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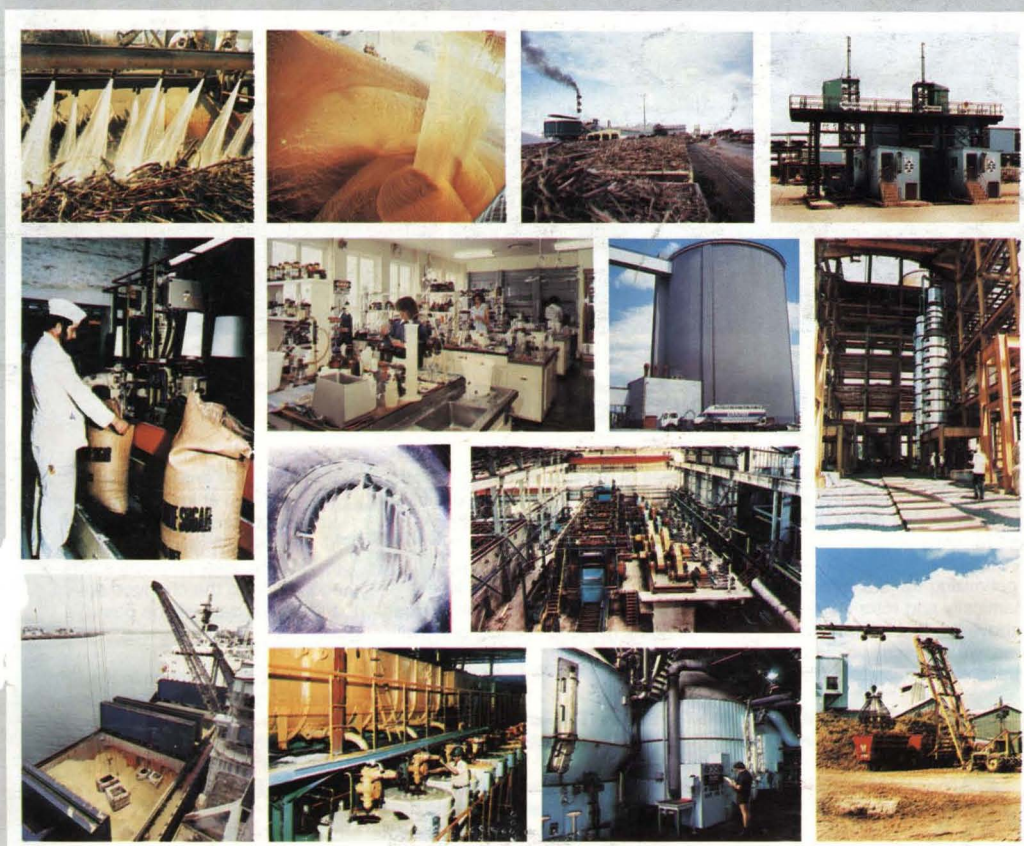

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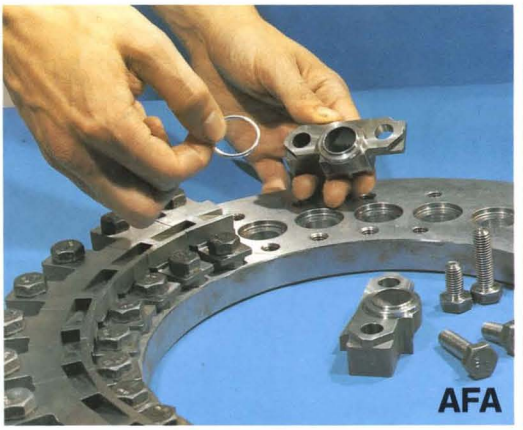

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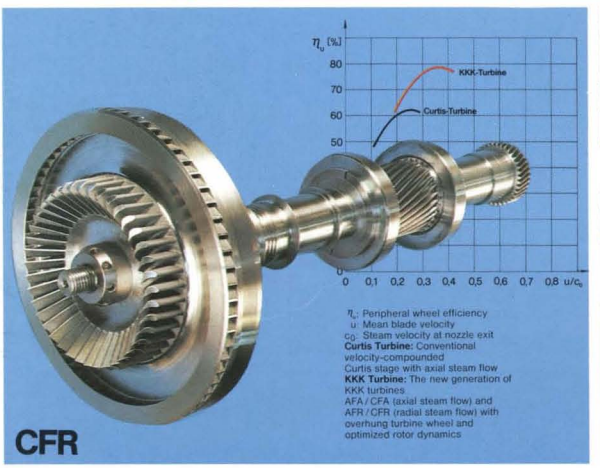

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News and views

Administration attack on the US sugar loan program

If the sugar loan rate had been 12 cents a pound instead of 18 cents, countries exporting sugar to the United States would have benefited in the past four years, according to a study by the US Department of Commerce.

Although most sugar exporters would have initially been worse off because of the lower price, greater access to the US market and a strengthening of the world price would have more than offset the smaller quota premium by about $2800 million.

The report, released in mid-May, was timed to coincide with the Department of Agriculture's decision to back a bill sponsored by Senator William Bradley, raising the US sugar quota and lowering the loan rate. It states that US policies provide support to 12,600 domestic sugar producers but have cost American consumers more than $3000 million a year and result in a 40% annual increase in imports of some sugar-containing products that compete with US goods. The study also says that the sugar program has displaced about 12,000 US jobs because of a 40% reduction of the US refining industry and offshore investment by manufacturers eager to obtain world-price sugar. Further, the debt burden in third-world sugar exporters has grown while they have had fewer dollars to buy American products.

US sugar import quota, 1988

The drought and virus yellows disease which have affected beet sugar prospects in the United States, plus increase in demand for sugar-sweetened soft drinks and ice cream which has resulted from the hot weather, have served to raise prices and have induced the authorities in that country to raise the import quota for raw sugar in the current year. The increase, of approximately 300,000 short tons, raw value, announced on July 22, brings the quota to 1,074,675 tons or a little more than the 1987 quota. Details of the revised entitlements for individual countries appear below:

	New	Previous
	short tons, raw value	
Argentina	43,175	30,100
Australia	83,335	58,100
Barbados	8,205	5,770
Belize	11,045	7,700
Bolivia	8,230	5,770
Brazil	145,590	101,500
Canada	11,045	7,700
Colombia	24,100	16,800
Congo	8,000	5,700
Costa Rica	19,577.5	13,110
Dominican Republic	176,710	123,200
Ecuador	11,045	7,770
Fiji	9,035	6,300
Gabon	8,000	5,770
Guatemala	48,185	33,600
Guyana	12,050	8,400
Haiti	8,000	5,770
Honduras	17,877	11,524
India	8,230	5,770
Ivory Coast	8,000	5,770
Jamaica	11,045	7,700
Madagascar	8,000	5,770
Malawi	10,045	7,000
Mauritius	12,050	8,400
Mexico	8,000	5,770
Mozambique	13,055	9,100
Panama	0	20,300
Papua New Guinea	8,000	5,770
Paraguay	8,000	5,770
Peru	41,165	28,700
Philippines	158,640	110,600
St. Kitts	8,000	5,770
El Salvador	28,815.5	19,766
Swaziland	16,065	11,200
Taiwan	12,050	8,400
Thailand	14,055	9,800
Trinidad	8,205	5,770
Uruguay	8,000	5,770
Zimbabwe	12,050	8,400
Specialty sugars	2,000	2,000
Total	1,056,675	757,880

Sugar exporters gave a warm welcome to the increase, but some may face difficulties in meeting the additional requirements of the American market later in the year, according to sugar market analysts[1]. The two main recipients of increased quotas – the Dominican Republic and the Philippines – may need to import sugar from the free market or bring forward 1989 sugar to meet the new allocations. For other quota countries the problem may be how to make up a cargo from their relatively small reallocations which for many involve less than 2500 tons.

Pakistan cane sugar production, 1987/88

Pakistan is deficient in sugar and is trying to become self-sufficient by making more and more for domestic requirements. In 1986/87 there were 41 factories in operation with a capacity of 103,200 tcd; in the recently finished season 44 units operated with a capacity of 110,200 tcd, and white sugar production rose by 28% over the previous year.

Cane was grown on an area of 855,140 hectares (762,000 has in 1986/87) and yielded a crop of 31.2 million tonnes (29.92 million tonnes in 1986/87). Of this a record 20.24 million tonnes or 64.88% was crushed for sugar manufacture over a 179-day season (157 days in 1986/87) and yielded an outturn of 1.74 million tonnes of sugar (1.25 million tonnes)
as well as 1,018,000 tonnes of molasses (666,075 tonnes), the latter a 34% increase. This should permit a substantial decrease in the need for white sugar imports.

The increased crushing of cane by the factories was accompanied by a reduction in that used for the manufacture of open-pan sugars, gur and khandsari, which has fallen from 56% to only 20% of total consumption (from 732,000 to 354,000 tonnes). Total sweetener consumption per caput has risen from 23.69 kg to 25.34kg in 1987/88; of this, the white sugar consumption has risen from 16.22 kg in 1986/87 to 21.88 kg in the year just closed.

World sugar balance[2]

The third estimate of the world sugar balance for the period September 1987 to August 1988 published by F. O. Licht GmbH provides no explanation of the recent increase in sugar prices on the world market. Updated figures for production and consumption in 1986/87 have reduced the initial stock figure for the start of the current year by 300,000 tonnes compared with the second

1 *Public Ledger's Commodity Week*, July 30, 1988.
2 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 285 - 294.

estimate, production is now set some 750,000 tonnes higher and consumption 370,000 tonnes higher. The net effect is to increase final stocks by 130,000 tonnes or 0.01% of consumption. Clearly the balance has not altered significantly and an explanation of the price rise has to be sought elsewhere. Details of the new balance appears below, together with the updated figures for 1986/87.

	1987/88	1986/87
	tonnes, raw value	
Initial stocks	35,186,000	37,067,000
Production	104,973,000	104,485,000
Imports	27,124,000	28,006,000
	167,283,000	169,558,000
Consumption	105,901,000	105,222,000
Exports	27,680,000	29,150,000
Final stocks	33,702,000	35,186,000
" " % consumption	31.82	33.44

Concerning the future, Licht comments that production will have to rise by 2 to 4 million tonnes in 1988/89 to prevent any further drawdown of stocks and higher prices. Normally this should not pose any difficulties but there are signs that there will be little or not growth at all. A no-growth scenario could pull down stocks to below 30% of consumption, which would be likely to lift prices; on the other hand, if crops should be higher than expected, the stock change could be insignificant. "Hence, cautious optimism seems in place, not losing sight of the fact that structural changes in the market have limited its upside potential."

Philippines land reform

The Philippines Congress has passed into law the land reform program which emerged as a compromise between the conflicting bills passed by the Senate and House of Representatives. Under the new law, private lands in excess of 50 hectares will be distributed to the farmers immediately the law comes into effect; those between 24 and 50 hectares will be distributed from the fourth to the sixth year and lands between 5 and 23 hectares after the sixth year. Landlords will be prohibited from owning more than 5 hectares each but their heirs, if older than 15, would be able to keep 3 hectares each.

Over a period of ten years some 5,400,000 hectares will be redistributed to more than 3 million farmers . Compensation will be paid to the dispossessed landowners in the form of cash and government bonds; the cash will be 25% for holders of more than 50 ha, 30% for those with 25 - 50 ha and 35% cash for the rest. Aid has been promised to finance the program by a number of countries while the government is seeking to recover funds alleged to have been placed in Swiss banks by former President Marcos. In addition, banks in the Philippines are providing funds.

World sugar prices

During the first three weeks of July the bullish trend in sugar prices continued, aided by purchases of sugar by China which lifted prices to the highest levels for almost eight years. Imports by that country have grown rapidly since they were at a low of 1 million tonnes in 1983/84 and are believed to have reached as much as 3.5 million tonnes to cover this year's domestic deficit. A number of Middle East countries have been in the market too, but there has also been an amount of speculative dealing which is difficult to entangle from genuine purchases to satisfy consumption requirements. The Soviet Union was reported to have bought sugar and to need more, while there was some belief that the US beet sugar crop was worse affected by drought than had been declared. Rain fell in the US Mid-West, however, and the soya bean market weakened, carrying sugar prices with it. Nevertheless, the London Daily Price for raw sugar, which had started the month at $344 per tonne, rose steadily to $393 by July 20.

There had been unease among many observers, however, who felt that prices had risen too quickly and further than was justified by basic supply and demand considerations. Consequently it did not come as too much of a surprise that a major correction took place and the price fell by $40 per tonne on July 21. The announcement of a 300,000 short tons increase in the US import quota brought a strengthening and the LDP rose to $380.80 per tonne on July 25, but this was a temporary relief, and over the rest of the month the sugar price fell drastically, to close on July 29 at $297 per tonne. The London Daily Price for white sugar had followed the raw sugar price but not so exaggeratedly; it started the month at $315, i.e. at a discount of $29 to the LDP, and this discount was about the $25 level during the first third of the month. As prices rose the discount also grew, to around $35-$40, but diminished as prices collapsed after July 20, ending the month at $22, with the LDP(W) at $275.

E. D. & F. Man described[3] the fall as the result of "a sudden wave of speculative selling.... A technical reaction, turned into a technical overreaction, made it difficult to halt the slide. The fundamental situation, however, remains constructive.... The large number of transactions this month (July) serves as testimony to a buoyant demand in the market."

Threat to Puerto Rico sugar industry[4]

A District Court judge has ruled that a Commonwealth law protecting Puerto Rico's sugar industry from competition is unconstitutional. It prevented the importation and repacking of sugar for local sale and thus eliminated the only economically viable competition to the heavily subsidized Sugar Corporation of Puerto Rico. The Corporation operates three factories and a refinery but at only one-third of capacity and has not made a profit since 1974. Ending its monopoly would cause the closure of the industry with consequent unemployment, and a wide range of government officials have attacked the judge's decision and vowed to protect the Sugar Corporation.

3 *The Sugar Situation*, 1988, (447).
4 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 334.

Product news

New AT-compatible industrial workstation

Action Instruments Europe has announced the release of its VU-PAC Model 8100 Industrial Operator Interface, a rugged industrial workstation with the power and versatility of an AT-compatible computer in a sturdy industrial package which greatly simplifies the operator interface. The benefit of VU-PAC is that it integrates an EGA colour monitor with function keys and all the other elements of a complete industrial workstation in the same compact package.

The unit's full-length 5-slot cardcage, together with 170 watt power supply and disk facilities are all conveniently located in one easily accessible pull-out drawer. The Model 8100 incorporates virtually everything needed for an industrial workstation, including a 5-slot passive AT backplane, an 80286-driven CPU card, Action's proven multi-function card, an EGA colour monitor with graphics adapter, data entry and function keypads, industry-standard 3.5-inch micro-floppy diskette, a 20MB hard disk, a 4-port serial co-processor card and many more extremely powerful expansion capabilities. In addition, the Model 8100 comes provided with MS-DOS 3.3, as well as CIM-PAC, Action's

powerful industrial monitoring and control software application package, complete with device specific drivers for most industrial PLCs. The 8100 front panel is sealed to IP65 standards and the CRT is protected by an impact resistant lexan shield.

Further details:

Action Instruments Europe,
St. James Works,
St. Pancras,
Chichester,
West Sussex PO19 4NN,
England.

First Krupp countercurrent cossette mixer for British Sugar

The Grevenbroich works of Krupp Industrietechnik GmbH has supplied its first countercurrent cossette mixer, worth around $600,000 to the British Sugar Corporation in Ipswich, England. The mixer has a low energy consumption and is capable of daily processing 6000 tonnes of beet cossettes for sugar juice extraction. The unit is to be arranged upstream of an existing RT diffuser and serves to cool the raw juice and thus reduce the risk of infection. The resultant energy saving is equivalent to 18 tpd of heavy oil, or more than $300,000 a year.

Measure rpm at a glance

For a very reasonable £160, anyone needing to measure movement, either rotational or reciprocating, can own a Tachometer 410 by Banair Ltd. This optical instrument is held in the hand and pointed, in the manner of a torch, at the piece of machinery whose motion is to be measured. The result is indicated immediately by a digital display, the range being 0.20 to 20,000 rpm, to three decimal places. A display-

hold facility is included.

There are five ranges of likely speed which can be pre-selected, as can imperial or metric measures. Tachometer 410, though optical in operation, is unaffected by fluorescent lighting or intense sunlight, so can be used in the workshop or out in the fields and will give that invaluable confirmation of operational speed so often necessary but not otherwise easily obtained.

Further details:

Banair Ltd.,
31 Highfield Industrial Estate,
Enterprise Road, Portsmouth,
Hants. PO8 0BJ, England.

Crossover pads pay for themselves

Electrical cable, hydraulic hoses and water and compressed air lines may be protected from damage and interference from vehicle and pedestrian traffic with Rhino-Hyde Crossover Pads. They are available in a wide range of widths, lengths and cable slot sizes. Custom sizes and designs are also available.

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Blooming Prairie, MN 55917,
USA.

The Quattro mini bulk container

Companies in the food processing industries now have a new, yet customer proven, "Big Bag" to complement their packaging needs. Bowater Bulk Packaging Ltd. have built upon their existing strengths of design, quality and ease of customer usage to develop the Quattro. Its design embraces a single piece of circular woven U.V.-stabilized polypropylene fabric, uniquely profiled to form the base and four integral lifting sleeves. This special design optimizes stress distribution throughout the bag, and so maximizes its lift/bodyweight ratio. Naturally, a lifting safety factor of 5:1 is standard, meeting the British Standards requirements.

The Quattro is available in both 500 and 1000 kg sizes which, together with optional filling and discharge facilities, means the basic design principle can be readily modified to meet a whole variety of on- and off-site demands. The Quattro can reduce filling and handling time (and therefore costs) and allows safe square stacking. In addition, users can specify full colour, full width printing on the bags. As an additional service Bowater are also able to advise on the selection, design and installation of bag filling machinery in areas requiring specialist involvement.

Further details:
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Prindar Oaks Works,
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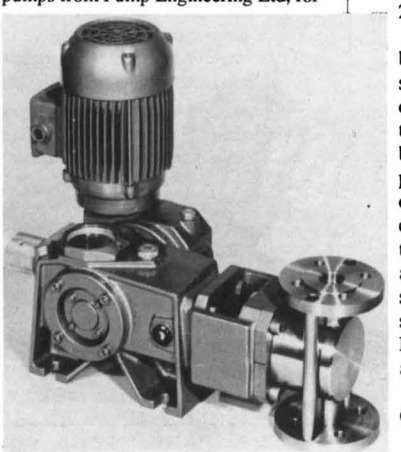
Barnsley, S. Yorkshire S70 3QS,
England.

More metering pumps

Accuracy, easy adjustment and versatility are features of new metering pumps from Pump Engineering Ltd, for applications where precise control of flow rates is essential. Hazardous and/or non-lubricating liquids and those for the chemical and food processing industries are amongst the fluids which can be handled by the pumps.



Forty four sizes in the M series cover flow rates from 2.8 litres/hour at 30 bar to 1566 litres/hour at 5 bar; the larger T series has 40 sizes with flow rates from 239 litres/hour at 140 bar to 21,407 litres/hour at 5 bar.

Versatile performance is achieved by offering different versions of the same basic machine, with a choice of two piston pumps – one with continuously flushed seals for non-lubricating liquids – and three diaphragm models to pump hazardous or "sterile" liquids or to maintain constant flow rates in fluctuating temperatures. The range of materials available for pump heads, piston seals and diaphragms includes stainless steels, Hastelloy, titanium, PVC, Teflon, PTFE, chloroprene and butyl rubber.

Motors are normally Brook Crompton Parkinson hose/weather-

continued on page 170

Cossette pretreatment and pressing

By G. C. Jones
(British Sugar [lc, Research Laboratories, Colney, Norwick, England)

Introduction

In British Sugar, as in many other beet sugar companies, the pulp after extraction is dewatered by pressing and drying to form a valuable animal feed co-product. The present method of making this dried sugar beet feed has a high energy demand, consuming about one-third of the total energy used in beet processing. The majority of the energy is used in the dryers, the energy requirement for removing a given amount of water by mechanical means in a press being very considerably lower than by evaporation in a dryer[1,2]. Therefore techniques which enable more water to be removed from the pulp before it enters the dryer will lead to a substantial reduction in energy costs.

This paper describes developments in pulp treatment before and after extraction, highlighting key areas currently under study which may lead to major increases in pressed pulp dry substance. The treatment of pulp before or after extraction is closely linked to the extraction process itself, and several of the developments to increase pressed pulp dry substance have led to modified methods of extraction. Similarly, alternative methods of extraction can use beet in different forms (e.g. comminuted) or give a different form of extracted pulp. Therefore several novel alternatives to the present diffusion process are also reviewed.

G. C. Jones

Figure 1 shows the effect of pressing pulp to different dry substances on the amount of water to be removed by drying. For example, a typical factory might press the exhausted pulp to 26% dry substance, then dry it to 88% dry substance. An increase of 1 unit in pressed pulp dry substance, to 27%, reduces the water to be removed in the dryers by more than 5%. An increase of 8 units in dry substance to 34% reduces the water to be removed by one-third. Techniques are now being developed which are claimed will give pressed pulp dry substances of 40% or in some cases 50%, reducing the water to be removed in the dryer to only one-half or one-third, respectively, of the original.

There are other possible opportunities besides the obvious potential for energy savings. Pulp dryer odour is a significant environmental problem at many sugar factories. Production of pulp of higher dry substance might be followed by improved drying techniques with a reduced effect on the environment, or may even make further drying unnecessary. Furthermore, some of the processes described below might lead to more drastic changes in the overall factory process for extraction and purification. The end result could be a novel integrated process to replace the conventional stages of diffusion, carbonatation, evaporation, sugar crystallization, and pulp pressing and drying.

After describing in outline the present factory process, the rest of this paper will go on to look at developments in the fields of beet modification prior to extraction, the extraction itself, and subsequent pulp treatment.

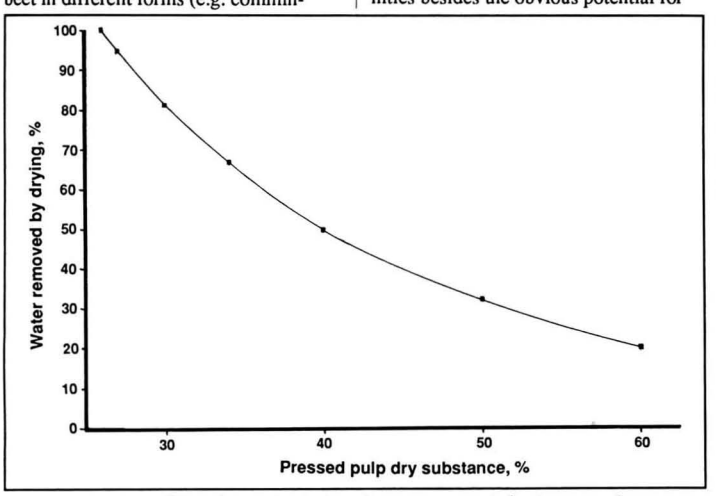


Figure 1. Effect of pressed pulp dry substance on amount of water removed by drying to 88% dry substance

The process

For the purpose of this paper, the processing of sugar beet can be considered as consisting of four basic steps.

These are: (i) beet modification, (ii) extraction, (iii) juice purification, and (iv) pulp treatment.

Beet modification

Beet modification converts the sugar beet as delivered to the factory into a form suitable for extraction. The sugar in a beet is contained within the cells and, to permit extraction, the cell walls must be rendered permeable. Normally this is achieved by heat. Denaturization occurs at temperatures above 50°C, and is rapid at the temperatures used in conventional diffusion. Chemical and electrical techniques have also been suggested. The process is sometimes referred to as plasmolysis, but strictly speaking is really cell denaturization.

To be extracted, the sugar must move through the bulk of the beet material to the surface. Therefore the

Paper presented to the 29th British Sugar Tech. Conf., 1988.

1 Anon: *Stord Bartz Review*, 1978, **4**, 19 - 22.
2 Cronewitz: *Zuckerind.*, 1980, **105**, 129 - 139.

beet should ideally be chopped or ground into fine particles to minimize the distance the sugar has to travel to the surface. However, the form of the beet material is also constrained by the design of the extraction equipment. Small beet particles could seriously affect the performance of continuous diffusers by blocking diffuser screens. The cossette with its V form for maximum surface area is a compromise between these factors. Several workers[3,4] have defined cossette factors, based on the dimensions of the beet particles, for use in diffusion calculations.

Extraction

The standard method for extracting sugar from beet is by countercurrent diffusion with hot water. The Robert battery diffuser was introduced in Austria in 1864. In the mid-twentieth century the battery diffuser was replaced by continuous diffusers. British Sugar currently operates three types of continuous diffuser, viz. the RT, DDS and BMA (tower) diffusers.

Diffusion is normally carried out under slightly acidic conditions. Factory water is generally alkaline, owing to the presence of ammonia, and must be neutralized to prevent alkaline degradation of the beet pectin and consequent softening of the pulp[5]. Acid conditions could be obtained by permitting some microbiological activity in the diffuser. However, this causes some sugar loss and it is economically preferable to achieve diffuser sterility and then control pH by judicious acid addition[6].

Since the mid-1950's, salts of polyvalent cations, particularly calcium or aluminium, have frequently been added to the water to act as pressing aids[7-10]. They are believed to increase pulp rigidity by crosslinking carboxylic acid sites on the beet pectin[11].

Novel developments in the extraction process and pressing aids are discussed further later in this paper. There is already at least one comprehensive review covering the whole field of diffusion[12].

Juice purification

Once the sugar has been extracted from the beet, it must be converted to a saleable product. This generally means crystalline white sugar. The conventional purification steps are two-stage carbonatation, and crystallization. Other techniques have been suggested, but have not been generally adopted. These include ion exchange[13], which is used in many instances as an addition to the conventional process (for example, decolorization, decalcification or recovery of molasses sugar) but not generally as a replacement for it. The use of membrane processes[14] has also been suggested.

It is not the object of this paper to discuss alternative juice purification processes, but it should be mentioned that any changes from the current extraction process may make other methods of purification more favourable, or even advisable. For example, Suiker Unie has developed an alternative extraction process for use on a variety of carbohydrate-containing roots. They advocate purification by ultrafiltration and subsequent ion exchange demineralization, before evaporation and crystallization.

Pulp treatment

The standard method in many countries, including Britain, for treating the beet pulp after extraction is to remove as much water as possible by mechanical pressing and then dry it in rotary dryers to a sufficiently high dry substance to give good storage characteristics. This dried pulp is then used as animal feed. In many companies, including British Sugar, molasses is added to the pulp prior to drying.

The removal of water from wet beet pulp by pressing can be regarded as a two-stage process. First, the water is compressed from the individual beet cossettes, and second, the expressed liquid permeates through the spaces between cossettes to drain from the bulk material. Water removal is facilitated by increasing pressure and retention time. However, increasing pressure can reduce the overall permeability of the bulk material by compressing drainage channels. There is some evidence[15] that a relaxation in pressure can give a limited re-absorption of expressed water.

Reorientation of the cossettes during pressing is advantageous, moving pulp from regions of high pressure (where compression has removed the most water from the cossettes) to regions of lower pressure with increased drainage. Austmeyer[15] reported laboratory results for pressing with and without shearing, under otherwise identical conditions. At 1 bar pressure the shearing action gave an increased dry substance of 27% compared with 19% without shearing, while at 10 bar pressure the dry substance values with and without shearing were 32% and 22%, respectively.

Excessive shearing action is to be avoided, since the production of fine particles by pulp breakage would tend to hinder drainage through the bulk material and block the mesh screens inside the presses.

Beet modification

Alternative beet forms

The traditional V-shaped cossette is the standard form used in sugar factories, combining physical strength with a large surface area. A few workers have suggested other shapes such as strips of flat[16] or square[17] cross-section but these have not been generally

3 Silin: "Technology of beet sugar production and refining" (Israel program for Scientific Translations, Jerusalem), 1964, 143.
4 Bjerkhog: *Socker*, 1948, **4**, 97 - 121.
5 Carruthers & Oldfield: *Paper presented to 9th Tech. Conf. British Sugar Corp.*, 1956.
6 Oldfield *et al.: I.S.J.*, 1977, **79**, 126 - 130, 157 - 162.
7 Carruthers & Oldfield: *ibid.*, 1957, **59**, 277 - 281.
8 Shore *et al.: ibid.*, 1983, **85**, 6, 43, 76.
9 Rousseau & Carriere; *Sucr. Franç.*, 1979, **120**, 301.
10 Bollman: *Zuckerind.*, 1981, **106**, 978.
11 Shore *et al.: Proc. 17th Assembly C.I.T.S.*, 1983, 151 - 180.
12 Genie: *Sugar Technol. Rev.*, 1982, **9**, 119 - 270.
13 Shore *et al.: Paper presented to Amer. Chem. Soc. Symposium on Chemistry and Processing of Sugarbeet*, 1987.
14 Nielsen *et al.: Sugar Technol Rev.*, 1982, **9**, 59 - 117.
15 Austmeyer: *Proc. 18th Assembly C.I.T.S.*, 1987, 295 - 347.
16 Berezovskii *et al.: Sakhar. Prom.*, 1971, (10), 11.
17 Terentev & Pushanko: *ibid.*, 1974, (5), 23.

adopted. Advantages claimed for flat cossettes include reduced energy requirement for the knives and diffuser motors, and reduced losses when processing deteriorated beet.

Novel extraction processes may not have the same constraints on beet form as conventional diffusion and therefore may use alternative forms. Comminuting the beet by grinding or crushing will increase the rate of diffusion of sugar from beet, provided that the method of extraction can cope with fine beet particles. The Suiker Unie extraction process referred to earlier uses decanter centrifuges, which can handle grated beet. In turn, the complete structural breakdown of the beet obtained by grating makes it possible to extract with cold water in this process.

Liming processes

Lime

In sugar beet, the cell walls consist largely of pectic substances, particularly the middle lamella[18]. The characteristic component of these substances is pectin, a linear polymer of α-D-galacturonic acid. About 50% of the carboxylic acid groups of beet pectin are esterified by methyl groups and about 30% of the hydroxyl groups are acetylated[19].

Under the alkaline conditions obtained when sugar beet is mixed with lime, beet pectin can undergo at least four types of reaction: (i) de-methylation at the carboxyl groups to liberate methanol; (ii) de-acetylation at the hydroxyl groups to liberate acetate; (iii) attachment of calcium ions to free carboxyl groups; and (iv) polymer degradation.

At ambient temperature, de-esterification (i) and de-acetylation (ii) predominate, releasing methanol and acetate ions, respectively, into the juice. At elevated temperatures, the pectin polymer is degraded by breakage of the glycosidic bonds (iv). However, this reaction takes place only at bonds adjacent to esterified carboxyl groups, so that de-esterification by cold liming protects the pectin from subsequent alkaline degradation when the pulp is heated in the diffuser.

The effect of liming beet juices at ambient temperature is to give an increased rigidity. The rigidity is retained through the diffusion process and subsequent pressing, and enables the pulp to be pressed to a higher dry substance.

There are other potential advantages to cossette liming. Since the pectin is retained in the pulp, the amount of pulp dry substance, sold as animal feed, is increased and the amount of non-sugars in juice is decreased. Other benefits include a reduced requirement for certain process aids. The factory would no longer use calcium salts as pressing aids, and since the diffuser is maintained under alkaline conditions there would be no requirement to control the diffuser pH by acid addition to diffusion supply water or diffuser midbay. There should be little potential for microbiological activity in the diffuser with possible reduced requirements for biocides or formaldehyde. There might also be savings in maintenance costs owing to reduced diffuser corrosion under alkaline conditions.

For at least eighty years, numerous workers have considered the possibility of pretreating beet with lime before extraction[20-29]. The most recent in this field are Randall and co-workers[30-32]. They studied the relative rates of the de-methylation and de-acetylation reactions at different temperatures, and found that de-methylation, the preferred reaction, proceeded faster than de-acetylation under most conditions. Furthermore, their results showed a greater degree of de-methylation relative to de-acetylation at 18°C than at 5°C and 36°C after ten minutes. Randall also quantified by shear strength measurements the increase in strength of the cossettes caused by liming.

British Sugar has studied cossette liming both in the laboratory and briefly in factory trials. In the laboratory we found that treating cossettes with 0.4% CaO on beet in the form of milk of lime gave the desired reaction even at very short retention times. Juice was extracted conventionally in a small battery diffuser, and purified by carbonatation. The second carbonatation juice obtained was of equal or greater purity than that obtained from unlimed beet, but was higher in lime salts owing to the release of acetate ions into the juice by the pectin de-acetylation reaction. A good white sugar could be crystallized from the juice. The extracted pulp could be pressed in a small hydraulic press to 7 units higher dry substance than unlimed pulp.

Two short factory trials have been carried out at King's Lynn factory which served mainly to establish practical methods of adding milk of lime to cossettes. It was found that one simple way to achieve this was by diluting the milk of lime with cold water to cool it and then circulating it through the juice addition system in the prescalder instead of raw juice. Further longer factory scale trials are planned for the 1988/89 campaign, to quantify the remaining uncertainties.

When treating juice from limed cossettes, other methods of purification besides carbonatation may be appropriate. For example, ion exchange processes using weakly acidic cation exchange resins[33] are especially suited to demineralizing feed streams where calcium is a major cation. It is an interesting possibility that cossette

18 McGinnis: "Beet sugar technology", (Beet Sugar Development Foundation, Fort Collins), 1982, p. 36.
19 McCready: *J. Amer. Soc. Sugar Beet Tech.*, 1966, **14**, 260.
20 Weinrich: U.S. Patents 803,945 (1905); 881,641 (1908); 950,035 (1910).
21 Borghi: *La Chimica e l'Industria*, 1946, **28**, 177 - 184.
22 Degtyar: *Sakhar. Prom*, 1948, (4), 28 - 29.
23 Bonelli: Italian Patent 573,733.
24 Idem: *Ind. Sacc. Ital.*, 1959, **52**, 399 - 411.
25 Loof & Pohl: French Patent 1,129,771.
26 Susic: *Prehr. Industrija, 1959, 13*, 566 - 572.
27 Goodban & McCready: *J. Amer. Soc. Sugar Beet Tech.*, 1965, **13**, 566 - 572.
28 Bobrovnik *et al.*: *Sakhar. Prom.*, 1977, (1), 11 - 13.
29 Vukov & Tegze: *Cukoripar*, 1973, **6**, 213 - 215.
30 Camirand *et al.*: *J. Amer. Soc. Sugar Beet Tech.*, 1981, **21**, (2), 159 - 174.
31 Randall *et al.*: *ibid.*, 1982, **21**, (3), 221 - 234.
32 Zaragosa *et al.*: *ibid.*, (4), 383 - 394.
33 Schoenrock: *Paper presented to the Amer. Soc. Sugar Beet Tech.*, 1985.

liming may enable juice to be extracted readily from beet by pressing, rather than by conventional diffusion.

Saccharate treatment of cossettes

A variation on cossette liming has been developed and patented by Ponant[34], in which calcium saccharate is added to the cossettes instead of lime. Calcium monosaccharate solution is produced by adding powdered calcium oxide to a sugar juice cooled to 20°C. Normally a proportion of the second carbonatation juice or raw juice would be used, typically about 20% on beet. This saccharate solution is fed onto the cossettes for a retention time of about 5 minutes prior to diffusion under alkaline conditions. The raw juice obtained is yellow in colour and can be purified by the normal two -stage carbonatation process. The pulp after diffusion has been pressed to about 40% dry substance.

The process has been operated for two years in a factory pilot plant, and the first full-scale plants should come into operation soon.

Other treatments

Freytag & Linden[35] have found that addition of a small proportion of ethylene to diffusion supply water increases the rate of diffusion of sucrose from beet and gives a higher purity raw juice. Alternatively, the beet cossettes could be treated with gaseous ethylene before diffusion. With the aid of electron micrography they showed that the ethylene caused the cell wall to swell, forming enlarged spaces between the cellulose microfibrils which presumably enhanced the diffusion process. In factory trials, pressed pulp dry substance was increased slightly, by 0.9%, and dryer fuel consumption reduced, consistent with an increase in the size of drainage pores in the pulp leading to improved removal of water whether as liquid or vapour.

Enzymes are commonly used to increase the extraction of juice from grapes and other fruit by breaking down the cell walls[36]. It is possible that a similar process might be developed for sugar extraction.

The use of electrical fields to denature the cell walls as an alternative to scalding has been suggested, particularly in the USSR. Several plant designs have been put forward[37-39] in which cossettes or whole beet are subjected to electroplasmolysis, but there are no reports of implementation on a factory scale. Advantages claimed include reduced diffusion temperature.

Extraction

Alternative diffusion techniques

The application of an electrical field during diffusion has been investigated by several Russian workers. At reduced diffusion temperatures Fedorenchenko *et al.*[40] found that electrical fields gave a more rapid extraction of sugar than was otherwise the case, probably by enhanced denaturation of the cell walls. Electrostatic precipitation of inorganic non-sugars and coagulation of large molecules such as proteins leads to retention of these components in the beet tissue[41].

The diffusion can be combined with juice purification by electrodialysis using ion exchange membranes[42]. Ion exchange membranes permit passage of either anions or cations by an ion exchange mechanism. If the electrodes in the diffuser are separated from the cossettes by suitable membranes then the ions migrate through the membranes and are thus separated from the sugar juice extracted.

Using a combination of these techniques, Bazhal *et al.*[43] have reported laboratory scale production of a juice by electrodialysis that only required treatment with carbon before evaporation and crystallization to give white sugar of acceptable quality. However, there are no reports of this technology being applied on a factory scale.

Russian workers have also investigated the effect of applying a low frequency vibration (3 - 120 Hz) to diffusers. Stratienko *et al.*[44] reported a marked increase in extraction rate under certain conditions which they suggested was due to alignment of the cossettes with the liquid flow, giving improved mass transfer. Once again, there are no reports of application on a factory scale.

Extraction by pressing

The Steffen pressing process was developed around 1900 and applied in several countries. British Sugar used it in two factories in the 1950's before replacing it by conventional diffusion. Recently it has been introduced into Frasnes factory in Belgium[45].

In Steffen pressing, the cossettes are scalded and a sugar juice is then extracted by pressing. Not all of the sugar can be extracted in this way and, to recover the remainder, the pressed cossettes undergo conventional diffusion. The press juice is generally higher in purity and concentration than the diffusion juice, but the mixture is similar to a normal factory raw juice and is purified by carbonatation in the same way.

A novel press is being developed in France, potentially capable of pressing exhausted beet pulp to 50% dry substance. The application of this "hyperpress" to a modified Steffen pressing concept has been suggested[46]. The cossettes are scalded then pressed in the hyperpress. Afterwards water is added and the cossettes are pressed again. No diffusion stage is required.

In laboratory tests of this system, 86 - 90% of the beet sugar was extracted in the first pressing, and 95 - 98% in the two pressings. Subsequent small pilot scale trials in 1985 gave up to 98.6% extraction. Current development of the

34 European Patent 92,466.
35 *Sucr. Belge*, 1957, **94**, 129 - 437.
36 Baumann: in "Enzymes and food processing", Ed. Birch *et al.*, (Applied Science Publishers, London), 1981, 129 - 148.
37 Zagorulko & I'kov: *Sakhar. Prom.*, 1953, (10), 15 - 18.
38 Koval USSR Patent 764,643.
39 Papchenko *et al.*: USSR Patent 1,005,758.
40 *Sakhar. Prom.*, 1983, (2), 23 - 24.
41 Karpovich *et al.*: *ibid.*, 1981, (10), 32 - 35.
42 Bazhal *et al.*: USSR Patent 912,756.
43 *Sakhar. Prom.*, 1982, (3), 19 - 22.
44 *Izv. Vuzov. Pishch. Tekhnol.*, 1970, **4**, 157 - 159; **5**, 88 - 92.
45 Lemaire & Petry: *Sucr. Franç.*, 1983, **124**, 457 - 464.
46 Pouillade *et al.*: *Proc. 18th Assembly C.I.T.S.*, 1987, 413 - 440.

hyperpress on a larger scale is aimed primarily at pressing of exhausted pulp, rather than at extraction, but if the hyperpress is developed to full scale factory operation then no doubt its application to extraction of sugar would be considered further.

Liming and pressing

The liming of beet cossettes prior to diffusion has been discussed above. It has been suggested that limed beet could be processed by pressing rather than diffusion since liming denatures the cell walls, permitting juice to flow readily from the beet[32]. Most recently, Randall *et al.* have studied pressing of limed beet tissue[47]. They observed that a single pressing step did not extract all the sugar from cossettes, and recommend two or even three pressing stages with addition of water at the second and third pressings to improve extraction. In British Sugar we have also studied liming and pressing, and we found that by cold pressing limed cossettes instead of diffusion it was possible to obtain a juice of 95% purity but an extraction of only 48% of the sugar in beet was obtained. Heating the cossettes with steam before pressing markedly increased extraction to 93%. This suggests that cell denaturization was incomplete under the conditions used for cold liming.

Other techniques

Hanssens & Koerts of Suiker Unie have developed and patented an interesting alternative to the conventional extraction/purification process. This could be applied to sugar beet and similar materials such as mangolds[48] to obtain sugar. It can also be applied to extraction of carbohydrates from other tuberous roots, particularly for recovering inulin from chicory or Jerusalem artichokes for subsequent conversion to fructose[49]. The use of mangolds as raw material is suggested because their superior storage characteristics compared to sugar beet would give an extended processing season.

As a first step, the roots are grated, for example with the type of equipment used in the starch industry for processing potatoes. This complete structural breakdown makes it possible to extract the carbohydrate by simply rinsing with cold water, without requiring any cell denaturizing by heat or other means. The use of a series of three or more solid bowl decanter centrifuges is suggested, operated in a countercurrent mode, with relatively dry pulp solids obtained at one end and juice at the other.

This process extracts more non-sugars than conventional diffusion, particularly high molecular weight compounds that diffuse more slowly than sucrose from the pores of beet cossettes in a diffuser. Therefore the traditional carbonatation purification system is replaced by ultrafiltration[50] to remove proteins, pectin, gums, and other high molecular weight impurities. This is followed by ion exchange demineralization of the permeate, to give an almost colourless juice with a purity of 95% total sugars on dry substances. This juice can be concentrated, and good quality white sugar crystallized from it in the normal way.

Other processes for extracting sugar from comminuted beet have been suggested[51,52]. A process developed and patented by Buckau-Walther[53] is interesting in using addition of lime and enzyme during the extraction.

Extraction of sugar from beet using non-aqueous solvents has been suggested. Possible solvents include liquid ammonia[54,55], ethanol[56], and mixtures of water and acetone or ethanol plus benzene[57]. In most cases the resultant extract solution is reported to be of higher purity owing to the lower solubility of major non-sugars than that of sucrose. However, there are no reports that such a radical change in the process has been seriously considered on a factory scale.

Pulp treatment

Pressing

The screw press is the standard press type for beet pulp. This gives continuous operation at appropriately high pressures, and long retention times, with some shearing action. Recent types incorporate hollow spindles to minimize the distance water must permeate through the bulk material before escaping from the press.

Other types of press have been suggested. If the wet pulp was to be pressed as a thin layer, water would have only a short distance to drain out of the bulk material, and therefore would do so readily even at high pressures. The hyperpress developed by Générale Sucrière in collaboration with ENSAM-ESERAM and ENSIA works on this principle[46]. In the hyperpress, pulp is spread onto a long sheet of filter cloth in a layer only about 10 mm thick. The cloth and pulp is then wound onto a bobbin. The rolled-up bobbin is transferred to a chamber with an elastic inner wall where it is subjected to a pressure of up to 50 bar by a hydraulic system. The bobbin is left under pressure for a short time (typically 10 to 15 minutes) then unrolled. The operating parameters of bed thickness, number of layers, press pressure and duration under pressure were examined on laboratory scale equipment before being applied to a pilot scale plant which has been installed at Nassandres factory. This is used to treat pressed pulp from the factory Stord presses. A final dry substance of 50% has been achieved on this scale. The pilot plant is being expanded into a three bobbin unit, capable of handling a continuous feed of pulp corresponding to 1000 tonnes of beet per day. With three bobbins, one would be loading or emptying at any given time while the

47 *Paper presented to 29th Tech. Conf. British Sugar plc*, 1988.
48 European Patent 126,512.
49 Koerts & Hanssens: European Patent 126,513.
50 Hanssens & Koerts: *Paper presented to Amer. Chem Soc. Symposium on Chemistry and Processing of Sugarbeet*, 1987.
51 Steckel: German patent 813,139
52 Skriplev: USSR Patent 549,472.
53 Zucher *et al.*: German Patent 3,150,314.
54 Palzer *et al.*: German Patent 1,139,080.
55 Kishihara & Shimizu: *Sci. Rpts. Hyogo Univ. Agric.*, Ser. Agric. Technol., 1965/66., **7**, 17 - 20, 46 - 50.
56 Braunsteiner: *Jahresber. Zuckerforschungs-Inst.*, 1967, 51.
57 Zavodsky: Czech Patent 214,999.

other two are under pressure. Interest in this novel press will depend on what engineering problems, if any, are encountered in scaling-up to a plant capable of handling a full factory throughput.

There are other types of press that operate on thin layers of feed, such as belt or roller presses, but these generally do not give such long retention times as the hyperpress.

One standard means of improving the dry substance of pressed pulp is by the use of salts of polyvalent cations, particularly calcium and aluminium. These can either be sprayed onto the pulp leaving the diffuser or be added into the diffusion supply water so that they contact the pulp in the tail end of the diffuser. Calcium chloride has been used as a pressing aid in British Sugar since the 1956/57 campaign[7] while, following factory trials in 1981/82[8], we changed to the use of gypsum (mineral calcium sulphate dihydrate). Earlier laboratory studies had shown that approximately half of the sulphate ions in raw juice are eliminated at carbonatation[58], whereas chloride ions are not eliminated, so the use of calcium sulphate rather than chloride gives a significant benefit in terms of reduced molasses formation. Vaccari *et al.*[59] have suggested the use of calcium bisulphite as a pressing aid, made from factory lime plus sulphur dioxide. Other calcium salts including calcium phosphate[9] and calcium citrate[60] have also been suggested.

The use of aluminium sulphate has also been suggested, and was explored by British Sugar in comparative factory trials[8]. It was concluded that it was less favourable than gypsum within British Sugar factories for three reasons: first, it is considerably more expensive for a given increase in pulp dry substance; second, the lowering of pH in the diffuser would undoubtedly increase corrosion; and third, it was observed during the trials that the addition of aluminium salts to the diffuser gave a significant increase in the volume of wet pulp. The effect was marked, but might not have been so easily observed at a factory which was not already slicing to the full capacity of the press station.

The reaction of polyvalent ions with beet pectin is normally regarded as an ion exchange reaction[11]. This approach suggests that increased benefits might be obtained if the beet pulp is treated with the calcium ions as early as possible in the diffusion process, preferably under alkaline conditions to increase the uptake of calcium ions relative to hydrogen ions on the carboxylic acid groups. This is consistent with the developments in cossette liming described above.

A recent development in pulp pressing has been the introduction of organic pressing aids by several manufacturers, including Biosoph Laboratories, Nalfloc, and Henkel-Nopco. These are generally based on copolymers of ethylene oxide and propylene oxide. Some are already in use in sugar factories as antifoams. Mottard & Carrière[61] reported trials of Biosoph additives at French factories and concluded that they increased the press throughput rather than the pressed pulp dry substance directly. In trials of Biosoph additives at British Sugar's Allscott factory we found that addition of their product Biospumex 281 to diffusion supply water at the rate of 14 ppm on beet increased the throughput of the presses by 3 tonnes of wet pulp per 100 tonnes beet. There was a mean increase in pressed pulp dry substance of 0.6% on manually controlled presses because of the ability to decrease the press speed, but on fixed speed presses the pressed pulp dry substance decreased by a mean 1.6%, to give an overall effect at the factory of 1% decrease in pressed pulp dry pulp substance. We suggest that the additive acts mainly as a lubricant, making the pulp more slippery. As a result there is a tendency for pulp to be extruded rather than pressed, to give a decrease in pressed pulp dry substance.

Two further additives were tested by British Sugar in factory trials at Cantley factory in the 1987/88 campaign, viz. Nalco Bioaudit 349 and Henkel-Nopco Clerol LQ217A. Bioaudit 349 behaved very similarly to the Biosoph product, giving an increase in press throughput but a mean 1.5% decrease in pressed pulp dry substance. Clerol LQ217A, however, gave a mean increase in pressed pulp dry substance of 0.6%. Further factory studies have shown the need for optimizing the addition level and point of addition for these products. This is clearly an area for further collaboration between the additive manufacturers and sugar companies.

Diffusive dewatering by sugar solutions

An interesting technique has been developed by Austmeyer[15] in Germany, in which pulp is dewatered by contact with concentrated sugar solutions. This is currently operating on a pilot plant scale at the Ochsenfurt factory. Pressed pulp is mixed in a 1:1 ratio with molasses, for example by pouring molasses onto the pulp in a screw conveyor. The molasses is preferably at a very high solids content (typically 94°Bx) and heated to 90°C to minimize the viscosity. After a short retention time the pulp/molasses mixture is separated in a suitable press, where the excess molasses (diluted by pulp water to about 60°Bx) is recovered and then evaporated before recycling to the beginning of the sequence. The molassed dewatered pulp is recovered at about 60% dry substance.

The probable mechanism is that water held internally within the pulp capillaries diffuses out, driven by the concentration gradient created by the molasses. Since the cell walls have been ruptured during diffusion, it is unlikely that osmosis, which requires the presence of a semi-permeable membrane, plays a major part. However, true osmotic dewatering is a known technique that can be applied to fruit and vegetable materials[62].

58 Carruthers *et al.: Paper presented to the 12th Tech. Conf. British Sugar Corp.*, 1959.
59 *Proc. 18th Assembly C.I.T.S.*, 1987, 349 - 368.
60 Credoz: French patent 2,587,723.
61 *Paper presented to the 28th Tech. Conf. British Sugar plc.*, 1986.
62 Ponting *et al.: Food Technol.*, 1966, **29**, 125.

ISJ Abstracts

Cane sugar manufacture

Exhaustion of final molasses

A. P. Chinnaswamy and S. Kaliayamurthy. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.117 - M.127.

It is shown how the replacement of batch centrifugals with continuous machines for low-grade work coupled with operation of batch crystallizers as a continuous unit reduced final molasses apparent purity to 25 - 26 compared with approximately 30 under the previous system.

Practical method to assess factory performance

S. Srinivasan. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.142 - M.157.

A system for assessment of factory performance involves (1) finding pol % cane directly from 1st expressed juice and the reported fibre content, (2) use of the Java ratio, and (3) calculating the "efficiency factor", i.e. recovery % cane/ pol of 1st expressed juice. It is shown how the system can be used to evaluate performance by comparison with set norms, using as examples data from factories where the cush-cush or bagacillo screen is located between the crusher and 1st mill or after the 1st mill.

Shifting of VLJ (vapour line juice) heater from last evaporator effect to 3rd effect vapour line for more steam economy and more capacity of evaporator set

P. Shekhariah. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.1 - E.13.

Using 4th effect vapour to heat raw juice raised the temperature by only 11°C to 46°C; by using 3rd effect vapour, the temperature was raised to 70°C. The resultant steam economies are shown for a quadruple- and a quintuple-effect evaporator.

Final molasses cooler - an attempt to bring down molasses temperature

S. K. Bhojaraj. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.14 - E.27.

A shell-and-tube heat exchanger with floating head is described which reduces the temperature of final molasses at Vuyyuru sugar factory from 60°C to 40°C at an hourly throughput of 15 tonnes.

Short-tube vapour line juice heater - a case study

D. P. Sharma and S. N. Sahu. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.28 - E.33.

As part of a steam economy scheme at the authors' sugar factory, a vapour line juice heater provided with 6-ft tubes and having a total heating surface area of 470 ft² was installed between the last evaporator effect and its condenser; because of an inadequacy of cane and the shortness of the season in which the heater was installed, tests could not be conducted at a juice throughput equivalent to 50 - 55 tch for which the unit was designed. However, at an equivalent of 30 tch, the heater raised the temperature by 43 - 45°F to 132 - 133°F and gave a steam economy of 4.3 - 4.5% on cane by comparison with the previous system using a vertical juice heater.

Use of organic Rankine cycle turbine for power generation from flue gases in the sugar industry

Y. Kumar and G. K. Kumar. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.34 - E.47.

The possibility is discussed of using boiler flue gases to heat e.g. toluene, the vapour from which is fed to a turbine to generate power; the system is based on the conventional Rankine steam cycle and assumes a typical arrangement of two boilers of 20 tonnes steam output (for a 1250 tcd factory) with flue gas leaving the air preheater at approx. 230°C, and a 90 bhp axial-flow, single-stage turbine generating up to 350 kW. Details are given of the plant and economics involved.

Boiler water treatment program

B. K. Gupta and R. P. Aggarwal. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.48 - E.64.

Details are given of boiler feed water treatment with NaOH, phosphates, sodium sulphite, cobalt chloride and (occasionally) sodium carbonate at the authors' sugar factory; application of the program in 1983/84 and 1984/85 prevented scale formation and corrosion in the boiler. The disadvantages of using untreated water and the merits and demerits of hydrazine as an alternative to sodium sulphite are discussed and standard specifications of treated water composition given together with sample analyses over a trial period.

D.C. drive for mills

K. S. R. Rao and N. Rudrappa. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, E.65 - E.71.

Mysore Paper Mills Ltd. operates a sugar factory together with a paper mill, with the two plants using an integrated power system. It was decided to replace turbine drives for the cane mills with 450 kW D.C. thyristor-controlled electric motors for a number of reasons which are given. The costs of conversion, which would normally be high for a typical sugar factory operating a low-pressure boiler, were minimal because of the existing high-pressure boilers, turbo-alternators and 11 kV switchboards, so that a transformer, thyristor panel, LT cabling were the only extra requirements apart from the motors. Advantages of the new system are indicated.

A formula for calculating mixed juice percent cane

L. G. Patil. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, C.6 - C.14.

A formula is presented for calculation of mixed juice % cane as a function of

added water % cane, bagasse Brix and moisture % and Brix of primary and mixed juices. Values of mixed juice % cane reported by eight Indian sugar factories are shown to be lower than values calculated using the formula by between 2 and 19 units; analysis of these differences indicated that they were attributable to differences between two methods used to calculate Brix % cane.

An introduction to the Thailand sugar industry

K. S. Shah, K. S. Mokha and J. L. Jain. *Indian Sugar*, 1987, **37**, 185 - 195.

An account is given of the history and development of cane sugar manufacture and refining in Thailand, with information on some of the equipment and processes used plus a list of factories and their capacities.

Production goals

D. Martinez. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 82 - 88.

Details are given of a performance assessment scheme used at South Coast Sugars Inc. in Louisiana in which targets are set for all important production parameters on a weekly basis and the results obtained compared with them. Meetings are held immediately after the actual figures are available, at which management and operations personnel discuss the results (with the aim of overcoming any problems so as to improve performance) and develop plans. Tabulated target and actual values for various sections of the factory and for specific parameters are discussed.

The economics of energy production from sugar cane

W. Keenliside and S. Clarke. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 89 - 97.

A computer program developed as a model of the material and energy balance of a raw sugar factory was used in an analysis of the economics of energy production as a function of cane variety, hourly crushing rate and boiler pressure (low or high); the hypothetical factory was assumed to produce sugar and/or ethanol (from molasses or clarified juice). The exercise demonstrates the effect of cane fibre and sugar content on the total factory revenue and shows the probable costs of power generation as a means of supporting the raw sugar price. While investment in power generating equipment may be justified where a reasonable price is obtained for the electricity (the amount produced normally exceeding the internal demands of a factory), at current costs a high-pressure steam system appears less attractive because of the costs of the new boiler equipment required.

Relationship between time factor and sugar recovery in the sugar cane agro-industrial process

G. L. Aleman. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 98 - 100.

The effect of the time factor on losses is discussed, including the delay between cane harvesting and processing and in heating mill juice before clarification, the adverse influence of prolonged residence times in clarification, evaporation and boiling, and the importance of the time factor in boiling. The advantages of the $2^1/_2$-massecuite boiling system and the disadvantages of the double-magma system are discussed.

Analysis of production data of sugar cane growers and processors

B. Glaz and J. F. Alvarez. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 10 *(Abstract only).*

A standard practice of commercial enterprises is to make decisions about production methods (treatments) based on analysis of the mean outputs of these treatments. Because of the varying environments under which sugar cane is grown and because of the potentially large effects that environments can have on treatments, it has been shown that a previously described method of stability analysis can provide a more complete analysis of treatments than does use of their overall mean outputs. However, for cane processors it is not certain if stability analysis would be as useful as for cane growers. If large differences among treatments do exist across environments, the technique could be useful; otherwise, cane processors may wish to use simple regression analysis rather than overall means. Examples of situations where stability analysis could be tried would be in testing different methods of controlling sugar grain size, adjusting boiler plant efficiency, drying bagasse or testing the fuel efficiency of bagasse at various moisture levels. For enterprises using computers, daily data collection and storage would not be limiting factors in using the suggested analyses. Calculations for the analyses could be done with inexpensive software that is available for most computer systems. With either stability or regression analysis, results can be displayed in a graphic format that can improve the decision-making process.

Dextranase and the US sugar industry

D. F. Day. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 109 *(Abstract only).*

Dextran control is a problem of growing economic importance to the raw sugar producer. One approach that has been successfully applied in other parts of the world is the addition of the enzyme dextranase to a process stream. A comparison of the various commercially available dextranases, their usage and their regulatory status are presented and the potential of a new dextranase preparation recently developed at the Audubon Sugar Institute (of Louisiana State University) is described.

Mixing technology for the sugar industry

H. L. de Faria. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 109 *(Abstract only).*

Because of the sugar industry's difficult market situation, production costs must

be as low as possible, and one efficient means that contributes to this is the use of optimally designed mixing equipment. In any sugar factory process where agitators are required, the flow field produced by the impeller has an enormous effect on the efficiency and hence on the economics of the entire plant, so that the correct selection and design of mixing equipment provides lower production costs and increased profitability. The optimum agitator design for each process is the result of many years of experience and continuous development. The behaviour of different mixing systems such as vacuum pans with stirrers, stirred columns with multi-stage impellers or pipelines with flowmixers have been studied extensively. These studies have been done under vastly different operating conditions, with both Newtonian and non-Newtonian fluids. The knowledge gained has been used with success in the optimal design of agitators for those processes where mixing is required.

Submersible arc welding mill roller shafts

J. Engolio. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 109 *(Abstract only).*

Submersible welding is new to the sugar industry, although it has been used in the shipbuilding industry for a few years. Previously, metallizing of mill journals was the only way to repair worn mill roller journals; it can be an effective process if the finished product is handled carefully, but when a mill roller is being reshelled or is in the lathe for grooving it is easy to damage the metallized journal. In 1983, a journal that had been metallized came apart during the harvest season. This prompted study of the Sub-Arc process then being used successfully in marine and shipbuilding shops. The advantage of this process is that it can be done by the factory itself and does not require special equipment. Sub-Arc will not be harmed when run in a steady rest of a lathe, since it is welded on and not sprayed on like a sleeve. Sub-Arc welding is more durable and will not come off the shaft as in the case of metallizing, while its cost is comparable to that of metallizing.

Storing white sugar in bulk

A. Meuret. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 110 *(Abstract only).*

This paper describes the theory of white sugar preservation, including the desorption curve, the effects of maturation and the effects of temperature. Conditions necessary for perfect storage of white sugar such as hermetic sealing, air-sugar equilibrium, heat insulation and automatic operations are discussed. The safety of storing white sugar in silos in regard to the origin of explosions and protection from them is considered in detail.

Automated flocculant preparation

C. Orta. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 110 *(Abstract only).*

Proper flocculant preparation can result in much increased flocculant efficiency. For the 1985/86 season, Atlantic Sugar Association installed an automatic juice flocculant preparation unit. Flocculant usage was reduced by almost 30% by comparison with the previous season. Operating experience and results are discussed.

A new target purity curve

J. A. Polack, S. J. Clarke, M. Saska and L. Serebrinsky. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 111 *(Abstract only).*

A new target purity curve has been developed for evaluating molasses exhaustion in US Mainland sugar factories. The curve, the equation for which is: Target True Purity = 42.8 - 13 log (Red. Sugar/Ash), was arrived at independently by both empirical and theoretical approaches. The empirical line was set by inspection of all the exhaustion data obtained from molasses survey samples drawn over the last five years. The line was placed at levels reached in practice only 5% of the time. Plant purities exceeded the line 95% of the time. Thus, the new line gives a practical target for US factories - it gives purities which demonstrably *can* be achieved but, in fact, rarely are. The theoretical approach combined measured solubilities, viscosity data from the literature and a mathematical model to generate a target purity equation. It coincided with the empirical line described above.

Microbiology of the sugar manufacturing process. I. Micro-organisms and their role

V. M. Kulkarni. *Bharatiya Sugar*, 1987, **13**, (1), 89, 91 - 94.

Direct and indirect methods of determining the numbers of micro-organisms in intermediate factory products are described and a list is presented of micro-organisms associated with sugar manufacturing processes as well as the product in which they are found.

Corrosion

C. P. Subhash and U. Naik. *Bharatiya Sugar*, 1987, **13**, (1), 123 - 125, 127, 129.

Factors contributing to corrosion, the electro-chemical theory of corrosion, factors that help to combat it and methods of preventing it are discussed.

Review of working of mills *versus* diffusers

D. S. Lande. *Indian Sugar*, 1987, **37**, 419 - 427.

Data are presented for three Indian factories which operated diffusers for 8 - 10 years and then discarded them because there was no increase in extraction but a rise in steam and electricity consumption, molasses % cane (caused by increased non-sugars extraction and inversion in diffusion), maintenance and operating costs and total sugar losses by comparison with milling alone. In addition, spares had to be imported - a process that could take much time. The theme of diffuser *vs.* mill is discussed.

Beet sugar manufacture

The efficiency of the extraction process in inclined twin-scroll diffusers

A. I. Fel'dman, E. V. Minenko, V. I. Asaulyuk and A. V. Emel'yanenko. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 123 *(Abstract only).*

The mass transfer process in inclined twin-scroll diffusers was investigated with allowance being made for longitudinal mixing of the phases. It was proposed to introduce additional coefficients characterizing the efficiency of the extraction process proper and allowing quantitative assessment of the effect of hydrodynamic factors and evaluation of the effect of scale and of design features on mass transfer. Efficiency coefficients have been obtained for all sizes of DDS diffusers and the nature of their variation determined.

Application of nephelometry to the monitoring of juice purification

J. M. Hochart, R. Delgove and J. P. Lescure. *Sucr. Franç.*, 1987, **128**, 403 - 412 *(French).*

Nephelometry, whereby turbidity is determined by measuring diffracted light perpendicular to incident light, was used in experiments on the monitoring of the performances of settlers, filter-thickeners and carbonatation mud filters at five sugar factories. Results are given in the form of diagrams together with correlation coefficients; equations are also given relating the measured turbidity to the suspended matter content for each type of filter. The results demonstrate the applicability of the technique to assessment of type of equipment, comparison of filter cloths, and checking cloths for wear.

Metal sugar silos of 10,000-ton capacity

O. Tuma. *Czechoslovak Heavy Ind.*, 1988, (1), 29 - 32.

An illustrated description is given of a 24 m diameter × 30 m high cylindrical silo of Czechoslovakian design and manufacture for storage of 8800 - 9200 tonnes of white sugar at a constant +25°C internal temperature (at an outside temperature down to – 25°C) and a relative humidity of 50 - 60%. Sugar is charged by means of a bridge attached at one end to the silo axis and travelling along a circular track at the other end at a height of 26.3 m; worm conveyors suspended below the bridge move the sugar towards the centre of the silo and also level the sugar surface. Sugar is unloaded at the bottom of the silo via discharge ports in a steel cupola; it enters a chute above a vibratory feeder by which it is transferred to a belt conveyor beneath the floor and then enters an elevator for removal to the transport point.

Comparison of two methods of obtaining sucrose from sugar beet with regard to the betaine content. III

M. Spanar, M. Kovac, Z. Jancekova and I. Kozar. *Bull. Potravin. Vysk.*, 1987, **26**, (1), 29 - 37; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (1), Abs. 1 R414.

Results are given of betaine determination in products (raw juice, syrup and molasses) prepared under laboratory conditions from raw juice extracted from cossettes by the conventional method and by a new method of extraction with a mixture of water and acetone. The betaine content was determined by HPLC. It was found that the products obtained by both methods contained approximately the same amount of betaine.

Surfactants in sugar crystallization

A. VanHook. *Sugar J.*, 1987, **50**, (6), 5 - 7.

Spontaneous nucleation, single-crystal and boiling experiments are reported in which the effects of surfactants were studied. No unusual habit modifications were found in crystals formed by spontaneous nucleation of surfactant-containing syrups at room temperature or 60°C; the same was also true of seeded syrups and of individual crystals grown to a considerable size, although there was suspicion of slightly reduced growth rate along the *c*-axis where anionic surfactants were involved (this and other unusual behaviour were to be investigated further). However, while the surfactants had no marked effect on the basic growth rate they did cause secondary nucleation but reduced conglomeration. A reduction in boiling time in the case of low-purity feed containing surfactant was attributed to a lubricating effect as well as to the secondary grain formation rather than to a reduction in solubility or viscosity. A study of surfactant adsorption gave inconclusive results but did suggest that most of the impurity is contained in the film adhering to the surface of the crystal which could not be removed even by careful purging. Surfactants improved the appearance of crystals.

Thoughts on techniques for sugar syrup decontamination

A. Preti. *Ind. Alimentari*, 1987, **26**, 1124 - 1128, 1136 *(Italian).*

White sugar as delivered to the industrial consumer often contains organic and inorganic impurities such as fibres and carbon, crystals of insoluble salts and traces of metal, etc. caused by abrasion and abnormal use of process equipment. There may also be bacterial contamination, although syrups of >55°Bx show a bacteriostatic effect (but the level may still be significant). The advantages and disadvantages of precoat filtration using diatomaceous earth and of the use of cartridge filters are indicated, and details given of the Profile porous polypropylene or nylon tubular element which has proved successful in treatment of 60°Bx syrup. Advantages of the Profile system are listed.

Heating low-grade massecuite before spinning

K. Wagnerowski. *Gaz. Cukr.*, 1987, **95**, 145 - 149 *(Polish).*

Reduction of low-grade massecuite viscosity by dilution with water or by reheating is examined and the latter method favoured. Equations are presented for calculating the temperature to which the massecuite should be heated, the consequent fall in viscosity, colour, amount of intermediate products and molasses sugar and improvement in C-sugar and white sugar purities as well as heat economy.

Treatment of sugar factory flume water using organic flocculants of Polish manufacture. Factory tests

T. Wolski and B. Polec. *Gaz. Cukr.*, 1987, **95**, 161 - 164 *(Polish).*

Tests at Melno sugar factory are reported in which Rokrysol WF-1 and Instar K-4 were added in varying quantities to flume water; at an optimum 50 - 55 g/m^3 the former flocculant was the more efficient, reducing the overall mineral and organic impurities content by 84% at a dosage rate of 54 g/m^3. However, neither flocculant reduced the COD or BOD_5 to any appreciable extent. Both preparations were in the form of gels, and lumps still occurred despite several hours of mixing with water at 40 - 50°C; moreover, pumping of the water tended to break up the flocs that had formed. It is considered preferable to use a flocculant in powdered form. Another major difficulty was caused by considerable fluctuation in the water flow rate, so that accurate proportioning of flocculant and water was not possible. The current high costs of flocculants is a major obstacle to their greater use in the Polish sugar industry.

Evaluation of the operation of a falling-film evaporator

P. Kadlec and Z. Bubnik. *Listy Cukr.*, 1988, **104**, 12 - 17 *(Czech).*

The performance is discussed of a prototype triple-effect falling-film evaporator provided with 8 m tubes plus a concentrator having 5 m tubes, all operating under pressure (which is reduced in the concentrator), and having a total heating surface area of 2520 m^2 (630, 1120, 630 and 140 m^2). Average juice residence time was 11.5 minutes, during which juice colour rose by only 17% and the final thick juice Brix was raised to 65°. The heat transfer coefficient in each vessel was close to the design value. Insufficient bleeding of 3rd effect vapour (only 50% of that planned) led to high condensation losses.

Changes in the content of certain nitrogenous compounds during raw juice purification

M. Wachowicz. *Listy Cukr.*, 1988, **104**, 18 - 21 *(Czech).*

The quantities of total N, ammoniacal and amide N, protein N and α-amino-N were determined in raw, prelimed, limed and thin juice from laboratory purification and the results tabulated. At all stages, the protein N as found by the tannin method was lower than that given by the Barnstein method as set out in official Polish factory control instructions. Preliming removed up to 25% of the protein matter, but most of it was precipitated in main liming. Of the total free amino-acids (averaging 220 ppm on sucrose), approx. one-third was removed in purification; the fall in content at each stage of treatment was almost parallel with the decrease in the quantities of glutamine and glutamic acid.

Carbonatation mud consistencies

A. Smelik, G. Halasova and S. Fuzy. *Listy Cukr.*, 1988, **104**, 22 - 24 *(Czech).*

Whereas batch filter-presses of the type used in factories some years ago produced a filter cake of sufficiently low moisture content that could be transported to the dump or transferred by belt conveyor, continuous rotary filters that replaced them yielded a cake that was of different structure and was too wet to be handled in the same way as previously. Rheological examination of carbonatation mud has shown that while the texture changes with temperature, the major effect is that of the dry solids content over a relatively narrow range. At >50% solids and 20°C, increase in dryness is accompanied by the occurrence of thixotropy and greater hysteresis; at <50% solids and 20°C, pseudoplasticity becomes transient and thixotropy disappears, while at 40°C the cake is pseudoplastic with reduced thixotropy at >53% solids, is in an intermediate state at 45 - 53% solids and becomes plastic at <45% solids. Use of a penetrometer showed that the consistency of 1st carbonatation mud falls rapidly with decreasing dry solids content.

Effect of soil penetration resistance and degree of compaction on yield, harvest quality and processing quality of sugar beet

J. Zahradnicek *et al. Listy Cukr.*, 1988, **104**, 31 - 37 *(Czech).*

Amongst the results of investigations was a fall in beet quality and sugar content and increase in nitrogenous matter as a result of greater soil penetration resistance and compaction; a considerable rise in compaction also led to high K and Na contents, but compaction did not noticeably affect the reducing sugars content or sugar losses in storage.

The density and specific surface area of carbonate matter from first carbonatation juice

A. Smelik, G. Halasova and S. Fuzy. *Listy Cukr.*, 1988, **104**, 37 - 39 *(Czech).*

The specific surface area of carbonatation mud gives an approximate guide to its separability; while investigations have shown that 1 kg of mud having an average pore size of 10 μm has a specific surface area in the range 1600 - 14,100 m^2, the value for dewatered mud will be typically 5700 ± 300 m^2. The contribution made by beet non-sugars and lime to the density of carbonatation mud is discussed; while the traditional liming process in Czechoslovakia uses 2.0 - 2.5% lime on beet (giving a mud density of 13 g/cm^3 at 50% dry solids), it is considered preferable to reduce the lime consumption to 1.2 - 1.8% (giving 12.5

g/cm^3), particularly since thermal degradation of the organic components to carbon causes an increase in density. A new carbon-carbonate material obtained by this means can be used as a filler in the rubber industry and for vulcanization.

Thermal degradation of carbonate matter

A. Smelik, S. Fuzy and G. Halasova. *Listy Cukr.*, 1988, **104**, 39 - 42 *(Czech)*.

Thermal degradation of substances in carbonatation mud causes a sequence of interconnected processes, by contrast with thermal dissociation of limestone for which heat transfer and CO_2 diffusion are the decisive factors. At a temperature up to 600 ± 50°C the liberation of CO_2 is blocked by the carbonized residue of organic matter. Hence, the greater the proportion of structure-forming carbon material, the smaller is the percentage of lime per unit time during calcination at 600°C. The carbon component in carbonatation mud is not charred at <850°C.

The drying properties of carbonatation mud

A. Smelik, G. Halasova and S. Fuzy. *Listy Cukr.*, 1988, **104**, 42 - 46 *(Czech)*.

Investigations demonstrated the possibility of dewatering carbonatation mud by natural drying in air at 24 ± 2°C and 50 - 60% relative humidity. The dry solids content was raised from 50.9% to 89.3% by exposing 8.5 mm diameter columns of mud to these conditions. Adding 5% carbonized mud reduced deformation of these columns and raised the final dry solids to 93.5% after 12 hr and to 95% after 16 hr.

The decolorizing action of sodium bisulphite on syrups

G. Vaccari, G. Sgualdino and A. Vignali. *Ind. Alim. Agric.*, 1987, **104**, 1177 - 1180 *(French)*.

Laboratory and factory tests were conducted on thin and thick juice decolorization using sodium bisulphite added in increasing quantities of SO_2 up to 300 ppm. There was a progressive fall in colour of laboratory samples stood for 2 hours at 80°C after addition of bisulphite as against a progressive increase in colour in the control, the reduction in colour being greater as the amount of bisulphite was increased, particularly over a prolonged period of standing; these results were confirmed by subsequent experiments in which demineralized juice samples were evaporated to 70°Bx in a rotary unit at 80°C. Factory evaporation trials substantiated the laboratory results, while storage of thick juice also demonstrated the benefit of bisulphite treatment in reducing colour formation (which is usually substantial in storage under Italian climatic conditions). Sodium bisulphite has a higher decolorizing efficiency than sodium sulphite while also being less melassigenic.

A way of improving the heat economy of a raw sugar factory with Appeldorn sugar factory as example

U. Curdts. *Zuckerind.*, 1988, **113**, 117 - 124 *(German)*.

Appeldorn and Ameln are two raw sugar factories that send their sugar to Elsdorf refinery; Appeldorn was erected in 1976/77 with an initial daily beet slice of 4500 tonnes which has been increased to a current 6200 tonnes. Comparison is made between the steam and electricity consumption in 1978 (when a quintuple-effect evaporator operated and a low-grade massecuite station was installed to allow production of molassed pulp, 50% of the run-off being processed and the steam consumption totalling 27.2% on beet), in 1981 (when the 1st and 2nd effects became 1a and 1b with a vapour compressor between 1b and the 2nd effect, all of the run-off was processed and the steam consumption totalled 24.66% on beet, with a newly installed Quentin unit accounting for 1.4% on beet) and in 1986 (when the evaporator was expanded to a sextuple-effect station with vapour compression, the diffuser capacity was increased to reduce juice draft, a $2^1/_2$-massecuite boiling scheme was introduced and steam consumption fell to 18.9% on beet). However, electricity consumption jumped when the vapour compressor was installed but was reduced to the original level (and in fact fell below the 1978 figure when expressed on sugar) by a number of measures including modifications to the electric drive and pump arrangements throughout the factory, reduction in the amount of pulp dried and adoption of anaerobic waste water treatment. Details are given of the amount of electricity consumed by the individual process stations and of the proportions of imported and factory-produced power in each campaign from 1977 to 1986.

Modernization and expansion of Dinteloord sugar factory from 12,000 to 14,400 - 16,400 tonnes/day beet slice

H. Wunsch. *Zuckerind.*, 1988, **113**, 126 - 131 *(German)*.

Details are given of the new equipment installed and of the various re-arrangements made in modernization and expansion of Dinteloord white sugar factory in Holland over a period of four years; the factory continued to operate during the changes. A list is appended of the equipment suppliers.

Use of monosaccharide-degrading infections in diffusion to improve pulp pressing

G. Pollach and F. Hollaus. *Zuckerind.*, 1988, **113**, 132 - 136 *(German)*.

See *I.S.J.*, 1987, **89**, 105.

Unconventional cooling-crystallization

G. Mantovani, G. Vaccari and G. Sgualdino. *Zuckerind.*, 1988, **113**, 137 - 140.

See *I.S.J.*, 1987, **89**, 109.

Starch based sweeteners

Characteristics and applications of immobilized glucoamylase

S. H. Cho and Z. U. Kim. *J. Korean Agr. Chem. Soc.*, 1985, **28**, (4), 233 - 238, E; through *Food Sci. Tech. Abs.*, 1987, **19**, Abs. 7 L 4.

Glucoamylases prepared from *Rhizopus* spp. were attached to porous glass and immobilized by glutaraldehyde-induced crosslinking. The porous glass used was ZrO_2-coated, of 40 - 80 mesh and 55 nm pore diameter. Up to 50 mg protein/g carrier could be immobilized. The substrate was an enzyme-modified thin-boiling 30% maize starch solution. Immobilized glucoamylase had an optimum pH of 7.0, higher than that of the soluble form. Km values of immobilized and soluble enzymes were 1.04 mM and 1.25 mM, respectively. The thermal stability of glucoamylase was increased by immobilization (optimal temperature 40 - 60°C). Continuous conversion of maize starch to glucose using immobilized glucoamylase enzyme produced a syrup having >90 DE.

Corn syrups

L. Hobbs. *Cereal Foods World*, 1986, **31**, (12), 852, 854, 856, 858; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (20), Abs. 20 R483.

The main types of corn syrup produced and their sugar composition are surveyed: maltodextrin of DE 12, syrups obtained by acid hydrolysis of starch having DE 27, 36, 42 and 55, high-maltose syrups obtained by acid/fermentative hydrolysis of DE 43, 49, 65, 70 and 95, and high fructose syrups containing 42 and 55% fructose. Their physicochemical properties are discussed as well as their degree of sweetness compared with sucrose, viscosity and freezing point as a function of concentration, properties and functional purposes of the syrups according to their composition.

The manufacture of high-fructose syrup from sweet potato. I. Liquefaction and saccharification of sweet potato starch

S. H. Chen, S. S. Tsai and C. C. Chou. *J. Chin. Agr. Chem. Soc.*, 1986, **24**, (3), 309 - 319; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (21), Abs. 21 R392.

In a study of sweet potato starch dilution and saccharification for HFS production, it was found that hydrolysis in 1.5M sulphuric acid solution at 100°C for 2 hours will yield a syrup having a DE of 90. Optimum conditions for enzymatic liquefaction of the starch with α-amylase (*Bacillus subtilis*) were: 30% suspension concentration, pH 5.5 - 6.0, temperature of 87°C, 0.2% enzyme and 0.3% $CaCl_2$ (on starch). Under these conditions, the DE rose to 12 within 1 hr. After cooling of the syrup to 60°C and adjustment of the pH to 4.5 with 0.1M HCl solution at 0.5% on starch, glucoamylase (*Rhizopus delemar*) was added; after 72 hours' hydrolysis the DE was 95. HFS from the hydrolysate was lighter in colour than that from an acid hydrolysate.

The heat of vaporization of glucose syrups

A. I. Kostov. *Sakhar. Prom.*, 1987, (12), 42 - 44 *(Russian)*.

Before they can be classed as glucose syrups, starch hydrolysates need purifying followed by concentration in evaporators and vacuum pans to an appropriate dry solids concentration. For these last two operations, knowledge of the boiling temperatures at different pressures and concentrations and of the temperature of vaporization is needed. Data on boiling points are available in the literature but not on the heat of vaporization. Babo's law relating to the reduction in vapour pressure of a liquid when a non-volatile substance is dissolved in it was found to be valid in the case of glucose syrups since the constant A in the equation is not temperature-dependent but is a function only of solids concentration. An equation has been derived for the heat of vaporization and values are tabulated for 0.1 - 0.8% concentration by weight at temperatures in the range 55 - 100°C at 5°C intervals and at pressures in the range 15 - 100 kPa at 5 kPa intervals. The relationship between heat of vaporization, boiling point and concentration is also shown in graph form. Values of the heat of vaporization at >0.5% dry solids differ considerably from the heat of vaporization of water and this must be allowed for in calculations.

Benefits of *Bacillus megaterium* amylase in dextrose production

R. E. Hebeda, C. R. Styrlund and W. M. Teague. *Starch/Stärke*, 1988, **40**, 33 - 36.

The glucose yield from saccharified starch is limited by the formation of maltose and isomaltose resulting from repolymerization of the glucose and by the presence of branched sugars not readily hydrolysed by glucoamylase enzyme. Reducing the solids at which saccharification is carried out reduces the disaccharide concentration and thus increases glucose yield, but at the expense of increase in evaporation costs and a risk of microbial contamination; glucose yield can also be increased by using a debranching enzyme to hydrolyse the α-(1 - 6) linkages during saccharification. Amylase derived from *B. megaterium* has been found capable of converting those sugars resistant to the action of glucoamylase to a form that is easily hydrolysed to glucose. The combined action of the amylase (BMA) and glucoamylase increased glucose yield by up to 0.7% in experiments while simultaneously reducing the isomaltose level and almost completely eliminating sugars having a degree of polymerization of at least 4. In addition, the normal glucose level can be reached in a much shorter reaction time in the presence of BMA, which also reduces the glucoamylase requirement, permits saccharification to a higher solids level and provides greater flexibility in operation.

Laboratory studies

Analysis of reducing sugars as their chromatophoric hydrazones by high-performance liquid chromatography

K. Muramoto, R. Goto and H. Kamiya. *Anal. Biochem.*, 1987, **162**, (2), 435 - 442; through *Anal. Abs.*, 1988, **50**, Abs. 1D126.

Reducing sugars were derivatized by heating with 4'-dimethylaminoazobenzene-4-sulphonohydrazide at 50°C for 120 min. The chromophoric hydrazones were separated on a column (5 cm × 4.6 mm) of ODS Hypersil (3 µm) with aqueous 25% acetone - 0.08M acetic acid (pH 6.5) as mobile phase (1.5 ml/min) and fluorimetric detection at 540 nm (excitation at 350 nm). The detection limit was 2 pmol of sugar and calibration graphs were rectilinear for 10 to 100 pmol of sugar.

Sugar analysis with the Shaffer-Somogyi micro-analysis, high-performance liquid chromatography and enzymic analysis in crop samples

M. H. M. Pluijmen. *Commun. Soil Sci. Plant Anal.*, 1987, **18**, 1049 - 1059; through *Anal. Abs.*, 1988, **50**, Abs. 1G1.

Determination of the reducing sugars content in crop tissues by a modification of the Shaffer-Somogyi thiosulphate titrimetric method was assessed in comparison with HPLC-refractometric and HPLC-enzymatic methods. In the titrimetric method the Carbonate 50 reagent contained 1 g of KI instead of 5 g and 200 ml instead of 250 ml of 0.1N KIO_3. A Sep-Pak C_{18} cartridge was used for HPLC, and enzymatic analysis was by the glucose-fructose UV method (Boehringer Mannheim). The occurrence of high results in the Shaffer-Somogyi method caused by positive responses from other compounds is emphasized.

Use of NIR spectroscopy for the analysis of sugar cane quality

A. French, C. B. Sverzut, L. R. Verma and F. A. Martin. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 104 *(Abstract only).*

Near-infrared reflectance (NIR) spectroscopy was compared with the standard press method for determining fibre, sugar, moisture % cane and pol % juice in cane samples. Whole stalks were chipped with a knife mill and the shredded samples divided into two subsamples; standard press analysis was performed on one subsample, while the second subsample was divided into four replicates for NIR analysis. The optical density (OD = $\log {}^{1}/_{R}$, where R = reflectance) was measured in the range 1100 - 2500 nm at 2 nm intervals. The instrument software was used to generate the 2nd derivative of the OD, from which a calibration equation for each quality parameter was obtained with four wavelengths. Calibration correlations of 0.991, 0.910, 0.987 and 0.989 were found for pol, fibre, sugar and moisture content, respectively. Comparison of the values of these parameters as estimated by the NIR method with those found by the standard press technique showed no statistical difference between the two methods; correlations between them were 0.957, 0.834, 0.956 and 0. 957 for pol, fibre, sugar and moisture, respectively. These results suggest that accurate estimates of cane quality can be achieved by the new method. Because chipping is the only sample preparation, considerable time could be saved by the use of NIR for cane quality analysis.

Direct determination of phosphorus levels in molasses samples by inductively coupled plasma

L. J. Henderson, R. P. DeStefano and A. B. Hutcheson. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 110 *(Abstract only).*

A new procedure for determining phosphorus levels in molasses samples without prior digestion was compared with the double acid, molybdate blue method. The direct digestion method is a rapid procedure that requires dilution in 0.1N HCl followed by direct injection into an inductively coupled plasma torch; it had a slope of 1.01 when regressed against the double acid method ($r^2 = 0.99$).

Determination of dextran and other high molecular weight substances in sugar cane factory products by gel permeation chromatography

Y. Oubrahim and M. Saska. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 110 *(Abstract only).*

The total content of high molecular weight (HMW) substances was determined in a number of samples collected in a cane sugar factory during the 1985 season. Initially, the HMW substances were concentrated using a hollow-fibre ultrafiltration system and then separated from the low molecular weight fraction on a series of GPC columns equipped with an RI detector. The samples were also analysed for dextran using the ASI II dextranase-based method, and the results were correlated with the GPC determinations.

Determination of trace quantities of acrylamides in sugar by means of capillary gas chromatography

P. Farkas and J. Tekel. *Listy Cukr.*, 1987, **103**, 275 - 279 *(Czech).*

Tests conducted in 1982/83 demonstrated the effectiveness of Synstabil in reducing evaporator scale; the preparation is a water-soluble, low-molecular, polyacrylonitrile-based polyelectrolyte containing a maximum of 50 ppm acrylamide and 5 ppm acrylonitrile. However, after addition of Synstabil at 10 - 20 ppm to thin juice, a residue of up to 0.38 ppm was found in sugar; the most important component toxicologically was acrylamide. A method developed for determination of acrylamide in sugar has been tested in which potassium bromide, concentrated hydrobromic acid and saturated bromine water are added to an aqueous sugar solution which is then subjected to bromination at 0 - 2°C for 6 hr. The excess bromine

water is removed with sodium thiosulphate and the resultant 2,3-dibromopropionamide extracted with ethyl acetate; the extract is purified on a silica gel column and analysed by gas chromatography on a glass capillary column (14 m × 0.3 mm) with an alkaline flame-ionization detector and OV-1 as stationary phase. Recovery from model sugar samples containing 100 µg and 20 µg acrylamide per kg was 70.0 % and 77.1%, respectively, and the detection limit was 1 µg/kg. Analysis of sugar samples from Modrany experimental sugar factory where Synstabil was used showed an acrylamide content below 0.99 µg/kg compared with a maximum permissible content of 38 µg/kg.

Use of the TNS computer to evaluate quartz control plates and check polarimeter tubes

E. Sarka, J. Gebler, K. Vrskova and H. Bruzkova. *Listy Cukr.*, 1987, **103**, 279 - 283 *(Czech)*.

The application of a program written in MBASIC to quartz control plate and polarimeter tube assessment at the Sugar Industry Research & Development Institute in Prague is described; block schemes for the two tasks and sample print-outs are presented. The system has cut the time normally spent in making the necessary calculations and in entering the details on appropriate forms.

Thin-layer chromatography (TLC) of sucrose and reducing sugars

S. G. Gupta, S. V. Patil, R. B. Natu and S. J. Jadhav. *Bharatiya Sugar*, 1987, **13**, (1), 97, 99, 101 - 104.

A general description is given of TLC as applicable to sucrose and reducing sugars determination, covering choice of adsorbent, preparation of plates, sample preparation and application, solvent systems and development of spots. R_f numbers of sucrose and reducing sugars as reported by different authors are summarized alongside the adsorbents, solvents and visualization methods used.

Concurrent HPLC analyses of carbohydrate distribution and 5-(hydroxymethyl)-2-furaldehyde using robotics

N. J. Mueller, N. L. Good, R. E. Bluth and L. E. Fitt. *J. Chromatogr. Sci.*, 1987, **25**, (5), 198 - 201; through *Anal. Abs.*, 1988, **50**, Abs. 2D155.

A system comprising a Z100 robotic arm, controller and accessories (Zymark Corp.) was programmed to conduct, concurrently, two separate HPLC analyses of corn syrups. Data were collected and analysed by using two Shimadzu C-R3A integrators programmed in BASIC. The system was evaluated by means of standard samples; the results agreed with those from conventional methods. The system is accurate, reliable, flexible, efficient and economical for routine laboratory analysis. The man-hours required are <10% of those needed for manual analyses; concurrent operation allows a substantial additional saving in manpower.

High-performance liquid ion-exchange chromatography

G. Schmuckler. *J. Liq. Chromatogr.*, 1987, **10**, 1887 - 1901; through *Anal. Abs.*, 1988, **50**, Abs. 2J11.

A review (with 21 references) is presented of the determination of amino-acids, sugars, organic acids, anions, cations and metal complexes by ion-exchange HPLC.

The technological value of sugar beet varieties susceptible and tolerant to rhizomania

G. Vaccari, G. Mantovani and G. Sgualdino. *Ind. Sacc. Ital.*, 1987, **80**, 203 - 204, 206, 208, 210, 212, 214, 216, 218, 220 *(Italian)*.

The dry solids contents of samples of brei from two beet varieties (one tolerant and the other susceptible to rhizomania), harvested on 8 different dates, were determined and the press juices then analysed for pol, pH, reducing sugars, certain oxy-acids, inorganic anions and individual and total amino-acids. Pol, Na, K and α-amino-N were also recalculated as meq/100 g brei dry solids. The importance of dry solids content is stressed, particularly where the crop has been grown under conditions of high rainfall. It is considered that conventional analytical methods are not always sufficiently reliable, particularly for purposes of comparison, but near-infra red spectrometry (already successfully applied to rapid determination of brei pol) is of value. The results are discussed in relation to the effects of rhizomania, especially where high rainfall is involved.

Determination of herbicide residues in agricultural crops, foods, soil and water by a chronometric method

J. Kovac, J. Tekel and M. Kurucova. *Z. Lebensmittel-Untersuchung u. - Forschung*, 1987, **184**, (2), 96 - 100; through *S.I.A.*, 1988, **50**, Abs. 88-148.

The method described is based on biochemical detection of herbicides on a silical gel thin layer after chromatographic separation. The detection reagent is a mixture of a homogenate of bean leaves (*Phaseolus vulgaris*) and the redox indicator 2,6-dichloroindophenol. Herbicides inhibit the Hill reaction in photosynthesis, resulting in the formation of dark blue inhibition zones on a pale yellow-green background when the chromatoplates are exposed to light. The dark blue zones disappear after a time which is proportional to the amount of herbicide in the zone. The method does not require a multiple clean-up procedure nor sophisticated instrumentation. It equals GC in sensitivity and precision. Detection limits are 0.01 - 0.001 ppm. Procedures to be used for analysis of various materials (including sugar beet, sugar, sugar juices and molasses) are given. When 0.1 or 0.5 ppm of one of four herbicides was added to beet, thick juice, molasses or sugar, recoveries were 81 - 98%.

By-products

Production of single-cell protein from bagasse. I. Study of bagasse hydrolysis and selection of yeast species. II. Study of the multiplication of *Trichosporon penicillatum* in semi-solid culture in trays

I. J. Pou, X. Figarella, M. J. Fernandez and J. Garrido. *Microbiologia Espanola*, 1985, **38**, (3 - 4), 81 - 88. II. J. Pou, M. J. Fernandez and J. Garrido. *Idem*, 89 - 95; through *S.I.A.*, 1987, **49**, Abs. 87-1661, 87-1662.

I. Of the conditions tested for hydrolysis of bagasse with sulphuric acid under a pressure of 1 atm, the optimum was treatment with 1% acid at a solid:liquid ratio of 1:5 for 30 min. Twenty yeast species were cultured in media containing the hydrolysate as carbon source. The highest yields of biomass (% on C source consumed) were obtained with *T. penicillatum* (68), *Hansenula anomala* (64), *Geotrichum candidum* (59) and *Rhodotorula rubra* (49).
II. A selected species of yeast, *T. penicillatum*, was cultured on a semi-solid medium containing hydrolysed bagasse as carbon source. Hydrolysis had been carried out with water of 0.5% sulphuric acid at 0 pressure or 1 atm and a solid:liquid ratio of 1:3. Under optimum culture conditions (30°C and an air flow of 6 litres/min per 100 g bagasse), conversion to protein was excellent (56 g protein/100 g reducing substances, thus increasing the protein content of the bagasse from 3.5 to 9.1%).

Effect of controlled aeration on glycerol production in a sulphite process by *Saccharomyces cerevisiae*

G. P. Kalle and S. C. Naik. *Biotechnol. Bioeng.*, 1987, **29**, 1173 - 1175; through *S.I.A.*, 1987, **49**, Abs. 87-1666.

A cane molasses medium (40% reducing sugars) was fermented with addition of 4 g sodium sulphite/litre hourly for the first 5 hr and aeration at 0, 0.34, 0.67, 1.4 or 2.2 vol/vol/min. As aeration was increased from 0 to 1.4 or 2.2 vol/vol/min, the maximum glycerol concentration more than doubled to 96 g/litre and productivity trebled to 16 g/litre/day. The yeast tolerated the high initial con-centration of sugars. Ethanol concen-tration in the fermented medium was only about 11 - 12 g/litre. Further increase of aeration to 2.2 vol/vol/min gave a much lower glycerol concentration and productivity. The process offers an alternative to vacuum fermentation.

The sugar beet – a suitable raw material for biotechnology

B. Kretschmer. *Lebensmittelind.*, 1987, **34**, 274 - 276 *(German)*.

The potential of beet sugar as raw material for ethanol fermentation is discussed within the East German context. The desirability of producing ethanol primarily as fuel is prompted by the exhaustibility of fossil fuel sources and the imports of coal, oil and natural gas into East Germany, mainly from the USSR. Ethanol as raw material for a range of chemical products is also considered. The advantages of sugar beet over corn, wheat and potato as a source of energy include the greater energy yield per unit cultivation area and the fact that the sugar is directly fermentable. Ways in which ethanol production can be optimized are indicated.

The effect of carbon dioxide pressure on molasses wort fermentation

L. V. Malysh, V. K. Yanchevskii, A. D. Kovalenko, V. V. Rudaya and N. D. Emel'yanova. *Ferment. i Spirt. Prom.*, 1987, (5), 30 - 33; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (1), Abs. 1 R358.

It has been found that increase in the partial pressure of carbon dioxide from atmospheric to 0.3 MPa in anaerobic fermentation of molasses leads to an increase in alcohol yield, but also increases the fermentation time by 25 - 30%, thus necessitating the use of special fermentation equipment to maintain the high pressure. The use of a lower pressure of 0.05 MPa allows a 10% reduction in the content of unfermented carbohydrates in the mature wort by reducing the inhibiting effect of dissolved carbon dioxide.

The question of fructose quality

N. I. Odorod'ko, N. A. Arkhipovich and A. A. Ostrovskaya. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 45 *(Abstract only)*.

To determine the efficiency of a technique developed for production of fructose from sucrose, the quality of the manufactured product was investigated. The composition of crystal fructose obtained under process conditions at Cherkassy refinery was determined and found to conform to standard requirements for a chemically pure reagent.

Stoichiometry of the alcohol fermentation of cane juice

J. Finguerut, H. A. Lucredi, K. H. Leimer and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1985, (33/85), 45 - 48 *(Portuguese)*.

The fermentation of the sucrose in cane juice does not give a 100% theoretical yield of alcohol and the stoichiometry of the process is examined in respect of other products. The main cause of the reduction of yield to 91% is formation of glycerol (8.2 kg/100 kg of alcohol), while others are formation of acids (3.3 kg/100 kg) and yeast (3.2 kg dry matter/100 kg alcohol). The authors note that contamination by lactic acid bacteria appears not to be important industrially.

Biodigestion of vinasse with up-flow mud blanket reactors

T. C. Lampoglia and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1985, (33/85), 53 - 56 *(Portuguese)*.

The anaerobic digestion process and its advantages and disadvantages for waste water treatment are described. The present use of vinasse and related problems are discussed as are the various parameters involved in design

and operation of an aerobic digestion system. The potential energy recovery by anaerobic digestion of vinasse is described, and an account given of research by Copersucar on the process.

Increase of effective production capacity for hydrated ethyl alcohol – alterations which can be effected in an anhydrous alcohol production unit

T. Igarashi, C. A. Gonzales and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1985, (33/85), 65 - 69 *(Portuguese)*.

Computer simulation was used to examine increased production of hydrated alcohol in a plant built for an hydrous alcohol. It was seen that the distillation column capacity was 2.5 - 2.7 times that of the rectifying column and a rearrangement whereby the dehydration column was used as a parallel rectifying unit proved successful in raising the capacity of the unit to the expected figure.

Direct contact heating and flash cooling of cane juice for alcohol production

W. Pizaia, D. T. Oliveira and C. E. V. Rossell. *STAB*, 1986, **4**, (6), 121 - 123.

Mixed cane juice needs to be treated before fermentation owing to its high content of undesirable bacteria, moulds and yeasts. A system has been developed whereby the mixed juice at 34 - 35°C is heated in three stages using multi-jet heaters fed with vapour from a pre-evaporator at 115°C and also vapours from flash tanks. The juice is heated thereby to 105°C and may be settled in a trayless clarifier or may pass direct to the flash tanks which are in series, with the last connected to a barometric condenser. The hot juice loses vapour which is returned to the multi-jet heaters while being cooled in stages ready for fermentation. The advantage of the system is that less steam is required than the conventional separate heating and cooling, and investment cost is low. It operated in factory trials at Usina Paredão in 1985.

Louisiana molasses

S. J. Clarke. *J. Amer. Soc. Sugar Cane Tech.*, 1987, **7**, 109 *(Abstract only)*.

The diversity of uses of final molasses, e.g. in blends for human consumption, as a fermentation feedstock and as animal feed, requires varying specifications for the molasses. These involve analyses which are not standard procedure for a sugar factory laboratory, e.g. colour and suspended solids for direct-consumption blends, non-fermentable reducing substances for alcohol production and gelling of molasses in animal feed production. Data are presented on these and other parameters measured in a study designed to give a fuller characterization of Louisiana molasses.

Effect of anti-foam agents used in sugar manufacture on foam dispersal during citric acid production

A. Nowakowska-Waszczuk, K. Kedziora, J. Balaban and A. Debiec. *Przem. Ferm. i Owoc.-Warzyw.*, 1987, **31**, (4), 26 - 27; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (3), Abs. 3 Ж375.

In an investigation of the effect of Spumole C, Spumole P, K-2 and K-3 (used as anti-foam agents in the sugar industry) on the development of *Aspergillus niger* in the production of citric acid by surface fermentation using molasses solution as substrate, it was found that strains of *A. niger* were highly sensitive to the preparations.

Aconitic acid – problems and potentials

S. G. Gupta and S. J. Jadhav. *Bharatiya Sugar*, 1987, **13**, (1), 33, 35 - 36.

The occurrence of aconitic acid in cane, its properties, methods of isolation, its recovery from molasses or juice by addition of Ca and anhydrous Mg chloride, its analysis, possible applications and potential availability in India are discussed.

Evaluation of synthetic methods of 5-hydroxymethyl 2-furancarboaldehyde (HMF) for large-scale preparation

A. D. Kulkarni, H. M. Modak and S. J. Jadhav. *Bharatiya Sugar*, 1987, **13**, (1), 53, 55 - 56.

Methods of hydroxymethyl furfuraldehyde synthesis from fructose are described.

By-products of the sugar industry as potential substrates for fermentation processes

S. Srikanta and N. G. Karanth. *Bharatiya Sugar*, 1987, **13**, (1), 65, 67, 69, 71.

A survey is presented of fermentation processes involving filter cake, bagasse and molasses, respectively.

Integrated plan for utilization of sugar cane trash for the production of biogas and particle board

P. G. Gosavi, V. S. Ghole and M. V. Hegde. *Bharatiya Sugar*, 1987, **13**, (1), 95 - 96.

A process is proposed for manufacture of particle board from moist leaf trash which is first crushed and the juice fermented to yield biogas and a slurry that is of value as a fertilizer. The residual solids comprise cellulose and lignin which are cooked, beaten, moulded into shape and hot pressed.

Continuation of the bioethanol file. The ADECA point of view

Anon. *Sucr. Franç.*, 1988, **129**, 31 - 33 *(French)*.

The prospects of using fermentation alcohol as motor fuel are discussed from the viewpoint of a major organization representing growers of the various crops (including sugar beet) that could act as feedstock. ADECA is currently involved in the experimental operation of four buses and a tractor fuelled by ethanol. The important position of the sugar industry in regard to fuel alcohol production is noted.

Diffusive dewatering is currently being studied by British Sugar on a laboratory scale. Results to date indicate that for a given molasses to pulp ratio, the pulp dry substance obtained after pressing the molassed pulp is linearly proportional to the molasses concentration (see Figure 2).

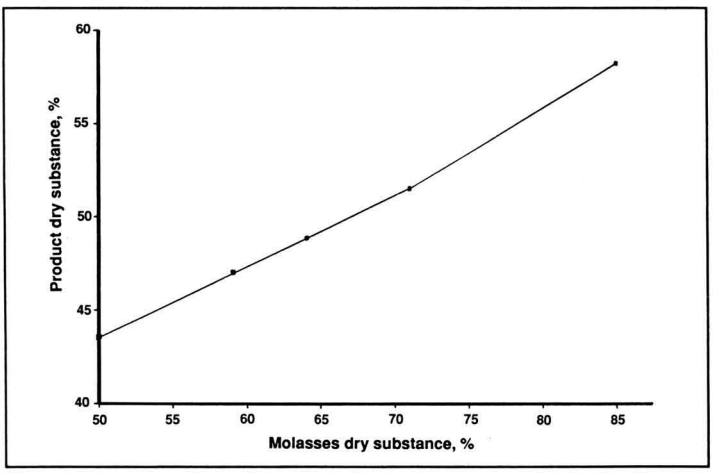


Figure 2. Diffusive watering

The studies by Austmeyer and British Sugar have been carried out using molasses as the most appropriate liquid, but it would seem likely that other concentrated solutions might have similar effects. The possibility exists of using molasses with other solids added to increase the solids concentration, perhaps to give a lower viscosity than concentrated molasses of the same solids content.

Other techniques

The application of enzymes to improve pulp pressing is being investigated by several workers. The effects of a wide range of enzymes on pulp have been studied by Caro[63] and by Matalla & Buchholz[64]. These included cellulases, pectinases, amylases, proteases, hemicellulases, and pectin esterases. In many cases they found significant increases in dry substance when treated pulp was pressed compared with untreated pulp. Caro reported a dry substance of 45% after treatment with *Aspergillus niger* mycelium. However he found that enzyme techniques also gave a decrease in the yield of pulp dry substance and reduced its feed value.

In 1984 Mottard studied the effect of pectin methyl esterase in the presence of calcium pressing aids[61]. In theory the enzyme should de-esterify the methylated carboxylic groups on the pectin, creating more sites for the calcium ions to bind to, and hence increasing the effect of the pressing aid. However, in practice no significant effect on pressed pulp dry substance was observed. Others including British Sugar are also studying the effects of enzymes but have not yet published their results.

Electroacoustic dewatering is a novel technique currently being developed by the Battelle Institute[65,66], combining application of an electric field and sound waves to a range of dewatering applications, including sugar beet pulp. A combination of several mechanisms are involved. When sound waves are applied to a suspension of solids in liquids the forces generated at the solid-liquid interface have the capacity to reduce the surface tension and apparent viscosity of the liquid, with a resultant increase in diffusion of water from the particles. Movement of the particles may also increase the migration of interstitial water.

Application of electric fields to suspensions can cause improved dewatering by several mechanisms, of which electro-osmosis is probably the most important. Muralidhara *et al.*[65] discovered a synergistic effect when electrical and acoustic dewatering were applied simultaneously during filtration. Early studies were applied to vacuum or pressure filtration of slurries of fine or colloidal particles, such as starch suspensions and sewage sludges. However, more recently the technique has been tried on fibrous particulate materials including sugar beet pulp and orange pulp[66]. In preliminary experiments it is reported to increase beet pulp dry substance from 23.1% to 26.7%. It is to be hoped that development of the process may lead to much greater increases. Electroacoustic dewatering equipment has been fitted to screw and belt presses of capacity 10 - 100 tonnes per day, for pilot-scale studies covering a wide range of application for this interesting new process.

Centrifugation is another technique often applied to the dewatering of sludges and filter cakes. However, Austmeyer[15] has shown that the pressures exerted on water in a capillary by centrifugation is relatively small even at high rotational speeds. He considered that under most circumstances there was no opportunity for using centrifuges to dewater pulp. One possible exception is in the diffusive dewatering process, described above, for separating the pulp and diluted molasses.

Integration with drying

Just as there have been developments in pulp pretreatment, extraction and pressing, so too there have been in pulp drying. Generally these have been

continued on page 167

63 *Zuckerindustrie*, 1985, **110**, 691.
64 *J. Microbial Biotechnol.*, 1986, **1**, 27 - 34.
65 Muralidhara *et al.*: in "Advances in solid-liquid separation", Ed. Muralidhara (Battelle Press, Columbus) 1986, 335 - 374.
66 Idem: *Paper presented to 5th Symp. on Separation Science and Technology for Energy Applications*, 1987.

Effects of impurities on hydrolysis of sucrose in concentrated aqueous solution

By T. L. Lowary and G. N. Richards*
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Introduction

Recently we have investigated the thermal degradation of non-crystalline sucrose (i.e. sucrose melts) at relatively low temperatures such as 120°C, at which pure crystalline sucrose is very stable[1]. At 120°C the degradation of non-crystalline sucrose is very much accelerated by the presence of sodium chloride and by reducing sugars, especially fructose. On the other hand, the sucrose was stabilized against the degradation by the presence of small amounts of sodium carbonate. These effects were attributed to an initial very slow thermal degradation of sucrose by mechanisms which have previously been detailed[2]. The initial products of this degradation are α-D-glucopyranose and fructosyl cation and the latter is rapidly degraded further to a complex mixture of products in which hydroxymethylfurfural predominates. These secondary degradation products include small proportions of acids such as levulinic and formic acids, and it is the initial trace quantities of these acids which induce the autocatalytic decomposition of the non-crystalline sucrose, resulting in the initial lag phase and then the rapidly increasing disappearance of sucrose. The effects of adding reducing sugars to the non-crystalline sucrose is to increase the rate of formation of the acidic secondary degradation products, and so to accelerate the sucrose degradation. Fructose is especially effective because of its own rapid degradation. Sodium carbonate (and any other weak base or alkaline buffer) stabilizes the non-crystalline sucrose by neutralizing the traces of acidic secondary degradation products, and we have postulated that sodium chloride may accelerate the degradation by lowering the dielectric constant of the melt and so favouring the heterolytic reactions involved in the degradation.

The above studies are relevant to several situations in sucrose manufacture and in food processing in which amorphous sucrose, in the presence of little or no water, is subjected to heat[1]. In many

T. L. Lowary

G. N. Richards

other "real life" situations, sucrose is heated in concentrated aqueous solutions at neutral pH.

In such cases the obvious dominant reactions are hydrolysis and subsequent degradation of the resultant fructose and glucose, especially the former. This may occur in sugar boiling during milling and refining and also in many food process operations. In some cases, e.g. in candy manufacture, the partial hydrolysis of sucrose may be beneficial to the process; in other cases it is not necessarily an intended result of the process. In such circumstances, impurities such as reducing sugars and salts are normally present and the results described below show that both types of impurity have dramatic effects on sucrose degradation.

The influence of salts on rates of acid-catalysed hydrolysis of sucrose (i.e. inversion) has previously been studied by several groups[3], normally using relatively dilute sucrose solutions, relatively concentrated acids (e.g. 0.1M hydrochloric acid) and similar molar concentrations of inorganic salts. In such systems, the addition of 0.1M salt may increase the rate of sucrose hydrolysis by about 8%, while 0.5M salt causes about 50% increase[4]. Both cation and anion effects of salts have been studied in such systems[5], magnesium being the most effective of the monovalent and divalent cations. However, the cation effects of salts demonstrated in these systems with low sucrose concentrations are very much less than those described in the present study with high sucrose concentrations and require very much higher relative concentrations of cation. Also, in the present study, using neutral pH and concentrated sucrose solutions, the low concentrations of salts produced dramatic changes in the form of the hydrolysis curve, especially by reducing an initial lag phase.

Experimental

Sucrose and all other substrates were Analytical Grade reagents used as received. All water was purified by distillation, followed by ion exchange treatment to resistivity greater than 18 megohm/cm.

A stock solution of sucrose and water (e.g. 20 g and 7.5 g, respectively) was prepared with minimal heating and a weighed amount of monosaccharide or salt added if required. Accurately weighed amounts (ca. 0.25 g) of the solution were transferred to glass test tubes which were then sealed and held under thermostatically controlled conditions at 100° ± 0.2°C for the required time. After cooling, the tubes were opened and the contents quantitatively dissolved in a measured volume (10 ml) of a stock solution of 5% ethanol in water. The solutions were analysed by HPLC with water eluant at 1.0 ml/min using a Waters Dextropak radial compression column at room temperature and detection by differential refractive index. The response factors of all components of the solutions were determined during each set of analyses with respect to ethanol using authentic compounds, and the response factors were used to determine concentrations in the final solutions. Low degrees of conversion (up to 2%) were calculated from the combined yields of glucose and fructose (except for experiments in which glucose and fructose were added) and for higher conversions, the sucrose content was used to calculate conversion. Glucose and fructose (R_T 3.5 min) do not separate in the above system and all of the salts used eluted before the

* Correspondence should be addressed to this author

1 Richards: *I.S.J.*, 1986, **88**, 145 - 148.
2 Moody & Richards: *Carbohydr. Res.*, 1983, **124**, 201 - 213, and earlier references therein.
3 Mauch: *Sugar Tech. Rev.*, 1971, **1**, 239 - 290.
4 Guggenheim *et al.*: *Trans. Faraday Soc.*, 1955, **51**, 1387 - 1391.
5 Wodtcke: *Z. Phys. Chem.* (Leipzig), 1962, **220**, 145 - 168.

monosaccharides. Sucrose eluted at 4.5 min and ethanol at 6.9 min.

Results and discussion

Figure 1 shows the rate of loss of sucrose at 100°C in a solution containing 20 g of sucrose and 7.5 g of rigorously deionized water. As with the thermal degradation of amorphous sucrose[1], a lag phase is observed in sucrose loss and we postulate the same type of explanation. That is, that the initial rate of hydrolysis of sucrose by water is extremely slow, but finite. The products are fructose and glucose, which degrade relatively rapidly under these conditions to produce a mixture of products, including some acids such as levulinic and formic (of course hydroxymethylfurfural is the major degradation product). These minor acid products from the initial hydrolysis products then induce the autocatalytic form of the curve shown in Figure 1. To verify the above hyphothesis, the addition of 10% glucose (based on sucrose) reduces the lag phase, while the same amount of fructose almost removes the lag (Figure 1), and in the same experiment, fructose was observed to be lost much more rapidly than glucose.

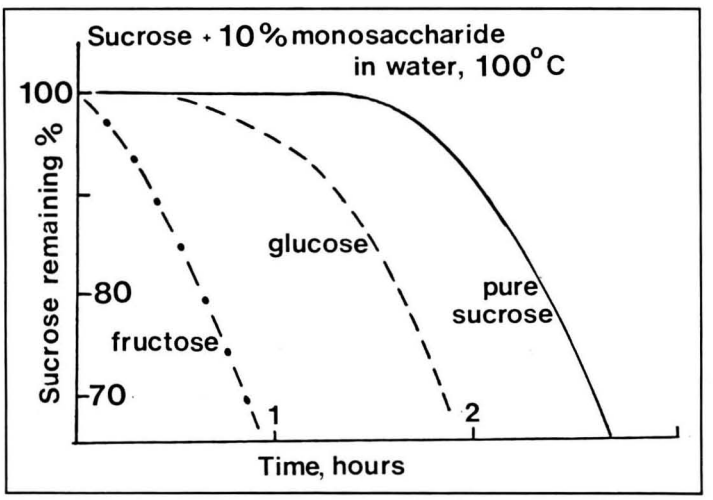

Fig. 1. Degradation of sucrose in water at 100°C; effect of added glucose and fructose

The effect of a small amount of an alkaline buffer on sucrose hydrolysis at 100°C is shown in Figure 2, where 0.05 moles of sodium acetate per mole of sucrose are seen to confer complete stability (within the accuracy of the experiment) on the sucrose for more than four hours. This is interpreted as being due to neutralization of secondary acidic degradation products which would form from any traces of primary hydrolysis products. The effect of sodium chloride on the sucrose hydrolysis is also shown in Figure 2. This is observed as a dramatic shortening of the lag phase in sucrose loss (i.e. an acceleration of the hydrolysis). This effect is produced by a ratio of only one mole of sodium chloride to 20 moles of sucrose. There are two possible types of explanation for this effect: either the sodium chloride accelerates the initial slow hydrolysis of sucrose and thus increases the initial rate of formation of primary products and hence the rate of formation of acidic secondary degradation products or, alternatively, the sodium chloride accelerates the rate of degradation of primary products (glucose and fructose) to acids. It is possible that both effects operate and on the present evidence we are not able to reach a definite conclusion.

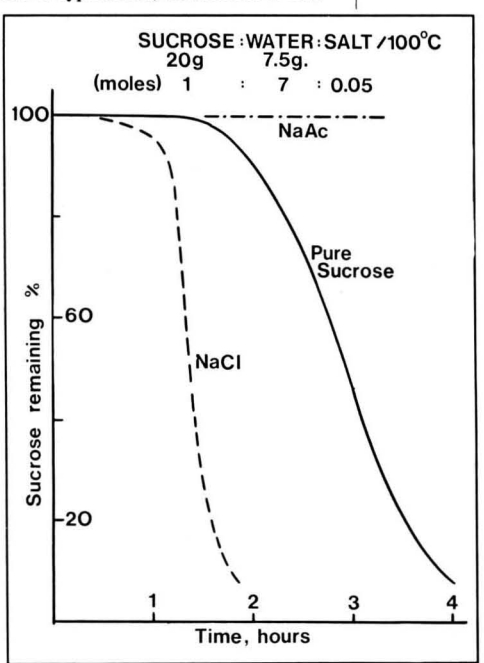

Fig. 2. Degradation of sucrose in water at 100°C; effect of sodium acetate and sodium chloride

The influence of other salts is shown in Figure 3. Cations have been chosen which are common and often abundant in sucrose processing, the anion is chloride throughout and the mole ratio of salt to sucrose has been maintained at 1:20. It is evident that calcium ions are more effective than sodium and that magnesium ions are much more effective in accelerating the sucrose hydrolysis. The other alkali metal chlorides were also studied but, within the accuracy of our experiments,

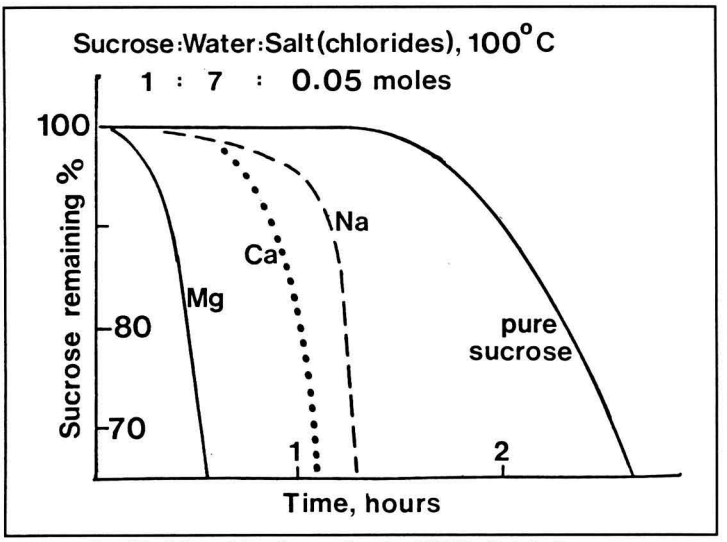

Fig. 3. Degradation of sucrose in water at 100°C; effect of salts

they produced the same effect as sodium.

The explanation of the influence of magnesium ions on sucrose hydrolysis must be speculative at this stage. The first step in hydrolysis of sucrose is most probably the scission of the oxonium ion shown in Figure 4, where G is glucose and F is fructose (other oxonium ions will form at alcohol hydroxyl groups). Any effect which increases the concentrations of the oxonium ion will increase the rate of hydrolysis and of course this is the basis of acid catalysis of sucrose inversion. One of the most familiar differences or trends between sodium, calcium and magnesium salts is the increasing tendency of the cation to form stable hydrates and this provides a possible explanation for the effects shown in Figure 3. In this system, it should be noted that the number of potential hydrogen-bonding sites of sucrose molecules exceeds the number of water molecules and that there will be competition for water molecules between sucrose and the cations (cf.[6]). The magnesium ions are likely to be especially effective in this competition and the water molecules which are hydrated to magnesium will have oxygen-hydrogen bonds which are more polarized (i.e more acidic) than free water molecules. Thus, as shown in Figure 5, there will be an increased tendency for transfer of hydrogen ion from a hydrated water molecule to any other electron donor such as the glycosidic oxygen of sucrose. This will have the effect of increasing the concentration of the oxonium ion shown in Figure 4 and

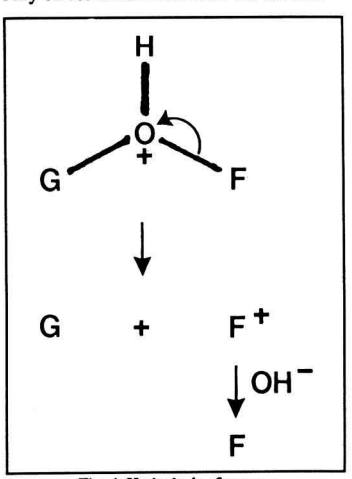

Fig. 4. Hydrolysis of sucrose

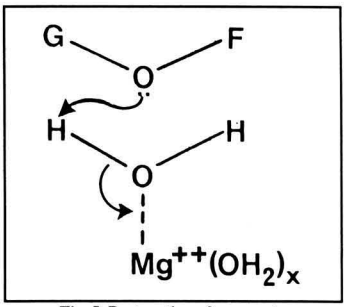

Fig. 5. Protonation of sucrose by hydrated magnesium ion

hence increasing the rate of hydrolysis. The effect is most pronounced in concentrated aqueous solution where there is competition for the water molecules between sucrose and magnesium ions. Thus, Figure 6 shows that magnesium chloride is much less potent in increasing sucrose hydrolysis when the solution contains 50 moles of water per sucrose molecule than with 7 moles of water per sucrose, while the sucrose: magnesium ratio is kept constant. The same figure shows little or no effect on the hydrolysis curve when the sucrose: water ratio is varied in pure water.

The above experiments are relevant to any sucrose process in which sucrose is heated with water, especially in the presence of impurities such as reducing sugars and salts. The effects are especially dramatic in concentrated sugar solutions. They indicate a need for particular concern when magnesium ions are present in significant amount, as may occur especially in sugar beet processing. It should be noted, however, that in "real life" the anions will not necessarily be halide. In juices especially, carboxylic acid anions such as acetate, lactate, citrate, etc. are present and these (and anions of any other weak acid) may exert alkaline buffering effects which will effectively stabilize the sucrose towards hydrolysis in the same way as the sodium acetate shown in Figure 1.

An earlier study by Parker[7] of the influence of salts, including magnesium

6 Mohauty and Das: *Thermochim. Acta*, 1981, **48**, 219 - 223.
7 Parker: *Sucr. Belge*, 1970, **89**, 119 - 126.

chloride, on rate of hydrolysis of sucrose in concentrated aqueous solution has concluded that "the effect of salts on reaction rate is not sufficiently pronounced to be considered significant". However, Parker's study was carried out in buffered solution and all of the rates with added salts were measured at pH 2.3 or lower. Under such conditions, the rate of sucrose hydrolysis is dominated by the *original* hydrogen ion concentration and the rate is constant from the start, without the lag phase found in the present study. The rate at such pH values is also very much higher and thus "swamps" the effects of salts which are described here. It should be emphasized that the effects we describe are relevant to concentrated, neutral, aqueous solutions of sucrose.

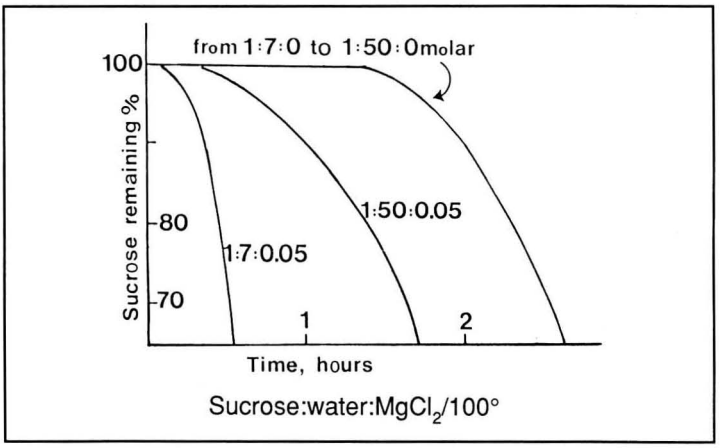

Fig. 6. Influence of water content on catalysis of sucrose hydrolysis by magnesium chloride

Cossette pretreatment and processing

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aimed at reducing the energy requirement of the drying process, by using either low temperature waste heat or steam. These are particularly appropriate when drying pulp that has been raised to a higher than conventional dry substance. Direct-fired dryers designed to handle pulp at say 26% dry substance would ignite the pulp produced at say 35 - 50% by some of the processes described in this paper. In addition, there is not normally enough waste heat to dry conventional pulp from 26% to 88% dry substance using low temperature drying powdered solely by this means. However this is much more practical if the pulp has already been raised to a higher than normal dry substance by these other means.

Alternatives to drying

An obvious alternative for reducing the energy requirement of pulp drying is to avoid the drying stage altogether. In some countries wet or pressed pulp is stored as animal feed by ensilage. Several workers have studied optimum ensilage conditions and methods of pretreatment[67,68]. The use of pressing aids and other additives in the factory process can affect the suitability of the pulp for ensiling[69].

Another option is to use the pulp as a fermentation substrate. Possible products that might be obtained from pulp feedstock in biotechnological processes include single cell protein, ethanol, and methane[70]. In view of the current worldwide interest in all aspects of biotechnology this is obviously a field for further exploitation. Allied to this is the enrichment of the protein content of pulp by incorporation of micro-organisms in fermentation, to give a more valuable animal feed[71]. This latter option still requires drying, however, so it is not strictly relevant here.

Conclusions

Numerous new processes and technologies are being developed to improve the extraction of sugar from beet and the efficiency of the subsequent pulp dewatering. Some are already being implemented on a factory scale, and it is likely that the next decade will see significant changes in the industrial processing of sugar beet. The new processes that prove to be most successful may integrate with the present mode of factory operation, but alternatively they may lead to new integrated systems replacing the traditional scheme. One such system is that being developed by Suiker Unie. Other speculative examples might include a combination of cossette pretreatment by lime or enzymes, extraction by pressing or hyperpressing, followed by diffusive dewatering of pulp and drying with waste heat. Time and experience will decide which processes are adopted by our industry.

Acknowledgements

The author wishes to thank Dr. Nele Okojie and Dr. Trevor Theobald for their assistance in preparing this paper.

67 Hollaus *et al.: Zuckerindustrie*, 1983, **108**, 1049 - 1058.
68 Beckhoff & Heller: *ibid.*, 213.
69 Vandergeten & Vanstallen: *Betteravier*, 1986, **20**, 212, 12 - 13.
70 Kjaergaard: *Sugar Technol. Rev.*, 1984, **10**, 183 - 237.
71 Durand *et al.: Rpt. European Commun. Comm.*, 1983, (EUR 8641).

Bagasse particles shape and size and their free-settling velocity

By Silvia Azucena Nebra and Isaías de Carvalho Macedo
(DE-FEC-UNICAMP, C.P. 6122, Barão Geraldo, Campinas, SP, Brazil 13081)

Methodology

The bagasse for the study came from a 37 × 78-inch milling tandem with two sets of knives and a Copersucar shredder. The sample was dried and divided into quarters. One of these was left in an open bag during some days until it reached equilibrium moisture content, determined to be 9.2% (dry basis).

From visual observation of the material it was evident that it was composed of two types of particles: some long and of fibrous shape, and others irregular, consisting of spongy pith[1,2]. It was decided to measure: (i) the dimensions of each type of particle, "fibres" and "powder", separately; and (ii) the weight percentages of each type. This last was carried out with another of the quartered parts.

First a sieve test of each sample was made. The samples from the Tyler sieves Nos. 8, 14 and 28 were divided by hand into "fibres" and powder"'; the sample from sieve 48 was quartered again and one of these quarters was divided in the same way. The samples from sieves 65, 100 and the bottom plate were too small to be divided in the same way, so the fractions adopted for each type of particle were the same as for sieve 48, since it was observed that both types of particles were present even in the last sieves.

Ten particles of each type were picked at random from each sieved size sample, adding up to a total of 152 particles. A vernier and a microscope were used for sizing them. Three dimensions with the vernier in larger particles and two with the microscope in the smaller, were measured. Fibre particles from Tyler sieves 8 to 28 were weighed using an analytical balance with a precision of 0.0001 g.

The terminal velocity in ambient air was determined only for fibre-type particles from Tyler sieves 8, 14 and 28. It was measured by allowing the particles to fall from heights of 4 and 6 metres, recording the time required. The temperature and pressure of the ambient air were known.

S. A. Nebra

I. de C. Macedo

Data treatment

The treatment of particle geometric data was different depending on the type of the particle and the measurement system.

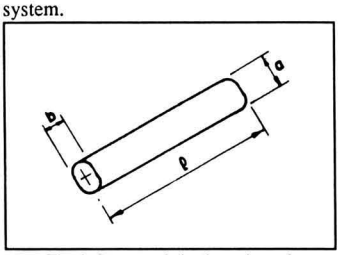


Fig. 1. Characteristic dimensions of fibre-type bagasse particles

In the case of fibre particles from Tyler sieves 8, 14 and 28, an elliptical prism form was chosen. This form is different from the parallelipiped adopted by Ponce *et al*[3]. The measured dimensions a, b, l (see Figure 1) were associated with an equivalent cylinder diameter of:

$$D_p = [(a^2 + b^2)/2]^{1/2} \quad (1)$$

The parameters below were computed:

maximum projected area: $A_p = al$ (2)

section: $S_p = \pi ab/4$ (3)

volume: $V_p = S_p l$ (4)

and density of each size: ρ

$$= \Sigma m_i / \Sigma V_{pi} \quad (5)$$

where i indicates each particle. This density was reduced later to dry bagasse density:

$$\rho_0 = \rho(1 - u) \quad (6)$$

where u is the moisture (wet basis). In the case of fibre from small sieve openings, measured with the microscope, the dimension a was adopted as the diameter.

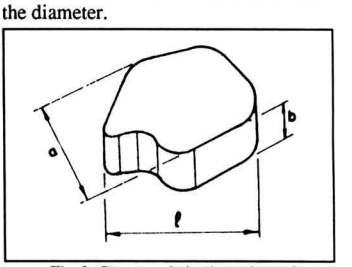


Fig. 2. Characteristic dimensions of dust-type bagasse particles

In the case of powder type particles (see Figure 2);

$$A_p = al \quad (7)$$

The mean diameter for each sieve material was computed according to the method of Kunii & Levenspiel[4]:

$$\ln d_p = (\ln e_s + \ln e_i)/2 \quad (8)$$

where e_s and e_i are the sieve openings of two consecutive sieves.

The more important mean values are in Table I, where the material from the bottom plate was added to that from

1 Lamb & Bilger: *Sugar Tech. Reviews*, 1976/77, **4**, 89 - 130.
2 Suárez *et al.*: "El almacenamiento de bagazo para la industria de derivados" (Instituto Cubano de In vestigaciones sobre los Derivados de la Cãna de Azúcar, Havana, Cuba.) 1982.
3 *I.S.J.*, 1983, **85**, 291 - 294.
4 "Fluidization engineering", (Wiley, New York) 1969, Chap. 3.

Table I. Mean values for particles of bagasse

M	Type	%	D_p, mm	d_p, mm	1/a	A_p, mm²	ρ_o, kg/m³
8	fibre	20.95	3.21		21.6	95.6	2.1×10^2
	powder	0					
14	fibre	14.91	1.34		10.0	35.0	3.4×10^2
	powder	1.84		1.68	2.0	5.96	
28	fibre	21.55	0.49		60.7	15.9	6.0×10^2
	powder	6.80		0.84	3.2	2.97	
48	fibre	10.42	0.32		35.7	3.40	
	powder	15.38		0.42	2.3	0.591	
65	fibre	1.80	0.22		35.9	1.60	
	powder	2.65		0.25	2.2	0.193	
100	fibre	1.45	0.15		28.7	0.509	
	powder	2.15		0.18	1.7	0.0767	

Tyler sieve 100. The complete data can be found in Nebra's Doctoral Thesis[5]. The fact that the bagasse density in Table I increases as the particle diameter decreases is explained by the fact that the fibre type particles of small diameter comprise only fibre without any spongy pith material adhering to it.

In order to determine the terminal velocity, the total height h and the time t were measured. The transient initial period introduces a systematic error, though it is small, so that it was preferred to use the equations below.

The particle movement equation is:

$$m_p\, dv/dt = m_p g - C_A(A_p \rho V^2/2) \quad (9)$$

where the buoyancy force was not considered.

Assuming that the terminal velocity is reaching asymptotically, the drag coefficient must obey the following equation:

$$C_A = K/Re_p \quad (10)$$

where K is a constant and $Re_p = D_p V/\mu$. Substituting (10) in (9) gives:

$$dV/dt + K\,(A_p/2m_pD_p)V = g \quad (11)$$

Integrating (11) twice an implicit equation in (g/V_t) can be obtained:

$$h(g/V_t)^2 - gt(g/V_t) - e^{-(g/V_t)t} - 1 = 0 \quad (12)$$

where $V_t = g/[K(A_p\mu/2m_pD_p)]$ (13)

Equation (12) was solved by trial and error using the Newton-Raphson method for each measured particle. By means of the least squares method, a correlation for fibre particles was obtained:

$$V_t = 2.410\ (D_p)^{0.3972} \quad (14)$$

for $1<D_p<6$mm where D_p is in mm and V_t is in m/s. For the drag coefficient of the fibre particles, the following correlation was obtained using the least squares method:

$$C_A = 2.067\ (Re_p)^{-0.2417} \quad (15)$$

for $10<Re<2000$ with a correlation coefficient = 0.6.

The data used to obtain (14) are shown in Figure 3 and those to obtain (15) in Figure 4. In Figure 3 the correlation (14) is compared with Grobert's data and Ponce's correlation reported by Arrascaeta & Friedman[6,7]. In the case of Ponce's correlation were used the values of d_p (mean diameter for each sieve), u = 0.092 (d.b) and 1.09 (kg/m^3) for the air density, as is indicated by those authors. In Figure 4 the correlation (15) is compared with well known values for the drag coefficient for infinite cylinders from Knudsen & Katz. The infinite cylinder is the more similar geometric form for the fibre particles. The correlation (15) is independent of the moisture of the particles.

Conclusions

The reason for the spread of the points in Figures 3 and 4 is not measurement error, which can be estimated at 10%, but is probably the material shape characteristics and the movement of some of the particles that veer around their symmetry axis. The difference between the correlations obtained by the different authors can be explained by the use of different methodologies and by the diversity of the material.

The experimental data obtained allow us to work with more security in the design of systems for pneumatic transport and drying of bagasse. An extension of this experimental work including different bagasse particles from other types of milling and from other types of sugar cane, could be interesting.

5 Nebra: Doctoral Thesis, (Universidade Estadual de Campinas, São Paulo, Brazil), 1985.
6 *I.S.J.*, 1984, **86**, 3 - 6.
7 *ibid.*, 1987, **89**, 68 - 71.

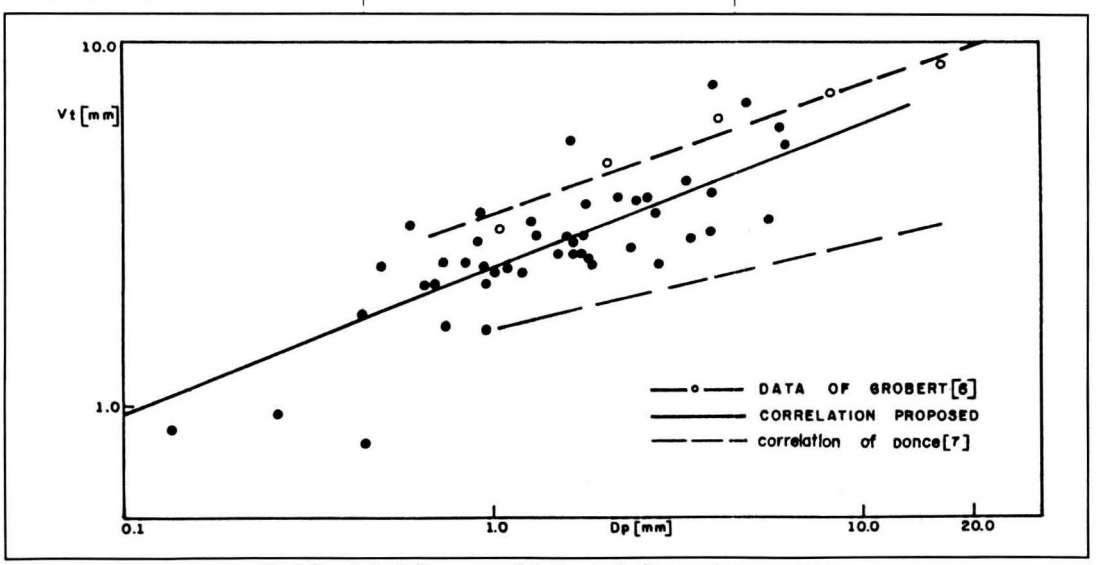


Fig. 3. Terminal velocity *versus* particle diameter for fibre-type bagasse particles

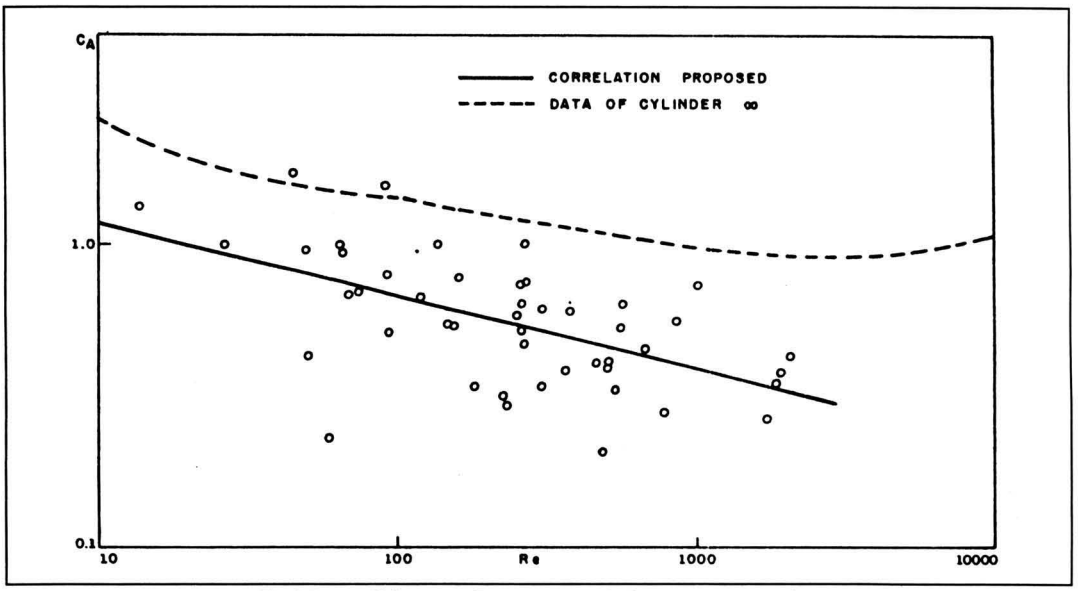


Fig. 4. Drag coefficient *versus* Reynolds number for fibre-type bagasse particles

Summary

An experimental study of typical shapes and size of bagasse particles and on their free-settling velocity was made. The drag coefficient for fibre shape particles as function of the Reynolds Number was obtained for $10<Re_p<2000$. These data are basic for the design of systems for pneumatic transport and drying of bagasse.

Forma y tamaño de partículas de bagazo y su velocidad de sedimentación libre

Se hizo un estudio experimental de las formas y tamaños típicos de las partículas de bagazo y sobre su velocidad de sedimentación libre. Se obtuvo el coeficiente de resistencia de las partículas con forma de fibra en función del Número de Reynolds en la gama $10 <Re_p<2000$. Estos datos son básicos para el diseño de sistemas para el transporte neumático y para el secado de bagazo.

Formes et dimensions des particules de bagasse et leur vitesse de sédimentation libre

On a effectué une étude experimentale des formes typiques et des dimensions des particules de bagasse, ainsi que de la vitesse de leur sedimentation libre. Pour les particules en forme de fibres, on obtenait le coefficient d'entraînement comme une fonction du nombre Reynolds pour $10<Re_p<2000$. Ces données servent de base pour la conception de systèmes de transport et de séchage pneumatique de la bagasse.

Product news

continued from page 156

proof models to IP 55, but pumps may also be supplied either in bare shaft form or with flameproof motors.

Further details:

Pump Engineering Ltd.,
Riverside Industrial Estate,
Littlehampton,
West Sussex BN 17 5DF,
England.

Simple, reliable level sensors

Like all the simplest devices, the Reli-A-Sense range of level sensors have no moving parts, which makes them reliable, maintenance free and immune from jamming. As transducers based on the capacitor principle they can also interface with more complex electrical control systems. The wide range, with flush or suspended mounting, covers many application requirements including flow and overflow detection, level detection, etc. The sealed unit incorporates low-voltage, solid-state electronics and cannot ignite combustible dusts or materials. It is also encased in polyurethane to maximize resistance to abrasion and corrosion.

Further details:

Tandem Products Inc,
520 Industrial Drive,
Blooming Prairie, MN 55917,
USA.

Facts and figures

US sugar imports and exports, 1987[1]

	1987	1986
	tonnes, raw value	
Imports		
Argentina	34,925	51,242
Australia	67,757	98,049
Barbados	21,425	0
Belize	13,624	51,192
Bolivia	6,127	6,142
Brazil	120,218	203,908
Canada	10,430	12,078
Colombia	40,737	116,529
Congo	6,805	11,230
Costa Rica	37,376	65,206
Dominican Republic	18,194	287,136
Ecuador	0	17,223
EEC	313	530
Gabon	6,986	0
Guatemala	57,237	120,217
Guyana	9,906	18,684
Haiti	6,831	0
Honduras	8,302	28,985
India	6,693	23
Ivory Coast	6,779	11,247
Jamaica	9,538	5,258
Madagascar	6,836	11,282
Mauritius	270	27,447
Mexico	206,867	103,733
Mozambique	18,987	20,131
Panama	11,342	33,562
Papua New Guinea	6,728	11,157
Paraguay	0	10,574
Peru	26,965	52,246
Philippines	132,601	213,004
St. Kitts	6,804	8,603
El Salvador	598	42,851
South Africa	0	35,125
Swaziland	25,230	25,057
Taiwan	9,982	18,715
Thailand	11,558	21,793
Trinidad	6,935	11,460
Uruguay	6,691	11,074
Zimbabwe	9,907	18,676
Other countries	22,778	14,632
Total	1,221,301	1,796,001
Exports		
Bahamas	7,319	7,786
Bermuda	212	484
Canada	101,246	70,496
Chile	47	5,000
China	148,814	0
Dutch Antilles	6,618	6,280
Egypt	12,840	0
EEC	184	247
Guatemala	275	28
Haiti	16,434	20,510
Iraq	192,120	86,216
Jamaica	22,718	32,427
Jordan	0	11,000
Mexico	250	0
Peru	51,840	114,819
Saudi Arabia	37	1,310
Somalia	0	11,500
Turkey	26,312	41,525
Other countries	2,064	2,595
Total	589,330	412,223

New Vietnam sugar factory[2]

Construction of a Cuban-funded sugar factory started on April 30 in Tay Ninh Province. When completed in 1990, the factory will crush 500 tonnes of cane per day which will be supplied by the Tay Bien state farm with 1200 hectares, and by surrounding villages.

Australian sugar embargo to end[3]

Australia is to end its embargo on sugar imports as part of a reform of industry support. When the current five-year Sugar Agreement between the Federal and Queensland governments ends on June 30, 1989, the embargo will be replaced by import tariffs and at the same time the domestic pricing system will be terminated, according to documents accompanying an Australian mini-budget. The tariffs will be 35% on raw sugar and 25% on white sugar but each will be reduced in stages to 15% on July 1, 1992. Initially the tariffs will provide the same protection as the embargo and domestic price arrangements but thereafter will open the market to competition of sugar at world prices. According to the Federal Minister of Primary Industry and Resources, John Kerin, continuation of the embargo is not justified, particularly as it prejudices Australian chances of convincing overseas producers, particularly the European Community and the United States, to remove their domestic support arrangements.

Portugal sugar imports, 1987[4]

	1987	1986
	tonnes, raw value	
Belgium	60	3,443
Brazil	64,253	0
Egypt	8,930	2,940
France	44,495	41,356
Germany, West	275	278
Holland	366	176
Italy	2,818	0
Spain	989	6,144
UK	314	176
Other countries	283,930	253,537
Total	406,430	308,050

Indonesia sugar expansion promotion[5]

The government of Indonesia continues to promote output under the expansion and rehabilitation program of sugar cane plantations, the renovation of sugar factories and the small-holders' sugar cane intensification program. Another program is planned to increase the installed capacities of sugar factories in Java from 33,750 t.c.d. at present to 42,500 t.c.d. Currently, much of the sugar producing capacity is in the hands of the government while about 65% of the cane is produced by smallholders. The remaining cane is produced by government or privately owned plantations.

Canada sugar refinery closure[6]

Lantic Sugar Ltd. has decided to close its sugar refinery at Oshawa, Ontario, with effect from August 5, primarily because of competition from increasing shipments of sugar from the US, which have eroded the market for Canadian refined sugar. The Lantic charges are in contrast to US sugar producers' assertions that rising imports of sugar-containing products, mainly from Canada, have disrupted US domestic markets and helped force a tightening of the federal sugar import quota.

Argentina-China barter agreement[7]

China and Argentina recently signed an agreement under the terms of which Argentina will ship up to 120,000 tonnes of sugar annually to China in 1988/89 and up to 1990/91, in exchange for a specific volume of coal. The pact also includes other products.

Brazil sugar and alcohol production, 1987/88[8]

Sugar production in the 1987/88 crop year, ended in April last, amounted to 8,477,000 tonnes, raw value, down 172,000 tonnes from the year before. Alcohol production reached 11,459 million litres, up 8.7% from the 10,537 million litres produced in 1986/87.

Sri Lanka sugar situation[9]

Sri Lanka's sugar industry is emerging painfully from the effects of five years of ethnic conflict. Production is on the decline and government sources put imports at an estimated 261,000 tonnes if local demand is to be met. Sugar production this year by the public sector is estimated at 26,000 tonnes while consumption is expected to be about 320,000 tonnes, according to a spokesman for the Sri Lanka Sugar Corporation (SLSC). Total production in 1987 declined by around 15% to 29,304 tonnes compared with a peak level the previous year of 34,325 tonnes. Sugar output by the SLSC in 1987 dropped by about 29% to 15,035 tonnes while production by the private sector rose 9% from 13,116 to 14,629 tonnes. With output expanding, the production executive for the Pelawatte Sugar Company said he was optimistic that the private sector would in future years overtake the public sector. Production at the SLSC's two factories, in the east of the country, have suffered from both the ethnic violence and a severe drought. The Kantalai dam was breached and cane was left unharvested because of terrorist activities, according to official sources. Government policy is not to achieve more than 50% self-sufficiency because of a shortage of land for sugar cane; further expansion would displace other crops such as tea, rubber, etc. The total area under cane fell marginally from 10,577 hectares in 1986 to 10,461 ha in 1987; however, the area under cane at Kantalai declined by 49% to 977 ha but this was balanced by a 19% increase at Pelawatte to 5204 ha.

1 *I.S.O. Stat. Bull.*, 1988, **47**, (5), 36 - 38.
2 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 262.
3 *Reuter Sugar Newsletter*, May 25, 1988.
4 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, S181.
5 *Amerop-Westway Newsletter*, 1988, (175), 9.
6 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 315.
7 *GEPLACEA Bull.*, 1988, **5**, (6), Sugar Inf. - 1.
8 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 300.
9 *Public Ledger's Commodity Week*, June 4, 1988.

ISSCT 20th Congress, 1989

A report by Dr. Gerald D. Thompson in the *South African Sugar Journal*[1] has given details agreed at the March 1988 meeting of the Executive Committee of the International Society of Sugar Cane Technologists concerning the 20th Congress to be held during October 12 - 21 next year in São Paulo, Brazil. Following revisions to the Constitution of the Society accepted at the 19th Congress, it was confirmed that the Executive Committee fulfils an advisory role and is responsible for ensuring that the Society moves in the direction intended by members; that the Congress Organizing Committee is responsible for holding the Congress and making all necessary arrangements; and that the Technical Coordination Committee is responsible for all technical matters of concern to the Society between and during congresses.

The individual membership fee is to be raised from US $20 to $30 and for Association, Affiliated and Institutional members from $150 to $225. The cost of the *Proceedings* is to be $130 for individual members, $180 for individual non-members and $225 for institutional non-members. Separate pre-Congress tours will be arranged for field and factory delegates in São Paulo state on October 13 and 14, while Congress technical sessions will commence on Monday October 16 and continue to October 20. A maximum of 133 papers are to be accepted, 70 of them agricultural and 63 on manufacturing topics. A maximum of 38 and 27 poster presentations, respectively, will be accepted and the deadline for papers is February 28 next. Preprints and abstracts of the poster presentations will be available at the Congress to members opting to purchase the *Proceedings*.

An optional post-Congress tour is to be offered in Colombia with charter flights to Cali on October 22 and a tour of the Cauca valley on October 23 and 24 with an optional extra day to visit Cartagena on October 25. Interested persons wishing to attend should make contact with their regional Vice-Chairman or the Congress Secretariat, c/o STAB, C.P. 532, Piracicaba, SP, Brazil 13400.

1 *S. African Sugar J.*, 1988, **72**, 195.

Facts and figures

British Sugar research expansion

British Sugar is doubling the size of its research establishment at Colney on the outskirts of Norwich. The company is investing more than £1.5 million in new laboratories, new offices and an extended library. The staff of 50 is likely to double by the end of 1989. Among the studies to be undertaken are ways in which British Sugar can diversify its activities, in particular the application of biotechnology into which field the Bristar Group has been moving and which is expected to have a large and beneficial impact on agriculture, food processing and food quality over the next ten years. The enlarged research laboratories will collaborate increasingly with the nearby University of East Anglia.

Thailand sugar production, 1987/88[10]

Sugar production in Thailand for the 1987/88 season, which ended on May 26, reached about 2,590,000 tonnes, tel quel, according to the Industry Ministry against some 2,535,000 tonnes the previous season. The country's 46 sugar factories crushed 27,190,000 tonnes of cane, compared with 24,440,000 tonnes in 1986/87 but the sugar content was lower owing to a severe drought in the second half of 1987 and recovery fell from 103.73 kg/tonne to 95.3 kg/tonne in 1987/88.

Refined sugar production in Indonesia

Tate & Lyle Process Technology has installed the first plant to produce refined quality sugar in Indonesia. The plant is at Bungamayang sugar factory in South Sumatra and incorporates Tate & Lyle's Talofloc process and Talo deep bed filter, which were commissioned in July. The plant, which is a remelt white end attached to the existing sugar factory, produces sugar of quality comparable to EEC Grade 1 for both industrial and domestic users.

OPEC Fund loan to Burundi

Following a $7 million loan in 1981, the Republic of Burundi has received an additional loan of $1 million from the OPEC Fund for International Development to complete the Mosso sugar project. This involves cultivation of 1925 hectares of land and construction of a factory for the processing of sugar cane to produce 16,000 tonnes of white sugar per year, as well as establishment of a township in the project area.

Corrigenda

In Table I of the article "Louisiana mill extractions in context"[11], the column heading EN should have been EM for measured extraction, corresponding to EP for predicted extraction. In Table II, the value of W for Model B tandem of six 3-roller mills is 50%. In line 24 of column 1 of page 122 the words "and usually numbers have had to be derived" should be inserted after "quantities".

Argentina sugar production, 1987/88[12]

A total of 14,355,000 tonnes of cane was crushed in the 1987/88 season of which 9,528,000 tonnes were used to produce sugar and the rest for alcohol manufacture. Sugar production totalled 980,655 tonnes, tel quel, including 943,991 tonnes of white sugar and 36,664 tonnes of raw sugar. The yield was 10.29%. The government has fixed the 1988 production quota at 1,050,000 tonnes, tel quel, of which 120,000 tonnes are for export and 930,000 tonnes for domestic consumption. Total domestic consumption is estimated at 1,008,000 tonnes, white value, but there should be no supply problem because of some 130,000 tonnes available from stocks.

Rain damage in Cuba[13]

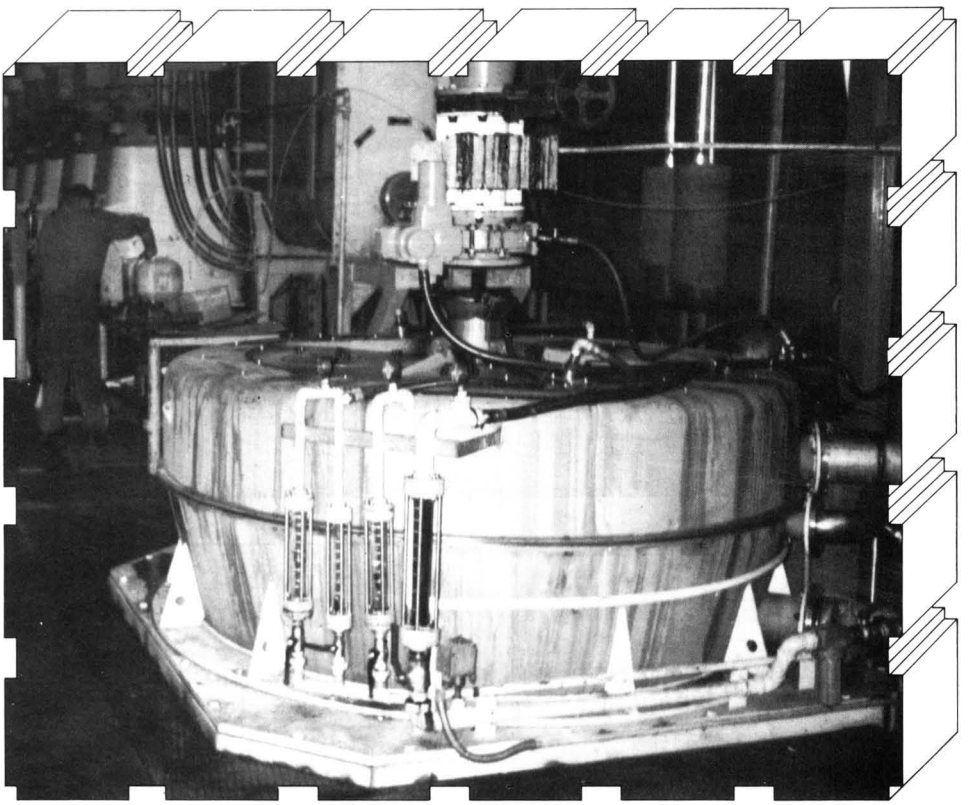
Torrential rains have damaged both cane plantations and raw sugar stocks, and trade sources have warned Japanese buyers that contracted shipments of sugar may be delayed owing to damage to railway lines, roads, farmland and sugar factories. One of the affected areas was the province of Ciego de Avila where a total of 3000 tonnes of refined sugar and 1000 tonnes of raw sugar are thought to have been lost, while at least 2000 hectares of recently planted sugar cane has been lost in neighbouring provinces. An overall estimate of damage nationwide is difficult to assess because, while some areas had their worst floods for 30 years, other areas received record rains which will benefit newly planted sugar cane.

Dominican Republic sugar exports, 1987[14]

	1987	1986
	tonnes, tel quel	
Raw sugar		
Algeria	27,810	0
Bahamas	659	0
Haiti	3,913	0
Morocco	70,040	0
USA	302,800	344,347
USSR	146,315	51,243
Other countries	10,932	9,683
Total	562,469	405,273
White sugar		
Bulgaria	11,618	0
Haiti	0	270
Korea, South	474	0
Morocco	0	24,638
Tanzania	10,803	32,005
USA	0	12,367
Other countries	4	0
Total	22,898	69,279

10 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 303.
11 *I.S.J.*, 1988, **90**, 119 - 123.
12 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 315 - 316.
13 *Public Ledger*, June 11, 1988.
14 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, S.233 - S.234.

bosco "BC-1500"
the new continuous sugar centrifugal with highest capacity



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

GRUPPO EFIM

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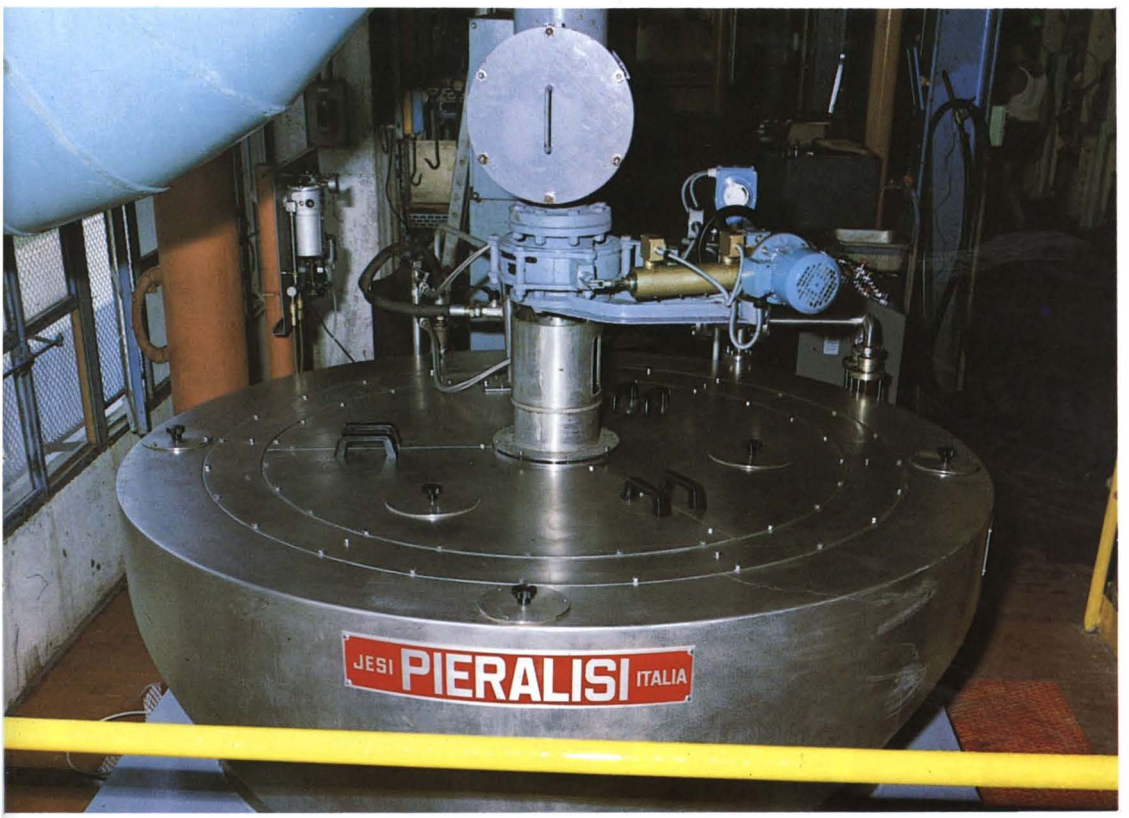

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