerind.*, 1989, **114**, 545 - 550 *(German)*.

The physical fundamentals of polarimetry and refractometry, factors affecting the two measuring methods, possible sources of error, the applicability of Biot's law concerning the rotation of optically active media and the principles on which polarimeters and refractometers operate are discussed and the types of instrument available described. The ratio of pol to Brix as an indication of purity is analysed and details given of the Schmidt & Haensch Cal-Q-Lator system which combines a DUR or DUR-S digital universal refractometer with a Saccharomat automatic polarimeter with quartz wedge compensator or a Polartronic universal circular polarimeter with automatic alignment, a computer and a

printer for automatic print-out of corrected °S, % pol and Brix with sample identification; the system can also be operated by remote control.

Analytical equipment and systems for measurement of the purity of technical sugar solutions

W. Kernchen. *Zuckerind.*, 1989, **114**, 552 - 555 *(German).*

Descriptions are given of instruments made by Dr. Wolfgang Kernchen GmbH, including the Sucromat automatic polarimeter for laboratory use, the Propol automatic process polarimeter which operates on the basis of magneto-optical compensation, the Abbemat-HP automatic laboratory refractometer and the Abbemat automatic process refractometer. Laboratory systems for purity determination are outlined, including the Sucrolyser-PC computerized system for measurement of pol, Brix and purity of raw, intermediate and end-products, and a versatile combination of process polarimeter and refractometer in an on-line system incorporating a computer.

Model experiments on enzymatic browning

K. Buchholz and I. Mikhael. *Zuckerind.*, 1989, **114**, 558 - 561 *(German).*

Tyrosinase obtained from beet press juice by irreversible adsorption on bentonite was immobilized and used as an enzyme-bentonite complex to oxidize tyrosine and dihydroxyphenylalanine (dopa) at varying temperature, concentration and pH of the respective solutions; HPLC, extinction at 480 nm in U.V. light and measurements with an oxygen electrode were used to analyse the reaction products. Dopa was oxidized much more rapidly than tyrosine. Incomplete oxidation caused e.g. by inadequate oxygen and a subsequent shift to an alkaline pH coupled with temperature rise led to the formation of soluble melanins, which could partially explain the dark coloration of juice observed in certain circumstances after purification.

Kinetic variations in sucrose crystallization with different inter-crystal distances

V. Maurandi, G. Vaccari, G. Mantovani and A. Rossi. *Zuckerind.*, 1989, **114**, 562 - 566.

Sucrose crystals of identical size were further crystallized in supersaturated solutions at a crystal : solution weight ratio R_c of 0.5 and 0.25 and their growth rate calculated under conditions of decreasing mother liquor supersaturation; the solutions were stirred with a small blade rotating at 200 rpm where the purity was high and at 20 rpm where it was low. The fact that the crystal growth rates were higher at an R_c of 0.5 than 0.25 and that this difference decreased as the non-sucrose concentration increased was attributed to disruption of the boundary layer which became thinner with the greater non-sucrose concentration. Curves of the growth rate exhibited depression at low supersaturation; at low non-sucrose concentrations they were parabolic and were of a higher order with increasing concentration. These results accord with those obtained by the authors with single crystals.

Clarification of sugar factory process samples with zinc salts for polarimetric sucrose determination

M. Auth and D. E. Rearick. *Zuckerind.*, 1989, **114**, 567 - 570.

While aluminium salts as an alternative to basic lead acetate (undesirable because of its toxicity) are reasonably effective in removing suspended solids, they are inefficient decolorizers and so are not suitable as clarifying agents for highly coloured products such as molasses. Tests on the use of ion exchange resins revealed problems associated with resin volume and moisture content, while active carbon adsorbed sufficient of the sucrose to give lower readings than with lead acetate clarification. No single reagent was found that precipitated or adsorbed colouring matter to the same extent as lead acetate, but addition of metal salts and NaOH, KOH or NH_4OH caused colour adsorption on the resultant metal hydroxide. Comparison of Zn chloride with Al chloride showed the former to give a lower solution colour (which under optimum conditions approached that obtained with lead acetate) and more rapid filtration than the latter when they are added to molasses together with ammonium hydroxide. On the basis of these and other results, factories of The Amalgamated Sugar Co. in the USA adopted zinc chloride as clarifying agent for process samples in all of their laboratories (but not for beet brei analysis for beet payment purposes) in the 1987/88 campaign. There is no statistically signific-ant difference between results for molasses sucrose using KOH and NH_4OH, but NaOH is not suitable as it gives very slow filtration. Further tests showed no significant differences in pol between clarification with lead acetate and zinc chloride in some cases, whereas in other cases significant but small differences were observed; these were attributed to the type of non-sugars present and to small differences in elimination of optically active non-sugars and were dependent on beet-growing area and possibly on seasonal variations, but are considered too small to indicate serious problems with the use of the chloride.

Determination of mercury in products of the sugar and confectionery industries

A. Stupkova and M. Kotoucek. *Listy Cukr.*, 1989, **105**, 121 - 125 *(Czech).*

Atomic absorption spectrophotometry was used to determine mercury as a foreign body in samples of consumption white sugar obtained from 10 sugar factories for the years 1986 and 1987. In 1986, only 7 out of 256 samples were found to contain more than the permissible 0.002 ppm mercury but the levels did not exceed 0.003 ppm; all samples from 1987 complied with the regulations. The advantages of the analytical method used over other methods are indicated.

The interrelationship of sugar crystal geometric parameters

K. Wagnerowski. *Gaz. Cukr.*, 1989, **97**, 65 - 68 *(Polish)*.

Sugar crystals often grow irregularly so that none of their physical parameters corresponds to their surface area or volume; but a regularly formed crystal having only one axis of symmetry and without any inclusions and plane defects is distinguished by length, thickness and width, of which the last is the best guide to the other geometric parameters. The surface coefficient and sphericity of crystals are analysed and the concept of equivalent diameter explained for a spherical and a cubic system. It is defined as the diameter of a sphere in terms of regular polyhedra of given sphericity; it corresponds well with crystal width and thus provides a precise measurement of a crystal and defines the interrelationship between the other geometric parameters. Tables show the values of each variable in terms of the surface coefficient.

Enzymic synthesis of 6^G-α-glucopyranosyl sucrose (theanderose) by transglucosylation of dextranase

T. Miki, H. Ito, S. Saito and M. Kamoda. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 41 - 45 *(Japanese)*.

TLC of hydrolysates of dextran produced by dextranase in the presence of sucrose yielded an unknown spot on the chromatogram which was assumed, from its R_f value and colour, to be a reducing trisaccharide (OS-1) containing fructose. After isolation of OS-1 by column chromatography and crystallization as its monohydrate, its specific rotation $[\alpha]_D$ was found to be +102.9° and its melting point 128 - 130°C; acid hydrolysis of the sugar yielded glucose and fructose in a molar ratio of 2:1, whereas hydrolysis by invertase gave isomaltose and fructose in a 1:1 ratio. Hydrolysis by α-amyloglucosidase obtained from *Aspergillus niger* yielded sucrose and glucose. These results, methylation analysis and ^{13}C NMR data showed the trisaccharide to have the structure 6^G-α-glucopyranosyl sucrose (theanderose). It is thought to be formed by the transfer of an α-glucosyl moiety of dextran to the glucopyranosyl residue of sucrose via dextranase transglucosylation.

Some considerations on total solids, Brix or sugar content in molasses

H. Tamaki, S. Kishihara and S. Fujii. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 55 - 59 *(Japanese)*.

The total solids, soluble solids and sugar components in a number of molasses samples were analysed by a number of methods. It is generally believed that the Karl Fischer method provides the most reliable measurement of moisture content or total solids; values of the latter parameter practically agreed with values obtained by drying at 105°C for 3 hours at atmospheric pressure or at 75°C for 5 hours at a vacuum of –74 mm Hg. Measurement of soluble solids by refractometer or hydrometer was unaffected by the suspended matter removed by centrifuging. Refractometric Brix practically agreed with the total solids content obtained by vacuum drying. In general, dissolved inorganic salts and dissolved amino-acids were considered to have an opposite but equal effect on the refractive index of sugars. Hydrometric Brix was much greater than the total solids content and was influenced by the ash content; the correlation between the ash content and the Brix difference had a coefficient of 0.802. Polarimetry gave a much lower sugar value than sucrose measured by HPLC as a consequence of the effects of various optically active substances. The fructose content in the molasses as measured by HPLC was greater than that of glucose in all but one sample.

Determination of acrylamide in sugar by capillary GLC with alkali flame-ionization detection

J. Tekel, P. Farkas and M. Kovac. *Food Addit. Contam.*, 1989, **6**, 377 - 381; through *Anal. Abs.*, 1989, **51**, Abs. 8F17.

Sugar (50 g) was dissolved in water and 37.5 g of KBr, 2 ml of concentrated HBr and 12.5 ml of saturated aqueous Br added. The solution was mixed and kept at 0 - 2°C for 6 hours. Excess of Br water was removed with 1M sodium thiosulphate and the 2,3-dibromopropionamide (**I**) formed was extracted with ethyl acetate (100 ml, then 2 × 50 ml). The combined organic phases were filtered, the filtrate concentrated to 1 - 2 ml and the concentrated extract cleaned up on a column of silica gel topped with anhydrous sodium sulphate. **I** was eluted with 15 ml of ethyl acetate, the eluate evaporated to dryness and the residue dissolved in ethyl acetate. The solution was analysed by GLC on a column (14 m × 0.3 mm) coated with OV-1, with temperature programming from 75°C (held for 1 min) at 15°C/min to 130°C, hydrogen as carrier gas and N-P selective detection. Recoveries of acrylamide added at the 100 and 20 μg/kg levels ranged from 65.9 to 77.5% and from 90.7 to 102.7%, respectively. Limits of detection were 1 - 10 μg/kg.

Micro-bore liquid chromatography and refractive index gradient detection of low-nanogram and low-ppm quantities of carbohydrates

D. O. Hancock and R. E. Synovec. *J. Chromatogr.*, 1989, **464**, (1), 83 - 91; through *Anal. Abs.*, 1989, **51**, Abs. 8J28.

The detector consisted of a single-mode diode laser beam focused by means of a microscope objective through a Z-configuration flow cell on to a position-sensitive detector. The system was used for the detection of simple carbohydrates after separation on a column (25 cm × 1 mm) of Adsorbosphere (5 μm) with aqueous 90% acetonitrile as mobile phase (50 μl/min); the eluate was delivered to the flow cell via a short PTFE (polytetrafluoroethylene) tube. The

detection limits were 68 and 65 ppb for fructose and sucrose, respectively. Corresponding coefficients of variation (n = 3) were 1.8 and 0.8%.

Sample preparation of sugar solutions in a beet sugar factory with the Steffen process

K. Saito, K. Ohno, T. Nakae and I. Yamanaka. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 69 - 78 *(Japanese)*.

A strong anion exchange resin was tested as an alternative to basic lead acetate for clarification of highly coloured samples such as high- and low-green syrup and low-grade massecuite prior to polarimetry. A cut in the preparation time resulted from use of the resin in dry form and of deionized water to dilute the sample. The two clarifying agents gave almost identical values of pol and apparent purity.

Laboratory studies in South Africa

Anon. *Ann. Rpt. Sugar Milling Res. Inst.*, 1988/89, 9 - 10, 12, 15 - 17.

Crystal deformation: An oligosaccharide fraction isolated from refinery molasses by chromatography on a carbon-celite column and found to contain most of the crystal elongating material was further fractionated on silica-based octadecylsilane (ODS) using water as eluent. Thin-layer refractive index profiles indicated the initial enrichment by comparison with the original oligosaccharide mixture and showed two purity peaks of which one contained at least two co-eluting compounds. The main advantages of ODS supports in such applications are the greater selectivity compared with cation exchange columns and the use of water as eluent rather than organic solvents as used with amine-modified columns. Although all the reverse-phase columns showed a progressive, fairly rapid irreversible deterioration in performance and the limited column lifetime expectancy proved disappointing, the technique is a viable means of obtaining small amounts of reasonably pure oligo-saccharides. Use of an anion exchange column coupled with a high-sensitivity pulsed amperometric detector will facilitate oligosaccharide isolation.
Colorant fractionation and measurement: Colour produced in *B*- and *C*-molasses by heating for up to 120 hours at 70°C was found to be insensitive to pH change and showed less U.V. response than the colour present initially. Response to empirical phenolic measurements increased by 5 - 10% while amino-N response decreased by 15 - 30%; considerable sucrose and monosaccharide degradation occurred. Fractionation of the colorants by size exclusion chromatography on HW 50 (S) in 0.1% sodium azide showed no qualitative differences between the colorant peaks on the chromatograms at an absorbance of 420 nm although most of the peaks increased significantly as a result of the heat treatment. Parallel monitoring of the eluent at 254 nm, refractive index and conductivity signals showed that the peaks had different characteristics, while stopped-flow wavelength scanning revealed differences in spectral behaviour, with peak elution volumes highly dependent on eluent composition (indicating extensive interactions on the gel phases used). Sugar boiled from solutions to which the heat-generated colorants had been added showed empirical colorant distributions that were similar to those of the mother liquor, implying that methods developed with the heated molasses samples can be directly transferred to sugar colorants.
Measurement of sugars by HPLC: Results obtained with two cation exchange HPLC columns, a Ca-based Waters SugarPak 1 and a Na-based Biorad HPX-87N column, confirmed that integration by peak height was more accurate than by peak area; the difference was probably due to the small amount of impurities in cane molasses. Procedures based on the use of external standards gave better results than where internal standards were employed, probably because of closely co-eluting impurities. Testing refractive index detectors for sensitivity and linearity showed that modern units with a built-in thermostated optical system produced a very low noise level and allowed sugar detection at the 1 - 5 ppm level. Comparison of HPLC with high-resolution GLC gave insignificant differences between the two techniques for fructose and glucose but showed a marginally higher HPLC value for sucrose.
Substitutes for mercuric chloride as sample preservative: The effect of addition of mercuric chloride as preservative to mixed juice showed that at 28°C a fairly rapid purity drop occurred without the chloride whereas there was very little difference between treated and untreated juice at 20° and 25°C, particularly during the first 3 hours. The ideal preservative must not change any of the chemical characteristics (e.g. pol and Brix) of the product and must not interfere with any analytical procedures to be carried out on the sample. A number of possible substitutes for mercuric chloride were tested, but none proved satisfactory.
Substitutes for basic lead acetate: Although clarification of mixed juice and final molasses samples with Al sulphate as a replacement for lead acetate was unsatisfactory, Al chloride gave encouraging results when used in a 2:1 ratio with Ca hydroxide plus active carbon and filter aid. The pol of mixed juice was generally lower than that given by lead acetate powder while that of molasses was higher.
Sucrose determination by the Jackson & Gillis method: Samples of mixed juice and final molasses were analysed for sucrose by the Jackson & Gillis modification of the Clerget method based on inversion by HCl. Although good correlation (r = 0.992 and 0.972 for juice and molasses, respectively) was found between the results and values given by GLC, statistical analysis revealed a bias; however the Jackson & Gillis values were within 1.7% of the GLC results whereas the Eynon & Lane method was found to overestimate sucrose by about 2.5%.

By-products

Formation of fructooligosaccharides from sucrose catalysed by immobilized β-fructofuranosidase obtained from *Aspergillus oryzae*

M. Kida, T. Yoshikawa, T. Senda and Y. Yoshihiro. *J. Chem. Soc. Jap., Chem. & Ind. Chem.*, 1988, (11), 1830 - 1835; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (8), Abs. 8 R1550.

In an investigation of the conditions under which fructooligosaccharides (A) were formed from sucrose subjected to the action of immobilized β-fructofuranosidase (B) obtained from *A. oryzae*, the optimum temperature and pH of A were 40°C and 7.9, respectively. Glucose formed from the sucrose reduced the activity of fructosyltransferase as happened in the case of the enzyme obtained from *A. niger*. The use of sucrose was effective since glucose was converted to fructose by glucose isomerase when the activity of the hydrolyase became greater than that of the transferase until consumption of B in the reaction was complete. For A to be obtained from sucrose under conditions of limited hydrolyase activity, two stages were required.

The energy benefit of producing methane from cane molasses vinasse

J. Pailleret. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 235 - 239 *(French)*.

It is estimated that anaerobic fermentation of vinasse would yield sufficient methane to serve the fuel needs of the distillery while reducing the pollution load by 85 - 90% and providing a fertilizer.

The production of ethanol E 95° fuel. Diesel-alcohol engines

Y. Lemaire. *Comm. 3e Congr. Assoc. Réun. Dev. Tech. Agric. Sucr.*, 1988, 240 - 257 *(French)*.

The possibility of using 95° ethanol manufactured from cane molasses as fuel in diesel engines is discussed; Garo controlled ignition and a system based on use of a special additive such as triethylglycoldinitrate (an ICI product marketed as Blendol) to produce ignition were tested and found to be practical. Siranala sugar complex in Madagascar is used as example to demonstrate the possible economic benefits of a distillery producing alcohol for diesel engine fuel in cane agronomy, e.g. for movement of irrigators and for pumping of the water, plus the advantages of the vinasse as a fertilizer.

Wofatit UF 93-invertase - an immobilized biocatalyst for industrial sucrose hydrolysis

J. Römbach, H. Kluge, J. Mansfeld and A. Schellenberger. *Lebensmittelind.*, 1989, **36**, 70 - 71 *(German)*.

Invertase, immobilized by covalently bonding on the surface of UF 93 (a 10% DVB cross-linked polystyrene) after activation with glutaraldehyde, has an activity of 1000 - 1200 U/g and a half-life of 360 days in 42% sucrose solution at 40°C. It is used at an East German lactose plant to hydrolyse 65°Bx liquid sugar that has been decolorized with resin to <25 ICUMSA units. At 40°C and an inverted sugar productivity of 760 g/hr/litre, 89 - 95% conversion is achieved. Ash content of the invert syrup is <0.12%.

A new approach for treatment of distillery and sugar factory effluent

S. Hitkari and M. Singh. *Indian Sugar*, 1989, **38**, 883 - 885.

Disadvantages of various methods for treatment of vinasse and sugar factory effluent are noted and a scheme proposed in which vinasse would be treated in a mud separation tank and by anaerobic lagooning for 70 - 90 days followed by fermentation with *Azotobacter* nitrifying bacteria. Sugar factory effluent could be treated directly with the bacteria after 5 days' retention in a collecting tank. BOD removal efficiencies of 47 - 97% depending on initial BOD levels (1000 - 6000 mg/litre) are considered possible with 24 hr treatment of effluent. Coupling the process with activated sludge treatment would be of advantage.

Molasses from the veld

C. Mayes. *Tate & Lyle News*, 1989 (June), 4 - 5.

An account is given of fodder products manufactured by United Molasses (UK Division) from cane molasses supplied by Simunye sugar factory in Swaziland. Millflow and Molablend are free-flowing liquids, the latter including lignin sulphonate to improve pellet hardness. Products in the Molaferm range each have a different level of condensed molasses solubles (CMS) which is an evaporated by-product of molasses fermentation that is higher in crude protein, minerals and inorganic matter than cane molasses and is more free-flowing. Molwhey combines molasses with by-products from the milk and cheese industries.

Oxidation of molasses to produce oxalic acid

A. Sattar *et al. Pak. J. Sci. Ind. Res.*, 1988, **31**, (3), 163 - 166; through *S.I.A.*, 1989, **51**, Abs. 89-0822.

Oxalic acid was produced by oxidation of sucrose in pure solution or in cane molasses. The reaction was carried out at 60 - 65°C with 65% nitric acid + 60% sulphuric acid, using vanadium pentoxide + tungsten oxide as catalyst. The yield from molasses, 65.3% on sugars, was comparable to that obtained from sucrose. The molasses had first to be freed from calcium salts by precipitation as calcium oxalate. The economics of the process would depend on absorption of the nitrogen oxides formed.

Demineralization of a molasses distillery waste water

F. G. Neytzell-de Wilde. *Desalination*, 1987, **67**, 481 - 493; through *S.I.A.*, 1989, **51**, Abs. 89-0842.

The use of vinasse in fodder is restricted by the high content of minerals, espec-

ially potassium. Tests are reported on the partial demineralization of vinasses by electrodialysis using conventional anion and cation exchange membranes. The vinasse was first centrifuged to remove suspended matter. In an electrodialysis unit operated at low voltage (to avoid high power consumption), 50 - 60% of the K was removed from the vinasse at a current efficiency of about 50 - 55% (which is low) and D.C. power consumption of 0.75 - 0.85 kWh/kg K removed. Transport of water and some organic components from the diluting to the concentrating stream also occurred. Progressive fouling of the membranes was not observed.

A note on live weight changes of sows fed final molasses

C. P. Díaz and J. Díaz. *Cuban J. Agric. Sci.*, 1989, **23**, 61 - 63.

Experimental data obtained for sows fed on molasses as the sole energy source showed a relationship (r = 0.85) between total live weight gain and gain during the first 60 days of pregnancy, whereby the latter factor represented 63% of the total gain.

Evaluation of ash from a sugar mill for broiler beds under two feeding systems

P. Pérez, L. M. Fraga, M. Valdivié, L. González and M. Febles. *Cuban J. Agric. Sci.*, 1989, **23**, 65 - 70.

Bagasse furnace ash was compared with wood shavings used as poultry litter for chickens aged 1 to 52 days. In one experiment, the birds were fed on a diet containing wheat as basic energy source, and in another a laxative diet based on raw sugar was used. Feed consumption was lower with both diets when the birds were reared on ash litter, but there was no difference in live weight gain between treatments in either experiment. There was less than unity difference in the percentage of dry matter in the ash litter at the end of the rearing period with the two diets, while there was a 10 unit difference as a result of the diets in the wood shaving litters, with the lower figure applying to the laxative diet; the feathers were cleaner in birds reared on ash because of the higher moisture absorption capacity which, coupled with an alkaline pH, would help prevent the development of undesirable micro-organisms. Because of this and the possibility of its re-use as poultry litter, ash is recommended.

Effect of the consumption of high levels of molasses on the structure and function of the ruminal wall of bulls

R. Ruiz. *Cuban J. Agric. Sci.*, 1989, **23**, 79 - 92.

Studies are reported on the changes caused in the structure, absorptive capacity and metabolic activity of the ruminal mucosa in bulls fattened on diets consisting of molasses and 2% urea *ad libitum*, restricted forage and protein supplement.

Utilization of sulphitation filter mud - present and future prospects

N. C. Jain and A. Bajpai. *Indian Sugar*, 1989, **39**, 15 - 24.

A review of the literature on filter cake utilization (47 references) concerns the agricultural value of the cake applied directly or used to prepare compost, its possible use to generate biogas, incorporation in animal feed diets, extraction of wax and other possible uses which have been the subjects of special investigations.

Possibilities of utilizing filter mud from sugar manufacture

M. A. Fishman, F. S. Peres, O. A. Bolotin and Yu. M. Prokudin. *Izv. AN MSSR, Ser. Fiz.-Tekhn. i Mat. Nauk.*, 1989, 10 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (13), Abs. 13 R1459.

Results of physico-chemical investigations have shown the possibility of utilizing filter cake as a filler instead of chalk for polymer materials, particularly a resinous mixture based on synthetic rubber used in the manufacture of articles. The use of filter cake is of considerable economic benefit.

Recovery of protein-rich by-products from sugar beet stillage after alcohol distillation

Y. V. Wu, H. C. Nielsen and M. O. Bagby. *J. Agric. Food Chem.*, 1989, **37**, 1174 - 1177.

Sugar beet was ground and incubated with 0.3 and 1.5 ml/100 g pectinase at optimum temperature and pH during 6 hr with periodical stirring using a spatula (the suspensions being too thick for magnetic stirring); the resultant slurry was then centrifuged for 20 min at 6000*g* and fermented to ethanol. While pectinase caused some reduction in viscosity, the level was still sufficiently high to cause problems in fermentation and vinasse treatment. The viscosity could be reduced by dilution with water which, however, also reduces the concentration of fermentable sugars and alcohol. Juice extracted from the ground beets by pressing was of low viscosity and gave a high yield of higher concentration alcohol. It also yielded 16 litres of vinasse solubles per kg of alcohol; treatment of this material, containing 24% crude protein, by combined ultrafiltration and reverse osmosis substantially reduced the nitrogen, solids and ash contents and yielded a small volume of concentrate and a large volume of permeate that could be re-used or safely discarded.

Production of sweetener containing fructooligosaccharides from sugar beet molasses

H. Fujisaki, T. Muratsubaki, T. Kamada and K. Sayama. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 27 - 32 *(Japanese)*.

Experiments were conducted on continuous production of fructooligosaccharides employing a fructose-transferring enzyme from *Aurobacidium pullulans*

AHU 9549 that was stored at – 40°C after immobilization with calcium alginate and thawed before use. At pH 5 and 55°C, the fructooligosaccharides were produced from 50% sucrose solution in a plug-flow reactor over a period of 25 days. When beet molasses was used as substrate, the oligosaccharide concentration was lower at 32% in a plug-flow reactor than in a continuous stirred tank reactor (32%), which was therefore adopted for the enzymatic reaction. Removal of betaine from the reacted liquor by chromatography with Dowex 50W resin in Na^+ form led to a rise in oligosaccharide concentration to 53%.

Evaluation method for chromatographic separation

K. Sayama and T. Muratsubaki. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 33 - 39 *(Japanese)*.

Application of Dowex small-particle strong cation exchange resin to recovery of raffinose, betaine, etc. from beet molasses by HPLC is discussed. Resin performance was assessed from parameters such as the number of theoretical plates, separation factor, exchange capacity and resolution; cross-linkage could be gauged from the resin moisture content, specific volume and capacity, and a resin having a cross-linkage of 4 - 6 DVB was suitable for chromatographic separation.

Possibility of utilizing condensates after concentration of molasses vinasse

H. Haberowa, E. Sobczak and M. Augustyn. *Przem. Ferm. i Owoc.*, 1988, **32**, (11), 6 - 9; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (15), Abs. 15 R1470.

In an investigation of the possibility of using condensate (from concentration of vinasse) in alcohol fermentation, it was found that replacement of mains water with condensate of pH 3 containing 0.032% and 0.045% alcohol increased productivity.

Hydrolysis of sucrose solutions with β-fructofuranosidase from immobilized yeast cells

S. V. El'chits, E. L. Vygovskaya and I. A. Krapivnitskaya. *Pishch. Prom.*, 1989, (4), 25 - 27; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (16), Abs. 16 R1446.

The possibility of using immobilized β-fructofuranosidase from cells of *Saccharomyces cerevisiae* to hydrolyse sucrose solutions was studied and the optimum ratios between biocatalyst and substrate concentrations established. It was found possible to re-use the enzyme a number of times and, with it immobilized on superfine basalt fibre in heterophase cultivation, for continuous hydrolysis of 20% sucrose solution.

Diffusive pulp dewatering

J. Arf, S. Matusch and C. Voss. *Zuckerind.*, 1989, **114**, 619 - 628.

A prototype DK 2500 beet pulp press developed and constructed by Braunschweigische Maschinenbauanstalt AG and Selwig & Lange GmbH on behalf of Süddeutsche Zucker-AG is described which incorporates two pairs of bevelled perforated discs connected by claw coupling and rotating with an angle of 4° between their axles so that a wide gap is formed between them at one pair of edges and a correspondingly narrow gap at the opposite pair because of the bevel. A 1:1 mixture of pulp and molasses of 30 - 34% and 90% dry solids content, respectively, is fed from a screw press to the pulp press which it enters through the widest gap between the discs. During rotation of the discs through 200° (which takes about 1 min), the mixture is subjected to a pressure that gradually increases from 4 to about 10 bar. The pressed mixture expands as the gap between the discs widens and is removed by a wedge-shaped plate. A pre-pressing stage ensures that the press receives a mixture of desirable consistency without the risk of back-mixing. The expressed liquid from the press is concentrated in a falling-film evaporator to 92% dry solids and recycled to the screw press. A final product of 65 - 70% dry solids was obtained at a throughput of up to 20 tonnes/hr in trials at Ochsenfurt in 1988/89. Bagging of the material proved successful in trials but was too costly; pelleting was also successful and was to be scaled-up for the next campaign. Vinasse was found to be a suitable alternative to molasses in the pulp mixture. Aspects of marketing of the molassed pulp as animal fodder are discussed.

Stillage re-use in batch ethanol fermentation

A. R. Navarro. *Taiwan Sugar*, 1989, **36**, (3), 20 - 25.

Experiments are reported in which a basal medium containing glucose and yeast was fermented with *Saccharomyces cerevisiae* ; after separation of the yeast, 65% by volume of the residue was distilled to separate the ethanol. Glucose, yeast extract and salt were added to the base amount of the original medium and the volume of the vinasse raised to its pre-distillation level. Fermentation was then repeated a number of times under varying conditions. The results of each set of experiments are discussed. While re-use of vinasse was shown to be technically feasible (depending on the type of process used), a number of factors need careful consideration, including the need to: (i) distill-off sensitive inhibitory substances that produce the yeast cells (of critical importance in extractive fermentation), (ii) feed essential nutrients at low concentration and (iii) remove salts or ions (which enter the system with the carbon source) before they reach critical levels. The possible benefit of slopping-back in processes using immobilized cells is discussed. Major advantages of re-using vinasse include a saving in nutrients, mineral salts and water, minimization of the amount of waste that needs treatment and hence a reduction in energy consumption, the possibility of re-using sugar unfermented in the initial process and increase in productivity.

because of frequent problems in the industry with excessive massecuite viscosities, emphasizes the need for identifying and adhering to the optimum massecuite parameters.

It is believed that the approach outlined in this communication can serve as a basis for a rational operation and control of modern crystallizers. Complications stemming from fluctuations in content of dextran and possibly other polysaccharides that could cause large deviations of the actual viscosities from the calculated ones can be easily handled with *in-situ* continuous viscosity monitors. A feed-forward type of control employing the present model can be used to deal with the slow response characteristics of large-scale crystallizers.

Optimizacion del funcionamiento del cristalizador de bajo grado

El enfriamento óptimo restringido (COC) fue definido como el enfriamiento óptimo limitado por la tasa de enfriamiento y la viscosidad de la masa cocida que puede ser obtenido y manejado en el proceso. Aunque éstos deben ser evaluados para cada instalación específica, se usaron valores, que se cree eran representativos, para calcular los perfiles de COC para un amplio rango de parámetros de masa cocida. Se encontró que cuando el contenido de sólidos totales del licor madre inicial es de 85.5, correspondiente a un índice Brix de masa cocida de 94.0, la pureza de las melazas finales está en su punto máximo. Cualquiera desviación desde el punto óptimo del índice Brix de masa cocida resultará en un aumento significativo de la pureza de las melazas finales. Se estima que por cada 0.6% de índice Brix de masa cocida por encima o por debajo del nivel óptimo, la pureza de las melazas finales aumentará en alrededor de 1.0 y 1.8 puntos respectivamente. La temperatura final COC, para los parámetros óptimos de masa cocida, es de alrededor de 30°C, esto es significativamente más baja que en las prácticas industriales verdaderas. Este apoya las observacíones industriales de que temperaturas finales más bajas se correlacionan con purezas de melazas finales más bajas, pero también, debido a los frecuentes problemas en la industria con masas cocidas de muy alta viscosidad, enfatiza la necesidad de identificar y adherirse a los parámetros óptimos de masas cocidas. Se cree que la aproximación delineada en esta comunicación puede servir como base para una operación y control racional de cristalizadores modernos. Las complicaciones que surgen de las fluctuaciones en el contenido de dextrana y posiblemente de otros polisacáridos que podrían causar grandes desviaciones de las viscosidades reales desde los valores calculados, pueden ser fácilmente manejadas con monitores de viscosidad continua *in-situ*. Un tipo de control de alimentación avanzada empleando el presente modelo puede ser utilizado para tratar con las características de respuesta lenta de los cristalizadores de escala mayor.

Optimisation de la performance du cristallisoir arrière-produit

Le refroidissement optimal forcé (COC) a été défini comme le refroidissemnent optimal limté par la vitesse de refroidissement et par la viscosité de la massecuite et pouvant être réalisé et appliqué dans le processus. Pour calculer les profils du COC entre de larges limites des paramètres de la massecuite, on a utilisé des valeurs considérées comme représentatives mais qui devront à nouveau être évaluées pour chaque installation spécifique. On a trouvé que la pureté de la mélasse finale était minimale pour une teneur en matières sèches totales de 85.5 (qui est la valeur initiale dans la liqueur-mère et qui correspond à un Brix de massecuite d'environ 94.0). Toute déviation de ce Brix optimum dans la massecuite aura comme résultat une augmentation significative de la pureté de mélasse finale. On estime que pour chaque 0.6% de Brix-massecuite au-dessus resp. endessous du niveau optimum, la pureté de la mélasse finale augmentera avec environ 1.0 resp. 1.8 points. Pour une massecuite correspondant à des paramètres optimales, la température COC finale est d'environ 30°C, c.à.d. significativement plus basse que la valeur appliquée aujourd'hui dans la pratique industrielle. Cela fournit un support aux observations industrielles comme quoi des températures finales plus basses correspondent à une pureté de mélasse moins elevée. D'autre part, étant donné les problèmes fréquemment rencontrés dans l'industrie avec des viscosités excessives des masscuites, cela souligne le besoin pour une définition et une application de paramètres optimales relatives à la massecuite. On estime que l'approche exposée dans ce travail peut servir de base pour une opération rationelle et pour le contrôle des cristallisoirs modernes. L'installation de moniteurs "in situ" continues de la viscosité peur aisément obvier aux complications, ayant comme origine des fluctuations dans la teneur en dextranes ou d'autres polysaccharides, et qui peuvent faire dévier largement les viscosités réelles des valeurs calculées. Un contrôle du type "feed forward" et basé sur le modèle exposé ici peut être utilisé pour tenir compte des caractéristiques à réponse lente propres aux gros cristallisoirs.

Optimisierung der Leistung von Nachproduktkristallisationsapparaten

Beschränkter optimalen Kühlung (COC) bedeutet man die optimale Kühlung, die durch die im Prozess erreichbare und kontrollierbare Kühlungsgeschwindigkeit und Füllmasseviskosität beschränkt wird. Obgleich man die letzteren für jede gegebene Installation schätzen muss, verwendete man anscheinend repräsentative Werte zur Berechnung der COC-Profile bei einem grossen Bereich von Füllmasseparametern. Festgelegt wurde, dass die endliche Melassereinheit minimal ist bei einem Gesamtfeststoffgehalt im Muttersirup von 85.5%, was einem Füllmasse-TS-Gehalt von ungefähr 94.0% entspricht. Jede Abweichung vom optimal-

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ICUMSA News

Editor: R. Pieck

Message from the President

In this issue we have two letters commenting on the change of direction of the last four years. As your President I welcome this. Indeed it was one of the reasons for setting up ICUMSA News. The dialogue should not stop here. Rather than run the risk of stopping the discussion by responding to these letters at this time, I propose that the issues raised be discussed further in the next issue and indeed at Colorado Springs if that is necessary.

It is with great regret that I advise the resignation, due to ill-health, of our General Secretary, Ted Whayman. He has just had a by-pass operation to rectify a heart problem. This was wholly successful and he is now recuperating at home. In seeking to reduce his future workload he has asked to be relieved of his duties as General Secretary. This, of course, I have accepted. In the remaining period of the 20th Session, Mr. Bob McCowage, General Referee for Subject 1, will assist me as Ted's replacement. On your behalf, I thank Ted for his contribution in the three years he has served our Commission and wish him a complete and speedy recovery.

To those people who have not yet decided whether to attend the Colorado Springs meeting, I would say "Don't miss it or you will be sorry". I met the organizing committee of the U.S. National Committee and also visited the Broadmoor venue in October. You can be assured that this is an outstanding conference venue in a beautiful city nestled at the foot of the Rockies. This will be the meeting at which we prepare the Commission for its second century. Not to be there will mean missing an opportunity to shape history. The Conference program and extracurricular activities available to delegates will make this a great Session.

Murray Player
January 1990

Subject 14 - Microbiology

Rapid microbiological tests

ICUMSA microbiological methods are available to check and compare the microbiological quality of sugars. Conventional methods are based on the visible growth of micro-organisms. After cultivation, the organisms have grown to an extent that it is possible to count them without a microscope. In order to determine the contamination by a particular organism, special media are employed. Furthermore, the specification of pH, oxygen content and temperature helps increase the selectivity for particular micro-organisms. The aim is to facilitate the adaptation of a micro-organism to a substrate and to shorten the lag-phase by improving the composition of the nutrient media. Generally when using ICUMSA media with membrane filters we have incubation times of 48-72 hours.

Microbiological tests are carried out to give assurance of product quality for downstream applications, assurance that the product was manufactured in a hygienic environment and that no pathogens are present. At the end of the production process sugar normally has a very low micro-organism content. Contamination can occur on conveyor belts or during inadequate storage. Our experience is that the major contaminants of sugar are spore-forming bacteria. Any vegetative micro-organisms present are likely to be inactive or damaged.

There are two important characteristics of microbiological control in sugar as far as the use of rapid methods are concerned:

(1) low micro-organism counts, and

(2) the prevailing occurrence of spores and inactive vegetative micro-organisms.

In order to determine low microbial counts in sugar the micro-organisms have to be concentrated by membrane filtration, so typically a 10 g sample is filtered. The use of membrane filtration for the enrichment of micro-organisms from sugars with low micro-organism counts simplifies the sample preparation and enhances the accuracy of detection.

The determination of spores and inactive vegetative cells requires some time for re-activation which has to be taken into consideration in the specification of the cultivation time.

Rapid methods are nevertheless time-saving because they establish micro-organisms in a food sample directly, and they also shorten the incubation period for the cultivation of micro-organisms. Rapid methods are not readily applicable, however, to the microbiological control of sugar because of low micro-organism content and the presence of spores and damaged cells. Such samples have to be concentrated and their incubation time has to be prolonged. First and foremost, rapid methods are important for foods with a short shelf life. In order to market such products it is important to check as quickly as possible that they do not contain spoilage organisms or pathogens.

Impedance measurement and microfluorescence techniques are rapid methods permitting a reduction in incubation time. The **impedance method** is based on the fact that metabolic products are concentrated in the nutrient solution during the growth of the micro-organisms causing a change in the conductance of the nutrient medium. However, a detectable change in the conductance occurs only when the cell population exceeds a threshold level of about 10^6 micro-organisms per cubic centimetre. Reproducible results obtained within a few hours are only found where higher microbiological counts exist in the form of vegetative cells. To measure low microbiological counts, e.g. yeasts in beet sugar, the sample preparation time and incubation time have to be increased. With the impedance measurement we have an automatic method permitting the checking of a large number of food samples with high microbiological counts. It is important, however, that the nature of the microflora be known, as the nutrient media

have to be chosen accordingly.

In the case of **microfluorescence techniques**, one involves counting microcolonies while the other involves counting organisms directly. With the microcolony fluorescence method a reduction of incubation time can also be achieved. Before the colonies have grown into macroscopic size they are stained with a fluorescent dye on the membrane filter so that it is possible to count colonies more easily with a fluorescence microscope. However, this reduction of the incubation time is accompanied by time-consuming microscopic work. With low microbiological counts the method becomes relatively inaccurate. Moreover, scanning a whole membrane filter for a single micro-organism is very tedious.

It is also possible to determine the microbiological count of a sample directly by counting under a microscope. The **direct epifluorescence filter technique** is a rapid method involving filtering the sample on a membrane with the adhering bacteria and yeasts being stained with fluorescent dye and counted microscopically. The disadvantage of this method is that it is not possible to distinguish clearly between living and dead cells. The method requires accurate preparation and experience in the use of a microscope. The counting of bacteria is exceptionally tiresome and inaccurate. This method is more suitable for yeasts, but again, the expenditure of work is too great for the search for only one yeast cell. Moreover this method cannot be used to count spores.

Another method for the direct inspection of micro-organisms in samples relies upon the properties of cell contents. The **adenosine triphosphate (ATP) content** of a sample is determined by measuring bioluminescence. ATP exists in all living microbiological cells in a nearly constant amount. The measurement is based on a luciferine-luciferase reaction with ATP, thereby emitting light proportional to the mole content of ATP. Because of the low microbial counts, this method is not suitable for measuring the extent of sugar contamination. Moreover, it is impossible to differentiate between species or to detect spores.

Endotoxins are produced by gram-negative bacteria. It is possible to determine a low endotoxin concentration directly with the **Limulus-test**. This method is, however, restricted to the detection of gram-negative bacteria. Even then it cannot be applied to actual cell counts as the endotoxins of dead cells interfere with the measurement. Since the bacteria occuring in sugar are mainly gram-positive, this test is not suitable for microbiological control in sugar factories.

There are some rapid tests which can differentiate between a gram-positive or gram-negative reaction. They have been developed mainly for the determination of pathogenic organisms. It is possible to detect *E. coli* in a sample by adding 4-methyl-umbelliferyl-β-glucuronide (MUG) to the culture medium. If *E. coli* grows in the medium the enzyme β-D-glucuronidase produced splits the MUG. The positive reaction can be detected with fluorescence (UV-light, 366 nm). Most rapid tests for determination of pathogenic organisms have been developed to shorten the time of identification, e.g. of salmonella, listeria and coliforms. These tests are mainly suitable for process control in order to find the cause of contamination and to eliminate them.

The emphasis in microbiological control of the sugar end product is on determination of product-specific micro-organisms. At present, conventional methods are still being used mainly because rapid methods do not give comparable results for the tests required.

Letters to the Editor

I. Letter from Leon A. Anhaiser, Vice President ICUMSA

The twentieth Session of ICUMSA, scheduled for 1990 in Colorado Springs, Colorado, USA, presents both a challenge and an opportunity for the organization in its efforts to adjust to the most prolific technological period known to man. It will also be a time when ICUMSA will be faced with important decisions about what type of organization it wants to be.

At this critical juncture in ICUMSA's history, it is worthwhile to pause and consider some of the issues facing ICUMSA and the questions they raise:

(1) There has been a trend toward the concept of only one official test method. At the same time, ICUMSA has indicated a willingness to implement IUPAC criteria for the evaluation and validation of methods. If more than one method meets these criteria, on what basis, then, can one method be accepted and one be denied?

(2) Allowing only one method implies a regulatory function. Obviously, ICUMSA is not in a position to dictate what methods a country or company can use. The exclusion of methods which qualify on their merits could result in the reduction of influence by our organization. On the other hand, having no limit on the number of methods implies a methods validation organization.

(3) ICUMSA methods have always been accepted on the basis of the need they fulfil for the sugar industry. If ICUMSA is perceived as a legitimate and prestigious organization, then its methods are accepted by the industry. If it is not perceived this way, then its methods are not accepted, no matter what ICUMSA says.

(4) ICUMSA already has more than one method in some instances : two HPLC methods and one GLC method for sucrose in molasses; HPLC and enzymatic methods for raffinose; two methods for copper in white sugar; two methods for lactic acid; several tests for loss on drying; three tests for particle size.

(5) What about too many methods? The expense and trouble of a collabor-

ative test is not lightly undertaken. One of the functions of a Method Review Committee could be to ascertain that a need exists for the method before the collaborative test is undertaken.

(6) What about comparability of test methods? The General Referee and Methods Review Committee could recommend that comparative collaborative studies be made whenever this is felt to be necessary. ICUMSA in the past has done this for a number of tests, including methods for loss on drying and chromatographic and other methods for sucrose in molasses, and so it is not a new concept.

(7) In the case of fundamental values and reference tables, it is appropriate, on the other hand, to have only one accepted and official value.

(8) ICUMSA meets only once every four years. At this rate, new methods of analysis require, at best, eight years before becoming official and usually twelve years is considered normal. Under this schedule, a method has a good chance of becoming obsolete before it is officially adopted.

(9) Should ICUMSA conduct yearly evaluations of methods and evolve into an organization able to cope with the growing need for more rapid dissemination of collaborative testing results and acceptable of new methods?

(10) What is the role of the National Committees in the scheme of methods evaluation?

The reorganization of the numerous committees was designed to enhance and consolidate subjects in what would seem to be a more effective manner of achieving the goals of the organization. Will all of those changes result in a more responsive ICUMSA? Does ICUMSA mean one method or does it enhance all scientific methods? Colorado Springs may hold the answer.

II. Letter from A. Emmerich and E. Reinefeld (Braunschweig, West Germany)

In a few months time ICUMSA members will meet for the 20th Session in Colorado Springs. Behind us we have a time with many changes within our organization. The next Session will probably be governed by discussions about the rearrangement of ICUMSA's activities, about its advantages, but also about its disadvantages. We should not overlook, however, the activities of many Referees during recent years, which will surely form an approach to our main object to provide well-founded methods of analysis for the industry, for the trade and for other parties interested in sugar. The writers intend to contribute some thoughts to this discussion based on their knowledge of the development of ICUMSA during recent decades.

The most important item will surely be the rearrangement of the Subjects and in this connection the subdivision into Products and so-called Scientific Subjects. This system will only work satisfactorily if the distribution of tasks between these two kinds of subjects is clearly defined and if there is a close cooperation between the Referees involved. For instance, investigations or collaborative tests on invert sugar determination in raw sugar should be planned by the General Referee 1 (Raw Sugar) together with the Referee 15 (Reducing Sugars) consulting also the Referees 8 (GLC), 9 (HPLC) and 11 (Enzymatic methods). Only in this way can superfluous duplication of work and diverging developments within ICUMSA be avoided. We should not question the rearrangement, as has been done in the past, but should fill it with life.

In order to achieve this it is our opinion that some sort of guidance for the working groups and their referees by a coordinating board will be necessary. Such a board has already been in existence since the 17th Session 1978 in Montreal : the "Steering Committee". It has been inactive, however, since that time. The members of the Steering Committee – one of them should be the Referee of Subject 3 (Methods Format, Collaborative Tests and Statistical Treatment of data) – should meet soon after a Session in order to review the results and to develop a catalogue of those tasks which are to be regarded as urgent. In the same period the Referees should be found and appointed by the President. The Referees responsible for the most important tasks should be informed accordingly within a short time after a Session, so there is time enough to plan necessary activities in close cooperation between the Steering Committee, the Referees and their associates. In this way it should be possible to start the investigation at the latest during the year following a session.

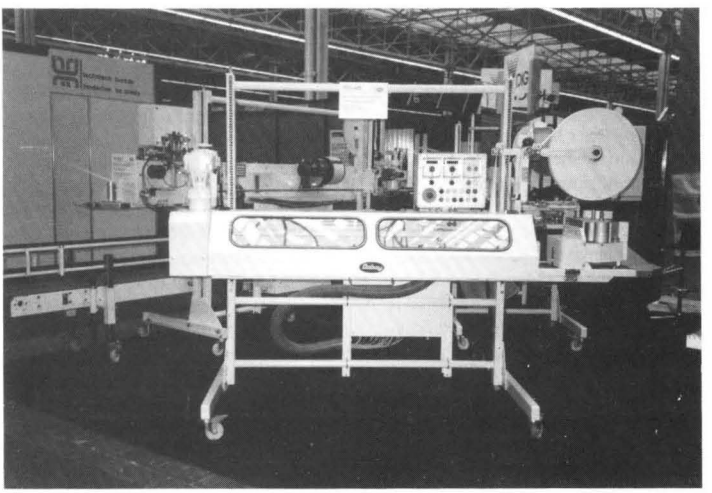
What has been common practice up to now? In most cases one year and more has passed before the report of the Proceedings has become available. During this time nothing happens. The activities for collaborative tests and for the discussion of the contents of the Reports to be presented have been, with only a few exceptions, limited to the year immediately before the next Session. Even then, the Referees have been practically left alone. And, after all, they have chosen from the Recommendations of the preceding Session those items which correspond to their preference and to their own ideas.

We think that tightening and guidance according to the proposals given above will lead to a more effective functioning of our Commission. Substantial preconditions have already been established. Since the 18th Session in Dublin (1982) criteria are available for the format of methods and for the adoption of ICUMSA methods. From that time there are instructions about the execution and the statistical evaluation of collaborative tests and these have only to be adapted to the international agreements within IUPAC.

In addition, a further problem should be thoroughly discussed once more : Should ICUMSA recommend only one method for every analytical purpose, or should more methods be admitted? There are good arguments for both alternatives. There is still time left for the National Committees to discuss this matter. In Colorado Springs we should have a decision.

Product news

The new FTS 600 – an alternative in bag closing



Paper sacks can be folded and taped by a new closing system that offers packers an alternative to sewing machines. Developed by Doboy, the Fold-Seal-Tape (FTS) is the only one of its type that avoids leaving extraneous thread or tape when the sack is opened and yet is suitable for use by packers rather than sack manufacturers alone. The first unit is the FTS 600 which seals 25 0r 32 kg sacks at speeds up to 600 an hour. Other models are to follow as the market demands.

Any size single or multiwall kraft paper sack can be handled, with the FTS closure providing a dirt and insect-proof seal in permanent or peelable "easy-open" form. This easy-open feature, obtained by only partial activation of the adhesive tape during sealing, is simple, quick and leaves no loose tape or thread to contaminate the product.

After opening, the tape remains firmly attached to the sack. In operation, a sack is first fed into a pair of heavy duty carrier chains and then trimmed to give a clean, precise top. The top is then folded over twice and an overtape with heat seal adhesive applied to the side of the sack and over the fold area. The tape is then completely heat sealed in the fold area and completely or partially sealed to the side of the sack, depending on whether a peel-open facility is required. If peel-open is chosen, the lower edge of the tape is left unsealed to give a point to grip. The completed seal is then run through a compression nip and discharged from the machine via a coding device if fitted.

Doboy is using an overtape with an instant heat fix coating that remains open only as heat is applied and sets immediately heat is removed. This means that long compression sections are avoided and also allows partial activation of the adhesive for the peel-open option to be controlled with greater accuracy.

Sacks or bags may be either pillow style or gussetted and fed from any of the proprietary makes of automatic sack feeding systems. As standard, the unit is manufactured to IP 54 electrical requirements and specifically designed for operation in dusty environments.

Further details:

Doboy Verpackungsmaschinen GmbH,
Kiebitzweg 16-18,
D-2000 Schenefeld/Hamburg,
Germany.

Optimization of low-grade crystallizer performance

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en Füllmasse-TS-Gehalt wird eine bedeutende Zunahme der endlichen Melassereinheit bewirken. Eine Zunahme der endlichen Melassereinheit um 1.0 und 1.8 Einheiten je 0.6% Füllmasse-TS-Gehalt über und unter dem optimalen Niveau bzw. wurde errechnet. Die endliche COC-Temperatur bei optimalen Füllmasseparametern liegt um 30°C, d.h. bedeutend tiefer als eigentlich in industrieller Praxis. Dies bestätigt industrielle Beobachtungen, dass niedere Endtemperaturen mit niederen endlichen Melassereinheiten in Beziehung stehen und, wegen häufiger mit übermässigen Fülmasseviskositäten verbundener Probleme in der Industrie, hebt hervor, wie es erforderlich ist, die optimale Füllmasseparameter zu identifizieren und an ihnen festzuhalten. Man glaubt, dass der in dieser Mitteilung umrissene Problemansatz als Basis zur Rationalisierung des Betriebes und der Kontrolle von modernen Kristallisationsapparaten dienen könne. Mittels kontinuierlich arbeitender Viskositätsüberwacher *in situ* sind Komplikationen leicht zu behandeln, die von Schwankungen des Gehalts an Dextran und möglicherweise an anderen Polysacchariden herrühren; solche Schwankungen könnten beträchtliche Abweichungen der wahren von den errechneten Viskositäten bewirken. Mit einer Art Feed-Forward-Kontrolle, die das gegenwärtige Modell benutzt, kann man sich mit der langsamen Reaktionscharakteristik von grossen Kristallisationsapparaten befassen.

New single-loop controllers for the food industry

FGH Controls Ltd. has developed a new range of single-loop controllers which are ideal for use in a variety of food manufacturing environments including sugar processing. Designated the Magipak II S560 series, each is a compact 3-term digital controller design-

ed to be easy to understand and operate which, once set up, can control the process without further intervention.

The Magipak II S560 will accept a wide range of thermocouple, resistance thermometer or linear voltage/current inputs and can be quickly reconfigured if a change of sensor is required. All operating commands are entered through a sealed membrane keyboard, while both the temperature and parameter values are displayed on a four-character LED.

High-low deviation indication is included, plus the option of two fully-programmable alarm relays. These can be set at high, low, indexed, indexed high or indexed low. In order to prevent unauthorized access to its scroll mode, the S560 contains the facility to enter a three-digit password; additionally, a security code can be used to restrict parameter adjustments.

Control options for the S560 series include continuous current, TP relay, TP logic or TP triac. Each instrument has galvanic isolation between input sensor and output, and between input sensor and mains supply. The PID terms can be manually inserted or, to speed up the process, the S560 has "Tune Aid", which is a semi-automatic facility designed to determine these automatically.

The S560 has automatic cold junction compensation which maintains very close tracking and is said by the manufacture to give accuracy to within 0.25%. It can operate as a stand-alone instrument or as part of a larger computer-controlled installation. The instrument measures only 96 × 48 × 212 mm and costs £170.00.

Further details:

FGH Controls Ltd.,
4 Protea Way,
Letchworth,
Herts. SG6 1JT,
England.

MFV pumps brochure

The high-flow low-head MFV pumps of Thompsons, Kelly & Lewis Ltd. are to be found in industry and agriculture, circulating water for process and irrigation and handling effluents. The mixed-flow, single-stage volute pumps cater for flows up to 700 litres/second at heads up to 23 metres, with sizes between 200 and 375 mm. The rigid design is based on a single-entry, solid cast iron casing with radial splitting to include back withdrawal of the rotating element. The pumps are capable of high efficiencies, are easy to install and maintain and keep running costs to a minimum. The shrouded impeller may be in cast iron or gunmetal, and the pump may be mounted on a baseplate for direct drive or three-point linkage. The leaflet is available from TKL at P.O. Box 160, Springvale, Victoria, Australia 31771.

BTG instruments for the sugar industry

A new brochure from the BTG Group describes the equipment they offer for the sugar industry. This includes specialized instruments for in-line measurement of viscosity, whiteness, turbidity and suspended solids as well as steam conditioning equipment. The MBT-100S viscosity transmitter is suitable for the measurement of massecuite viscosity in crystallizers and examples are installed in US and French sugar factories. The MBT-150 is a reliable means of measuring thick juice Brix, while the MEK-2030 instrument is designed for control of pan boiling through viscosity measurement. The BT-D brightness transmitter measures the whiteness of wet or dry sugar and can be provide an alarm for the centrifugal operator and/or automatically divert off-colour sugar to remelt, as well as provide a record of quality. The SLD instruments can measure suspended solids for monitoring of juice clarification and filtration, suspended solids in effluents, etc. while the BTG steam conditioning valves govern steam temperature and saturation. Copies of the brochure are available from BTG Källe Inventing AB, Box 96, S-66100 Säffle, Sweden.

Automatic particle size analysis

A new ready-to-use package from Labcon Ltd. provides a quick and easy solution to the laborious routine of particle size analysis. The Epson Pine computer-based system, mounted in a purpose-made splash-proof case, is pre-programmed to control both sieve shaker and electronic balance and to produce a rapid print-out of analysed data. It features simple, screen-prompted operation, on-screen graphic display, memorizing of sieve sizes and weights, storage of results and remote or in-built printer options. It is compatible with all sieve shakers and many commonly used balances with an R232 interface.

Further details:

Labcon Ltd.,
24 Northfield Way,
Aycliffe Industrial Estate,
Newton Aycliffe,
Co. Durham DL5 6EJ,
England.

Purac

The Purac company offers an extensive range of services in the field of water and waste water treatment. A new brochure describes and illustrates these services, which range from consultation to laboratory studies, process design, turnkey contracting, equipment supply and maintenance and training. Techniques include flotation, filtration, sedimentation, microbiological treatment, anaerobic fermentation and composting, while industries served include municipal water supply and waste water treatment, the pulp and paper industry, the chemical and steel industries and the food industry. The last includes the sugar industry; in fact the Anamet process used for waste water treatment in the sugar industry was developed by the Swedish sugar industry and a division of the company was originally a division of Sockerbolaget AB. Copies of the brochure are available from Purac AB, Box 1146, S-22105 Lund, Sweden, or one of its subsidiaries in England, Spain, Tunisia, the USA or West Germany.

A simple and safe replacement for dry lead subacetate

By Stephen J. Clarke and Joy Bourgeois
(Audubon Sugar Institute/Sugar Station, Louisiana Agricultural Experiment Station, Baton Rouge, LA 70803-7305, USA)

Lead subacetate has long been the reagent of choice for juice clarification for pol measurements, in part owing to its simplicity. However, health and environmental circumstances demand that its use must soon cease. There have been a number of attempts to find a suitable replacement and these have been recently reviewed by Clarke & Legendre, along with a discussion of the financial impact of continued use of lead subacetate[1]. Under Louisiana conditions the disposal costs for the lead residues could be several hundred thousand dollars per factory per year. They also describe a multistep reagent system based on the sequential addition of calcium hydroxide, aluminium chloride and filter aid.

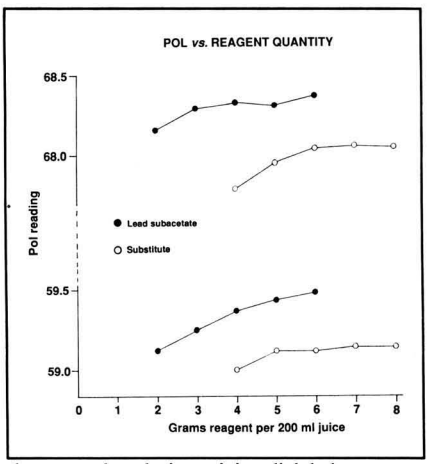
The ideal reagent to replace dry lead subacetate for juice analysis should have several features: (i) it should be a stable and non-hygroscopic dry powder which can be added without weighing, with the result independent of the quantity used; (ii) it should react completely and very quickly just by shaking or stirring and without use of any additional equipment; (iii) filtration should be rapid to give an optically clear solution with low colour; (iv) it must present no waste disposal problems. A reagent meeting these requirements has been developed by mixing three dry powdered materials. The mixture is dry and stable but loses some activity over several days when kept in an open container in the laboratory.

The components are
(A) Aluminium chloride hydroxide [C.A. Registry #12042-91-0 with empirical formula $Al_2Cl(OH)_5$]; this material has been used to coagulate waste water, stabilize clay soils, as a corrosion inhibitor and an antiperspirants.
(B) Powdered calcium hydroxide.
(C) RM10-NKT, a product of the American Colloid Company, composed of minerals, principally bentonite, and polymeric flocculants. Its major use is in industrial waste water treatment and it is environmentally benign.

The components A, B and C are mixed in the ratio 10:1:2. Each is a fine powder and good mixing is critical. Component C has a grey colour and the mixed reagent should be an even grey. The mixture should be kept loose and not packed hard. The mixing takes only a few minutes and is best done on a daily basis, preparing only sufficient reagent for the day. If reagent is left over, it can be combined with the following day's fresh material. For press juice analysis, between 5 and 6 g of reagent are required for 200 ml of juice. Less reagent is used for low concentration samples such as for filter cake and bagasse analyses and for mill residual juice. In tests, no filter-aid was used and the filter paper and polarimeters (all automatic) used were those routine in the factory laboratories. The filtration rate was usually higher than with the lead reagent and the colour often a little yellower. Clarity was very good and no problems were encountered in clarifying stale cane. The estimated cost per analysis is about $0.10.

The cane quality laboratory (core sampler plus press) in Louisiana is the major user of lead subacetate, with several hundred analyses per day performed at each factory. The new reagent was compared with lead subacetate by the laboratory personnel at several factories and the results showed excellent correlation. At Jeanerette, the substitute reagent gave, on average, 0.14 units lower than with lead. Other laboratories gave similar results, some with more scatter owing to variation in quantities of lead used, poor mixing of the divided samples and the use of flow-through cells with limited sample volumes.

The substitute reagent was also compared with dry lead for the process analyses for which the latter is normally used. The results, from several factories, again showed excellent correlation, with the substitute giving slightly lower values as before.



Five composite press juice samples were clarified with increasing amounts of lead subacetate and substitute to determine whether reagent quantity had any effect. The results for two samples, of high and low pol, are shown in the Figure. At 4 g reagent per test the substitute gave slightly cloudy filtrates with lower pol while 6 g of substitute gave good results at about the same value as the lower lead concentration. The higher lead values observed would therefore appear to be due, at least in part, to use of excessive amounts of lead subacetate.

Work is continuing on this reagent system with regards to dextran removal and boiling house analyses. Preliminary tests show that it can be used for polarimetry of raw sugar. A full paper, including all the statistical data, will be published as soon as possible.

New name for Finnsugar

Finnish Sugar Co. Ltd. (Suomen Sokeri Oy.) has changed its name to Cultor to reflect increased business outside the sugar market. The company's largest division is now that concerned with animal feeds, which accounts for 28% of net sales, against 20% for the sugar division and 17% for the food division.

1 *Paper presented to Sugar Industry Tech.*, 1989.

Facts and figures

US consumption of HFS[1]

US consumption of high fructose syrup is forecast by the US Department of Agriculture to total 6,080,000 short tons, dry basis, during the calendar year 1989, up from 5,890,000 tons in 1988. Of 7500 million bushels of corn used commercially in 1989/90, about 10% will be used for sweeteners and starch, half of this being for HFS manufacture.

Morocco sugar expansion[2]

Beet and cane crops are to be expanded in Morocco, the targets being 3,326,000 tonnes and 1,924,000 tonnes, respectively. Sugar production is expected to rise to 655,000 tonnes.

Tanzania sugar industry modernization[3]

The Sugar Development Council in Tanzania has announced plans to modernize its four sugar factories and to raise the combined capacity from some 230,000 to 330,000 tonnes per annum. However, current performance falls well below theoretical capacity limits as the 1988/89 crop only amounted to 90,000 tonnes of white sugar. Shortage of cash has prevented a proper maintenance and spare parts program over the years. The General Manager of the Corporation has launched a five-year investment program involving some $400 million. It is intended that part of the funding should be raised from the foreign exchange earnings generated by exports to the EEC under their ACP quota.

South African Sugar Technologists Association

The 1990 Annual Congress of the S.A.S.T.A. will be held during June 11 - 14, the official opening and first technical meeting at the Holiday Inn in Durban. Subsequent factory technical sessions will be held at the Mount Edgecombe Experiment Station and the agricultural technical sessions at the Huletts Country Club, also in Mount Edgecombe. Information for intending participants is obtainable from the SASTA Secretaries, SASA Experiment Station, Private Bag X02, Mount Edgecombe, Natal, South Africa 4300.

Asociación de Técnicos Azucareros de México

The Mexican Sugar Technologists Association (ATAM) has moved to Río Niagara No. 11, Col. Cuauhtemoc, Delegación Cuauhtemoc, México, DF 06500 (Telephones: + 52-533-30-40/49).

West German sugar company merger[4]

Companies operating seven sugar factories have founded Nordzucker GmbH in Braunschweig and two banks are expected to accede to the newly formed company should the federal cartel office authorize their participation. The companies' assets are to be transferred to the new company in 1990 and all production facilties are to be united.

New Indian sugar factory[5]

A new 220 million rupees sugar factory was opened recently at Kanniruppu, near Svagangai, in Tamil Nadu. The factory is computerized and has a crushing capacity of 2500 tcd. Six more factories are to begin production within two years and the state government has drawn up a long-term project for setting up chemical based on molasses, of which a surplus will then be available.

Zimbabwe sugar production fall[6]

Zimbabwe's sugar production in the 1989 crop year is estimated at 460,000 tonnes, tel quel, compared with 428,000 tonnes in 1988. A sharp decrease to 390,000 tonnes is expected for 1990, owing to a water crisis in the country which necessitated a reduction of irrigation.

Ingersoll-Rand acquisition of Swedish centriifugals business

In November, Ingersoll-Rand Company, of Woodcliffe Lake, New Jersey, announced its purchase of the batch centrifugal business of Nils Weibull AB, of Hässleholm, Sweden. It will become part of the American company's Industrial Process Machinery Group which includes California Pellet Mill Co. and Silver Engineering Works Inc. The Weibull range will provide a complementary source of batch machines to join the Silver range of continuous centrifugals.

PERSONAL NOTES

The death occurred on October 18, 1989, of the late **Dr. K. S. G. Doss**, former Director of the National Sugar Institute in Kanpur, India. Born in 1906, he graduated from Mysore University and carried out research and taught at the Central College, Bangalore, between 1927 and 1943. From 1943 to 1957 he worked at the N.S.I. as Physical Chemist, Professor of Sugar Technology and latterly as Director, after which he became Director of the Central Electrochemical Research Institute in Karaikudi. Since retirement in 1967 he has served as a Consultant to a number of organizations and maintained a close interest in sugar technology, working on several process improvements. He was the author of many papers to Indian and international scientific bodies, including a number published in this Journal.

We regret to report the death on November 24 of **Ervin Muller**, who was Chairman of the British National Committee of ICUMSA for the 18th and 19th Sessions. He was also Referee for "Sampling of sugar and related products". He was a gifted statistician and linguist, joining the Research Department of Tate & Lyle Ltd. soon after World War II. From there he took a number of technical positions in Tate & Lyle refineries, finally becoming Chief Chemist. In retirement, he acted as Joint Editor of "Sugar Technology Reviews" and always maintained his keen interest in ICUMSA activities.

1 *USDA Sugar and Sweetener Situation and Outlook Rpt.*, Sept. 1989, 3.
2 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 560 - 561.
3 *Czarnikow Sugar Review*, 1989, (1790), 156.
4 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 539.
5 *Indian Sugar*, 1989, **39**, 270.
6 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 543.

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