INTERNATIONAL SUGAR JOURNAL













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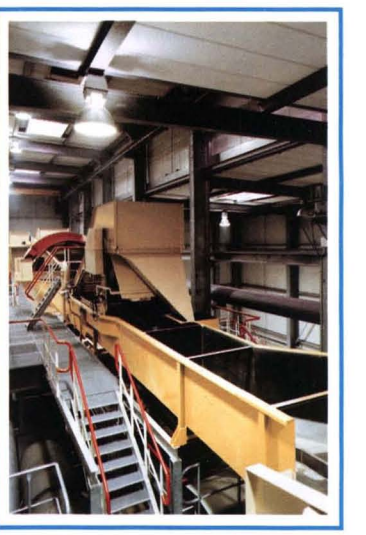

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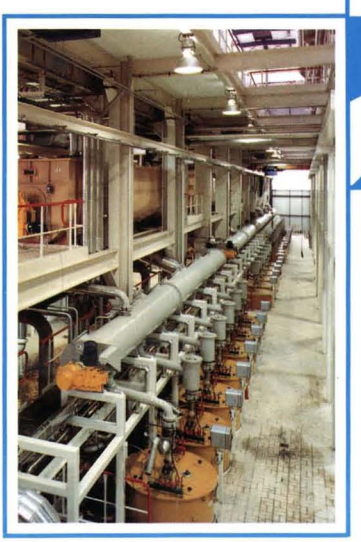

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News and views

World sugar prices

The surplus stocks which overhung the world sugar market five years ago have been eroded steadily and have reached a very low level. This has been known for some time, however, so that it does not explain the remarkable rise in values during the month of June. The London Daily Price of raw sugar started the month at $247.80 per tonne and rose almost immediately to the $250-$270 level at which it stayed until June 20. It rose to $289 per tonne by June 22, dipped to $280.50 on June 24, recovered to $289 on June 27, $328 on June 28 and fell back to $318 at which price it finished the month before rising to $344 on July 1, a level not seen for six years.

For the first part of the month, up to June 17, the LDP(W) showed a premium of around $6.00 but the rise in raw sugar values then took them above the corresponding white sugar price by increasing amounts. Consequently, the LDP(W), which started the month at $255 per tonne was within the range $261 - $267 between June 2 and June 17, rose to $282.50 on June 22 but fell back to $275.50 before climbing to $312.50 on June 28. It then fell again to $299.50 on June 30 before reaching $315 on July 1.

There have been a number of factors responsible for the upward trend in prices: the major one has been a high level of purchases by China, while others include a 300,000-tonne swap arranged for the USSR, mention by F. O. Licht of the likelihood of a further drawdown of stocks in 1988/89, flooding in Cuba and declaration of *force majeure* regarding some of that country's exports, and the effects of drought in the US mid-west which has both cast a shadow over the sugar beet crop and also resulted in buoyancy in the grain and soya markets which has rubbed off on the sugar market. It has also been suggested that with a fall in domestic output, the US might need to increase its import quota next year by 500,000 short tons or more. Besides Cuba, a number of other exporters have been reported to be in difficulty over meeting their obligations and steady demand has consequently strengthened the market.

The economics of farm subsidies

If the rich world stopped subsidizing its farmers it would create jobs, instead of losing them. The European Community alone could have lost 3 million jobs through the Common Agricultural Policy. Moreover, abolition of farm support policies would pare nearly $40,000 million from the US budget deficit and better the US external trade balance by some $42,000 million.

In addition, developing countries – hitherto thought certain to lose through agricultural liberalization by the industrialized countries – would instead gain some $26,000 million a year, while even the poorest among them could pay off some of their crippling foreign debts.

These are among the startling conclusions of a new set of studies launched at a seminar in London in May. The Centre for International Economics, in Canberra, Australia, which produced the studies, claims that they are an important and innovative contribution to the cause of farm reform. The studies cover the effects of unilateral agricultural liberalization in and on the US, Japan, the EEC, Korea and the developing countries as a whole. They broadly conclude that the manufacturing and service sectors have borne the cost of farm support which, contrary to received wisdom, has cost jobs instead of creating them.

In West Germany, for example, liberalization of agriculture could result in the creation of an estimated 850,000 new jobs, a rise in output in the non-agricultural sectors of 9% and an increase in exports of up to 26%. However, agriculture itself could see employment and output decline by 24% with a 17% fall in land values.

In the US studies, the main losers from the removal of farm support, currently amounting to direct costs of $30,000 million annually, would be owners of farmland. However, net revenue gains to the US Treasury would provide sufficient funds to compensate farmers, while gains to the economy as a whole would be substantial, the studies indicated.

Everyone knows that protectionism is a problem; the spiralling cost of farm subsidies and storage of surplus produce are a burden to taxpayers and world trade has become distorted. But the public are unaware of the real cost of protection and the studies are intended to provide evidence which will convince people to demand reform from their governments.

This could be when they realise that abolition of protection can provide important gains elsewhere in the economy. For instance, abolition by Japan of protection of beef would result in higher US beef sales to Japan and more yen for the US with which to buy Japanese cars. Further, protection has encouraged overcapitalization of land and farm assets whereas the money could have been more gainfully employed in manufacturing.

Copies of the papers presented at the seminar are available from the Centre in Canberra or from the Trade Policy Research Centre, 1 Gough Square, London E.C.4, England, at a price of £30.00.

Record Australian sugar crop[1]

The 1987/88 sugar cane harvest in Australia was a record in spite of reduced yields due to the dry conditions during most of the season. Sugar output totalled 3.5 million tonnes or 1.9% more than was produced the year before. Production is expected to rise further next season with some estimates as high as 3.8 million tonnes.

World sugar production

Recently estimates of world sugar production have been published by four authorities: F. O. Licht GmbH, C. Czarnikow Ltd., E. D. & F. Man and the International Sugar Organization. Although they are on different bases, the

1 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 268.

range is quite limited, from 104.2 to 104.9 million tonnes, raw value.

Czarnikow mentions[2] that, while the new estimates have been increased *in toto* by a modest 0.3%, this masks significant changes in the figures for individual countries, especially among producers in the Far East. In India, the pattern of production as the current season has developed indicates that the effects of last year's severe drought have been overcome, and the estimate has been raised to 9.5 million tonnes, while the Indian Sugar Mills Association predicts a final result slightly higher. Consumption too has risen more than expected earlier, and is now set at 10.25 million tonnes, raw value. Average consumption growth has been 10% per annum over the present decade.

Production in Pakistan this season has also seen a reversal of fortune and, from an expectation of one of the poorest crops in recent years it now seems that a new record will be established. The latest estimate, at 1,950,000 tonnes, is 40% higher than the low forecasts a year ago after the drought. At one stage, very pessimistic reports were circulating about the Thailand crop but they continued crushing until near the end of May and the production forecast is now raised from 2.4 to 2.72 million tonnes.

Crop prospects in China have continued to decline with falling yields and smaller areas devoted to arable crops, including sugar. Although the authorities have introduced subsidies and gains are expected next year, the estimates for 1987/88 are set at 830,000 tonnes, raw value, for beet sugar (925,000 tonnes in 1986/87) and 3,970,000 tonnes for cane sugar (4,875,000 tonnes in 1986/87).

Improved milling rates and comments from Cuban sources have resulted in a 100,000-tonne increase in that country's forecast crop, while poor weather has reduced crop prospects in a number of Central American countries, including Guatemala, Honduras and El Salvador. Further gains have been made in the USA and the Mainland Cane estimate has been raised to 2,140,000 tonnes.

Total beet sugar is set at 38,791,000 tonnes against 38,311,000 tonnes for 1986/87, while the cane sugar figure is almost unaltered at 65,436,000 tonnes against 65,392,000 tonnes. The overall production figure of 104,227,000 tonnes contrasts with a consumption estimate of 107,063,000 tonnes, i.e. a shortfall of 2,836,000 tonnes which will further reduce stocks. To avoid a further drawdown of stocks in 1988/89 Czarnikow believes an increase of production of 4.0 million tonnes or more will be needed but such an expansion does not seem probable at the moment.

Brazil sugar export arrangements

The Brazilian government announced in mid-May that it would end the federal monopoly on sugar exports[3]. The President of the Sugar and Alcohol Institute (IAA) said that a new system of auctions of export sale contracts would be held on a sealed-bid basis while private export contracts could be made by sugar producers without reference to the auction system. However, near the end of the month President Sarney agreed to extend the IAA's monopoly for another year, bowing to intense pressure from cane sugar producers[4].

New companies formed by Bookers and Tate & Lyle

Tate & Lyle PLC has agreed with Booker PLC to merge its Tate & Lyle Agribusiness division (TLA) with Booker Agriculture International Ltd. (BAI). The new company, to be owned equally by both groups, will be called Booker Tate Agribusiness International Ltd. (BTAI), and will be the largest of its kind in the world. The principal activities of BTAI will continue to embrace (i) the provision of corporate management and technical advisory services to major sugar industries in Kenya, Somalia, Swaziland, Jamaica, Sri Lanka, Papua New Guinea, Indonesia, Zambia, Guyana, Belize, Trinidad, Sudan and Uganda, producing together some 1,400,000 tonnes of sugar per annum; (ii) the provision of corporate management and technical advisory services to tea, coffee, oil palm and other agricultural enterprises in a number of countries; (iii) responsibility for a number of livestock operations in certain countries; (iv) an engineering project management business with current contracts encompassing hotels, textile mills, etc., and (v) agricultural and land use consultancy worldwide. The merger of BAI and TLA reinforces their continued commitment to profitable agricultural development overseas and will facilitate an enhanced level of professional service to existing and future clients.

The two groups have also agreed to merge their sugar machinery businesses of Fletcher and Stewart Ltd. and of Smith Mirrlees into a new company to be known as Fletcher Smith Ltd. which will be located in Derby. The merger of skill and experience of the two oldest specialist suppliers in the UK into a single organization will enable the new company to offer improved service and a comprehensive range of machinery for the worldwide cane and beet sugar sectors. Fletcher Smith Ltd. will be 65% owned by Booker and 35% by Tate & Lyle. It will have increased scope for research and development which is an essential ingredient in providing cost-effective technology. To supplement its own established designs it has licences for some of the most technologically advanced sugar processing equipment available, obtained through close association with centres of technical excellence in the main sugar producing countries. The company will thus be in a strong position to compete effectively in world markets in the years ahead.

Indonesian sugar refinery project[1]

CSR Limited may join forces with an Indonesian company to build a Aus$40 million refinery near Jakarta. The move would leave Australia well placed to supply raw sugar to an expanding region.

2 *Czarnikow Sugar Review*, 1988, (1773), 65 - 66.
3 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 261.
4 *Financial Times*, May 27, 1988.
5 *Australian Canegrower*, 1988, **10**, (4), 7.

Product news

Controlling pressure at British Sugar

British Sugar has selected mechanical pressure gauges supplied by Sydney Smith Dennis for recording and monitoring the pressures in its sugar beet processing plants. SSD is one of four main contractors to British Sugar and has been selected to supply instrumentation equipment to all of the organization's 13 factories.

One of the factories already using SSD equipment is at Brigg, in South Humberside, where between 30 and 40 safety pattern pressure gauges have been installed for monitoring the pressure of steam, hot water, oil, gas and air.

The gauges are contained within a black DMC plastic case and have stainless steel internal components, which are essential since the instruments can often come into contact with ammonia. By standardizing on stainless steel for these components, British Sugar is able to ensure that it possesses gauges suitable for use in any part of the plant, eliminating any problems with interchanging.

The order from the Brigg factory was clinched late last year and represents a significant accolade for SSD's equipment, since British Sugar is an extremely cost- and quality-conscious company.

Sydney Smith Dennis has built up a reputation as a leading manufacturer of mechanical pressure and temperature gauges and British Sugar is showing a great deal of interest in their potential applications.

Further details:

Sydney Smith Dennis Ltd.,
Crossgate Drive,
Nottingham, England.

Wire cloth data book

To mark the company's 100th Anniversary in 1987, Haver & Boeker, of Oelde, in West Germany, have produced a new catalogue providing details of their complete range of wire cloths. It provides 24 tables showing widths, wire diameter, open surface, weights, apertures, materials, etc., for a wide range of cloths many of which are to various German and International Standards, including those for sieve analysis. Some of the headings are in English but the bulk of the language used is German, naturally enough. Only a small knowledge of German would be necessary, however, to be able to make use of this catalogue, which is available from Haver & Boecker, P.O. Box 3320, Ennigerloher Strasse 64, D-4740 Oelde, Westfalen, Germany.

Speed and efficiency of Air Tubes impress British Sugar

British Sugar were so impressed with a pneumatic conveyor system installed by Air Tube Conveyors Limited at their Ipswich sugar factory that they are ordering another. Air Tube Conveyors, who manufacture and install air tube systems, initially installed one point-to-point air tube in the factory's sugar beet reception area. "We used to have a roller conveyor system to do this, but it was inefficient and caused problems. The new Air Tube Conveyor system is very successful. It is quick, efficient and secure," said a spokesman for British Sugar. Two more air tubes were installed in the sampling bay and a further three have been ordered for a second bay.

Further details:

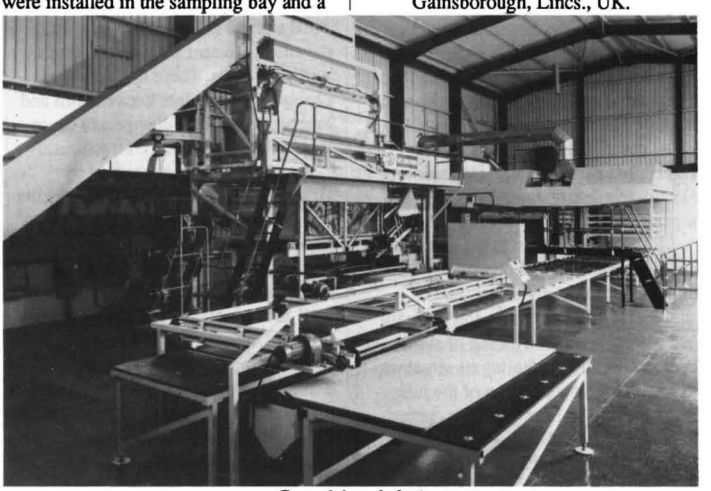
Air Tube Conveyors Ltd.,
Birmingham Road,
Warley,
West Midlands B69 4HE,
England.

Better bagasse paper production

Turning bagasse and similar waste into fibre board is a paying business, especially with timber prices soaring. Compak specialises in machinery and systems for just such by-product utilization and has successfully exported them to countries such as Haiti. On-going research has shown that production efficiency is greatly improved by utilizing larger boilers for raising platen-heating steam and as a result the standard specification now includes a 1200 lb/hr, 150 psi Bradlee boiler. This not only achieves consistently higher press platen temperature but also enables production volume to be considerably increased. Additional benefits are the compact design, low maintenance and long life qualities of the Bradlee boiler.

Further details:

Compak Systems,
Gainsborough, Lincs., UK.



Compak board plant

Sugartech 88

29th British Sugar Technical Conference

The 1988 Technical Conference of British Sugar plc, given the name Sugartech 88 by its organizers, was held at the Grand Hotel, Eastbourne, between June 20 and 23. Guests included 53 technologists from fourteen other countries and 12 from UK companies other than British Sugar, while the works managers from all thirteen of the UK's beet sugar factories participated as did 41 of the technical staff from the headquarters in Peterborough and Research Laboratory in Norwich.

All were invited to a reception in the evening of June 20 but the Conference proper began the following morning when a welcome and introduction were given by Dr. Malcolm Branch and Mr. R. J. Bass, Directors of British Sugar and the two joint Conference Chairmen. The Conference had four themes for 1988, namely "Pretreatment of cossettes and dewatering of pulp", "Crystallization", "Long-term storage of sugar" and "Sugar beet as animal feed".

Mr. N. W. Broughton, Head of the Research Laboratory, served as Chairman for the session dealing with the first of these. It consisted of four papers, the first of which: "Cossette pretreatment and pulp pressing" by Mr. G. C. Jones of the Research Laboratory, reviewed the new techniques which have come to the fore in recent years aimed at providing a better juice and/or pulp in either greater recovery or better suited as animal feed. The second paper, by Dr. N. Senapati of Battelle Laboratories, Columbus, Ohio, USA, described the work he and his co-authors have done on the application of electro-acoustic techniques to the separation of water from beet pulp.

The third paper was presented by Dr. J. M. Randall, recently retired from the US Dept. of Agriculture, and summarized the results he and his team had achieved in "The liming of sugar beet tissue" and so altering its structure to permit easier separation of the juice. Work on similar lines has been carried out in France and Mr. J. Ponant, Miss S. Foissac and Mr. A. Esnault described their work on the treatment of beet with calcium saccharate in their paper "The alkaline extraction of sugar beet".

In the afternoon, Mr. M. Shore, Director of Research, took the chair and presided over the presentation of two papers on the second Conference theme. The first paper, "Continuous cooling crystallization – CCC system", was presented by its authors, Professors G. Mantovani and G. Vaccari of the University of Ferrara, and described the results obtained with the pilot plant installed in an Italian sugar factory whereby saturated syrup at 80°C was seeded and cooled over 3 - 4 hours to about 30°C to provide a magma which could be separated to a white sugar of EEC 2 quality in a continuous centrifugal. Dr. D. Schliephake then presented a detailed account of studies in the Braunschweig Institute on crystal agglomeration in sugar boiling and its reduction.

The following day was devoted to the third Conference theme, under the Chairmanship of Mr. Bass. The work described arose from a four-year study on the structure of concrete silos and the stored sugar. Most of the silos used by British Sugar are of pre-stressed concrete construction and have been built during the past 25 years, ranging in size from 8000 to 27,000 tonnes capacity. Total storage is for 686,000 tonnes, and the silos represent an investment of £90 million pounds. There is a very large change in live weight between full and empty silos and the change can cause interactions between the structures.

These have been studied by British Sugar engineers and also by the construction companies Taylor Woodrow and John Laing, and by consultants including W. S. Atkins & Partners and Campbell, Reith & Hill, as well as academic workers from Manchester University and Imperial College, London University. Tests were made using small model silos, while others were carried out using a silo at the Felsted sugar factory where beet sugar processing had been discontinued. Measurements showed the size of the stresses caused by eccentric discharge of sugar and emphasized the need to stick closely within the guidelines established a few years ago for removing sugar from the silos.

The papers concerned with silo design and operation included the following: "The concrete sugar silo" by Mr. A. L. Gilbertson (of W. S. Atkins); "Silo foundation choices and performance related to site investigation data" by Professor P. Rowe (Manchester University) and Mr. F. V. S. Bayliss (John Laing); four papers on sugar silo behaviour "Eccentric discharge tests at Felstead silo No. 2" by Mr. S. J. Driver and Mr. P. Dawson (Taylor Woodrow), "Tests on sugar silo models" by Mr. R. E. Hobbs (Imperial College) and Mr. I. H. Reith (Campbell, Reith & Hill), "Comparison of the Felsted silo and the model silo" by Mr. I. Ll. Davies (Taylor Woodrow) and "Preliminary studies on the use of simple models to predict the behaviour of sugar in a 12,000-tonne silo" by Mr. D. Sargent (British Sugar).

"Silo interactions" were described by Professor Rowe and Mr. Gilbertson while Mr. Davies discussed the implications for silo operators. A related paper by Mr. G. Wilson, Mr. A. W. Mason and Mr. Sargent, all of British Sugar, was an account of "The quality of sugar for silo storage and the requirements of a silo in order to maintain product quality".

On June 23, Mr. T. P. J. Dyke, Agricultural Director of British Sugar, took the chair for the final session and, after an introduction to the theme by Dr. Branch, the first paper, by Dr. J. I. Harland, Senior Nutritionist of British Sugar, emphasized "The contribution of sugar beet feeds to livestock nutrition" and its importance as a co-product rather than a by-product for the sugar beet processor. Dr. J. Haaksma, of the Sugar Production Institute at Bergen-op-Zoom in Holland then presented a paper on the "Application and value of by-products from the sugar and alcohol industry in animal nutrition" and Dr. R. Jones of the Welsh Plant Breeding Station described

continued on page 147

High pol raw sugar

By John H. Payne

Historical

High pol raw sugars have been produced around the world, probably almost since the advent of the centrifugal machine. They are made simply by washing off most of the molasses from the crystals in the centrifugal. Usually the product is sold locally for direct consumption. Hawaii is no exception. Washed raw sugars have been made here at least since Noël Deerr's time and are still being made.

In some instances washed raw sugars reached international trade, notably in the Caribbean basin, with the turbinados of Louisiana and Cuba, and the demeraras, originally from Demerara (Guyana). Turbinados were made by washing in the centrifugals with water and steam or superheated water. The product was a light yellow, free-flowing sugar, usually of large grain size. Its practical use was commercial in the food industries like meat packing and pickling.

In 1938 when the California & Hawaiian refinery became interested in the possible production of turbinado sugar in Hawaii, seven samples of Louisiana sugars purchased on the mainland market showed an average analysis of:

Pol	99.4
Moisture	0.05
Ash	0.15
Invert sugar	0.15
Colour, °Stammer	5.2†

† This is roughly equivalent to Attenuation Index $a^*_{420} \times 10$. At that time the C & H standard for crystal colour was "not over 7.0 °Stammer".

Some local turbinados prepared earlier at Ewa Plantation Company showed a pol of 99.4 and Stammer colour 7.1°.

Interest in sugars other than raws has waxed and waned in Hawaii throughout the century. Alexander and Baldwin explored the manufacture of white sugars almost continuously from 1913, when William Searby, of shredder fame, proposed a process at Hawaiian Commercial and Sugar Company, to the advent of the Sugar Act of 1934, which limited the mainland market for offshore refined products.

In 1916 Kahuku Plantation Company was making 25 short tons a day of white sugar, Maui Agricultural Company made a refined product through the 1920's, and Kahuku followed again in 1930 with a study of the carbonatation process.

There followed cyclical investigations: turbinados by C & H in 1937; ion exchange by HSPA in 1945; Elguanite by Grove Farm Company in 1951; affined sugar equivalent by HSPA and C & H in 1965; and high pol, low colour sugar by HSPA and C & H in 1977 and in 1987.

The HSPA Experiment Station study in 1965 confirmed that sugars equal to and better than the product of the C & H affination station could be made in Hawaii simply by better washing in the centrifugals. Shown in Table I are data from one series of tests made by Payne at Waialua Agricultural Company in September 1965. No changes were made in the sugar boiling procedures and the only change in operating the centrifugals was more effective washing. The average pol shown was 99.26 and the whole raw colour 7.9.

Table I

					Not washed		
Sample	Pol	Moisture	D.F.	Dry pol	S. grain	F.R.	Raw colour
1	99.10	0.15	0.17	99.25	9	271	8.2
2	99.16	0.27	0.32	99.43	13	268	7.8
3	99.28	0.20	0.28	99.48	19	272	6.5
4	99.19	0.18	0.22	99.37	7	259	9.2
5	99.28	0.14	0.19	99.42	8	258	8.8
6	99.29	0.16	0.23	99.45	8	256	8.2
7	99.41	0.16	0.27	99.57	8	260	7.4
8	99.33	0.23	0.34	99.56	7	262	7.3
Molasses					Ref. sol.	Pol	Purity
1					83.88	51.90	61.87
2					84.66	51.36	60.67

Technology

Commercial raw cane sugar is a two-phase system consisting of solid sucrose crystals surrounded by liquid molasses. The crystals are almost pure sucrose, for in any crystallization phenomenon the molecules of a substance are subject to forces of orientation which strongly exclude foreign materials. Thus the impurities within the crystal are mostly those entrapped by imperfections in the crystal arising from restraints imposed by the conditions obtained during the process. The pol of well-formed crystals is therefore at the 99.9 level. The colour of the crystal parallels the pol, of course, depending upon the amount of entrapment and the nature of the colorants therein.

The quality of a raw sugar is therefore governed largely by the quantity of the liquid portion, the molasses, which is superficial to the crystal. The manufacture of a high pol, low colour sugar is an exercise in materials separation – crystals from molasses. The responsible equipment involved is the centrifugal station where the bulk of the molasses is removed by centrifugal force and the remainder by displacement with water. The technique of water usage governs the fine tuning of the separation, and hence the quality of the product.

As in all materials processing, the quality of the product is also a function of the quality of the feed; hence the massecuite should be tailored to achieve optimum centrifugal performance. Consequently, sugar boiling is the starting point in making a high pol sugar.

Sugar boiling

Systems: Hundreds of sugar boiling "schemes" can be found in the

literature but there is only one that is sound technologically; that which approaches as closely as practicable a high-purity to low-purity flow in the simplest manner. The exception to this is low-grade sugar which, although its purity is high, in the range of syrup, is a mixture of almost pure sugar crystals and very low purity final molasses. It should thus be considered a low-purity material, and best retained in the low-purity stream.

From a practical standpoint, there is a wide variation in the purity of incoming material, so boiling procedures must be changed accordingly. In automated procedures, however, it is advantageous to standardize a program at attainable purities. This requires some deviation from the strict counter-current purity principle. What is best thus gives way in part to what is most practical.

The traditional *A*-, *B*- and low-grade boiling system is sound and simple and efficient in the production of high pol, low colour, raw sugar. The crystals in *B*-strikes are close to the same quality as from *A*-strikes. The difference is that the *B*-molasses is of lower purity and higher colour so that, to achieve the same quality in *B*-sugar as in *A*-sugar, more molasses must be removed in the centrifugals.

Use of magmas of any sort does not fit into the concept outlined, better quality being obtained by full seeding with slurry.

Crystals: The objective is to grow flawless crystals of consistent size, uniformity of size being more important than actual size. Very small crystals can plug the interstices between larger crystals and block the flow of molasses in centrifugation. Small crystals usually originate near the end of the boiling period during the long-established pattern of increasing the dissolved solids content of the molasses ("Brixing-up"). Spontaneous nucleation will take place if the threshold supersaturation is exceeded, because sucrose is not being deposited on the faces of the crystal rapidly enough to keep pace with the evaporation of water. The foremost cause of a deficient sucrose deposition rate is that the crystal content is insufficient, not enough seed having been used. Experience indicates that rarely is too much seed employed. A second factor is that, when the pan is nearly full, circulation is sluggish so that the rate of crystallization is lower. Also, with poor circulation, feed is slow to mix with the molasses; this produces zones of high purity liquor in which the critical threshold supersaturation is lower, giving rise to spontaneous nucleation.

For these reasons the solids content of the molasses should be increased only enough, from the beginning of the strike to the end, to maintain a supersaturation commensurate with the decrease in purity of the molasses. This should be done gradually throughout the boiling period and not speeded up at the finish.

Small crystals take longer to wash in the centrifugals than large crystals but they wash more uniformly. This relates to the larger channels between large crystals making plug flow less likely. A size range of 0.6 to 0.8 mm is satisfactory.

Conglomerate crystals cannot be tolerated because molasses cannot be removed without overwashing. Conglomerates form early in the boiling when the crystals are small (less than 0.15 mm), so care must be taken to proceed slowly through this critical size range in the pans.

Massecuite consistency: Massecuite consistency at the time of striking is an important factor as well as the nature of the crystals, because it affects the feeding of the centrifugals. At the optimum consistency the massecuite flows rapidly through the gate and forms a vertical wall in the basket. If the consistency is too high the wall is thicker at the bottom than the top, making uniform washing impossible. If the consistency is too low, massecuite will slop around the bottom causing the spindle to wobble.

Consistency is governed by crystal content, viscosity of the molasses and temperature. Massecuite Brix is not a complete measure of consistency so uniformity is best maintained by consistency readings. Final adjustment can be attained by controlling the temperature in the mixer, although some refiners control also by addition of diluting liquor to the mixer.

Mixer

The mixer is an often-neglected adjunct to the centrifugals. Good performance in the centrifugals requires an appropriate mixer. The two important considerations are (1) that the mixer be at a level which will give enough head for rapid filling of the basket and (2) have some means of maintaining a relatively constant head.

A good loading time is about 10 seconds so that the head should be sufficient to give this as maximum. If the level in the mixer changes, the time for loading changes so the centrifugal timing program must change. Use of large diameter mixers will keep the head change moderate. The level should not be allowed to fall below a minimum, except when liquidating. A separate mixer for *A*- and *B*-strikes is essential.

Centrifugals

Attention to details is the secret of effective removal of molasses from the crystals in the centrifugals. An outline of these for each step follows.

(i) *Loading valve:* The loading valve must give a fast, clean cut off. Dripping is not permissible. As indicated previously, the loading time should be approximately 10 seconds. The size of the opening is set to direct the stream to the bottom of the basket – not high on the spindle.

(ii) *Spray nozzles:* Spray nozzles are placed as far away as possible from the face of the sugar in the basket. The number of nozzles and angle of direction are such that the face of the sugar is covered completely, uniformly and with little overlapping.

(iii) *Water:* In washing, the

hotter the water the better. The temperature should be as close to 100°C as practical. First cell condensate from the evaporator is ideal for this use. Water pressure at the spray nozzles must be uniform and high enough for effective spraying. The water pump and piping must be designed to give a pressure of 60 psi at the nozzles. Nozzles require constant monitoring to insure against plugging.

(iv) *Washing:* Crystal washing improves with the quantity of water applied but rapidly reaches a point of little change with increasing amount.

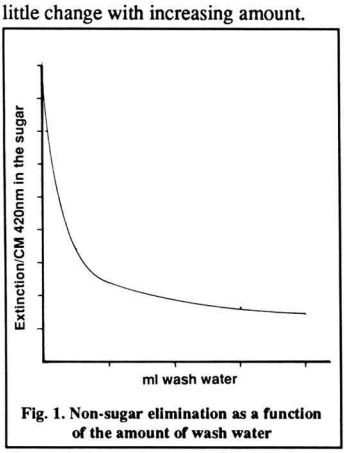


Fig. 1. Non-sugar elimination as a function of the amount of wash water

Figure 1 shows the general form of a washing curve. The reason for this is shown in Figure 2, which shows how water can pass through a layer of crystals without contacting many of the surfaces[1]. This vividly points out the value of a plug flow displacement of molasses by water initially. If water is applied before drainage of molasses leaves channels between crystals then the molasses is pushed out more completely by the water. Water should there-fore start while there is still a continuous mass of crystals and molasses.

Washing is most efficient if the water is applied in two stages. The first, the plug flow wash, should start just as the molasses leaves the face of the sugar, and stops when the water reaches the screen. This might be called the displacement stage.

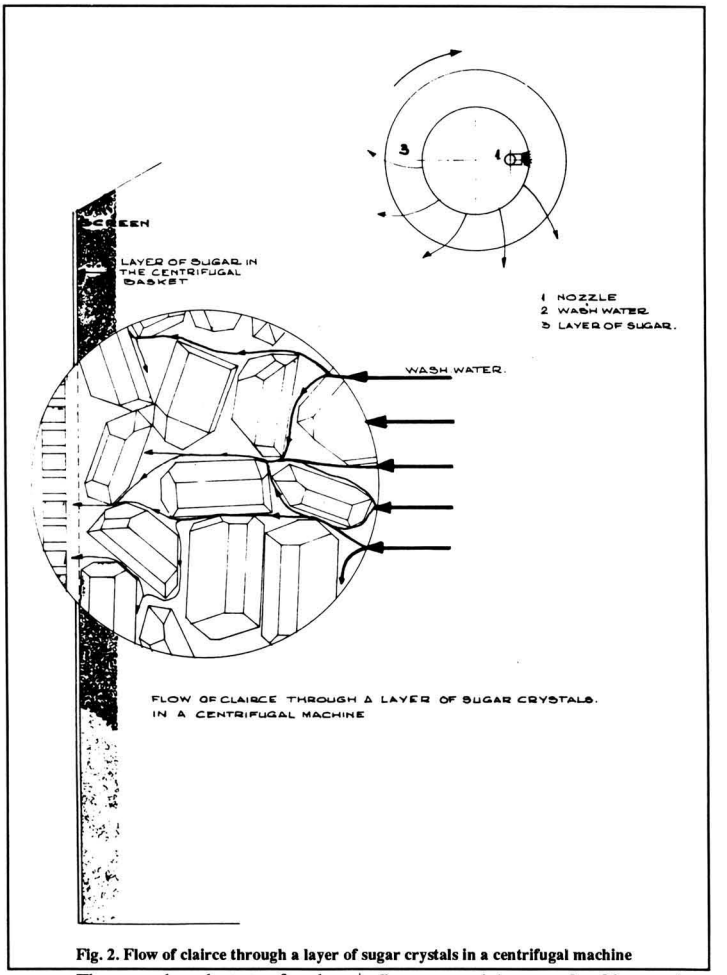


Fig. 2. Flow of claircе through a layer of sugar crystals in a centrifugal machine

The second wash starts after the first water has been purged, and is intended to wash off the remaining coating of molasses. It will be less efficient than the first and will cause most of the dissolving of sugar, so should not be prolonged. The time used for this stage depends upon the degree of washing desired and the size and quality of the crystals.

The precise timing of the water applications and the quantities of water used in each must be determined by trial. As a preliminary trial on an *A*-strike, the first water might start after 30 seconds, spray for 6 seconds, and 20 seconds later spray the second water for 5 seconds. The timing varies with the quality of the massecuite.

If one-stage washing is used, the water is applied, as in the case of two-stage washing, just as the molasses leaves the face of the sugar. The wash is then kept on for a longer period. Single washing requires more water and there is a larger increase in the purity of the

1 Reproduced from van der Pol *et al.*: *I.S.J.*, 1987, **89**, 72 - 78.

molasses. In both procedures the important consideration is to apply the water before the molasses is purged while the crystals are protected from dissolving by the molasses layer. This keeps molasses purity rise to a minimum. An acceptable purity rise is 1 to 2 points at a water rate of less than 5% on massecuite.

(v) *Wash separation:* Separation of the first and second washes is a useful procedure. The first wash is mostly molasses of low purity and is returned to the usual molasses tank. The second wash, however, of higher purity because of dissolved sugar, is better returned to the same type of strike from which it came, thus avoiding some intermingling of high- and low-purity feed stock. Wash separation permits higher pan drops.

(vi) *Steam:* Use of steam in the basket after washing has not been shown to be effective. Steam does not penetrate through the sugar. It does increase the temperature but 100°C water gives sufficient heat. Steam is a nuisance in the equipment and often causes dripping.

(vii) *Screens:* To ensure good drainage, double backing screens are helpful. Five (5) and eight (8) mesh are commonly used.

A- *and* B-*massecuites*

Coincident with the procedure of removing more molasses to increase the pol of the sugar, South Africa started the practice of using a magma of the *B*-sugar for seed on the *A*-strikes. The remainder of the *B*-sugar, not needed for magma, was remelted. The stated purpose was to make only commercial sugar – the *A*-strike. The use of a refining step – recrystallization – for part of the sugar would of course improve the quality of the remelted sugar, but some 10% more pan capacity is needed. The mere shifting of part of the crystallization from the *B*-pans to the *A*-pans would be without significant effect.

Making a very high pol sugar does not require any move from the conventional *A*-, *B*-, *C*-strike routine. Operational procedures for the centrifugals however, are different for the *A*- and *B*-massecuites. Because of the lower purity more *B*-molasses will have to be removed from the *B*-crystals to get the same pol as crystals from *A*-massecuites. Also, being more viscous, *B*-molasses is more difficult to displace from the crystals.

Consequently, the timing for *B*-massecuites will be different from that for the *A*-massecuites in the direction of a longer cycles at all stages. Somewhat more dissolving of sugar will occur as well as a higher increase in molasses purity.

Drying

Very high pol sugar from properly operated centrifugals does not need adjunctive drying. The sugar flowing from the machines is hot so the moisture in the thin molasses layer is reduced to close to equilibrium with the atmosphere by the time the sugar has cooled. Cooling, however, is important and the sugar should not go into storage at a temperature above 40°C. The transport system, from the centrifugals to storage, should be designed to provide this cooling. A combination of grasshopper conveyors, ventilated bucket conveyors and free fall will accomplish drying as well as cooling. At a pol of 99.4 the moisture content should be at the 0.10% level.

Conclusions

By following procedures such as those outlined or similar ones, a high-pol raw sugar can be made in the present standard Hawaiian sugar factory equipment without resorting to steps normally part of refinery processing. By increasing the pol to the 99.4 level the commercial raw colour would decrease in parallel. At the present 99.0 pol average, the ratio of commercial raw colour to crystal colour is about 3 to 1. Data indicate that at 99.4 pol the ratio would fall to 2 to 1. At the average crystal colour of 5.1 ($a^*_{420} \times 10$) for the industry during the first half of 1987, the commercial raw colour would therefore be about 10.2. This should be a figure meeting the requirements of a refinery.

Acknowledgment

The advice of George Conrad, of the Western States Machine Company, on the operation of centrifugals is gratefully acknowledged.

Facts and figures

Colombia sugar exports, 1987[1]

	1987	1986
	tonnes, raw value	
Chile	0	4,261
Dutch Antilles	1,205	64
Ecuador	4,025	40
Korea, South	0	12,000
Morocco	0	28,000
Peru	19,483	2,665
Surinam	0	2,630
Trinidad	4,924	5,000
Tunisia	0	12,000
USA	54,372	145,155
USSR	12,000	0
Total	96,009	211,815

Genetically engineered sugar beet[2]

Plant Genetic Systems, a Belgian biotechnology company, has announced that it has genetically engineered sugar beet to be resistant to the herbicide phosphinotricin; now, European sugar beet farmers, who spend some two or three times more on weed control than they do on seeds, should be able to use phosphinotricin – a non-selective herbicide which would kill the normal sugar beet – and so cut down on the number of herbicides applied.

Swaziland sugar production, 1987/88[3]

Swaziland's sugar production in the 1987/88 crop was back to a more normal level of 456,000 tonnes after the previous year's record of 537,000 tonnes. As a consequence, raw sugar exports are expected to fall by more than 10%.

Belize sugar exports, 1987[4]

From 105,008 tonnes in 1986, exports of sugar from Belize fell to 84,416 tonnes, raw value, in 1987. From 55,441 tonnes in 1986, exports to the US fell to only 16,998, while those to the EEC rose slightly from 43,972 to 44,345 tonnes in 1987. Exports to Canada rose from nil to 23,073 tonnes while those to the USSR fell to nil from 5595 tonnes in 1986.

1 *I.S.O. Stat. Bull.*, 1988, **47**, (3), 8.
2 *Chem. & Ind.*, 1988, (10), 306.
3 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 245 - 246.
4 *I.S.O. Stat. Bull.*, 1988, **47**, (3), 4.

Power co-generation in sugar factories

By P. B. Nurse
(Tate & Lyle Technical Services, England)

Introduction

Cane sugar factories produce their own fuel, bagasse, to raise steam for power generation and process requirements, often with the added advantage of providing electrical power for adjacent facilities, such as workshops, offices, etc. The design of the sugar processing equipment, in particular the degree to which thermal economy measures are adopted, can be arranged to achieve a balance between the quantity of bagasse produced and the steam demand for processing sugar, or to achieve a surplus of bagasse which could be used for by-product operations such as generating electrical power for export.

With the advent of escalating fuel oil prices in the early 1970's, a number of existing sugar factories improved the thermal economy of their operations to allow for the generation of electrical power for export from the surplus

P. B. Nurse

bagasse produced; this has usually been achieved by installing new boilers designed to generate steam at higher pressure and temperature, and supplying new turbines, termed "topping turbines", for the generation of additional electrical power, with exhaust from these turbines powering the existing low-pressure turbines which drive the cane knives, shredder, mills and existing alternators. The improved boiler efficiency at the higher steam pressure and temperature allows for more steam to be generated from the same quantity and quality of bagasse, from which additional electrical power can be generated economically.

Hawaii has been particularly successful in developing the sale of electrical power to the state grid from a number of sugar factories. These factories are able to generate surplus power (up to approximately 20 MWh depending on factory capacity) from bagasse during the cropping season, which extends for 8 to 10 months of the year, and commercial fuel is used during the out-of-crop period in order to satisfy the all-year power requirements of the grid. One sugar factory installed a bagasse drying and densification plant to store dried surplus bagasse, with an improved calorific value, for use during the out-of-crop period. A similar densification plant was also installed at a Mauritian sugar factory but the concept has not been widely adopted and the Hawaiian factories mainly rely on utilizing all surplus bagasse during crop.

The Hawaiian factories have developed co-generation usually by replacing existing boilers with high

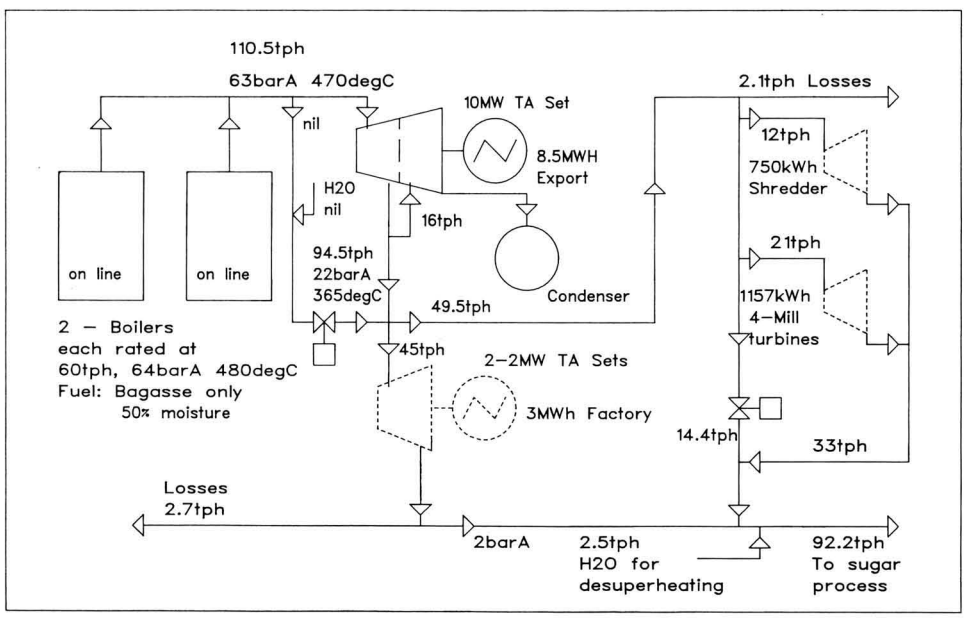


Fig. 1. Co-generation system – Option 1

pressure units operating at steam pressures and temperatures in the range of 600 to 900 psig pressure and 540 to 830°F temperature (42 to 63 BarA, and 282 to 443°C). One factory is operating with high pressure steam condition of 1264 psig (88 BarA) pressure and 825°F (440°C) temperature. The alternator turbines are designed for operation in the pass-through mode as described above but in some cases fully condensing units are also used.

However, the development of this type of power generation has not been implemented worldwide and has been restricted to specific areas such as Hawaii. The reasons for this limited development must primarily be economic but there are other aspects which may affect the decision to proceed and any case should be considered for any new project. Some of these aspects are outlined later in this paper.

The economics of power generation for export will vary depending on the circumstances of the country concerned and from one sugar factory to another. The main influencing factors will be the price paid for the power and the capital cost involved. Each project should be evaluated separately but this aspect has not been considered for this paper.

Technically, there is little to prevent the generation of additional electrical power for sale to public utilities either by modifying existing sugar factories or designing new sugar factories specially for this purpose.

It is some of these technical aspects which are discussed in this paper, including the influence of the thermal economy of the sugar factory, the condition of the high pressure steam employed and the contribution of drying bagasse. Three possible arrangements of power generation are described to indicate the potential level of export power that can be generated.

Technical considerations

The selection of a suitable power generation system, which will achieve maximum economic output, should be the prime consideration for a co-generation scheme whether it is to be at an existing sugar factory or at a new "green-field" project.

To achieve the objective of maximum output there are a number of technical aspects which will affect the amount of power which can be generated and which must be evaluated when deciding the concept of the project. These include the following:

(i) *The thermal and fuel requirements of the sugar factory and how these requirements can be minimized to release the maximum amount of bagasse for power generation.* For a new sugar factory project maximum thermal economy can be included in the design from the conceptual stage with minimum additional capital cost. However, improvement in thermal economy for an existing sugar factory could involve considerably more capital expenditure because replacement of existing equip-

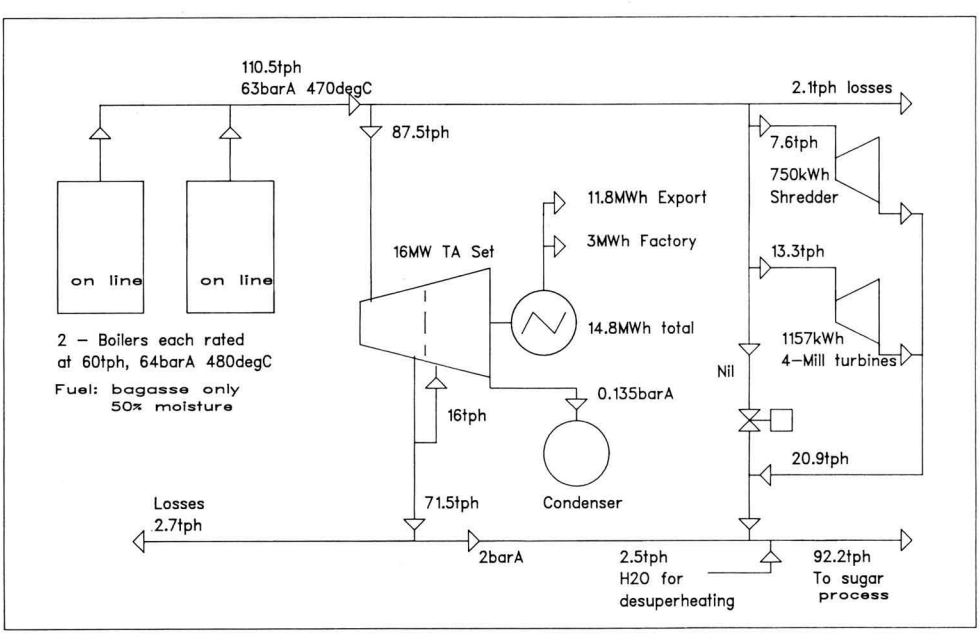


Fig. 2. Co-generation system – Option 2 (in-crop operations)

ISJ Abstracts

Cane sugar manufacture

Energy conservation by bagasse drying

M. Y. Lonkar and A. A. Ansari. *Indian Sugar*, 1987, **37**, 265 - 268.

A rotary bagasse dryer and its operation on boiler flue gas are outlined with the aid of diagrams.

Modernization of the sugar industry using electronic systems

Anon. *Indian Sugar*, 1987, **37**, 331 -332.

The advantages are listed of two microprocessor-based systems, one for automatic pH control in preliming and sulphitation and the other for pan monitoring on the basis of resistivity, viscosity, temperature and massecuite level from which are computed purity, Brix and supersaturation (all seven parameters being displayed on a panel).

Factory research in Australia

Anon. *Ann. Rpt. Bureau Sugar Expt. Stations*, 1987, 30.

Cane fibre characteristics: Tests were conducted on samples of cane varieties prior to their release to find those that could cause problems during the milling process. The procedures followed involved an impact test on a 10-mm core taken longitudinally from the centre of the stalk, determination of the shear strength of a 5-kg sample prepared in a standard manner, determination of the pith content by screening a prepared sample using a 10-mm mesh screen, and measurement of the fibre content. The results for 9 varieties tested during the 1986 season showed that all but one (Q 140) had impact readings within an acceptable range and all had an acceptable pith content, with Q 141 recording the highest level of 78.8% and a very low shear strength, indicating that it could well be a very soft variety. Besides a very high impact reading, Q 140 also had a relatively high shear strength associated with the presence of long, hard fibres that could give trouble in milling. Five other varieties (Q 110, Q 133, Q 135, CP 44-101 and H 56-752) had shear strengths close to the upper limit.

Low-grade centrifugals: Since it was thought likely that centrifugal screens having a higher % open area would allow higher centrifugalling rates for the same purging efficiency and purity rise, a series of trials was carried out at two factories. At Fairymead, two identical BMA K1100 machines were used, one fitted with standard Balco screens having 60 µm slots and an open area of about 6% and the other with Vecoflux screens having 60 µm slots but about 15% open area. At Millaquin, two identical BMA K1000 machines were used in two series of tests; in one series, the Vecoflux screen was compared with a Balco screen of standard 6% open area and in the other series the Vecoflux was compared with a Balco screen of 10% open area. At Fairymead, the machines were operated at the maximum rate at which the target sugar purity could be maintained, while at Millaquin motor loads and water rates were maintained constant in a study of the effect of screen open area on sugar and molasses purity. Results from all the tests indicated no difference in performance or capacity of any significant magnitude as a result of differences in the screen open area, so that the added expense of purchasing a screen of greater open area would appear to be unjustifiable.

Manufacture of commercial sugar massecuites in a single strike using the seeding process

E. Cardet. *ATAC*, 1986, **45**, (1), 18 - 21 *(Spanish)*.

The volume of footing on which an *A*-strike is boiled is usually too great to allow formation of crystals large enough for a commercial product. Consequently the pan has to be cut to another and the crystal developed to the required size either in one or two further strikes. It is considered possible to develop a commercial strike direct from seed but this requires only a small volume of seed magma and strict control of supersaturation. Details of such a procedure are described, with the calculations required and a discussion of the advantages of the method.

Technico-economic aspects of the improvement of power factor in sugar factories and its relationship with the centrifugal area

E. Crespo I., A. de Quesada M. and M. Balsiro E. *ATAC*, 1986, **45**, (1), 28 - 35 *(Spanish)*.

In the electrical power network of a sugar factory the most critical section is in the area of centrifugation, especially where automatic machines are used governed by static converters. A brief theoretical description is given of the principal energy parameters which characterize the behaviour of a battery of ASEA batch centrifugals. Thence, the variables which influence the magnitude of the energy demand and their interrelationships are analysed. An algorithm is presented which permits compensation of the power factor of a battery, including its ancillaries; its effectiveness is analysed from the technico-economic aspect. Further, an example of its application to a concrete situation is provided.

Multijet utilization in juice sulphitation for sugar manufacture

D. T. Oliveira and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1985, (33/85), 49 - 52 *(Portuguese)*.

A multijet device was employed for juice sulphitation and was found to give sugar of the same quality as with conventional sulphitation towers with in some cases a reduction in sulphur usage. Further the cost of the equipment is only one-fifth of that of the towers.

Studies on the clarification of juices with settling aid Morarfloc A-40 H

S. K. Srivastava and R. P. Shukla. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.1 - M.14

Laboratory clarification experiments showed that, at an optimum dose of 3 - 4 ppm, Morarfloc A-40 H (an Indian-produced anionic polyacrylamide) proved very slightly superior to Separan AP-30 in terms of settling rate and mud volume while giving the same juice clarity; these results and gum removal were much better than when the juice was not treated.

Further studies on recirculation of second carbonatation mud in first carbonatated unfiltered juice

S. C. Sharma and P. C. Johary. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M. 15 - M.43.

Experiments in which 2nd carbonatation mud was recycled to unfiltered 1st carbonatation juice at a 1:4 mud:juice ratio showed a slight rise in purity when they were conducted in February but a slight fall in purity in March when the temperatures were higher and the dextran content much greater. Best results were achieved at a mud-juice contact time of 12.5 minutes. Mud recycling also tended to reduce juice colour, CaO and MgO contents. In view of the seasonal difference in effect on juice purity, mud recirculation is not advised under Indian conditions; instead, the authors advocate sweetening-off 2nd carbonatation mud and discarding it.

An improved three-massecuite boiling system

N. R. K. Mohan. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.44 - M.59.

By graining on a lower-purity medium and boiling the low-grade massecuite to a purity at dropping of 48 - 49 compared with 58 - 59 in conventional 3-massecuite boiling, sugar purity % solids was raised from 9.87 (the average for April 1984) to 9.95 in April 1985; the corresponding purity drops from syrup to final molasses were 48.68 in 1984 and 52.75 in 1985. Full details are given of the two schemes.

Automatic pan boiling

D. N. Maid. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M. 60 - M.70.

See *I.S.J.*, 1986, **88**, 122A.

Adoption of 0.04 mm nickel screen in place of 0.06 mm in a *C*-foreworker continuous centrifugal

H. P. S. Bhatia. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.71 - M.84.

Because of excessive molasses losses, the nickel screen on a Buckau-Wolf continuous low-grade centrifugal was replaced with one of smaller perforations (0.04 instead of 0.06 mm); results indicated a fall in molasses Brix, pol and purity by comparison with a machine equipped with the screen of larger perforations and operating in parallel. The increase in sugar recovery was calculated for one month at 40.5 tonnes.

New technique for continuous centrifugal machines for high-grade massecuite curing

K. P. Singh. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.85 - M.89.

For *A*-massecuite curing, the author advocates blowing hot air through nozzles in a pipe welded around the inside edge of the monitor casing so as to decelerate the velocity of crystals and thus reduce crystal breakage.

A case study - evaporator cleaning

C. L. Patel and D. R. Patel. *Proc. 49th Ann. Conv. Sugar Tech. Assoc.*, 1986, M.90 - M.95.

The amounts of NaOH, soda and HCl used for evaporator cleaning were experimentally reduced at the authors' factory, with the result that the time needed for the task was considerably shorter; other benefits included a rise in the average syrup Brix and a reduction in total losses.

Increasing the exhaustibility of final massecuites by use of Pan Thrill-S, Mark I

S. C. Sharma, S. K. D. Agarwal, B. C. Jain and S. K. S. Gupta. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.96 - M.104.

Addition of 60 ppm Pan Thrill-S, Mark I – a surfactant of Indian manufacture – to low-grade massecuite and use of a smaller dose in the *B*-pan improved the boiling and curing properties, with a considerable reduction in boiling and purging times, increase in massecuite Brix and a fall in final molasses purity.

Upgrading the khandsari industry: Anandsari steam-based process saves bagasse, improves recovery

M. Anand. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.104 - M.116.

Details are given of a proposed scheme for khandsari production which is based on the system used in conventional cane sugar factories, i.e. with the use of steam for juice heating, evaporation and concentration. The result would be a considerable saving in bagasse and a higher sugar recovery.

Dependence of sugar recovery on PJ pol and imbibition

D. Raj. *Proc. 49th Ann. Conv. Sugar Tech. Assoc. India*, 1986, M.128 - M.141.

Multiple regression analysis of factory data was used to establish a relationship between recovery % (y), primary juice pol (x_1) and % imbibition (x_2). This equation, $y = 0.795\ x_1 + 0.0061\ x_2 - 2.76$, was found to be applicable to data over a wide range of pol and imbibition, so that it is of value for monitoring factory recovery and allowing remedial measures to be carried out where necessary while also allowing adjustment of pol and imbibition to achieve a given target recovery.

Beet sugar manufacture

A scheme for automatic control of electric heating of low-grade massecuite

O. M. Zhurbitskii and A. G. Shcherbatyuk. *Sakhar. Prom.*, 1987, (12), 20 - 22 *(Russian)*.

A massecuite reheater designed as a horizontal single-sectioned steel casing with internal horizontal electrodes has a power rating of 60 - 80 kVA. Details are given of an automatic temperature control system based on a thyristor voltage regulator which was tested at a sugar factory.

A massecuite boiling process with crystal nucleation using a special slurry

J. Grabka. *Sakhar. Prom.*, 1987, (12), 22 - 25 *(Russian)*.

Tests conducted at Ropszice and Lublin factories in Poland and at Kobelyakskii factory in the USSR compared the effects on boiling of seeding with a milled sugar slurry as against icing sugar; at least one of the slurries was prepared with isopropanol. Results for each factory are tabulated and showed that use of a seed slurry improved exhaustion, cut the boiling time by 10%, improved the sugar grain size distribution and reduced the sugar colour, increased massecuite crystal content and decreased steam consumption.

Determination of steam consumption in an evaporator under varying working conditions

T. I. Storozhuk, P. P. Moskalenko and V. N. Usychenko. *Sakhar. Prom.*, 1987, (12), 32 - 33 *(Russian)*.

Three sets of conditions that could arise in a multiple-effect evaporator are examined mathematically: (i) optimum conditions where the quantity of water removed in the form of vapour bleed and by flash evaporation in the concentrator between the final effect and the condenser is the same as the amount that must be evaporated to give a required Brix, (ii) where the amount of water evaporated exceeds that required for a given Brix, and (iii) where insufficient water is evaporated for Brix purposes. The steam consumption in cases (ii) and (iii) under steady-state conditions and for Brix values differing from that required can be found by a trial-and-error method using a series of values of vapour consumption in the *A*-pan, in the syrup heater and in the pan feed tanks, but greater accuracy is possible using a graph method which is described.

Observations and investigations on the juice purification process

E. Reinefeld and D. Miehe. *Zuckerind.*, 1988, **113**, 15 - 21 *(German)*.

A survey is presented of research conducted at the Institute for Agricultural Technology and Sugar Industry at the Technical University, Braunschweig, on juice purification processes. Discussion of optimum prelimer design includes reference to the importance of progressive rise in juice alkalinity; a model continuous cascade system incorporating six stirred vessels and back-mixing by recycling to the preceding vessel using displacement pumps was employed in investigations to determine the effect of the back-mixing on the pattern of alkalinity rise. It was found that, as expected, increase in back-mixing caused a smoother rise in alkalinity; the residence time curve also tended towards that of an ideal stirred vessel with greater back-mixing. Benefits of cold preliming that lead to a reduction in juice colour are listed; in experiments at 50 - 52°C an improved mud uniformity was achieved in all cases, but the settling properties and mud volume varied as a function of the amount of juice recycled; 300% back-mixing gave the highest settling rates and smallest mud volumes, but temperature rise to about 60°C at the same level of back-mixing gave a heterogeneous mud and an increase in turbidity, although this temperature-dependent increase was lowest at 300% back-mixing. With rise in temperature, the range of pH values at which mud properties are optimum becomes narrower and the importance of pH becomes greater in both the vessel receiving the back-mix and the vessel from which it is transferred; if mud of inadequate density enters a vessel where the pH level is unsuitable, there is risk of so much calcium leaving the mud (in the form of constituents of which the Ca salts contain a product of lower solubility) that the coagulate disintegrates or even redissolves. The possibility of darker juices occurring at higher temperatures, e.g. as a result of higher concentrations of melanin precursors or invert sugar, applies to pre-carbonatation at approx. 80°C in the Braunschweig carbonatation system; since the temperature cannot be reduced to 30°C without adversely affecting the overall effect of the process, air is injected at a pH favourable for oxidation of the melanin precursors, a measure that is also used to reduce the colouring effect of invert sugar degradation at a relatively low alkalinity in the inter-liming stage. The overall effect is a thick juice colour reduction of about 30%, while the higher turbulence created by the air is of benefit in vessels that are too large. Research into main liming conditions has shown that optimum is a residence time of 15 - 20 min at 85°C regardless of the type of equipment used (a 5- or 6-stage cascade system is not necessary). While there has been a tendency to reduce the lime dosage, it is stressed that there is a minimum below which filtration difficulties, excessive coloration and juice hardness could occur; moreover, it is well known that lime does not just provide the requisite alkalinity but also acts as filter aid in carbonatation and, when converted to carbonate, offers an appreciable adsorption surface. Investigations of 1st carbonatation in recent years have concentrated on vessel design to improve gas distribution; the aim has been to hold the dissolved $CaCO_3$ briefly above the saturation point at any one time and in any one part of the vessel so as to avoid so-called "mixed alkalinities". So as to achieve this, the

residence time distribution would have to be that of an ideal stirred vessel, but homogeneous mixing of the two phases, which are of very different volumes and for the most part flow counter to each other, is extremely difficult and numerous methods have been used with greater or less success. Particular mention is made of external recirculation of the vessel contents using a pump that does not adversely affect the mud structure; in the "shuttle carbonatation" system developed by Süddeutsche Zucker-AG, recirculation takes place in a separate vessel in which the limed juice is mixed with a considerable excess of recycled carbonatation juice and then fed to the carbonatation vessel, so that any mixed alkalinity is restricted to the region of the target final alkalinity and undissolved calcium hydroxide in the limed juice is dissolved and enters the carbonatation vessel at a reduced concentration. Details are given of the principle of carbonatation in a bottom-fed pipe which was tested in the 1930's and proved to have a number of advantages as well as exhibiting major snags; the aim was to provide mud particles of a narrow size range and hence greatest possible adsorptive capacity in relation to colouring matter and lime salts. The question of final pH of 1st carbonatation juice is discussed, and the advantages and disadvantages of a value >11.2 are briefly examined.

Aspects of vessel design for juice purification

S. Matusch. *Zuckerind.*, 1988, **113**, 27 - 29 *(German).*

A representative of Selwig & Lange GmbH describes the optimum types of vessel for preliming, main liming and carbonatation, including: a vertical prelimer which carries out a combination of preliming in 8 compartments, stabilization and cold main liming and is provided with a special recirculation pipe layout with individual throttling to give an optimum pH pattern; a bottom-fed liming tower developed by Süddeutsche Zucker-AG in which each compartment has a stirrer, so that homogeneous mixing is achieved at a favourable residence time distribution; and a vertical carbonatation tank in which a concentric circulation pipe is located above a number of horizontal, parallel gas distribution pipes. Details are given of the method of operation of each type of vessel and some indication is given of performance. [The diagrams are unfortunately in the wrong order, so that they do not tally with the text describing them.]

Dry liming

W. Uhlenbrock. *Zuckerind.*, 1988, **113**, 30 - 32 *(German).*

At Bedburg sugar factory prelimed juice is heated to 86°C and then limed with pieces of burnt limestone measuring 30 - 40 mm at 1.6% CaO on beet; the limestone is fed into a rotary drum (provided with a horizontal stirrer shaft and sand discharge means) via a slaking drum that rotates with and is located at the top of the liming vessel. Dry liming gives a juice of lower colour than juice treated with milk-of-lime, as indicated by graphs comparing the two juices.

The Danish juice purification system

R. F. Madsen. *Zuckerind.*, 1988, **113**, 33 - 37 *(German).*

Details are given of the DDS juice purification system developed over the last 30 years which includes preliming at 30°C with 0.2% CaO, fractional cold liming with 0.2 - 0.3% CaO, hot liming at 85°C with 0.3 - 0.4% CaO on beet and continuous carbonatation. The aims of juice purification are listed and an indication given of how far these goals are achieved. The possible benefit for juice colour reduction of injecting air at various stages, including diffusion, is discussed; good oxidation is achieved in preliming and the cold stage of main liming, while oxygen dissolved in the juice achieves the same end in hot liming, which process also brings about almost complete invert sugar degradation. Recycling of carbonatation mud has been the subject of a number of tests; return of undiluted mud from the filter-thickeners to preliming improved filtrability. The possible relationship between distribution of lime doses and sugar colour was also studied; it was statistically confirmed that increasing the lime dose in hot liming from 0.54 - 0.58 to 0.65 - 0.70% CaO on beet reduced sugar colour by about 10%, but further increases brought no noticeable improvement. The importance of 1st carbonatation alkalinity for juice decolorization, filtration coefficient and the avoidance of floc formation is stressed; however, the optimum alkalinity depends greatly on beet quality, and is lower with very good beet than with poorer beet.

Hyperpressing of pulp and cossettes

F. Pouillade, J. Vetter, R. Plever and P. Delalandre. *Zuckerind.*, 1988, **113**, 38 - 45.

See *I.S.J.*, 1987, **89**, 176.

The kinetics of sucrose degradation in DDS inclined twin-scroll diffusers

A. I. Fel'dman, N. A. Tveritina and A. A. Lipets. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 42 *(Abstract only).*

Experimental determinations were made of the rate constants of sucrose degradation by beet cell invertase and as a result of microbial activity. An equation was derived relating the rate constants to process temperature, and a sample calculation is given of sugar losses caused by inversion and acid formation in the head section of a DS-12 diffuser.

Analytical investigations of heat transfer in DDS inclined twin-scroll diffusers

A. I. Fel'dman, A. V. Emel'yanenko, E. V. Minenko, N. A. Tveritina and A. A. Lipets. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 60 - 62 *(Russian).*

Temperature conditions in DDS diffusers of 2000, 3000 and 4200 tonnes/day capacity were calculated on the basis of a mathematical model and kinetic coefficients of the heat transfer process. It was found that the additional heat fed into the diffuser from the steam jackets allowed the temperature of the cossettes-juice mixture in the head section to be raised by 13 - 17°C depending on the temperature of the steam; however, increasing the steam temperature by 30°C raised the temperature of the mixture by only 4°C while adversely affecting the technico-economic parameters of diffusion. The external heating efficiency in the range studied was independent of diffuser diameter; the temperature of the cossettes-juice mixture in the head section, also unaffected by trough diameter and undergoing little change with the temperature of the heating steam, was below the norm set and should be raised, it is suggested, by a direct injection of steam into the mixture. A system is proposed in which steam is fed via slots in tubing connected to the main feed line; the sections of tubing thus act as spray nozzles to provide regularly distributed supplementary heating of the cossettes-juice mixture and raise its temperature by up to 15°C at relatively low steam consumption. Raw juice purity was raised by 0.6 units and fermentation losses fell by 0.1% on beet at a 10% reduction in juice draft. No dilution of juice was observed as a result of a reduction in the ratio between the liquid and solid phases caused by the steam, the quantity of which did not exceed 1.5% on beet.

Conductimetric determination of the solid phase content in crystallizing systems

V. I. Tuzhilkin. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 97 - 99 *(Russian)*.

The theory of massecuite conductivity measurement as a means of controlling the crystal content is expounded and experiments are reported with model solutions of 65 - 100 purity made up from molasses and white sugar of 0.1 - 1.0 mm grain size. Crystals were added to the solutions and the difference established between the resistance measurements before and after addition; the experiments were conducted at 40 - 90°C. A relationship was found between relative resistance and crystal content (for which an equation was developed) that was independent of purity, temperature, crystal size and non-sugars content. Reasonably close agreement was found between laboratory and factory-scale tests.

Analysis of longitudinal mixing of the phases in inclined twin-scroll diffusers in beet sugar manufacture

E. V. Minenko and A. I. Fel'dman. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 118 *(Abstract only)*.

Analysis showed that the degree of longitudinal mixing of beet cossettes and extractant in diffuser sections was determined by the structure of the phase stream. The least longitudinal mixing took place in the middle part of the trough where flow of both phases approximated to displacement, whereas it was greatest at those spots where phase loading and unloading occurred and terminal non-uniformity arose. The degree of longitudinal mixing was associated with change in the physico-mechanical properties of the cossettes.

Allowing for the effect of fermentative degradation of sucrose in analysis of mass transfer in diffusers

A. I. Fel'dman, N. A. Tveritina and A. A. Lipets. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 119 *(Abstract only)*.

A method is presented for calculation of mass transfer in beet diffusers in which allowance is made for the sugar losses resulting from fermentative degradation of sugar by beet cell invertase and micro-organisms entering the diffuser with the extractant and cossettes. It is shown that the accuracy of calculating mass transfer rises by 7 - 37% when the amount of degraded sucrose is considered in determining the ratio between the masses of the participating phases. Sample calculations are given.

Investigations of mass transfer in inclined twin-scroll diffusers of differing capacity

E. V. Minenko and A. I. Fel'dman. *Izv. Vuzov, Pishch. Tekh.*, 1987, (5), 119 *(Abstract only)*.

Mass transfer was investigated in DDS inclined twin-scroll diffusers of differing capacity. For all sizes one single character of change in the mass transfer coefficient was established. The degree of mass transfer depended on the conditions of contact between the cossettes and extractant and these were in turn governed by the structure of the phase streams.

A mathematical model of the massecuite boiling process

M. Kminek and E. Kryslova. *Sb. VSCHT Praze*, 1986, **R8**, 163 - 199; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (1), Abs. 1 R418.

A mathematical model of the boiling process is presented as well as differential equations defining the relationship between crystallization rate, heat transfer and mass transfer. Comparison is made of calculation and experimental values, and a block diagram is given plus an algorithm written in Fortran.

Characteristics of sugar beet development in Czechoslovakia in 1970 - 85

L. Schmidt and O. Sebikova. *Listy Cukr.*, 1988, **104**, 1 - 11 *(Czech)*.

Tabulated values are given of the mean weight of beet roots and leaves, beet pol and sugar, conductimetric ash and α-amino-N contents in Bohemia and Moravia during 1970/85 and molasses and sugar yields are calculated from these. Comparison is made with values reported for 1920/69. Air temperatures and rainfalls are also noted.

Sugar refining

Lime consumption in raw sugar processing

T. I. Turban, Yu. D. Golovnyak, R. Ts. Mishchuk, L. D. Shevtsov and L. D. Bobrovnik. *Sakhar. Prom.*, 1987, (10), 29 - 32 *(Russian)*.

In an investigation of the effect of lime on the decolorizing effect of remelt liquor carbonatation, the effect of one and the same quantity of lime was greater when the remelt liquor resulted from raw sugar than when *C*-sugar was melted in *A*-run-off; generally, decolorization rose with increase in lime to a maximum after which it remained almost constant or increased only very slightly. A method is described for calculation of the minimum quantity of lime that will give a required level of raw sugar remelt decolorization, whether on its own or mixed with normal factory remelt. A nomogram is also presented from which the lime content in treated raw sugar remelt can be found as a function of colour content.

The use of inorganic sorbents for sugar syrup decolorization

O. S. Solov'eva, V. V. Zueva and V. A. Loseva. *Tez. Dokl. Resp. Nauch.-Tekh. Konf. Mol. Uchenykh i Spets. po Uskor. Sozd. i Osvoen. Nov. Tekh., Tekhnol. i Povysh. Kach. Gotov. Produkts. Pishch. Prom.*, 1987, 298 - 299; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (20), Abs. 20 R450.

Work was conducted on the selection of a sorbent for decolorization of sugar syrups. The inorganic sorbents investigated were silica gel, alumina gel, activated carbon, clay and chalk. Their decolorizing efficiencies were determined with 2nd refinery syrup. The exhausted alumina gel was regenerated by an acid/ alkaline method using NaOH at 15 - 30°C for 5 - 10 min, followed by rinsing with distilled water and immersion in 0.1N sulphuric acid solution in which it was held with mixing for 5 - 10 min at 40 - 50°C; after further rinsing with water, it was ready for re-use in decolorization.

Pre-treatment of low-quality sugar

V. A. Golybin, V. V. Smol'yaninov and V. V. Navolokin. *Sakhar. Prom.*, 1987, (11), 22 - 23 *(Russian)*.

In a study to determine the effect of treatment method on the colour of remelt liquor where the melted sugar was of relatively high colour, 21 - 34% decolorization was obtained by carbonatation followed by sulphitation where the initial colour was 3.6 units (the results depending on the amount of lime used in the range 0.05 - 0.25% CaO). However, for a sugar of 3.7 - 3.8 units initial colour, treatment with powdered active carbon was also needed after carbonatation and sulphitation, giving a maximum decolorization efficiency of 64.3% at 0.25% CaO and 0.10% carbon on sugar (compared with 0.05% carbon); use of 0.25% carbon raised the efficiency to 50 - 73% (depending on lime usage). However, this scheme necessitates the use of extra equipment as well as the increased quantities of materials, and treatment with 0.25% carbon alone of a remelt from sugar of 3.2 units initial colour is considered preferable, giving 48 - 51% colour removal.

The effect of certain factors on the viscosity of products of sugar manufacture

L. A. Sapronova. *Sakhar. Prom.*, 1987, (11), 45 - 47 *(Russian)*.

Artificial massecuites prepared from refinery molasses (saturated with sucrose) and crystals of low-grade sugar from the pan station were washed with alcohol dried and fractionated; the fractions were then held at a constant 30°C, gas bubbles removed under vacuum and the viscosity measured at pH 6.7. Results showed that viscosity increased with crystal size, pH and the amount of gas (CO_2, air, etc.); even as small a concentration of gas as 3.6 cm^3/ 100 g caused a 14% rise in viscosity, indicating the need to stop air entering massecuite during mixing and to prevent the occurrence of CO_2 which results from melanoidin formation.

Evaluation of raw sugar quality from the refiner's point of view

R. Ghulam, A. Amjad, H. Tafazzal and P. Najma. *Pakistan J. Agr. Sci.*, 1987, **24**, (1), 32 - 35; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (1), Abs. 1 R422.

For best processing and low production costs, raw sugar needs to be of high quality. From the point of view of refineries, the most important raw sugar parameters are the moisture, ash, reducing matter, sucrose and starch contents, pol, colour and crystal granulometry. It is noted that the quality of raw sugar samples obtained from four Pakistan sugar factories satisfied the requirements of pol and sucrose content with one exception where the sucrose content was low. All samples exceeded the standards for moisture, ash and starch content and also had a high reducing matter content with one exception.

Trends in the purification of cane and beet sugar solutions in the sugar refining industry

O. Janigova. *ATAC*, 1986, **45**, (1), 21 - 28 *(Spanish)*.

A review of the literature from 1962 to 1981 indicates that the clarification method giving the best quality products is carbonatation, and the best decolorization method is use of a combination of carbon and ion exchange resins. The possibility of using surface-active agents and oxidants in the process is also analysed.

Economic prospects of decolorization of refinery liquids with ozone

J. R. Pérez and O. Amat B. *ATAC*, 1986, **45**, (1), 39 - 43 *(Spanish)*.

An economic assessment is made of refinery liquor decolorization with ozone and an estimate made of the initial investment and operating costs. The process is considered to offer technical and economic possibilities for replacement of carbon treatment and pilot plant studies will permit better evaluation.

Starch based sweeteners

Response curves for the determination of glucose concentration using a glucose sensor

R. Nagata. *Res. Rpts. Ariake Techn. Coll.*, 1987, (23), 81 - 84; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (16), Abs. 16 R444.

Response curves obtained with a special sensor for glucose concentration were used to determine the rate constant of glucose isomerization. Tests were conducted at pH 5.6 (0.05M Na acetate solution), 20°C and a glucose concentration <0.5 g/litre. It was found that the reaction approximates to one of 1st order.

Hygroscopic properties of powdered starch syrup semi-products

Yu. S. Sebulov and G. O. Magomedov. *Izv. Vuzov, Pishch. Tekh.*, 1987, (4), 69 - 71 *(Russian)*.

The hygroscopic properties of a powdered product obtained by spray-drying a starch-derived syrup were investigated; results showed that storage at 18 - 20°C was best carried out at a relative humidity of 60%. An amorpho-crystalline product containing 30% sugar solids was found to be less hygroscopic than an amorphous product containing 20% or 80% solids while its specific volume fell to a much greater degree than that of the amorphous sugar when the nature of the water changed from that of bound water in a unimolecular layer to water adsorbed as a polymolecular layer.

A comparative study of zeolite and resin adsorbents for the separation of fructose-glucose mixtures

C. Ho, Chi Bun Ching and D. M. Ruthven. *Ind. Eng. Chem. Res.*, 1987, **26**, 1407 - 1412; through *S.I.A.*, 1987, **49**, Abs. 87-1307.

In the production of HFS, fructose-glucose mixtures are generally separated by simulated countercurrent adsorption on either a cation exchange resin in Ca^{++} form or a CaY synthetic zeolite. The kinetics and equilibria of sorption of fructose and glucose on these adsorbents were studied experimentally by pulse and step chromatographic methods. A CaX zeolite had practically no selectivity between glucose and fructose, but the selectivity of CaY was comparable to that of Ca^{++} ion exchange resins. The best resin adsorbents had somewhat higher equilibrium selectivities than the CaY zeolite, but the zeolite adsorbent had the advantage of a much smaller mass transfer resistance for a given particle size. In an operating unit, the two types of adsorbent require somewhat different flow conditions. If axial mixing can be minimized, the superior mass transfer properties of the zeolite result in a much smaller volume of adsorbent being required. Under perhaps more realistic conditions with regard to axial mixing, the performance of the two adsorbents becomes almost identical.

The role of immobilized invertase in technology for production of invert syrups

V. G. Chichua, D. B. Lobzhanidze, S. G. Tukvadze, I. G. Dzhapiridze and N. A. Kiknadze. *Tez. Dokl. Resp. Nauch.-Tekh. Konf. Mol. Uchenykh Spets. po Uskoreniyu Sozdan. Osvoen. Nov. Tekh., Tekhnol. Povysh. Kachestva Gotov. Produkts. Pishch. Prom.*, 1987, (1), 296 - 298; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (20), Abs. 20 R457.

Work has been conducted on production of active and stable silicate-linked complexes of insoluble invertases. Silochromes were used as carriers: S-80 with a pore diameter of 250 - 300 Å and S-120 with a pore diameter of 200 - 350 Å. Bonding of the enzyme was carried out with glutaraldehyde using diazo coupling. An immobilized invertase of high specific activity was obtained using $TiCl_3$ and was capable of 60 - 70% inversion of a 50 - 60% sucrose solution.

Dextrose

F. W. Schenk. *Cereal Foods World*, 1986, **31**, (12), 858 - 859, 862; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (20), Abs. 20 R481.

A short survey is presented of the technology and equipment used in the manufacture of glucose from starch and of basic trends in its use in the food and other industries. From 1965 to 1984 there was negligible change in the volume of glucose production in the USA with increase in individual years, averaging 467,000 long tons per year. The main consumers are the baking and confectionery industries and soft drink manufacture. An intensive rise in the production of glucose-fructose syrup and corn syrup in the USA is noted.

High fructose corn syrup

J. E. Long. *Cereal Foods World*, 1986, **31**, (12), 862, 864 - 865; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (20), Abs. 20 R482.

A survey is presented of schemes for producing HFS containing 42% fructose, of the composition of HFS containing 42, 55 and 80 - 90% fructose, of their relative sweetness, properties and quality control. It is noted that from 1972 to 1985, HFS production in the USA rose from 111.6 to 4,719,000 long tons. The ratio of 42% to 55% HFS altered from 88:12 in 1978 to 36:64 in 1985, while the prospects are for 30 - 35:65 - 70. The main HFS consumers are the soft drinks industry (72.2%), baking, confectionery, food manufacture and infant foods (7.2, 6.2, 5.8 and 4.5%, respectively).

Thermophysical characteristics of maltose and its aqueous solutions

M. A. Gromov. *Sakhar. Prom.*, 1987, (11), 59 - 61 *(Russian)*.

Data from the literature on thermophysical properties of maltose syrups obtained from starch are discussed and formulae presented for calculation of the various parameters at 20°C to fill any gaps. The parameters are: density, heat capacity and specific heat, thermal conductivity and heat diffusivity.

Laboratory studies

A comparison of sample preparation procedures for high performance liquid chromatographic determination of sucrose in molasses

A. W. Wight, J. M. Datel and W. H. van der Walt. *Food Chem.*, 1986, **22**, (1), 27 - 35; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (23), Abs. 23 R387.

Results are given of parallel determinations of the sucrose content in a number of samples of beet and cane molasses using two HPLC methods which differed only in the preparation of the samples. In one series additional purification of the solution was carried out (method 1) in which neutralized lead acetate solution was added and the solution passed through a mixed bed of ion exchange resins in H^+ and HCO_3^- form and then through a membrane filter of 0 - 6 μm pore size. In both cases the samples were diluted to a sucrose concentration of 0.5 - 1.5%. Chromatography was conducted on a cation exchange resin in Ca^{++} form at 65°C. Statistical evaluation of the results showed that the supplementary pre-treatment of the samples increased accuracy but also gave a difference between the two sets of values.

The theory of sucrose crystallization

Yu. D. Kot. *Sakhar. Prom.*, 1987, (12), 15 - 17 *(Russian)*.

Because of marked differences between true crystal growth rates obtained in pure solution in laboratory experiments and values calculated on the basis of sucrose molecule transfer by diffusion, doubt is expressed about the validity of the diffusion mechanism theory in the case of the layer of solution adjacent to the crystal surface, the view being expressed that the model and equations used to evaluate crystallization are oversimplified and that it is more probable that movement occurring in the crystallizing mass is accompanied by periodical renewal of the adjacent solution as a function of the adhesive forces (which fall with increase in the non-sugars concentration in the solution, as demonstrated by the lower surface tension of molasses by comparison with pure solution and by the adverse effect of a surfactant on crystallization in a high-purity solution). It is considered essential to examine molecular diffusion under conditions of a time-dependent changing distribution of concentration in a periodically changing boundary layer, and appropriate equations are developed. It is shown mathematically how, at small values of time, the crystallization rate is considerable as a consequence of a fall in concentration of the boundary layer and that it very much exceeds the crystal growth rate resulting from the difference in concentrations between the outer and inner boundaries of the motionless layer adjacent to the crystals.

Carbonyl-containing compounds in the formation of melanoidins under conditions of sugar manufacture

L. D. Bobrovnik, V. N. Rudenko and O. G. Edigarova. *Sakhar. Prom.*, 1987, (12), 25 - 27 *(Russian)*.

Studies are reported on the reactions of acetaldehyde, glyceraldehyde, dihydroxyacetone and glucose with glutamic acid to form colouring matter which was fractionated and the C, H, N and O found for each fraction; infra-red spectra indicated similarity between the colorants and those formed on a glucose and fructose basis in the normal sugar manufacturing process. Glucose reacted more slowly with glutamic acid than did the aldehydes and dihydroxyacetone.

The specific heat of pure sugar solutions

M. A. Gromov. *Sakhar. Prom.*, 1987, (12), 27 - 28 *(Russian)*.

Comparison of experimental values of the specific heat of pure sugar solutions C (as published in the literature and covering various temperature and concentration ranges) with values calculated by means of a formula developed by Yanovskii & Arkhangel'skii in 1929 show that the formula is still valid and for a wider range of concentrations and temperatures than originally proposed. The maximum difference between experimental and calculated values was ± 3.8% for solutions of 10 - 50% concentration by weight at boiling point. The formula takes the form:

$$C = 4187 - 4559\ n + 7.50\ Tn,$$

where n = concentration by weight as a fraction and T = temperature (°K); it is valid for concentrations of 10 - 90% and for temperatures in the range 0 - 100°C. A formula developed by Zel'tser & Malyarov gave values differing by ±4.4% from those calculated by the Yanovskii & Arkhangel'skii formula and its validity covered a smaller range.

Instructions for the determination of the specific rotation of fructose

A. Emmerich. *Zuckerind.*, 1988, **113**, 49 - 50 *(German, English)*.

In 1969, the Codex Alimentarius Commission published a collection of analytical methods for sugars that were regarded as necessary for verification of the Codex Standards for some sucrose products, including fructose, as well as for starch hydrolysis products. However, the instructions contained so many errors and misprints as to remove any quasi-legal authority from them. The Codex Committee on Sugars decided not to publish a new and amended issue of the instructions but to draw up a list of the methods required for the purposes of the Codex and give references to sources in the literature that described the procedures. However, no details existed of a method for determining the specific rotation of fructose, and the author was asked to fill the gap. Details are given of the apparatus, reagent (ammonium hydroxide) and procedure to follow.

Solubility of calcium carbonate in the presence of salts and sucrose

N. M. Podgornova, V. M. Perelygin and I. F. Bugaenko. *Izv. Vuzov, Pishch.*

Tekh., 1987, (5), 48 - 50 *(Russian)*.

The solubility of calcium carbonate was determined in aqueous solutions of sodium chloride, acetate and sulphate and in aqueous sugar solutions in the presence of the Na salts at 80°C. All three salts considerably increased $CaCO_3$ solubility, with Na sulphate having the greatest and NaCl the smallest effect, although the solubility in very dilute chloride and acetate solutions was the same at identical contents of the salts, indicating the dependence of carbonate solubility and of the activity coefficients of the salts on ionic strength in accordance with the Debye-Hückel theory. The presence of sucrose caused a marked change in the carbonate solubility isotherms; at low Na salts concentrations, sucrose increased carbonate solubility whereas the reverse applied at high salts concentrations. The nature of the relationship between carbonate solubility and the total contents of the Na salts in binary and ternary mixtures was the same as that for individual salts, but the influence of the mixtures on solubility showed definite departures from the additive rule. An empirical equation is given for carbonate solubility in an aqueous sugar solution containing all three Na salts.

Determination of organic acids in sugar cane process juice by high-performance liquid chromatography: improved resolution using dual Aminex HPX-87H cation exchange columns equilibrated to different temperatures

J. D. Blake, M. L. Clarke and G. N. Richards. *J. Chromatography*, 1987, **398**, (1), 265 - 277; through *S.I.A.*, 1987, **49**, Abs 87-1615.

The application of HPLC to the quantitative analysis of organic acids in sugar cane process juice is described. Separation of these acids was achieved on Aminex HPX-87H cation exchange columns. Resolution was improved by connecting two columns in series and equilibrating them at different temperatures. The acids in the sample were first isolated on DEAE-Sephadex A-25 anion exchange resin equilibrated with 0.5M isobutyric acid. They were eluted with 0.5M sulphuric acid and injected directly onto the HPLC column after filtration through a 0.45 μm membrane. This method allowed the simultaneous determination of oxalic, *cis*-aconitic, citric, phosphoric, malic, *trans*-aconitic, succinic, glycollic, lactic, formic and acetic acids. Isobutyric acid was also separated on this system and provided a useful guide to the loading capacity of the anion exchange resin.

Analytical research in Australia

Anon. *Ann. Rpt. Bureau Sugar Expt. Stations*, 1987, 30 - 31.

In the past, particle size analysis has been restricted to low-grade products having particle sizes up to 550 μm; the HIAC particle size analyser has proved very precise and the most suitable instrument for the purpose but its adaptation to sugar products necessitated the development of strictly specified techniques for sub-sampling and sample preparation. The upper operating limit of the instrument was raised to 2000 μm following the acquisition of a larger measuring head; this enabled the analyser to be used on 58 samples of shipment sugar from three factories. Experiments to compare the analyser results with those of the standard grist method showed that the latter were significantly influenced by crystal elongation. However, while the particle size analyser gave a more realistic estimate of crystal size, its high capital costs and involved analytical and sample preparation techniques make it unsuitable for routine use in factory laboratories, and it is best used in research institutions or central analytical laboratories. Investigations on the use of a membrane filter to remove suspended matter from juice samples prior to polarimetry showed that none of the membranes tested was able to provide sufficiently finite sample partitioning, and the colour of the filtrates was too dark; however, the search for suitable membranes that would give a clear, light-coloured solution is to continue.

Pulsed coulometric detection of carbohydrates at a constant detection potential at gold electrodes in alkaline media

G. G. Neuburger and D. C. Johnson. *Anal. Chim. Acta*, 1987, **192**, (2), 205 - 213; through *Anal. Abs.*, 1988, **50**, Abs. 1C13.

The transient amperometric response at gold electrodes of a polarograph is integrated and divided by the integration time of up to 1000 millisec in order to extend the linear dynamic range compared with pulsed amperometric detection. A flow-injection system was used, incorporating a flow-through detector containing a gold rotating-disc indicator electrode, a vitreous-carbon counter-electrode and a reference saturated calomel electrode. Charge-potential plots were obtained by application of a 3-step waveform with a computer to undertake amplification, current integration and sampling operations of the analogue signal. Evaluation of the system by determination of glucose and sucrose gave detection limits of 1.0 and 2.5 μM with linear dynamic ranges of 2.2 and 1.7 decades, respectively.

Indirect determination of sulphur dioxide in sugar with an iodide-selective electrode

C. Chen. *Lihua Jianyan, Huaxue Fence*, 1987, **23**, (3), 170; through *Anal. Abs.*, 1988, **50**, Abs. 1F19.

The sample (15 g) was dissolved in 35 ml of water, followed by addition of 2 ml of Zn acetate with shaking. After 5 min, the mixture was filtered and diluted to 50 ml. The test solution (10 ml) was treated with 1 ml of ethylenediaminetetraacetic acid (EDTA), 50 ml of iodine solution and water to volume. Determination was performed with an iodine-selective electrode *vs.* the saturated calomel electrode. The calibration graph was rectilinear for 0.3 - 5.0 μg/ml of sulphur dioxide.

By-products

Trident's place in a changing industry

T. Orvis. *British Sugar Beet Rev.*, 1987, **55**, (4), 10.

A representative of Trident Feeds, a British Sugar subsidiary, briefly describes how tests have revealed that not only dairy cattle can be fed on molassed beet pulp but also sheep, beef cattle and pigs. Inclusion of 12.5% molassed pulp in rations can produce a marked improvement in the gross margins with barley-fed beef cattle, while up to 30% can be incorporated in pig rations without any significant reduction in appetite or growth rates. Molassed pulp has also proved of value as an absorbent for silage effluent to prevent pollution and help retain the nutritional value of the effluent; this is particularly useful when large quantities of silage are made under very wet conditions.

The diversification of the sugar industry

E. Latorre. *Barbados Sugar Rev.*, 1987, (56), 29 - 31.

Cane by-products utilization is discussed as a means of maintaining sugar industries in the face of unfavourable market conditions.

The use of sucrose in the chemical industry

E. Reinefeld. *Zuckerind.*, 1987, **112**, 1049 - 1056 *(German)*.

A survey is presented of the use of sucrose and of its degradation products and derivatives as raw material in the chemical industry. Of the degradation reactions, the most important on an industrial scale is inversion; brief mention is made of the main products of fructose and glucose reduction, but greater attention is paid to the organic acids obtainable by oxidation and their derivatives. Reactions in which the sucrose molecule remains intact, e.g. esterification and etherification, are discussed, followed by halogen derivatives, partial esters and ethers, organo-metallic compounds having a marked biocidal effect and sucrose derivatives obtained by substitution of the hydroxyl groups using protective groups that form a temporary sheath around them (an expensive operation that limits industrial application to products of high value). Reference is also made to comparatively recent work on derivatives of pivalic esters of sucrose.

Enzymatic synthesis of oligo- and polysaccharides from sucrose

K. Buchholz. *Zuckerind.*, 1987, **112**, 1059 - 1062 *(German)*.

A survey is presented of the literature describing the use of enzymes to derivatize glucose and fructose obtained by sucrose inversion, the synthesis of oligo- and polysaccharides using dextransucrase, and application of transglucosidases to production of sugars (other than fructose) from the glucose moiety in sucrose.

Studies on the fermentative production of L-lysine. VI. An improvement of L-lysine producing strain by mutation of regulatory gene

Y. T. Liu. *Rpt. Taiwan Sugar Research Inst.*, 1987, (116), 39 - 53.

A mutant strain of *Brevibacterium flavum* resistant to aspartic acid hydroxamate (a powerful growth inhibitor) increased the yield of L-lysine to 40% when cultured on a molasses medium by comparison with only 30% using the mother strain, *B. flavum* HA92Y. Both batch and fed-batch fermentation tests were carried out and gave satisfactory results.

Food and energy from crops: an international perspective

L. G. Reeser. *Sugar y Azúcar*, 1987, **82**, (12), 14 - 15, 18.

The potential of cane as a source of ethanol against the background of declining sugar markets is discussed, with brief mention of other forms of cane by-products utilization.

Blood electrolytic composition and acid base balance in pigs fed high levels of sugar cane final molasses

L. Savón, R. J. Alvarez, R. Larduet and G. Martínez. *Cuban J. Agric. Sci.*, 1987, **21**, 273 - 280.

It has been found that the inclusion of more than 30% final molasses in pig feed is the main cause of aqueous faeces and hence of poor performance, and that this negative effect is possibly associated with a high mineral content, particularly K. Investigations revealed a relationship between metabolic and respiratory factors as a function of pH in pigs fed on a high molasses diet, but no significant differences were found in the average Na, K, Mg and P levels in blood serum between pigs fed on molasses and those given normal commercial feed, although the Cl levels and osmotic pressure varied in both treatments. The results suggest that the sampling period should be extended so as to discard the possibility of a compensated disorder.

Utilization of energy from bagasse pith

Anon. *Taiwan Sugar*, 1987, **34**, (5), 14 - 15.

Data from recent milling seasons showed that only about 30% of the bagasse pith at Pingtung pulp mill was utilized as fuel in a boiler designed to burn it together with oil to produce extra steam. Pith is not easy to handle or store because of its large volume and flammability. Details are given of the physical and calorific properties of pith as well as the approximate chemical composition of two samples, and two projects are described for the utilization of energy from pith burning. One involved two boilers, each of 50 tonnes/hr capacity, fired on pith and/or bagasse, pith and oil or oil alone; details are given of the equipment for bagasse depithing and wet pith dewatering, pith conveying and storage, ash handling and flue gas dust separation. The other project involved the supply of a sugar factory with steam

and power from a pulp mill using pith boilers. Results showed that bagasse depithing improved the quality of the pulp, cut the costs of bagasse storage and provided energy savings.

A note on the metabolizable energy of dehydrated final molasses diets for broilers

R. J. Alvarez and L. Savón. *Cuban J. Agric. Sci.*, 1987, **21**, 281 - 284.

Addition of CaO to final molasses gives a dusty and poorly hygroscopic product (dehydrated final molasses) which was considered of potential value as an energy component in poultry feed. However, investigations showed that the metabolizable energy values of diets fed to chickens and the apparent retention of dry matter fell considerably as the levels of the molasses rose. The results are attributed to a high ash content, particularly calcium, in the molasses product, and further studies are needed to find ways of reducing the ash content and increasing the energy input.

Degradation of sugars by the action of immobilized enzymes

H. Plainer and B. G. Sprössler. *Lebensmittelchem. u. Gerichtl. Chem.*, 1987, **41**, (4), 91; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (24), Abs. 24 R323.

Sugar solutions may be used as substrates for enzymes. However, when they are used in column processes, they get clogged or are contaminated by micro-organisms, while diffusion becomes difficult at a low molecular weight. At the same time as bound glucose isomerase is being widely used in starch manufacture, other enzymes that cause sugar degradation are only starting to be used on an industrial scale. The properties of immobilized enzymes produced by Röhm GmbH of Darmstadt, West Germany, are presented and details given of reactions involving them, the purposes for which they may be used and process parameters. The formation of by-products occurs as a result of enzymatic transfer; by-products mentioned include isomaltose, lactotriose and 6-kestose. A graph is presented of the relationship between the formation of free *o*-kestose from a 50% sucrose solution at pH 4.5 and 40°C and the free and immobilized invertase content.

A biological process for sulphate removal from industrial effluents

J. P. Maree, A. Gerber and W. F. Strydom. *Water SA*, 1986, **12**, (3), 139 - 144; through *S.I.A.*, 1987, **49**, Abs. 87-1637.

Some effluents from the mining industry contain high concentrations of calcium sulphate as well as heavy metals. A biological process for the treatment of such effluents is described. As a carbon source, (cane) molasses was added to the incoming effluent. In the first stage, carried out continuously in an upflow anaerobic packed-bed reactor, sulphate was reduced to hydrogen sulphide, which precipitated heavy metals as the corresponding sulphides. The end-products of this stage (hydrogen sulphide, calcium carbonate and soluble organic matter) were removed in batch conditions by applying air stripping, clarification and aerobic treatment consecutively. With a molasses dose of 3 g/litre of effluent, approx. 90% of the influent sulphate was removed in a hydraulic retention time of 10 hr. The final effluent was free of heavy metals and cyanide and had a COD of 300 mg/litre. The carbonaceous residue consisted of phenol, which originated from the molasses but which is harmless to most of the mining metallurgical processes.

Biogas production from distillery slops using an upflow anaerobic filter reactor

C. M. Silverio *et al. NSTA Technol. J.*, 1985, **10**, (3), 27 - 41; through *S.I.A.*, 1987, **49**, Abs. 87-1652.

Laboratory tests on the treatment of cane vinasse in this type of reactor are described. The vinasse contained approx. 85,000 mg COD/litre and loadings tested were 10, 15, 20 and 30 g COD/litre/day. With increasing organic loading, total solids reduction increased to 63%; pH was fairly stable at 6.6 - 7.0 but alkalinity tended to increase. At the maximum loading, output of biogas (containing 65 - 75% methane) was 2.35 litres/litre digester volume/day, or 6.756 litres/litre influent.

Treatment of distillery waste by upflow anaerobic filter

R. V. Gadre and S. H. Godbole. *Indian J. Environmental Health*, 1986, **28**, (1), 54 - 59; through *S.I.A.*, 1987, **49**, Abs. 87-1653.

In previous tests on anaerobic digestion of cane vinasse, results were unsatisfactory when the retention time was <20 days. Two laboratory-scale upflow anaerobic filters were used to treat (A) vinasse diluted 1:1 and (B) undiluted vinasse. Hydraulic retention times (HRT) of 30, 20 and 15 days were used for 60, 90 and 50 days, respectively. The % removals of COD and total volatile solids and the methane content of biogas decreased with HRT, but even at a HRT of 15 days they were acceptable (respectively 62%, 60% and 60% in A and 55%, 44% and 59% in B). An important finding was the inbuilt buffering capacity of the system which would make it unnecessary to neutralize the vinasse before treatment.

Drying beet pulp with superheated steam using mechanical vapour compression

P. Costa. *J. Fr. Electrotherm.*, 1987, (24), 39 - 41; through *Ref. Zhurn. AN SSSR (Khim.)*, 1988, (3), Abs. 3 R478.

The possibility has been demonstrated of using superheated steam to dry beet pulp. The closed-circuit plant used includes a dryer, 12 fans to circulate the steam, a condensing superheater, a two-stage centrifugal compressor and two belt conveyors to carry the pulp. Vapour flow from the dryer to the compressor was 20 tonnes/hr, and superheated steam feed to the dryer was at the rate of 1000 tonnes/hr.

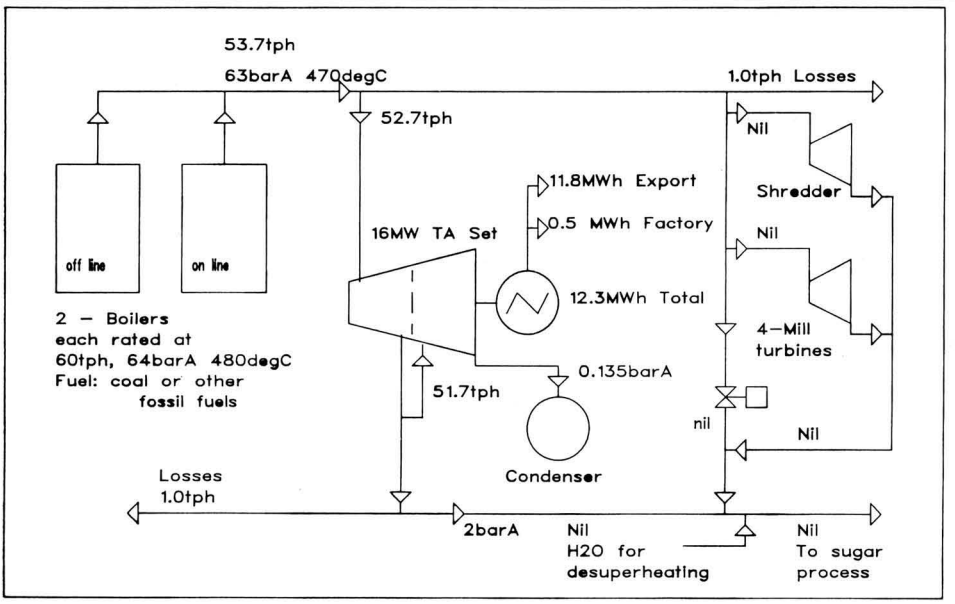


Fig. 3. Co-generation system – Option 2 (out-of-crop operations)

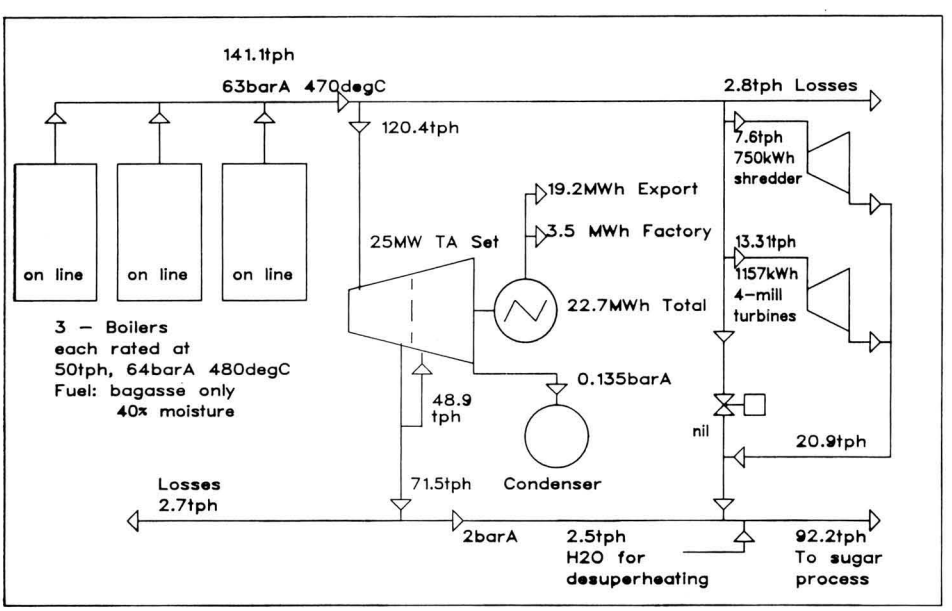


Fig. 4. Co-generation system – Option 3

ment may be required. [The thermal modifications necessary to reduce the steam consumption of a 4000 tcd (175 tch) sugar factory from 110 tph, produced from all available bagasse, to 92 tph are outlined in Appendix 1. The latter steam consumption rate is used for the power generation options considered for this paper.]

(ii) *The selection of the high pressure (H.P.) steam condition which will maximize the thermal heat drop through relevant turbine drives.* The highest possible steam pressure and temperature should be selected, given the constraints of special materials required for turbine and boiler construction and the treatment of water for boiler feed. (The effect of pressure and temperature of the H.P. steam on the theoretical heat drop through the turbine is outlined in Appendix 2. H.P. steam condition of 63 BarA and 470°C at the steam turbine is assumed for the options considered.)

(iii) *Drying of bagasse, using waste heat from the boiler flue gases, to improve the calorific value.* Bagasse drying should be considered in the context of the waste heat available from the boiler flue gases, and the capital cost involved. Surplus bagasse made available by this means would all be available for converting into electrical power. (Improvement in calorific value of bagasse as a result of drying is shown in Appendix 3. A bagasse moisture of 50% is assumed for Options 1 and 2, and 40% for Option 3.)

Electrical power generation system

The three arrangements of electrical power generation considered for this paper are based on the assumption that all available bagasse produced is utilized for in-crop generation of steam for process and power generation require-ments. A commercial fuel, such as oil or coal, is used for out-of-crop generation to maintain continuity of electrical power supply throughout the year.

Steam for process is assumed to be the same for each option based on the improved thermal economy arrangement described in Appendix 1 and shown in Figure 6.

The three options are as follows:
Option 1: The electrical power generation system is incorporated into an existing sugar factory where the existing prime movers are driven by steam at 22 BarA pressure and 365°C temperature. New boilers and an additional turbo-alternator are provided, the latter designed to operate with steam at 63 BarA pressure and 470°C temperature, and passout steam to the existing prime movers. (Refer to Figure 1). The moisture of the bagasse fuel to the boilers is taken at 50%.
Option 2: The electrical power generation system is incorporated into the design of a new factory so that all steam turbines, including shredder and mill drives, operate with steam at 63 BarA pressure and 470°C temperature. (Refer to Figure 2). The steam flow required during the out-of-crop to generate the same export electrical load is shown in Figure 3. Bagasse moisture is taken at 50%.
Option 3: The electrical power generation system is the same as Option 2 except that bagasse is dried to 40% moisture, permitting the generation of additional power. (Refer to Figure 4).

In-crop generation: The estimated electrical power generated for export for each option considered, is as follows:

Option	Export power, MWh
1	8.5
2	11.8
3	19.2

In the case of Option 1 all export power is generated by the new turbo-alternator and the existing alternator continues to provide the factory requirements.

For Option 2 the alternator provides electrical power for both factory and export. The additional power produced in Option 2 is achieved as a result of the lower steam consumption rate of the shredder and mill turbines operating at the higher steam pressure and temperature.

In Option 3 the increased load is achieved as a result of the additional steam generated from the drier bagasse. The factory load is increased by 0.5 MW to accommodate extra power required for the bagasse drying equipment, etc.

Out-of-crop generation: The alternator turbines are operated in the full condensing mode during the out-of-crop and the steam consumption in this mode is considerably reduced for the same power generated.

It is estimated that about 53 tph of steam is required for Option 2, (refer to Figure 3), and as a consequence only one boiler would be operated, allowing the other unit to undergo maintenance.

Alternatively, both boilers could be operated during the out-of-crop if additional alternator capacity is provided and the public utility can purchase the additional power. However, consideration would have to be given to boiler maintenance.

General aspects to be considered

The concept of producing sugar and electrical power for export, the latter on a continuous basis throughout the year, imposes certain difficulties and constraints on the operation of the sugar factory, which no longer can be taken as a manufacturer of sugar only. Once a commitment has been undertaken to sell electrical power, and provided the market for the power is assured, the sugar factory must take steps to ensure that the export of this power is maintained on a continuous basis and that the service provided is reliable.

Aspects which should be considered include:

(i) The market for electrical power by the public utility or district, in terms of maximum and minimum demand and total kWh generated each year, needs to be clearly established.

(ii) A long-term contract with the public utility and/or local district authority should be established, which ensures a favourable return in terms of capital investment on plant specifically purchased by the factory for the gener-

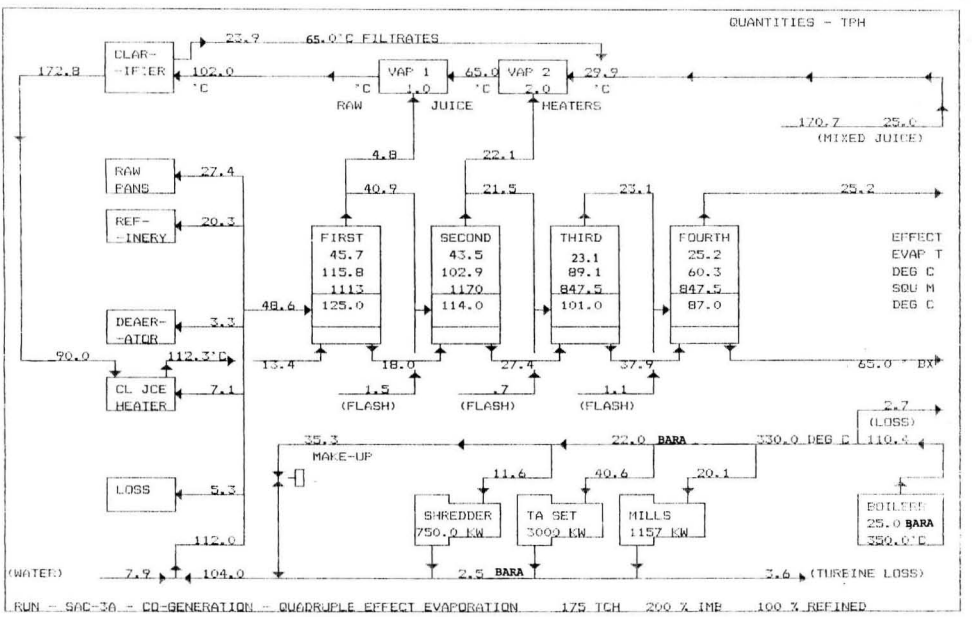


Fig. 5. Factory steam balance

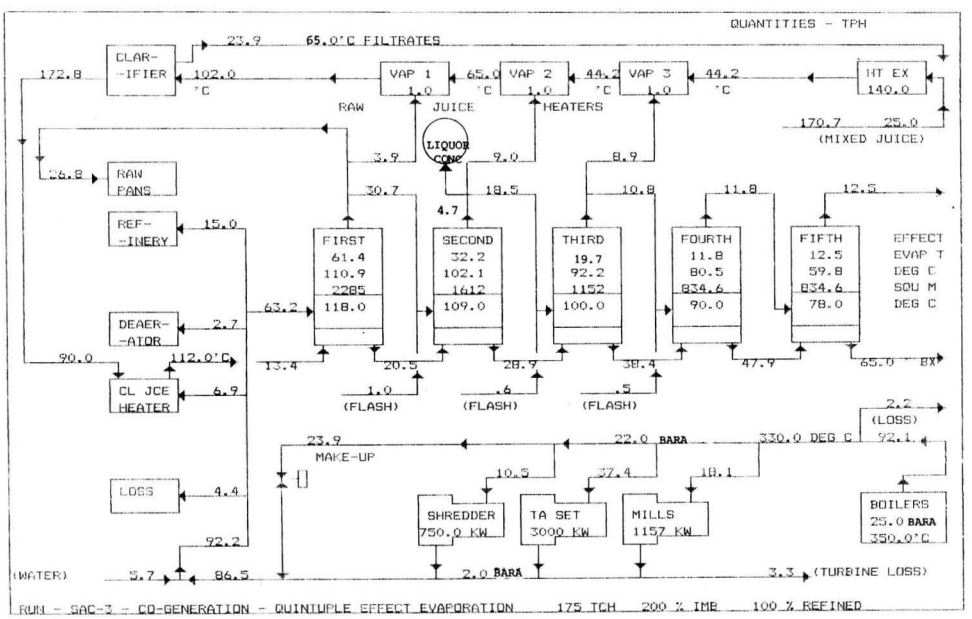


Fig. 6. Factory steam balance

ation of electrical power for export. The price paid for power should reflect the cost of bagasse used to generate the power during the crop, and the cost of generating power during out-of-crop when coal or other fossil fuels are used. The price paid for power generated out of crop should take into consideration variations in the price of the fossil fuel, which cost will change from time to time, with a minimum price per unit of power, clearly established.

(iii) The responsibility of who installs and maintains the high tension transmission distribution lines and transformer gear and the reticulation of lower voltage power to the consumer needs to be established; also whether the factory will operate continually in parallel or not with the public utility and/or other sources of power supply to a specific district near the sugar factory.

(iv) The equipment required to produce the electrical power for export must be reliable. In this regard, it will be necessary to provide, in some instances, certain stand-by or ancillary equipment and in any event to provide the equipment necessary to produce good quality water for the boilers. The number and capacity of boilers selected should be such that one boiler can be taken out of service at a time, during the out-of-crop, for maintenance.

(v) The operation and maintenance of the boilers, turbo-alternator and associated ancillary equipment must be of the highest order to ensure reliability. In this regard it is essential to provide qualified and competent staff and the necessary spares to ensure that this objective is achieved and maintained.

(vi) There will be times when the generation of electrical power will take precedence over, and at the expense of, the manufacture of sugar. These occasions may not be frequent but could involve, for example, curtailing the production of sugar to ensure that the export of electrical power is maintained to fulfil contractual obligations.

Appendix 1. Factory thermal economy

The conventional cane sugar factory is normally designed to utilize the bagasse from the sugar extraction stage as fuel to generate steam for processing requirements and to drive the main prime movers, such as alternators, which provide the electrical power needs of the factory.

It is usual to design the sugar processing plant to obtain a balance between the quantity of bagasse produced and the steam requirement of the process. This balance is achieved by selecting the appropriate processing equipment to give the necessary level of thermal economy.

It therefore follows that, if there is a need for additional steam which could be used for by-product operations such as generating electrical power for export, this could be made available, within certain limitations, by employing more thermally efficient plant for the sugar process.

Using the following basic parameters, the steam balance for a 4000 tonnes cane per day factory producing 100% refined sugar is considered, (refer to Figure 5):

Milling rate	175 tch
Pol in cane	11.5%
Fibre in cane	14%
Imbibition water on fibre	200%

This factory requires 110 tph of steam, or 63% on cane, and this is produced from all the available bagasse, equivalent to 50.5 tph at 50% moisture, after allowing for process requirements and fuel for mill stops. A quadruple-effect evaporator is employed for juice evaporation and the vacuum pans, both for raw and refined sugar boiling, are operated using exhaust steam. Juice heating is carried out using Vapour 1 and 2.

By comparison, the steam consumption of a factory incorporating the following thermal economy measures and operating with the same basic parameters, is reduced to 91 tph or 53% on cane (refer to Figure 6).

(a) A quintuple-effect evaporator is employed instead of a quadruple-effect unit.

(b) The raw sugar vacuum pans are operated on first vapour instead of exhaust steam.

(c) Primary juice heating is carried out using Vapour 3 instead of Vapour 2.

(d) A heat exchanger is employed to recover waste heat from condensate used for imbibition water at the milling plant by heating the juice coming from that station.

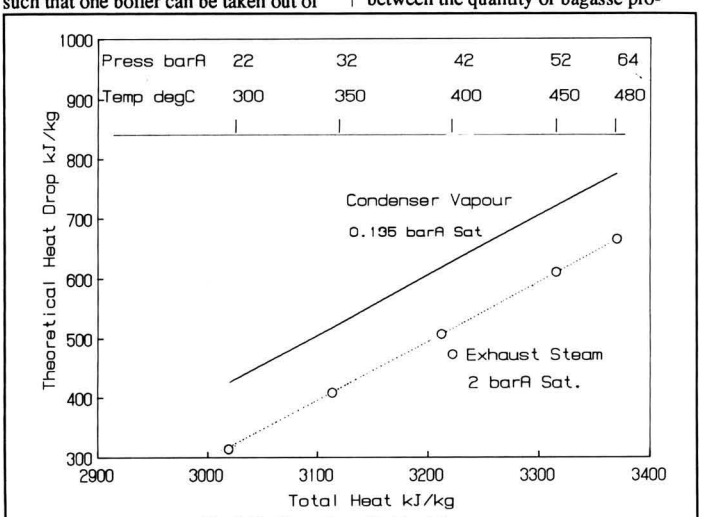


Fig. 7. Turbine – theoretical heat drop

(e) A liquor concentrator using Vapour 2 is included to increase the density of the fine liquor supply to the refinery vacuum pans.

In addition, the exhaust pressure has been reduced from 2.5 to 2.0 BarA as this will reduce the steam consumption of the turbines.

The incorporation of these thermal economy measures results in a saving of some 18 tph of steam which can be used for additional electrical power generation. This latter process arrangement is used for assessing various electrical power generation options considered in this paper.

Appendix 2. High pressure steam condition

The selection of the pressure and temperature at which high pressure steam is generated will have a significant influence on the potential amount of power that the alternator turbine can generate.

For a modern sugar factory it is normal practice to select a steam pressure of 22 to 32 BarA and temperature of 300 to 365°C. These steam conditions allow the thermal design of the factory to accommodate low-cost single-stage turbines for driving the prime movers, such as the mills, without adversely affecting the balance between the lower pressure steam demand of the process and high pressure requirements of the prime movers. In addition, a high level of process thermal economy can be achieved without affecting this balance.

However, when maximum electrical power generation is to be achieved, higher steam pressure and temperature conditions must be employed to maximize the available energy in the steam, in line with power station practice. For example, if a turbine exhausting at 2 BarA is supplied with steam at 64 BarA and 480°C instead of 22 BarA and 300°C, the theoretical heat drop through the turbine (i.e. the potential power that can be developed) is increased from about 310 to 660 kJ/kg of steam, (refer to Figure 7). Similarly, if a turbine is exhausting to a condenser at 0.125 BarA the heat drop increases from about 425 to 775 kJ/kg of steam.

It follows that the highest practical steam pressure and temperature should be selected, taking into account the limitations imposed by expensive materials for boiler, turbine and piping construction, and the limitations of quality and treatment of boiler feed water.

The high pressure steam condition is assumed to be 64 BarA pressure and 480°C temperature for this paper.

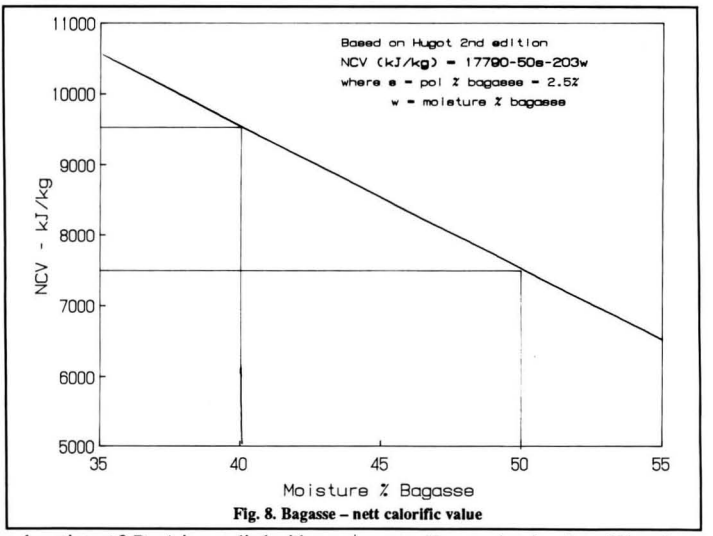


Fig. 8. Bagasse – nett calorific value

Appendix 3. Bagasse fuel

Bagasse leaving the milling plant normally has a moisture content of about 50% and this bagasse is supplied as fuel direct to the boilers. The nett calorific value (NCV) of bagasse at this moisture content is about 7500 kJ/kg. The calorific value of bagasse can be improved by pre-drying before it is combusted, using waste heat from the boiler flue gases, and if the moisture content is reduced to 40% the NCV will increase to about 9500 kJ/kg, (refer to Figure 8).

A substantial nett gain in energy, (after allowing for the energy required to operate the drying equipment), is available from this improved calorific value of bagasse for conversion into electrical power via the production of additional steam. Electrical power generation options in this paper are based on bagasse moisture at 50% for Options 1 and 2, and 40% for Options 3.

Paper presented to British Soc. Sugar Cane Tech., 1987.

continued from page 136

the beneficial "Effects of incorporating molassed sugar beet in grass silage"; the molasses pulp absorbs nutrients from the silage which otherwise leaks away and is a cause of a loss of value as well as creating a nuisance because of the drainage of BOD into soil water.

The final paper of the Conference, on "Pulp effects obtained by the alkaline extraction process of beet sugar on minerals, measured on growing lambs" was presented by Dr. F. Meschy, of UCB in France, after which the proceedings were closed by Dr. Branch and Mr. Bass.

The organization and facilities at Sugartech 88 were in the capable hands of Mr. J. S. Hogg, Mr. P. B. James and Mrs. R. Butterworth of the British Sugar headquarters staff and were a credit to them. Abstracts or fuller versions of the papers presented will appear in this Journal in due course.

TRANSPORT

Carriage and damage to bulk sugar at sea ... a question of stability

By J. A. Pearson and J. E. Somner

Some years ago a bulk raw sugar carrier was lost at sea with all hands somewhere between South and North America. There was no SOS and no trace. US lawyers were involved in heavy claims for loss of life involved and posed the following:

....."we are specifically interested in the properties of raw sugar insofar as it concerns carriage in a vessel that encounters extraordinary heavy weather."

..... "the properties of bulk sugar and the likelihood of it remaining in a stable position within the vessel during transportation."

..... "it is our contention that the carriage of this bulk sugar in no way was the cause of the sinking of the vessel with its unfortunate loss of life of all hands."

In short the defendants wanted proof positive that sugar could not cause the accident.

At first sight, with some twenty million tonnes of sugar in various forms and packs being transported safely by sea every year for the last fifty years, this should not be too difficult. However, there seem to be no published references to any specific problems of safety at sea due to the nature of sugar. Neither Lloyds survey handbook nor the British Standard 4672 "Guide to hazards in transport by sea" make any mention of danger apart from "cargo sweat" and "ship's sweat". There have been serious collisions at sea but the ship got home. The only loss of life recorded was a freak accident to a passenger on deck. No boards are needed as with grain. No special fire or explosion precautions are needed as raw sugar is always somewhat damp.

Of course, now that there is the first BIBO ship, there are a number of special built-in precautions and the prospect of more and more VHP sugar means more dust and possibly increased risk... indeed the dramatic fire at Thames refinery in London recently makes one wonder whether we are now at a new threshold and that the steady increase in pol provides the writing on the wall.

The lost ship had been carrying conventional raw sugar, however, and we could not prove that its carriage could not under any circumstances cause the loss of the ship. Needless to say, all the then available technical, chemical, and physical properties of raw and white sugar (angles of repose, moisture, compaction, fire explosion and safety factors) were produced but did not amount to proof positive as needed by the lawyers. The only evidence lay in the experience of ship owners and masters that sugar was not a cause of instability.

In the end, the legal case was settled and the file would probably have remained closed save for a visit to a sea water damaged ship where the damage was observed from the very opening of the hatches. In fact, a marine surveyor had joined with the pilot so we had extra warning. Usually surveyors arrive when the most important evidence has been disturbed.

What we particularly noticed was the complete levelling of the sugar in the hold which showed that at some stage the surface must have been completely liquid. It did not need too much in the way of arithmetic to realise the tonnage of water which must have entered the hold.

We have all seen syrup on the top of magma or massecuite, and this does not call for much comment, as it eventually drains or mixes with the sugar. However, not so many of us have seen hundreds of tonnes of syrup on top of bulk raw sugar in a hold and then the final discharge of relatively dry sugar by normal grabs and conveyors. What happens is this; a layer of supersaturated syrup or molasses forms which slows down the rate of solution and impedes the drainage of the surface syrup. Eventually a barrier develops and sweet water accumulates on the surface.

Inspection of sea water damage photographs from other ships made us realise that they too must have had free surface water on the top of cargo in their holds. From observation we moved on to measurement and then estimates which showed that a considerable tonnage of syrup or water could have been sloshing around in a storm in areas which could not be visited. No one would know the state of the problem. Whether the tonnages and position in the hold were such as to affect stability is another matter.

It is not easy to calibrate an experiment of this kind but we made an attempt. We simulated a scenario of sea water entering a hold through the McGregor hatches during a storm lasting for ten hours and we believe that the picture develops along the lines discussed below.

The ship which provided us with the evidence was a standard freighter in the 10,000 to 12,000-tonnes class, engaged on a routine voyage. She had taken on board in Mauritius a full cargo of bulk raw sugar destined for London. Shortly after sailing she encountered a tropical storm which lasted for several hours. When the weather calmed down she had developed a list to starboard which could not be corrected by pumping the bilges.

According to the log there was in fact no significant amount of water to be found in the bilges until about ten days after the storm and even when this was cleared the list remained. Some damage to the deck housings had been incurred, but nothing which would render the ship unseaworthy, and the voyage was continued without further incident.

Routine inspection of the holds had revealed that in two of them the surface of the cargo was washed white in places and the captain notified his agents in London as he came up the English Channel that there might be a claim from the receivers for sea-water damage. There were then two fortunate occurrences from our point of view:
(1) the ship was delayed for two or three days in the approaches to the port so the agents had more time than usual to mobilize their technical team and
(2) the time of high tide was such that she came on to the berth after midnight and the cranes were only just starting to discharge the cargo when we arrived on board.

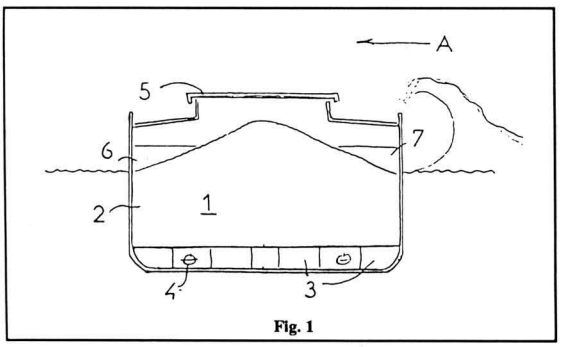


Fig. 1

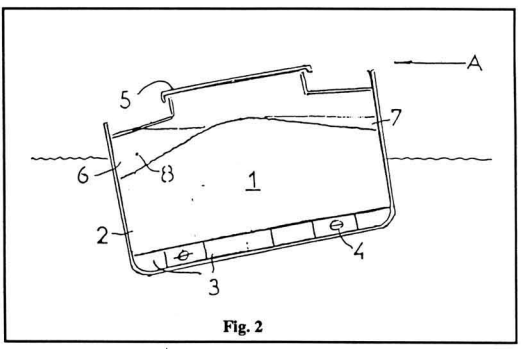


Fig. 2

To illustrate the events which followed, Figure 1 is a cross section of the hold (1) as it would have appeared when the ship put to sea. She is shown sailing towards us and the hold we are looking at is one of four, occupying about three-quarters of the ship's length. The sugar (2) lies at its natural angle of repose or less, depending on whether or not spreaders have been used for loading it.

A typical hatch is about 15 metres wide and 20 metres long. The deck extends another 4 - 5 metres to each side, and about the same fore and aft to the bulkheads separating this hold from the next compartment of the ship. Piled to a depth of about 10 or 12 metres at the peak, such a hold contains some 2000 to 3000 tonnes of sugar.

Our particular ship had hatches of the McGregor type which are the most widely employed design for this class of vessel. The covers (5) consist of six or eight rigid steel panels which span across the opening from side to side with butt joints between them, and they are held down by clamps all round the edges of the coaming. There is a resilient seal at each joint, but the material has to be fairly tough to withstand climatic extremes. Inevitably it also suffers impact damage every time the covers are manoeuvred into place. They let in a little water but, when general cargo is carried, it is normally in showerproof cases or containers and no damage is caused. The water cascades over the packages and into the bilges (3) where it accumulates until there is sufficient to warrant starting a pump (4) to clear it.

In fair weather the hold is accessible through a small opening in the deck and a vertical ladder, but as soon as there is a warning of heavy seas these are all covered and secured. In really rough weather it is not safe to venture on deck and the crew will usually be confined to the bridge, the engine room and the accommodation, all of which are at the after end of the ship.

We can only guess at the conditions inside the cargo space at sea by trying to imagine that the room in which we are sitting represents a section of the hold and the ceiling above us is the McGregor hatch. We are at a level just below the top of the sugar pile, which extends some ten to fifteen metres to either side and is separated from the deep blue sea by a single layer of steel plate. Below us, about ten or twelve metres down, is the double bottom of the ship.

When the sea is calm there is more of the hull under water than above it. When it blows up rough, depending on the direction of the waves, a vessel measuring around 150 metres long may plunge head-on through them or roll sideways until the deck is awash. Figure 2 shows a roll of 10 degrees from the vertical. A standard SD 14-type freighter can, we are told, roll to 35 degrees either side and recover, provided that the centre of gravity of the cargo does not shift. These are the extreme conditions.

A fairly frequent occurrence – which brings us back to our ship alongside the Thames Jetty – is the breaking of heavy seas over the midships section during a moderate to severe mid-ocean storm.

As the discharge of sugar went ahead, two particular features caught our attention. First, there was the familiar flattening and whitening of the top surface of the sugar. In this case we watched the grabs break into it and the sugar which lay under the deck out of their direct reach had remained standing almost vertical and the strata below the surface were very distinct.

The white affined sugar was not just a thin crust. It was a heavy uniform layer about 200 to 300 millimetres thick which, had it not been for the weight of the large grabs at Thames, would undoubtedly have had to be broken up before discharge could commence. They were heavy enough to dig through it and then we observed that the white crust was separated from the unaffected raw sugar by a sharp black line across the entire width of the hatchway and the space under the deck. Below it the sugar was quite normal until, as might be expected, the bottom of the hold was approached and it became very wet on the side towards which the vessel had been listing. Needless to say, on completion of the unloading she came back on to an even keel.

Remembering free water floating on the massecuite in a crystallizer we wondered if the same thing could happen on a pile of sugar. Having in mind the condition of the edges of the McGregor covers, we considered that an average gap of half a millimetre would

not be unlikely between the panel sections and around the edges of the coaming. That is about the thickness of five sheets of office paper.

We assumed that the waves coming over the hatch would each last for an average of three seconds and that as the ship rolled she would take on board no more than two waves per minute. We further assumed that the velocity of the water striking the hatch would be about 20 knots, or 30 km/hr. About one half of the total length of the joints would be exposed to water impinging on the hatch from one side of the ship. The total aperture size of the cracks in a hatch cover of 15 metres by 20 metres would be about 28,000 square millimetres or the equivalent of a single hole 190 millimetres (just under four inches) in diameter. Through a hole of this size, in the course of an hour, the waves could pour 90 tonnes of water into the hold. This would be not too much to worry about if it went quickly down to the bilges, but if it were to be sprinkled widely over a pile of sugar it might not do so.

We needed to find out exactly where it would go to and how quickly. The test was designed to study what happens in the zone which extends from about 300 mm above the surface of the sugar to a depth of 300 mm below it under our supposed conditions at sea. There was no question of using a small model of the complete ship because properties like surface tension, viscosity, and fluid head pressure do not vary to scale. The experiments had to be carried out on a representative section of the sugar in the critical zone by subjecting it to the equivalent amount of falling water per unit of surface area, spread over the same length of time as the storm might be expected to last.

The results of each test were recorded photographically at timed intervals. Four typical examples from one test are shown in Figures 3 - 6. The sequence begins with the sugar as it appears when it is loaded into the hold, while the second picture shows how, within half an hour under a dripping

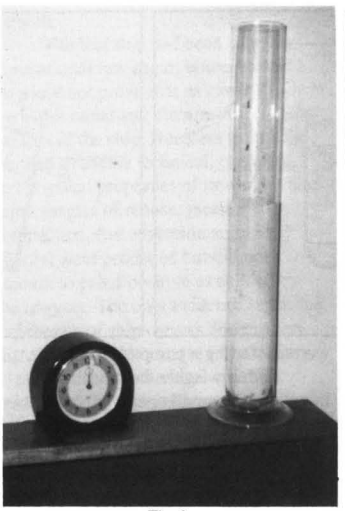


Fig. 3

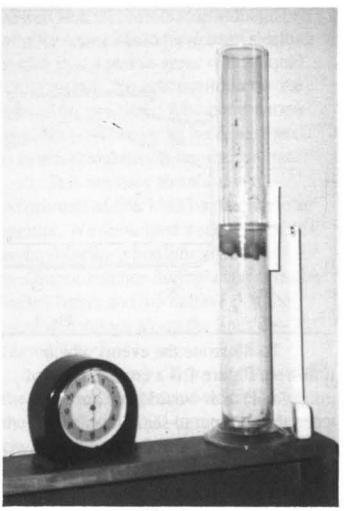


Fig. 4

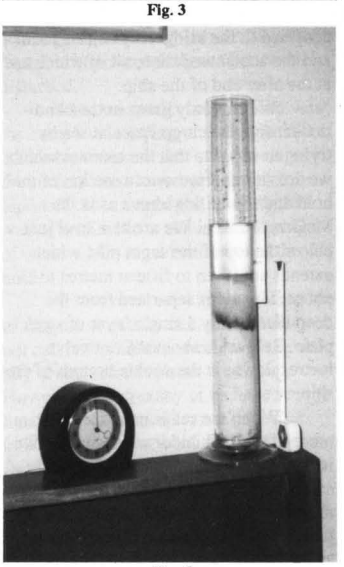


Fig. 5.

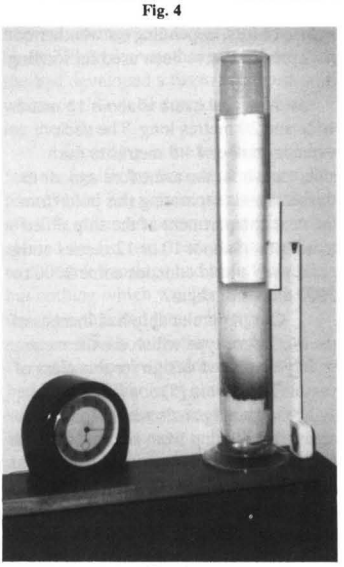


Fig. 6

hatch, the top layers of crystals begin to merge together and resist the downward movement of liquid until syrup can be seen accumulating on the surface. Affination then takes place and, as the molasses concentrates under the washed crystal layer, they combine to form an even more impervious zone, resistant both to the downward movement of water and the escape of air from the void spaces below.

The remaining pictures confirm that, after three or four hours, percolation becomes very slow indeed and any further leakage from above will add directly to the depth of free water on the surface of the cargo. Every millimetre by which this is increased in the actual

ship creates approximately another tonne of unrestrained top weight which will surge towards the lee side every time she rolls in the sea, and if two or more hatches were to leak in this way their effect would be cumulative.

This test was repeated under a range of conditions and so far the only variation to which it is noticeably sensitive is the grain size and regularity of the sugar. A large grained Demerara allows the water to drain through it so rapidly that none remains on the surface at all, but this not the case with typical small, mixed grain raw of reasonably high pol. After six hours, not only was all the water still on the top of the cargo and above the centre of buoyancy of the ship, but a substantial proportion of it was unrestrained and could cause loss of stability.

An increased effect can be illustrated if one supposes that a hatch cover became displaced after 30 minutes so as to let in three times the amount of water from every wave. One hour later and there is a potential disaster. It is conceivable that the crew in this situation might not be aware of the sluggish behaviour of the ship. Even if they were, so long as the water is beyond the reach of the bilge pumps there is nothing that they can do about it.

Having demonstrated a risk, we were concerned to find some means of avoiding it or at least reducing it to the greatest possible extent. A device has been suggested[1] whereby any water on the surface of the sugar would be decanted into the bilges with every roll of the ship. The principle is illustrated in Figures 7 and 8.

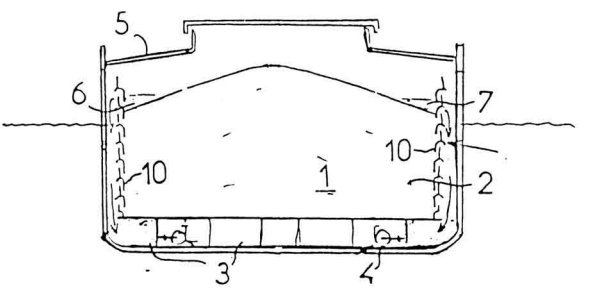


Fig. 7

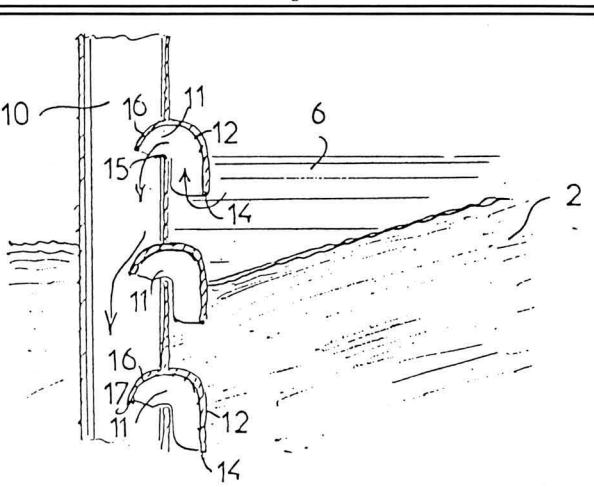


Fig. 8

Paper presented to British Society of Sugar Cane Technologists, 1988.

1 UK Patent Application 8802872 of February 9, 1988.

Facts and figures

Barbados sugar exports, 1987[2]

Exports of sugar from Barbados in 1987 totalled 79,559 tonnes, raw value, against 88,354 tonnes in 1986. The major destination was the EEC with 52,998 tonnes (51,632 tonnes in 1986) while 6548 tonnes went to the US (12,089 tonnes in 1986). The destinations of the remaining 20,013 tonnes are unknown whereas in 1986 the balance of exports included 3512 tonnes to Canada and 21,121 tonnes to the USSR.

Tanzania sugar production, 1987/88[3]

Sugar production in Tanzania in 1987/88 increased by 9.1% to 103,530 tonnes from 94,926 tonnes in 1986/87, but fell short of the official target of 108,000 tonnes.

Charcoal from bagasse[4]

The Mexican Institute of Steel Research has obtained satisfactory results in the manufacture of charcoal from bagasse; one product has a fixed carbon content of 44.99%, volatile matter of 44.77% and 10.24% ash content, and a calorific value of 6930 kcal/kg, while another contains 72.25% fixed carbon, 12.50% volatile matter and 15.25% ash, with a calorific value of 6567 kcal/kg. Yields range from 20% to 58%, depending on the temperature, with a carbonization time of 2 - 4 hours. The charcoal can be compressed into tablets or briquettes, making it easier to handle, and it may be used as fuel, reducing agent, for making activated carbon, etc.

Belize sugar production decline expected[5]

Cane and raw sugar production this year are expected to fall to 750,000 and 78,000 tonnes, respectively, against 789,000 and 88,000 tonnes in 1987, owing to low cane prices, drought and smut disease. This worries the national petroleum company Petrojam which planned to start alcohol production from surplus cane in 1989.

2 *I.S.O. Stat. Bull.*, 1988, **47**, (3), 3.
3 *Reuter Sugar Newsletter*, April 20, 1988.
4 *GEPLACEA Bull.*, 1988, **5**, (5), Sugar Inf.-1 - 2.
5 *Latin American Commodities Rpt.*, April 21, 1988.

Fiji sugar exports, 1987[6]

	1987	1986
	tonnes, raw value	
China	64,017	30,934
EEC	174,769	174,469
Japan	16,263	0
Malaysia	117,307	66,097
New Zealand	42,767	41,120
USA	23,154	14,736
Total	438,277	327,356

New Egyptian sugar factory[7]

Sugar cane is grown mainly in Upper Egypt and crushed in ten public sector factories, many of them antiquated and in poor repair. A renovation program financed by the Agency for International Development and other donors is slowly updating these factories. A new plant at Gerga, in Sohag governorate, became fully operational in early 1988 with a capacity for crushing one million tonnes of cane per season. An expansion of the cane area will be needed to supply this factory.

Success in sugar promotion[8]

In response to a multi-million dollar domestic advertising campaign to boost sugar consumption, usage in Australia in 1986/87 expanded for the third year in a row, and a further 1 - 2% increase is forecast for the current season. This contrasts with a decline in consumption in the early 1980's. Similarly, an advertising campaign begun three years ago has succeeded in raising consumption on the Spanish mainland back to traditional levels of about a million tonnes. Another factor has been the sugar producers' success in limiting production of high fructose syrup to 80,000 tonnes a year.

Finland sugar imports, 1987[9]

	1987	1986
	tonnes, raw value	
Brazil	24,529	0
Cuba	68,322	62,798
EEC	3,785	2,573
Mauritius	0	14,044
Mexico	12,363	0
Swaziland	14,319	0
Total	123,318	79,415

HFS plant in Malaysia[10]

Malaysia's first high fructose syrup plant started operations in late 1987. The capacity of the plant is small, using 50,000 tonnes of corn annually. The potential for HFS use in the soft drink and sauce industries is reported to be promising, particularly in the light of the artificially high sugar price in the country.

Poland sugar situation[11]

The beet harvest in 1987 was more than a million tonnes below the level of the previous season but warm sunny weather helped to improve sugar extraction by some 10% over that of a year earlier. Final production for 1987/88 is now estimated at 1,675,000 tonnes, white value, which compares with 1,740,000 tonnes produced in 1986/87. In all, 78 factories were operational during the campaign, the same as the year before. The new factory at Glinojeck had not reached its full capacity of 6000 tonnes of beet per day, while the old 1200 tonnes/day factory in Izabelin has been closed. The factory at Lublin has recently completed a modernization program at a cost of 5000 million zloty. A computer system has been installed and it is hoped to reduce the campaign from around 130 to 95 days. The refurbished plant will have a capacity to produce some 320,000 tonnes of white sugar.

USSR sugar imports and exports, 1987[12]

	1987	1986
	tonnes, raw value	
Imports		
Australia	181,575	149,400
Barbados	0	20,320
Belize	0	5,334
Brazil	387,555	567,800
Colombia	12,000	0
Costa Rica	47,906	0
Cuba	3,750,333	3,860,711
Czechoslovakia	6,450	0
Dominican Republic	144,934	49,751
EEC	0	8,025
Guatemala	61,340	58,905
Guyana	0	26,670
Honduras	28,582	5,200
Hungary	12,709	3,225
Mauritius	15,750	14,700
Mexico	181,194	0
Nicaragua	49,428	57,354
Poland	2,255	0
Rumania	0	9,339
El Salvador	15,008	0
Swaziland	41,300	29,400
Thailand	103,964	292,808
Zimbabwe	14,000	12,192
Total	5,056,283	5,171,134
Exports		
Afghanistan	43,543	131,230
Bangladesh	0	8,049
Benin	0	6,520
Bulgaria	15,061	15,153
Guinea-Bissau	892	0
Mali	4,558	0
Mongolia	43,399	43,012
Tanzania	0	2,172
Vietnam	10,750	43,321
Yemen, South	52,623	52,742
Total	170,827	302,199

Australian sugar industry museum[13]

On April 27, the Queensland Primary Industries Minister opened the Australian Sugar Industry Museum at Mourilyan, which is an officially sponsored project under the Australian Bicentennial Authority. Displays have been arranged to provide a chronological presentation of the history of the industry, leading to its mechanization, with a display which highlights the industry's first successful harvester poised for action amid rows of burnt cane. The museum features exhibits of rarely seen artifacts and photographs, an area devoted to mill machinery and a transport section featuring an 1890's Fowler locomotive, a 1925 Fordson tractor with wooden wheels and a Farmall tractor with steel wheels.

Swaziland sugar exports, 1987[14]

	1987	1986
	tonnes, raw value	
Canada	215,941	177,909
Comoros	0	217
Finland	14,313	0
France	39,146	0
Lesotho	2,457	0
Morocco	0	15,873
Mozambique	9,201	2,479
Namibia	6,884	1,170
Portugal	18,431	37,038
Singapore	14,939	0
Sri Lanka	0	10,964
UK	50,685	132,389
USA	10,374	16,825
USSR	5,714	72,264
Other countries	47,812	30,677
Total	435,897	497,805

PERSONAL NOTES

The Engineering Division of British Sugar plc, led by the Engineering Director **R. J. Bass**, has been restructured with the formation of three new groups providing cost-effective high quality services: the core business group; the Bristar Engineering group; and a special projects group. The first of these, led by Chief Engineer **J. S. Hogg**, is concerned with engineering development (Manager: **A. J. Randall**), project design management (Manager: **A. F. Anderson**) and engineering and technical services to British Sugar (Manager: **S. McCarey**). It will be concerned with trouble-shooting during the campaign as well as year-round services to packaging operations, support for process and related control systems, specialist commissioning, and technology transfer, project proposals, feasibility studies, plans and designs, etc. Bristar Engineering is concerned with capital investment, Group engineering for the Bristar companies (Group Engineer: **D. A. G. Brown**), health safety and the environment (Manager: **J. N. Smith**) and quality assurance development (Manager: **G. Wilson**), while the third group, led by **N. R. Twaite**, will provide engineering consultancy and design to outside clients and to British Sugar/Bristar when requested.

6 *I.S.O. Stat. Bull.*, 1988, **47**, (3), 16.
7 *Amerop-Westway Newsletter*, 1988, (174), 8.
8 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 247, 257.
9 *I.S.O. Stat. Bull.*, 1988, **47**, (3), 17.
10 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 264.
11 *Czarnikow Sugar Review*, 1988, (1773), 77.
12 F. O. Licht, *Int Sugar Rpt.*, 1988, **120**, S145, S191.
13 *BSES Bull.*, 1988, (22), 5.
14 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, S10, S193.

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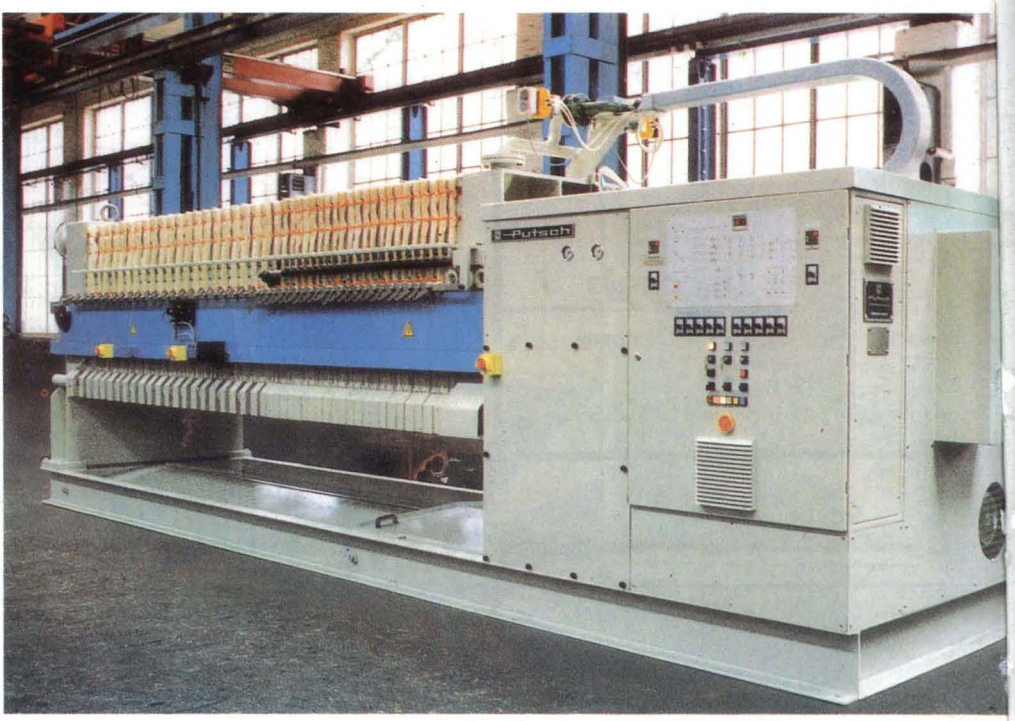

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