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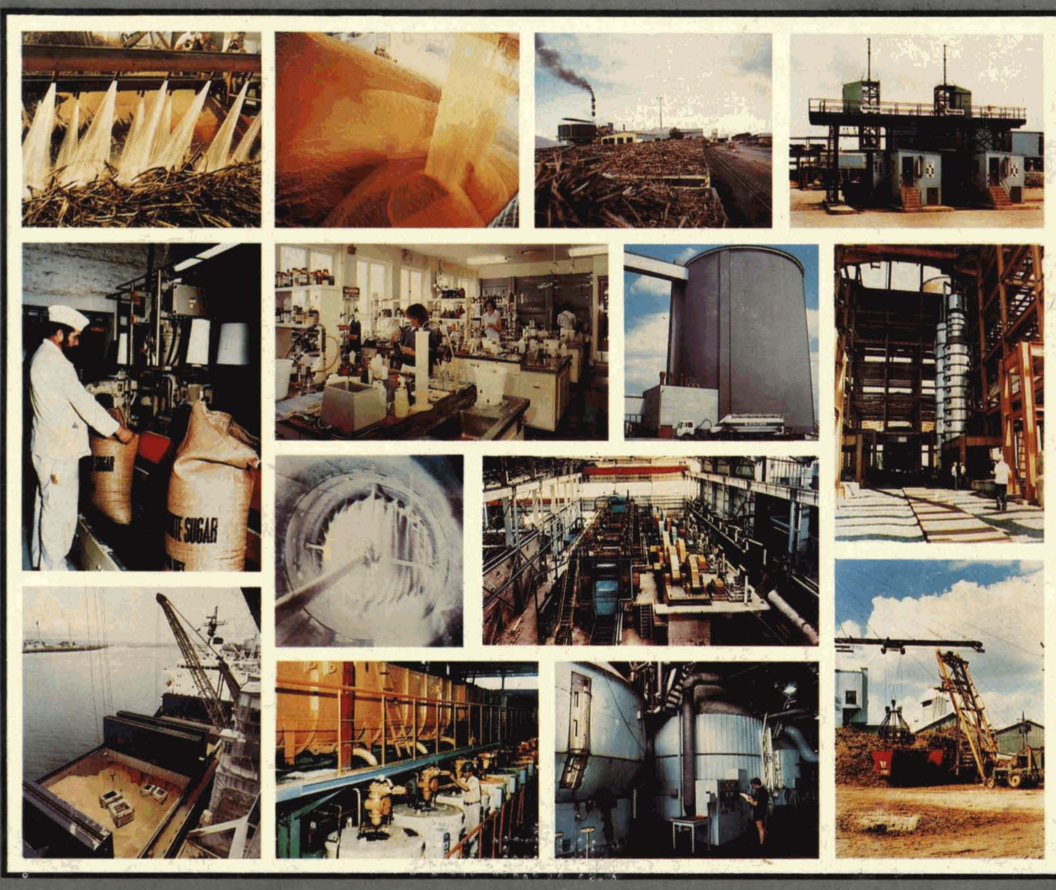

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NOTES AND COMMENTS

European beet sugar production, 1983/84[1]

F. O. Licht GmbH have just published their first estimate of beet sugar production in Europe for the current campaign and the figures are reproduced below. The very heavy rains which delayed sowing in the spring, and the subsequent very hot, dry summer had been widely expected to reduce production markedly from the record crops of the 1982/83 campaign, and Licht's figures reflect this, with most 1983/84 figures lower than those of the previous campaign, or at best about the same, except for the USSR and Italy where recoveries are expected from the poor crops of 1982/83.

Licht point out that part of the expected decrease in sugar outturn results from the deliberate reduction of beet area in response to the excess production and low world sugar prices of 1982/83. Furthermore, since the estimates are based on initial beet tests they may well be modified appreciably as the campaign progresses.

	1983/84	1982/83	1980/81
		tonnes, raw value	
West Europe			
Belgium	790,000	1,200,000	1,120,000
Denmark	400,000	584,000	522,000
France	3,260,000	4,822,000	5,567,000
Germany, West	2,800,000	3,590,000	3,689,000
Greece	325,000	322,000	351,000
Holland	755,000	1,229,000	1,135,000
Ireland	195,000	242,000	183,000
Italy	1,415,000	1,282,000	2,226,000
UK	1,050,000	1,543,000	1,187,000
Total EEC	*10,990,000*	*14,814,000*	*15,980,000*
Austria	380,000	612,000	486,000
Finland	125,000	116,000	88,000
Spain	1,235,000	1,226,000	1,097,000
Sweden	315,000	389,000	374,000
Switzerland	117,000	120,000	135,000
Turkey	1,850,000	1,860,000	1,521,000
Yugoslavia	770,000	712,000	871,000
Total West Europe	*15,782,000*	*19,849,000*	*20,552,000*
East Europe			
Albania	40,000	42,000	40,000
Bulgaria	160,000	180,000	145,000
Czechoslovakia	810,000	885,000	747,000
Germany, East	680,000	810,000	739,000
Hungary	535,000	587,000	601,000
Poland	1,850,000	2,012,000	1,873,000
Rumania	630,000	652,000	663,000
USSR	7,600,000	6,800,000	6,200,000
Total East Europe	*12,305,000*	*11,968,000*	*11,008,000*
Total Europe	28,087,000	31,817,000	31,560,000

World sugar prices

Firm market conditions prevailed at the very beginning of August and the London Daily price of raw sugar increased from £179 on August 1 to reach £193.50 on August 3. A reaction then occurred, based in part on concern at the large quantity of sugar released by the EEC authorities, and the LDP fell to £181 on August 5. After this reports of sales of refined sugar to the USSR encouraged the market and the price rose to reach £187.50 by August 9. Rumours that Brazil had sold or was about to sell substantial quantities caused some unease in the market and the price fell again to £169 before recovering the next day to £178. The LDP(W) had been affected by these reports and rumours of white sugar trading and availability, and the premium over raws, £21 on August 1, fell to £10 at one stage, although it recovered later in the month, reaching £21 again on September 1.

During the second half of August, there was some movement in both directions but with a generally downward trend, attributed by a number of observers to speculative effects.

C. Czarnikow Ltd. recently discussed the role of speculators in the sugar market[2]:

"Practically since terminal markets were first established there have been speculators who have been willing to assume market risks in the expectation of profit. Traditionally they have been watchful for opportunities to arbitrage from one market to another or to straddle from one delivery period to another. In essence the operators are self-seeking, but their activities are of benefit to the market as positions are normally only opened when delivery months are thought to have become out of line and their operations tend to restore more normal relationships.

"Although perhaps partly growing out of the speculator's relationship to the commodity markets, the investment funds which are currently of such significance bring a much greater sophistication to their activities. Though they normally have no intrinsic individual interest in commodities, looking at them merely as possible vehicles in which to place money entrusted to them by financial institutions such as insurance companies and pension funds, they have become deeply involved in areas where they invest. Currently they not only call on the expertise of commodity analysts and employ computer techniques, but they also closely monitor price relationships. Thus it sometimes occurs that a price movement in one commodity triggers off movements in others. This is the type of reaction seen in August when rallies in sugar prices have been sparked off by strong buying in the gold, grain and soya bean exchanges."

Mexican sugar reorganization[3]

The long-awaited restructuring of the Mexican sugar industry has finally been initiated through a decree issued by President Miguel de la Madrid Hurtado. As part of the reorganization of the Mexican sugar industry, a new organization — Azucar S.A. — has been created. This new official entity takes over the operations of the National Sugar Industry Commission (CNIA), the National Union of Sugar Producers (UNPASA), the National Sugar Financing Agency (FINASA) and the Social Works Trust for Producers with Limited Resources (FIOSER). The Director of the new company Azucar S.A. is Luís Rodríguez Duahlt, a former CNIA Managing Director.

One of the first statements by the head of the consolidated Mexican sugar organization was to confirm that Mexico achieved a record crop in 1982/83. Early in the year, both industry and government sources predicted a reduction in sugar output owing to the severe drought which had plagued major growing regions.

[1] F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 441-444.
[2] *Sugar Review*, 1983, (1663), 153.
[3] F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 417.

Especially hurt was the Herasteca region, north-east of Mexico City, where a portion of the crop was lost owing to drought. Despite these very pessimistic forecasts, Mexico turned out 2,855,412 tonnes, tel quel, of sugar – substantially above the previous crop level. The better performance in 1982/83 is attributed to better utilization of installed mill capacity, especially in the state-owned factories. Moreover, despite the drought, weather has been generally favourable and there have also been no labour problems.

The new head of Azucar S.A. said that Mexico would not import any sugar in 1983/84. However, whether this is a realistic assessment remains to be seen; industry sources expect imports to continue for the next few years and that the country will not be self-sufficient before 1985 or 1986. However, this will also depend on the progress of the reorganization plan which largely depends on the cooperation of all segments of the industry. It is the aim of the industry to decentralize management, to strengthen regional responsibility and to improve living conditions for cane growers and mill workers. It is hoped that this will solve some of the problems of the Mexican sugar industry. It is hoped that placing direct responsibility on officials of Azucar S.A. and on cane growers and mill operators will increase efficiency. Comments by various spokesmen of the industry stressed that a major requirement will be that factory maintenance and modernization is carried through by skilled personnel. Spare parts for replacements, as well as new machinery, will have to be acquired in time to avoid production breakdowns.

Despite official statements that no imports will be needed, industry sources say that Mexico will still import at least 700,000 tonnes of sugar and possibly more. A spokesman for Azucar S.A. admitted that some 500,000 tonnes will have to be imported in the last quarter of 1983 as a reserve cushion. However, no figures for total imports so far were given. Unofficial estimates place these at approximately 1 million tonnes.

Industry sources say that the reorganization of the sugar sector is a step in the right direction and will, it is hoped, eliminate mistakes and bottlenecks of the past. Industry sources also demand that subsidies be eliminated and that the retail price of sugar be increased to 45 or 50 pesos per kilogram (30.6 or 34 US cents). With this measure it is hoped to reduce sugar subsidies to $12,800,000 annually if production continues to rise. If there should be a major increase in production, imports could be reduced to zero.

One problem is that the authorities are unable to stop the thousands of US citizens who buy sugar in Mexican border areas for 10 US cents per pound and take it across the border, causing shortages in northern Mexico. A Mexican senator has recently urged the authorities to raise the price of sugar until it is as expensive as in the US, in order to stop this outflow.

EEC Commission proposals on CAP change[1]

The high cost of the Common Agricultural Policy and the considerable drain this has proved to be on the funds of the European Community in recent years has led on the one hand to a call for an increase in funds and on the other to pressure for expenditure to be limited. To some extent these two approaches can be considered to go hand in hand. Whilst a case can be made for maintaining the income of farmers and farm workers at realistic levels, it is also realistic to expect steps to be taken to trim areas of greatest expenditure, especially where no immediate benefit to the Community appears to be involved.

As a consequence of this pressure, the EEC Commission has submitted to the Council of Ministers a package of proposals designed to adjust the Community agricultural regime. This will not come into effect without the agreement of Ministers, but it is more than a discussion paper in that it aims to improve the Common Agricultural Policy and limit its rapidly rising costs. Already various pressure groups have begun voicing their objections to the proposals; as may be expected, some consider the proposals go too far, whilst others feel they are too conservative.

So far as sugar is concerned there have been no recommendations specifically slanted at this sector. However, it has been proposed that monetary compensation amounts should be dismantled. This would presumably follow the usual series of pressures and compromises, but it is hoped that the final form of the changes will be decided by the end of this year.

Taiwan sugar development program[2]

During the recent six-year plan period, the Taiwan sugar industry completed a number of investment projects, renovated manufacturing equipment, improved transport capability and sugar cane production techniques, and raised the sugar yield ratio and cane production per unit area. However, rising domestic prices, oil prices and wages have increased the cost of sugar production.

It is therefore the intention of the government, as stated in the four-year plan (1982-85) for the industrial sector, that the sugar industry shall continue to strengthen the renovation of production equipment and the improvement of technology, stress research and development, and promote managerial diversification. In this context, development priorities include the conversion of plants now producing raw sugar to the manufacture of white sugar, increase of mechanization of cane field operations and transportation, and improved production equipment and operational techniques (equipment automation, increase in energy efficiency and adoption of labour-saving measures).

More specifically, the aim is to produce 900,000 tonnes annually by 1985 (as against an estimated equivalent total of 763,000 tonnes in 1981). This means that the white sugar conversion project of the Taiwan Sugar Corporation, for higher efficiency, better product quality and equipment safety, is of crucial importance. The project is to convert five factories (Suantow, Hsinying, Chiali, Shanhua and Hualien) from raw to white sugar manufacture, increasing the annual production of the latter by 180,000 tonnes.

In addition, TSC's second-phase transport automation project provides for the establishment of an automated transportation system and development of mechanized loading, unloading and reloading. TSC is also to improve the irrigation and drainage system of its nucleus estate plantations and build a molasses processing plant at its factory in Taitung.

GATT and the Nicaragua/US dispute[3]. – The General Agreement on Tariffs and Trade (GATT) has decided to set up an arbitration panel to investigate Nicaragua's sugar dispute with the US which arises out of the decision in May 1983 by the US to cut by 90% the supply quota previously allotted to Nicaragua.

1 C. Czarnikow Ltd., *Sugar Review*, 1983, (1660), 137.
2 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 439-440.
3 *Public Ledger's Commodity Week*, July 16, 1983.

Geometric properties and density of bagasse particles

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Introduction

In the past decade great interest has been shown in renewable energy sources owing to the significant increase in the price of oil. At the same time, the production of by-products from bagasse, such as paper, artificial wood, animal feed and different chemical products, has acquired a new importance, especially for the economies of many developing countries.

In order to utilize bagasse as a fuel or as a raw material in a more efficient manner, the processes which involve chemical reactions and mass, momentum and energy transfer must be optimized. This requires a knowledge of the properties of the particles which determine settling velocities, residence times in gas streams, drying and combustion rates, pneumatic classification, cyclone efficiency and other significant process variables.

Some information exists in the world literature on the properties of whole bagasse particles or of its finer fractions. Grobart[1] studied the settling velocities for bagasse fractions separated by screening. Boizán *et al.*[2, 3] published the results of various studies on the density, specific surface and shape factor for screened fractions of bagacillo and pith using Ergun's method[4, 5] which is based on the pressure drop of air flowing through a packed bed. Blanco & Ramírez[6] determined the density of partially depithed bagasse saturated with water, using a pycnometer. However, these studies already reported in the literature do not supply all the information needed for the optimization of bagasse processing.

In the present study, the density and a number of geometric properties were determined for fractions of whole, dry bagasse, from the coarser to those retained by a screen of 0.841 mm aperture, but passed by one of 1.19 mm aperture.

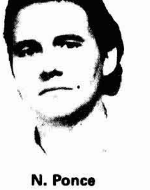
Materials and methods

During the 1980/81 season, nine samples, each of 20 kg or so of bagasse, were taken from the mill train of the Pablo Noriega sugar factory, where experimentation is carried out by the Instituto Cubano de Investigaciones Azucareras (ICINAZ). The mill train is equipped with three sets of revolving knives, a Fulton shredder and five Fulton mills. The very high degree of preparation obtained corresponds to modern trends in the world cane sugar industry. During the sampling period the speed of rotation of the second set of cane knives was varied a number of times. Sugar cane varieties J 60-5, My 5715 and CP 5243 – classified as soft, medium and hard, respectively – were crushed.

The bagasse samples were dried in the open, care being taken to avoid loss of fine material. The moisture content after drying varied between 8 and 12%; this moisture range corresponds to the equilibrium moisture content of whole bagasse determined by Guerra[7] for typical Cuban climatic conditions. Samples of 50 g of dry bagasse, obtained from the original 20 kg samples by repeated quartering, were screened for 20 minutes using standard screens and an electric vibrator. The screen sizes were the following (in mm): 22.4, 16.0, 11.2, 8.0, 5.6, 4.0, 2.36, 1.19, 0.841, 0.595 and 0.354, material passing through the last being collected in the bottom. Every fraction retained by the screens of 0.841 mm aperture and larger was quartered repeatedly until a sample conveniently sized for sub-classification was obtained.

The sub-classification consisted of the hand separation of the sample into two sub-fractions or groups by visual differentiation: sub-fraction A comprising particles with a high length:width ratio and consisting mainly of fibre tissues, and sub-fraction B comprising particles with a significantly lower length:width ratio, consisting mainly of spongy pith with little or no fibre content. The particles could be clearly separated into these two categ-

1 *Control, Cibernética y Automatización,* 1973, **7**, (4), 3 et seq.
2 *ibid.,* 1980, **14**, (2), 36-42.
3 *ibid.,* (3), 37-42.
4 *Anal. Chem.,* 1951, **23**, (1), 151 et seq.
5 *ibid.,* 1952, **24**, (2), 388 et seq.
6 *Sobre los Derivados de la Caña de Azúcar (ICIDCA),* 1980, **14**, (1), 34-38.
7 *Ing. Quím.* (Universidad de La Habana), 1971, **6**, (6).



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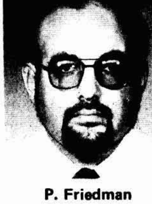

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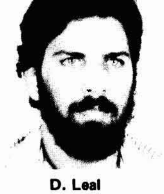

D. Leal

ories, but all of them were approximately rectangular prisms with their faces nearly flat and parallel.

Based on these observations, the parallelipiped was chosen as the geometric model for characterizing the bagasse particles retained by screens of 0.841 mm aperture or larger. The linear dimensions of length, width and thickness were measured for each particle using either a microfilm reader or a microscope, depending on the size. Three or four measurements were made and the average value reported. The number of particles in each group obtained by sub-classification ranged from 20 to 60, except for the coarsest fraction which included fewer particles. The three linear dimensions were measured for more than 4000 particles, so that the number of individual measurements exceeded 36,000.

The averages of length, width and thickness were the input data for a computer program which calculated the properties of each particle along with the mean and standard deviation for each sub-fraction. The volume-weighted mean and its standard deviation were also calculated. The properties were: length, width, thickness, volume, specific surface relative to volume, surface of the largest face, equivalent diameter (diameter of a sphere with volume equal to that of the particle), shape factor (ratio of the surface area of sphere of equal volume to the surface area of the particle), length:width ratio and thickness:width ratio. The global density of each sub-fraction was calculated by using the sum of the volumes of the particles in the sub-fraction and the weight of these same particles, the last determined using an analytical balance.

Finally, for each property and each sub-fraction, using the mean values computed for each sample, the arithmetic mean and the standard deviation of the sample means were calculated, and also the mean of the sample standard deviations. Equations relating the properties of each sub-fraction with the screen size were obtained using a linear regression program on a hand calculator.

Results and discussion

For any given sub-fraction, the dispersion of the values of any property over the nine bagasse samples is represented by the standard deviation of the sample means, denoted as SD_M whereas the dispersion of the property over the individual particles of a sample is accounted for by the mean of the standard deviations of the samples, SD_P.

Table I shows the average size distribution of the samples after screening and sub-classification. The deficit of 3.06% is due to variations in moisture content, material loss and weighing errors. The fractions studied (average screen size from 1.02 to 19.2 mm) constitute 71.02% of the whole dry samples. The sum of the sub-fractions B makes up 17.58% by weight of the whole dry samples and 28.6% of the total weight of those fractions from which sub-fractions B were separated. The ever-increasing proportion of sub-fraction B as the size diminishes leads one to suppose that, in the finer fractions where sub-classification was not carried out, the proportion of B was probably greater than 50%.

Table I. Particle size distribution

Average screen size, mm	Weight %					
	Total fraction %. whole sample		Sub-fraction B% whole sample		Sub-fraction B% total fraction	
	Avg.	SD_M	Avg.	SD_M	Avg.	SD_M
0.177	3.72	2.27				
0.474	11.96	1.38				
0.718	13.30	1.12				
1.02	11.19	0.99	5.06	0.95	45.2	5.6
1.78	17.63	1.80	6.89	1.36	39.1	8.4
3.18	7.16	1.47	2.28	1.14	31.8	12.0
4.8	13.77	1.09	1.95	0.69	14.2	4.5
6.8	4.38	1.06	0.77	0.37	17.6	6.2
9.6	7.16	1.48	0.63	0.31	8.8	4.8
13.6	4.47	1.40	0.00	0.00	0.0	0.0
19.2	2.20	1.21	0.00	0.00	0.0	0.0
22.4	0.02	0.05	–	–	–	–
Deficit	3.04					
Total	100.00		17.58			

The mean values of the properties are shown in Table II. As may be seen, for each sub-fraction, the values of the different properties are consistent with the

Table II. Geometric properties and density of bagasse particles

	Average screen size mm	Width, mm			Thickness, mm			Length, mm			Surface, cm²			Volume, cm³			Specific surface, cm²/cm³		
		y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M	% SD_M	y	% SD_M	% SD_P	y	% SD_M	% SD_P
Sub-fraction A	1.02	0.62	18	29	0.45	15	22	13.25	15	22	0.286	15	30	0.0038	24	46	81.51	13	25
	1.78	1.51	14	27	0.79	11	30	13.47	16	27	0.651	13	34	0.0164	19	55	44.25	13	26
	3.18	2.39	11	22	1.24	7	31	15.16	14	32	1.14	19	33	0.0431	26	51	28.22	7	24
	4.8	3.31	7	26	1.57	9	41	19.92	13	35	2.02	19	37	0.1029	28	53	22.26	12	26
	6.8	4.46	7	28	2.03	7	33	22.85	10	29	3.09	13	33	0.2070	17	52	16.97	10	28
	9.6	5.33	11	30	2.31	12	33	28.04	9	32	4.44	18	31	0.3448	28	49	14.66	12	26
	13.6	6.60	9	37	2.90	8	43	31.80	9	30	6.26	11	35	0.6216	15	63	12.36	10	34
	19.2	6.70	22	45	3.09	20	55	41.84	7	35	8.44	21	50	1.0939	31	100	12.97	22	45
	A	3.29	11	30	1.55	10	36	20.55	12	31	2.48	16	36	0.1949	24	58	32.09	12	26
Sub-fraction B	1.02	0.97	5	16	0.67	10	21	3.20	13	21	0.114	12	25	0.0019	16	41	59.85	5	13
	1.78	1.80	6	20	1.21	11	22	4.39	13	29	0.307	10	33	0.0096	14	48	34.47	5	19
	3.18	2.64	4	15	1.79	6	20	7.34	11	25	0.744	9	26	0.0346	10	39	22.39	3	15
	4.8	3.78	7	20	2.33	11	24	9.80	12	28	1.40	15	32	0.0899	22	49	16.87	9	17
	6.8	5.02	10	18	3.17	8	25	12.24	11	29	2.35	18	32	0.2005	24	46	12.76	9	20
	9.6	6.41	8	18	3.70	16	28	14.39	11	29	3.42	17	37	0.3592	29	56	10.88	10	24
	B	2.20	6	19	1.43	10	23	5.73	12	27	0.631	14	32	0.0819	19	47	36.46	5	16
	A + B	3.01	10	28	1.52	10	32	16.71	12	31	2.001	16	36	0.1657	22	55	33.22	10	23

Table II. (Continued)

	Average screen size mm	Area of greatest face, cm^2			Equivalent diameter, mm			Shape factor (dimensionless)			Length:width ratio			Thickness: width ratio			Density $g.cm^{-3}$	
		y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M	% SD_P	y	% SD_M
Sub-fraction A	1.02	0.0810	17	34	1.88	9	16	0.401	8	11	24.68	34	46	0.764	12	20	0.281	18
	1.78	0.1988	12	38	3.05	7	18	0.477	6	12	10.18	31	43	0.543	11	28	0.232	22
	3.18	0.3554	21	34	4.28	8	16	0.525	3	14	7.03	14	49	0.532	11	28	0.203	12
	4.8	0.6508	19	40	5.60	9	18	0.516	4	15	6.66	12	53	0.484	8	30	0.224	21
	6.8	0.9972	14	36	7.10	6	18	0.534	4	14	5.82	13	52	0.475	5	31	0.178	15
	9.6	1.4520	18	34	8.41	10	17	0.526	3	15	6.01	9	55	0.455	8	33	0.176	17
	13.6	2.0169	11	36	10.18	6	23	0.526	5	16	5.96	19	53	0.460	8	35	0.154	20
	19.2	2.6945	21	46	11.21	14	31	0.496	5	18	8.36	28	65	0.481	8	34	0.139	14
	A	0.8000	17	37	5.61	9	19	0.500	5	14	9.51	26	48	0.53	9	30	0.211	17
Sub-fraction B	1.02	0.0298	12	25	1.54	5	12	0.668	4	7	3.34	18	32	0.703	13	22	0.1105	22
	1.78	0.0784	11	35	2.58	5	16	0.702	3	7	2.57	17	36	0.677	11	23	0.0844	25
	3.18	0.1937	12	28	3.99	4	12	0.687	3	7	2.85	11	30	0.689	8	23	0.0913	7
	4.8	0.3757	14	34	5.42	8	14	0.680	2	8	2.76	15	28	0.624	9	25	0.0928	24
	6.8	0.6199	19	34	7.07	9	16	0.694	2	7	2.52	8	33	0.645	8	28	0.0793	14
	9.6	0.9235	13	39	8.47	9	19	0.688	3	8	2.53	15	41	0.600	10	28	0.0764	10
	B	0.170	13	31	3.19	6	15	0.690	3	7	2.85	15	34	0.68	11	23	0.0933	17
	A + B	0.63	16	36	4.98	8	18	0.55	4	11	7.78	23	43	0.57	10	27	0.1807	17

formulae used for their calculation; that is, the volume is the product of the three basic linear dimensions, the surface area is double the sum of the three binary products of these, and so on. However, the averages for different sizes reported in lines A, B and A + B (obtained by weighing with weight fractions of Table I) do not satisfy the geometric relationships mentioned above and should therefore be considered as only rough approximate values. Thus, any estimation of bagasse behaviour based on the values reported herein should be made in respect of separate fractions, rather than attempting to use only one or two overall values.

The equations relating the properties (y) with the average screen size (x) – the average of the apertures of screens which retain a given fraction and the previous screen through which it has passed – obtained by linear regression, are shown in Table III, as is the square of the linear correlation coefficient, r^2. The only property with a low correlation coefficient is the shape factor, even though a good fit is shown graphically, owing to the fact that this property is approximately constant, showing little variation with average screen size. A similar characteristic is observed in the case of the density of sub-fraction B.

Many of the properties show a straight-line relationship with average screen size on logarithmic coordinates, although some deviation appears at the extremes of the size range studied. In the case of many granular materials, the width of the particle tends to determine its passage or retention through the screen openings. In this case, in the equation for width, y would equal x, so that both the intersect i and the slope p would be equal to 1. However, with the bagasse, values of i = 0.83 and p = 0.80 were obtained for the subfractions A and i = 1.02 and p = 0.83 for B. This is due to the interference caused by the length (high length: width ratio) and the fact that only particles in an almost completely vertical position could pass through the screen openings. Of course, this effect is not so pronouced in the case of sub-fraction B.

For the latter it may be seen that the product of the three basic linear dimensions is consistent with the volume; that is, the sum of the exponents of the regression equations (0.83 + 0.75 + 0.70) = 2.28, which approximates to the exponent of the volume (2.33) while,

Table III. Regression equations for the properties of bagasse particles*

Property	Unit	Sub-fraction A		Sub-fraction B	
		Equation	r^2	Equation	r^2
Width	mm	$y = 0.83x^{0.80}$	0.94	$y = 1.02x^{0.83}$	0.98
Thickness	mm	$y = 0.52x^{0.65}$	0.98	$y = 0.72x^{0.75}$	0.90
Length	mm	$y = 1.59x + 11.37$	0.98	$y = 3.16x^{0.70}$	0.98
Surface area	cm^2	$y = 0.31x^{1.16}$	0.98	$y = 0.12x^{1.53}$	0.98
Volume	cm^3	$y = 0.0047x^{1.90}$	0.98	$y = 0.00214x^{2.33}$	0.98
Specific surface	cm^2/cm^3	$y = 66x^{-0.64}$	0.94	$y = 56x^{-0.76}$	0.98
Area of largest face	cm^2	$y = 0.09x^{1.19}$	0.98	$y = 0.03x^{1.59}$	0.98
Equivalent diameter	mm	$y = 2.04x^{0.61}$	0.98	$y = 1.58x^{0.76}$	0.98
Shape factor	–	$y = 0.48 + 0.0027x$	0.15	$y = 0.68 + 0.00084x$	0.05
Length:width ratio	–	$y = 0.75 + 18.29/x$	0.85	$y = 3.08 - 0.073x$	0.72
Thickness:width ratio	–	$y = 0.43 + 0.31/x$	0.92	$y = 0.71 - 0.0116x$	0.91
Density	$g.cm^{-3}$	$y = 0.28x^{-0.22}$	0.92	$y = 0.10x^{-0.13}$	0.60

*·y denotes the value of the properties and x the average screen size for each fraction.

similarly, the product of the coefficients (1.02 x 0.72 x 3.16) = 2.32 which approximates to the coefficient of the volume equation (2.14, allowing for the factor of 1000 due to the linear dimensions being in mm and the volume in cm^3).

Furthermore, the equivalent diameter is proportional to the cubic root of the volume (exponent 0.76 approximately one-third of exponent 2.33) and inversely proportional to the specific surface (exponent −0.76) as should be the case for bodies or particles of the same shape but different sizes. The surface is proportional to the square of the equivalent diameter or of the thickness (the exponent 1.53 is about double their respective exponents of 0.76 and 0.75) and to the product of width and length (the exponent is equal to the sum of these respective exponents 0.83 + 0.70). The specific surface is approximately equal to the ratio of surface area to volume (coefficient 56 = 0.12/0.00214 and exponent −0.76 is approximately equal to 1.53 − 2.33). In the case of sub-fractions A similar results are found, although with less close agreement owing to the aforementioned effect of the length:width ratio on the results of screening. This effect is much less important for sub-fractions B.

In general, pronounced differences may be observed between particles of sub-fractions A and B, particularly in density and shape factor. This confirms the usefulness of visual sub-classification in order to obtain more accurate results.

In comparing the different samples, it was not possible to determine differences of geometric properties or density resulting from the type of cane (hard, medium or soft), speed of rotation of the second set of knives, or mill setting since, in all cases, the degree of cane preparation was quite high and probably had a more important effect than minor variations in cane quality and mill setting.

Very few data exist in the world literature which afford comparison with the results of this study. In the case of the specific surface, Boizán[3] obtained values of 33.48 and 34.80 cm^2/cm^3 for an average screen diameter of 1.595 mm, using two variants of Ergun's method[4, 5]. In this study, values of 44.25 and 34.47 cm^2/cm^3 were obtained for sub-fractions A and B, respectively (for average screen size 1.78 mm) using the more precise method described above. For average screen size of 1.02 mm, Boizán reported values of 43.41 and 46.41 cm^2/cm^3, which are considerably lower than those of 81.51 (sub-fraction A) and 59.85 cm^2/cm^3 (sub-fraction B) as found in the present study.

Regarding the shape factor, Boizán[3] reports the values of 0.2775 and 0.4730 for 1.02 mm using two variants of Ergun's method[4, 5], whereas values of 0.401 (for A) and 0.668 (for B) were found in this study. In the case of 1.595 mm average screen opening, Boizán reports 0.4484 and 0.6133, while values of 0.477 (for A) and 0.702 (for B) were found in this study for the average screen size of 1.78 mm.

Density values ($g.cm^{-3}$) of 0.2320 and 0.1464 were obtained by Boizán[2] for the 1.595 mm fraction using two variants of Ergun's method[4, 5], while values of 0.281 (for A) and 0.1105 (for B) for the 1.02 mm sub-fraction, and 0.232 (A) and 0.0844 (B) for the 1.78 mm sub-fraction were obtained by the direct method used in this study. Blanco & Ramírez[6], using a pycnometric method, reported an average value of 1.53 $g.cm^{-3}$ for partially depithed bagasse (9-11% by weight), saturated with water. Using the value of 80% reported by Grobart[1] for the critical moisture content of whole bagasse, and considering that 1 cm^3 of depithed bagasse saturated with water would contain 1.53 x 0.80 = 1.22 g of water, the density of dry bagasse (if no volume change arises from the moisture change) would be 1.53-1.22 = 0.31 $g.cm^{-3}$; with 10% of moisture the density would be 0.34 $g.cm^{-3}$ which is the value obtained by using the equation for sub-fraction A in this study for an average screen opening of 0.414 mm. It should be mentioned that this sub-fraction consists of single fibres or fine fibre bundles with a density that would be similar to that reported by Blanco & Ramírez[6].

Conclusions

(1) The importance of bagasse as a renewable fuel and raw material for the developing countries is increasing.

(2) Data already published on physical properties of bagasse particles, which might be used in process design for drying, combustion, pneumatic transport and classification, cyclone separation and storage, are only a starting point of the knowledge required for such purposes.

(3) The results of this study differ from those of previous researchers, probably because of differences in the material studied and of the use of more direct methods of measurement in this case, which should lead to more accurate results.

(4) The use of the values and of the mathematical correlations herein is recommended for estimation of the behaviour of bagasse particles retained by screens with openings of 0.841 mm and greater.

(5) Any use of these properties to predict the behaviour of bagasse particles should take into account a number of separate fractions inasmuch as global averages for the values of their properties are not consistent whereas the values for individual fractions are all in good agreement.

Summary

The three basic linear dimensions (length, width and thickness) were measured in nine samples of whole dry bagasse which had been classified by screening and sub-classified by visual separation. The mean values and the standard deviations were calculated for these measurements as well as volume, surface area, ratios of linear dimensions, equivalent diameter, shape factor and density of the particles. Equations obtained by linear regression are proposed for these properties, which show a good fit. The results of this study may be used for mathematical modelling and design calculations for different processes such as drying, combustion, pneumatic transport and classification, separation in cyclones and storage.

Propriétés géométriques et densité des particules de bagasse

Dans neuf échantillons de bagasse sèche entière on a mesuré les trois dimensions de base (longueur, largeur et épaisseur). Ces échantillons avaient été classifiés par tamisage et sousclassifiés par une séparation visuelle. On a calculé les moyennes et les déviations standards pour ces mesures ainsi que le volume, la surface, les rapports des dimensions linéaires, le diamètre équivalent, le facteur de forme et la densité des particules. Des équations obtenues par régression linéaire sont proposées pour ces propriétés pour lesquels on note une bonne correspondance. On peut utiliser les résultats de cette étude pour des modèles mathématiques et pour le calcul des dessins en rapport avec les différents processus tels que le séchage, la combustion, le transport et la class-

ification pneumatique, la séparation par cyclone et le stockage.

Geometrische Eingenschaften und Dichte von Bagasse-Partikeln

Die drei grundlegenden linearen Dimensionen (Länge, Breite und Dicke) wurden in neun Proben unzerteilter trockener Bagasse gemessen, die zuerst durch Sieben und dann durch visuelle Trennung klassifiziert waren. Die Mittelwerte und die Standardabweichungen sowie Volumen, Oberfläche, Verhältnisse der linearen Dimensionen, äquivalente Durchmesser, Formfaktor und Dichte der Partikel wurden berechnet. Durch lineare Regression erhaltene Gleichungen werden für die Eigenschaften vorgeschlagen, die diesen gut entsprechen. Die Ergebnisse dieser Untersuchung können für mathematische Modelle und Konstruktionsrechnungen verschiedener Verfahren wie Trocknung, Verbrennung, pneumatischer Transport und Klassifizierung, Trennung in Zyklonen und Lagerung verwendet werden.

Propriedades geométricas y densidad de partículas de bagazo

Las tres básicas dimensiones lineales (longitud, ancho y espesura) se han medido en nueve muestras de bagazo entero seco que se han clasificado por tamizado y sub-clasificado por separación visual. Los valores promedios y desviaciones standardes se han calculado para estas mediciones así como volumen, área superficial, relaciones entre dimensiones lineales, diámetro equivalente, factor de forma, y densidad de las partículas. Los autores proponen ecuaciones obtenidas por regresión lineal para estas propiedades, que muestran un buen ajuste. Los resultados de este estudio pueden usarse para modelación matemática y para calculaciones de diseño para diferentes procesos tal como secado, combustión, transporte y clasificación pneumática, separación en ciclones y almacenamiento.

Experience of Australian sugar cane mills equipped with spherical roller bearings

By GUNNAR BERGLING (SKF, Gothenburg, Sweden)

The first Australian cane mill to be equipped with rolling bearings was described[1] in some detail in 1976. Since that mill was commissioned in 1974 12 milling units, with 72 spherical roller bearings fitted on the roll shafts, have been delivered.

The Bundaberg Foundry Company, Bundaberg, designed and built the first mill of the new design for the Pleystowe mill at Mackay. The application, bearing selection and lubrication were discussed thoroughly with SKF. Gatley[2] gives a detailed account of the design and also analyses the benefits of using rolling bearings in sugar cane crushing mills. Two more mills were subsequently delivered[3].

Despite the heavy loads involved, the selected high-capacity bearings of series 241 had a basic rating life of approximately 70,000 hr. As the rotational speed is low, about 5 r.p.m., it is essential that the lubricant, in this case a grease, has a base oil with a very high viscosity. However, no such ideal grease was available on the market. As a compromise, a bentonite grease, Shell Darina S2, was selected although its base oil viscosity of 760 $mm^2.sec^{-1}$ at 40°C ought to have been twice as high and lithium would have been preferable as the thickening agent.

G. Bergling

The bearing application is shown in Fig. 1 which is reproduced from the Ackeus article[1]. After eight years' operation, the experience gained with the rolling bearings has been excellent. Four out of the 18 mill bearings have had to be replaced, primarily on account of the ingress of cane juice. The piston ring seal and the lip-type seals have had their weaknesses. The piston rings jam and axial forces arise, with wear and impaired protection in consequence. The lip-type seals have been too pliable and therefore difficult to fit. They can also be deformed when fresh grease is being applied and the garter springs have been known to jump off. Steps may easily be taken to remedy these weaknesses, as will be seen later.

The bearing applications for the other sugar cane mills equipped with roller bearings were designed without the participation of SKF. However, apart from the choice of bearings, the design does not differ basically from that shown in Fig. 1. Bearings of the lighter 240 series have been selected and in consequence the basic rating life in a number of applications with high roll pressures is only 10,000 to 15,000 hr for the top roll bearings – and this provided that the lubrication is satisfactory [a_{23} = 1 in equation (1) below].

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[1] Ackeus: *Ball Bearing Journal*, 1976, (186).
[2] Gatley: *Mech. Eng. Trans. Inst. Engineers, Australia*, 1977.
[3] Jacklin *et al.*: *Proc. 16th Congr. ISSCT*, 1977, 2179-2186.

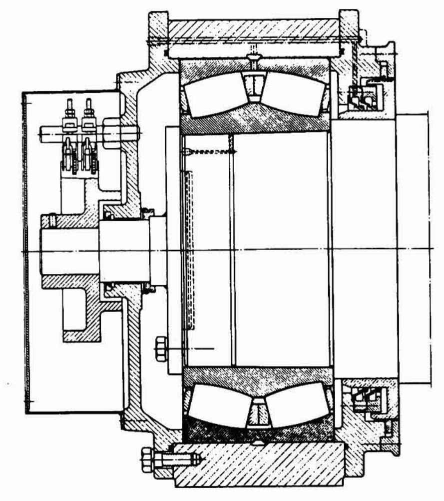

Fig. 1. Bearing arrangement for top roll of mill

Taken by itself, this basic rating life may be adequate – the running time is about 3000 hr per year – but provides no margin for additional forces and poor lubrication conditions. Unfortunately the lubrication has proved to be quite unsatisfactory in most cases. For instance, the majority of the sugar mills have chosen to use a lithium-base grease, Castrol EP L3, that has been employed with good results in other applications but has a base oil viscosity that is quite inadequate for the low rotational speed of the rolls.

According to Fig. 2, taken from the SKF General Catalogue, a kinematic viscosity ν_1 of 500 $mm^2.sec^{-1}$ at the operating temperature is recommended for a bearing of the size concerned, i.e. a mean diameter about 650 mm,

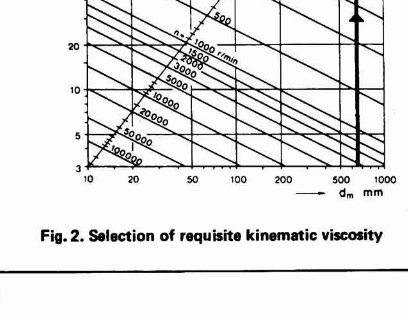

Fig. 2. Selection of requisite kinematic viscosity

running at 4 to 5 r.p.m. The base oil of the said grease has a viscosity ν of only 70 $mm^2.sec^{-1}$ at a likely operating temperature of 60°C. If the ratio κ of the actual lubricant viscosity to the recommended viscosity is obtained, i.e.

$$\kappa = \frac{\nu}{\nu_1} = \frac{70}{500} = 0.14$$

it is possible, with the aid of the diagram (Fig. 3), to estimate the influence the selected lubricant will have on bearing life.

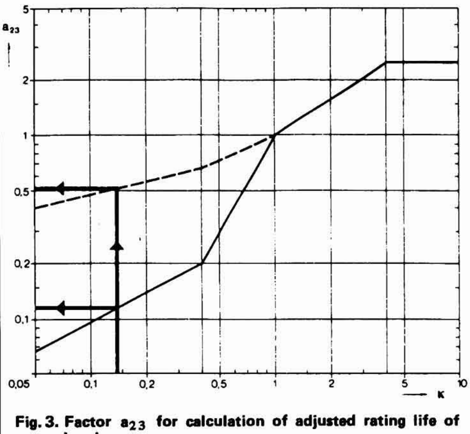

Fig. 3. Factor a_{23} for calculation of adjusted rating life of bearings

The diagram is taken from the SKF General Catalogue and refers to oil lubrication. However, it serves as a guideline that may be used for grease lubrication as well. The factor a_{23} read off from the diagram gives a direct indication of the extent to which the life will be affected, see equations (1) and (2) below.

In the example under consideration the a_{23} factor is 0.12 to 0.5. The top value applies to a lubricant with effective EP (extreme pressure) additives and good, clean operating conditions; the bottom value normally applies to ordinary lubricants. However, even if in this case the grease has EP additives, it is to be expected that the bottom value will be approached if contaminants get into the bearings, i.e. nearing an adjusted rating life of only 0.12 x 10,000 = 1200 hr. The aggressive cane juice is particularly dangerous and if it is allowed to remain for any length of time there will be an additional curtailment of the life span.

The markedly corrosive nature of the cane juice is evidenced by Fig. 4. The grease had a 6% content of water and juice. Corrosion of the areas of the raceway in contact with the rollers occurred under static conditions and, when the bearing started to rotate, flaking, initiated by the corrosion, soon began in patches coinciding with the roller spacing.

The high incidence of bearing failure at the sugar mills that have used Castrol EP L3 grease and inefficient seals, often in conjunction with the infrequent regreasing, is scarcely surprising. Therefore, in spring 1981, representatives of SKF visited all the sugar processing plants in Australia that have mills equipped with spherical roller bearings and had detailed discussions at the Sugar Research Institute (SRI), Mackay. Follow-up visits were paid, after two more seasons, in November 1982 and the recommendations made by SKF and SRI were found to have had a decidedly favourable effect. Although there

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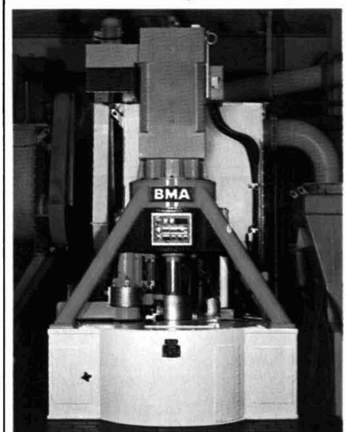

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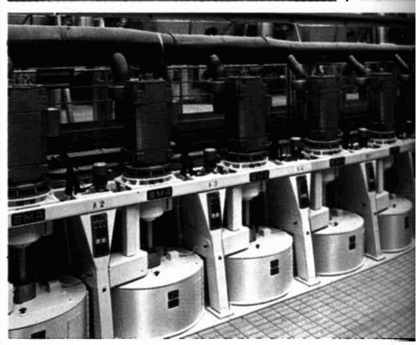

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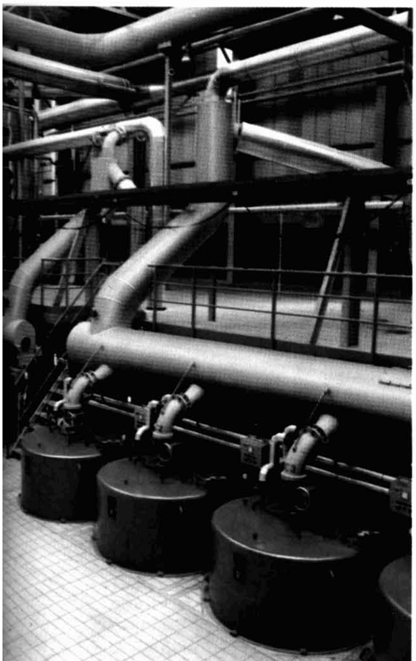

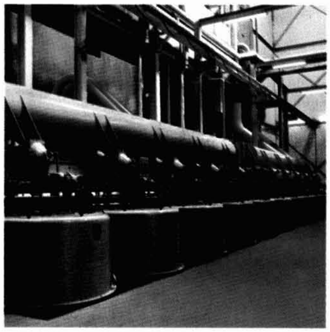

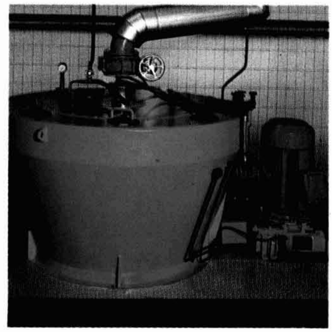

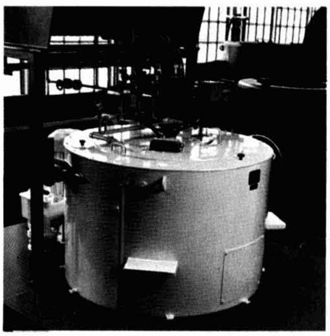

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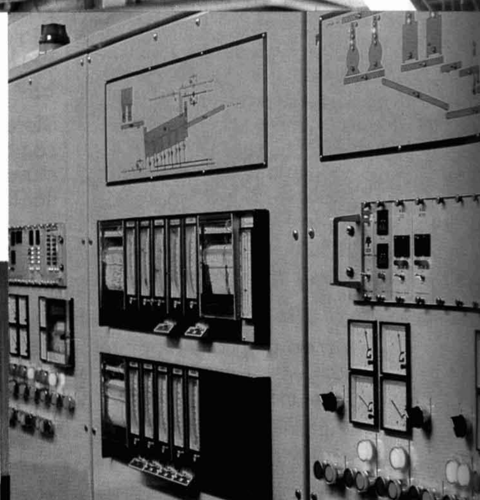

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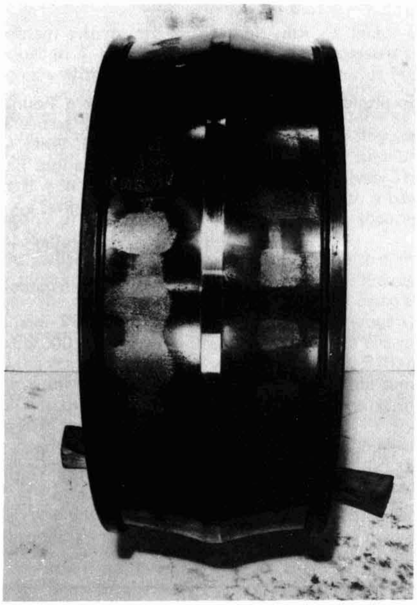

Fig. 4a. Corrosion and fatigue resulting from grease having a 6% water and cane juice content

Fig. 4b. A partial enlargement of 4a

had not been time to improve the lip-type seals in the majority of the applications, the bearings – with isolated exceptions – had worked well as a result of better maintenance, with frequent and regular re-lubrication, and the use of greases with higher viscosity base oils.

These findings confirm that spherical roller bearings are highly reliable cane mill components that are easy to maintain and do not contaminate their surroundings. However, in view of the heavy loading and the aggressive cane juice, it is necessary to select the bearing size, seals and lubrication with care.

Life calculation

The adjusted rating life L_{10ah} of the bearing should be at least 50,000-60,000 hr. If the condition of the bearings is then checked between seasons, either by visual examination or by, for example, shock pulse measurement, the risk of production stoppages is kept to a minimum. The residual life of a roller bearing from the time that fatigue, in the form of raceway or roller flaking, become apparent is usually estimated to be at least 5% of L_{10ah}. Consequently even when fatigue is initiated in a bearing at the start of the season, the bearing may be expected to remain operational throughout that season.

The actual load acting on the bearing is to be used as a basis for the life calculation and not just the component force that the hydraulic cylinder imposes on the top roll bearing housing, even if this would be simpler.

SRI at Mackay have carried out an interesting analysis of the actual loads imposed on the bearings at various postions on a three-roll mill (see Fig.5) and the maximum load on the top roll bearings was found

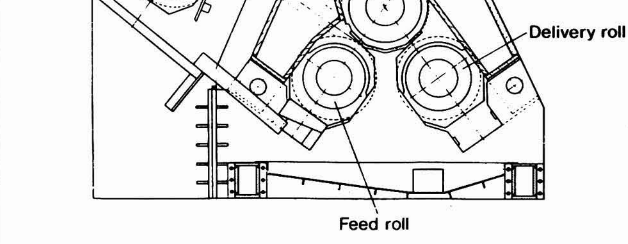

Fig. 5. Diagram of cane mill with integral crusher

to be 59% of the total vertical load acting on the top roll. The corresponding figures for the delivery and feed rolls were 41% and 21% respectively.

These figures may be used for the calculation of the equivalent dynamic bearing load. There are in addition the frictional forces emanating from the bearing housing guide ways and the coupling, but these forces are difficult to determine and fluctuate in magnitude and direction. They may be ignored if the bearing meets the life requirements proposed earlier.

For the vast majority of roller bearing applications the adjusted rating life of the bearing may be calculated with sufficient accuracy by using the familiar bearing life equation[4]

$$L_{10a} = a_{23}\left(\frac{C}{P}\right)^{10/3} \qquad (1)$$

where

L_{10a} = adjusted rating life in millions of revolutions
C = basic dynamic load rating, N
P = equivalent dynamic load rating, N
a_{23} = life adjustment factor for bearing material and lubrication.

The exponent $^{10/3}$ is a compromise between a factor 3 applicable to light loading and ball contact and the factor 4 applicable to heavy loading and line contact (see Fig. 6). The basic dynamic load rating C is the bearing load that gives a basic rating life of 1,000,000 revolutions and is adjusted for the exponent $^{10/3}$ as shown in the figure.

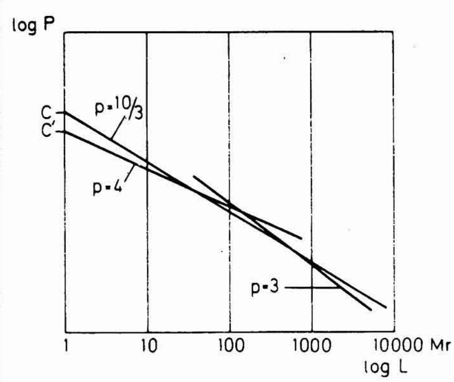

Fig. 6. Life equation, $L = \left(\frac{C}{P}\right)^p$, reproduced as a graph with logarithmic axes and with different values for the exponent p

For heavy loading, a more accurate result is obtained by using the basic dynamic load rating C′ in the figure and the exponent 4. This is true, for instance, of cane mills where the loads are very heavy and the speeds are low. In view of the continual improvement in bearing material, higher basic dynamic load ratings are listed in the latest edition of the SKF General Catalogue and therefore the more accurate method of calculation is to be recommended for cane mills where

$$\frac{C}{P} < 2.5$$

with $C' = \frac{C}{1.26}$ for spherical roller bearings,

$$L_{10a} = a_{23}\left(\frac{C}{1.26 \cdot P}\right)^4 \qquad (2)$$

Example: In the case of the Bundaberg Foundry Co. cane mill described earlier the vertical load on the top roll is 5,500,000 N. What will the rating life of the top roll bearings be if C = 8,800,000 N and the speed n = 5 rpm? A suitable grease is selected that gives $a_{23} = 1$.

$$P = 0.59 \cdot 5{,}500{,}000 = 3{,}250{,}000 \text{ N}$$

The L_{10ah} rating life (expressed in hours) will be

$$L_{10ah} = L_{10a} \cdot \frac{10^6}{n \cdot 60} = \left(\frac{8{,}800{,}000}{1.26 \cdot 3{,}250{,}000}\right)^4 \frac{10^6}{5 \cdot 60}$$

$$L_{10ah} = 71{,}000 \text{ hr}$$

Sealing

On a basis of his experience as Chief Engineer at Bundaberg Foundary Co. Ltd., Thomas Gatley has improved the sealing arrangement shown in Fig. 1. SKF has acted in an advisory capacity and the new design, as shown in Fig. 7, is expected to solve the sealing problems encountered previously.

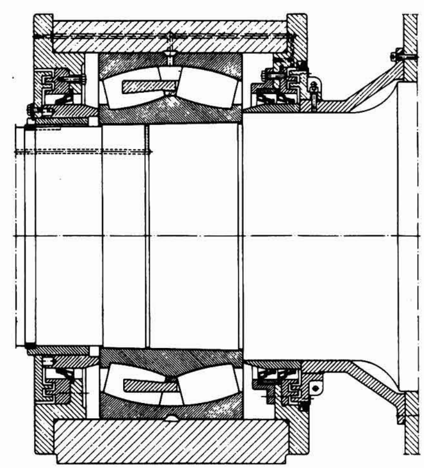

Fig. 7. Bearing arrangement for top roll of cane mill

The lip-type seals are stiffer and their garter springs are retained more firmly than before. In addition, the seal lips have conical back-up plates to prevent deformation of the lips upon assembly or when regreasing. A rubber V-ring seal at the entrance to the labyrinth seal serves as a first line of defence against the ingress of cane juice, bagasse and dirt. Sealing efficiency is enhanced by continuous relubrication of the labyrinth seal. A worn V-ring may easily be replaced by a new V-ring vulcanized in position during a weekend. The seal manufacturer supplies standard tooling for this purpose. The new

[4] "SKF General Catalogue".

sealing arrangement will be tried out next year at Pleystowe Mill.

Lubrication

To obtain satisfactory lubrication, with a κ factor at least equal to 1, of cane mill bearings it is necessary to use a grease with a base oil viscosity in excess of 500 $mm^2.sec^{-1}$ at the operating temperature (see Fig. 2). Such greases are not easily available on the open market. Therefore, at the suggestion of SKF, Molub Alloy has produced the requisite lithium-grease with sulphur/ phosphorus and molybdenum disulphide additives. The grease is designated Molub Alloy 870 and, with a base oil viscosity of 1776 $mm^2.sec^{-1}$ at 40°C. meets, theoretically at least, the aforesaid requirement.

The drawback with a grease of this quality is that the price is higher than that of ordinary lithium base greases. However, the overall costs could be reduced by using an inexpensive lithium base grease for the continuous relubrication of the seals and initially packing the bearing and all the space in its housing with Molub Alloy 870, or another equivalent lithium base grease with the same base oil viscosity, and then regularly relubricating the bearing with this grease once or twice a week.

The bearing application is to be provided with ducts to enable grease samples to be taken from behind the seals at the end of the season without it being necessary to open up the bearing arrangement. If there is no sign of fluid penetration past the seals and, for instance, shock pulse measurement indicates that the bearing is in good condition, relubrication is all that is required before the start of the next season. This is the way to obtain simple and efficient maintenance and a reliable bearing arrangement which, in contrast to plain bearing schemes, does not require water cooling.

Another advantage with rolling bearings is that the drive shaft torque is 20 to 25% lower than with plain bearings[2]. If bagasse is used as fuel the corresponding saving in energy may not appear to be significant. However, a reduction in torque enables the designer to cut the cost of the drive unit and the lower torque is of particular advantage when it comes to the design of the large gears that drive the rolls. The 20% reduction in torque is especially important where the increasingly common 9-foot mills are concerned. With mills of this size the limits of the manufacturing and operational capacities for the large gears are being approached.

Summary

An account is given of experience with cane mills fitted with roller bearings in Australia, and the importance of proper lubrication explained in relation to achieving satisfactory bearing life. Failure of the bearings in the units at Pleystowe have been largely due to the ingress of cane juice, and new sealing and lubricating methods have been designed to avoid this.

Expériences obtenues par les sucreries Australiennes de canne avec des moulins équipés de coussinets à rouleau sphérique

On rapporte l'expérience acquise en Australie avec les moulins à canne sur lesquels on a installé des coussinets à rouleau sphérique. On explique l'importance d'un graissage adéquat afin d'assurer une durée de vie satisfaisante aux coussinets. L'insuccès de ces paliers dans les moulins de Pleystowe fut pour une large part dû à l'infiltration de jus de canne. On a conçu une meilleure étanchéité et d'autres méthodes de graissage afin d'éviter cet incident.

Erfahrungen australischer Zuckerrohrmühlen mit Tonnenlagern

Es wird über Erfahrungen mit Tonnenlagern in australischen Zuckerrohrmühlen berichtet. Die Bedeutung der richtigen Schmierung für eine zufriedenstellende Lebensdauer der Lager wird erläutert. Schäden an Lagern in der Mühle der Zfb. Pleystowe waren größtenteils auf das Eindringen von Rohrsaft zurückzuführen; neue Dichtungen und Schmiermethoden wurden erarbeitet, um dies zu verhindern.

Experiencia de molinos de caña en Australia proveido con rodamientos de rodillos esféricos

Se presenta un informe sobre experiencia con molinos de caña proveido con rodamientos de rodillos en Australia y la importancia de lubricación apropriada se explica respecto del logro de una vida satisfactoria del rodamiento. Fallas de los rodamientos en las unidades de Pleystowe se atribuyen en grande parte al ingreso de jugo de caña y nuevos métodos de sello y lubricación se han diseñado para evitarlas.

Hawaii sugar factory closure[1]. — After 1983 the Hawaiian cane sugar crop seems likely to be less than one million short tons. The Puna mill is scheduled to complete its processing by April or May 1984 and then close permanently. Puna normally produces 10-15% of the Hawaiian sugar crop.

China sugar imports and exports, 1982[2]

	1982	1981	1980
	tonnes, raw value		
Imports			
Argentina	18,249	0	0
Australia	402,281	367,239	300,590
Brazil	146,938	12,883	0
Colombia	49,800	0	0
Cuba	915,311	573,246	512,095
EEC	117,478	26,422	0
Fiji	43,708	0	32,630
Hong Kong	1,667	67	0
India	92,809	0	0
Japan	0	0	216
Malaysia	1	1	0
Philippines	198,776	92,719	44,443
Swaziland	26,657	0	0
Thailand	549,243	112,956	56,153
	2,562,918	1,185,533	946,127
Exports			
Canada	22	14	16
EEC	76	57	49
Hong Kong	25,725	25,067	38,121
Indonesia	0	35,500	50,004
Japan	0	11	0
Malaysia	0	10	0
Mali	0	0	5,055
Mauritius	0	3	0
New Zealand	6	3	0
Pakistan	0	0	26,412
Saudi Arabia	22,838	0	0
Singapore	2,146	298	3,347
Sweden	1	0	0
Thailand	0	0	37,854
USA	82	223	42
Unknown	99,104	83,814	74,100
	150,000	145,000	235,000

1 USDA *Sugar & Sweetener Outlook & Situation*, 1983, **8**, (2), 8.
2 *I.S.O. Stat. Bull.*, 1983, **42**, (6), IV-V.

High-performance liquid chromatographic determination of sugars on cation exchange resins

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Introduction

Classical and official methods currently used by the sugar industry for determining sucrose and reducing sugars have served well over the years despite their drawbacks and limitations. Traditional polarimetric measurements and chemical reduction methods incur interference from many other compounds and are incapable of distinguishing between the major reducing sugars, glucose and fructose. However, recent developments in the field of high performance liquid chromatography (HPLC) have made rapid and reliable sugar separations and analyses possible, without the limitations of other techniques.

Basic features of HPLC

The salient features of a HPLC system include a high-pressure pump capable of delivering a solvent (mobile phase or eluent) from an external reservoir to a separator column (containing stationary phase) via an injector which introduces the sample into the solvent stream. Separation is due to the specific interactions between sample molecules and the stationary and mobile phases. The resolved components emerging from the column are detected by a differential refractometer (or U.V. spectrophotometer) whose output signal is recorded on a strip-chart and/or processed by an integrating device. Since retention time (time from injection to detection) is characteristic of a compound, identification is achieved by comparison of retention times of sample components with those of known standards. The areas or heights of the resulting peaks are quantified against those of appropriate standards.

Previous work

Several HPLC methods using cation exchange resins (PS-DVB; polystyrene cross-linked by divinyl benzene) with water as the eluent have appeared in recent literature, for the separation of carbohydrates. These methods were directed mainly at separating sugars in corn syrups[1-3], food extracts[4] and low purity cane sugar factory products[5-7] using Aminex resins. However, researchers have failed to obtain adequate separation of sugars on these resins when working with high purity cane sugar factory material. Difficulties arise when the reducing sugars are present in small amounts relative to sucrose. As a result the glucose peak is often obscured by the large sucrose peak, thus making quantification rather difficult[6-9].

A comprehensive review of ion exchange chromatography of saccharides is provided by Jandera & Churacek[10] and the mechanisms involved in these separations have been discussed by Goulding[11].

W. P. P. Abeydeera

Column selection

After consideration of published data, it was decided to use a Shodex S-801/S column (7.8 x 250 mm) containing a microparticulate (10 μm) cation exchange resin in the sodium form. This resin exhibits both ligand exchange and size exclusion properties. An excellent review on the application of size exclusion columns is given by Miller *et al.*[12].

Mechanism of separation

Depending on their geometry, the hydroxyl groups of the different sugars interact with the sodium ions to varying degrees, resulting in different elution times. This applies mainly to molecules of relatively low molecular weight (glucose, fructose etc.) which can enter the pores of the resin and establish temporary links with the counter-ions. The more complex molecules, of higher molecular weight, have greater difficulty in entering the pores and therefore will be eluted more rapidly.

The main objectives were:

(i) To develop a simple but an efficient HPLC technique capable of separating and estimating sucrose, glucose and fructose in process material and to use true purities as determined by this method in calculations involving exhaustion studies: and

(ii) To explore the possibility of employing HPLC techniques on a routine basis at BSES in order to

Paper presented to the Australian Society of Sugar Cane Technologists, 1983.

1 Brobst *et al.*: *Proc. Amer. Soc. Brewing Chem.*, 1973.
2 Conrad & Palmer: *Food Technol.*, Oct. 1976, 84-92.
3 Scobell *et al.*: *Cereal Chem.*, 1977, **54**, (4).
4 Palmer & Brandes: *J. Agric. Food Chem.*, 1974, **22**, 709-712.
5 Wong-Chong & Martin: *ibid.*, 1979, **27**, 927-932.
6 Clarke & Brannan: *Proc. 38th Meeting Sugar Ind. Tech.*, 1980, 102-112.
7 Charles: *I.S.J.*, 1981, **83**, 169-172, 195-199.
8 Nomura: *Ann. Rpt. H.S.P.A. Expt. Sta.*, 1979, 42-43.
9 Schaffler: Unpublished comments on HPLC made at ICUMSA, 1982.
10 *J. Chromatography*, 1974, **98**, 55-104.
11 *ibid.*, 1975, **103**, 229-239.
12 *Perkin-Elmer Liquid Chromatography Applications*, 1981, (LC211).

alleviate some of the work load incurred by the use of wet chemical methods.

Experimental

A Perkin-Elmer series 2 liquid chromatograph was employed in the isocratic mode with purified water as the solvent. A guard column (Waters Associates) packed with a cation exchange resin (BC – $X_8 Na^+$) preceded the analytical column. An in-line precolumn filter (2 μm) was placed between the guard column and the injector to remove any particulates that were not removed during sample treatment. For monitoring the column effluent, a differential refractometer (Refractomonitor – LDC) having a low cell volume (5 μl) was used. Injections were performed manually by a Rheodyne 7125 injector fitted with a 20 μl loop. The output from the detector was electronically processed by an integrating unit (HP3390A).

Mobile phase: Double-distilled, deionized boiled-out water, filtered through a 0.2 μm millipore filter under vacuum and maintained at 70°C with continuous stirring, was used.

Standard solutions (calibration mixture): Sugars and dextrans used were of AR grade and were dried overnight under vacuum at 60°C before weighing. Standards containing sucrose, glucose and fructose were prepared in purified water (mobile phase) using the appropriate quantities required for a particular analysis (Table I). For accurate work, the component concentrations in the standard should closely match those in the sample. Dextran and sometimes raffinose were also included in the standards to resemble the profiles of eluting sample species. The standard solutions were filtered through 0.2 μm membranes using a Swinnex filter and held in an ultrasonic bath for two minutes.

Process material: All factory materials except raw sugar were analysed on a routine basis using the technique given below. Samples were taken without dilution in order to eliminate errors associated with such a procedure.

Sample preparation: Each sample was thoroughly mixed and an appropriate quantity (see Table I) was weighed accurately to ± 0.1 mg in a nickel dish, dissolved in warm water, transferred to a 100 ml flask, cooled to room temperature, and made up to volume. An appropriate aliquot (Table I) was then taken in a 50 ml flask and diluted to volume. This dilution step was not required in the case of juices. A 20 to 25 ml portion of this solution was centrifuged at 13,500 r.p.m. for 10 min and the resulting supernatant was filtered through a 0.2 μm Swinnex millipore filter into a McCartney bottle. The bottle was sealed and held in an ultrasonic bath for two to three minutes and stored in a refrigerator until ready for injection. The time delay between sample preparation and injection was not allowed to exceed sixty minutes.

Table I. A scheme for preparing standards and test samples*

Sample type to be analysed	Approx. composition of the calibration mixture required, mg per ml			Preparation of test sample		
	Sucrose	Glucose	Fructose	Approx. weight (W) in g per 100 ml (soln A)	Aliquot of solution A required in 50 ml	Factor for conversion to weight %
A-massecuite	11.5	0.15	0.25	5.0	20	× 25/W
B-massecuite	11.5	0.25	0.40	4.3	20	× 25/W
C-massecuite	7.5	0.25	0.40	4.0	15	× 100/3W
A-molasses	10.0	0.30	0.45	4.0	20	× 25/W
B-molasses	7.5	0.40	0.60	4.0	20	× 25/W
C-molasses	4.5	0.45	0.70	4.0	15	× 100/3W
C-sugar	17.0	0.20	0.30	5.0	20	× 25/W
Syrup	11.0	0.20	0.20	4.5	20	× 25/W
Clarified juice	16.0	0.15	0.15	11.0	—	× 10/W
Raw juice	17.0	0.12	0.12	9.0	—	× 10/W

* The above table should be treated only as a guide to sample and standard preparation; the actual weights to be taken depend on the composition of the test sample

Operating conditions: Typical operating conditions for the HPLC system were as follows: Flow rate: 0.5 ml/min; Column temperature: 50°C; Detector temperature: 35°C; Detector sensitivity: 4 x 10^{-5} RI units f.s.d.; Detector output: 10 mV; Peak width range: 0.16 to 0.64 min; Integrator attenuation: 2 ↑ 3 (i.e. attenuating signal by 8). System back pressures were of the order of 1.7 to 2.1 MPa (250 to 300 psi) at a flow rate of 0.5 ml/min.

Results and discussion

Under the operating conditions employed, a mixture containing dextran, raffinose, sucrose, glucose and fructose was separated in less than fifteen minutes (Figure 1). The same applied to test samples. Raffinose, through present only in trace amounts in sugar cane, was included in the standards to represent kestoses because of the lack of authentic standards for the latter. Elution of a mixture containing the above together with glycerol and ethanol was completed in less than 18 minutes (Figure 2). In the case of test samples the first elution peak represented the higher order oligomers, organic acids and inorganic ions. Compounds commonly used as internal standards (e.g. mannitol, sorbitol, inositol etc.) were found to be coeluted with either glucose or fructose.

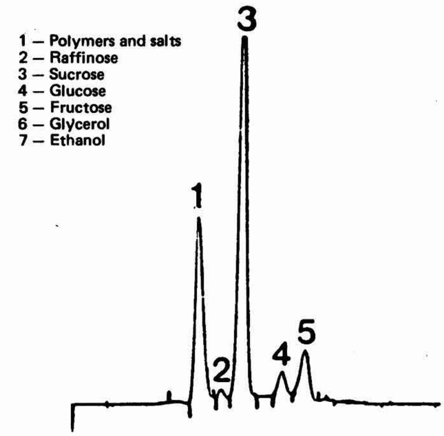


Fig. 1. Separation of sugar standards on Shodex S-801/S using water as the mobile phase**

** Chromatographic conditions as in text.

Column performances and quality of separation

The optimum column temperature was found to be 50°C. The column efficiency (N) calculated on a glucose peak using standard analytical conditions gave 4000 theoretical plates and this represented a reasonable efficiency. Any gain in efficiency at elevated temperatures (N = 7500 at 80°C) was offset by the loss of adequate resolution between individual sugars.

Raffinose and sucrose are base-line separated (R_S* = 1.6) and so are sucrose and glucose (R_S = 3.0). Fructose

* A R_S value of 1.5 represents base-line separation.

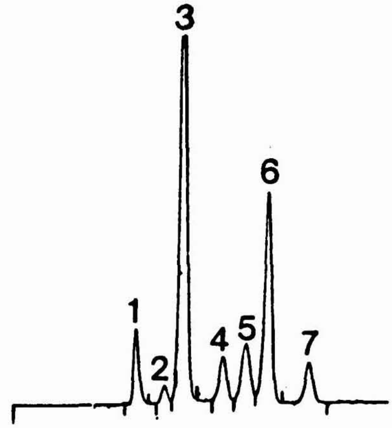


Fig. 2. Separation of a mixture containing dextran, raffinose, sucrose, glucose, fructose, glycerol and ethanol on Shodex S-801/S

and glucose separation is better than 99% (R_S = 1.45) with fructose and glycerol showing a similar degree of resolution. Also, glycerol and ethanol are base-line separated (R_S = 3.0). In fact, glycerol and ethanol can be separated from each other as well as from the major sugars – a separation which is difficult to achieve with other cation exchange resins (e.g. Aminex HPX-87). In final molasses, a peak eluted just after fructose (Figure 3) has been tentatively ascribed to glycerol since the retention time of this peak was identical to that obtained for pure glycerol in a standard mixture containing sucrose, glucose and fructose. When the molasses samples showing this characteristic peak were "spiked" with glycerol, the latter was found to co-elute with the unknown species (Figure 4). It is interesting to note that

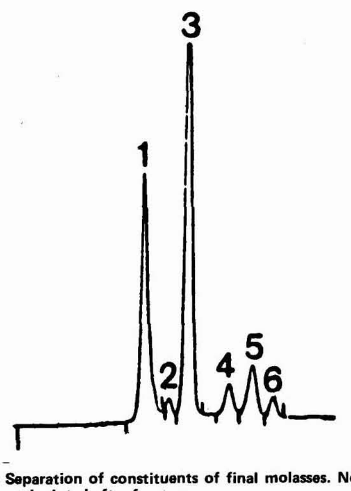


Fig. 3. Separation of constituents of final molasses. Note the peak eluted after fructose

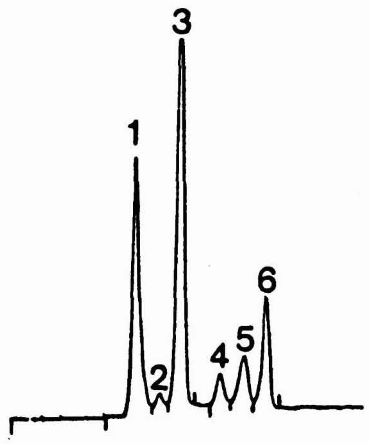


Fig. 4. Separation of sample in Fig. 3 after spiking with glycerol

Charles[7], working with Hawaiian raws, found glycerol in the thin film of molasses covering the crystal.

There was no evidence of on-column inversion of sucrose and this was periodically confirmed by injecting a pure sucrose standard and monitoring the column effluent to identify any traces of glucose and fructose. The quality of the analytical column has been remarkable, especially when one considers the fact that nearly 2000 samples of pan stage products (containing inorganics and colorants) have been analysed without having to regenerate the resin. The column was found to have very little flow resistance and hence low back pressures. Retention time repeatability has been excellent (better than 0.1% RSD for sucrose and 0.2% RSD for both glucose and fructose) and at the time of writing this paper there was no evidence of loss in efficiency or resolution.

The Shodex column fails to resolve certain combinations of saccharides. For example, glucose and mannose are only 90% resolved, as are glucose and galactose. Both mannose and galactose are coeluted with fructose. These limitations apply also to many other cation exchange resins. Trace level concentrations of mannose, galactose, arabinose and xylose present in cane sugar process material would have very little influence on the quality of separation.

Quantification of sucrose, glucose and fructose

Quantification was accomplished by comparing the response factors (amount/peak height) of the sample components with those of similar retention times (Table II) stored in the integrator memory after eluting a standard solution.

Peak height measurements were preferred to peak area, mainly because poor resolution, if occurring, would have significantly less effect on the height than area. The calibration mixture was analysed after every four or five sample runs. If the deviations of response factors were found to be greater than 2 σ, a recalibration was performed to obtain new response factors.

The detector response to varied concentrations of each sugar was linear throughout the range of concentrations found in the injected samples (Figure 5). Although the standard curves were linear over at least a 300-fold range (2-600 μg), the slopes varied significantly for individual sugars.

Table II. Elution of carbohydrates and polyhydric alcohols from a Shodex S-801/S (Na^+) column*

	Retention time data	
	Molecular weight	Retention time (min)
Dextran 110	110 000	7.23
Raffinose	594.52	8.90
Trehalose	378.33	9.77
Sucrose	342.30	9.93
Maltose	360.31	10.12
Glucose	180.16	12.28
Mannitol	182.17	12.49
Galactose	180.16	13.17
Sorbitol	182.17	13.20
Mannose	180.16	13.24
Xylose	150.13	13.33
Fructose	180.16	13.59
Inositol	180.16	13.84
Glycerol	92.09	14.81
Ribose	150.13	16.81
Ethanol	46.07	17.07

* Conditions of elution as given in the text.

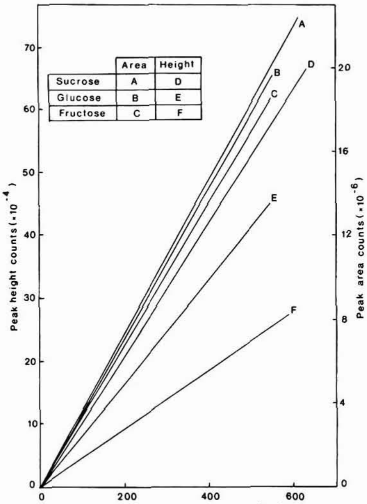


Fig. 5. Linearity plot. Peak height/area *vs.* amount of sample injected

Injection volumes of 20 μl were employed for all quantitative evaluations. Since high concentrations of solute can degrade the reproducibility of these size exclusion columns, concentrations greater than 2.5% w/w were not injected. Generally, the refractometric Brix of all injected solutions fell between 0.8°Bx for *C*-molasses and 2.0°Bx for *C*-sugar.

Extremely good base-line stability was attained at a setting of 4×10^{-5} RI units f.s.d. and this was considered as the highest sensitivity acceptable for routine-type determinations. If the signal to noise ratio is greater than five the detection limit of the system is 2 μg. This corresponds to 0.01 g/100 ml with an injection volume of 20 μl. With a RI setting of 2×10^{-5}, 1 μg levels could be detected but such high sensitivities were not used in this work.

Precision and accuracy

In order to examine the precision of the method a number of subsamples (> 6) from each type of sample were analysed on two different days. Approximately half the number of subsamples were run on each day. The results of these determinations are presented in Table III. The RSD values of < 0.3% w/w for sucrose and 2.0% w/w for fructose are highly promising and satisfactory, especially when one considers the difficulty in obtaining a representative sub-sample from either a massecuite or a *C*-sugar. The results for glucose (less than 4.0% w/w RSD) showed more scatter than those for fructose.

Table III. Precision of sugar analysis by HPLC (using process material)

Sample type	Sugar type	Mean % W/W	Standard deviation	RSD % W/W	95% confidence limits
B-massecuite n = 10	S	73.59	0.15	0.20	± 0.11
	G	1.27	0.04	3.15	± 0.03
	F	1.46	0.02	1.37	± 0.01
C-massecuite n = 10	S	64.10	0.11	0.17	± 0.08
	G	2.00	0.07	3.50	± 0.05
	F	2.64	0.05	1.89	± 0.04
C-molasses n =7	S	33.96	0.10	0.29	± 0.09
	G	2.72	0.10	3.68	± 0.09
	F	5.17	0.11	2.13	± 0.10
C-sugar n = 8	S	83.39	0.15	0.18	± 0.13
	G	0.77	0.03	3.89	± 0.03
	F	1.27	0.01	1.11	± 0.01

n Number of subsamples analysed.

There is no definitive method against which the accuracy of the HPLC results can be assessed. Hence any quantitative evaluation of the method must place a reliance on recovery experiments. Accordingly, known amounts of sucrose, glucose and fructose were added to a variety of samples in approximately the same proportions as encountered in practice and the resulting "spiked" samples were subjected to the entire analytical sequence, without any bias.

Table IV shows the percentage recoveries of added sugars in different sample types. Average recoveries obtained were 99.51, 99.78 and 101.48 for sucrose, glucose and fructose respectively. These results indicate that the method described is essentially quantitative and has adequate accuracy for the analysis of these sugars. Also, the recovery data showed least scatter for sucrose (0.58% RSD) and highest scatter for glucose (2.28% RSD), with fructose showing a much lower deviation than glucose (1.29% RSD).

Influence of non-sugars on chromatographic separation

Inorganic or ash constituents: The effect of inorganic salts on saccharide separations was studied by adding various ionic species (e.g. K^+. Mg^{++}, Ca^{++}, Na^+, Cl^-, SO_4^{--}, PO_4^{---} and NO_3^-) to a standard solution containing sucrose, glucose and fructose. The amounts added were similar to those encountered in technical sugar solutions. The area:height ratios for the sugars remained fairly consistent showing that inorganics have very little, if any, influence on the elution behaviour of saccharides. The cations displaced sodium ions from the guard column and they were eluted with the anions before sucrose. Our experience so far has been that, with the solute levels being used in routine analyses, the guard column did not require replacing until after the completion of at least one hundred analyses.

Organics and colorants: Aconitic and lactic acids did not appear to exert any influence on the separation.

Table IV. Recovery of sugars added to process material

Sample type		Sucrose				Glucose				Fructose			
		Initial conc., g/100 ml	Added, g/100 ml	Measured, g/100 ml	Recovery, %	Initial conc., g/100 ml	Added, g/100 ml	Measured, g/100 ml	Recovery, %	Initial conc., g/100 ml	Added, g/100 ml	Measured, g/100 ml	Recovery, %
C-molasses	1	1.3752	1.0014	2.3787	100.09	0.1153	0.1021	0.2193	100.87	0.2145	0.2002	0.4180	100.80
C-molasses	2	1.4420	2.0004	3.4117	99.11	0.1157	0.1008	0.2167	100.09	0.2207	0.3024	0.5243	100.23
B-massecuite	1	3.0239	2.0008	4.9470	98.45	0.0564	0.2240	0.2888	103.00	0.0598	0.3508	0.4260	103.75
B-massecuite	2	2.9358	1.0023	3.9290	99.77	0.0549	0.1406	0.1905	97.44	0.0596	0.2023	0.2596	99.12
C-massecuite	1	2.5808	1.5001	4.0757	99.87	0.0747	0.2498	0.3260	100.46	0.1040	0.3002	0.4120	101.93
C-massecuite	2	2.5638	1.2007	3.7587	99.85	0.0798	0.1514	0.2323	100.48	0.1057	0.3005	0.4140	101.92
Syrup	1	2.8330	1.5016	4.2928	99.04	0.0243	0.2010	0.2275	100.98	0.0208	0.1056	0.1278	101.11
Syrup	2	2.8760	0.7515	3.5913	99.00	0.0153	0.1036	0.1138	95.71	0.0198	0.2482	0.2743	102.35
C-sugar	1	3.9776	1.4014	5.3940	100.28	0.0358	0.1574	0.1963	101.60	0.0865	0.2015	0.2955	102.60
C-sugar	2	4.2045	1.1999	5.3868	99.67	0.0285	0.2520	0.2725	97.15	0.0675	0.3015	0.3728	101.03
		Overal average recovery, % ± SD RSD (%)		99.51 ± 0.58 0.58		99.78 ± 2.27 2.28				101.48 ± 1.31 1.29			

Aconitates were eluted just before lactates but both peaks appeared in the region taken by the ionic constituents, higher oligomers and dextrans. Pan stage products contain appreciable quantities of colorants, namely polyphenols and phenolic acids which are attracted to the resin matrix. A guard column serves here in adsorbing the phenolics to prevent fouling of the analytical column.

It has been reported frequently that cation and anion exchange resins could be used for colour and ash removal in HPLC work without affecting the composition of sugars. In this regard, several cation and anion exchange resins and also non-ionic copolymers were tried, with little success. The resins, which were effective in removing ionics and colorants, were also found to adsorb some of the constituent sugars. However, some preliminary tests conducted with certain disposable mini-columns packed with hydrophobic material (e.g. Sep Pak C18 and Bond Elut C18) revealed that such columns could efficiently and effectively remove colorants as well as proteins from final molasses and raw juice without appreciable adsorption of sugars. Such cleaning-up procedures would necessitate the use of internal standards.

Table V. Comparison of Lane & Eynon reducing sugar averages with HPLC glucose and fructose averages

Sample type	n	HPLC Glucose (%)	HPLC Fructose (%)	HPLC Glucose + fructose (%)	Lane & Eynon reducing sugars %	Lane & Eynon—HPLC (glucose + fructose)	HPLC glucose to fructose ratio	Linear Regression relating L & E reducing sugars to HPLC glucose and fructose	Corr. coeff.	Level of significance (p)
Final molasses	25	2.48	5.15	7.63	12.15	4.52	0.48	L & E (R_S) = 0.4366 (HPLC) + 8.8123	0.73	$p < 0.05$
C-massecuite	5	2.20	4.47	6.67	10.04	3.37	0.49	L & E (R_S) = 0.9233 (HPLC) + 3.8762	0.85	$p < 0.05$
C-sugar	17	0.97	1.92	2.89	4.39	1.50	0.51	L & E (R_S) = 1.2435 (HPLC) + 0.7757	0.98	$p < 0.05$

Proteins: Proteins, if present in substantial quantities, could irreversibly bind to the resin, causing loss of active sites. However, protein determinations carried out on some raw juice and final molasses samples showed only trace amounts in the prepared solutions (0.04 to 0.07 g/l).

Comparison of HPLC glucose and fructose with classical Lane & Eynon reducing sugars

Several samples of pan stage products were analysed for reducing sugars by both Lane & Eynon and liquid chromatographic methods. The results are set out in Table V.

The combined glucose and fructose as determined by HPLC was found to be always lower than the reducing sugars obtained with the Lane & Eynon method. The differences increased from *C*-sugar to final molasses, thus showing the dependence of this value on the level of impurities. There are many process material impurities, both organic and inorganic, which are capable of reducing copper and are consequently determined as reducing sugars by the Lane & Eynon method. Also, there are other reducing sugars produced during boiling operations (e.g. psicose, mannose) which can contribute to the discrepancies found in classical reducing sugar determinations. On the other hand, LC methods are generally free from interference from such substances and can be considered to be more accurate.

HPLC vs. *polarimetric methods*

The sources of error associated with polarimetric measurements can be highlighted if a brief comparison is made between the polarimetric and HPLC techniques.

HPLC	Polarimetry
The constituent sugars are separated simultaneously, allowing the individual measurement of each.	Measures the net effect of optically active compounds (sugars + non-sugars) simultaneously.
No interference from constituent sugars or non-sugars if suitable columns and operating conditions are selected.	Inorganic salts can modify optical rotation of sugars. Constituent sugars may interfere with optical rotation of the sugar under analysis
Sample preparation is simple without involving multistep clarification procedures.	Sample preparation is generally accompanied by dilution, precipitation, filtration, all of which contribute to error in the final estimate.
No prior chemical treatment or derivatisation is required. Sample identity is preserved.	Acids used in inversion can hydrolyse the higher saccharides (e.g. kestoses) causing changes in their optical properties.

Tables VIA and VIB contain the results obtained by analysing a range of *C*-grade products from a northern and a central mill respectively. Sucrose determinations by classical methods are compared with those using HPLC techniques.

Table VIA. Comparison of average estimate of sucrose by HPLC and classical methods (Northern mill)*

Sample type	n	HPLC	Double pol	Single pol	HPLC—single pol	HPLC—double pol
Cyclone						
C-molasses	13	35.63	36.33	31.92	3.71	—0.70
C-molasses	55	35.14	36.07	32.01	3.13	—0.93
C-massecuite	13	62.41	63.26	60.64	1.77	—0.85
C-sugar	52	85.41	—	85.86	—0.45	—

*Figures for sucrose by chemical method not available.

Table VIB. (Central mill)

Sample type	n	HPLC	Double pol	Chemical sucrose	Single pol	HPLC—double pol	HPLC—chemical sucrose	HPLC—single pol
C-molasses	25	32.64	33.55	34.05	31.80	—0.91	—1.41	0.84
C-massecuite	8	52.62	53.97	54.21	52.21	—1.35	—1.59	0.41
C-sugar	19	76.88	77.47	77.72	77.37	—0.59	—0.84	—0.49

Figures 6, 7, 8, 9 and 10 represent the general analytical trends and relationships between various methods of analyses. Regression equations for these trends are also worked out in Tables VII and VIII. The large correlation coefficients indicate that there is a fairly close relationship between HPLC and classical sucrose measurements. However, the fact that the slopes do not equal unity and the intercepts do not equal zero indicates differences between the methods. These differences will depend on the amount and nature of the impurities.

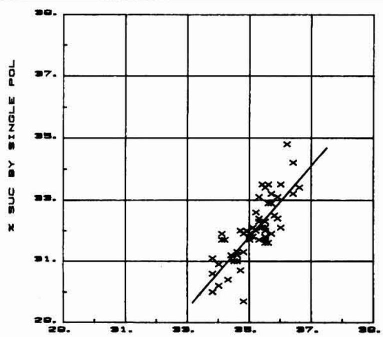


Fig. 6. % sucrose by single pol *vs.* HPLC sucrose (*C*-molasses from a northern mill)

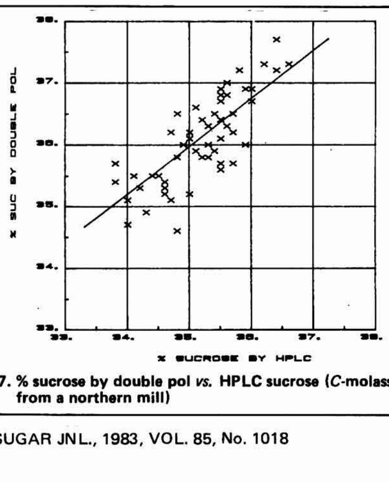


Fig. 7. % sucrose by double pol *vs.* HPLC sucrose (*C*-molasses from a northern mill)

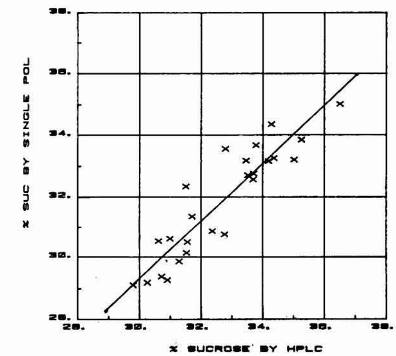


Fig. 8. % sucrose by single pol *vs.* HPLC sucrose (*C*-molasses from a central mill)

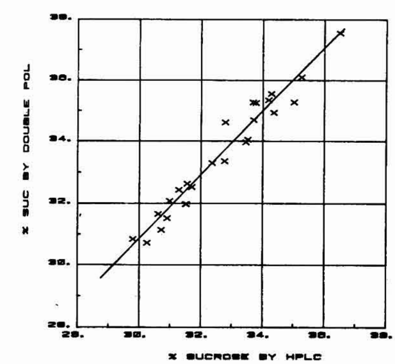


Fig. 9. % sucrose by double pol *vs.* HPLC sucrose (*C*-molasses from central mill)

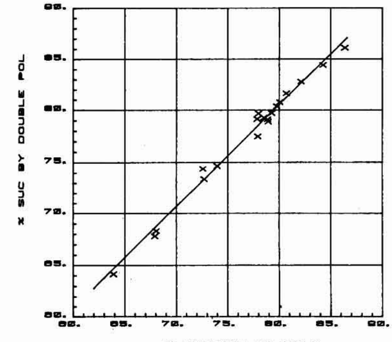


Fig. 10. % sucrose by double pol *vs.* HPLC sucrose (*C*-sugar from a central mill)

Table VII. Analysis of samples from a northern mill; Correlation between sucrose by HPLC and single pol

Sample type	n	Regression equation	Correlation coefficient r	Standard error of estimate	Level of significance p
Cyclone					
C-molasses	13	Single pol = 1.4375 × HPLC – 19.3041	0.85	0.40	$p < 0.05$
C-molasses	55	Single pol = 1.1483 × HPLC – 8.3332	0.78	0.65	$p < 0.05$
C-massecuite	13	Single pol = 0.7565 × HPLC + 13.6069	0.91	0.52	$p < 0.05$
C-sugar*	52	Single pol = 0.9819 × HPLC + 1.9935	0.98	0.56	$p < 0.05$

Correlation between sucrose by HPLC and double pol

Sample type	n	Regression equation	Correlation coefficient r	Standard error of estimate	Level of significance p
Cyclone					
C-molasses	13	Double pol = 1.0813 × HPLC – 2.1958	0.81	0.35	$p < 0.05$
C-molasses	55	Double pol = 0.7969 × HPLC + 8.0671	0.78	0.45	$p < 0.05$
C-massecuite	13	Double pol = 0.7445 × HPLC + 16.8010	0.96	0.38	$p < 0.05$

*Double pol figures not available.

Table VIII. Analysis of samples from a central mill; Correlation between sucrose by HPLC and double pol

Sample type	n	Regression equation	Correlation coefficient r	Standard error of estimate	Level of significance p
C-molasses	25	Double pol = 1.0316 × HPLC – 0.1322	0.98	0.41	$p < 0.05$
C-massecuite	8	Double pol = 0.9719 × HPLC + 2.8295	0.95	0.54	$p < 0.05$
C-sugar	19	Double pol = 0.9958 × HPLC + 0.9139	0.99	0.62	$p < 0.05$

Correlation between sucrose by HPLC and chemical method

Sample type	n	Regression equation	Correlation coefficient r	Standard error of estimate	Level of significance p
C-molasses	25	Chemical sucrose = 1.0405 × HPLC + 0.0835	0.97	0.45	$p < 0.05$
C-massecuite	8	Chemical sucrose = 0.7137 × HPLC + 16.6475	0.91	0.55	$p < 0.05$
C-sugar	19	Chemical sucrose = 0.9424 × HPLC + 5.2724	0.99	0.85	$p < 0.05$

Correlation between sucrose by HPLC and single pol

Sample type	n	Regression equation	Correlation coefficient r	Standard error of estimate	Level of significance p
C-molasses	25	Single pol = 0.9333 × HPLC + 1.3335	0.91	0.76	$p < 0.05$
C-massecuite	8	Single pol = 0.7528 × HPLC + 12.5879	0.89	0.67	$p < 0.05$
C-sugar	19	Single pol = 0.9793 × HPLC + 2.0829	0.99	0.98	$p < 0.05$

The following observations were made in the course of this investigation.

1. With low purity material, HPLC methods generally gave lower sucrose levels than both double pol and chemical sucrose.
2. Chemical sucrose and double pol figures agreed well (within one unit).
3. With high purity material, all four methods showed good agreement.
4. No consistent trend was observed between HPLC sucrose and single pol measurements.

Summary

A simple and reliable method for the determination of sucrose, glucose and fructose in cane sugar factory material has been developed. Separation of sugars is achieved by elution with water from the cation exchange resin and detection with a differential refractometer. The separation of the three major sugars can be completed in less than 15 minutes. The method lends itself to quantification and requires only minimal sample preparation.

Détermination par chromatographie liquide à haute performance de sucres sur résines échangeuses cationiques

Une méthode simple et sûre pour la détermination de saccharose, glucose et fructose dans des matériels d'usine à canne a été développée. La séparation des sucres est achevée par élution à l'eau de la résine à échange cationique et détectée par réfractomètre différentiel. La séparation des trois principaux sucres peut être réalisée en moins de 15 minutes. La méthode peut être quantitative et demande un minimum de préparation pour l'échantillon.

Hoch-Druck-Flüssigkeits-Chromatographie für die Bestimmung von Zuckern auf einem Kationenaustauscher

Eine einfache und verläßliche Methode für die Saccharose-, Glucose- und Fructosebestimmung in Fabriksrohrsäften wurde entwickelt. Die Trennung der Zucker wird durch Eluierung mit Wasser vom Kationen-Austauscherharz erzielt und diese werden mit einem Differentialrefraktometer erfaßt. Die Methode eignet sich zur Quantifizierung und erfordert nur minimale Probenvorbereitung.

Determinación por cromatografía líquida de funcionamiento alto (HPLC) de azucares sobre résinas para cambio de cationes

Un método, sencillo y confiable, para la determinación de sacarosa, glucosa y fructosa en materias del ingenio azucarero se ha desarrollado. Se logran la separación de azucares por elución con agua de una résina para cambio de cationes y su detección por un refractómetro diferencial. Se puede completar la separación de los tres azucares mayores en menos de 15 minutos. El método se presta a cantificación y no requiere más de preparación minimal de la muestra.

CANE SUGAR MANUFACTURE

Indonesian goal sugar self-sufficiency. R. M. Hadipoero. *Sugar y Azúcar,* 1982, **77**, (12), 18-19, 22. – The Indonesian government program of sugar industry expansion is outlined; it involves rehabilitation of existing factories on the island of Java and construction of new ones on other islands. The total of 78 factories (18 of them new ones) are intended to produce some 3 million tonnes of sugar and make the country self-sufficient in sugar.

Design of pinions for mill roller drives. S. Brunelli and M. Miayesi. *Brasil Açuc.,* 1982, **100**, 222-235 *(Portuguese).* – Mathematical theory for designing the shape of teeth, etc., for a mill roller pinion is discussed and illustrated.

The effect of phosphates, calcium and flocculant on settling of insoluble particles in sugar cane juices. L. G. Rodriguez, P. M. Fabregat, A. V. Gukalov and D. Calsado. *Izv. Vuzov, Pishch. Tekh.,* 1982, (5), 140-141 *(Russian).* Laboratory experiments were conducted at 95°C on settling of a water-diluted raw sugar solution to which cellular tissue, soil, potassium monophosphate and milk-of-lime had been added. An aqueous 0.1% solution of Magnafloc was used as flocculant. The phosphate, Ca and flocculant contents were in the ranges 210-475, 290-450 and 0-4 $mg.litre^{-1}$, respectively. From the results, an equation was derived for calculation of settling rate ($cm.min^{-1}$) as a function of phosphate, Ca and flocculant contents, and for calculation of mud density as a function of phosphate content (neither Ca nor flocculant having any effect on this parameter).

Economies of size in Louisiana sugar cane mills. H. Shapouri and L. Angelo. *Sugar y Azúcar,* 1983, **78**, (1), 35-39, 64. – In an examination of the sugar production costs in 23 Louisiana sugar factories of three size ranges (daily crushing rates of 2400-3500, 3501-4500 and 4501-7800 short tons of cane) operating during the 1978-79 and 1979-80 seasons, it is shown that the costs were higher per ton of cane crushed and per pound of raw sugar produced for the small mills than for the medium-sized and large ones. The costs of labour, fuel, materials and supplies fall rapidly with increase from small to medium size, after which cost increases to some extent. While cane transportation costs are expected to rise with size of factory, large mills have the benefit of economy of scale.

Crystallization kinetics of cane sugar syrups. A. Marquez S. and V. G. Tregub. *Izv. Vuzov, Pishch. Tekh.,* 1982, (6), 79-82 *(Russian).* – An equation for calculation of massecuite crystal content in terms of time and kinetic factors in boiling has been obtained analytically for a "grano fino" massecuite, and its validity confirmed by investigations conducted at Pablo Noriega sugar factory. The coefficient of shape of the kinetic curve *n,* applicable to nucleation of Cristal 600 seed slurry and incorporated in the equation, depends on the supersaturation coefficient of the concentrated solution and its temperature. Results showed that the number of crystals per unit massecuite volume increased in the initial period of boiling when seed slurry was injected for nucleation, after which it fell almost to its initial value as a result of the dominant effect of recrystallization.

Measurement of milling torque. D. M. Jenkins. *Paper presented to the 18th Congr. ISSCT,* 1983, 26 pp. Various methods for measurement of cane mill torque are described. For prime mover torque, both indirect and direct approaches may be used; direct measurement can be made on the output shaft of the unit by means of strain gauges, the low-level signal from which must be amplified before it is transmitted by means of totally enclosed high-quality sliprings or by radio telemetry. The torque at the tailbar driving the mill or pressure feeder may be measured either by determining the deflection over a known length of shaft or by strain gauges (the latter not requiring any direct calibration as was needed with displacement transducers). Of three methods used to transmit the continuous torque signal from the rotating shaft to a recording device, the easiest to use in practice is radio telemetry, which is briefly described. The methods for measurement were tested, and that involving strain gauges found to be more accurate than the use of D.C. differential transformers while also showing less hysteresis (probably because of the requirement for mechanical movement in the system). Moreover, the use of strain gauges permits elimination of the bending effect on tailbars. By the methods described, an accuracy of ± 3% is possible in the measurement of mill torque.

The determination and comparison of some reliability indexes of sugar equipment in some Cuban sugar mills. A. López-Calleja H.-L., V. Shubin and M. Muñiz C. *Paper presented to the 18th Congr. ISSCT,* 1983, 28 pp. Reliability, i.e. probability that equipment will continue to function when required, was determined in the case of three Cuban sugar factories. Statistical information on stoppages was classified by cause, and the net working time between failures and lost time were established. The probabilistic distributions for both factors were determined at a failure number ⩾ 10. Equations were obtained for establishing reliability, and graphs constructed of amount of cane crushed *vs.* lost time. The reliabilities of the major equipment were compared between the three factories.

Latest developments in cane sugar machinery and process equipment. R. Schaer. *Paper presented to the 18th Congr. ISSCT,* 1983, 41 pp. – A survey is presented of latest developments in cane and bagasse diffusers (with examination of the time required for adequate compression to be applied and the squeezed liquid to drain in order to achieve a required bagasse moisture), in cane mills, vertical crystallizers, centrifugals and in anaerobic treatment of waste water.

The performance of tubular and direct-contact juice heaters. P. G. Wright. *Paper presented to the 18th Congr. ISSCT,* 1983, 20 pp. – Formulae are presented for calculation of heat transfer and pressure drop in tubular juice heaters and their application discussed[1]. Mention is also made of direct-contact juice heaters as used in a number of Australian sugar factories, and their performance and outlet juice temperature control are discussed.

[1] See Wright: *I.S.J.,* 1982, **84**, 212.

Methodology for determination of the optimum mixed juice heater. A. Valdés and O. Gómez. *Paper presented to the 18th Congr. ISSCT,* 1983, 24 pp. — A model heater was designed and constructed, and pilot-plant trials conducted in order to determine the effects of the main variables on performance. Four 72-hour test cycles were carried out over three ranges of juice flow velocity and temperature. Results showed that heat transfer and hydraulic pressure drop increased with increased velocity, while scale deposition decreased at the higher velocities and lower juice temperatures. From determination of the internal film heat transfer coefficient, an equation has been developed for calculation of heat loss: $Nu = 0.0258\ Re^{0.8} Pr^{0.33} (\mu/\mu_W)^{0.14}$, where Nu is the Nusselt number, Re is Reynolds' number, Pr is the Prandtl number and μ and μ_W are juice viscosity and juice viscosity at the wall temperature ($Pa.sec^{-1}$), respectively. Optimum design parameters (relative to technical and economic factors) were established for different times of continuous operation. While the values will vary because of world market prices, the methodology is valid for obtaining relative values.

Evaporation station control by micro-computers. M. Pascual M. and J. Lage C. *Paper presented to the 18th Congr. ISSCT,* 1983, 21 pp. — An account is given of the computerized digital control system used for operation of the quadruple-effect evaporator at Batalla de las Guasimas sugar factory; the system is the first of its kind in Cuba. The Brix of the syrup leaving the evaporator is maintained at a pre-set level, independent of clarified juice flow, etc., by means of level control in the four effects and vapour cell, pre-heater temperature control, and vacuum control in the 4th effect. Control of these parameters is by means of a micro-computer, while another micro-computer is responsible for information display, via a closed-circuit colour television, in the form of bar diagrams for each control variable and associated manipulated variable, as well as a chart of syrup Brix during the preceding hour. In addition, every 8 hours is displayed information on evaporator performance, total steam consumption and quantity of juice processed. Both soft- and hardware have been arranged so as to permit their use in any other process control system, thus leading to ultimate automation of the entire manufacturing process.

Present practices and future perspectives for vacuum pan control. R. Consuegra, O. Llompart and P. Friedman. *Paper presented to the 18th Congr. ISSCT,* 1983, 17 pp. The advantages and disadvantages of the conductimetric and rheometric methods of boiling control, as stated in the literature, are reviewed, from which it is concluded that neither method is completely adequate for low-grade strikes. Experiments are reported which showed that conductimetric control was better than manual control, while the use of an ultrasonic sensor to measure massecuite viscosity as a function of crystal content was found to give promising results; sensitivity to changes in pan conditions was the same as with conductivity measurements. The possibility of adapting the system to optimization of the boiling process is discussed.

Sugar and climate. T. M. Betancourt del Monte. *Paper presented to the 18th Congr. ISSCT,* 1983, 31 pp. Ventilation in sugar factories was investigated at 19 Cuban plants, the calculation methods used being based on the chimney effect and showing the adverse effects of limited window area, considerable ceiling height and the use of wall and roof materials having high heat transfer coefficients. The working conditions for each process station are discussed, and the methodology used to obtain and analyse the data is described.

Use of surface-active substances in imbibition water to reduce pol and moisture of bagasse in sugar factories. N. A. Ramaiah and S. K. Srivastav. *Paper presented to the 18th Congr. ISSCT,* 1983, 13 pp. — While, in experiments, cationic surfactants proved unsuitable as wetting agents in reducing bagasse pol and moisture content, non-ionic and anionic surfactants contributed to an increase in sugar extraction in milling. A mixture of these, known as Sushira, added at 8-10 ppm on cane with imbibition water to bagasse from the penultimate mill, reduced bagasse moisture by about 2 units and pol by 0.2-0.4 units. (See also Murugkar *et al.*: *I.S.J.*, 1980, **82**, 156; Ramaiah *et al.*: *ibid.*, 1981, **83**, 215.)

Determination of microbial losses at the tandem by means of the spontaneous fermentation test. M. T. Hernández N., M. E. Pérez R. and R. Sánchez M. *Paper presented to the 18th Congr. ISSCT,* 1983, 35 pp. — The spontaneous fermentation tests, as applied in the beet sugar industry for determination of sucrose degradation in diffusion, was used to determine conditions under which microbial decomposition (as represented by the quantity of organic acid formed) was maximum in cane milling. Results showed that they were a temperature of 37°C and a pH of 5.5. The benefits of disinfection with formalin on sugar recovery are indicated.

Influence on sugar cane juices of clarification by the sulphitation and phosphatation processes. A. A. El-Kader, A. El-K. Mansour and A. A. Yassin. *Paper presented to the 18th Congr. ISSCT,* 1983, 24 pp. — Investigations in Egyptian cane sugar factories are reported in which juice sulphitation was compared with phosphatation. Results showed that sulphitation gave a faster settling rate and a lower mud volume than phosphatation, while the latter gave a lower juice turbidity. Phosphatation also gave a lower ash, CaO, colour, gum and protein content and better filtrability. Free amino-acids and colorants were isolated by ion exchange and analysed by paper and thin-layer chromatography and infra-red spectrometry, revealing the same 15 amino-acids and 7 polyphenolic acids in both types of juice and thus demonstrating the inability of either form of clarification to bring about complete elimination of colouring matter.

Comparative study on various constituents of sugar cane juice affecting settling in the sulphitation and phosphatation processes. A. A. El-Kader. *Paper presented to the 18th Congr. ISSCT,* 1983, 24 pp. — The rate of settling was determined for juice treated by one of the two title processes with and without additon of gum arabic, sodium silicate, soluble starch, tannic acid, urea and wax, respectively. The effects of these additives on juice physical parameters and composition, purity rise, reducing sugars degradation and mud volume were also determined as a contribution to evaluation of the two clarification methods. The results are given in the form of time charts and tables.

Application of cultural broth as alpha-amylase preparation for starch removal in sugar processes. C. L. Lai. *Paper presented to the 18th Congr. ISSCT,* 1983, 17 pp. A strain of *Bacillus* sp. H-23 capable of producing relatively heat-stable alpha-amylase was selected for use as a cultural broth in starch elimination. The alpha-amylase produced had a half-life of 42 minutes at 90°C. Laboratory-scale experiments showed that addition of 0.5 $ml.litre^{-1}$ of the broth to 22°Bx factory syrup hydrolysed about 43% of the starch within 10 minutes at 80°C. Amylase activity was considerably affected by Brix, increase in which was accompanied by a fall in the degree of starch hydrolysis, so that a low Brix is recommended, e.g. such as found in the 2nd effect of an evaporator.

Some aspects of material balance calculations in raw sugar boiling. R. Suárez R. and C. M. de Armas C. *Paper presented to the 18th Congr. ISSCT,* 1983, 19 pp. Various procedures described in the literature for establishment of material balances for the boiling process are described and an attempt made to evaluate them. While they fail to take account of factors such as crystal growth ratios and crystal yields, a linear programming technique based on a BALINPRO program does; moreover, future use of digital computers will, it is thought, permit development of equations for calculation of the physical relationships between variables in boiling and thus provide guidance on purities.

An analysis of three methods for calculation of boiling systems. F. G. Carver and P. M. Cervello. *Paper presented to the 18th Congr. ISSCT,* 1983, 21 pp. — The authors use three methods to calculate material balances for 2- and 3-massecuite systems, and show that the Cobenze cross-diagram method based on purities is only of advantage for quantities measured in terms of volumes of massecuite boiled when the approximation is good. A method using Brix and pol of each product, but (as with the Cobenze method) not taking into account water added and evaporated, was marginally better than the first method, whereas the third method (advocated by the authors) is based on mass, Brix, pol and water (whether added or evaporated). This method gives a more accurate prediction of all the quantities in circulation, while the overall system breaks down into smaller systems of equations involving only three unknowns for which use of a programmable calculator or microcomputer is recommended. Changes in Brix and/or pol and in the boiling system can thus be investigated very quickly, either from day to day or more frequently, while comparison of boiling systems is also facilitated.

Production systems in the boiling house: a methodology for design and management. C. M. de Armas and L. Rostgaard. *Paper presented to the 18th Congr. ISSCT,* 1983, 25 pp. — A linear programming model of the boiling process has been developed and applied to analysis of different schemes at Camilo Cienfuegos factory as well as to process management. Details are given of the model and of the associated methodology.

A simplified periodical reporting system for the Indonesian sugar factories. S. G. Gandana. *Paper presented to the 18th Congr. ISSCT,* 1983, 13 pp. — Details are given of a simplified system used in the Indonesian sugar industry to report process data and assess station performances.

A review of research into the pelleting, baling and storage of bagasse in Australia. R. N. Cullen and R. J. Stalker. *Paper presented to the 18th Congr. ISSCT,* 1983, 22 pp. Investigations of bagasse pelleting and baling for storage as boiler fuel in Australia (where neither form of compaction has been widely practised) are discussed. Details are given of the equipment needed for the two operations as well as for loose storage, and comparison is made between the costs of the three procedures for a typical factory. The effect of bagasse drying on boiler efficiency is discussed, and reference made to a mathematical model developed for determination of the relationship between boiler operating parameters and the size of a bagasse storage facility. Aspects of bagasse pelleting and the factors affecting the maximum rate at which bagasse can be compressed are examined, and the significance of results of investigations into these factors for the design of a less expensive, more energy-efficient pelleting machine is indicated.

A comparison of air pre-heaters and bagasse drying systems for energy efficiency. W. Keenliside. *Paper presented to the 18th Congr. ISSCT,* 1983, 24 pp. Analysis of boiler operation shows that use of an air pre-heater would increase steam generation under comparable conditions of operation; use of a bagasse dryer would also increase efficiency, but extra power would be consumed in its operation, so that the benefit would be no greater than with use of an air pre-heater. However, the bagasse saved would have to be pelleted for future use, and this would entail reducing the moisture content from 50% to 15%; otherwise, the excess bagasse could be used to generate steam for provision of surplus electricity, although it has been found that public utilities are not always prepared to buy excess power because the supply cannot be guaranteed and there is instability in the line frequency. Therefore, use of excess bagasse as boiler fuel is strictly limited except during times of lengthy mill stoppages. The only advantage of using dry bagasse rather than pre-heated air lies in a faster combustion rate and thus considerable reduction in supplementary fuel consumption when there is a sharp rise in steam consumption.

Retention time distribution and sucrose hydrolysis as criteria for the optimization of the evaporation process. E. C. Wittwer and W. Mauch. *Paper presented to the 18th Congr. ISSCT,* 1983, 31 pp. — Among measures discussed as a means of conserving energy and reducing bagasse consumption is conversion from vacuum evaporation to pressure evaporation. While such a change would lead to greater sucrose hydrolysis and colour formation as a consequence of the higher temperatures, it is pointed out that retention time and its distribution also affect the reactions taking place in the juice, and that, while an increase in temperature without change in retention time would raise sucrose hydrolysis from e.g. 0.019% to 0.045% on sucrose in juice, increase in temperature with corresponding reduction in the total retention time from 46.3 to 25 minutes would reduce the increase to 0.005% absolute — such an increase being considered justifiable in view of the fuel-saving advantages of pressure evaporation.

Multiple-effect evaporator performance analysis for design and operation. L. González P., E. M. Rivas B. and C. de Armas C. *Paper presented to the 18th Congr. ISSCT,* 1983, 34 pp. — Reference is made to the use of a mathematical model of an evaporator system to determine the effect of a number of operating variables and thus optimize the process. Parameters studied included those affecting syrup Brix (a value of 60-65° being required for boiling purposes), the evaporation rate per unit area h.s. and per unit of steam consumed, and the effect of scale on heat transfer and evaporator performance.

BEET SUGAR MANUFACTURE

Methane fermentation of effluent from agro-food industries. G. Albagnac and D. Verrier. *Biomasse Actualités,* 1983, (Suppt. 2), 17-21 *(French).* — The merits of methane fermentation of effluent are discussed, and biological features of the process indicated. Characterization of substrates on the basis of their COD and suspended solids concentration is explained, and four processes that may be used are described, including the IRIS process for sugar factory effluent and vinasse, the Upflow Anaerobic Sludge Blanket (UASB) process as used in the Dutch sugar industry, and the use of anaerobic filters for vinasse treatment. The two last processes necessitate careful arrangement of effluent distribution so as to avoid the creation of preferential flow paths. The choice of process as a function of the initial effluent COD is discussed, as are the energy aspects of treatment and future prospects.

The use of gas turbines in the sugar industry. J. C. Giorgi. *Sucr. Franç.,* 1983, **124**, 39-45 *(French).* — The advantages of a gas turbine as a means of supplementing boiler operations are discussed, and a simple turbo-alternator/boiler scheme is described for a sugar factory of 8000 tonnes daily beet slice, in which exhaust gas from the turbo-alternator is fed to the boiler at the rate of 77 tonnes.hr^{-1} and fired together with the normal boiler fuel to produce 100 tonnes of steam per hr. The fuel injected into the turbine also produces 2800 kWh of electricity via the alternator. Costs are briefly touched on, and equations are given for calculation of important parameters.

Construction of a mathematical model of the sucrose crystallization process. V. I. Tuzhilkin, M. A. Karagodin and A. I. Sorokin. *Izv. Vuzov, Pishch. Tekh.,* 1982, (6), 76-79 *(Russian).* — A mathematical model of the boiling process has been constructed which permits a study of the interrelationship between heat and mass transfer, of crystallization kinetics and of various automatic control algorithms. The model does not include nucleation.

Trials with active silicic acid as flocculant at Ramon sugar factory. I. F. Bugaenko *et al. Sakhar. Prom.,* 1983, (2), 21-23 *(Russian).* — Silicic acid formed by mixing 2% sodium silicate with 2% aluminium sulphate for 30-40 min, followed by dilution with water to 0.1% (as SiO_2) was added to 1st carbonatation juice at 2 ppm in one week's trials. Results showed that the flocculant increased the settling rate by 44.7%, reduced the clear juice filtration coefficient by 26% and the colour by 6.5%, and increased purity by 0.3 units. The flocculant was much cheaper than other preparations such as polyacrylamide.

Supplementary cleaning of beet by air blowing. V. V. Krivosheya. *Sakhar. Prom.,* 1983, (2), 34-35 *(Russian).* After mechanical impurities accompanying beets into the slicer had blunted the knives, a system was devised for blowing air through the beets as they fell from the main belt conveyor onto the weigher. The system was tested and found to have a positive effect in preventing recurrence of the problem and hence in helping to improve cossette quality.

Economizing in fuel and energy resources — results and problems. A. I. Khomenko. *Sakhar. Prom.,* 1983, (2), 35-39 *(Russian).* — Using the example of "Petrovskii" No. 2 sugar factory at Aleksandrovka, the author shows how it is possible to reduce fuel and energy consumption, at the same time highlighting the major causes of excessive consumption.

The effect of salts deposition on steam turbine reliability and efficiency. L. P. Ignat'ev, B. M. Margulis and B. S. Margulis. *Sakhar. Prom.,* 1983, (2), 39-43 *(Russian).* The problems created by deposition of salts, entrained with steam from the boilers, on turbine components are discussed and means of avoiding such difficulties are indicated, covering periodical cleaning with wet steam and maintaining a satisfactory system of boiler feedwater (particularly condensate) treatment.

Factory trials on a compartmented juice heater before 2nd carbonatation. A. A. Pochechun, B. M. Yanchuk, V. A. Yavor and Yu. S. Razladin. *Sakhar. Prom.,* 1983, (2), 43-45 *(Russian).* — A juice heater consisting of vertical tube sections linked alternately at the top and bottom so as to form a continuous tube "coil", with a main steam line passing horizontally through the middle of the configuration, was tested for heat transfer and scale formation; stainless steel, carbon steel and brass were compared, and the first found to be best as regards the amount of scale deposited. While carbon steel had the highest initial heat transfer coefficient, within 4-5 days that of stainless steel had caught up with it, and within 20-25 days was much greater. Scale formation on the brass tubes was greater than on the stainless tubes, but, because of its very high initial value, the heat transfer coefficient remained the highest of the three sets of values.

Investigation of the efficiency of domestic and foreign disinfectants. K. Magyar. *Cukoripar,* 1982, **35**, 138-143; 1983, **36**, 27-30 *(Hungarian).* — Of 11 disinfectants tested for their efficiency in reducing the bacterial counts in diffusion juice (as expressed by log N_O/N, where N_O and N are the bacterial counts in untreated and treated juice, respectively), Antiseptol (a West German product) at 10-40 ppm gave the best results, followed by Kamin RMO (from Poland) at 2 ppm and hydrogen peroxide at 3145 ppm. The other products included formalin, a number of Hungarian products and a Czechoslovakian preparation. However, from statistical evaluation of the results it is concluded that rated performances of commercial disinfectants were exaggerated, and that it was very difficult to attain the same performances under sugar factory conditions.

The occurrence of colouring matter and factors affecting its quantity. L. Paradi. *Cukoripar,* 1982, **35**, 135-138; 1983, **36**, 30-33 *(Hungarian).* — An investigation was undertaken of colouring matter levels in beet sugar factory products as measured at 560 nm. Results indicated the sharp increase in colour from thin juice to evaporator thick juice, with further increase during boiling and crystallization, although most of the colour then entered the run-offs and molasses. The positive effect of thin juice sulphitation in reducing by 35% the colour increase in evaporation is shown; sulphitation of 1st product massecuite reduced stored white sugar colour by 0.5-1.0 units.

Evaluation of water analyses in regard to its re-utilization. L. Haraszti. *Cukoripar,* 1983, **36**, 33-38 *(Hungarian).* Reference is made to analyses of sugar factory effluent, as carried out in Hungary since the late 1960's, for suspended matter, COD and NH_4^+ ion concentration with a view to evaluating the performance of flocculants and possible recycling of the treated water. Results have shown that application of even a very small quantity of flocculant, e.g. 0.5 or 1.0 $mg.litre^{-1}$, will cause a considerable reduction in the suspended matter content and COD. Tabulated data include details of the efficiencies of various Dow products, Struktol I 658 and Cyanamid A 30 as well as CaO (applied at 500 $mg.litre^{-1}$) expressed in terms of suspended matter and COD after 30 minutes' treatment on two separate days in January 1982.

Cleaning sugar beet by means of air stream. B. Mayrhofer and P. Mikus. *Zuckerind.,* 1983, **108**, 138-144 *(German).* Use of a horizontal jet of air to remove mechanical impurities from a vertical stream of beets falling from the end of a conveyor belt is proposed, and a mathematical model constructed for use in analysing the various geometrical and other parameters involved.

The problem of scale formation in beet sugar factory evaporator stations and confronting it. A. Megalopoulos and G. Tsangarlis. *Hellenic Sugar Ind. Quarterly Bull.,* 1982, (50-51), 21-36 *(Greek).* — The problem of evaporator scale formation is discussed and typical thin juice and thick juice Ca and Si contents indicated. Two methods of reducing scaling are described, viz. thin juice decalcification and use of scale inhibitors. The quantities and steps in thin juice decalcification with ion exchange resin are described, and mention made of tests conducted in two French sugar factories involving use of phosphonate (effective in reducing $CaCO_3$ scale) in one factory, and polyacrylate (active against Ca oxalate) in the other. A diagram is presented showing a scheme in which 6 $ml.m^{-3}$ phosphonate was added to deionized thin juice of 15-16°Bx; this juice was then pre-evaporated in three parallel systems to 35°Bx, after which 3 $ml.m^{-3}$ inhibitor was added. Subsequent additions of the chemical were made after the 2nd evaporator effect (2 $ml.m^{-3}$) and 3rd evaporator effect (3 $ml.m^{-3}$). By this means, a 94% reduction in Ca and Si content was achieved.

The influence of beet tops on determination of sugar content, beet quality and the sugar manufacturing process. Z. Georgios. *Hellenic Sugar Ind. Quarterly Bull.,* 1982, (50-51), 37-46 *(Greek).* — Investigations have shown the losses in predicted sugar recovery that may result from excessive topping. The pol difference between topped and untopped beet can be in the range 0.19-0.73°S according to topping height and size of beet. On the other hand, insufficient topping will increase the invert sugar content, K, Na, noxious N and molasses losses. Therefore, it has been calculated that it is necessary, where untopped beets are processed, to increase the total slice by 5-11% in order to achieve the same sugar production as with topped beet; this increase makes allowance for the extra transport costs involved.

Optimization of the process of sugar extraction from beet. K. G. Adamopoulos, P. A. Christodoulou and H. I. Petropakis. *Hellenic Sugar Ind. Quarterly Bull.,* 1982, (50-51), 57-79 *(Greek).* — The theory of beet diffusion is explained, and the important parameters

indicated. Factors which have an effect on diffuser performance are discussed, and means of optimizing conditions so as to obtain maximum sugar extraction in a DDS diffuser are described. Recommendations include a mean temperature of 72°C (with stages of 72°-74°-74°-68°C), a juice draft averaging 111% (106-118%), a scroll speed of 0.8 rpm corresponding to an hourly beet throughput of 120 tonnes, an average pH of 6.0 (5.8-6.2) and a water hardness no greater than 12°dH. Under these conditions, losses should not exceed 0.11%.

Sucrose losses in diffusion. Residence time of cossettes in the diffuser. V. Maurandi, A. Rossi, G. Mantovani and G. Vaccari. *Sucr. Belge,* 1982, **101**, 391, 401. — See *I.S.J.,* 1983, **85**, 150.

Some aspects of the economics of thick juice refining. P. S. Worthington. *Sucr. Belge,* 1982, **101**, 403-421. See *I.S.J.,* 1983, **85**, 179.

Analysis of residence time spectra for optimization of multiple-effect evaporation. E. Wittwer. *Zuckerind.,* 1983, **108**, 218-226 *(German).* — The value of analysing residence time spectra for optimization of continuous flow-through vessels is examined, and reference then made to investigations at two West German sugar factories in which the true residence time curves were determined and compared with ideal theoretical values on the basis of a specially developed equation relating to a stirred vessel cascade made up of vessels of different sizes. Comparison between the two evaporators, one having effects of identical size and the other having effects of different sizes, showed that any difference between the overall mean residence times was so small (with the slight advantage going to the former evaporator) as to prevent any conclusions being drawn on the question of effect size in relation to residence time.

Suggestions for conversion of furnaces of oil- or gas-fired flue boilers to coal. R. Wieser. *Zuckerind.,* 1983, **108**, 226-228 *(German).* — The author describes design modifications that would allow an oil- or gas-fired furnace to burn coal (in the form of dust or lumps) and thus permit a 25% saving in fuel costs. The question of flue gas filtration and of ash disposal is discussed.

A system of laboratory control within a central control scheme for a raw sugar factory. B. Ticha. *Listy Cukr.,* 1983, **99**, 63-64 *(Czech).* — The role that the laboratory can play within the overall central control of a sugar factory is discussed, and a system described in which continuous monitoring of 1st and 2nd carbonatation juice alkalinity, of the CO_2 content in carbonatation gas, of the milk-of-lime density and of thick juice Brix is maintained by the central control via measurements fed from the laboratory by means of closed-circuit television. Details are given of a rapid method for determining the purity of massecuite, syrup and molasses which permits hourly recordings of the parameter, and some suggestions are made regarding cleaning and drying of laboratory glassware, and on suitable means of sampling various juices and waters.

Rationalization of purification lines. I. Z. Pochyly and J. Bejtlerova. *Listy Cukr.,* 1983, **99**, 65-71 *(Czech).* Since it is of advantage for factories to use modern, continuous juice purification techniques, a scheme has been developed which uses as much of the equipment used in batch schemes as is practical, and thereby permits conversion to a continuous scheme at reduced investment costs. Flow diagrams are given of the existing standard batch scheme used in Czechoslovakian factory for liming and 1st carbonatation and of the new, continuous scheme; the essential equipment change is replacement of a progressive prelimer and a main liming vessel in the batch system with a Dolinek-Koran vertical limer in the new system. Details are given of modifications to specific pieces of equipment and processes. The scheme has already been used as part of a purification line reconstruction at two factories.

Preliminary heat treatment of beet cossettes. N. S. Karpovich, V. N. Kukhar and P. P. Gaidenko. *Sakhar. Prom.*, 1983, (3), 24-26 *(Russian).* — Cossettes treatment in tower diffuser prescalders is described, and a heat balance calculated. The quantities of circulation juice required for prescalding at varying temperatures and mass flows in a diffuser have been determined, on the basis of which a number of recommendations are made for establishment of optimum conditions.

The dependence of the specific heat capacity of sugar beet on its moisture content. A. V. Sadych, V. A. Mikhailik, I. A. Oleinik and I. G. Bazhal. *Sakhar. Prom.*, 1983, (3), 27-28 *(Russian).* — The importance of knowledge of the specific heat capacity (s.h.c.) of beet for storage and processing is emphasized. While the relationship between s.h.c. and moisture content has been established for temperatures in the range 15-20°C, it is important to know the relationship for temperatures in the range 60-80°C, i.e. corresponding to diffusion and cossettes prescalding. Calorimetric studies were carried out, from which empirical equations were derived for 20, 40, 60 and 80°C at confidence limits of ± 34, ± 16, ± 27 and ± 28 $j.kg^{-1}.°C^{-1}$, respectively.

Conditioning of air for cooling of sugar and creation of optimum conditions for its storage in warehouses. A. F. Zaborsin and A. Usmankulov. *Sakhar. Prom.*, 1983, (3), 30-32 *(Russian).* — The authors point to the difficulties of bringing the temperature of sugar down to the level required for storage during the hot time of the year, when the air intended for dryer/coolers has a temperature of at least 25°C, instead of a required 15-17°C. A number of recommendations are made on ways of overcoming the problem, and an air cooling and drying system is described.

Analysis of the process of massecuite centrifugalling in a thin layer. V. I. Pugachev. *Izv. Vuzov, Pishch. Tekh.*, 1983, (1) 55-60 *(Russian).* — The massecuite spinning process in the conical basket of a continuous centrifugal was investigated. On the basis of the physical factors and the fundamental laws of filtration, a mathematical model has been developed which combines the basic technological parameters of the massecuite and the design parameters of the centrifugal with performance and throughput.

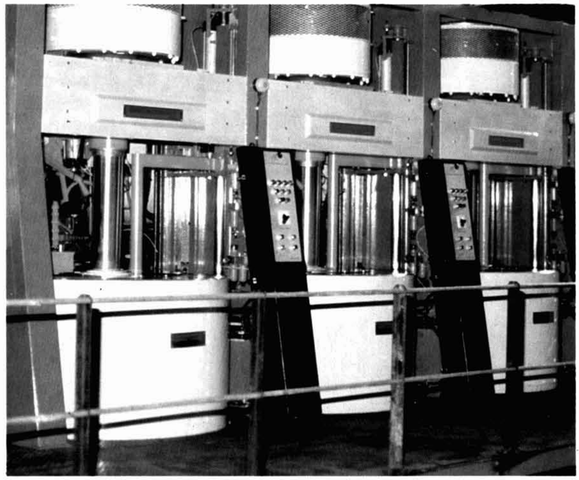
The transfer of high-molecular compounds from beet cossettes in the diffusion process. S. P. Olyanskaya, L. I. Zagorodnyaya and P. P. Zagorodnii. *Izv. Vuzov, Pishch. Tekh.*, 1983, (1), 93-95 *(Russian).* — From laboratory studies of the diffusion process, an equation was derived for calculation of the quantities of high-molecular impurities that are extracted together with sugar from cossettes as a function of pH, temperature and residence time. Fit of the equation to actual factory diffusion was confirmed, but only under optimum conditions, since normally there was too much disruption to the process pattern to permit evaluation.

Contribution to a study of pulp pressing. J. C. Giorgi, R. Gontier and G. Rousseau. *Sucr. Franç.*, 1983, **124**, 123-127 *(French).* — Investigations were conducted on the effect of pH, temperature and additives on the moisture content reduction in pressed pulp. Results showed that temperature had a major effect, whereby a fall from 74° to 69°C caused a fall in moisture content by 1.5 units, while a 1 unit reduction in pH from 5.5 to 4.5 caused a drop in moisture by at least 1 unit. Addition of 750 $g.tonne^{-1}$ beet of $CaSO_4$ also contributed to a drier pulp. The fate of ions added to diffusion water was also studied. About 80% of added Ca^{++} was found in the pulp, 80% of the K^+ in the juice, while one-third of added sulphate was found in the pulp and the rest in the juice; of this, 60% was precipitated during juice purification, but the amount remaining in the juice was still greater than the amount introduced by the beets.

New applications of the Cheops process for optimum control of process stations. G. Windal, F. Boom and A. Deleurence. *Sucr. Franç.*, 1983, **124**, 143-147 *(French).* — Details are given of the Cheops computerized system of boiling control as applied to 1st massecuite boiling and to continuous low-grade boiling at Cambrai sugar factory. The continous pan is divided into 16 compartments and is provided with vacuum and pressure controls as well as four conductivity control lines. The flow of standard liquor is a function of steam pressure, values of which (regulated by computer) are fed to the liquor holding tanks. The pan has operated satisfactorily, sometimes with no variation in the evaporation conditions whatsoever over periods exceeding 24 hours. Some information is given on the Macsym computer, which incorporates a 16 bits microprocessor; the program is written in BASIC language. Adaptation to the five 1st massecuite pans has been rapid, permitting complete automatic control within one week of installation. Computerized control of partial prescalding of cossettes based on the "cold spot" system described earlier[1] has been applied at Maizy sugar factory; the computer monitors the performance of the belt conveyor type of heat exchanger developed by Extraction De Smet S.A. The Solar 16-40 system is housed in the laboratory some 100 m from the heat exchanger and is linked to a slave unit at the prescalder. Information is available on a VDU. Mention is made of a number of teething problems that have been solved.

The structure of filter cake and its settling and filtration properties. I. F. Bugaenko and E. P. Ishina. *Sakhar. Prom.*, 1983, (4), 41-42 *(Russian).* — It is suggested that aggregates in prelimed juice are formed as a result of the negative charge of the albumins and pectins (attributed to their carboxyl groups) and the positive charge of the Ca^{++} ions in the $CaCO_3$ particles; this mechanism provides an explanation of the beneficial effect on settling and filtration of recycled unfiltered 1st carbonatation juice or mud. The carbonate particles in the recycled material are of a greater density than the high polymers and thus impart greater "rigidity" and density to the aggregates; the greater the number of carbonate particles forming aggregates with the polymers, the better will be the mud structure—this explains the positive results of recycling 2nd carbonatation mud.

[1] Ducatillon & Gontier: *I.S.J.*, 1983, **85**, 215.



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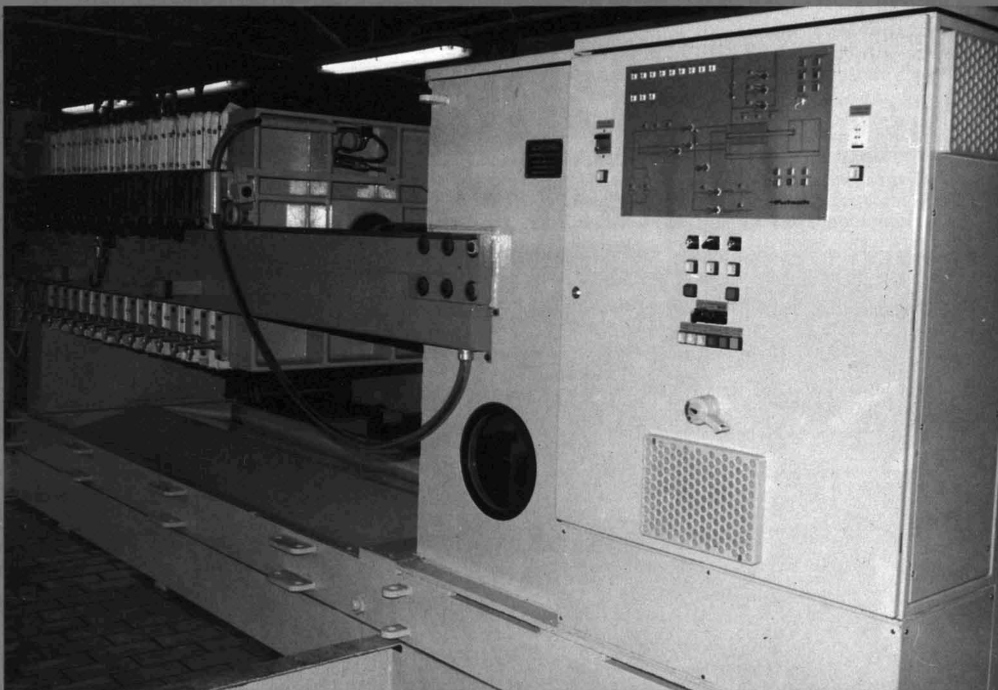

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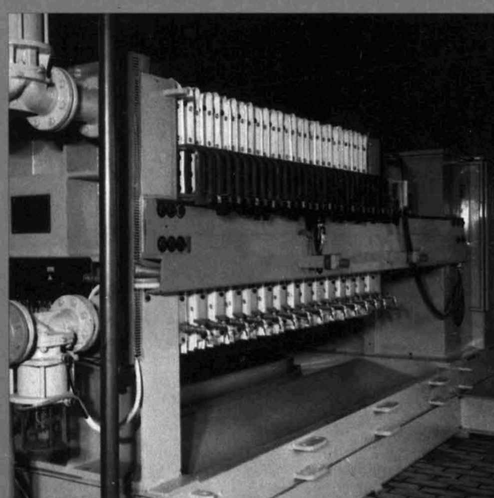

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LABORATORY STUDIES

Determination of the invert sugar content in sugar factory juice. H. Gruszecka. *Prace Inst. Lab. Badaw. Przem. Spozyw.*, 1980, **33**, 129-142; through *S.I.A.*, 1983, **45**, Abs. 83-112. — Two methods for the determination of reducing sugars in beet factory juices were developed. A redox reaction with cupric sulphate in alkaline solution was carried out, and the colloidal Cu_2O produced was removed by centrifuging. Excess copper in the resulting clear solution was determined either by photocolorimetry or by spectrophotometry. Values obtained by the two methods are compared.

Quality evaluation of cane raw sugar. E. Gutknecht. *Lebensmittelind.*, 1983, **30**, 83-86 *(German)*. — The author complains that East Germany has no system of quality control for imported cane raw sugar, and discusses the various criteria developed by ICUMSA and in the USA for establishment of the refining quality of cane sugar. Guidelines for determination of sucrose, water, crystal size, osmophilic yeasts, ash, colour, filtrability, reducing matter and temperature are set out; they are based on systems described in the literature, and it is stressed that they would have to be altered periodically. Mention is made of the advantage enjoyed by East Germany of importing cane raw sugar from only one country (Cuba). Reference is made to investigations conducted by Camara[1] on a number of imported cane raw sugar samples. The results are given for affined and unaffined sugar and show how, because of poor storage properties, some of the quality parameters were inadequate for efficient processing; the ash content, colour and crystal quality of the affined samples were particularly inadequate. Inexplicable fluctuations occurred in some cases.

Rapid HPLC methods for separation and quantitation of a mono-, di- and tri-saccharide mixture and applications. H. M. Ghernati, K. Abdeddaim and M. H. Guermouche. *J. Liq. Chromatogr.*, 1982, **5**, (9), 1725-1748; through *Anal. Abs.*, 1983, **44**, 3F27. — Mono-, di- and trisaccharides were separated on a column (30 cm x 3.9 mm) of μBondapak NH_2, with aqueous 80 to 90% acetonitrile containing 0 or 1% of acetic acid as mobile phase in both isocratic and gradient modes. Detection was by differential refractometry. Down to 4 μg of individual sugars could be determined.

Polysaccharides as sucrose crystal habit modifiers. I. Influence on crystal *c*-axis elongation. J. A. Cremata, F. Cumuná and L. Cordero. *Paper presented to the 18th Congr. ISSCT*, 1983, 22 pp. — It was found that, during the interval between cane cutting and milling, a large quantity of low-molecular weight polysaccharide was accumulated (particularly in chopped burnt cane), while the dextran level increased with time. Both affected sucrose crystallization; dextran increased massecuite and molasses viscosities and reduced the crystallization rate, while the polysaccharide fraction caused elongation of the *c*-axis of the sucrose crystal, as confirmed in model systems. Results of experiments suggested that other impurities, perhaps of the oligosaccharide type, could also induce *c*-axis elongation.

Polysaccharides in diffusion juice from non-limed and limed cane. Y. Nakasone. *Paper presented to the 18th Congr. ISSCT*, 1983, 21 pp. — Experiments were conducted on isolation of polysaccharides from deionized diffusion juice using alcohol extraction; separation was made by paper and liquid chromatography, while the two fractions (out of three) found to contain glucose were subjected to sub-fractionation on a DEAE-cellulose column. Juice obtained from cane that had been treated with lime to pH 6.7 before diffusion yielded the same glucans as untreated juice (of pH 5.5) but in higher quantities, while a newly formed glucan of high molecular weight was attributed to the cold lime treatment and consequent microbial contamination. Both juices contained various hemicelluloses.

Non-sugars and their influence upon the sucrose crystal habit. J. Hormaza M., B. E. Martín R., E. L. Ramos S., A. León G. and M. Díaz R. *Paper presented to the 18th Congr. ISSCT*, 1983, 29 pp. — A study on the effect of non-sugars on the sucrose crystal has shown that oligosaccharides produced by microbial action are the compounds having major effect on the crystal habit (elongation along the *c*-axis), while polysaccharides had no significant effect, irrespective of their molecular weight. The investigations were conducted on pure sucrose solution and *B*-massecuite.

The preliminary study of free amino-acids in green tops of sugar cane. T. T. Yang, K. M. Huang and W. H. Yu. *Paper presented to the 18th Congr. ISSCT*, 1983, 17 pp. Amino-acids in the green tops of F 160 cane were determined by paper chromatography. Details are given of the 29 compounds identified; seven unidentified ninhydrin-positive compounds were also revealed. By far the highest content in stalk juice and sheath was that of asparagine, while glutamine was the most dominant in the leaf, followed closely by alanine and glutamic acid. The high content of free amino-acids and other nutrients suggests the possibility of using green tops for yeast and beverage production; asparagine and glutamine may play an important role in the translocation and storage of cane nitrogen.

The analysis of dextran in sugar production. E. J. Roberts, M. A. Clarke and M. A. Godshall. *Paper presented to the 18th Congr. ISSCT*, 1983, 22 pp. — See *I.S.J.*, 1983, **85**, 10-13.

The effect of temperature on the kinetics of electro-retention of colouring matter from aqueous solutions of sucrose. M. P. Kupchik, I. G. Bazhal, L. G. Vorona and L. D. Bobrovnik. *Izv. Vuzov, Pishch. Tekh.*, 1983, (1), 35-38 *(Russian)*. — The effects of sucrose concentration (0, 30, 40 and 65%) and temperature (20, 50 and 90°C) on the kinetics of colouring matter removal from aqueous solutions by electro-filtration[2] were investigated. Results showed that retention of the impurities on the granules of the filter bed under the effect of interaction between the impurity particles and the granules in an electric field decreased with temperatures rise at up to 40% concentration but increased with temperature rise at the higher concentration.

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1 Thesis (Humboldt University, Berlin), 1982.
2 Bazhal *et al.*: *I.S.J.*, 1982, **84**, 26.

BY-PRODUCTS

Utilization of press mud – status of information. O. P. Vimal and S. P. Kale. *Indian Sugar,* 1982, **32,** 457-461. The literature on filter cake utilization is surveyed (61 references), covering its use as a fertilizer and soil conditioner, as raw material for cane wax recovery, and as a binder for use in the building industry.

An emulsifying agent suitable for elaboration of sugar cane wax emulsions for vegetables, citrus fruits and others. J. A. Rodriguez V. *Paper presented to the 18th Congr. ISSCT,* 1983, 14 pp. – A cane wax emulsion was prepared by melting the wax or wax plus rosin and adding sodium soap chips (obtained from toilet soap manufacture) during continuous stirring; once the wax was dissolved, hot water was slowly added, followed by preservative, and the emulsion then homogenized and filtered. The emulsion was successfully used to wax citrus fruits.

Clarifier mud – possible source of acetic acid. W. A. Mellowes. *Paper presented to the 18th Congr. ISSCT,* 1983, 17 pp. – The feasibility of producing vinegar from clarifier mud was investigated. Two methods were tested: (1) sterilization of the mud followed by fermentation and then solids separation, and (2) sugars separation followed by fermentation. Method (1) proved unsuitable because of excessive energy requirements and poor yeast dispersion, while method (2), possibly using a settling process, gave a yield of 175 ml of vinegar of 7% strength from 1 kg of mud diluted with 1.12 litres of water.

A pilot plant test of L-lysine fermentation with cane molasses. Y. T. Liu and S. L. Sang. *Paper presented to the 18th Congr. ISSCT,* 1983, 28 pp. – Larger-scale pilot plant trials of the fermentation process earlier tested on a smaller scale[1,2] are reported. Descriptions are given of the equipment, which included a 5000-litre fermenter and two types of agitator. From determination of the effects of agitator speed and aeration ratio on fermentation, it was concluded that the process must be operated under highly aerobic conditions; yield increased considerably with increase in agitator speed up to 250 rpm and with increase in aeration ratio up to 0.5 v/v, although maximum yield (32.54% on total sugar) was obtained at 300 rpm and 0.5 v/v aeration ratio. Of three feed methods tested with use of a turbine disc as agitator, feeding with constant amounts of molasses and nutrients at 4-hour intervals proved more satisfactory than feeding with molasses alone or with molasses and nutrients where the amounts of the molasses were doubled in the last three feeds (made every two hours).

Consideration of the production of SCP as human food. R. Gómez, I. Valdés, M. Klibansky, M. A. Otero and O. Almazán. *Paper presented to the 18th Congr. ISSCT,* 1983, 16 pp. –Trials are reported on single-cell protein manufacture from cane molasses using various yeasts. Best performances were given by *Kluyveromyces fragilis* 1930, *Candida pseudotropicalis* C-23 and *Saccharomyces cerevisiae* D. Details are given of yields, reduction of the ribonucleic acid content (approximately 80% with high protein and amino-acid recoveries) and biomass losses. Some modifications to the industrial process as conceived for Cuban conditions are suggested.

Bagasse biological degradation using ***Sporotrichum pulverulentum.*** I. Gutiérrez, N. Fernández, I. Goire, O. Sardiñas, N. Romero and J. Carlos R. *Paper presented to the 18th Congr. ISSCT,* 1983, 23 pp. – A study on bagasse delignification by *S. pulverulentum* as an aid in mechanical pulp manufacture is reported. Use of native strains of the fungus from Sweden permitted 38% lignin degradation (corresponding to 3% delignification). Nitrogen had a marked adverse effect on the lignolytic activity and therefore should be present in only a minimum quantity. Mycelium brought about a higher yield loss and degraded cellulose without affecting the lignin by comparison with the use of spores. The optimum temperature for lignin degradation was 30°C. Yields achieved were of the order of 80-83% at a loss of 16% carbohydrate. The results compare with yields of 80-85% and a lignin reduction of 3-4% obtained in the cold soda pulping process.

Experimental evaluation of bagasse storage in bale systems. J. Lois and R. Suárez. *Paper presented to the 18th Congr. ISSCT,* 1983, 31 pp. – The influence of storage time on bagasse temperature, moisture content, granulometry, morphology (with and without mechanical treatment), chemical analysis and solubility in hot water, NaOH and alcohol was investigated in the case of wet-baled raw bagasse, wet-baled depithed bagasse and pre-dried, depithed bagasse. Results showed that both wet-baled bagasses suffered greater deterioration than the pre-dried bagasse, but no conclusions could be drawn on the effect of storage time (for a number of stated reasons). The brightness of the wet-baled bagasse was seriously affected, whereas that of the pre-dried bagasse was not significantly affected by storage.

Research experience in papermaking for sugar cane bagasse. R. Molina, A. Abril, A. Hernández, L. Rodríguez and C. Aguero. *Paper presented to the 18th Congr. ISSCT,* 1983, 15 pp. – A short review is presented of research conducted by ICIDCA in Cuba on bagasse paper manufacture, covering: the fundamental properties of bagasse pulp, its properties relative to paper manufacture, the blending of bagasse and wood pulps, pulp treatment according to paper quality requirements, the effect of pulp fines on paper quality, improvement in the strength properties of bagasse paper, and the use of "control" additives such as anti-foam agents and aids to retention and drainage in the papermaking process. (Illustrations and tables that should have accompanied the article have been inadvertently omitted.)

Bagasse newsprint – has it arrived: Past history, present status and future possibilities. J. E. Atchison. *Paper presented to the 18th Congr. ISSCT,* 1983, 55 pp. – The history of efforts to manufacture newsprint from bagasse since 1856 is outlined. While there have been countless failures, with full-scale projects launched without the proper approach, i.e. without the required preliminary pilot plant and trial runs, so producing only a type of newsprint that would not be acceptable on the world market, ICIDCA in Cuba has adopted a more

1 Liu: *I.S.J.,* 1981, **83,** 27.
2 Liu & Sang: *ibid.,* 251.

cautious, planned approach and has established a pilot plant as well as a demonstration plant for purposes of optimizing the technology for bagasse newsprint manufacture. Various processes developed for newsprint production with and without use of mechanical pulp are discussed, and the importance of mechanical pulp is stressed. On the basis of results obtained to date, prospects of successful bagasse newsprint manufacture in the future are examined, and observations made on the type of mill likely to be built for the purpose and on the importance of sound bagasse newsprint technology for developing countries.

Carboxymethyl cellulose production from bagasse paper and dissolving pulps. S. Ashkienasi C and C. J. Triana F. *Paper presented to the 18th Congr. ISSCT,* 1983, 22 pp. Trials are reported on the manufacture of carboxymethyl cellulose from bagasse paper pulps and dissolving pulps of various qualities. Results demonstrated the feasibility of manufacturing CMC from bagasse pulp in Cuba and thus permitting substantial savings in hard currency.

Production of methane gas from stillage on a commercial scale in India. P. J. M. Rao. *Paper presented to the 18th Congr. ISSCT,* 1983, 18 pp. — Information is given on distillery waste treatment by anaerobic digestion at K.C.P. Ltd. in India. The process reduces the BOD of the vinasse by about 90% (from an initial 30-35,000 ppm) and provides some 18 m^3 of gas per kilolitre of vinasse. The gas has a calorific value of about 4500 $kcal.m^{-3}$, and it is estimated that treatment of all the vinasse from the distillery would provide sufficient boiler fuel to replace about 10 tonnes of coal per day, or about half of the total consumption.

A study on the production of biogas from filter press mud. A. Guillermo N. and M. S. Leal S. *Paper presented to the 18th Congr. ISSCT,* 1983, 20 pp. — Laboratory trials on anaerobic treatment of filter cake are reported. Results showed that biogas yields from fresh cake were far superior to those from cake that had been stored for 4-6 months. Maximum yield of 142% on dry material was obtained at 37°C (compared with 21-28°C), a cake dry solids content of 10% (compared with 8%), a 3% pith content (compared with no pith), and with addition of 5 $g.litre^{-1}$ lime (compared with no lime addition).

A scheme for improved ethanol recovery in distillery practice. B. A. Baliga, A. K. Srivastava and N. G. Karanth. *Maharashtra Sugar,* 1983, **8**, (3) 29-30. — The conventional process used in India for ethanol manufacture from molasses involves the use of open fermentation vessels. While the reasons given are that collection of CO_2 and its utilization are not feasible, and the cleaning, maintenance and contamination of open vessels are reduced by comparison with closed vessels, it is admitted that ethanol is lost (estimated to be 0.9% of the total production) by entrainment in the vapour along with CO_2. Laboratory experiments are described in which ethanol losses were reduced by passing the fermenter vapours through an absorber; for this, a lid has to be installed on the fermenter. The economics of the scheme are indicated.

The development of by-products from sugar cane in Cuba. H. Noa S. *Sugar y Azúcar,* 1983, **78**, (2), 126-130. An account is given of cane by-products utilization in Cuba, covering bagasse, molasses and filter cake; cane tops and leaf trash are mainly used as animal fodder. A list is presented of bagasse board factories, bagasse pulp and paper mills, distilleries and rum plants, and yeast plants in Cuba. By-products research and development work is also outlined.

Alcoholic fermentation process control by high-performance liquid chromatography. J. Morawski, A. K. Dincer and K. Ivie. *Sugar y Azúcar,* 1983, **78**, (2), 170-172, 174, 177. — Alcohol fermentation processes are outlined where HPLC is of potential value as a means of monitoring e.g. hydrolysis, distillation efficiency and fermentation kinetics.

The causticizing and lime recovery systems of a new bleached bagasse pulp factory with the sulphate process. H. Y. Tao. *Taiwan Sugar,* 1982, **29**, 201-210. — Details are given of the equipment and processes used in the IHI causticizing and lime recovery systems of a bleached bagasse pulp factory designed and manufactured by Kawasaki Heavy Industries Ltd. for Taiwan. Comparison of average performance data for 1 month's operation with rated performance data show that the systems operated at a high efficiency without any major problem. Installation of a flue gas dryer for filtered lime mud is the only modification considered necessary, while yet further improvements are expected to come about with the use of precise chemical control and control of such parameters as flow, level and temperature.

Final molasses levels in poultry manure supplementation for yearlings fed forage. M. Nuñez, A. Delgado and I. Córdova. *Cuban J. Agric. Sci.,* 1982, **16**, 257-262. In trials in which young bulls were fed on rations containing 1.5 kg/day poultry manure (as protein source) plus varying quantities of molasses:urea mixture and forage *ad libitum,* the liveweight gains failed to respond to the molasses:urea component; this is attributed to the energy contributed by the poultry manure and particularly the slower degradation of uric acid than of urea, a factor that is beneficial to the rumen.

Yeast growing on sugar cane pith hydrolytic molasses for broilers. M. Valdivié and O. Fundora. *Cuban J. Agric. Sci.,* 1982, **16**, 263-266. — Yeast grown on "molasses" obtained by hydrolysis of cane pith was found in chicken feeding trials to be as effective in terms of bird performance (including weight gain) as yeast grown on final molasses. The yeast grown on the "hydrolytic molasses" had a lower protein content than torula yeast (38 and 45%, respectively), which is attributed to a higher ash content in the former yeast.

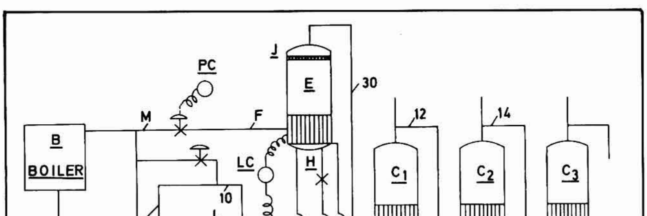
Pressed pulp — an alternative to pulp drying. Effect of temperature and additives on ensilage results. J. Beckhoff and C. Heller. *Zuckerind.,* 1983, **108**, 213-217 *(German).* While pressed pulp of 20-23% dry solids content has proved valuable as animal fodder, it suffers from the disadvantage of poor keeping qualities. Drying, on the other hand, consumes much energy, so that the only alternative is ensilage. Results of investigations have shown that optimum conditions are an initial temperature of at least 45°C and a temperature reduction of about 1°C per day. The size of silo is governed by agronomic factors. Additives are of no benefit where the pulp is ensiled hot, but addition of molasses or molasses mixtures to the pulp before ensilage favours the process; the molasses sugar contributes to increased lactic acid formation. Cold pulp can be stored only when additives are used; best and cheapest are small beet fragments, which occur in any factory, although molasses or molasses mixtures will also promote ensilage of cold pulp.

PATENTS

UNITED KINGDOM

Thermal power plant. British Sugar Corporation Ltd., of Peterborough, England. **2,041,098.** January 31, 1979; September 3, 1980; October 27, 1982.

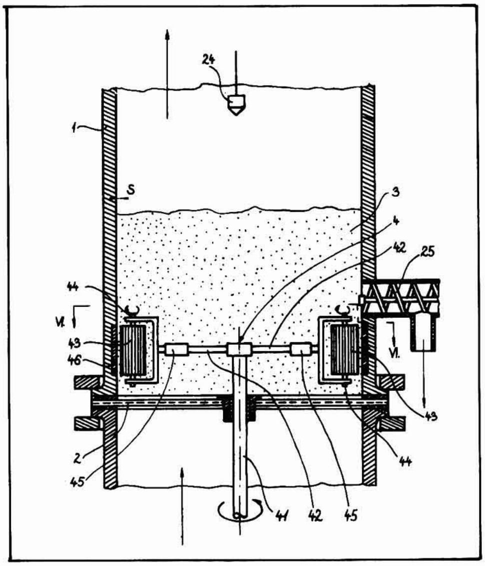
The boiler B generates steam for driving a back-pressure turbine A. The steam exhaust from the turbine A passes along line 10 to the calandria of the first stage C_1 of a multiple effect evaporator. Condensate from the first stage C_1 is recycled to the boiler B through collectors D_1 and Ds. Distillate from the first stage C_1 passes through a line 12 to the calandria of a second stage C_2 of the evaporator. Condensate from the second stage C_2 (which contains impurities from the liquid being evaporated) passes to a collector D_2. Distillate from the second stage C_2 similarly passes through a line 14 to the calandria of third stage C_3, and condensate to a collector D_3 at a lower pressure than the collector D_2. The collectors D_2 and D_3 are connected in series so that, when the levels of their contents permit, the distillate passes from D_3 to D_2. Distillate is pumped from the collector D_2 by a line 40 and level control valve G to a still E. If necessary, chemical dosage is added via valve L and line 40.



The still E is heated by steam direct from the boiler B through a line F, pressure controlled at PC by a valve M. Throughput of the still E is controlled by varying the steam pressure supplied to it. The still E is provided with an entrainment preventer J and feeds distillate through a line 30 and the line 10 as make-up into the first stage C_1 of the evaporator. Condensate from the still E is passed through a line 32 to the collector Ds, while blowdown H is passed to the collector D_3. Surplus from the collector Ds is passed to a storage tank K where it is useful for starting-up or shutting-down operations in the event of breakdown.

Fluidized bed dryer. MTA Muszaki Kemiai Kutato Intezet, of Viszprem, Hungary. **2,046,121.** February 28, 1980; November 12, 1980.

The vertical cylindrical chamber 1 includes an air distributor 2 supporting a bed of material, e.g. sugar, fluidized by heated air delivered upwards from below distributor 2. Exhausted air passes through a cyclone, from which separated sugar is returned to the bed, and



a wet deduster which produces a solution of sugar which is mixed with the syrup feed sprayed onto the bed through nozzle 24. The water content of the syrup is evaporated and the sugar deposited on the particles forming the upper surface of the bed.

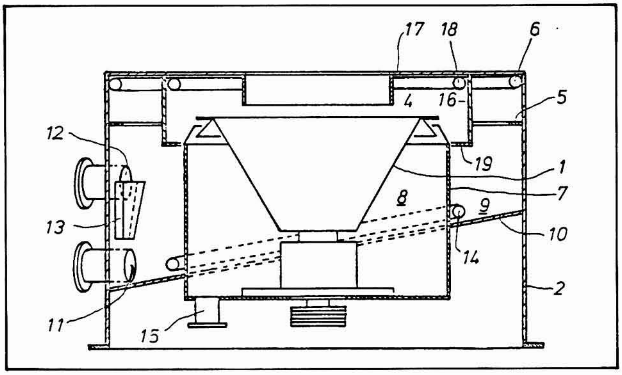
Larger particles sink in the bed and are trapped by rollers 43 symmetrically mounted on shafts 44 carried by brackets on arms 42 extending from the rotating shaft 41 which may also carry a mixer in the form of guide blades which direct the larger particles towards the rollers. The rollers are spaced a distance S from a preferably knurled anvil plate 46 on the lower inside wall of the chamber 1, just above air distributor 2 and the larger particles are reduced in size to the desired maximum S by passage through the slit formed between rollers 43 and plate 46. To avoid accidental damage to the roller mechanism a flexible section 45 of arms 42 allows the clearance to exceed S. Sugar having a controlled particle size is withdrawn from chamber 1 through the scroll conveyor 25.

Continuous centrifugal. Hein, Lehmann AG, of Düsseldorf, Germany. **2,046,610.** March 17, 1980; November 19, 1980.

Massecuite fed into the centrifugal is separated into

Copies of specifications of United Kingdom patents can be obtained on application to The Patent Office Sale Branch, Block C, Station Square House, St. Mary Cray, Orpington, Kent, England (price £1.45 each). United States patent specifications are obtainable from: The Commissioner of Patents, Washington, D.C., USA 20231 (price 50 cents each).

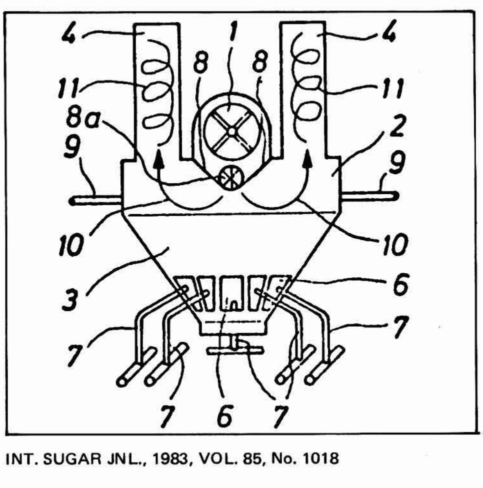
mother liquor, which passes through the basket into chamber 8 and so out of the machine through port 15, and sugar which travels a short distance beyond the circumference of the upper part of the cone and is intercepted by annular baffle 16 mounted on the cover 17. Substantial crystal damage takes place, facilitating dissolving of the sugar in liquid provided through perforations in the annular pipe 18. The sugar and syrup mixture produced runs over the edge of baffle ring 19 and into compartment 9. Solution is completed by the action of the annular heater 14 and the syrup discharges through port 12.



When the centrifugal is to be used to prepare a magma rather than a syrup, crystal breakage on discharge from the conical basket is to be avoided, and the baffle 16 and ring 19 are removed from cover 17. Discharged sugar is then intercepted by the inner wall of the casing above baffle ring 5 but is not damaged because of the loss of kinetic energy in its further travel. Liquid is supplied through perforations in annular pipe 6 at such a rate as to provide a magma which passes over ring 5 into chamber 9 and down the sloping bottom 10 to be discharged through port 11.

Caster sugar manufacture. A. von Bennigsen-Mackiewicz and C. von Bennigsen-Mackiewicz, of Banteln, Germany. **2,048,938.** June 27, 1979; December 17, 1980.

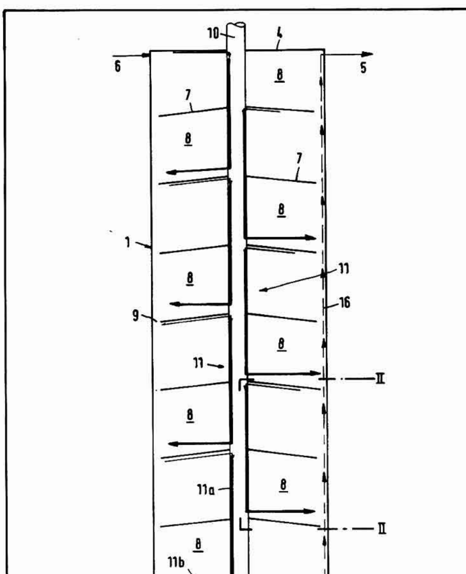
Caster sugar is manufactured by the action of a hammer mill 1 on a supply of granulated sugar. The mill is mounted above a container 2 having a conical or prismoidal lower section 3 provided with fluidization surfaces 6 to which air is admitted through pipes 7.



The inflow of air carries sugar particles in suspension into the filters 4, aided by additional air supplied through pipes 9; they follow the path indicated at 11 but are trapped by a filter material. At intervals the air flow is stopped and the sugar falls into container 3, from which it is discharged through a bottom port. There may be more than one such unit mounted side by side or one on top of another whereby the sugar is doubly treated.

Juice prelimer. Selwig & Lange Maschinenfabrik, of Braunschweig, German. **2,049,724.** June 13, 1979; December 31, 1980; October 20, 1982.

The preliming tank is in the form of a cylinder 1 into the conical bottom 2 of which raw juice is admitted through entry 3. The cylinder is provided with a cover 4 under which is an entry 6 for milk-of-lime and an overflow 5 for limed juice. Within the cylinder is a rotating shaft 10 driven by a motor (not shown) and carrying a series of slightly conical baffles 7 which separate the cylinder into compartments 8. Perforations in the baffles allow juice to flow upwards from one compartment to the next.

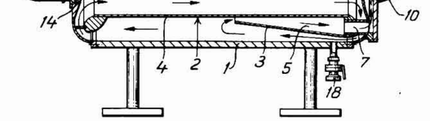


Mounted on the shaft are a number of pipe sections 11 which extend vertically downward (11a) and then radially outward (11b). The upper end of each vertical pipe 11a is belled outwards while an adjustable stopper controls the size of cross-section of the opening into the pipe. As shaft 10 rotates, centrifugal force sends the contents of pipe 11b into the appropriate compartment 8, drawing into pipe 11a juice from the compartment 8 above and so providing a partial reverse-flow of juice within the cylinder.

Preparation of sucrose mono- and di-esters. Tate & Lyle Ltd., of London, England. **2,052,492.** May 27, 1980; January 28, 1981. – Succrose is reacted (at 70°-90°C) with [< 2 moles (0.9-1.5 moles) of] an alkenyl ester (a vinyl or isopropenyl ester) of a long-chain fatty acid in a polar aprotic solvent [a fully substituted amide such as a N,N-dialkyl formamide, a N,N-dialkyl acetamide, or a N-alkyl azacycloalkanone (dimethyl formamide or N-methyl pyrrolidone)] in substantially water-free conditions and in the absence of an acid catalyst [but in the presence of less than 2% (< 0.7%)(< 0.2%) by weight of a basic catalyst such as an alkali metal salt of a weak acid (K_2CO_3)].

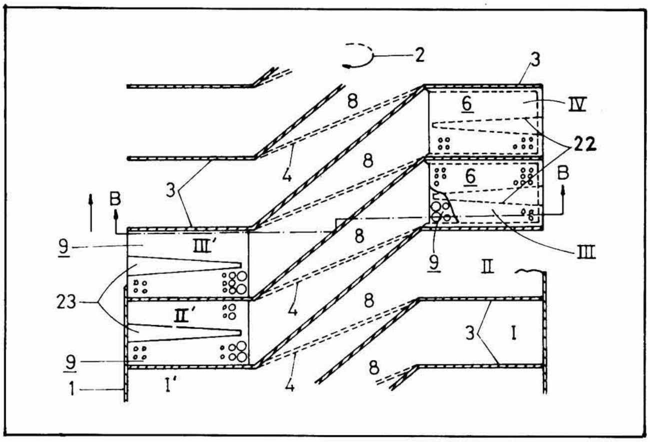
Loop reactor for dissolving sugar. H. Burgert, of Giessen, Germany. **2,055,050.** June 12, 1980; February 25, 1981.

The reactor comprises a cylindrical vessel 1 within which is a tubular section 2 having a main wall 4 and a concentric double wall 3 forming a compartment 5 having a small annular inlet 6. Compartment 5 communicates by way of pipes 7 with the outflow pipe 10 and material entering this pipe is sucked along pipe 12 by pump 11, into conduit 13 and so to nozzle 14 which delivers into the tubular section 2 at the other end from outflow pipe 10.



Solid material such as sugar is fed into pipe 8 which delivers into the top of the vessel, and dissolving liquid such as water is admitted through pipe 9. The mixture follows the directions of the arrows, and is recirculated by the pump 11 while it is withdrawn from conduit 13 through pipe 15 and valve 16, the latter operated by the level control 17 in pipe 8 so that the rate of removal matches the rate of feeding. A drain cock 18 is provided for emptying the vessel.

Beet diffuser. Soc. Sucrière d'Etudes et de Conseils S.A., of Tirlemont, Belgium, and Fives-Cail Babcock, of Paris, France. **2,055,611.** July 16, 1979; March 11, 1981; November 3, 1982.



The diffuser is in the form of a drum 1 divided into compartments formed by a conveying screw. This is constituted by a succession of diametral solid portions 3 connected by inclined solid partitions 4. The compartments are subdivided into two series of cells I, I', II, II', etc., by lifting elements formed above perforated plates 6 which are conected in twos by a solid wall. Two series of inclined passages 8 are provided in the central zone of drum 1 to direct the fractions of solid materials, e.g. beet cossettes, lifted by the plates 6 so that they pass into a cell of the same series spaced at the distance of two cells in the direction opposite to that of the conveying effect of the screw. The liquid separating from the fractions of solid materials in the compartments flows into the cell of the other series of cells immediately upstream of the original, mixing with a new solids fraction with which it travels until these new solids are lifted out by a plate 6 on rotation of the drum.

In order to provide better mixing of the liquid with new solids, a completely or partly perforated plate 9 is provided before the entrance of each cell, with an aperture 22 to the edges of which are fastened the bottom edges of a hollow perforated projecting guide element 23. The juice draining into the cell falls on this element and the majority is deflected by its inclined surfaces so that it flows into the solids in a direction substantially parallel to the axis of the drum. U-shaped baffles may also be fitted to adjacent partitions 3 in order to bring about variations in flow speed by restriction of the cross-sections of passage, thus also improving mixing and sugar extraction.

Spanish HFCS imports and consumption[1]. – The Spanish sugar industry is being threatened by the increasing usage of high fructose corn syrup. Sugar is increasingly being replaced by this product for the manufacture of cola drinks and new outlets are being found for HFCS preparations. Spanish sugar experts say that imports into Spain in 1982 amounted to 190,000 tonnes. As yet, the government has not taken any steps to control the imports, but these can be expected in the future as the new socialist government has promised to create 800,000 new jobs during its four-year mandate. Since sugar beet cultivation is very labour-intensive in Spain, it is to be expected that the government will protect the domestic sugar industry.

[1] F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 330.

Philippines sugar exports, 1982[1]

	1982	1981
	tonnes, raw value	
Algeria	20,685	0
China	198,776	92,719
Hong Kong	4,468	0
India	0	8,648
Indonesia	86,321	217,583
Iran	0	14,428
Iraq	75,725	23,050
Japan	315,102	121,227
Korea, South	98,725	157,519
Malaysia	15,413	19,899
Mexico	13,696	0
Morocco	0	26,930
Portugal	0	22,059
Saudi Arabia	0	15,033
Sri Lanka	39,988	33,104
USA	222,893	188,558
USSR	209,306	336,836
	1,301,098	1,277,593

Barbados sugar crop decline[2]. — Industry sources in Barbados have said that the 1982/83 season, which ended in July, has not reached the production target of 90,000 tonnes and is probably below the 80,550 tonnes produced in 1981/82. This figure was itself the lowest for 34 years and compared with 96,000 tonnes in 1980/81 and 135,000 tonnes in 1979/80. The bad 1982/83 result is attributed to illegal burning of the cane plantations. Export availability from the 1982/83 crop will be 70,000 tonnes at best, against 121,000 tonnes from the 1979/80 crop; this former quantity will be exhausted by the 49,300 tonnes, white value (53,600 tonnes, raw value) quota for delivery to the EEC and the 19,600 short tons (17,800 tonnes) quota for delivery to the USA.

Egypt sugar expansion[3]. — The sugar beet area for the 1983/84 campaign has been enlarged to 8820 hectares, against 6033 ha for 1982/83, and sugar production is expected to rise from 18,572 tonnes, raw value, to about 35,000 tonnes. The cane area for 1983/84 has also been enlarged to 82,890 ha against 78,827 ha in 1982/83, representing an increase of 5.15%. The cane crop in 1982/83 amounted to 6.67 million tonnes and this is expected to rise to 7.27 million tonnes in 1983/84. Cane sugar production is expected to decline by about 2% compared with the previous season, however, because the 1983/84 cane crop has suffered from unusually cold weather during the growing season. Egypt has long intended to increase its production of sweeteners and, in addition to the introduction of a beet sugar industry a few years ago, it has commissioned the construction of a new factory to produce high fructose corn syrup, expected to enter into operation during the second half of 1984 and to produce some 96,000 tonnes of HFCS per year.

Record sugar production in Costa Rica[4]. — Sugar output in the 1982/83 season has hit a record high of 196,400 tonnes, tel quel, compared with 181,500 tonnes in the previous season. The previous record was 194,700 tonnes, produced in 1976/77. The record production will provide 58,000 tonnes available for export without having to import sugar for the domestic market. Costa Rica's quota for supply to the US was recently raised from 42,000 short tons, raw value, to 58,000 tons (52,000 tonnes).

Florida sugar production 1982/83[5]. — A record 1,306,647 short tons (1,185,390 tonnes) of raw sugar was produced during the 1982/83 season in Florida, making the state once again the top US producer. Almost 13 million tons (12 million tonnes) of cane, grown on 350,000 acres (142,000 hectares), was crushed. Excellent growing conditions were experienced during the summer and autumn of 1982 and no severe frosts occurred during the winter. Rain caused periodical factory shutdowns because cane could not be harvested and the crop was consequently extended to 171 days.

Finance for new Chinese sugar factories[6]. — China's Fujian province is reported to have been preparing a privately placed Yen Bond issue in Japan in August as the first Chinese province to float foreign bonds. The bonds, worth some 5000 million yen, with a 10-year maturity, will be used to raise funds chiefly for construction of sugar plant facilities.

Singapore sugar imports, 1982[7]

	1982	1981
	tonnes, tel quel	
Australia	96,774	101,984
China	1,973	303
Fiji	14,250	25,500
Hong Kong	123	107
Japan	1,086	445
Korea, South	983	447
Malaysia	1,685	995
Other countries and adjustments	672	167
	117,546	129,948

Sugar from bagasse[8]. — Daiichi Seito, an Okinawa raw sugar producer, says it has developed a new method to extract sugar from bagasse. A company spokesman told Reuters that the company produced 427 tonnes of raw sugar from 4000 tonnes of bagasse during January/April. The new method uses a newly-developed centrifugal separator which uses 30% less electricity than an electrolytic dialyser, a machine developed by other Japanese firms for the same purpose, but not yet in commercial use, the spokesman said.

Polish sugar exports 1982[9]. — Calendar year exports of sugar from Poland totalled 163,000 tonnes, up substantially from the 13,000 tonnes exported in 1981, according to official data.

Morocco sugar production. — Morocco produces sugar from both beets and cane as well as possessing a small refinery. A drought in 1980/81 hampered development of both crops so that the rain-fed beet area fell to 11,475 ha from 20,847 ha in 1979/80[10] while the irrigated beet area rose from 42,655 ha to 44,671 ha. Yield in the rain-fed areas reached 27.03 tonnes/ha (against 23.10) and in the irrigated area was 40.39 tonnes/ha (against 40.12). The total beet crop of 2,114,681 tonnes yielded 308,913 tonnes of sugar, raw value. In apparent anticipation of the continuation of water problems in 1981/82 the irrigated area sown to beets was reduced to 35,646 ha although the rain-fed area sown recovered to 21,669 ha. The total crop increased to 2,313,559 tonnes of beet which yielded 337,673 tonnes of sugar, raw value. Preliminary figures for the 1982/83 crop show a total of 2,400,000 tonnes of beet grown on an area of 62,000 ha and yielding 350,000 tonnes of sugar. The area of cane harvested has risen from some 4000 ha in 1979/80 and 1980/81 to 7247 ha in 1981/82 and 7669 ha in 1982/83, while it is planned to raise this to 13,200 ha for 1983/84. The cane crushed has risen from 276,388 tonnes in 1979/80 to 354,301 tonnes the next season, 593,734 tonnes in 1981/82 but only 501,882 tonnes in 1982/83. The projected crop for 1983/84 is 710,000 tonnes. Sugar production from cane in 1979/80 was 26,790 tonnes, raw value, rising to 33,586 tonnes in 1980/81, 54,656 tonnes in 1981/82 and 52,194 tonnes in 1982/83, with 83,000 tonnes projected for 1983/84. Water shortage would appear to be the main reason why sugar production in Morocco, particularly from cane, has not been able to keep pace with domestic consumption. In addition the main beet growing areas of the Gharb and Tadla are at times subject to water rationing. As a consequence, there has been a continuing need to import sugar to the extent of 300,000 to 350,000 tonnes per annum for the past four years.

Pakistan cane crop reduction[11]. — Sugar cane production in Pakistan in the 1982/83 season has fallen by about 11% from 36 million tonnes harvested from an area of 946,700 hectares to 32 million tonnes from 889,500 ha. The average yield is thus down from 38.03 tonnes to 35.98 tonnes per hectare. The decrease in the crop is due primarily to low prices paid for cane intended for gur manufacture and difficulties for growers in disposal of their cane to sugar factories. Although khandsari prices have recovered, those for gur and white sugar have fallen and there are large stocks in the country so that prices are likely to remain low. There is very little chance of the sugar being exported.

1 *I.S.O. Stat. Bull.*, 1983, **42**, (2), 33.
2 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 332.
3 *World Sugar J.*, 1983, **5**, (12), 35.
4 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 332.
5 *Sugar y Azúcar*, 1983, **78**, (6), 6.
6 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 357.
7 C. Czarnikow Ltd., *Sugar Review*, 1983, (1641), 56.
8 *Amerop Newsletter*, 1983, (116), 17.
9 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 383.
10 *World Sugar J.*, 1983, **6**, (1), 21.
11 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 401.

Swaziland sugar exports, 1982[1]

	1982	1981	1980
	tonnes, raw value		
Canada	29,619	29,522	0
China	26,657	0	0
EEC	128,763	123,675	126,711
Finland	42,102	0	0
Indonesia	0	0	11,390
Malaysia	13,329	0	14,233
Morocco	15,868	0	29,491
Portugal	34,305	15,748	12,200
Sri Lanka	5,424	0	0
USA	42,508	175,947	111,815
USSR	0	0	10,702
Yemen, North	5,424	0	0
Other countries	108	0	3
	344,107	344,892	316,545

New membership of the ISA[2]. — Uruguay's application for membership of the International Sugar Agreement has been accepted by the Executive Committee and by the Council. Uruguay is now an Annex II member which means that it has no basic export quota but is allowed to export up to 70,000 tonnes annually. In recent years Uruguay's sugar production has been insufficient to provide for exports. An application by the Congo for membership has also been accepted; sugar production in the 1982/83 season exceeded domestic requirements so that sugar will be available for export, although in limited quantities.

New US HFCS plant[3]. — Cargill Inc. was to start construction of a $100 million corn wet milling plant at Eddyville, Iowa, this summer, the company announced. When completed in early 1985, the plant will be able to produce more than 300,000 short tons of HFCS, 100,000 tons of corn syrups and 75,000 tons of industrial and food-grade starches per year. It will use a nearby steam and power generating plant bought by Cargill in 1981.

Louisiana sugar cane crop improvements[4]. — Louisiana growers believe that with new cane varieties and improved cultural practices they can consistently grow 25 short tons of cane or more per acre and obtain 10% or better sugar recovery. In the 1970's, Louisiana growers obtained yields varying from 20 to 25 tons of cane per acre with an average sugar recovery of 8.5%, the lowest in the United States. However, cane yields were 26.9 tons in 1981/82 and 27.5 tons in 1982/83; sugar recovery was 10.7% in 1981/82 and 10.2% in 1982/83. A Louisiana cane crop near the 1982/83 area of 250,000 acres, with a yield of 25 tons/acre would produce 600,000 tons of sugar, raw value, after deducting for seed cane. This is under 1981/82's 712,000 tons and 1982/83's 645,000 tons but considerably more than the 491,000 tons of 1980/81.

Tongaat-Hulett Group Ltd. annual report, 1983. — Whilst the total South African sugar production in 1983 was the highest ever recorded, the Group's share was disappointing, owing to the poor quality and reduced quantity of cane from the seriously eldana borer-affected areas of North Coast Natal and Zululand, from the 1982/83 summer drought and the largest cane fire on record which burnt 73,000 tons of cane in the Maidstone area. In addition, work stoppages resulted in the deterioration of cut cane and consequent losses in the sugar factories. Total sugar production in the Sugar Division of Tongaat-Hulett was 859,706 tons (40.5% of the total) against 882,932 tons (43.0%) in 1982. Mill recoveries were higher than the average, Darnall having the highest and Maidstone the second highest of the industry's 17 factories. Hulett Refineries increased refined sugar output from 493,000 to 525,000 tons in order to produce for export on behalf of the South African Sugar Association. The first phase of the new sugar factory at Felixton is scheduled for commissioning in December 1983 after which the Empangeni factory will be closed. The second phase will begin and should be completed in 1984/85, when the existing mill at Felixton will be closed. Production at the Triangle factory in Zimbabwe amounted to 140,000 tons of sugar and 39,200,000 litres of ethanol but the returns were adversely affected by reduced world prices and talks are being held with the government on increases in domestic prices. Production in the coming season is expected to include about 180,000 tons of sugar and 40,000,000 litres of alcohol. Areas supplying the Group's factories in South Africa have been badly affected by drought and while the results for the next season cannot be predicted they will undoubtedly be poorer than in 1983.

Taiwan sugar exports, 1982[5]

	1982	1981	1980
	tonnes, raw value		
Hong Kong	11	3,385	678
Indonesia	0	0	13,153
Japan	130,349	89,275	156,864
Korea, South	127,736	163,929	202,363
Malaysia	0	0	12,455
Saudi Arabia	65,764	38,806	23,914
US	56,013	0	0
Other countries	463	477	423
	380,336	295,872	409,850

Bulk handling and storage conferences. — The Powder Advisory Centre, of P.O. Box 78, London NW11 0PG, is organizing a conference on the design of silos for strength and flow, to be held during November 7-9 at Stratford-upon-Avon, England, and a second, on pneumatic conveying technology, to be held during September 4-6, 1984 at the University of Kent in Canterbury, England.

Great Western sugar factories for sale[6]. — Great Western Sugar Company has offered to sell six of its twelve sugar factories to beet growers. The factories are located in Goodland, Kansas, and five Colorado locations of Fort Morgan, Greeley, Loveland, Ovid and Sterling. The six have been offered to the Mountain States Beet Growers Marketing Association of Colorado and Kansas, and represent about 20% of the company's total volume of sugar in the 1983 crop, according to B. W. Dyer & Co.

Pakistan sugar production, 1982/83. — The 36 sugar factories in Pakistan, with a total cane crushing capacity of 71,130 t.c.d., worked an average of 172 days in the 1982/83 season, some starting as early as the first week of September and some working until the first week of June. A total of 12,511,000 tonnes of cane was crushed, 14% less than in 1981/82, and 1,110,000 tonnes of white sugar was produced, against 1,269,000 tonnes last season, a drop of 12½%. Molasses production in 1982/83, at 533,800 tonnes, was 17.6% less than the previous season. The only note of increase was an improvement in recovery which rose from 8.68% in 1981/82 to 8.87% in the 1982/83 season.

Bangladesh sugar industry rehabilitation finance. — In July the World Bank announced that its affiliate, the International Development Association, had approved a US $28,100,000 credit for projects in Bangladesh[7]. It will include a $20,000,000 credit for a plan to rehabilitate the sugar industry and $8,100,000 for an agricultural extension agent training program. Additional funds for the $25,700,000 sugar effort include a total of $4,500,000 from Bangladesh and government-owned sugar companies (Thakurgaon, Rangpur and Rajshahi) and $1,100,000 from the Somali Bank. Bangladesh will also contribute $1,400,000 to the $9,900,000 agricultural training project. The IDA has also agreed medium term credit of $100 million as part of the $176.9 million rural development project, with part of the balance expected to come from Canada ($17,200,000) and the UK ($10,500,000)[8].

US preferential treatment for Caribbean sugar exporters[9]. The Caribbean Basin Initiative was passed by both houses of the US Congress by the beginning of August and was promptly signed by the President. This measure will exempt various products, including sugar, originating in countries of the Caribbean basin from payment of US import duty. It is not intended that this should become an open-ended exemption and there will be a limitation at 110% of the maximum levels shipped to the US in the past. Further, it is not yet certain when implementation will take place.

PERSONAL NOTES

Ervin Muller, until November 1982 Chief Chemist of Tate & Lyle Refineries Ltd., which he joined in 1948, has been appointed co-editor of *Sugar Technology Reviews*. Appropriately, he succeeds **Murray Hutson**, another former Chief Chemist of Tate & Lyle and co-editor since 1977, who has now become a member of the publication's Advisory Board.

1 *I.S.O. Stat. Bull.*, 1983, **42**, (2), 38.
2 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 396.
3 *Amerop Newsletter*, 1983, (116), 17.
4 *USDA Sugar & Sweetener Outlook & Situation*, 1983, **8**, (2), 7.
5 *I.S.O. Stat. Bull.*, 1983, **42**, (2), 9.
6 F. O. Licht, *International Sugar Rpt.*, 1983, **115**, 452.
7 *Amerop Newsletter*, 1983, (117), 18.
8 *Standard Chartered Review*, August 1983, 27.
9 C. Czarnikow Ltd., *Sugar Review*, 1983, (1660), 138; (1661), 144.

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