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News and views

World sugar prices

The rise in world sugar prices continued during March, the main constructive features being the improved statistical picture and demand by purchasers in advance of higher prices. From \$146 per tonne on February 28, the first trading day in March saw a rise of \$10 and a further \$9 by March 4. After a week of consolidation when Cuba raised its estimate of 1985/86 production, the price started to climb again, to \$171.50 on March 12, aided by news of cancellation of sales by Brazil and purchases by China, India, Pakistan, North Yemen and the USSR. This steady flow of buying tenders brought the price , on March 27 to \$204 per tonne, its highest since August 1981, and an

increase of nearly 40% during the month. The white sugar price also increased but not in so marked a fashion, from \$177 on February 27 to \$220 at the end of the month – a 24% increase – while the premium over raws declined, in line with

less buoyant demand, from \$31 to \$18 per

The effects of currencies on sugar income

tonne.

C. Czarnikow Ltd. recently discussed the returns to sugar producers in relation to currency movements¹. Improvement in world market prices has been impressive over recent months, but prices expressed in US dollars do not necessarily reflect the whole story. The dollar has been falling in value against some of the major Western European currencies so that the net change in price is not so great. During the eight months to March 1986 the average of the Paris spot price for white sugar, expressed in French francs, has risen by only 10%, which is insignificant compared with the rise in raw sugar prices in US dollars.

Producers in the EEC receive a highly satisfactory price for that proportion of their production which is consumed in the Community; this in general enables them to cover their fixed costs so that their quota exports and, even more, their Csugar can be set against only marginal costs. Nevertheless, the French and West German growers are proposing, according to initial forecasts, to reduce the area sown to beet this year by, respectively, 10.0 and 3.6%, which must to some extent reflect their disenchantment with the present level of prices on the world market.

Producers of cane raws have seen a much greater increase in the return they receive for their product but are still not able to obtain a price which reflects their costs. In the past, many of them were in a similar position to the EEC producers in that they could set their fixed costs against their US quotas and the needs of their domestic markets and hope for a return from the world market which covered their marginal costs. The support measures for domestic producers in the USA have led to a rapid reduction in that country's import needs and shipments to the USA can no longer be used to subsidize exports to the world market.

The effect that this has had on the industries of a few suppliers in what might be termed the US sphere of interest is revealing when one compares the situation obtaining a decade ago with what is happening now. In 1976, with quota arrangements not in operation, the Dominican Republic shipped 971,000 short tons and the Philippines 915,000 tons. This year, over a period of thirteen months, they have quota entitlements of, respectively, 302,000 tons and 232,000 tons. The effects of these dramatic outlet reductions have played no small part in the present depressed situations of the industries in those countries.

In 1976 Brazil refrained from delivering sugar to the USA but her regular pattern was to ship more than half a million tons and in some years more than a million tons. Currently, the 13months limit has been set at 302,000 tons. Erosion of this guaranteed and highpriced outlet must surely affect the attitudes of all the suppliers to the USA and it may be expected that there will be no great alacrity to endeavour to expand exports in response to currently ruling world market prices.

European Parliament consideration of the sugar regime²

The Comittee on Agriculture, Fisheries and Food of the European Parliament has been considering the sugar arrangements of the EEC. Its subcommittee on budgets is primarily interested in ensuring that the sugar regime should, as far as possible, be selffinancing and endorsed the Commission's proposal to introduce an elimination levy to offset the accrued deficit on financial restrictions.

The sub-committee on Development and Cooperation concerns itself with the effect that Community agreements have on third countries and was considerably more critical and at times guite hostile to the Commission's proposals: it drew attention to the fact that cane sugar producers in developing countries have often little choice but to continue to grow sugar cane, whatever the price, and it was of the view that the Commission should pursue a policy aimed at reducing the beet sugar surplus within the Community more vigorously than it is doing at present. In particular, it proposed that the existing B-quota should be abolished in five equal stages over a period of five years.

These views, differing considerably in approach and in any case not binding in any way, will of course be considered by the Commission. For the current year it would seem to be too late for any change to be made in the general nature of the arrangements for sugar. However, they will have to be considered again in two years time. The current impression, and this is one which is underlined by the views from the European Parliament, is that the very best the beet growers and processors can hope for in the current economic climate is a policy of budget neutrality and financial stringency where matters of price are concerned.

A new sugar cycle

C. Czarnikow Ltd. has recently pointed out that, contrary to the fashionable view a year ago that structural changes in the sugar market would ensure that prices would remain low indefinitely,

1 Czarnikow Sugar Review, 1986, (1747), 34 - 35. 2 F. O. Licht, Int. Sugar Rpt., 1986, **118**, 142

News and views

the laws of supply and demand have not been repealed and that the cyclical nature of the sugar market has reasserted itself³. Following the all-time low prices of June/July 1985 the deficit has grown although a major setback to the steady improvement in the supply and demand situation might have been caused by the US Farm Bill which has limited the outlet for US quota holders, but this in turn may cause many suppliers to impose more stringent limits on their production.

The first stage of the new cycle was masked by the activities of Cuba which, in making sales to end users well in excess of its own production, deprived the free market of demand from final outlets. "We have now seen a strong rally in prices from very low levels, albeit to levels which are still low, partly as a result of Cuba now buying to fulfil her obligations. The key question facing sugar today is not whether or not there is to be a recovery in prices but at what level that price recovery might falter. The protectionist action by developed countries has made the free world market outlet smaller as a percentage of production and therefore potentially even more volatile. On the other hand, a larger proportion of demand is now from less developed countries so that we can expect that higher prices will limit buying earlier than on previous cycles."

European beet area, 1986

F. O. Licht GmbH recently published⁴ its first estimate of the area to be sown in 1986 in the various European countries. The figures are reproduced below with comparative areas for 1985. This first estimate, Licht notes, "must come as a disappointment to all those who had hoped for a strong reaction to the current distressed state of the world sugar market. However, even after three years of low world prices, farmers show little inclination to cut the area sown to sugar beet to any great extent. This seems to be the result of of the insulation of domestic sugar markets from the vagaries of world prices. Another factor is the prospect of higher prices in 1986/87. But it should not be overlooked that in most countries fairly high yields were achieved last year

so that, normal weather assumed, European production may well be down on last year."

This seems even more likely when the changes for individual countries are considered; the largest reduction is expected to take place in France, where yields are high, and the biggest increases are expected in Italy and Poland where they are low. With average yields, it is likely that sugar production next campaign will be about the same as in 1985/86 in spite of a 1.74% increase in area.

	1986	1985	
	hee	clares	
Belgium	117,000	125,000	
Denmark	74,000	74,000	
France	427,000	474,000	
Germany, West	400,000	415,000	
Greece	44,000	43,000	
Holland	130,000	129,000	
Ireland	36,000	34,000	
Italy	260,000	225,000	
Spain	180,000	175,000	
ÚK.	203,000	202,000	
EEC	1,871,000	1,896,000	
Austria	30,000	43,000	
Finland	31,000	31,000	
Sweden	51,000	51,000	
Switzerland	15,000	15,000	
Turkey	400,000	323,000	
Yugoslavia	163,000	150,000	
West Europe	2,561,000	2,509,000	
Albania	10,000	10,000	
Bulgaria	50,000	52,000	
Czechoslovakia	210,000	209,000	
Germany, East	216,000	231,000	
Hungary	105,000	101,000	
Poland	500,000	443,000	
Rumania	315,000	310,000	
USSR	3,450,000	3,425,000	
East Europe	4,856,000	4,781,000	
Total Europe	7,417,000	7,290,000	
	.,,		

Initiatives for a new ISA5

Discussions have been taking place on a semi-official basis concerning a new International Sugar Agreement, but progress has hardly been encouraging. Importers have made it clear that any initiative must come from the exporting countries and they in turn are leaving matters to the big four exporters – Australia, Brazil, Cuba and the EEC. It seems likely that any new draft Agreement, if it is to be successful, will have to be far simpler in concept than the agreement of the past, while any provisions calling for the international financing of stocks seem most unlikely to receive general acceptance. Indeed, current thinking is that a new Agreement might ignore the question of stocks altogether.

Mr William Miller has retired from the post of Excutive Director of the International Sugar Organization and the panel charged with recommending a successor has been unable to come to a decision. In the meantime, the Secretary of the ISO, Mr. Constantine Politoff, has been designated Officer in Charge, to act in place of the Executive Director. There will be no opportunity for the full Council to consider appointing a new Executive Director until, at the earliest, its meeting in May and even then it might be some months before he could take office. The lack of urgency being shown in filling a post which is of considerable importance when there is a fully operational Agreement may well encourage the belief that there is in some quarters a corresponding lack of urgency to establish a new ISA.

British Society of Sugar Cane Technologists

The 5th Annual General Meeting of the B.S.S.C.T. was held at the Royal Commonwealth Society in London on April 8 during which Dr. M. C. Bennett was re-elected President, Dr. R. A. Yates Vice-President, and Mr. J. E. Morton confirmed as Secretary-Treasurer. Much discussion revolved around the forthcoming ISSCT Congress in Indonesia in August.

After lunch, papers were presented by Simon Harris on the EEC and the sugar market, by Dr. Derek Fewkes in a review of the pests attacking sugar cane and by Mr. Iain Macdonald on immobilized invertase in the production of liquid sugar. Dr. Alan Yates presented a paper on behalf of his colleague Roger Taylor on items influencing decisions on cane irrigation. The meeting was then closed by the Chairman.

³ Czarnikow Sugar Review, 1986, (1747), 33.

⁴ Int. Sugar Rpt., 1986, 118, 113 - 116.

Product news

Abay in Bulgaria . . .

Abay of Belgium have won a \$46m contract to provide a turn-key plant in Bulgaria. Processing 570 tonnes of corn a day, the plant will produce a very wide range of dextrins, starches, glucose and syrups, etc. Abay's success is built on technology derived from close cooperation with The American Maize Product Co. of Stamford, Connecticut, U.S.A.

... and in Italy

Following a contract to make a technical and financial appraisal of the Celano sugar factory, the Consulting Dept. of Abay has been appointed to oversee the subsequent re-organization.

New conveyors eliminate spillage

Simon Macawber now have a permanent demonstration rig for customers to test their own materials. Using continuous low friction polyethylene in place of inclined idlers, the manufacturers claim elimination of spillage. The result is greatly reduced wear, jamming and pollution, as well as savings in loss of materials. Their design service can meet any customer's requirement, including completely enclosed systems to eliminate dust and contamination.

Further details:

Simon Macawber Ltd., Shaw Lane Industrial Estate, Doncaster, U.K.

Bagasse disposal - a revolution?

Deterioration of bagasse by fermentation could be a problem of the past. Sucres et Denrées/Amerop have launched BAGATEX 20. It's a new biologicallybased system to prevent fermentation, bale the bagasse and reduce water content by two-thirds. After maturing for 20 days under cover, the bales can be stored in the open for 2 years or more without significant deterioration.

Further details:

Cie. Commerciale Sucres et Denrées, 133 Ave. des Champs - Elysées, 75380 Paris Cedex 8, France.

Raising invert syrup quality

Quality is an important criterion for the syrups used in the soft drinks industry. Now British Charcoals & MacDonalds (a Tate & Lyle subsidiary) are promoting the use of immobilized invertase, to improve invert syrups made from sucrose. Use of Brimac immobilized invertase is not only cost-effective in giving high throughput from small plant investment; it also produces invert syrups which meet all recognised standards with particularly low HMF content and colour. For 95% invert syrups produced from a 50% solids sucrose feed, process costs are around \$0.005 per kg of solids treated. British Charcoals & MacDonald act as technical consultants as well as enzyme suppliers

and also offer a plant installation service.

Further details: British Charcoals & MacDonalds, 21 Dellingburn Street, Greenock, U.K.

Largest application for Cromweld 3CR12 at British Sugar in York

One of the largest applications to date for the revolutionary 3CR12 corrosionresisting steel from Cromweld Steels Ltd. has now successfully been in operation at British Sugar's plant at York for the 1984/85 and the 1985/86 campaigns. 3CR12 material was used throughout for the construction of a new patented design of cyclone separator, flue gas ducting, and dryer outfall housing hood of a large rotary beet pulp dryer plant, shown here.

Further details:

Cromweld Steels Ltd., Cornwall House, Sandy Lane, Newcastle-under Lyme, Staffs. ST5 0LZ, U.K.



PROCESS MANAGEMENT

The nature of first carbonatation By Christian Møller

(A/S De Danske Sukkerfabrikker, Gørlev, Denmark)

Introduction

The lime-carbon dioxide purification of raw juice with two separate carbonatations was introduced into the beet sugar industry as early as 1859 by Perrier & Possoz and, in spite of numerous attempts with alternative purification substances, the same basic processes are still preferred everywhere today.

In the course of time, the lime/carbon dioxide purification process has been modified innumerable times. Progressive preliming was introduced in the thirties and the two carbonatations are now carried out continuously. Finally, we have mud recirculation as a condition of the fully automated filtration station.

However, the preliming effect is normally completed and the pectins and other lime-precipitated substances are mostly formed at an alkalinity of only about 0.15% CaO, so the main quantity of lime added to the juice obtains its decisive effect during the first carbonatation, which is the basic juice purification process.

Theory of first carbonatation

Important contributions to understanding of the nature of the first carbonatation were given by Smolenski1, who studied the adsorption of different Ponceau dyes during the precipitation of calcium carbonate, positively charged by an excess of Ca++ ions. Dubourg² studied the solubility of lime in sugar juice and the precipitation of calcium carbonate during the carbonatation of limed sugar juices. According to Dubourg, a saccharate-carbonate compound, C12H21O11-Ca-CO3-Ca-C12H21O11, was formed, which split on hydrolysis and further carbonatation with positively charged calcium carbonate, +Ca-CO₃-Ca+, as intermediate compound.

Dubourg's theory of formation of saccharates and the formation of saccharatecarbonate compounds during the preliminary part of the carbonatation process explains why the precipitation of calcium carbonate in limed sugar juices promotes extraordinarily a positively charged deposit of calcium carbonate acting as an effective adsorbent during



C. Møller

carbonatation. These characteristics make the lime/carbon dioxide purification really ideal for the beet sugar industry and almost impossible to substitute by anything else.

The optimum alkalinity

Figure 1 shows the laboratory set-up in Gørlev used for standard carbonatation experiments. We use filtrate colour measurements at pH 7 and 420 nm as a very sensitive measure of the degree of juice purification obtained. Most of our experiments concerned with a study of first carbonatation were carried out at 82°. We found the first carbonatation to have a more or less pronounced optimum alkalinity with minimum filtrate colour depending on quality of juice, amount of



lime added, temperature, type and quantity of additional substances and method of carbonatation.

Figure 2 shows examples of carbonatation experiments with typical

 Sucr. Belge, 1939/40, 59, 181 - 188, 202 - 207, 221 - 224.
 ibid., 1950/51, 70, 237 - 240; "Sucrerie de Betteraves" (Baillière, Paris) 1952, pp. 179 - 181.



samples of limed juice having different values of alkalinity (A) prior to the carbonatation. Our experiments fully confirmed the investigations of Smolenski and Dubourg. The colour minima are accompanied by a certain level of lime in solution - mostly between 0.05 and 0.07% CaO - to secure a positively charged deposit of calcium carbonate. In addition, Figure 2 demonstrates that it is imperative to compare any juice qualities and purification methods only at the optimum alkalinity, as the results are otherwise rather misleading. The adsorption effect is lost on overcarbonatation and cannot be restored by addition of a supplementary quantity of alkaline juice. This is in accordance with the Dubourg model of the saccharate-



carbonate compound and its irreversible decomposition to sucrose and positivelycharged calcium carbonate.

Carbonatation tank

This very important observation is decisive for the design of the carbonatation tank which should provide perfect circulation properties to make it impossible to allow any part of the juice to come - even temporarily - to a lower alkalinity than the optimum. This may be obtained in a simple way by means of a baffle plate forming a conduit for the downward-flowing juice and providing a real physical separation between this juice and the upward-flowing juice stream, movement of which is promoted by the carbon dioxide gas. This may be seen in Figure 3 which is a sketch of the Gørlev carbonatation tank.

Influence of different electrolytes on the optimum alkalinity

According to Figure 2, the optimum

alkalinity is accompanied by a certain residual Ca++ concentration in the filtrate. Arising from this we have found that addition of small quantities of NaOH to the limed juice is able to move the optimum alkalinity towards higher alkalinities, as the NaOH after transformation to carbonate reduces the concentration of Ca++. At the same time we found a rise in the colour obtained; by contrast, an increase in the Ca++ concentration obtained by the addition of CaCl₂ to the limed juice causes a displacement of the optimum alkalinity towards lower alkalinities (see Figure 4), together with a drop in the minimum colour.

As a consequence of the positively charged calcium carbonate being responsible for the adsorption effect during the first carbonatation, addition of strongly charged colourless anions to the juice should be able to suppress the colour removal by acting as a competing



The nature of first carbonatation



adsorbable substance. This is why the addition of sodium citrate in small quantities provokes a drastic increase in the colour obtained (see Figure 5). As the lime content in the juice is quite normal we conclude that some coloured substance has been displaced by the citrate addition. Since citric acid is a normal constituent of raw juice, it is clear that increasing quantities in the juice will have a bad effect on the juice purification obtainable.

Similarly to the effect of citrate, sulphate also has a damaging effect on juice purification even though it is less than the effect of citrate (see Figure 6). In addition, Figure 6 illustrates the far weaker effect of sodium chloride on the juice purification, as we have to use a quite high concentration to get any effect on the juice colour obtained.

Effect of lime quantity and temperature

The effect of increasing alkalinity of the limed juice going to the first carbonatation is illustrated by Figure 7

which shows the colour obtained after carbonatation of raw juice samples from four different years, limed to increasing alkalinity levels. At lower alkalinity levels the improvement of the colour at a fixed extra lime addition is far bigger than at higher alkalinities of about 1.0% CaO. This indicates clearly the character of the first carbonatation as an adsorption process. At Gørlev factory the practical alkalinity level is about 0.85% CaO.

The effect of increasing temperature during the carbonatation process is illustrated in Figure 8. Different raw juice samples were limed to the alkalinity (A) and in turn carbonatated at different temperatures to the optimum alkalinity giving the lowest filtrate colour. All graphs show a marked temperature influence. They all show increasing colour above a temperature of about 82°C while some show a further colour improvement when the temperature falls towards 72°C. The effect is very dependent on the quality of the juice.

Influence of electrolytes on the elimination of citric acid and silicon

In addition to the harmful influence of citric acid on juice purification mentioned above, we followed the elimination of citric acid³ during the carbonatation process (see Figure 9). Carbonatation of the limed juice without further additions shows increasing content of citric acid in the filtrate below an alkalinity of about 0.10% CaO. Addition of 0.06M CaCl₂ has a marked suppression effect on the content of citric acid in the filtrate. By contrast, addition of 0.04M NaOH gives a marked increase in the citric acid content.

Figure 10 is another example of elimination of citric acid during similar circumstances along with the elimination of silicon⁴. The suppression effect of CaCl₂ addition and the converse effect of the addition of NaOH on the elimination of citric acid and silicon are similar to the

Betriebskontrolle der Zuckerindustrie", 1983

³ Büsching: Zucker, 1968, 21, 531 - 535. 4 Reinefeld & Schneider: "Analytische



effect on the colour removal from the juice described above. However, we do not find any increase in the content of citrate and silicon at higher alkalinities owing to their character as slightly soluble lime components. It is likely that the adsorption process governing colour removal during the first carbonatation is also decisive for the elimination of citric acid and silicon even if a slightly higher alkalinity may be necessary and so a compromise is the result.

Increased content of citric acid reduces the deliming effect in the decalcification station whereas a higher content of silicon in the thin juice increases the risk of scaling-up of the evaporator bodies.

The effect of dilution

We found that dilution of the limed juice prior to carbonatation had a harmful effect on juice purification (see Figure 11). This is a logical consequence of the carbonatation being an adsorption process. The lower the concentration of impurities in the juice, the smaller will be the quantity accumulated at the active surface of the precipitated calcium carbonate. This effect may be compensated by increased lime addition to the juice, but this means a greater expense at the lime station, which is why it is profitable - also in respect of juice purification - to be able to run the diffuser at the lowest possible draft.

Conclusions

Our investigations underline that first carbonatation is an adsorption process, as predicated by Smolenski many years ago. The formation of calcium carbonate during the carbonatation of limed raw juice promotes a positively-charged deposit. We found optimum juice purification at a final Ca++ level in the juice typically between 0.05 and 0.07% CaO. When lowering this lime content in solution through prolonged carbonatation the adsorptivity is partly lost and cannot be restored; the juice is badly purified as a consequence. That the first carbonatation process is an adsorption process is illustrated by our experiments with small quantities of different electrolytes added to the limed juice prior to the carbonatation. These substances are adsorbed in competition with the coloured substances. Our results have shown that strongly charged ions such as citrate are especially harmful and even sulphate has a marked







Pakistan sugar imports¹

From Pakistan it is reported that the government intends to import a further 100,000 tonnes of white sugar. The cane supply to the sugar factories is less than had been estimated and they have been closing earlier than scheduled. Industry sources say there will be a gap of 300,000 tonnes this year between production and consumption.

New sugar factories for India²

The Tamil Nadu state government has decided to establish 30 more sugar factories in the context of India's projected demand of 11,500,000 tonnes by the end of the 7th Plan period in 1990. Cane yield in Tamil Nadu is the highest in the country at 45 tonnes/acre and has risen steadily from 35 tonnes/acre in 1982/83, reflecting the awareness of the industry in improved farming. There is need to strengthen agronomic practices, however, such as by proper water management instead of reliance on over-abundant supply for irrigation of cane.

New Indonesian sugar factory³

Sumitomo Corporation and Hitachi Zosen Corporation have jointly received an order worth 8500 million yen for the supply of a new 8000 t.c.d. sugar factory for P. T. Gula Putih Mataram. Construction began in December last and is expected to be completed by May 1987. Under a



influence on the juice colour obtained. The position of optimum alkalinity is influenced by addition of limited quantities of $CaCl_2$ or NaOH, and the elimination of citrate and silicon are influenced similarly to the colour of the filtrate. However, reasonable elimination of citric acid and silicon may require a slightly higher alkalinity than does optimum colour removal.

Increasing lime addition improves the juice purification but at a somewhat decreasing rate at higher lime levels. The effect of carbonatation temperatures above 82°C is harmful to juice purification whereas the effect of temperatures slightly lower than 82° is not uniform. Consequently our maximum carbonatation temperature in the Gørlev factory is 82°C. Dilution of limed juice with water prior to carbonatation is harmful to juice purification in accordance with its nature as an adsorption process.

> five-year program, Indonesia plans to set up 18 sugar factories in order to raise domestic output; the new order is the eighth received by the two firms under Indonesia's plans.

Finland sugar production, 19854

The four Finnish sugar factories processed
704,005 tonnes of beet in the 1985 campaign,
producing 73,913 tonnes of white sugar, 16,218
tonnes of raw sugar, 30,961 tonnes of molasses
and 52,010 tonnes of pulp.
1 F. O. Licht, Int. Sugar Rpt., 1986, 118, 91.
2 Sugar Scene, 1986, 4, (1), 18.
3 F. O. Licht, Int. Sugar Rpt., 1986, 118, 110.
4 Zuckerindustrie, 1986, 111, 187.



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FACTORY ENGINEERING

The continuous centrifugal clarifier

By M. C. Shieh

(Kwangchow Design and Research Institute of Light Industrial Machines, Ministry of Light Industry, People's Republic of China)

Fourteen years ago, the author designed a continuous centrifugal clarifier (450 mm in diameter and 750 mm in length) which was tested at Cheng Yue Mill in Kwangtung Province, a sulphitation white sugar factory having a grinding capacity of 500 tonnes per day in 1971. The continuous centrifugal clarifier was tested in the clarification of second heater juice and resulted in the removal of 98.7% of the solids content of the juice without the use of any flocculant and gave a pol content of only 3.6% in the cake.

- The continuous centrifugal clarifier mainly comprises a rotating drum bowl, screw shaft, differential gear box, feed attachment and driving device as shown in the diagram. The drum bowl is an imperforate circular drum having a straight cylindrical portion and coextensive conical section which are joined together with bolts. The screw shaft comprises a tubular axis having a trunnion welded on each end and a double screw blade supported with uprights welded to the axis. The drum bowl is supported with two roller bearings fitted on the bowl shaft and the screw shaft provided coaxially with the bowl passes through the hollow trunnions of the bowl and is supported at one end with a ball bearing and at the other end with a ball bearing installed in the differential gear box. The bowl is driven by a motor through a slip clutch and v-belts at one end, the other end having attached a gear A meshed with gear B fitted on the counter shaft of the differential gear box. The slip clutch allows the clarifier to start smoothly and permits fitting of a smaller capacity motor.

By interchanging pulleys of different diameter attached to the slip cluch various speeds of the bowl may be obtained. Owing to the fact that the screw shaft is coaxial with the bowl, the suitable differential speed of leading or lagging of the screw will be obtained by selection of appropriate gears C and D. The sediment is conveyed by means of relative rotation between the bowl and the screw.

The feed pipe is supported on a cantilever bracket and stretches into the screw shaft but is kept clear of any



moving parts. The juice is fed tangentially through the inlet pipe to flow over into a distribution chamber and spray onto the annular juice pool. The radial depth of the juice pool is regulated as desired by changing the radial position of the doors mounted on the end plate of the bowl. The action of centrifugal force causes the small suspended particles to be concentrated on the inner surface of the drum bowl and conveyed axially by rotation of the paddle of the screw at the differential speed between the bowl and screw. The precipitated solids are moved continuously and displaced gradually into the "beach" where the solids are separated from the juice pool and drained by the action of centrifugal force. Further on, the mud is washed by hot water led in from a washing pipe for desugarization. After the residual wash water has drained the mud cake is exhausted from the annular discharge outlet arranged on the small end of the conical section. The clear juice flows along the spiral path and is thrown out from the outlet door while the residual foam floating on the inner surface of the juice pool is arrested by the angle ring welded to the end plate, conveyed longitudinally to the beach area and mixed with the mud.

The following are the main technical data of the continuous centrifugal clarifier:

Diameter of drum bowl	450 mm
Length of drum bowl	750 mm
of which :	
cylindrical portion	300 mm
conical portion	450 mm
Included angle of bowl co	ne 2 × 11° 55
Lead of screw	135 mm
Threads of screw	2
Drum speed, rpm	1800/1410
The maximum equivalent	gravities
at clear juice outlet	652/400

Through the pilot tests we expected to discover the maximum treatment capacity of the clarifier, what was the most suitable speed of the drum bowl and what happened with various differential speeds between the bowl and the screw, because the suspended particles in sulphitation juice are very loose and difficult to settle, especially after being disturbed. Unexpectedly, however, the tests were stopped very soon owing to a shortened campaign and were not resumed later. From the results shown in the table, it would be possible and worthwhile to use a continuous centrifugal clarifier instead of the conventional cumbrous apparatus for juice treatment not only to save

The continuous centrifugal clarifier

Trial No.	1	2	3	4	5
Date	April 7	April 8	April 9	April 9	April 9
Time, min	30	120	60	75	115
Bowl speed, rpm	1800	1800	1800	1800	1410
Differential speed, rpm*	-6.6	+19.9	+19.9	+19.9	+15.6
Juice pool depth, mm	65	65	45	55	55
Inlet juice, tonnes/hr				1.58	1.22
Inlet juice temperature,°C		86	98	90	92
Solids removal efficiency,	% 94.3	95	87.5	96.9	98.7
Cake: Pol, %		8.7		3.6	9.7
Moisture, %		73.5		78.6	68.5

investment and reduce the area occupied, but also to simplify the working process, provide easy control and decrease inversion loss. It can provide complete subsiding, mud removal, cake washing and draining in one machine without any perforated sheet or filter cloth.

Summary

A brief account is given of a solid bowl centrifuge used for a short series of trials on cane juice at a sugar factory in China, and the good results achieved in separation of suspended sulphitation mud particles.

Le clarificateur continu centrifuge

On rapporte en bref au sujet de la centrifuge à panier solide utilisé dans une courte série d'essais sur jus de canne dans une sucrerie en Chine. On cite les bons résultats obtenus pour la séparation de

particules de boues de sulfitation se trouvant en suspension.

Die kontinuierliche Klärzentrifuge

Ein kurzer Bericht wird über den Einsatz einer Vollmantelzentrifuge für Zuckerrohrsaft in einer chinesischen Zuckerfabrik gegeben und über die guten Ergebnisse, die bei der Abtrennung von suspendiertem Sulfitationsniederschlag erzielt wurden.

El clarificador contínuo centrífuga

Se presenta un reporte breve sobre una máquina centrífuga con cesto sólido que se ha empleado para una corta serie de ensayos con jugo de caña en una fábrica de azúcar en la China. Se describen las buenas resultas obtenido en la separación de partículas en suspensión de lodo de sulfitación.

CHEMISTRY

Densities of Aqueous Sucrose Solutions

By Thelma M. Herrington and Elspeth L. Mole

(Department of Chemistry, University of Reading, Reading, England)

Introduction

In recent years we have been studying the properties of aqueous solutions of non-electrolytes and examining the formal connexions between the thermodynamic properties of solutions and molecular properties using rigorous statistical mechanical considerations^{1, 2}. In this paper our earlier work³ on aqueous solutions of sucrose is extended to a higher temperature.

Experimental

Materials

The sucrose, supplied by Tate and Lyle Ltd., Liverpool, was 99.993% pure; the impurities were 0.002% invert sugar, 0.002% ash and 0.003% other organic



T. M. Herrington

matter. It was not recrystallized further but dried in vacuo at 60°C and stored under vacuum. Doubly-distilled, deionized water was used in the preparation of all solutions; any nonionic impurities were less than one part in 10⁶. The water was always deaerated immediately before use. The molar mass of sucrose was taken as 342.3019 g/mol

and of water 18.0153 g/mol. Density determinations

The densities of sucrose solutions of molality >0.8 mol/kg were determined in Ostwald-Sprengel type pycnometers. The apparent molar volumes of dilute solutions were determined with a dilatometer, the operation of which has been described previously³ (further experimental details are given elsewhere⁴).

Results

The density of each degassed

References

- 1 McMillan & Mayer: J. Chem. Phys., 1945,
- 13, 276. 2 Hill: *ibid.*, 1959, **30**, 93. 3 Garrod & Herrington; *J. Phys. Chem.*, 1970. 74, 363.
- 4 Mole: Thesis, Reading University, 1975.



Cane sugar manufacture

Design, construction and performance of a large evaporator vessel at Fairymead mill

P. B. Quinan, J. P. Degnian and D. N. Wainwright. Proc. Australian Soc. Sugar Cane Tech., 1985, 241 - 246. An evaporator vessel of 5100 m² heating surface is described that was built to operate as a 1st effect in place of older vessels in a quadruple-effect system handling juice from 600 tonnes of cane per hour. It has tubes of 38.1 mm diameter (the smallest currently in use in the Australian sugar industry) and 44 downtakes of 150 mm diameter as a means of reducing the juice pressure head and thereby possibly increasing the heat transfer coefficient. Evaporation loadings of up to 32 kg/m²/hr (with frequent weekly averages of 30.5 - 30.7 kg/m²/hr) were obtained: there was wide variation in the heat transfer coefficient, which ranged from 2600 to 4400 W/m²/hr (representing 80 - 130% of typical sugar industry values in Australia). The downtakes reduced the boiling liquid height above the calandria by about 50% and gave a very even juice surface.

A modular evaporator concept

D. J. Wright. Proc. Australian Soc. Sugar Cane Tech., 1985, 247 - 251. A proposed means of increasing the heating surface of an evaporator effect by a relatively small amount is described, in which the existing vessel is split axially along the original welded joint line of the calandria, each exposed half of the calandria then plated and a parallel-wall module inserted between the two halves. The end plates of the calandria in the module are fitted with vertical ribs that match those on the calandria of the existing vessel, making the three calandrias self-supporting along their length. Stays in the steam lanes of the module calandria support the flat sides, while suitable stays in the vapour space eliminate the need to rib the flat surfaces of the module. Provision is made for addition of further modules, for which bolted flanged joints are recommended.

Advantages and disadvantages of the suggested design are listed.

Ammonia-induced corrosion of copper effet tubes at Pleystowe mill

P. C. Ivin, L. J. Watson, C. Doyle and J. A. Abraham. Proc. Australian Soc. Sugar Cane Tech., 1985, 261 - 270.

Severe corrosion of copper tubes in the final evaporator effect was found to be caused by high concentrations of ammonia produced in reactions involving aminoacids from the juice. The concentrations were greatest near the top tube plate and in the region of the incondensable gas vent pipes, and it was here that the corrosion was worst. The installation of separate condensate pumps to the earlier effects in the evaporator reduced the overall mass flow of ammonia through the final effect, but the resultant change in distribution of incondensable gases about the vent pipes caused higher ammonia levels at one sampling point. Metallurgical and chemical examination of the corroded tubes confirmed the unsuitability of copper in final evaporator calandrias because of its susceptibility to the high ammonia concentrations present; brass, although subject to the same attack in severe cases, seems to have a higher corrosion resistance because of its zinc component, but stainless steel has superior general chemical resistance on both the steam and juice sides of tubes and is probably more cost-effective in the long term

Insulation deterioration of 11 kV alternators - Pioneer mill

N. L. Condie. Proc. Australian Soc. Sugar Cane Tech., 1985, 297 - 298.

After the insulation on the stators of a pair of 11 kV alternators was found to be in such a poor condition that there was a risk of failure, the alternators were sent away for repair. The stators were cleaned, had an anti-corona paint applied and were revarnished as well as tested. The alternators are 20 years old, and the question arises as to whether similar equipment of comparable age at other sugar factories has also deteriorated in the same way.

Cyclonic combustor developments

E. G. Williams, W. B. Crawford and W. R. F. Fairbairn. *Proc. Australian Soc. Sugar Cane Tech.*, 1985, 299 - 306.

The cyclonic combustor is a particular type of small furnace used to burn crushed coal or sawdust, and two specially developed combustors were installed at particle board factories in Australia. Experience with them is described, and trials conducted by the Sugar Research Institute are briefly reported, which showed that a combustor will successfully burn bagasse containing up to 32% moisture. Residence times are too short for higher moisture contents to be handled, and further design work would be needed to ensure complete combustion of bagasse as normally leaving the cane mills.

Fluidized bed combustors and their application to sugar mills

N. R. Sheridan. Proc. Australian Soc. Sugar Cane Tech., 1985, 307 - 314.

The possible application of a fluidized bed combustor to burning of bagasse or other waste material for co-generation of steam and electricity, particularly for sale of electricity to the public grid, is discussed.

Vibration monitoring as an "oncondition" maintenance technique

S. A. Domanti, M. G. Topfer and B. W. Wood. Proc. Australian Soc. Sugar Cane Tech., 1985, 315 - 320.

On-condition maintenance is defined as preventive maintenance initiated as a result of knowledge of the condition of an item from routine or continuous checking; its addition to the traditional breakdown and scheduled maintenance systems is a consequence of the use of more sophisticated monitoring devices and techniques. The use of vibration monitoring to determine the condition of machinery is discussed and exemplified by identification of bearing failures and misalignment of a coupling.

Final drive gear failure at Millaquin mill

J. C. Fleming and L. Mathiesen. Proc. Australian Soc. Sugar Cane Tech., 1985, 321 - 325.

During the 1984 crushing season, the final drive gear on the No. 3 mill at Millaquin failed, and it was found that the rim of the final drive gear on No. 2 mill was cracked in five places, so that the factory faced the threat of losing half of its crushing capability. The procedures adopted so as to enable the factory to continue crushing at the same rate of about 340 tch are described.

Refurbishing of scraper and return plates

R. E. Bickle and R. J. Harrison. Proc. Australian Soc. Sugar Cane Tech., 1985, 327 - 329.

Non-traditional techniques used to refurbish cane mill scraper and return plates as a cost-cutting exercise are outlined. In both cases, the treated plates have operated successfully for two seasons. Apart from the cost benefits, there are other potential advantages which are listed.

The 2.75 m shredder installation at Farleigh mill

C. D. Clarke. Proc. Australian Soc. Sugar Cane Tech., 1985, 331 - 335.

A new 2.75 m wide, 1.83 m diameter shredder installed for the 1983 season is described. Generally of conventional design, the shredder has to accept cane from a conveyor only 1.5 m wide, which has necessitated installing two deflector plates over which the cane flows in the chute before entering the shredder below; one plate splits the flow while the other spreads it into a uniform bed at the entry to the shredder. A grid having an angle of wrap of 116° is carried on pivot pins fixed in adjustable mountings on the side members of the shredder casing; the grid can thus be raised or lowered so as to adjust the space between it and the shredder rotor, and has contributed to a seasonal average preparation factor of 90.36 with daily results ranging from 89 to 93.5 over a wide range of cane varieties having fibre contents of 13.2 - 16% at crushing rates of 420 - 460 tch. Maintenance of the shredder is discussed.

A successful application of a tramp iron magnet

C. D. Clarke. Proc. Australian Soc. Sugar Cane Tech., 1985, 337 - 340.

An electromagnet was installed in the transfer chute between two belt conveyors discharging cane in the feed chute above the shredder. Design requirements of the magnet and its performance and maintenance are described. In 1983, 0.91 tonnes of tramp iron was removed, and in 1984 0.85 tonnes; as a result, damage to shredder hammer tips and grid bars was markedly reduced.

Semi-Kestners for steam economy in sugar factories

K. N. Agarwal and D. P. Sharma. *Indian* Sugar, 1985, **34**, 801 - 806.

The vapour cell and the first two effects in the quintuple-effect evaporator at Dhampur sugar factory are semi-Kestner units. while the last three effects are conventional. Vapour cell bleed heats the batch vacuum pans, 1st effect vapour is used for final heating of sulphitation juice, 2nd effect vapour is used for preliminary heating of this juice and heating of the continuous pan, while 3rd effect vapour is used to heat raw juice. Mention is made of the high evaporation rates in semi-Kestner evaporators and of measures to reduce their relatively high entrainment levels. Calculation of the heat balances shows a total steam consumption of 44.5% on cane.

Bagasse solar drying system

Anon. Sugar J., 1985, 47, (12), 6 - 10.

A pilot hybrid passive-active solar system for drying of bagasse to be used as fuel at Porvenir sugar factory in the Dominican Republic is described and some performance data reported. The bagasse passed on a belt conveyor below a sloping transparent cover and was heated and dried by air flowing from a passive wall (of 45° slope) and by the heat from water fed from a set of active collectors (of 20° slope and constituting the topmost section of the plant) to heat exchangers below the conveyor belt. In most cases, the moisture content was reduced from 50% to 36 -44%, although a final value of 33% was also achieved. While the performance of the passive wall was unaffected by a film of dirt and exceeded all expectations (giving temperature rises in the range 18 -27°C and extremes of >30°C, and air flows of 150 - 200 ft/min even when the exhaust fans were inoperative), the temperature of the water from the active collectors fell towards the end of the month of the tests as a result (it is suspected) of accumulation of dust and road dirt.

Desalination by electrodialysis in a cane raw sugar factory

R. Touyama et al. Proc. Research Soc. Japan Sugar Refineries Tech., 1985, 34, 74 - 81 (Japanese).

The electrodialysis system used for molasses desalination at the raw sugar factory of Daiichi Seito Co. Ltd. since 1981/82 is described. In a conventional scheme using anion and cation exchange membranes, problems have occurred with the anion exchange membranes, namely organic fouling of the resin and a fall in pH of the solution being treated with consequent increase in sucrose decomposition. Therefore, the anion exchange membranes have been replaced with non-selective ion permeable PVA membranes. With 60% desalination, the purity of B-molasses rose by about 7.0 -7.5 units, allowing use of a 4-boiling scheme instead of the previous 3-boiling system. Sugar yield rose by 0.3 - 0.4% on cane, and the raw sugar quality was very much improved. The molasses ash content was decreased, particularly K and Mg. There was no deterioration in the membranes after nine months' storage at the end of the first campaign.

Beet sugar manufacture

Automation of sugar factory process control

J. Dobrzycki, M. Ludwick and S. Wawro. Listy Cukr., 1985, 101, 145 - 148 (Czech).

The introduction of computers for process control makes new demands of techniques for measuring various physical parameters, and the authors describe how the problem has been met at the Sugar Technology Faculty of Lodz Polytechnic in Poland. The methods described include ones for: sampling press water, removing impurities and measuring its Brix as an indication of diffusion losses; measuring the concentration of CaO in liming; determining carbonatation juice filtrability; automatic venting of an evaporator; automatic analysis of condensate used as boiler feed water; and determination of reducing sugars.

The content of selected metals in consumption sugar

A. Dandár, V. Karla, A. Rippel and M. Ciznarova. Listy Cukr., 1985, 101, 154 - 158 (Czech).

A number of metals and arsenic were determined in white sugar samples from seven sugar factories during the 1983/84 campaign and the average values compared with data from the literature, including the standards of various countries. Results are tabulated for Cd, Pb, As, Cu, Zn, Ni, Cr, Mn and Fe. The values for all the elements investigated were below the maximum permissible limits.

An arrangement for automatic dosing of disinfectants into a diffuser

L. Kristufkova and O. Mikus. Listy Cukr., 1985, 101, 158 - 160 (Czech).

An automatic system for formalin injection is described. Tested during 1984 at an experimental sugar factory, it injected 7.5 litres of the disinfectant at each of four points (to the press water just before it entered the diffuser, to the front end of the diffuser and to compartments 2 and 3) at 4-hourly intervals. Each injection took 85 seconds, and the total daily dosage rate represented 0.016% on beet. The system proved reliable, with no adverse effects of the formalin on seals or on the materials used for construction. The system should be flushed out with water in the case of a shutdown.

Synstabil, a Czechoslovakian anti-scale agent

R. Stengl, J. Kreckova and V. Molcar. Listy Cukr., 1985, 101, 161 - 163 (Czech).

Synstabil is an acrylate-based polymer solution having a viscosity of about 40 mPa/sec which was tested during two campaigns at Modrany sugar factory as an evaporator scale inhibitor at the rate of 10. 20 ppm thin juice. Results showed that the layer of scale in all effects was thinner than when Polystabil VZ (a Stockhausen product) was used previously at 7 - 20 ppm; moreover, the scale was softer and porous, so that it was easily removed by water jets. Both at Modrany and at Hrochuv Tynec, the scale was hard when Polystabil VZ was used. However, during the 1984/85 campaign, in four out of 13 factories that had deliberately opted for Synstabil, it was considered less effective than Polystabil VZ, while Synstabil failed to come up to expectation at a fifth factory (the evaporator having to be boiled out seven times with trisodium phosphate and once with HCl); Synstabil was considered to make a marked contribution to processing at the other factories.

The role of capillary forces in sucrose crystal adhesion to the surfaces of a vacuum pan

A. I. Ukrainets, V. O. Shtangeev, E. A. Amelina and A. M. Parfenova. *Izv. Vuzov, Pishch. Tekh.*, 1985, (2), 60 - 64 (*Russian*).

In view of incrustation resulting from noticeable adhesion of sugar crystals to working surfaces in a continuous vacuum pan, investigations were conducted to establish the degree of adhesion of single sugar crystals to various polished materials, viz. carbon steel, stainless steel, copper, titanium, tin, Teflon (polytetrafluoroethylene), lead, glass and Perspex (polymethyl methacrylate); a special technique was used in which an electric current applied torque to a rod system carrying the crystal which was thus brought into contact with slabs of test material. After a given time during which the crystal and material were pressed together, the direction of the current was changed, and the two separated. Results showed quite high average forces of cohesion with each material, with very little scatter in each set of values (possibly a consquence of heterogeneity in crystal geometry). Greatest adhesion was with glass and the two steels. The cohesive force was independent of the pressure applied and time of contact, but (it is suggested) was a function of the capillary forces of micromenisci occurring in the contact zone, even under air-dry conditions; these menisci were caused by the presence of layers on the surface of a crystal. The capillary forces depended on the wetting edge angle, so that there was correlation between the cohesive force and the degree of wetting of surface materials by syrups, as confirmed by screen droplet tests in which the smallest edge angles, i.e. highest wettability, occurred in materials of greatest cohesive force (glass, steel and copper). The mechanism of incrustation is explained in terms of these findings. Of possible methods of preventing incrustation, injection of condensate to form a surface film and dissolve any crystals is considered the most effective¹.

Drying white sugar with infrared rays

Le Chan Bin', A. F. Bulyandra and B. I. Verbitskii. *Izv. Vuzov, Pishch. Tekh.*, 1985, (2), 94 - 96 (*Russian*).

Tests are reported on infra-red drying of a 14 - 20 mm layer of sugar having a moisture content of 1.1 - 1.6% and exposed to radiation intensity in the range 3000 - 5000 W/m². Best results were obtained at 4500 W/m² and a time of 10 minutes, which was 50% faster than in a

1 Ukrainets et al. : I.S.J., 1983, 85, 247.

drum dryer (no final moisture contents are given); further reduction in the drying time would be achieved by means of turbulence and mixing of the sugar. The heat absorption properties of sugar were investigated, in which the temperature of the sugar rose sharply in the initial stages as a consquence of considerable absorption of the infra-red rays and their penetration to a certain depth within the sugar crystal; a period of constant drying rate occurred where there was balance between the heat that raised the temperature of the sugar and the heat used to evaporate the moisture, after which (with bound moisture removed) there was a sharp rise in the amount of heat available to raise the sugar temperature, and the last traces of moisture (in the capillaries between adhering crystals) were removed. In the final stage, there was a rise in temperature at the surface of the crystal. It is suggested that an initial radiation intensity of at least 6000 W/m² is practical without risk to sugar quality while reducing the overall drying time.

How can one tackle the problem of reducing energy costs in sugar factories?

B. Goublomme. Sucr. Belge, 1985, 103, 27 - 30 (French).

A system of calculating optimum energy consumption in a sugar factory is described in which products containing available heat (evaporator and A-pan vapours, condensate, recirculation juice and press water) are located in a diagram having a horizontal temperature scale, while products and processs requiring heat are equally indicated. Thus, the total energy available and required at each temperature level is obtained and plotted on a temperature- enthalpy graph. Assuming a temperature difference of 10°C required for efficient operation of a heat exchanger, the point at which the two curves have a minimum temperature difference of 10°C is found, and the distance from this point to the right-hand vertical axis is measured off against the horizontal energy scale, showing the amount of energy needed and at what temperature. The method also shows

where any excess energy has to be removed to the condensers or air coolers. Application of the scheme to a Belgian sugar factory is shown by way of example.

Components of the effect of sugar solution purification by carbonatation

M. I. Daishev, T. P. Trifonova and L. G. Skuina. Sakhar. Prom., 1985, (7), 18 - 20 (Russian).

A theory of the mechanism of carbonatation is expounded which concentrates on the two-stage formation of calcium carbonate and non-sugar adsorption by it. Since conversion of CO₂ from the gaseous to the liquid phase takes place more slowly than adsorption of Ca(OH)₂, there is an excess of Ca++ ions, so that the system has a positive charge; however, this charge is neutralized by CO3-- ions and by anions of the alkaline salts of polybasic acids, including those such as oxalic and citric acid having a greater affinity with Ca++ ions and forming with them low-solubility salts as well as high-molecular polybasic compounds including colorants. Irreversible adsorption of the non-sugar anions and their replacement with an equivalent number of CO3- ions is descriptive of an ion exchange process which, however, differs from classical ion exchange. The adsorbed anions have an equivalent weight which is 3.5 - 4 times greater than that of the carbonate ions. The overall reaction takes on a different guise if the lime salts content is very high; instead of the formation of carbonate ions and of alkaline salts of polybasic acids in the final stage of the reaction, insoluble calcium carbonate is formed, and the greater concentration of Ca++ ions in the solution creates increased adsorptivity. Two methods are described for determination of the equivalent weight of adsorbable anions; while both gave the same result, the method recommended is the simpler of the two and involves liming with 2% CaO on dry solids for 20 minutes at 85°C, neutralization with acetic acid to pH 9, thorough filtration,

and carbonatation with 25% CaO on nonsugars.

The behaviour of calcium hydroxide in sugar solutions

D. V. Ozerov and A. R. Sapronov. Sakhar. Prom., 1985, (7), 20 - 23 (Russian).

Investigation of the behaviour of Ca(OH)₂ added to sugar solutions (filtered juice to which sugar was added) showed that initially some was dissolved while, simultaneously, saccharates were formed and sucrose was adsorbed onto the active nuclei of the undissolved hydroxide. Some of the Ca(OH)₂ then passed into solution with the formation of activated complexes having sucrose adsorbed chemically on their surfaces; the occurrence of these complexes corresponded to unsaturated hydroxide. The increase in concentration of the complexes slowed with increase in the content of Ca(OH)2, the solubility of which increased. Use of the hydroxide in the form of activated complexes for the juice treatment reduced fresh lime consumption, increased colloid coagulation and hydrolysis of amides and reducing matter, and decreased the lime salts content.

The relationship between the ζ -potential of CaCO₃ and organic acids and electrolytes present in a solution

S. P. Olyanskaya, V. A. Tsekhmistrenko and L. M. Khomichak. Sakhar. Prom., 1985, (7), 24 - 26 (Russian).

The effects of various amino and oxyacids, K and Na compounds on the positive zetapotential of $CaCO_3$ obtained from laboratory carbonatation were studied. In all cases involving the organic acids, the potential fell with increase in acid concentration, although lactic acid had the least effect and little of it was removed from the solution by adsorption on the carbonate; the degrees of aspartic and glutamic acid removal were almost the same, although the former acid caused a greater drop in the zeta-potential than was consistent with its level of adsorption.

Beet sugar manufacture

Even at low concentrations, citric acid caused a sharp fall in the zeta-potential, and increase in its concentration could result in a change from positive to negative and a marked fall in the adsorption capacity of the carbonate. At low concentration, K and Na hydroxide, carbonate and sulphate caused the zetapotential to rise, but increase in their concentration led to a fall in the potential and even (particularly in the case of the carbonate) a change to negative; the K compounds had a greater polarizing effect.

An automatic control method for the sugar crystallization process

V. I. Tuzhilkin, A. I. Sorokin, A. R. Sapronov, M. V. Lysyuk and M. Traore. Sakhar. Prom., 1985, (7), 26 - 29 (Russian).

The theoretical basis of boiling control based on resistivity is discussed and experimental work reported. A nomogram is presented in which resistance is given as a function of massecuite crystal content up to 60% in 10% intervals and of initial purity (78, 80, 82, 86, 90, 92 and 94) at 1.12 supersaturation and 70°C. Since most Soviet sugar factories operate a twoboiling system, the pattern of purity change can be divided into two phases: (1) with initial values of 86 - 92 and final values of 76 - 82, and (2) with values of 76 - 82 and 62 - 68, respectively. An automatic control scheme is outlined in which the measured resistance, crystal content and initial purity of the pan contents are used as inputs for calculation by computer of the final purity [= (initial purity - crystal content)/(1 - 0.01 crystal content)] and the resistance corresponding to the crystal content: final purity ratio. Change in the syrup feed (ΔQ_{syr}) to accord with changes in the other parameters is given by $-K_{reg}(R_{true} - R_{calc})$, where $K_{reg} =$ amplification factor in proportional control, and R = resistance; the calculated value is fed via a digital-analogue converter to the syrup feed control. Laboratory tests with an experimental unit have shown that the system smooths out fluctuations in boiling parameters,

including supersaturation, thus allowing increased crystal growth rate with consquent reduction in the boiling cycle and improvement in white sugar granulometry.

The Sh-1-PSha beet piler

N. A. Emel'yanov, L. P. Kinash, B. F. Chernogub, V. V. Lakhterman and I. P. Il'chuk. Sakhar. Prom., 1985, (7), 34 - 35 (Russian).

Details are given of the Sh-1-PShA mobile piler which is provided with hydraulic jacks for locating in a fixed position, and a belt conveyor which can pivot through an angle of 45° from slightly below the horizontal (an end section of the conveyor being hinged so as to allow the beets to travel horizontally to the top of the pile even though the rest of the conveyor is inclined). Hourly capacity is 45 tonnes of beet, and maximum piling height is 7.2 m. The unit is designed for piles less than 24 m wide.

An improved system for automatic control of a battery of FiLS-100 filters at Chishmy sugar factory

A. A. Gotsun, V. I. Strel'nikov, A. A. Slavyanskii and V. A. Pugachev. Sakhar. Prom., 1985, (7), 35 - 38 (Russian).

Details are given of an automatic control scheme introduced and tested on a battery of nine FiLS-100 filter-thickeners for 1st carbonatation juice. The system is designed to control the levels in filtered and unfiltered juice tanks, partial discharge of the thickened mud and juice pressure in the feedline, as well as providing light signals indicating the position of gate valves, excessive levels in the juice and mud tanks and operation of the regeneration cycle (full or partial program). The filters have brought a number of benefits, including removal of juice settlers from the purification scheme and 0.02% absolute (on beet) fall in undetermined losses.

A scheme for utilizing ammoniacal condensates as

diffuser feed water

B. A. Melent'ev and V. P. Chupakhina. Sakhar. Prom., 1985, (7), 38 - 39 (Russian).

In the system introduced at a Ukrainian sugar factory, condensate is mixed with air in the first stage of deammoniation; the mixture enters a tank through a screen which breaks up the bubbles of air entraining some of the ammonia. The condensate is then treated in another tank acting as 2nd stage deammoniator, after which it is mixed with 0.01 - 0.015% CaO (on beet) and finally treated with SO₂. Use of the treated condensate in diffusion has raised raw juice purity by 0.4 - 0.6% compared with the previous system, and reduced the pectin content from 1.57 to 1.11\% on dry solids.

A sampling cock for vacuum pans

N. I. Maslii. Sakhar Prom., 1985, (7), 39 - 40 (Russian).

Sampling cocks manufactured by a particular factory in the USSR have proved potentially dangerous in use on vacuum pans, with risk of scalding of the pan man when the vacuum falls suddenly. However, a cock made by engineers at a sugar factory is described which is highly recommended for its safety and ease of operation and removal of incrusted sugar. It is also highly suitable for massecuite seeding with icing sugar.

Combating microflora in beet sugar manufacture

L. G. Belostotskii and V. Z. Nakhodkina. Sakhar. Prom., 1985, (7), 40 - 42 (Russian).

The bacteriological situation in sugar factories is discussed in general terms, with a list of species found and advice on disinfection of the various pieces of equipment and process stations. Measures to reduce bacterial populations are indicated, and the recommendation made to use more than one rapid method to determine counts in view of discrepancies that may occur.

Waste heat utilization in connexion with pulp drying

K. E. Austmeyer and U. Bunert. Zuckerind., 1985, **110**, 659 - 670 (*German*).

Possible means of reducing process heat consumption in the boiling house are briefly indicated, followed by potential uses of waste heat throughout the factory. Sources of waste heat are examined, and their heat transfer rates calculated, assuming that, for maximum utilization, the available potential heat is reduced to an ambient temperature averaging 10°C and assuming a beet slice of 5000 tonnes/day. While the heat transfer rate of boiler flue gas in a well-organized sugar factory is much lower than that of pan vapours (e.g. 5.4 MW as against 19.3 MW), the available waste heat is at a much higher temperature (182°C compared with 60°C) and boiler flue gas is the only source out of the five discussed which is suitable for high-temperature beet pulp drying. Residual condensate (40% on beet) has a temperature of 70°C and will yield 5.8 MW, while flue gas from hightemperature pulp drying in a conventional drum will give a maximum of 28.8 MW, although cooling from 120°C and condensation greatly reduces its available heat; it may be used as heating medium for a low-pressure boiler, but again there are limitations on the amount of recoverable heat. Waste gas from carbonatation will provide only 1.2 MW and, if it is to be used in low-temperature pulp drying, must be almost saturated and have a condensation temperature in the range 85 - 92°C. A basic heat scheme for a white sugar factory without any waste heat utilization, but with a high level of energy efficiency, is compared with a factory scheme in which the raw juice draft is 107% instead of 110% (giving 112% thin juice on beet compared with 115% in the basic scheme), pulp is pressed to a greater dry solids of 35% and is dried by both medium-temperature drying (using condensate and 3rd effect evaporator bleed to heat air to an inlet temperature of 90°C) and final drying using boiler flue gas, white sugar is

boiled on raw sugar crystal footing, partial vapour compression is used in association with continuous boiling, and the boiler pressure is increased from 59 to 74 bar. As a result, the total fuel consumption is reduced from 4.4% to 2.66% nominal coal. Nevertheless, as with all air-heated dryers, the large volume of heat emitted in the flue gas from the medium-temperature drying is unused, and ways of utilizing it should be sought.

Waste heat utilization for juice heating in association with pulp drying

F. Amding. Zuckerind., 1985, 110, 675 -

The wet dust separation plant for pulp dryer flue gas treatment at Munzel sugar factory includes a hydrocyclone for removal of large dust particles, a venturi nozzle fed with condensate to wet the fine dust particles and make them considerably heavier, and a second hydrocyclone for separation of the wetted particles, which are discharged to a settling tank from which the condensate is recycled to the venturi nozzle. During the wetting of the fine dust particles, the condensate absorbs heat from the flue gas so that its temperature is raised from 30° to 70°C: simultaneously, because of the large surface area of the droplets, it is able to absorb SO₂ or SO₃ from the flue gas, whereby its pH is reduced to 6, allowing some of it to be used as diffusion feed water: some is also used to heat untreated press-water to which the dust concentrate from the settling tank is added. The settling tank is divided into two compartments to handle the condensates at 30° and at 70°C; before entering the tank, the cooler condensate has already heated raw juice from 25° to 45°C and thereby been cooled from 52°C. Calculation of the savings in oil fuel resulting from recovery of the heat from the pulp dryer flue gas shows a pay-back period of 4.8 years. Extension of the plant was to be made in 1984 with use of boiler flue gas as heating medium for pulp drying.

Heating of air for low-

temperature (pulp) drying

H. Kleber. Zuckerind., 1985, 110, 686 - 688 (German).

The various considerations in reducing atmospheric emission and drying of beet pulp at Lehrte sugar factory are discussed, and details given of the scheme that was introduced and tested in the 1984/85 campaign. Condenser water at 50 - 52°C is heated to 59°C by condensate used to desulphurize flue gas from lowtemperature pulp predrying, while it is further heated to 62°C with water used for dust separation from the same flue gas as well as from boiler flue gas; the heat from the condenser water is then used for lowtemperature pulp drying. The SO₂ containing wash water is used as diffuser feed water. Some results from the campaign are reported.

Effect of hydrolysing enzymes on the pressing quality of beet pulp

T. Caro. Zuckerind., 1985, 110, 691 - 692 (German).

Tests are reported in which 10-g samples of pulp of 21 - 25% dry solids were shaken for up to 50 hours at 37°C in an Erlenmeyer flask with 30 ml of enzyme solution; the pressing quality of the pulp was determined every 5 hours using a stamping press. Cellulase raised the pulp dry solids by 2.5 units compared with 17% for untreated pressed pulp, pectinase raised it by 6.5 units, while a complex of cellulase and other enzymes raised the dry solids to 29%. In all cases, pressing improved with fall in pH to 3.5, the enzymes started to have effect after 10 hours, but this effect started to fade after 30 hours, while after 50 hours pressing deteriorated as a result of loss of solid material, which was ascribed to the growth of organisms. The addition of Aspergillus niger in mycelial form reduced this, and raised the dry solids to 45%, while doubling the amount of enzyme accelerated the degradation but raised the dry solids to 47%. However, in both of these cases, the residual solids consisted mainly of lignin and other substances not usable as fodder.

Laboratory studies

Measuring errors in the use of lasers as light sources in polarimeters and saccharimeters

K. Zander and W. Seiler. Zuckerind., 1985, 110, 485 - 489 (German).

While lasers are of major advantage in polarimeters and saccharimeters for their light intensity, monochromaticity and wavelength stability compared with conventional light sources, a major disadvantage is the high coherence of the light waves (the opposite to randomness), since measuring errors may occur as a result of multi-beam interference on planeparallel optical components such as cover glasses, Faraday modulators and quartz control plates. Results of experimental and theoretical investigations demonstrate the effects of birefringence and incorrect adjustment of optical components on measurements when He-Ne lasers are used. In the case of quartz control plates, the potential error in calibration of the polarimeters and saccharimeters has been estimated using the guidelines given in the OIML (Organisation Internationale de Métrologie Légale) Recommendation No. 14 (Saccharimètres polarimétriques). Advice is offered on how to reduce the measuring error.

The role of phenolic substances in the coloration of sugar factory juices

I. K. Vukov and K. Hangyál. Cukoripar, 1984, 37, 135 - 139. II. K. Vukov. *ibid.*, 1985, 37, 22 - 24. III. K. Vukov and K. Bara. *ibid.*, 53 - 55 (Hungarian).

I. The literature on the behaviour of phenols in the beet and in beet processing and on their effect on colour formation in juices and sugar is reviewed with 40 references. Tyrosine at 7.6 ± 5.6 mg/100 g beet represents the major phenol, but the total content of polyphenols (represented by caffeic acid, chlorogenic acid, ferulic acid and *p*-coumaric + sinapic acids) is about the same at 7.0 ± 5.7 mg/100 g. The phenol content in the beet root fluctuates markedly. Significant quantities of dopa (dihydroxyphenyl

alanine) occur as a result of damage to the beet tissue, which, together with fungal infection, causes the greatest change in the anatomical arrangement and phenol content, particularly in the leaf blade, collar and young parenchymatous tissue. Beet variety and location also cause differences. The enzyme, polyphenol oxidase (PPO), oxidizes tyrosine to form dopa, which in turn is oxidized enzymatically to form melanins, while oxidation of the polyphenols present gives polyquinones, which are also colorants; PPO has greatest activity at pH 5.5 - 6.0 and 25°C. The enzyme fraction is somewhat heat-tolerant, and activity has been measured for some minutes at 100°C, complete inactivation requiring 1 hour at this temperature. Only a small proportion of the colorants formed from phenols via polyquinones are soluble, while the greater amount of colouring matter is represented by insoluble melanins which in part form complexes with iron polyphenol; the insoluble melanins are precipitated by liming, while the soluble melanins and the iron polyphenol complexes are precipitated during 1st carbonatation, although a degree of reversible adsorption will occur depending on the active alkalinity. The non-oxidized polyphenols are removed e.g. by filtration, while contact with atmospheric oxygen oxidizes some of the highly-coloured polyquinones to give soluble melanins. During evaporation. some of the polyphenols form highlycoloured complexes with dissolved iron but are finally removed with the molasses at the sugar end.

II. Information on the type of colouring matter formed from phenols is obtained from spectral curves traced by Sorgato¹ to which is applied the formula $E = b\lambda^m$, where E = extinction coefficient, $\lambda =$ wavelength , b is a constant and m characterizes the colorant fraction. Although the relation is not strictly applicable to all cases, m does differentiate between colorants formed from phenols (m = -1.5 ± 0.9 or $-1.8 \pm 7 \times 10^{-3}$) and those formed by sugar degradation (m = -5.5 ± 0.9 or $-5.7 \pm 1.9 \times 10^{-3}$). Considerable differences in values found in

factory juices are attributed to: (1) marked fluctuations in the tyrosine and polyphenol contents in the beet, mainly as a consequence of the topping method, (2) differences in the extent of oxidation of the phenolic compounds in raw juice, in the oxidase activity and in the oxygen content, (3) differences in the oxidized polyphenols contents in purified juice, and (4) distortion caused by possible formation of highly-coloured melanoidin or caramel.

III. The colour complexes of high molecular weight formed by phenols and dissolved iron during evaporation pass through to the boiling house, but can be removed to a large extent by carbonatation of various products, particularly *C*-sugar remelt.

Sugar analysis by highperformance liquid chromatography. I. Resin column

K. Sayama, Y. Senba and T. Muratsubaki. Proc. Research Soc. Japan Sugar Refineries' Tech., 1985, **34**, 26 -31 (Japanese).

HPLC was used to analyse the sugars in the beet molasses. The Aminex HPX-87C resin column chosen was highly stable over a long period, and suitable for factory use. The use of deionized water as eluant reduced the running costs and simplified operation. Betaine was well separated, but there was overlap of the peaks for raffinose and kestose, sucrose and melibiose, glucose and galactinol, and fructose and inositol, although the amount of melibiose in molasses is so small that the method is suitable for sucrose determination. The column is not suitable for Steffen molasses because of its high ash content. Where HPLC is to be applied to monitoring of raffinose during its hydrolysis, the raffinose concentration should first be established enzymatically. During analysis of beet molasses, 0.5% w/w mannitol was found.

¹ Proc. 8th Int. Congr. Ind. Agric. (Brussels), 1950, (1), 241 - 251.

By-products

Modern processes of ethanol manufacture by fermentation

J. P. Arlie, D. Ballerini and F. Nativel. *Rev. Inst. Franç. Pétrole*, 1984, **39**, (6), 781 - 805; through *Biomasse Actualités*, 1985, (36), 14 (*French*).

A survey is presented of a number of alcoholic fermentation processes. An economic comparison is made between the Biostil continuous process and the continuous multi-stage Vogelbusch-Speichim process for ethanol manufacture from molasses. It is concluded that the former process is possibly superior to the latter, depending on the yields obtained. In general, while batch fermentation gives high yields (of the order of 90%), the fermentation time is long (36 - 72 hours) and the final must concentration is limited to a maximum of 10% by volume (beyond this level, the process is inhibited), so that it is not possible to use solutions in the fermenter that contain more than 20% sugar.

The application of vacuum to intensification of molasses wort fermentation

V. K. Yanchevskii, A. D. Kovalenko, V. V. Rudaya, N. D. Emel'yanova and A. A. Egorov. *Ferment. i Spirt. Prom.*, 1984, (8), 4 - 7; through *Ref. Zhurn. AN SSSR* (*Khim.*), 1985, (9), Abs. 9 R367.

Investigations were made of anaerobic fermentation of molasses wort having a dry solids concentration of 24, 28, 30, 32 and 34%. It was found that, while 24 - 28% was the maximum concentration for conventional fermentation methods, the use of vacuum permits removal of some of the alcohols and alcohol products formed and their replacement with undiluted molasses, thereby considerably increasing the wort concentration.

The physiological condition of yeasts in molasses wort fermentation with recycling of yeast suspension

L. V. Levandovskii, A. D. Kovalenko and V. L. Yarovenko. Ferment. i Spirt.

Prom., 1984, (8), 28 - 29; through Ref. Zhurn. AN SSSR (Khim.), 1985, (9), Abs. 9 R368.

During development of technology for accelerated wort fermentation with yeast recycling, an investigation was conducted on the number of dead and budding cells, the specific sugar assimilation rate and the effect of dilution rate on these parameters. It was established that increase in the dilution rate increased the specific assimilation rate in the head vessel to 0. 62% w/w per hr compared with 0. 37% in the control, while in the third vessel it was raised to 0.27%. At a dilution rate of 0.42 - 0.45 per hr, there was a fall in the yeast multiplication rate at a high yeast concentration in the medium, and the number of dead yeast cells increased as a result of a high recycle coefficient (60 -70%).

Projection of bioethanol competitiveness

K. Meinhold, H. Kögl and H. Haimböck. Zuckerind., 1985, **110**, 501 - 504 (German).

The economics of fuel alcohol production from various plant sources, including sugar beet, are discussed under West German conditions and compared with those of gasoline from crude oil.

On-farm molasses storage and feeding trials in NSW

D. N. Williams and R. L. Watts. Proc. Australian Soc. Sugar Cane Tech., 1985, 53 - 57.

The volume of molasses coming from the three sugar factories in New South Wales has risen by 20% since 1978, and local sales of it have increased from 70% to 100% of production, half of the total amount being used for feeding of livestock, especially dairy cattle, in the region. On the basis of present herd numbers and sizes in the north coast region, there is a potential market for approximately 45,000 tonnes of molasses annually, which is almost double the present market for livestock feed. Full exploitation of this market is assuming greater importance in view of competition from higher-purity refinery boil-out syrups. While molasses is a cheaper source of energy than grain in the region, its sodium and phosphorus contents (both needed for high milk production) are low (the presence of excess potassium possibly exaggerating the low Na status). In addition, dairy farmers in the region do not usually feed mineral additives with molasses, while molasses feeds do lead to high levels of faecal moisture, a fact that discourages farmers from feeding molasses. Trials in which bentonite was added with the molasses showed that the additive was of no advantage for energy utilization, had an adverse effect on mineral supplements and provided only slight reduction in faecal moisture content. Mineral additives, chiefly Na and P, enhanced the feed value of molasses, while a desalted molasses gave encouraging results (but no details are available). Although grain-fed cows gained more bodyweight than molasses-fed animals, the latter produced more milk per day. The cost of molasses plus minerals was lower than that of grain plus minerals. The advantages of on-farm bulk storage of molasses to provide a buffer against seasonal shortages and price increases are discussed, and construction of an earth dam for molasses storage (as used on past occasions for emergency purposes) is described.

Alkali-treated bagasse as a medium-quality roughage for ruminants

G. D. Tudor, P. R. Martin, P.A. Inkerman, E. K. Bromage and D. H. Foster. *Proc. Australian Soc. Sugar Cane Tech.*, 1985, 59 - 63.

While the quality of bagasse as roughage is low because of its low digestiblity and edibility, improvements have been brought about by treatment with NaOH to dissolve the lignin, silica and hemicellulose but not the cellulose. Experiments are reported which were aimed at determining the effect of alkali' treatment and supplementation with various additives such as molasses, urea and protein. Mixing with 6% NaOH on

By-products

dry fibre and with one part molasses to four parts bagasse plus 1.5% urea maintained the weight of steers for 84 days, while addition of various protein supplements increased intake by 12 - 48% and the liveweight by 8 - 21% compared with the controls. Cattle fed the basal diet supplemented with a complex protected protein mix converted food to liveweight 57% more efficiently than did animals fed a higher protein Rhodes grass (Chloris gayana) chaff; the organic matter digestibilities of the alkali-treated bagasse and Rhodes grass diets were 55.6 and 61.4%, respectively. However, the death of one animal from suspected kidney failure suggests the need to reduce the NaOH concentration.

Ethanol production in developed countries

T. P. Lyons. Ind. Bev., 1984, 13, (6), 476 - 482; through Ref. Zhurn. AN SSSR (Khim.), 1985, (12), Abs. 12

Alcohol production from various raw materials and its possible use in the pharmaceutical and perfume industries, as disinfectant and detergent, etc. are discussed. Use of a cheap raw material opens up the possiblity of alcohol utilization as a fuel in up to 20% alcohol:gasoline mixtures. Modern distillation technology permits production of alcohol of any purity and for any purpose. Technological schemes are given for alcohol production from raw materials containing starch (converted to carbohydrates by hydrolysis), sucrose and other sugars (molasses, sorghum, etc.) and cellulose that is also convertible to carbohydrates. Continuous processes designed for fuel alcohol production provide for the use of plant consisting of 10 or more fermenters. Future manufacture of fuel alcohol will depend on solving the problem of cellulose saccharification.

Fermentation of molasses wort by combination of Saccharomyces cerevisiae and Saccharomyces carlsbergensis

yeasts

V. N. Shvets, S. R. Rodosiichuk, L. R. Reshetnyak, N. I. Grushitskii and L. N. Torop. *Izv. Vuzov, Pishch. Tekh.*, 1985, (1), 53 - 57 (*Russian*).

While *S. carlsbergensis* has been found to provide complete raffinose fermentation and a much higher fermentation activity of the yeasts produced from the ripened mash, *S. cerevisiae* gives a higher alcohol and yeast yield, so that a combination of the two yeasts was considered more suitable. Experiments are reported in which the optimum ratio was found to be 4:1 *S. cerevisiae* (strain V-30): *S. carlsbergensis* [strain F or 8a(M)]; adding the *S. carlsbergensis* in alcohol yield as a result of the raffinose fermentation.

Ensiling molassed sugar beet feed with grass

G. Macleod. British Sugar Beet Rev., 1985, 53, (2), 70 - 71.

The advantages of ensiling shredded molassed pulp with grass are discussed, and some advice is offered.

Industrial applications of the fixed-biomass anaerobic digestion process for methane production

Anon. Ind. Alim. Agric., 1985, 102, 593 - 601 (French).

Accounts are given of application of the patented SGN anaerobic process in which the biomass is fixed on a bulk plastic medium of large specific surface area (230 m²/m³) and of large void volume (>95%). Among the applications mentioned is treatment of vinasse from a molasses distillery in Guadeloupe using a demonstration plant embodying a reaction vessel of 10 m3 effective capacity and a gas tank of 5 m3. At a daily charge of 20 kg COD/m3 and a vinasse COD concentration of 45 - 65,000 mg/litre, the plant reduced the BOD by 85 - 90% and the COD by 65 - 75%; the 8 m³ of gas per m³ of reactor volume produced per day contained 55 - 65% methane, representing 20 - 22 m3/m3 vinasse. Details are also

given of the results obtained at Thumeries sugar factory in France, where daily treatment of 16 tonnes of COD at an hourly effluent rate of 100 m³ and a COD concentration of 7000 mg/litre reduced the COD by at least 90% and produced 5000 m³ of methane per day, using this to raise steam and allowing the plant to pay for itself within a calculated 7 years.

Yeast growth by the eight-hour system of VNIIKhP

A. D. Dmitriev and N. M. Semikhatova. *Khlebopek. i Konditer. Prom.*, 1984, (1),
38 - 42; through *Ref. Zhurn. AN SSSR (Khim.)*, 1985, (13), Abs. 13 R405.

A new method of manufacturing yeasts has been developed by VNIIKhP (All-Soviet Research Institute of the Baking Industry) which allows more effective use of air, water, heat and electrical energy while giving increased throughput, yield and quality. The method involves growth of seed yeasts by a protracted scheme with intermediate withdrawal of the culture medium for the 1st stage in fermenting commercial yeasts with simultaneous seeding of the 2nd stage from the 1st stage. The seed yeasts constitute 35 - 70% of the total molasses used in each stage. The process takes 8 hours during which the charge is built up simultaneously in the fermenters of both stages and with constant air consumption of 3400 - 3500 m³/hr. There is thus no need for separation of yeasts from the wort, for washing or for prolonged storage of the seed material, while losses of feed medium contained in the wort are eliminated and the amount of the more concentrated waste water discharged into the drain is reduced. The increased seeding of the fermenters allows the growth cycle of the commercial yeasts to be reduced to 7 - 8 hours, while simultaneous operation of all 1st and 2nd stage fermenters with simultaneous buildup of charge provides uniform use of air over a period of days and considerably facilitates its distribution and control. Curtailing the overall process increases sterility and generative activity of the yeasts and improves quality parameters and yield of the end product, which is suitable for drying and prolonged storage.

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Patents

UNITED KINGDOM

Inductively coupled load monitoring of a cane mill roller shaft

Sugar Research Limited, of Mackay, Queensland, Australia. **2,129,138.** October 3, 1983; May 10, 1984.

A system for monitoring the load on a rotating shaft, e.g. as in a cane mill, incorporates a strain-gauge bridge that is attached to the shaft and provides an electrical output which is proportional to the load. Between the monitoring system and a remote decoding system is a contactless inductive coupling in the form of an inner coil fixed to the shaft and an outer coil located on a stationary part of the mill. The power supply and signal from the strain-gauge bridge pass through the coupling, the frequency of the power transmission signal and that of the return signal being separated by a band pass filter which is located on the decoding side of the coupling. The signals from the straingauge bridge pass to a voltage-tofrequency converter and modulator and then, via the coupling, to the filter, demodulator and frequency-to-voltage converter. The indicator of the signal representing the load on the shaft may be in the form of a gauge, a digital read-out system or a means of controlling the load.

Preparation of high-dextrose starch hydrolysates

CPC International Inc. **2,129,806.** October 29, 1982; May 23, 1984.

A starch hydrolysate containing at least 93% (95% or more) dextrose by weight is prepared (continuously) from a corn starch, a maltose syrup having a D.E. of not less than 40% and a maltose content of not less than 45%, or a diluted or partially converted starch having a D.E. of 20 or lower (12 - 20), by contact with immobilized glucoamylase at pH 3 - 7 (3 - 4) (3.5) and 40 - 70°C (45 - 55°C) for a time that is governed by the flow rate of the substrate.

Glucose isomerase immobilization

Novo Industri A/S, of Bagsvaerd, Denmark. **2,129,809.** October 5, 1983; May 23, 1984.

Glucose isomerase is immobilized by contact, in an aqueous medium, with a cross-linking agent such as glutaric aldehyde of 0.001 - 5% (0.005 - 1%) w/v concentration and with a water-soluble salt which does not react with the crosslinking agent or inactivate the enzyme (e.g. sodium sulphate, sodium phosphate, potassium phosphate, potassium citrate, etc.) and has a concentration between 0.2M and saturation (0.5 - 3M).

Solid fructose

Tate & Lyle plc, of London, England. 2,133,796. January 9, 1984; August 1, 1984; November 13, 1985.

A fructose syrup containing approx. 95% fructose and having a Brix of 88° (not less than 93°) (95 - 98°) (after suitable pretreatment to remove impurities that might precipitate during processing) is dispersed at a very high shear (20,000 -100,000/sec) (2000 - 200,000/sec) in alcoholic medium [e.g. ethanol containing <4% (<2%) water or a 1:1 methanol : isopropanol mixture] at 0. 2 - 1.5 ml of solvent per g of syrup (up to 3 ml/g) (0.1 -2.0 ml/g) (0.2 ml/g) (0.3 - 1.5 ml/g) (<0.5 ml/g) ($\geq 0.5 \text{ ml/g}$) in which fructose is soluble to the extent of 1 -10% (2 - 6%) (3 - 5%) by weight at a mixing temperature of 20 - 55°C (40 -45°C) (50°C). The precipitate comprises particles made up of very fine, loosely agglomerated white microcrystals; when dried, it yields a free-flowing powder containing microcrystals having a maximum dimension of <50 µm and particles of 75 - 300 µm. At least 95% of the crystals are generally rod-shaped with a length of 10 - 30 µm and a width of 2 -10 µm, and the product has a bulk density of <0.65g/ml (0.5 - 0.55g/ml).

Mill rolls

Z. P. Chen, of Kaohsiung, Taiwan. 2,134,215. January 24, 1983; August 8, 1984.

For juice drainage purposes, top roll 1 of



a cane mill is provided with a number of peripheral V-shaped grooves 10 and holes 4 that extend from the bottom 11 of each groove through shell 12 into inner channels 3 that extend throughout the length of roll 1. Thus, holes 4 and channels 3 provide an additional exit through which most of the juice can be discharged. The walls of holes 4 converge towards the periphery of shell 12, while the walls of channels 3 diverge towards the ends of roll 1, so increasing the crosssection in the direction of juice flow and reducing the likelihood of clogging by fine fibres or other impurities.

Antifoam agent

Atochem, of Courbevoie, France. 2,135,985. March 2, 1984; September 12, 1984.

An antifoam agent that is effective when added to hot beet raw juice comprises 80 - 98% by weight of a fatty acid derivative containing 12 - 20 carbon atoms, a product resulting from the condensation of propylene oxide and ethylene oxide with ethylene diamine, and 2 - 20% by weight of an aliphatic acid phosphate, the aliphatic group containing 18 carbon atoms.

Fermentation method for producing L-glumatic acid

Takeda Chemical Industries Ltd., of Osaka, Japan. 2,136,432. March 15, 1984; September 19, 1984.

L-glumatic acid is produced by culturing a micro-organism belonging to the genus *Brevibacterium* or *Corynebacterium*, e.g. *B. thiogenitalis, B. flavum* or *C. glutamicum*, on a medium containing glucose, sucrose or molasses, etc. and acetic acid as carbon sources in a carbohydrate : acetic acid ratio of between 80 : 20 and 40 : 60 by weight (between

70: 30 and 50: 50 by weight) (60: 40 by weight) and oleic acid at <60 mg/litre. The incubation temperature is 23 - 37 $^{\circ}$ C and the pH of the medium is maintained at pH 7 - 8.5.

Fermentation of sugar solutions

Edme Ltd. of Manningtree, Essex, England. **2,140,821**. May 4, 1984; December 5, 1984.

In fermentation of sugar solutions to produce ethanol, by-products occur that impart flavour and/or colour to the fermented liquor and which are usually removed by distillation. At least partial removal of the flavour and/or colour can be brought about, in the absence of distillation, by adding 5 - 10 g/gal calcium carbonate or magnesium carbonate, 8 - 12 g/gal active carbon and 5 20 g/gal of filter aid such as kieselguhr. The substances may be added together or separately, with removal of the solids before introduction of the next additive.

Fertilizer composition from vinasse

ENI Ente Nazionale Idrocarburi, of Rome, Italy. (A) **2,141,419**. (B) **2,141,420**. June 11, 1984; December 19, 1984.

(A) To vinasse in a stirred vessel containing 35 - 65% (50 - 60%) dissolved solids by weight is added concentrated or aqueous diluted sulphuric acid of 1.69 -1.84 (1.84) kg/litre s.g. in an amount constituting 1.3 - 1.8 parts by weight per part K in the vinasse. Desalting by the acid takes place in the presence of an organic solvent such as a lower aliphatic alcohol (ethanol) having 1 - 6 (1 - 4) carbon atoms or a ketone (acetone or methyl ethyl ketone), added (3 minutes after the sulphuric acid) at 10 - 25 parts by volume per 100 volumes of vinasse. At least one organic or inorganic substance containing P and/or N (urea, a nitrate,

ammonium salt, superphosphate, concentrated vinasse, etc.) is added to give a total N content of not less than 3% by weight at organic N content of not less than 1.5% by weight, a P content (as P_2O_3) of not less than 4% by weight, a K content (as K_2O) of not less than 5% by weight and an organic C content of not less than 8% by weight. The resultant precipitate is separated and dried.

(B) Vinasse is treated in the presence of an organic solvent with phosphoric acid of 1.5 - 1.69 kg/litre s.g. in an amount equivalent to 2.7 - 3.4 parts by weight of K in the vinasse, so as to provide a fertilizer of the same composition as in (A).

* * *

Abstracts of the following applications for UK patents have appeared in previous issues of this Journal and the applications have been granted subsequent to preparation of our abstracts. The *ISJ* reference to our abstract and the date of granting of the patent are listed below.

2,060,346	I.S.J., 1984, 86, 26. April 26,
2,085,746	1984 I.S.J., 1986, 88, 20A. February
2,086,757	<i>I.S.J.</i> , 1986, 88 , 20A. June 27, 1084
2,090,514	<i>I.S.J.</i> , 1986, 88 , 11A. April 11,
2,104,793	I.S.J., 1986, 88, 22A. February
2,111,843	<i>I.S.J.</i> , 1986, 88 , 32A. March 12, 1986

In addition, the following applications were withdrawn subsequent to preparation of our abstracts:

2,064,581	I.S.J., 1984, 86, 27.
2,065,699	I.S.J., 1984, 86, 61.

UNITED STATES

Simulated countercurrent sorption process employing ion exchange resins with periodic back-flushing

R. G. Fickel, of Roselle, IL, USA, assr.

UOP Inc. 4,319,929. November 19, 1979; March 16, 1982.

Simulated countercurrent adsorption of a component from a fluid feed mixture (an aqueous solution of fructose and glucose) on an ion exchange resin [an alkali metal or alkaline earth (Ca) salt of a nuclearly sulphonated styrene cation exchanger containing (4% of) a cross-linking agent (divinylbenzene)] is provided by passing the solution through a column of resin which includes sequential and connectedly an adsorption zone, a purification zone and a desorption zone. The adsorption zone is maintained between the feed inlet and downstream raffinate (glucose) output. The purification zone is immediately upstream of the adsorption zone and defined by the absorbent located between an extract (fructose) outlet stream upstream and the feed inlet downstream. The desorption zone is immediately upstream of the purification zone and is defined by the adsorbent between a desorbent (water) inlet upstream and the extract (fructose) outlet downstream. The feed mixture is passed into the adsorption zone and a raffinate (glucose) output stream withdrawn from the zone. A desorbent (water) is passed into the desorption zone under conditions to desorb the extract component (fructose) from the adsorbent and an extract output stream withdrawn from the zone which holds the extract and the adsorbent. Through the column of adsorbent are advanced periodically the feed input, raffinate (glucose) outlet, desorbent (water) input and extract (fructose) output to effect the shifting of zones through the adsorbent. Periodically (after the periodic advances of feed input, etc.), the adsorbent is backwashed by water or, preferably, feed mixture which enters the column through the feed input while a back-flush output is withdrawn upstream.

(See also US Patent 4,293,346¹)

Photocopies of the original papers abstracted in this section will usually be available, except where prohibited by the publishers. Such photocopies are available only for research purposes or private study; use for any other purpose is a breach of copyright. It should be noted that photocopies are *not* translations but are in the original language of publication which, if not English, is indicated in italic type at the end of the reference. A charge of $\pounds 0.20$ or \$ 0.40 per page is made for such photocopies which includes airmail postage. Payment should be sent with the order.

In the case of United Kingdom patents, copies may be obtained on application to The Patent Office Sale Branch, Block C, Station Square House, St. Mary Cray, Orpington, Kent, England (price £1.95 each). United States patent specifications may be obtained by application to Box 9, Patent and Trademark Office, Washington, DC 20231, U.S.A. (price \$1.00 each). concentrated solution of sucrose was determined at 35°C using two Ostwald-Sprengler pycnometers. Duplicate densities agreed to within $\pm 1 \times 10^{-5}$ g/cm³. Density values are given in Table I. The value for the density of water was taken from Bigg⁵. The apparent molar volume was calculated from the densities using the equation

$${}^{\phi}V = (1/\rho - 1/\rho_1^0)/m + M_2/\rho \qquad (1a)$$

Table I. Densities and apparent molar volumes of aqueous sucrose solutions at 35°C. *Dilatometric determinations			
m, mol/kg	ρ , g/cm ³	[¢] V, cm ³ /mol	
Water	0.9940357		
0.01193*	0177 10001	212.88	
0.01294*		212.89	
0.01666*		212.90	
0.01669*		212.91	
0.01672*		212.89	
0.01791*		212.91	
0.8200	1.08414	213.76	
1.3053	1.12527	214.31	
1.7004	1.15401	214.61	
2.2407	1.18754	215.09	
2.4689	1.20009	215.27	
2.4727	1.20025	215.29	
2.8173	1.21780	215.47	
2.8292	1.21836	215.50	
2.9377	1.22324	215.67	
3.1286	1.23198	215.75	
3.4326	1.24486	215.92	
3.4914	1.24700	216.05	
3.8483	1.26073	216.21	
4.0058	1.26659	216.22	

For a 1 mol/kg solution the error in molality, δm , must be $\sim 10^{-4}$ mol/kg and $\delta(\rho - \rho_1^0) \sim 10^{-5}$ g/cm³ to give an accuracy of ± 0.01 cm³ in $^{\Phi}$ V, whereas at a dilution of 0.1 mol/kg the accuracies must be ten times better to achieve the same accuracy in ^{\$V}. At molalities lower than 0.8 mol/kg a dilatometric method was used to give an accuracy comparable to that of the pycnometric method at higher molalities. If we consider mixing a small volume of a concentrated solution

containing n2 moles of solute, and of apparent molar volume ${}^{\phi}V_{Init}$, with a much larger volume of pure solvent. then the apparent molar volume of the resulting solution is given by

$$^{\phi}V = {}^{\phi}V_{\text{Init}} + \triangle V/n_2 \tag{1b}$$

where $\triangle V$ is the volume change on mixing. Thus, if ^{\$VInit} is known with an accuracy of ± 0.01 cm³/mol from pycnometric densities, and $\triangle V/n_2$ can be obtained with a similar accuracy, ^{\$V} is known to within ± 0.02 cm³/mol in the final dilute solution. Values for the apparent molar volumes, ϕV , of the concentrated solutions were smoothed graphically to give the values recorded in Table I, and these smoothed values were used to calculate the apparent molar volumes of the dilute solutions, also recorded in Table I.

The apparent molar volumes were fitted to a polynomial in the molality using the equation

$$^{\phi}V = V_2^{\circ} + RT\{A'm/2 + B'm^2/3 + ...\}$$
 (2)

where V_2° is the partial molar volume of sucrose at infinite dilution. The best fitting polynomial was found by the null hypothesis; the coefficients are given in Table II. The results for the apparent molar volume of sucrose are represented to within ± 0.01 cm³/mol. Values at 5°, 15° and 25°C obtained in our previous work³ are also included.

Theory

The activity coefficient of the solute for a dilute solution of a non-electrolyte in a solvent can be written as a power series in the molality

$$\ln \gamma_2 = \mathrm{Am} + \mathrm{Bm}^2 + \dots \tag{3}$$

(This is analogous to the Debye-Hückel limiting law expression for an electrolyte

Table II. Coefficients of the polynomial ${}^{\diamond}V=V_{2}{}^{\diamond}+RT\left\{A'm/2+B'm^{2}/3+\ldots\right\}$					
Т, °К	V_2 , cm^3/mol	A' × 10 ⁴ , kg/mol/atm	$B' \times 10^4$, kg ² /mol ² /atm		
278.15	207.62	1.752	-5.61		
288.15	209.97 211.49	1.166	-1.13 -1.64		
308.15	212.87	0.931	-0.97		

Notation

- activity of solute on the molality a scale b_{11}^{0} cluster integral for one molecule
- of solute and one of solvent in pure solvent
- B_{22}^{*0} integral defining the interaction between two solute molecules in pure solvent
- B₁₁^{*0} integral defining the interaction between a solute and a solvent molecule in pure solvent
- G Gibbs energy
- k Boltzmann's constant
- molality of solute m
- M molar mass of solvent in kg/mol
- number density of solute (n_2/V) n
- N Avogadro's constant
- number of moles of solvent n_1
- number of moles of solute n_2
- R gas constant
- S repulsive contribution to B11*0
- Т absolute temperature
- V total volume of solution
- ¢V apparent molar volume
- V_2^{e} partial molar volume of solute at infinite dilution
- \bar{V}_2 partial molar volume of solute
- $\mu_1 \ \mu_1^0$ chemical potential of solvent
- chemical potential of pure solvent
- μ_2 chemical potential of solute
- standard chemical potential of μ_2° solute
- activity coefficient of solute on Y2 the molality scale
- osmotic pressure π
- ϕ^{A} attractive contribution to B11*0
- ρ density of solution
- $\rho_1{}^0$ density of pure water
- isothermal compressibility κ coefficient of solvent

as a power series in m²). From the Gibbs-Duhem equation

$$a_2 \left[\frac{-\partial \mu_1 / RT}{\partial a_2} \right]_{T,\rho} = m M_1 \qquad (4)$$

and hence

$$-\mu_1/RT = -\mu_1^0/RT + mM_1 + Am^2/2 + 2Bm^3/3 + \dots$$
 (5)

and the Gibbs energy of the solution is 5 Bigg: Br. J. Appl. Phys., 1967, 18, 521.

Densities of aqueous sucrose solutions

given by

$$G/n_1 RT = \mu_1^0/RT + M_1 m \mu_2^{\circ}/RT - M_1 n + M_1 m ln(M_1m) + Am^2/2 + Bm^3/3 + \dots (6)$$

The total volume of the solution is given by $V = (\partial G / \partial P)_T$ so that

$$V/n_1 = V_1^0 + M_1 m V_2^{e} + RT \{A'm^2/2 + B'm^3/3 + \dots \} (7)$$

where the dash represents differentiation with respect to pressure. Then as

$$V/n_{1} = V_{1}^{0} + M_{1}m^{\phi}V.$$
(8)

$${}^{\phi}V = V_{2}{}^{\phi} + RT \{A'm/2 + B'm^{2}/3 + ...\} (9)$$

which is the same as equation (2).

The coefficients of this power series may be related to solute-solvent and solute-solute interactions. For a dilute solution of a solute in a solvent, the osmotic pressure can be written as a power series in the number density of the solute n $(n=n_2/V)$ in an exactly analogous manner to expressing the pressure of a gas as a power series in the concentration:

$$\pi/RT = n + B_{22}*n^2 + B_{222}*n^3 + \dots$$
 (10)

The McMillan-Mayer virial coefficients¹ are related to the intermolecular forces in the same way as the virial coefficients of a gas, e.g.

$$B_{22}^{*0} = 2\pi N \int_{0}^{\alpha} (1 - e^{-\omega^{22}/kT}) r^{2} dr \qquad (11)$$

where ω^{22} is the average intermolecular potential between two solute molecules in pure solvent. (In dilute solution $B_{22}^* \sim B_{22}^{*0}$). The coefficients A, B, etc. of equation (6) can be related to the virial coefficients of equation (10) using the equation

$$m \left(\frac{\partial \mu_2}{\partial m} \right)_{T,P} \left[1 - \frac{n_2}{n_1} \left(\frac{\partial n_1}{\partial n_2} \right)_{T,\mu_1} \right]$$
$$= \frac{\partial \pi}{\partial n_2} (1 - n_2 \bar{V}_2) \quad (12)$$

and it is found, for example, that

 $A_{22}V_1^{\ 0} = 2B_{22}^{\ *0} - V_2^{\ \bullet} - B_{11}^{\ *0}$ (13)

where $A_{22} = A/M_1$, and $B_{11}^{*0} = -Nb_{11}^0$, where b_{11}^0 is the cluster integral for one molecule of solute and one of solvent in pure solvent². Now B_{11}^{*0} is given by

$$B_{11}^{*0} = 4\pi N \int_0^\infty (1 - e^{-\omega^{11/kT}}) r^2 dr \qquad (14)$$

where ω^{11} is the average intermolecular potential between one molecule of solute and one of solvent in the pure solvent and r is the distance apart of the centres of the molecules. For sufficiently large values of the intermolecular distance, r, the potential goes rapidly to zero, while if r becomes very small, that is if the molecules approach each other so closely that overlap of electronic shells occurs, the molecules repel each other strongly. Between these two extremes, the two molecules are attracted to each other by dipole-dipole interactions and London or dispersion forces. Thus B₁₁*⁰ consists of two parts: an attractive and a repulsive contribution. Now B11*0 can be obtained from equation (13) but this requires values of the osmotic pressure and solute activity coefficients for the solution. A value can be obtained for B₁₁^{*0} from apparent molar volume data alone using equation (69) of

Garrod & Herrington⁶. $B_{11}^{*0} = V_2^{\circ} - RT\kappa$ (15)

Discussion

The coefficients A' and B' from the expansion of the apparent molar volume as a power series in the molality [equation (2)] represent the pressure dependence of both solute-solvent and solute-solute interactions and it is difficult to relate these coefficients to intermolecular behaviour. However, from the partial molar volume at infinite dilution information on solute-solvent interactions can be readily obtained using equation (15). Values of B_{11}^{*0} calculated from V_2^{\bullet} are given in Table III: the necessary compressibility data for water were taken from the compilation of Bradley & Pitzer⁷.

Let us consider the two contributions to B_{11}^{*0} . Let R be the distance of closest approach of two molecules, then repulsion will occur for values of r less than R, and attraction for values of r greater than R, and the integral can be split into repulsive and attractive parts as follows:

$$\frac{B_{11}^{*0} = 4\pi N \int_{0}^{R} (1 - e^{-\omega^{11}/kT})r^{2} dr}{6 \text{ Garrod & Herrington; } J. Phys. Chem., 1969, 73, 1877.}$$

7 Bradlev & Pitzer, *ibid.*, 1979, **83**, 1599.

Table III. Attractive contribution to the solute-solvent interaction coefficient B₁₁*⁰, cm³/mol $RTx, cm^3/mol$ $cm^{-\phi^{*}}$, cm³/mol 1, °K V_2 , cm³/mol Sucrose + water 278.15 207 62 206 48 270 1.14 Sucrose + water Sucrose + water 288.15 209.97ª 1.13 208.84 267 298.15 211.49ª 1.11 210.38 266 Sucrose + water 303.15 212.43 1.11 211.32 265 Sucrose + water 308.15 323.15 212.87 1.14 211.73 213.75 264 214.92b 1.17 262 Sucrose + water Sucrose + water 343.15 216.95 1.27 215.68 260 Hexamethylene 108.87^d 107.73 tetramine + water 278.15 1.14 193 Hexamethylene 109.76^d 288.15 1.13 108.63 192 tetramine + water Hexamethylene 298.15 110.58^d 1.11 109.47 191 tetramine + water Glucose + water 298.15 112.2 1.11 111.1 246 t-Butanol + water 298.15 87.8 1.11 86.7 146 Urea + water 298.15 44.2 1.11 43.1 143 a Garrod & Herrington³; b Herrington & Jackson⁹; c This work; d Herrington & Mole¹⁰.

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$$+ 4\pi N \int_{R}^{\infty} (1 - e^{-\omega^{11}/kT}) r^2 dr \qquad (16)$$
$$= S + \phi^A, \qquad (17)$$

where S is the repulsive and ϕ^A the attractive contribution. By considering the shape of the mutual potential energy curve for a pair of molecules, it can be seen that for 0 < r < R, ω^{11} is mostly positive and very much greater than kT, so that S is positive. For $R < r < \infty$, ω^{11} is negative and comparable with kT so that ϕ^{A} is negative. Thus the sign and magnitude of B₁₁^{*0} depends on the relative magnitude of S and ϕ^A .

If the form of the potential function ω^{11} is known, then the integration can be performed to yield B₁₁^{*0}. It is assumed that the sucrose molecule approximates to a prolate ellipsoid with semiaxes 5.9 Å and 3.5 Å, and the water molecule to have a diameter of 3.04 Å. For a hard sphere of radius a₁ and a hard prolate ellipsoid with long axis 2b2 and short axis 2a2

$$B_{11}^{*0} = \frac{4}{3}\pi a_1^3 + \frac{4}{3}\pi a_2^2 b_2 + 2\pi a_1 b_2 \left[a_2 \left\{ (1 - \varepsilon^2)^4 + \frac{\sin^{-1}\varepsilon}{\varepsilon} \right\} + a_1 \left(1 + \frac{1 - \varepsilon^2}{2\varepsilon} \ln \frac{1 + \varepsilon}{2 + \varepsilon} \right) \right]$$
(18)

where $\varepsilon^2 = (b_2^2 - a_2^2)/b_2^2$ according to Isihara⁸. This gives, for the repulsive contribution to B_{11}^{*0} , S = 476 cm³/mol, so that at 35°C the attractive contribution $\phi^{A} = -264 \text{ cm}^{3}/\text{mol.}$ Values at other temperatures are given in Table III; values of V_2^{\bullet} are taken from Garrod & Herrington³ and Herrington & Jackson⁹. It can be seen that the attractive contribution increases with decreasing temperature. Data for hexamethylenetetramine + water¹⁰ are also given in Table III; the temperature dependence of the attractive contribution is the same as for sucrose. The solute-solvent attraction is greater for sucrose than for hexamethylenetetramine, which is consistent with the sucrose molecule having many more sites available for hydrogen-bond

formation. Values for urea + water, glucose + water and t-butanol + water are also given for comparison. The urea molecule is assumed to be a prolate ellipsoid with semiaxes of 3.0 Å and 2.4 Å, using Corev-Pauling models; for glucose the semiaxes are 4.8 Å and 3.2 Å; t-butanol is assumed to be a sphere of radius 3.0 Å. The repulsive contributions for urea + water and glucose + water are calculated from equation (18) and for t-butanol + water from

$$S = \frac{\pi}{2} (R_1 + R_2)^3$$
(19)

where R_1 and R_2 are the hard sphere diameters. V_2° is 44.2 cm³/mol at 25°C for urea¹¹, 112.2 cm³/mol for glucose¹² and 87.8 cm3/mol for t-butanol + water¹³. As may be seen from Table III, at 25°C the solute-solvent attraction decreases in the series sucrose, glucose, t-butanol as the number of hydroxyl groups, and presumably the degree of hydrogen-bonding, decreases. Similarly the attraction is less for urea than for hexamethylenetetramine as fewer hydrogen-bonds are possible. Urea is capable of forming three hydrogenbonds with water, but the attractive part of its interaction with water is similar to t-butanol. In support of this, nmr data¹⁴ show that urea-water hydrogen-bonded interactions exist but are very shortlived. From a practical viewpoint the comparable values of the attractive contribution, ϕ^A , for sucrose and glucose reflect the extensive hydrogenbonding with water, and are responsible for the high viscosity of their solutions and glass forming capability. For ready solubility in water the solute-water interactions must overcome the solutesolute interactions in the crystal. For two molecules of similar size and shape V_2° is a direct measure of the attraction with water; for example at 25°C for cellobiose¹⁵, V_2^{\bullet} is 211.98 cm³/cm which is almost the same as that of sucrose. However this does not reflect the solubility of the compound as cellobiose is considerably less soluble than sucrose. In cellobiose the crystal structure is a

three-dimensional network with each molecule contributing 7 hydrogenbonds, whereas in sucrose each molecule forms only 5 intermolecular hydrogenbonds, so more bonds have to be broken on solution in the former case. The attractive interaction between sucrose and water decreases with increasing temperature consistent with the glass transitions in the neighbourhood of room temperature for sucrose and glucose glasses. Thus the use of simple intermolecular potentials produces solute-solvent interactions of the correct order of magnitude and is useful in comparing the behaviour of different molecules with water.

Acknowledgement

We thank the S.E.R.C. for the award of a Research Studentship to E.L.M.

Summary

Apparent molar volume data for solutions of sucrose and water are reported at 35°C. Theories of dilute solutions are applied, assuming a rigid particle model for the repulsive potential, to solute-solvent interactions.

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Taiwan sugar exports, 19851

	1985	1984
	tonnes,	raw value
Bangladesh	10,327	13,588
Djibouti	0	11,414
Hong Kong	1.521	218
Japan	64,897	30,014
Korea, South	66,185	26,135
Saudi Arabia	11.414	0
Singapore	2,193	0
Sri Lanka	25,110	11.631
US	23,776	36.826
Other countries	147	0
Total	205,570	129,826

FACTORY ENGINEERING

A microprocessor based system for regulation of lowgrade sugar strikes

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Introduction

The main objective of good pan boiling is to get the highest yield of well formed crystals grown from an initial size of 3 - 5 microns to an ultimate size of 0.3 mm in the least time most economically with minimum energy consumption. One therefore desires to boil the massecuite under properly maintained conditions of vacuum and steam/vapour pressure such that a uniform evaporation rate is balanced by the quantity of water entering the pan as a component of the feed molasses/syrup. The most important parameter in sugar boiling is the degree of supersaturation, which is dependent on many other variables.

The vacuum pan boiling process is dependent on the various process variables such as Brix, purity, supersaturation, crystal content, level of the massecuite, vacuum, steam flow rate, molasses feed rate, etc. Brix, purity and supersaturation of the massecuite play dominant roles in the pan boiling process, throughout the strike. These variables are as such very difficult to measure on-line owing to nonavailability of appropriate sensors. They can, however, be estimated from values of other variables such as conductivity and viscosity at the desired operating temperature.

The present paper describes the studies made on A.C. resistivity and viscosity of low-grade strikes and describes a system which computes and displays on-line values of purity & Brix of the boiling strikes. Using this system, some of the results obtained in the regulation of lowgrade sugar strikes are also discussed.

Measurement of basic pan parameters

The basic parameters taken for observations are : (i) A.C. resistivity, (ii) viscosity, (iii) temperature and (iv) level. The measurement techniques for these variables are described below :

Measurement of A. C. resistivity

It has been observed by the authors and also reported by others that it is more convenient to measure A.C. resistivity rather than the conductivity as the former bears a definite relationship with Brix of syrup or massecuite (and hence, also with





its viscosity). The A.C. resistivity increases as the massecuite or syrup is concentrated. At a particular purity of a medium, the A.C. resistivity values correspond to a particular profile of Brix values and hence also to the degree of supersaturation of that medium. Hence, by studying the various profiles of A.C. resistivity at various purities, one can get the complete profile of massecuite behaviour with respect to Brix indirectly.

G. N. Acharya

Based on these reasonings, the panometer was specifically designed¹ to cover the resistivity profiles corresponding to low-grade strikes. The sensing is done by a specially designed electrode constructed with two square bar electrodes.

The panometer, based on a novel technique (protected by Indian patent number 155299) utilizes a pseudo bridge configuration powered with a constant A.C. voltage source (1/10 KHz, 10 volts peak-to-peak) through a very high resistance. This constant A.C. current source excites the electrode and the signal across the electrode is electronically processed such that only the real part of the A.C. resistivity is picked up while the imaginary part containing effects due to capacitive coupling and stray capacitance is eliminated. The real part is directly indicated on a meter scale and may also be displayed digitally or recorded.

Measurement of viscosity

Viscosity was measured with the help of a viscometer in which a cylinder, over a hollow shaft linked by springs to an inner shaft, is rotated at constant speed. With increasing viscosity or higher consistency, the mutual angular displacement between the two shafts becomes larger.

The viscosity was measured in terms of 4 - 20 mA current output corresponding to a torque of 0.02 - 1.8 Newton-metres respectively.

Measurement of temperature

The temperature was sensed using a PRT 101 type linear platinum resistance thermometer, a sensor with a positive temperature coefficient. It shows total resistance change of 39.2 ohms when heated to 100°C. To avoid drift in the temperature readings, a high-stability current source capable of delivering a current of about 1 milliampère is used for feeding the PRT 101 sensor. The sensing is done with high-accuracy operational amplifiers with low temperature drift and low offset errors. The voltage across the sensor is then displayed in terms of temperature after processing through an electronic block comprising a selfcontained unit operating at 230V and 50Hz power supply and termed "Temperature transmitter" which provides both voltage and current outputs for onsite digital display and long-distance transmission of the temperature information for the system located in the centralized cabins. The PRT 101 sensor is connected through a circular cell connector and a switch used to put the "Temperature transmitter" in either sensoron or a standby mode.

Measurement of level

Some of the significant parameters during boiling, such as Brix, purity and supersaturation, follow a definite profile during the entire strike and the controller uses different settings for these related to the massecuite level. Thus the measurement of level becomes an essential feature in boiling low-grade strikes.

The level is measured by discrete sensing with a series of electrodes mounted at fixed distances along the outside of a pan. As the massecuite reaches these, contacts are made and the level is then displayed

1 I.S.J., 1982, 84, 294 - 299; 1984, 86, 131 - 135.

digitally while the information is also transmitted to a remote recorder. The sensing and processing is done by electronic modules/sub-systems.

Location of sensors

Sensors must be mounted at proper locations where they give measurements representative of the actual process dynamic conditions, if they are to give the correct information in the form of electrically measurable quantities related to ictual process dynamics. In order to provide good and consistant results, sensors for measurement of viscosity, temperature and level were installed at the downtake of the calandria where uniform mixing of massecuite takes place giving petter circulation and more uniform lensity.

Microprocessor-based pan monitoring system

A MIcroprocessor based Pan MOnitoring System, designated as MIPMOS, was designed, developed and field-tested at commercial sugar factories. The unit acquires the process data, viz. A.C. resistivity, viscosity, temperature and level of the massecuite, and displays them on a central console. Based on the above on-line measurement the unit computes Brix, purity and degree of supersaturation using the techniques described in the following sub-sections.

The system is developed around an Intel 8-bit 8085A central processing unit along with various peripheral devices, including a floating point arithmetic processing unit. The system software includes: input data acquisition, signal conditioning and filtering, computation of polynomials, code conversion and format adjustments, displays, real time monitor, curve fitting/regression and look-up table program. A photograph of the system is shown in Fig. 1.

Collection of data at the pan

A systematic record of the data was made during low-grade pan boiling. The different observations and results obtained are described below.

The three basic boiling zones, i.e. metastable, intermediate and labile zones,



Fig. 1

were established for syrup medium with the help of the panometer. The C-graining operation was completed with the help of the panometer using A.C. resistivity as a reference variable. The various critical points, i.e. the slurry feeding point, grain hardening, molasses feeding, bringing the mass together, etc., were standardized with respect to the resistivity values. The slurry feeding points for different purities of the medium were determined and the slurry was thereafter added only when the desired value of resistivity was reached for any particular value of the purity of the starting media. This gave rich and sufficient grain, but is dependent on the on-line determination of the purity of the starting medium. On-line direct measurement of purity is difficult owing to lack of appropriate sensors, but it could be estimated from the simultaneous measurement of A.C. resistivity and viscosity as described below.

On-line estimation of purity

The relationship between viscosity and resistivity for different purities has been studied¹, and it has been observed that purity has a distinct role, affecting both viscosity and resistivity measurements. One can estimate the purity of a medium by measuring only the above two variables, viscosity and A.C. resistivity, and reading the corresponding purity from a graph. This estimation has been done automatically by establishing a functional relationship among the above three variables such that purity can be expressed as a function of A.C. resistivity and viscosity.

Fig. 2 shows the relationship between resistivity and purity at distinct viscosity levels. It is evident from the figure that purity may be expressed as a linear function of resistivity given by the expression.

P = M R + C (1) where M and C are slope and intercept, respectively, which are functions of viscosity.

i.e. $M = a_0 + a_1V + a_2V^2$ (2) $C = b_0 + b_1V + b_2V^2$ (3) From (1), (2) and (3), P can be expressed as

$$P = (a_2R + b_2)V^2 + (A_1R + b_1)V + (a_0R + b_0) \quad (4)$$

where a_0 , a_1 , a_2 and b_0 , b_1 , b_2 are polynomial constants which can be found by regression analysis of the actual data. The purity computed from the set of data shown in Figure 2 agrees well with that determined from laboratory analysis. The accuracy is well within $\pm 0.5\%$ (which is





well acceptable in the sugar industry). Typical computed and actual purity values are given in Table I. It may be concluded that, at a given purity, viscosity increases with the increase in resistivity and tends to saturate

		Table I		
Resistivity	Purity (Computed)	Purity (Actual) from graph	% Error	
400.8	63.39656	63.5	0.1628906	
412.8	64.52752	64.5	0.04266547	
424.8	65.65848	65.5	0.2419625	
434.4	66.56342	66.5	0.0950863	
446.4	67.6942	67.5	0.2877016	
Polynomial coeffi $a_0 = 0.1040452$, $b_0 = 72.14383$, b_1	cients are: a ₁ = 0.0231353, a ₂ = 0.0050 = 112.26822, b ₂ = 0.59265	03465. 871 (Viscosity 5.0 mA ≡	0.05 Newton-metre)	
Equation (4) has been realized on the microprocessor based pan monitoring system (MIPMOS) which acquires on-line the A.C. resistivity and viscosity. The microprocessor computes the purity levels, i.e. high crystal content or low non-sugars.				
following the abo	ve equation and displays	On-line estimation of B	rix	
it automatically.		The relationship between resistivity and		

Brix taking purity as a parameter was also studied by the authors¹. Resistivity increases slowly as Brix increases up to a level of 85° and then increases at a faster rate as the Brix rises further. This may indirectly imply that there is an upper limit of Brix for *C*-boiling and that the resistivity also reaches a limit at higher Brix readings. The viscosity or stirrer current and Brix also follow a similar profile at different purities. Using similar curve fitting techniques as described above, Brix can be expressed as a function of viscosity taking purity as a parameter.

Table II shows the computed and actual values of Brix using regression techniques.

It may be seen from the tables that there is a good correlation between the computed and actual values within \pm 0.5%. Using a similar exercise the degree of supersaturation may be computed likewise.

Effect of temperature on viscosity and resistivity

Temperature affects both resistivity and viscosity. Figure 3 shows the variation of resistivity with temperature. The variation of viscosity with temperature has already been described. It may be seen from the graph that, within the pan temperature range, the variations are not very steep and these variables have a selfbalancing effect. This is due to the fact that resistivity decreases with temperature increase as does viscosity. Therefore, if the measurements are under identical operating conditions (suitable selection of sensors in the pan) the latter have a selfbalancing effect on the resistivity and viscosity.

Boiling low-grade sugar strikes The graining operation has been briefly discussed above. Using resistivity as a

	Tab	le II. Computa	ation of Brix from mea	sured data			
Viscosity, cp	Viscosity,	Torque	Viscosity sensor	Brix	Brix	%Error	
	milli-pascal	(N-m)	current, mA	(Computed)	(Actual)	
4114.28	14,400	0.025	3.70	74.07945	74.1	- 0.0277273	
8253.14	28,886	0.050	4.90	78.11081	78.0	0.1420633	
11,554.42	40,440	0.070	5.30	79.24951	79.2	0.0625282	
13,205.14	46,218	0.080	7.10	83.10473	83.1	0.0057013	
14,855.71	50,200	0.090	7.30	83.40491	83.4	0.0058712	
(Polynomial coefficients and	$a_0 = 55.8898, a_1$	= 6.115276, a ₂ =	= 0.3204432)				





reference variable, the graining operation was performed as per the standardized profile. Starting from an initial slurry size of 3-5 microns, grain was developed to a uniform size of approximately 65 microns, while the resulting crystal size was about 150 microns. Further, *C*massecuite boiling was performed using the standardization chart resistivity. The degree of supersaturation was kept within the metastable zone by maintaining the steady rise in the resistivity from an approximate value of 1000 ohm-cm to a final value of 2500 ohm-cm. It was observed that, on average, a 20% reduction in the total boiling period and a 25% reduction in the total water consumption may be achieved as compared with manual control. This results in overall energy conservation.

Conclusion

The paper has highlighted the studies made on the measurement of resistivity and viscosity of low-grade boiling strikes (simultaneous measurements made under identical conditions). One finds that there is a definite relationship among the various process variables such as resistivity, viscosity and temperature. This simultaneous dual measurement leads to the automatic on-line estimation of both purity and Brix of the massecuite which ultimately leads to the determination of degree of supersaturation.

The paper describes how low-grade boiling can be done by monitoring the A.C. resistivity of the massecuite within the metastable zone as identified with the help of a panometer. The critical process steps are regulated with respect to the resistivity after incorporating corrections for purity. This therefore helps in giving long but continuous drinks while keeping the evaporation rate constant; one can thus regulate molasses feed with respect to a definite resistivity program which could be stored in the memory of a microprocessor based system for automatic annunciation and control.

Summary

Studies have been made of the A.C. resistivity and viscosity of low-grade massecuites, and a system developed for computing the values of Brix and purity from these two parameters, temperature and level, and for displaying them during a srike. The system permits automatic control of boiling.

Un système de régulation pour cuisson arrière-produits, basé sur microprocesseur

On a étudié la résistivité au courant alternatif et la viscosité de massecuites d'arrière-produits. La pureté déduite de ces deux paramètres a permis de développer un système pour en calculer le brix et la pureté. On les affiche au cours de la cuisson, en même temps que la température et le niveau. Ce système permet le contrôle automatique de la cuisson.

Ein Mikroprozessor gestütztes System für die Kontrolle von Nachprodukt-Suden

Untersuchungen wurden durchgeführt über den spezifischen Widerstand

Facts and figures

Australia sugar exports, 19851

	1985	1984
	tonnes,	raw value
Canada	477,144	399,657
China	452,290	261,697
Japan	568,998	527,860
Korea, South	343,410	353,753
Malaysia	437,865	280,892
New Zealand	100,473	100,589
Papua New Guinea	0	31
Singapore	103,653	81,048
US	157,535	214,071
USSR	0	347,782
Venezuela	0	16,356
Other countries	10 029	6.877
m i	10,025	0,011
Total	2,651,424	2,590,613

Distillery for El Salvador²

A new distillery is to be erected in the Ahuachapan area. The Central Bank has granted financing for the purchase of 840 hectares for growing of cane for the distillery, most of the alcohol production of which will be exported.

Zaire sugar situation³

Consumption is reported to be back to the mid-1970's level of 75,000 - 85,000 tonnes per year and averages 3 kg per caput although this figure is largely meaningless in such a vast country with varying living standards. Nevertheless, present population trends indicate an increase of three quarters by the end of the century and, with some increase in living standards, at least double present sugar consumption. Production from the three existing sugar factories and one new construction should reach 100,000 tonnes/year

Continued from page 97

(Wechselstrom) und Viskosität von Nachproduktfüllmassen und über Systeme, die die Trockensubstanz und die Reinheit aus diesen beiden Parametern, sowie der Temperatur und dem Füllstand berechnen und diese während des Sudes anzeigen. Das System erlaubt die automatische Regelung des Kochprozesses.

Un sistema basado en el microprocesor para regulación de templas de azúcar de bajo grado

Se han estudiado la restividad a C.A. y la viscosidad de masa cocida de bajo grado, y se ha desarrollado un sistema para calcular los valores de Brix y pureza de estos dos parámetros combinado con temperatura y nivel, y para desplegarlos mientras de la cocción. El sistema permite el control automático del proceso de cocción.

by 1990 but this is still not likely to meet requirements and further investiment in new capacity will be needed to meet demand.

lvory Coast sugar industry restructure4

A team from the French development agency CCCE has visted the Ivory Coast to discuss the possible funding of \$32.1 million scheme to restructure the loss-making state-owned sugar producer Sodesucre. The visit follows the government's rejection of terms set by the World Bank for funding, jointly with the CCCE, of a \$93.5 million project which would have included the introduction of private management at Sodesucre's four remaining sugar complexes. The new, substantially scaled-down project would require \$24 million in external funding. Improvements in irrigation, energy consumption, transport and training are among the project's components.

Mozambique sugar factory destruction

It is reported⁵ that rebels have destroyed the Marromeu sugar factory in Mozambique, which was about to be taken over by the British company Lonrho Ltd. following an agreement with the government. This would be a further severe blow to the country's sugar industry after destruction of the factory near Luabo last year.

Zimbabwe distillery project6

National Chemical Products has commissioned a \$400,000 alcohol distillery at Hippo Valley Estates. It is expected that the new plant, with an annual capacity of 400,000 - 500,000 litres, will make the country self-sufficient in alcohol solvents used in the printing, paint and packaging industries

Belgian campaign results, 1985/867

Beet yield in Belgium during 1985/86 reached 51.78 tonnes/ha, compared with 50.5 tonnes/ha in 1984/85, while sugar content was substantially higher at 16.7% against 15.16%, and the tare content was down to 14.24% from 26.20% in the previous crop. White sugar production reached 942,581 tonnes, up more than 100,000 tonnes from 1984/85.

Austria sugar production, 19858

From a total of 2,406,955 tonnes of beets, 423,168 tonnes of white sugar, 1521 tonnes of low-grade sugar (raw value) and 47,509 tonnes of molasses were produced in Austria during the 1985/86 campaign.

Spreckels Sugar move

After 88 years in San Francisco, Spreckels Sugar Division of Amstar Corporation has moved its corporate headquarters to Hacienda Business Park in Pleasanton, California. The move brings the headquarters closer to their four processing plants in the state's Central Valley and will save some 30% in rent.

Cuba sugar exports, 19859

	1985	1984
	tonnes,	raw value
Albania	21,981	14,673
Algeria	80,666	40,935
Angola	51,029	45,658
Bulgaria	399,531	360,107
Canada	152,279	241,070
China	680,134	705,054
Czechoslovakia	133,678	226,489
EEC	6,995	27,050
Egypt	181,676	137,911
Ethiopia	0	4,809
Finland	75,508	39,340
Germany, East	277,152	278,773
India	108,498	40,999
Iraq	130,154	112,719
Japan	511.375	231,087
Kampuchea	0	1,626
Korea, North	24,072	21,262
Libya	113,156	44,345
Malaysia	52,180	39,269
Mexico	0	52,702
Mongolia	4,717	0
New Zealand	0	44,044
Peru	0	54,411
Poland	134,350	0
Portugal	0	84,974
Rumania	62,516	272,088
Senegal	13,195	20.554
Sri Lanka	13,195	0
Surinam & Dutch	,	
Antilles	1.083	974
Sweden	14.264	0
Switzerland	1.510	2.934
Svria	62,989	132,703
Tunisia	76.112	26,910
USSR	3,709,272	3.649.996
Venezuela	123,094	0
Vietnam, North	3,137	37,456
Yugoslavia	0	20,878
Other countries	2,705	2,710
Total	7,209,008	7,016,510

Sweden sugar production, 1985/8610

In the 1985/86 campaign in Sweden 2,161,069 tonnes of beet were processed to give 256,325 tonnes of white sugar, 65,900 tonnes of raw sugar, 77,668 tonnes of molasses and 138,542 tonnes of beet pulp.

New sugar factory for Pakistan

The 41st cane sugar factory in Pakistan - Pangrio

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- 4 World Sugar J., 1986, 8, (7), 25.
- 5 Amerop-Westway Newsletter, 1986, (147), 18.
 6 Standard Chartered Review, February 1986, 9.
 7 F. O. Licht, Int. Sugar Rpt., 1986, 118, 85.

- 8 Zuckerindustrie, 1986, 111, 188. 9 I.S.O. Stat. Bull., 1986, 45, (2), 13 14.
- 10 Zuckerindustrie, 1986, 111, 188.

¹ I.S.O. Stat. Bull., 1986, 45, (3), 2.

Facts and figures

Sugar Mills Ltd., at Deh Rajauri in the Badin district of Sind Province - has gone into a trial season. It has an initial capacity of 2000 t.c.d., expandable to 3000 Lc.d., and in a normal season is expected to produce about 51,300 tonnes of white sugar. The factory cost the equivalent of £15.3 million, including £2,326,000 in foreign exchange.

Inter-American Sugar Cane Seminar, 1986

The 1986 Inter-American Seminar is to be held during September 24 - 26 at the University of Miami Auditorium. The topic chosen is "Energy and By-Products from Sugar Cane" which contemplates phases such as bagasse for energy, paper and feed; final molasses for rum, alcohol and feed; filter-cake for agricultural use, etc., and the related matters derived from the sugar industry or by-products, such as pollution prevention, distillery waste disposal, etc. For additional information readers are advised to get in touch with Inter-American Sugar Cane

Seminars, 3690 N.W. 62nd Street, Miami, Florida 33147, U.S.A. [Telephone (305) 633-0351; Telex 153665 Siasucas].

Cuban assistance for the Tanzania sugar industry¹¹

A Cuban delegation has arrived in Tanzania in order to visit the country's sugar factories and cane plantations and assist in boosting sugar production which is currently some 130,000 tonnes a year.

Switzerland sugar production, 1985/8612

The two sugar factories in Switzerland sliced a total of 790,123 tonnes of beet to produce 127,726 tonnes of white sugar and 32,967 tonnes of molasses.

Cuban sugar factory expansion¹³

Central Uruguay, at Jatibonico in Sancti Spiritus province, is to be enlarged from its current 5500 t.c.d., to 17,500 t.c.d., which will make it the largest in Cuba. The extension work started in 1984 and will be complete in 1988. Cuba has also been granted a credit of 850 million yen by the International Investment Bank to finance a sugar factory project in Camaguey.

Fiji sugar exports, 198514

	1985	1984
	tonnes,	raw value
Canada	19,025	0
China	57,933	20,537
EEC	185,670	181,934
Japan	14,918	15,154
Korea, South	0	12,569
Malaysia	61.932	67,803
New Zealand	36,154	22,418
Portugal	29,007	0
Singapore	14,504	14.433
US	0	35,509
Total	419,143	370,357

India sugar supply and demand¹⁵

Sugar production in India in the 1985/86 season is estimated at 6.7 million tonnes which, with a carryover stock of 1,608,000 tonnes from 1984/85 brings an availability of nearly 8.3 million tonnes. However, the natural increase in consumption on the domestic market places demand at 8.7 million tonnes. In order to maintain adequate forward stocks of around 1.4 million tonnes, imports of 1.8 million tonnes will be needed during the period.

Brazil sugar exports, 1985 ¹⁶			
	1985	1984	
	tonnes, re	aw value	
Algeria	257,512	410,615	
Bangladesh	0	10,826	
Canada	21,000	20,000	
Chile	7,577	66,313	
EEC	29,500	0	
Egypt	211,572	315,119	
Ghana	32,478	32,478	
India	247,624	285,700	
Iran	102,847	152,260	
Iraq	229,298	161,607	
Jordan	25,333	15,156	
Kenya	29,198	28,581	
Madagascar	3,431	8,369	
Mexico	0	13,641	
Moroco	108,000	149,000	
New Zealand	19,000	0	
Nigeria	353,541	11,390	
Peru	0	23,872	
Portugal	51,624	59,950	
Saudi Arabia	12,342	54,942	
Somalia	0	14,290	
Sri Lanka	53,481	38,491	
Surinam	1,083	0	
Sweden	22,800	48,800	
Syria	12,991	58,028	
Trinidad	0	10,000	
Tunisia	67,991	71,626	
US	359,693	271,917	
USSR	335,148	612,037	
Venezuela	13,641	94,500	
Total	2,608,705	3,039,508	

Italy sugar expansion¹⁷

Italian sugar production in 1986 is expected to rise to about 1.5 million tonnes, white value, compared with 1.2 million tonnes in 1985, according to industry sources. The higher output is attributed to an expected 16% increase in 1986 beet plantings over those of 1985. The total area sown to beet is estimated at 260,000 hectares this year against 225,000 ha last year.

Barbados sugar exports, 198518

Raw sugar exports from Barbados in 1985 fell to 77,840 tonnes from 85,884 tonnes in 1984. The principal destination was the EEC with 53,750 tonnes (73,427 tonnes in 1984), while the US received 17,635 tonnes (7352 tonnes in 1984) and Canada 6376 tonnes (5105 tonnes). The balance of 79 tonnes went to other destinations in Central America.

Norway sugar imports, 1985 ¹⁹			
	1985	1984	
	tonnes, w	hite value	
Austria	0	4,860	
Belgium	463	1,042	
Denmark	90,943	83,607	
Finland	4,482	21,625	
Germany, West	34,306	15,386	
Sweden	865	4,809	
UK	33,794	22,626	
Other countries	256	465	
Total	165,109	154,420	

New sugar factories in India20

With two new sugar factories in the cooperative sector taking shape at Sampoornagar (Lakhimpur Kheri) and at Pooranpur (Pilibhit District), the industry in Uttar Pradesh state now totals 101 factories. A new factory is under construction at Vataria Valia, in the Broach district of Gujarat, while five more are to be set up in the Vidarbha region of Maharashtra during the next two years.

Major sugar exporters talks on a new ISA

Representatives of the four principal sugar exporting countries are to meet during the next meeting of the ISO council meeting starting on May 19, to explore the practicality of preparations for negotiating a new International Sugar Agreement. Similar meetings were held during the meeting in February but the question of Cuba's demand to export freely to the Eastern Bloc, strongly opposed by Australia, remains a stumbling block.

Rumania sugar economy setback²¹

According to official sources the Rumanian beet crop fell by nearly 9% in 1985 to 6,446,000 tonnes against 7 million tonnes in the previous year. The fall in sugar output was even worse, with 582,000 tonnes, white value, produced against 805,500 tonnes in 1984/85. The 1985 beet target had been 10.83 million tonnes and that for sugar was 960,000 tonnes.

Finland sugar imports, 198522

Apart from 2,614 tonnes of raw sugar imported from the EEC, the rest of Finland's 1985 sugar imports of 64,567 tonnes, raw value, came from Cuba. In the previous year, imports of 75,623 tonnes, raw value, had included 37,524 tonnes from Cuba, 12,565 tonnes from Brazil, 12,612 tonnes from the EEC and 12,922 tonnes from the Philippines

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US sugar imports, 198523

	1985	1984
	tonnes,	raw value
Argentina	147 880	200 328
Australia	121,395	232,225
Barbados	16,130	00
Belize	12.633	26.436
Bolivia	16.876	8,450
Brazil	308,777	322,955
Canada	17,357	13,460
Colombia	164,456	59,555
Congo	7,762	7,511
Costa Rica	3.045	83,661
Dominican Republic	429,828	483,627
Dutch Antilles	5	87
Ecuador	25,398	17,524
EEC	442	474
Fiji	0	29,113
Gabon	3,245	0
Guatemala	102,732	137,152
Guyana	5,495	102,360
Haiti	0	15,682
Honduras	45,136	91,077
Hong Kong	73	0
India	18,360	49
Ivory Coast	11,165	0
Jamaica	20,450	0
Madagascar	11,221	14,531
Malawi	36,706	33,156
Mauritius	10,115	31,090
Mexico	15,936	2
Mozambique	8,883	25,592
Nicaragua	5,469	5,479
Panama	61,459	55,288
Papua New Guinea	11,383	0
Peru	90,540	97,717
Philippines	314,921	377,618
St. Kitts	4,722	70
South Africa	52,351	75,580
Swaziland	16,508	43,801
Thailand	33,786	38,631
Trinidad	9,439	0
Uruguay	4,451	7,461
Venezuela	7	0
Zimbabwe	14,348	39,140
Other countries	and a second second	
and unknown	0	250,369
Total	2,274,669	3,021,312

Mexico sugar factory closures²⁴

Azúcar S.A. has shut down eight unprofitable sugar factories because of scarcity of financial resources and the high cost of servicing the debts of government factories. Current plans to increase productivity include the modernization and expansion of 12 (out of 50) state factories and could include the closure of more unprofitable ones.

Guyana sugar exports, 198625

As usual, most of Guyana's raw sugar exports of 230,387 tonnes were exported to the EEC (185,931 tonnes, against 172,901 out of the 1984 total of 214,914 tonnes). Other destinations included the US with 22,721 tonnes against 36,113 tonnes in 1984, Portugal with 11,481 tonnes (0) and Canada with 9271 tonnes (5740).

New sugar factories for Rumania²⁶

According to official sources four new sugar factories are to be erected by 1990. They are to be located at Lechinta, Falciu, Racari and Tatarani but no further details are available.

South Africa sugar exports, 1985 ²⁷		
	1985	1984
	tonnes,	raw value
Angola	1,776	0
Burundi	869	0
Canada	181,202	555,211
Comoros	4,845	0
Hong Kong	7,403	0
Israel	74,424	60,262
Japan	399,783	287,970
Korea, South	227,595	104,363
Mozambique	11,157	0
Portugal	30,121	0
Sri Lanka	13,765	0
US	67,020	62,236
Zaire	13,935	0
Other countries		
and unknown	1,663	11,291
Total	1,035,360	1,081,333

Jamaica sugar factory closure²⁸

The state-owned Duckenfield sugar factory is to be closed at the end of the current season after losing \$J 16 million (nearly \$US 3 million) over the past three years.

Belize sugar exports, 198529

Total raw sugar exports from Belize in 1985 amounted to 95,530 tonnes against 101,540 tonnes in the previous year, and included 44,792 tonnes for the EEC (47,123 tonnes in 1984), 25,247 tonnes for Canada (12,402 tonnes), 12,959 tonnes for the US (36,943 tonnes) and 12,532 tonnes for Portugal (0). No sugar was exported to Ecuador, against 5072 tonnes in 1984.

Brazilian Sugar Institute reprieve30

The Brazilian government is to delay indefinitely the proposed dismantling of the Sugar and Alcohol Institute, according to the Commerce and Industry Minister, although it will eventually be dismantled. The proposal had been made by the former Commerce Minister, Roberto Guzmão, who retired in February.

Costa Rica alcohol plants³¹

Costa Rica is to open - almost back-to-back two alcohol facilities in its Guanacaste region. One will be used as an up-grading facility and the other will be a full-scale production plant. Costa Rica has had a 200,000 litres/day production facility in operation since 1979; the up-grading plant, which was due to begin operations by April 1986, is to produce 240,000 litres/day using azeotropic distillation, a method which the US Customs has twice rulled as constituting a

"substantial transformation" whereby the product is allowed duty-free access to the US under the Caribbean Basin Initiative. The other plant, to be operated by Taboga, a sugar company, was expected to start producing 180,000 litres/day of alcohol from cane in March.

Malawi sugar exports, 198532

Exports from Malawi rose sharply last year to 142,588 tonnes from 89,442 during 1984. Destinations included Burundi (3780 tonnes), Canada (20,748 tonnes), the EEC (20,748 tonnes), Mozambique (2381 tonnes), Portugal (24,173 tonnes), Rwanda (217 tonnes), the US (36,838 tonnes) and Zaire (14,663 tonnes), while 39,788 tonnes were for unknown destinations.

Dominican Republic sugar emergency³³

The Dominican Republic's sugar industry is not expected to produce more than 700,000 tonnes this year, against average annual output of just 1 million tonnes. The government declared a state of emergency for the industry and sent soldiers and civil servants into cane fields to assist with the reaping. The industry has been hit by the absence this year of 18,000 cutters from neighbouring Haiti. The government cancelled the 6-month contracts of most of these workers because of low world sugar prices, while others were not able to enter the country because the borders were sealed.

EEC prices for ACP sugar³⁴

The EEC finally softened its stance on sugar prices paid to the African, Caribbean and Pacific (ACP) countries when the Farm Ministers agreed to permit an increase of 1.3% in prices paid to the producers, but only after devising a complex formula allowing Community producers compensation in the form of an MCA prefixation. The increase, announced on March 26, will be effective for the period to July 31, 1986 but may still be rejected as inadequate by the ACP countries.

Fall in Australian income from sugar exports35

In its latest report, Australia's Sugar Board estimates that total revenue from sugar for the twelve months to June 30 will be down \$A 100 million to \$A 700 million. By 1988 all of Australia's long-term contracts for sugar sales will have ended and are unlikely to be renegotiated. In 1983 nearly half of Australia's sugar sales were covered by such contracts but those which have expired have not been renewed

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