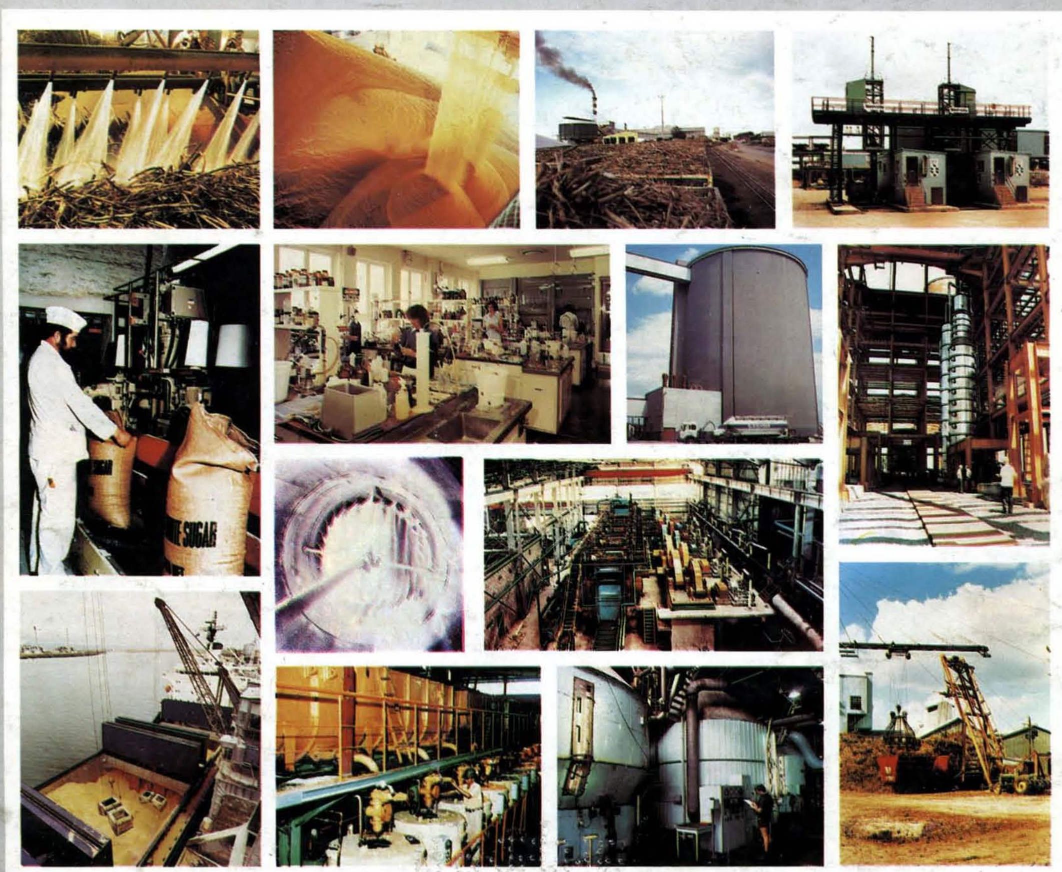
INTERNATIONAL SUGAR JOURNAL



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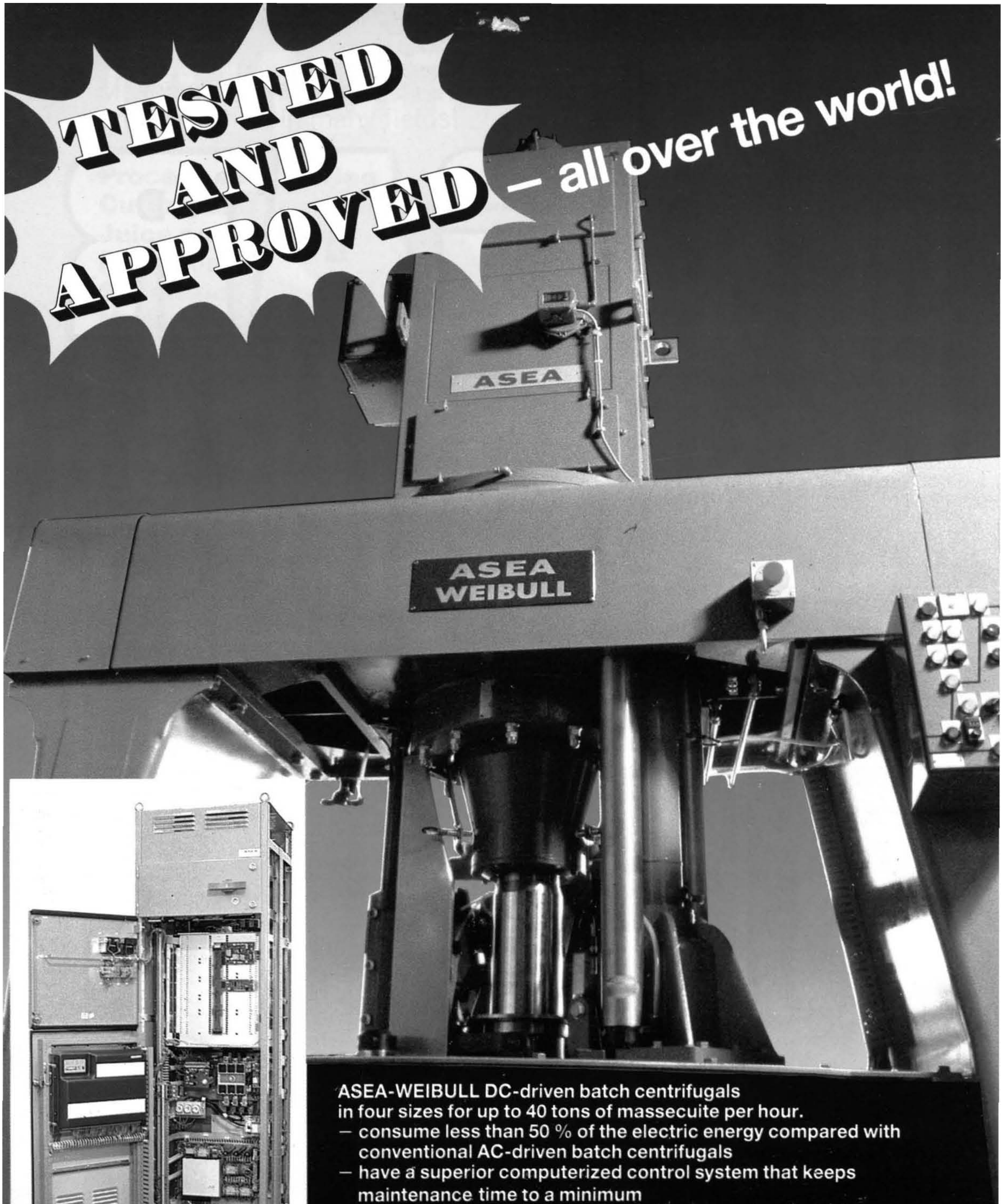
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News and views

World sugar prices

The sugar markets had little news to stimulate activity during April and prices were very steady throughout the month. The London Daily Price for raw sugar started the month at $170.50 and on April 29 was $176.50. On April 23 the LDP dipped to $166.50 as a consequence of activity on the metal markets and reports of Soviet imports brought about a short-lived increase to $186 on April 30. White sugar prices behaved in much the same fashion, with an LDP(W) of $190 on April 1 and $190.50 on April 29, with a dip to $182.50 on April 23 and a rise to $197.50 on April 30.

Australia sugar industry rationalization

In a recent letter to readers of *Australian Canegrower*[1], Mr. Fred Soper, Chairman of the Queensland Cane Growers' Council, summarized the outlook for the Australian sugar industry. He pointed out that the world market for sugar is a shrinking one, and that policies of important countries such as the USA, the EEC and Brazil (he might have added Japan) make it unlikely that there will be any long-term increases in outlets and prices. With little chance for expansion of total Australian production and rising costs, survival depends on action to decrease costs, and Mr. Soper considers that producing the same total crop with fewer factories and fewer growers is the only alternative.

Moves are afoot in this direction[2]; a merger plan has been put forward for the formation of a "super-cooperative" by amalgamation of five existing cooperatives in the Mackay area; the Pleystowe factory of CSR Ltd. would be sold to the new group and eventually closed. The Sugar Milling Adjustment Committee has also proposed that there be reassignments of cane from the Goondi factory to others in the Innnisfail district, especially the Babinda factory; the Goondi mill would be closed, whereas the future of the Babinda mill has been under a cloud for some time and this would be lifted if the SMAC plan were adopted.

Not surprisingly, the proposals have aroused controversy and opposition but there are strong grounds for rationalization and government finance is available to assist the process of change. As Mr. Soper says, "If we, for whatever reason, fail to take advantage of this situation, changes will still occur, but there will be a lot more people hurt. We cannot expect the Government (taxpayer) to continue to help us over problems if we are not prepared to make an occasional difficult decision to help ourselves".

Withdrawal of sugar from EEC intervention[3]

Following a shift in the EEC Commission's export rebate policy, caused by producers' complaints, most of the sugar recently offered and accepted into intervention[4] has been withdrawn. Commission sources said that the latest export rebate granted was only 0.5 e.c.u. below what producers claim is needed to obtain a price equivalent to the intervention price. At the tenders before Easter the gap had been substantially greater, which caused the producers to offer the sugar into intervention. The higher rebates in relative terms reflect in part a Commission wish to accelerate exports in order to be able to start new crop licences as early as possible this year.

European sugar beet area, 1987

F. O. Licht GmbH recently published its second estimate of the areas to be planted to beet in Europe this year[5]. In the EEC, the introduction of an elimination levy has not stopped an increase in the accumulated debt on sugar exports, and stringent pricing has led in some cases to price reductions in national currencies. Consequently, the two producers with the strongest currencies – West Germany and Holland – are planning to cut back on sugar production; France is also likely to cut its beet area by a further 0.25% and a partial retrenchment is likely in Italy where the area was increased sharply by 22% in 1986. Austria, Yugoslavia and Turkey plan to expand sugar production by increased beet areas in 1987 but little change is expected elsewhere in West Europe and few changes are expected in East Europe. The forecast areas are tabulated below:

	1987/88	1986/87
	hectares	
Belgium	112,000	118,000
Denmark	69,000	69,000
France	420,000	421,000
Germany, West	385,000	399,000
Greece	30,000	44,000
Holland	130,000	138,000
Ireland	37,000	38,000
Italy	270,000	275,000
Portugal	1,000	1,000
Spain	182,000	195,000
UK	200,000	201,000
Total EEC	1,836,000	1,899,000
Austria	39,000	28,000
Finland	31,000	31,000
Sweden	51,000	52,000
Switzerland	15,000	14,000
Turkey	400,000	349,000
Yugoslavia	160,000	136,000
Total W. Europe	2,532,000	2,509,000
Albania	10,000	9,000
Bulgaria	52,000	50,000
Czechoslovakia	195,000	196,000
Germany, East	215,000	205,000
Hungary	107,000	96,000
Poland	460,000	425,000
Rumania	275,000	280,000
USSR	3,400,000	3,440,000
Total E. Europe	4,714,000	4,701,000
Total Europe	7,246,000	7,210,000

Licht derives a total for Europe of 7,246,000 ha and has sought an estimate of the likely region of sugar outturn by applying for each country the average sugar yield for the past six years. The total is calculated as 33,421,000 tonnes, against 35,017,000 tonnes for 1986/87 and 34,068,000 tonnes for 1985/86. There is scope for considerable variation

1 1987, **9**, (2), 3.
2 *ibid.*, 8 - 9.
3 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 189.
4 *I.S.J.*, 1987, **89**, 82.
5 *Int. Sugar Rpt.*, 1987, **119**, 185 - 187.

from the forecast but yields were fairly high for 1986/87 and this increases the chance of a significant reduction in European outturn in 1987/88.

Asian sugar expansion unlikely

The 10-month high for world sugar prices and forecasts of further rises are not luring the major Asia-Pacific producers into boosting output, according to a survey of the region's sugar industries by Reuters[6]. Although the price rally has brought about a mood of cautious optimism, several producers are forecasting declines in production and none has specific plans to boost plantings.

The low rainfall of the 1987 Queensland summer wet season means it is possible that Australian output will fall this year even though farmers have been encouraged by the improved market outlook to increase inputs such as fertilizer for the current crop. Some slight freeing of the tightly-regulated industry has allowed farmers to plant up to 15% more land than in the past, but industry sources do not expect this to lead to any surge in output, even though it has been officially estimated that Australia could boost production to about 5 million tonnes without any great investment and sell its massive exportable surplus on quality and reliability.

India, the region's largest producer, has no immediate plans to resume sugar exports in 1987 despite satisfactory domestic production and attractive world prices, according to an ISMA spokeman, but could consider resuming exports from 1988 if the current buoyancy in sugar and cane production continues. India expects to produce at least 8 million tonnes of white sugar in 1986/87 against a million tonnes less in 1985/86, but will continue to import sugar, mainly to build up a buffer stock of 1 million tonnes.

Poor weather is expected to cut Thailand's cane crop this season to 22.5 million tonnes from 24 million tonnes in 1985/86. Output is expected to decline from 2.48 to 2.30 million tonnes of sugar. China, both a major producer and importer, is expected to see output from beet and cane decline to 5.26 million tonnes in 1986/87 from 5.53 million tonnes in 1985/86, owing to area cuts reflecting lower prices for sugar compared with free market grain.

Philippines sugar output is also expected to decline to 1.3 million from 1.5 million tonnes in 1985/86, owing to the financial problems of cane growers; however, many may respond to higher prices with revived planting in 1987/88. In Indonesia farmers are reluctant to plant cane owing to low prices and 1987 output is forecast to be unchanged from 1986.

Ferruzzi Group sweetener expansion

The Italian Ferruzzi Group, having been thwarted in its attempt to purchase British Sugar plc, recently announced that it had reached an agreement with CPC International to buy its corn wet milling plants in Europe for $630 million[7]. The deal includes 13 starch and high fructose syrup plants that employ 5000 people in eight member countries of the EEC and facilities and trading operations in other member countries. The plants have an annual production capacity of approximately 66,000 tonnes of HFS, dry basis, which represents about 25% of total output in the Community.

Eridania Zuccherifici S.p.A, a subsidary of the Group, has made a cash offer of 40,000 million lire to acquire the production facilities of two other Italian sugar companies, Società Romana Zucchero S.p.A. and AIE-Mizzana S.p.A.[8]. The two companies have three plants with an aggregate slicing capacity of more than 20,000 tonnes/day.

Brazil alcohol/sugar production problem

With new cars coming onto the road at 80,000 a month, all powered by alcohol-burning engines, Brazil is locked into the need to provide increasing amounts of alcohol as a fuel. Even if oil became very cheap, the new cars will not burn gasoline and plants would have to be built to make alcohol from oil as a raw material. Brazil has concentrated on alcohol manufacture from sugar cane, however, as a rational means of limiting foreign exchange costs for oil while achieving self-sufficiency in fuel. As described earlier[9], domestic sugar demand has been increasing and there is greater demand for cane to make into sugar; competition for supplies has thus caused problems in regard to meeting sugar export commitments.

At the end of April, the Brazilian National Commission on Alcohol was meeting to decide on the 1987/88 production plan. The National Petroleum Council (CNP) and the Sugar and Alcohol Institute (IAA) have different opinions as to the use of cane[10], calling for greater allocations of cane for alcohol and sugar, respectively.

The IAA estimates 1987/88 sugar cane production at 238 million tonnes, up from 210 million in the 1986/87 crop. It recommends production of 13,200 million litres of alcohol and 7.6 million tonnes of sugar. This would mean that 900,000 tonnes of sugar committed for exports in 1987/88 would have to be renegotiated for delivery in 1988/89, according to the IAA which is using a domestic sugar consumption estimate for 1987/88 of 6.5 million tonnes, down from 6.8 million tonnes expected for 1986/87. Moreover, the IAA has recommended at 105% increase in retail sugar prices and a 104% increase in alcohol prices to further cut domestic consumption and reduce government subsidies.

On the other hand, the CNP has called for an alcohol production of 15,100 million litres and 4.1 million tonnes of sugar; the IAA points out that this would not be sufficient to meet domestic demand. Some compromise will have to be reached, but it seems likely that 1987/88 will be another year in which Brazil cannot meet all its sugar export commitments.

6 *Public Ledger's Commodity Week*, March 7, 1987.
7 *GEPLACEA Bull.*, 1987, 4, (4), Mkt. Rpt. -9.
8 *Public Ledger's Commodity Week*, April 25, 1987.
9 *I.S.J.*, 1986, **88**, 221.
10 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 193.

Product news

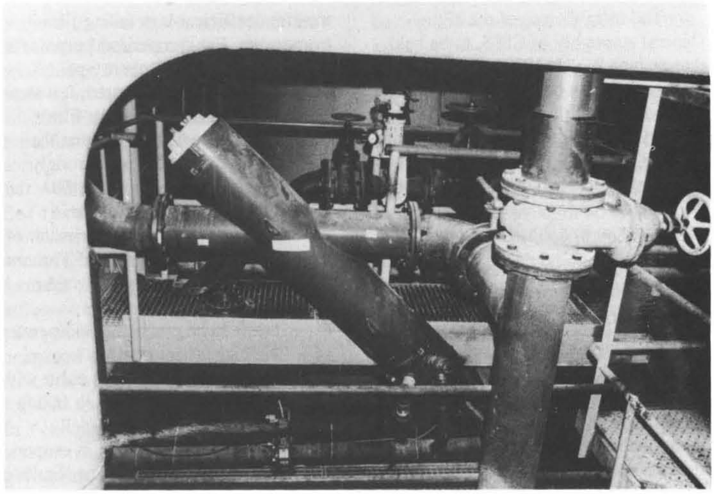
Filtomat in the beet sugar industry

The Filtomat automatic, self-cleaning filter described earlier[1] is available in a wide range of sizes and screen fineness and can serve a number of purposes in the beet sugar factory. Variables affecting the type of filter and screen include the degree of recycling, heat conversion, water consumption, operating temperatures and the amount and nature of the soil on the beets. Installations at beet sugar factories in Belgium, Holland and Sweden have shown that major savings are possible in filter maintenance costs and reduced downtime for washer spray nozzles and heat exchangers.

One Dutch sugar factory has six Filtomat filters, dealing with flows of between 10 and 400 m³ per hour and particles from 9000 down to 100 microns. This and other installations include the following: For *beet washing*, a Filtomat M310 (10-inch pipe, as illustrated) with 200 micron screen, handles 400 m³/hr at a pressure of 10 bar. This unit has been in operation for more than five years, preventing recycled water sprayed onto beets on the vibrating screen from clogging spray nozzles. This has saved the cost of one man previously required for continuous cleaning.

Raw juice filtration is through a Filtomat M308 (8-inch pipe) with a 9000 micron screen; 250 m³ is handled at a pressure of 5 bar and the unit has been in operation for three years, removing beet pieces and fibres and thus preventing blockages of the spiral-flow heat exchangers. Prior to its installation the heat exchangers were cleaned four times during the campaign, requiring two men for two days each time. This is no longer necessary and a reduction in nozzle wear has also been achieved.

Two M304 and a M308 Filtomat have been used for *cooling water* treatment. One M304 has a 120 micron screen handling 80 m³/hr of surface water at 3 - 4 bar for the cooling system of the carbon dioxide pumps, resulting in lower maintenance and fewer problems. The second M304 has a 200 micron screen and filters 300 m³/hr of surface water at 2 bar pressure to prevent fouling of a plate heat exchanger. The M308 unit with a 200 micron screen filters 300 m³/hr of surface water at 2.5 bar pressure for the turbine cooling system.



Milk of lime is filtered through a M303 Filtomat with a 400 micron screen which operates at 2 bar pressure and removes coarse particles from 40 m³/hr of slaked lime suspension; this reduces the risk of clogging of the lime dosing installation.

A M308 Filtomat with a 200 micron screen is used for filtering *recycled waste water* after anaerobic purification; this has reduced fouling of plate heat exchangers. Trials have been carried out on *thick juice filtration* and preliminary results are very promising. *Condensate* is filtered and 40 - 70°C through a M304/L unit with a 30 micron screen at 3 - 6 bar pressure and a flow of 60 m³/hr prior to recycling via an ion exchanger bed to remove ammonia. The bed had clogged frequently owing to pipe scale and particle carry-over prior to the installation but subsequently has run for a complete campaign without cleaning.

Further details:
Atkins Fulford Ltd.,
Edgworth Road,
Sudbury, Suffolk, UK.

Technical brochure on conveying

Everything from individual conveyor components to complete handling schemes are featured in Universal Conveyor Co. Ltd's colourful new 48-page bulk handling brochure. It covers static troughed belt conveyors, gantries, trippers and covers, portable and self-erecting mobile units, radial conveyors from stockpiling and shiploading, screenloaders, belt and plate apron feeders, screw and electro-vibrating feeders, drag link, scraper, steel slat and screw conveyors, bucket elevators, steep-angle sidewall belt conveyors, plus bins and structures.

Copious full-colour illustrations of recent installations are interspersed with informative technical notes. Also included is an introduction to Universal's comprehensive range of belt conveyor components: idlers and drums plus drive and tension units and intermediate sections which enable customers to assemble their own conveyors, based on standard ranges and with full advice from the company's technical team.

Further details:
Universal Conveyor Co. Ltd.,
Humberstone Lane,
Leicester LE4 7JT,
UK.

Commission Internationale Technique de Sucrerie 13th General Assembly, 1987

The main themes of the 13th General Assembly of CITS, to be held during June 8 - 12, 1987, in the Congress Centre of the city of Ferrara, at the invitation of the Italian sugar industry, are "Sugar degradation", "Colour" and "Pulp". We have previously published a list of papers to be presented and include below the summaries in English.

Sweet sorghum as raw material for sugar manufacture in Hungary (K. Vukov and J. Barta)

Sweet sorghum can be grown successfully in Hungary, mainly for fodder. The yield is approximately 50 tonnes/ha and dry matter yield 17 - 18 tonnes/ha, greater than maize for silage. It is advantageous for ensilage purposes to express part of the juice from the chopped crop (about 25 - 45% of the mass). By treatment with starch- or hemicellulose-splitting enzymes, clarification and evaporation, the juice obtained as a by-product is made into a "whole sorghum syrup" suitable for the manufacture of potassium- and magnesium-rich fruit syrups, nectars and similar dietetic foods.

The pressing of the chopped material by means of horizontal two-spindle screw presses is satisfactory, but it is hindered by seeds in the tops. It is proposed that industrial processing should take place in apple juice concentrate plants during a pre-campaign in August. Another alternative would be juice extraction with pulp presses in beet sugar factories, enzymatic treatment in suitable tanks there; the filtration must be carried out in apparatus specially developed for the purpose. The evaporation of the clear juice can be carried out in a vacuum pan or alternatively in a suitable two- or three-stage evaporator. The concrete solution will depend on the results of a technico-economic study.

Heat transfer, residence time distribution and colour formation in evaporators
(G. Witte and T. Cronewitz)

The paper reports on the authors' experience with determination of heat transfer coefficient k in falling film evaporators. For comparison purposes k values measured for Robert-type evaporators are also presented. It was not possible to confirm for falling film evaporators a previous claim that the heat transfer coefficient was strongly dependent on the specific juice flow rate b, defined as the juice flow rate in relation to the wetted inner perimeter of the tubes, over the range 2 - 15 l/hr/cm. Colour formation and residence time distribution were shown in the experiments to be practically independent of b. The higher heat transfer, known from earlier measurements to occur with increased juice concentration in falling film evaporators, was substantially confirmed. Colour formation in evaporators is discussed in detail. The results of model calculations on colour increase during concentration are compared with actual measured development.

The influence of alpha-amino nitrogen, potassium and sodium on colour formation in thin juice
(P. Christodoulou, D. Hadjiantoniou and G. Zountsas)

During the 1985 and 1986 campaigns 310 beet samples from various regions of Greece were processed to thin juice in the pilot plant at the Central Laboratory. A classical juice purification was used for processing of the samples to thin juice. Pol,α-N, K and Na contents of the beets were determined as well as the colour of the thin juice produced. It was found that the colour formation in thin juice is a direct function of the α-N, K and Na content of the beets.

The inclusion of colour and ash compounds in beet white sugars (N. W. Broughton, D. Sargent, B. J. Houghton and A. Sissons)

Studies of the distribution of solution colour and potassium, a typical ash component, in granulated white sugar by means of a laboratory sugar washing technique are described. It was concluded that colour and ash can be found in all layers of the sugar crystals. A reduction in the ICUMSA colour of up to 38% (average 29%) was observed by removing the outer layers of the crystal and, in most cases, the reduction of the potassium concentration of the sugar, by up to 50% (average 38%), followed a closely similar pattern.

The washing technique used saturated and partially saturated sugar and water solutions to remove the outer layers of sugar crystals progressively and has been compared with an earlier technique using ethanol and water solutions and found to offer some advantages. Laboratory sugar boiling tests with lithium chloride added at three different stages showed the inclusion of ash components into the crystal throughout the pan cycle. The use of lithium as a marker showed that the sugar washing technique was not perfect and, as expected, small quantities of material present in the surface film remained with the sugar after washing.

The relationship between crystal size and the colour and potassium content is also described for a production white sugar (519 µm M.A.). It has been shown that below about 600 µm the colour and potassium concentration of the crystals are directly proportional to their surface area. Fine and coarse fractions were shown to make relatively small contribution to the overall colour and potassium content of the sugar.

Clostridium thermohydrosulfuricum, once fought — soon utilized? (H. Klaushofer)

C. thermohydrosulfuricum was first isolated in 1964 from the juice in an extraction tower. It is an aerobic, highly thermophilic organism, able to proliferate in tower zones with liquids ranging from 0.5 to 2.0% dry matter. Where the extraction juice contains sulphite ions, possibly from sulphitation for acidification purposes, considerable quantities of H_2S will be formed. From sugar the bacterium produces ethanol, lactic acid, acetic acid, carbon dioxide and hydrogen and during the last eight years it has become of interest for two reasons outside sugar technology. The one area concerns direct thermophilic saccharide fermentation, in particular in symbiosis with *C. thermocellum*, an anaerobe able to decompose cellulose. The cellulose and xylose formed by this organism is transformed into ethanol by *C. thermohydrosulfuricum*. Unlike other processes proposed, with this process saccharification and fermentation proceed at their respective optimal temperatures and the otherwise necessary special production step for cellulase can be dropped. The alcohol concentrations obtained so far are as yet much too low for economical ethanol production. The second potential application is in the field of ultra- or hyper-filtration. Like many mesophilic and thermophilic bacterial species, *C. thermohydrosulfuricum* has an outer cell wall layer (the S-layer) consisting of macro-molecules of protein nature. The molecules of this layer form a regular two-dimensional crystalline grid having the characteristics of an isoporous membrane. The S-layer can be detached and, after removal of the detaching agent in vitro, can be induced to aggregate (self-assembling). S-layer fragments, layered on commercial microfiltration membranes and possible cross-linked, result in an ultra-filtration membrane with pores of a uniform size of 4 - 5 nm and great stability.

Use of monosacharide-forming infections in the extraction with the aim of improving pulp pressing
(G. Pollach and F. Hollaus)

Decomposition of monosaccharides had been observed during studies of the efficiency of desired infections in the extraction plant of a sugar factory during the 1985 campaign. Within the framework of the present paper an attempt was to be undertaken during the 1986 campaign to determine whether these findings could be confirmed and what the results of a cost-benefit study would be within this context. For this purpose, several assessments of the pressability of beet pulp and sugar losses were made under conditions of an uncontrolled infection. A further study was intended to determine whether the continuous of the extraction towers could limit the infection without interfering with the pressability. Finally, an attempt was made to achieve a comparison between infected and sterile operation of the extraction plant with the aid of shock dosing.

While in experiments during the first 15 days of the campaign better results were achieved by means of uncontrolled infection than with formalin dosing, in respect of strong influence on the pressed pulp dry substance, experiments later in the campaign showed that limitation of the infection by continuous dosing with formalin gave more favourable results. In a comparison between shock dosage and uncontrolled infection, the latter gave better results as in the 1985 experiments, owing to the decomposition of glucose and fructose and the improvement in pressability of the exhausted slices, in spite of the sharp reduction in energy prices that had taken place in the meantime.

Beet pulp drying in superheated steam under pressure
(A. S. Jensen, J. Borreskov, D. K. Dinesen and R. F. Madsen)

Aktieselskabet De Danske Sukkerfabrikker (the Danish Sugar Corporation) have developed a new method for drying beet pulp. The particles to be dried are conveyed into a modified cellular fluidized bed under pressure. The particles are carried by a vertical superheated steam flow circulated within a closed vessel. In the cells, an intimate contact is achieved between the particles and the superheated steam, and at the same time the particles are conveyed from the first to the last cell in such a way that the smaller particles with the shortest drying time will reach the last cell before the larger ones. The steam developed by evaporation from the particles is discharged from the closed system and can be used for other purposes, e.g. in the sugar factory evaporators.

The method was developed in basic laboratory tests and subsequently, in having an evaporation capacity of 1000 kg/hr. A full-scale unit has been working at Stege sugar factory since the beginning of the 1985 beet campaign. The method offers three major advantages: *Energy saving* — as the steam leaving the plant can be used for the first stage in the juice evaporation this results in a saving of up to 80% of the amount of fuel used in traditional drum dryers; *No pollution* — in contrast to other methods of drying, there is no emission to the atmosphere nor any outlet to sewage; and *Improvement of the quality of the dried beet pulp* — as the drying takes place without admission of air, oxidation of the dried material is avoided. It has not been possible to measure any loss of dry matter. No impurities from flue gas can mix with the dried pulp.

Reactions of monosaccharides in aqueous alkaline solutions
(J. M. de Bruijn, P. W. van der Poel, A. P. G. Kieboom and H. van Bekkum)

A systematic investigation of the influence of some reaction parameters on the alkaline degradation of monosaccharides is presented. The formation of substantial amounts of oligomeric products (up to 50%) besides the well known C_1-C_6 acidic degradation products, e.g. lactic acid, has been emphasized. These so-called $C_{>6}$ acid products comprise a complex mixture of compounds with an average molecular weight comparable with from 2 to more than 4 monosaccharide moieties and are thought to be formed via aldolization of (di)carbonyl compounds. The kinetics of the alkaline isomerization and degradation of hexose have been studied by the use of a new kinetic model, including both the interconversion and degradation of glucose, mannose, fructose and psicose. On the basis of new (additional) insights, a mechanistic picture of the alkaline degradation of monosaccharides is developed. The fructo-formose reaction, i.e. the alkaline degradation of fructose in the presence of formaldehyde, is discussed. The results of this fundamental research conveniently describe the conversion of invert sugar and formaldehyde in the liming procedure in sugar manufacture.

The development and application of continuous ion exclusion (K. W. R. Schoenrock)

The alarming displacement of sugar in the marketplace by lower-priced substitute sweeteners demands that the sugar industry avail itself of all pertinent technology to meet that challenge. While significant improvements have been made in the past in equipment design and automation, basic technology has essentially remained unchanged in over 100 years. Ion exclusion has recently been advanced where it is now especially attractive for the sugar industry to raise productivity and reduce cost. The "Contex" process is presented which represents state-of-the-art in continuous ion exclusion. Its integration into the sugar-end operation for the treatment of *B*-green syrup increases sugar production by about 16%. Revenue gains of $59,000/day are possible at a current US market prices when handling about 100 short tons of non-sugars per day. The main operating costs are associated with the disposal of a low Brix (~ 5%) raffinate containing separated non-sugars. The process opens up possibilities for spring and summer campaigns utilizing stored liquors for improved utilization of fixed-investments cost.

Cane sugar colorants in processing operations (M. A. Clarke, M. A. Godshall, W. S. C. Tsang and E. J. Roberts)

Cane sugar colorants are divided into four classes and some properties of colorant classes are described. A series of simple tests has been applied to colorants throughout cane sugar refineries; reactions of some types of colorant with refinery processes are reported. Studies on cane sugar factories, comparing milling with diffusion, have been made with the colour tests. The syrup clarification process has shown to remove colour as well as turbidity and polysaccharides. Preliminary laboratory results on distribution of high molecular weight colorant in cane sugar crystal are reported. Some speculations on the nature of the high molecular weight colorant are put forward.

Computer analogical simulation of diffusion (G. V. Genie)

The computer analogical simulation of diffusion has been applied to the comparison of tower diffusers with rotary diffusers as concerns the influence of mixing and convection of juice. Mixing is more harmful in rotary diffusers, but it is more than compensated by a faster juice convection and this explains why the extraction time is substantially shorter than in tower diffusers. The application of the computer analogical simulation method to the crystalline of sucrose is proposed.

Kinetics and technology of low-grade massecuites exhaustion (V. Maurandi, G. Mantovani, G. Vaccari and A. Rossi)

Kinetic studies at a low temperature (15°C), described in a previous paper, have been extended to 40°C and to higher impurities concentration, with the aim of obtaining further technological information on the technical possibilities of molasses exhaustion. At 150°C and an impurities:water ratio (I/W) of 1.1, the growth rate depressions at low supersaturations are of a very high order and therefore show exponential character, the Kossel-Stranskii equation being valid. On the contrary, at 40°C and an I/W ratio of 2.55, the kinetic order is about 2, the Burton, Cabrera & Frank equation being valid. In other words, in the experimental conditions followed by the authors, there is greater influence of the temperature, which reduces the kinetic order, compared with the increase of the impurities, which causes its rise. On a basis of the experimental growth data, the time needed for molasses exhaustion is indicatively evaluated. This time has an order of magnitude of about 55 hours, when a residual molasses supersaturation of approx. 0.07 is obtained with an I/W ratio of 2.55. This is higher than previously calculated where the growth rate depression at low supersaturations was not taken into account.

Odour emission and control in the Dutch sugar industry (B. C. Huisman, L. H. de Nie, H. J. Peters and P. W. van der Poel)

Among the various enviromental problems of the Netherlands, the odour emission from sugar factories has become a permanent point of discussion between the sugar industry and the authorities. In 1983, Suiker Unie and CSM and the authorities agreed to execute a long-term research program with regard to this subject. The aim of the program is to identify and measure the odour sources, to calculate their effects on the surrounding area, to investigate the possible abatement techniques for the most important sources and to calculate the cost of a yet to be agreed effective odour abatement program.

After four years of intensive research by the Netherlands Organization for Applied Scientific Research, TNO, Apeldoorn, an overall picture of the odour sources at nine sugar factories was completed. It showed that at each factory 25 - 30 odour sources can be distinguished, of which an average of 6 sources per factory appears to be responsible for 90 - 95% of the total emission. With specific sources, certain variations in processing were tested for their odour-reducing effect. During the investigation some interesting experiences were obtained with respect to the reduction of the odour emission of certain important sources by process adjustments. Small-scale tests were carried out to determine the odour-reducing effect of possible abatement techniques. The waste water problems related to these techniques were determined at the research stage.

With the present state of knowledge (March 1987) a reduction of the odour emission concentration (in residential areas) of 80% might be considered technically feasible. The yearly cost connected with these possible measures for the whole Dutch sugar industry are calculated to be excessive (Hfl. 15-20 million). The remaining odour emission, moreover, will in most cases still exceed by many times the draft odour concentration limit of the Dutch Minstry of Environmental Affairs (VROM). In the paper, a survey is given of the odour measurement techniques applied, the results of the investigations and the odour abatement small-scale tests, and the considered full-scale odour abatement measures.

Automation of evaporation
(J. C. Giorgi)

In a modern sugar factory, the heat consumption is low, the Brix from the evaporating plant is high and the different plants are generally controlled in such a way that their inlet steam flow is independent of the evaporating pressures. These facts involve instability of the evaporating plant and it would be useful, therefore, to have it controlled by an efficient process control. In order to study such a process, a model was built and, when fed with industrial data, allowed the efficiency of any algorithm to be tested during the intercampaign. It was thus possible to define several modules which allowed: Brix stabilization at the evaporator outlet, regulation of the controlled Brix mean value; and control of the evaporator temperature. However, the constraint was adopted of limiting the instantaneous variation of steam flow so as not to upset the functioning of the boiler. These modules, tested on models, were used industrially with success but worked only independently of each other. When coupled, they must have a particular form, to avoid oscillations. This coupling was successfully tested on the model. Industrial testing will be carried out next year at the sugar factory at Lillers.

Incidence of pressing additives on the ionic balance of the sugar factory (P. Devillers, J. P. Lescure, G. Deruy, P. Largeat and J. P. Lamy)

Modification of the structure of pulps by the action of polyvalent ions, in particular those of calcium and aluminium, has been utilized for a long time by sugar factories to increase the efficiency of their pressing. These processes have consequences on the quality of the pulps as well as on the purity of the products of manufacture. By means of quantitative balances, a study has been made of the distribution of the pressing aids in the pulp as well as along the line of manufacture. Aluminium, generally added as aluminium sulphate, is quantitatively fixed on the pulp. The dosage has to be correct, however, in order to avoid excessive concentrations in the pulp sold as cattle feed.

Calcium is less well fixed and sometimes precise control permits excessive addition of calcium sulphate to be avoided. The greater part of the sulphate anions introduced into a diffuser is found in the raw juice. The lime-carbonate juice purification is not very efficient for removing sulphate, since about 40% passes through. These sulphates tend to crystallize in the second and third strikes, which leads to an enrichment in the intermediate products and to return of the ash to the first strike pan stage. The distribution of the organic anions is not modified as a result of the use of pressing aids.

The thermal dehydration of pulp in a large-scale steam dryer (P. Valentin)

Süddeutsche Zucker-AG has, during past years, developed a concept for multi-stage thermal dehydration of exhausted and pressed beet pulp without direct use of primary energy and employing only the potential of waste heat and that of recoverable heat from sugar manufacture. The technical tools for this concept are: a low-temperature dryer, and a live steam dryer. In this concept, the drying at low temperature in the first drying stage calls for the exclusive use of waste heat. In the sugar factory at Offstein an evaporation of more than 32 tonnes/hr has been attained with a dryer employed in this manner. For the second stage at Offstein a conventional drum dryer is still used. The two-stage concept has not yet been realized in the live steam dryer installed at the Gross-Gerau sugar factory. The live steam dryer works in parallel with the conventional high-temperature dryer. It is planned in the long term to install a low temperature dryer after the live steam dryer.

From a technological point of view, both the low-temperature dryer and the live steam dryer are to be classified with convective dryers. The basic principles of the live steam dryer are briefly described and compared with conventional drying. The concept of the live steam dryer in relation to the thermal balance of sugar manufacture is explained. Detailed information is given on the incorporation of the live steam dryer in relation to the power plant and use of steam from the turbines. The vapours so obtained are used as a source of energy for the manufacture of sugar. Introduction of drying with live steam into the energy sector of the sugar plant must be optimized from several points of view, details of which are given. The essential technical parameters of the live steam dryer installed at the Gross-Gerau sugar factory and the results obtained are presented.

Additives and colour formation: action of hydrogen peroxide (C. A. Accorsi, M. Peretti and P. Fontana)

Following a survey of the range of hydrogen peroxide reactions, the authors examine the effects of this additive on difusion juice and thick juice. These are juices that differ markedly in both their qualitative and quantitative composition. Results confirmed that hydrogen peroxide, when added in diffusion, acts as a non-specific bactericide and at the same time accelerates the formation of melanin by facilitating its adsorption and elimination through the pulp. The usual colour enhancement that occurs during evaporation indicates that the peroxide reaction does not involve the formation of particular, or particularly reactive, colouring substance precursors. Hydrogen peroxide has a marked reaction range vis-à-vis thick juice components.

The greater concentration of such solutions, combined with alkalinity, enhances decomposition of hexoses and leads to the formation of acids and consequent drop in pH values. The resulting decolorization shows that melanoidin and caramel, which make up the main colour fraction in thick juice, are also attacked by peroxide. The removal of colour depends on both the quantity and the concentration of the added peroxide.

The decrease in pH, however, limits the amount that can be employed, which in turn limits the extent of decolorization. Factory tests in which moderate amounts of peroxide were added (about 0.1% w/w) confirmed laboratory test results, i.e. unexpected return of colour did not occur during crystallization, *A*-sugar had less colour, and the ash content was practically the same as without peroxide. It should be pointed out, however, that the effect of temperature must be accurately checked and necessitates further study.

Process technology principles of mechanical dewatering of cossettes

(K. E. Austmeyer)

The water removal properties of a compressible mass depend on the compressibility of the solid material skeleton and the permeability of the liquid phase. The higher the permeability of the press cake in its compressed state, the quicker will be the dewatering process; pressure applied and time are the relevant operational parameters of this process step. In technical presses, in which the pressure field corresponds as a rule to high gradient, the shearing imposed on the interior of the press cake provides an improvement of the dewatering results. To be sure, this also brings about a considerable increase in the requirement of mechanical energy to be used. After the treatment of some theoretical models, the basic demands of the conception of technical presses are explained. Physical properties such as compressibility and permeability are altered markedly when pressed pulp is mixed with concentrated sugar solution which it then adsorbs. Owing to the concentration gradient, diffusive or rather convective transport of the capillary-bound water takes place into the external solution. This partition of the water makes possible the introduction of a simple and energy-economical separation concept. Even centrifuging of thus treated cossette material leads to very good results. The possibilities of this method of working, as well as the fundamental physical mechanisms, are considered in detail. Further, a technical concept for one of the first press stages of a later dewatering installation is introduced, comprising mixing and separation devices as well as a multi-stage evaporation plant. The notable reduction of energy consumption, compared with traditional drying plants, is an essential characteristic of this method of operation.

Use of bisulphites in diffusion plants as sterilizing agents, pulp pressing aids and for decolorization

(G. Mantovani, G. Vaccari and G. Sgualdino)

Bearing in mind the favourable results obtained in a previous series of experiments, the authors employed bisulphites during the 1986 campaign in some sugar factories processing different raw material as well as having distinct diffuser characteristics. The results led to the following conclusions:

– Correct introduction of optimal doses of bisulphites at the head and tail of the diffuser allows avoidance of infection. The results obtained are comparable to those achieved in the presence of formalin.

– The addition of a sufficient amount of bisulphite at the tail of the diffuser enables pressed pulp to be obtained with a satisfactory dry substance.

– Adding sulphuric acid simultaneously with sulphur dioxide leads to high values for dry matter content in the pressed pulp. However, corrosion phenomena can occur, together with an increase in the ash content of the products of manufacture.

– The use of bisulphites in the diffuser allows a remarkable improvement of the thick juice to be obtained.

– The use of bisulphites does not require special or expensive modification of existing plants.

Influence of pressing additives on the process of pre-exhaustion of cossettes by presses (C. A. Accorsi, G. Cerolini and F. Zama)

The use of pressing aids, generally metal cations in the form of more or less soluble salts, has become routine in mechanical pulp dehydration. Several authors have suggested just a lime treatment, this procedure being designed to eliminate anion melassigenic action and to assure at the same time the exchange between alkaline ions and Ca^{++}. The treatment of the cossettes with such an additive should affect favourably pulp pressing capacity. The availability of presses ahead of diffusion made it possible to study the effects of calcium sulphate and calcium hydroxide in the form of milk of lime on cossettes. The addition of calcium sulphate, whether carried out at the inlet of the countercurrent cossette mixer or in the mixer feeding the presses invariable leads to positive results which are more marked in the second case. The cossettes acquire enhanced mechanical characteristics and can be pressed more thoroughly, i.e. without excessive splitting. The standard RT diffusion plant can reach an increase of over 60% in throughput with respect to rated capacity. This additive does not affect diffusion juice quality. The effects of calcium hydroxide were investigated by varying temperature and concentration, i.e. the two factors that modify its action. The cossettes were treated directly in the mixer before the presses so as to keep contact time to a minimum. A cossettes temperature of about 80°C and Ca^{++} amount of the order of 60-70 ppm have a negligible effect on processing. When concentration was increased to 140 ppm, difficulties in pressing and diffusion ensued as a result of pectin breakdown, while the quality of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adversely affected, despite particularly arduous processing conditions.

When the cossettes temperature was progressively reduced from 82 to 50°C and the amount of milk of lime was increased at the same time from 60 to 150 ppm of Ca^{++}, there resulted an increase in press energy absorption that became quite marked from 65°C and 100 ppm upward. Under these conditions, the mechanical processing limits of the presses were 50°C as to minimum temperature and 220 ppm as to the maximum of lime for cossettes treatment. With the addition of 220 ppm of the calcium ions at 58°C, even low-temperature diffusion did not lead to satisfactory exhaustion and a slight decrease in juce quality was also found. Results improved when the cossettes were heated, at the press outlet, before diffusion. It was not possible to establish any relation between pulp pressability at the diffusion outlet with the addition to the cossettes. This may be due to the effects of concentration. However, if the action of pressing aids, usually added with diffusion water, is not limited to an improvement of the mechanical characteristics of the tissues but contributes, through contraction following reticulation, to the true expulsion of water, it cannot be ruled out that these treatments ahead of diffusion may only affect pulp consistency.

Crystal aggregate formation from pre-agglomerated structures (D. Schliephake and T. Frankenfeld)

The formation of sucrose crystal aggregates by simultaneous growth of independent single particles in a flow environment is, as shown at previous Assemblies, highly unlikely. As more intense crystal aggregate formation is observed particularly with the entry of seed crystals dispersed in iso-propanol (slurry, of mean grain size $d_k \sim 8$ µm), a model of aggregate formation from dependent particles was constructed; the seed crystals are already agglomerated in the inert fluid. By introduction into a supersaturated sucrose solution it is possible to form very quickly, owing to the small mass requirements, crystalline bridges between the individual particles which touch each other. Such a crystal aggregate is not separable by normal treatment in suspension; as established experimentally, the state of dispersivity obtained in the slurry is hardly altered, even on addition of a supersaturated sucrose solution. With agglomerate-free seed crystals it is possible to obtain agglomerate-free final crystals.

On a basis of the van der Waals forces of attraction between the agglomerated particles, it is possible to determine the resistance to traction of the agglomerates in relation to their size and the single particle number. By comparison of these resistances with the transferable hydrodynamic propulsion tensions, respectively, in slurry suspension, it is possible to determine the minimal agglomerate sizes. These theoretically obtained agglomerate sizes were confirmed by results of experiments with defined slurry suspensions.

Properties of the structural material of pulp in regard to mechanical dewatering and the resulting possibilities for further development of pulp presses (T. Cronewitz)

The influence of the ionogenic loading of pectin components of beet pulp fibres on the attainable solids content was examined on a laboratory scale with a curb press (47 bar, 4 layers) and on an industrial scale with a screw press. The studies showed that the valency of the metal ions, as well as the level of loading, calculated from the sum of all monovalent to trivalent ions, are important. The increase in solids content, determined as meq/100 g beet pulp dry solids, was of the same order after converting bivalent cations to trivalent cations as after increasing the total loading. In the laboratory experiments as well as on the industrial scale, an increase of about 0.2% solids content (absolute) corresponded to each meq/100 g d.s. When assessing the influence of pH level on pressing, it should be remembered that the sum of metal ions bound on the pectin fibres decreases at lower pH and therefore influences the pressability negatively. With regard to the further influence of the pH value on the pressing, the stability of the structural matter was examined; this influences the yield of pulp dry matter. The influence of pH on the specific throughput of screw presses was determined quantitatively; it fell with drop in pH value. The influence of pH on the attainable solids content thus combines several effects. At constant screw velocity, the solids content increases by about 0.5% (absolute) for each reduction by 0.1 pH. At constant throughput and the same fall in pH, however, the increase in solids content is about 20% smaller.

The comparison of specific data from double-screw and single-screw presses allows the conclusion that development of screw presses with the aim of increasing solids contents should be possible. This is supported by the fact that the fine pulp content of the press water is not increased in spite of raising pressed pulp dry solids from 20 to more than 30%. The measured pulp size reduction in the presses is not very great in relation to the deviation of this size. The d.s.-dependent increase in current demand of the current large press units should be considered as critical. With a small curb press, the highest value for solids content in beet pulp was 73%, using 900 bar pressure. On the industrial scale, with high-pressure multilayer pressing, more than 50% solids content can be reached at the moment, while with a screw press only about 30% solids content can be achieved. The possibilities and limits for technical development of beet pulp pressing can be derived from these facts. The development of multi-layer pressing for continuous processing of beet pulp could continue on the principle of a band press – plate press combination. The use of compressed air to drive out residual water in the press is proposed. The application of a programmable automat to simulate the processes in a screw press is suggested.

Unconventional cooling-crystallization (G. Mantovani, G. Vaccari and G. Sgualdino)

From a previous series of experiments the authors concluded that inclusions in sucrose crystals of both colour and ash are greater the more severe the conditions of the crystallization. The authors have continued their research with the aim of studying the possibility of crystallizing white sugar of commercial quality from syrups normally employed for the production of first product raw sugar. The crystallization was, however, carried out under gentler conditions than those of traditional industrial boiling. A tentative processing scheme was established in which crystallization was carried out by cooling and in several stages. Sugar quality, the energy balance and plant characteristics are more favourable in the case of crystallization by cooling than with the traditional process.

Anaerobic fermentation of by-products and residues of the sugar industry (K. Buchholz, E. Stoppok and H. J. Arntz)

The aim of the investigations was to develop an alternative for the utilization of pressed beet pulp and solid wastes such as beet particles and leaves. Central questions were yields which can be obtained and waste material remaining after fermentation, maximal conversion rates in the hydrolysis stage, and the possible need for chemicals. A two-stage reactor system was utilized for continuous experiments with hydrolysis of pectin and araban and acid formation in the first stage and further break-down of fine particles and methane formation in the second stage. The maximal reaction rate in the first stage was 9 kg C.O.D./m^3/day at a load of 25 kg/m^3/day. Rheological problems limited mixing at higher load rates.

Pilot scale investigations in a 15m^3 stirred tank with beet residues gave similar results at loads of 2 tonnes/day (16.7 kg C.O.D./m^3/day). No additional chemicals were necessary. Methane yields obtained with the two-stage reactor system were excellent; about 90% of theory (with 350 litres CH_4 per kg C.O.D.) for pressed beet pulp and around 80% for residues, depending on their composition. Most interesting was the observation that extracellular polysaccharide hydrolysing enzymes could be found in the anaerobic hydrolysis reactor. By selecting appropriate conditions (batch fermentation), it was possible to increase significantly the yields obtained. By means of a two-stage membrane system with cross-flow filtration and ultrafiltration, stable concentrated enzyme preparations could be obtained with endo-pectin-lyases, pectate lyases, endo-arabanases, endo-galactanases and endo-ß-glucanases.

Drying of pulps with superheated steam and mechanical recompression of vapour (-. Pouillade, -. Boy Marcotte and -. Roche)

The energy crisis in the years 1981/84 greatly encouraged specialist energy engineers to suggest better and better performing energy systems. In the field of pulp drying, G.T.S., with the Bertin company, studied and then developed a drying technology using superheated steam. The recompression of this steam allows the calories which formerly were lost from the dryer in the moist exhaust air to be retained in the system. The energy needed for drying has been reduced from 800 to 200 kWh/tonne of water evaporated. With the cooperation of Etablissements Promill, an industrial dryer was erected in the C.F.S. sugar factory at Villenoy. The expected electrical energy consumption has been reached and the losses through burning pulp have been totally eliminated. At this factory the recovery of dry substance has been improved by 5.7%. The promotors – G.T.S./Bertin/Béghin-Say/Serete – have licensed the Promill company for the commercial development of this technology which is ready for industrial application.

Study of the kinetics of colour formation in the sugar house (K. Hangyál, F. Örsi and E. Bara-Anyos)

The effect of pH, temperature and reaction time on colour formation in sugar factory thick juices was studied. The examined ranges were: pH 7.5 - 10.0, temperature 70 - 90°C, and reaction time 0 - 30 hours. No correction was made for the pH decrease caused by sugar destruction which is therefore included in the kinetic model established. The change in colour is described by the model as a function of reaction time as well as pH and temperature of the starting solution. The correctness of the kinetic model was shown when values calculated from the equation were compared with measured data. According to the results, the role of temperature is of particular importance with regard to colour formation. The work is to be continued in two directions: to determine the rate of colour formation on the basis of corrected pH values and to determine the rate of formation of high molecular weight colour bodies as a particular factor in sugar colour.

Influence of forced pressing of exhausted cossettes on the quality of press water (K. Hangyál and E. Gryllus)

There is a trend towards increasing dry substance in beet pulp remaining after the extraction and, at the same time, increasing the amount of pulp press water by means of new devices, technologies aimed at lowering losses in pulp drying, and improving storage in silos and feeding of cattle. Factory investigations have been carried out for determining the quality of press water obtained in larger quantities. The effect of the surplus of press water on losses in diffusion and on white sugar yield has been determined. It has been found that both sugar and non-sugars content are higher in press water when the pressing effect is increased. The concentration of the individual components and the concentration relative to that in beet or extraction water depends partly on their diffusion constants and partly on whether the component originated in the beet or the extraction water, and whether it is found in dissolved or bound form in the beet. By increasing the pressing, the concentration of sugar relative to non-sugars rises giving a higher purity in the

ISJ Abstracts

Cane sugar manufacture

Reduced boiling house loss and boiling house performance

P. K. More. *Bharatiya Sugar*, 1986, **11**, (7), 67, 69 - 70.

The concept of reduced boiling house performance is explained and a formula developed by the author is analysed, showing the derivation of the various loss factors and the effect of juice purity. The failure of a formula developed by Noel Deerr to indicate boiling house performance in contrast to the new formula is demonstrated.

The technical and economic significance of the first cane diffusion plant in Indonesia

S. Singh. *Zuckerind.*, 1986, **111**, 767 - 772.

Details are given of the BMA cane diffuser installed at Kedawung factory of 2000 tcd nominal capacity, and performance data are presented for the 1985 season, showing a reduced extraction of about 98% at a juice draft between 96% and 111% on cane, a bagasse pol between 0.57% and 1.15% and a bagasse moisture averaging 52% (higher than expected because of faulty hydraulics at the final dewatering mill). Cane fibre content ranged from 12.37% to 16.19%.

Jamaica: harvest management – the stale cane problem

W. McPherson. *GEPLACEA Bull.*, 1986, **3**, (07), 4 pp.

In a discussion of stale cane, the author considers that a significant part of the problem may be due to erratic factory crushing, whereby a considerable amount of freshly delivered cane may be held over for later processing (it is stated that carry-over quantities equivalent to or even exceeding 24 hours' crushing are not unheard of); it is suggested that the cane available at the factory at 6.00 a.m. should be adequate for only 4 - 5 hours' crushing, and that sufficient fresh cane should be supplied to ensure that the factory has enough to continue operations. Factory breakdowns also may result in harvested cane being left in the field.

Sugar cane juice purification by treatment with live steam

P. Fabregat, M. Darias and L. D. Bobrovnik. *Izv. Vuzov, Pishch. Tekh.*, 1986, (2), 62 - 64 *(Russian)*.

First expressed juice was filtered and then treated with live steam at 0.172 - 0.363 mPa and a rate of 1 kg steam to 12 - 40 kg juice (raising the temperature from 33 - 42° to 51 - 90°C) in investigations at Las Villas Central University in Cuba. The juice was then subjected to conventional cold liming, heating and clarification, and analysed. Results showed that, by comparison with the controls, steam treatment reduced the colloid content and the Ca, Mg and phosphates in colloidal form as well as the protein content without any change in pH (indicating the absence of sucrose inversion and of reducing sugars degradation). The volume of liquid to that of solid impurities, as a measure of purity, rose in all cases of steam treatment, which increased the settling rate and reduced mud volume. Reference is made to the relatively low costs of manufacturing and operating the special mixer used to bring steam into contact with juice.

Studies on the settling rate and mud volume in juice of some promising sugar cane varieties

V. Dubey and S. S. Dua. *Indian Sugar*, 1986, **36**, 99 - 104.

The settling rate, mud volume and purity rise as a result of clarification were determined for juice from six varieties at three stages of crop maturity. Results are discussed and the data given in graph and tabular form.

Computerization of the cane accounting system – a case study

S. S. Ranade and R. L. Khedekar. *Bharatiya Sugar*, 1986, **11**, (9), 9 - 10, 12 - 13, 15 - 17.

Details are given of the computerized cane reception and accounting system introduced at Ugar Sugar Works Ltd. The success of the system is attributed to the closeness of its design to the previous manual system, the idea being to optimize with minimal changes. The software can be modified and made totally compatible with the cane accounting system of any sugar factory.

Acid boiling and periodical cleaning of evaporator brass tubes

S. Ramabrahman. *Bharatiya Sugar*, 1986, **11**, (9), 19 - 20.

While boiling with soda and HCl gave a soft scale which presented no problems in subsequent mechanical cleaning, the total process took more than 40 hours. By eliminating the soda boiling, cleaning took less than 20 hours using only HCl and Rodine 213 inhibitor, followed by brushing. Advantages of the new system are listed, and the savings in time and money calculated.

High sugar recovery – the performance of sugar factories in Andhra Pradesh

J. D. Chougule. *Bharatiya Sugar*, 1986, **11**, (9), 41 - 42, 45 - 46.

The performances of 31 factories in Andhra Pradesh from 1976 to 1984 are discussed.

Sugar loss from cane deterioration based on a factory scale test

C. C. Wang, L. C. Lee, W. H. Shih and W. H. Pan. *Taiwan Sugar*, 1986, **33**, (3), 8 - 12.

Cane deterioration in Taiwan has been determined by the iodine test for some years; the results of this give an indication of the fall in pol, which is closely related to rendement as expressed by ESG (equivalent sugar granulated). However, the decrease in true rendement at Kaohsiung factory was much greater than the ESG value; investigations revealed the discrepancy to be due to the presence of high levels of dextran. The implications of this are discussed, including the effect on calculation of the sugar share under a scheme operated by the Taiwan Sugar Corporation.

TSB back in full production

Anon. *S. African Sugar J.*, 1986, **70**, 267.

The damage by a major fire at the Malelane factory of Transvaalse Suikerkorporasie Beperk (TSB) is briefly described. The fire broke out during the non-crop period in a bagasse shed, whence it spread rapidly along the conveyor to the No. 5 boiler house (the only exclusively bagasse fired boiler at the factory). Repairs, costing R2 million, had to be completed within 9 weeks so as to allow the next cane processing season to start on time.

The Indonesian sugar industry – an overview of its past and present

A. Goedhart. *Sugar y Azúcar*, 1986, **81**, (7/8), 99, 102 - 103, 106, 108, 121 - 122, 124.

A general account is presented of the Indonesian sugar industry, including its structure and organization, with mention of new sugar projects.

Factory research in Réunion

Anon. *Rpt. Centre d'Essai de Recherche et de Formation* (Réunion), 1985, 8 - 17 *(French)*.

A new sugar factory technology division was set up at the Centre in 1985; from operational and control data provided by the five sugar factories in Réunion a weekly bulletin is prepared using Multiplan software and sent to each factory together with a commentary on its performance during the previous week. With the creation of the new division, CERF is now an associated member of the SMRI in South Africa to which monthly composited molasses and sugar samples are sent for analysis; the results are communicated to each factory. Application of a scanner to crystal sizing is mentioned, and mathematical expressions are given for diameter, thickness and weight; correlations were established between the mean size of a crystal and its thickness and between the equivalent diameter and its weight. Comparison between continuous and batch centrifugals for *A*-massecuite showed that the former gave a higher pol sugar, a slightly larger crystal and a lower rate of dissolution but also a very much greater rate of crystal breakage. Modifications to high and low vacuum control and optimization of the amounts of bagacillo, flocculant, lime and sweetening-off water reduced the filter-cake pol substantially after abnormally high cake losses had occurred in the rotary filters; filter performance data are tabulated for each factory. Suggested modifications for the next season included: reducing the particle size of bagacillo used as filter aid, cutting the mud residence time in the clarifiers, increasing the bagacillo:mud ratio, raising the temperature of the bagacillo/mud mixture to 85°C, eliminating the recirculation tank below the filters and increasing the amount of sweetening-off water (but using care in its application). Installation of a vacuum crystallizer at one factory led to a level of *A*-massecuite exhaustion that was sufficient to allow complete elimination of *B*-massecuite boiling; a 5.9% average gain in crystal weight was achieved.

Improving combustion efficiency in bagasse-fired sugar factory boilers

A. J. Proctor and P. J. Kemp. *Sugar y Azúcar*, 1986, **81**, (7/8), 134, 136, 139.

The combustion efficiency of the bagasse furnace at Waialua Sugar Co. in Hawaii was initially raised by improving damper operation, preventing air leaks into the furnace where they could disrupt control of the fire, adjusting the bagasse blowers so as to provide uniform distribution in the fire box, and creating greater turbulence of air and bagasse in the grate zone. Further improvement in efficiency was achieved by adding a combustion catalyst and slag modifier to the bagasse.

Ash balance for pan boiling system

C. H. Chen and H. C. Tseng. *Rpt. Taiwan Sugar Research Inst.*, 1986, (112), 27 - 40 *(Chinese)*.

The ash content and purity of 33 samples of massecuite and of the corresponding sugar and molasses were determined and an empirical equation was obtained from the results for calculating ash distribution between sugar and molasses; use of the equation permits estimation of the ash balance for various boiling systems using a simulation technique. Results show that about 80 - 90% of the total ash was removed in the boiling house and that raw sugar ash could be reduced by 32% using a suitable boiling scheme.

Continuous centrifugal screen evaluation

P. L. M. Vermeulen, C. Mack and R. Ramphal. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 47 - 51.

Historically, the conventional screen used on *B*-centrifugals has an open area of 10% and a slot width of 0.09 mm, while that on *C*-machines has 7% open area and a slot 0.06 mm wide. However, after a screen with 12% open area and a slot width of 0.06 mm was found to give greater throughputs, such screens were fitted to all the *B*- and *C*-centrifugals at Umzimkulu. Comparative tests were conducted on screens with 7%, 10%, 12% and 14% open areas fitted in Western States continuous centrifugals; the screen data and slot arrangements are given for each of four series of tests and the results tabulated. It was confirmed that increase in the open area up to 12% raises throughput and reduces molasses purity, whereas with a 14% open area there was a marked fall in throughput as a result of severe blinding of the screen and molasses purity was slightly higher than with 7% open area. The average life of screens with 12% open area during the 1985 crushing season was 10 weeks on *C*-massecuite and 6 weeks on *B*-massecuite.

Beet sugar manufacture

Increasing the adsorption of non-sugars during sucrose extraction from beet cossettes

O. V. Moroz, A. A. Lipets and D. L. Korilkevich. *Sakhar. Prom.*, 1986, (8), 20 - 23 *(Russian).*

Calcium bisulphite effectively controls aerobic thermophiles and mesophiles in raw juice and, by reducing protopectin hydrolysis, improves the quality of juice obtained in diffusion. The bisulphite can be formed by reaction between press water (limed to pH 11.5) and condenser water (adjusted to pH 5.8 - 5.9 with sulphurous acid) according to a method developed and tested by the authors. The two waters are mixed together in a ratio of 1:3 press water : condenser water. Reducing matter in purified juice was reduced by 50% and the colloids by 22.5 - 30.0% compared with the previous campaign without treatment, while 1st carbonatation mud settled better and the thermal stability of juice was improved in evaporation.

The use of FPAKM filter-presses for 1st carbonatation mud filtration

V. A. Bondarenko *et al. Sakhar. Prom.*, 1986, (8), 25- 28 *(Russian).*

The performance of a battery of three FPAKM-25 automatic filter-presses in trials at Yagotin factory is discussed. Mud from filter-thickeners having a density of 1.15 - 1.25 g/cm^3 was filtered for 3 minutes, then sweetened-off with 100% water on mud for 1.3 - 1.8 minutes and dried with compressed air for 2 min. Sugar losses were 0.07 - 0.10% on beet. In operation under normal factory conditions, mud was filtered for 30 - 45 seconds, washed for 60 - 90 seconds and dried to 35 - 40% moisture in 90 sec; the complete cycle, including auxiliary operations, took 5.5. - 6.0 min. Sugar losses were 0.5 - 1.5% on mud.

Optimization of the operation of automatic centrifugals on *A*-massecuite

V. G. Andreev *et al. Sakhar. Prom.*, 1986, (8), 30 - 33 *(Russian).*

With automatic centrifugals, no allowance is made in the program for variations in time to accord with massecuite properties that depart from the optimum, so that occasional changes have to be made to the program on the basis of the colour of the white sugar leaving the centrifugal; equally, there is no means of accurate fixing of the time at which washing of the sugar should commence, which is immediately after separation of the mother liquor. A system is described in which the molasses entering the monitor casing strikes an arm that forms part of a sensing element which also carries a plate; the force of the impact is directed via this plate to a transducer which transmits a signal to a recorder and manometer, thus allowing the washing operation to be optimized with benefits in the form of reduced water, heat and electricity consumption, lower losses and raised sugar quality.

UOEA device for automatic cleaning of pH meter electrodes

Yu. V. Goryainov, S. N. Gritskevich and K. A. Varfolomeeva. *Sakhar. Prom.*, 1986, (8), 33 - 35 *(Russian).*

An automatic electrode cleaning system is described in which lime salts deposit is removed by compressed air injection of 40 - 120 ml of 3.5% HCl solution for 2, 4 or 8 seconds at preset intervals. The system operated for 42 days without any problems in tests, and in trials with a pH-261 meter maintained the measuring accuracy within permitted limits of error.

Use of oil in limestone calcination

R. Ya. Gurevich *et al. Sakhar. Prom.*, 1986, (8), 35 - 37 *(Russian).*

Operation of a fully automatic oil-fired lime kiln over a period of two months demonstrated its reliability, with a gas CO_2 content of 26 - 28%; however, the use of oil as fuel has some disadvantages by comparison with solid fuel, including greater complexity of operation and less flexibility in adjustment to daily fluctuations in the factory slice. On the other hand, there are a number of advantages over coke firing, including a substantial saving in running costs.

Experience in the use of a SM 4000 mobile mixer tank at a beet reception station

G. A. Tovstenko *et al. Sakhar. Prom.*, 1986, (8), 43 - 44 *(Russian).*

The mixer tank described is designed for use in spraying piled beet with chemicals to inhibit sprouting, rotting, etc.

The processing value of different beet qualities

C. Heller. *Zuckerind.*, 1986, **111,** 739 - 741 *(German).*

The author discusses EEC regulation VO 2497/69 which currently applies to beet payment and which is based on a threshold of 16% sucrose content, with a 2.75% penalty or premium for contents below or above this. It is shown how the break-even point (price per 100 kg recoverable sugar) may be calculated for beets of varying quality, allowing better evaluation of the processing of different beet varieties and deliveries.

Pulp drying without use of primary energy but using only sugar factory waste heat and evaporation potentials

M. Kunz and P. Valentin. *Zuckerind.*, 1986, **111,** 741 - 750 *(German).*

Comparison of low-, medium- and high-temperature drying of beet pulp and of the use of superheated steam shows that the low-temperature process consumed most energy and superheated steam drying the smallest amount, while (independent of the specific consumption in each case) primary energy usage can be reduced only by use of vapour compression, waste heat utilization and multiple evaporation. An account is given of developments in two-stage drying over recent years, and a system is described for two-stage pressing, with concentration of the water from the 2nd stage by multiple evaporation and recycling of the concentrate to the 2nd stage. Embodiment of the two-stage concept in pulp drying is then described; the 1st stage is at a low temperature and uses waste heat from the boiler flue gases, pan vapours and condensate. Superheated steam used in the 2nd stage is derived from the turbogenerators, and the vapours from the pulp dryer are fed into the superheated steam network for utilization in factory processes. The effects of the proposed drying scheme on the requisite extended energy system of the factory and the fundamentals of superheated steam drying are examined.

Soil - a cost item to farmer and factory

N. Smith. *British Sugar Beet Review*, 1986, **54**, (3), 8 - 9.

During the period 1981/86, the amount of soil accompanying beet deliveries at the factories of British Sugar plc ranged from 826,000 to 1,255,000 tonnes; the costs involved in its separation and disposal are discussed. Maintenance of plant, including sixty 60-m diameter mud thickeners used for separation, currently costs £750,000 per year, while the amount of soil is so great that there is more than enough for local dumping as top soil, and disposal of the remainder incurs extra costs. Moreover, the soil presents a major problem in the form of pipeline and plant erosion. The beet grower is also faced with the costs of transporting the soil with the beets and the author points to the desirability of efficient use of suitable cleaner/loaders at the farm.

Beet data collection system

P. Leaton. *British Sugar Beet Review*, 1986, **54**, (3), 14 -16.

A description is given of the new computerized system for beet data collection at British Sugar factories based on the use of a Data General MP100 microprocessor. All the individual load weights and tarehouse data are supplied to the microprocessor together with grower/truck details, and the information sent to the computer in the factory office which transfers it to the mainframe computer at Peterborough (the British Sugar headquarters). Comparison is made between the new and old systems of beet data collection, and advantages of the new scheme are listed.

Colloids in products of beet sugar manufacture

V. A. Loseva and R. P. Lisitskaya. *Izv. Vuzov, Pishch. Tekh.*, 1986, (2), 21 - 23 *(Russian).*

Experiments showed that, in the range pH_{20} 3.5 - 6.0, the optimum for colloid coagulation was 5.0 - 5.2. This was confirmed by subsequent tests in which 2nd carbonatation juice purity was highest when the raw juice pH_{20} was adjusted to 5.2 by sulphitation followed by precarbonatation, addition of polyacrylamide flocculant and conventional purification.

Frictional properties of wet beet pulp

A. A. Romanov, V. I. Sentsov, Yu. D. Borisenko and G. A. Mkhitar'yants. *Izv. Vuzov, Pishch. Tekh.*, 1986, (2), 127 *(Abstract only).*

Frictional properties of pulp were determined in the form of static f_0 and dynamic f coefficients of external friction and the static coefficient of internal friction ψ_{sd}. Since values of ψ_{sd} are greater than those of f_o, it is necessary, when developing a screw press, to calculate the retaining capability of the channel from the static friction forces as characterized by the appropriate coefficients.

Probabilistic aspects of the hydrodynamics, heat transfer, recirculation and recrystallization in bulk crystallization of sugar

B. V. Kuz'menko, V. O. Shtangeev, I. S. Gulyi, V. A. Lagoda and S. I. Reznikov. *Vopr. Khimii i Khim. Tekhnologii*, 1986, (80), 7 - 12; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (16), Abs. 16 R464.

The interaction is examined between the hydrodynamics, heat transfer, recirculation and recrystallization, factors which affect the size distribution of sugar crystals in boiling and the basic indicators of their fractional composition. An equation is given for crystal growth and dissolution, and experimental data are presented for the dependence on time of the mean calculated temperature and supersaturation.

Conversion of proteinaceous substances during raw juice purification

V. A. Loseva and R. P. Lisitskaya. *Izv. Vuzov, Pishch. Tekh.*, 1986, (3), 27 -29 *(Russian).*

The quantitative change in proteins at the various stages of purification were studied; two schemes were followed: the conventional Soviet system and one involving addition of an optimum amount of ammonium sulphate, sodium sulphate or sodium sulphite to the raw juice (for pre-coagulation of non-sugars), preliming, liming with 0.05% CaO on juice and gassing to pH_{20} 7.0 - 7.2, followed by addition of 0.001% polyacrylamide on juice, after which the juice was treated by the conventional scheme. The proteins and their degradation products were determined by a photocolorimetric method based on the biuret reaction. Results, which are tabulated, showed that coagulation of high molecular compounds by the added salts reduced the protein content by 10 - 12% in preliming and by 8 - 10% in main liming by comparison with conventional purification; there was no difference in effect between the three salts. The total amount of protein removed in purification was 30 - 40% greater than that of protein degradation products.

Quality of the raw material and sugar yield

S. Swietlicki. *Gaz. Cukr.*, 1986, **94**, 49 - 52 *(Polish).*

The effect of beet quality on sugar recovery is discussed with reference to Polish conditions, and agronomic factors governing beet quality are examined, as well as beet storage conditions and duration.

Arrangement of heat management with Wielkopolski sugar factories as example

G. Kowalska. *Gaz. Cukr.*, 1986, **94**, 52 - 53 *(Polish)*.

The systems used in sugar factories in a major sugar-producing area of western Poland for utilization of steam and heat sources are discussed, including the positive role played by factory modernization in a country where a large number of the factories are old.

Tensometric measurement of the weight of coke and limestone at a sugar factory

J. Najmola and J. Wajs. *Gaz. Cukr.*, 1986, **94**, 54 - 59 *(Polish)*.

The principle on which strain gauges operate is explained and their application to level measurement and proportional feeding discussed. An automatic system for proportioning coke and limestone in a kiln is described.

Sugar factory waste water treatment in expanded-bed anaerobic reaction vessels

P. A. Garcia E. and F. Fernandez-Polanco. *Sucr. Franç.*, 1986, **127**, 251 - 255 *(French)*.

A laboratory-scale bottom-feed reaction vessel was used for up to 500 days to treat effluent of 6500 mg/litre average COD (3300 - 15,600 mg/litre) from a Spanish sugar factory at 33°C, with PVC particles of <0.6 mm diameter as support. Recirculation of some of the liquid from the top of the vessel was designed to expand the bed of untreated material by 20% of its initial volume. Average pH, suspended solids content and volatile solids content of the feed were 5.5 (4.9 - 6.7), 160 mg/litre (22 - 1300 mg/litre), and 120 mg/litre (21 - 560 mg/litre), respectively. Up to 93% COD conversion was achieved at a charge of 150 kg COD/m^3 per day and a residence time of 1 hour. A proportion of volatile solids to total solids of up to 91.4% in the granules of biomass formed was indicative of the absence of mineralization of $CaCO_3$, accumulation of which is one of the main problems in conventional anaerobic treatment of sugar factory effluent.

Vibratory analysis in predictive maintenance

J. Mabit. *Sucr. Franç.*, 1986, **127**, 257 - 259 *(French)*.

Predictive maintenance, as widely used in the aeronautical and nuclear industries, is designed to predict failures caused by wear and tear and to forestall them by monitoring operational parameters, analysing lubricants and measuring the level of vibrations and analysing the results. The application of vibratory analysis to diagnosis of machinery problems is described in general terms and with reference to turbines.

Influence of certain conditions in diffusion on pulp pressability

A. Carrière, P. Mottard and G. Rousseau. *Ind. Alim. Agric.*, 1986, **103**, 629 - 637 *(French)*.

Currently 45 French sugar factories add calcium sulphate in diffusion so as to improve pulp pressing. Investigations of ion distribution in diffusion showed almost total extraction of K^+ and Na^+ ions from the cossettes, while studies in the UK have shown that 27% of the Ca in cossettes entered the juice. SO_4^{--} ions are readily soluble, and 65% of the total sulphate in cossettes and added $CaSO_4$ was found in the juice. While the sulphate content (ppm) in pulp remained almost constant with change in the dry solids content, it fell sharply when expressed as % dry solids, confirming its marked presence in the liquid phase. $CaSO_4$ was a major source of Ca but less so than the cossettes. Very good correlation was found between the dry solids content of exhausted cossettes, the dry solids content of pressed pulp and pulp dry solids % beet. The prescalding temperature did not appear to affect the dry solids content of exhausted cossettes but did slightly favour the pressed pulp dry solids content. Trials with hard water or ammoniacal water acidified to pH 6 using sulphuric acid showed that the time of contact of calcium sulphate affected neither juice quality nor pulp dry solids; however, non-acidified ammoniacal water tests indicated a positive effect of the time of contact: an increase from 19% to 22% dry solids with increase from 5 to 60 min for 2000 ppm $CaSO_4$. The overall results indicated the probability of major competition between H^+, K^+, NH_4^+ and Ca^{++} ions and hence the need to establish optimum conditions for pressing in regard to these components. Biospumex 284 non-ionic surfactant added to diffusion at 15 ppm failed to have any positive effect on pulp dry solids content, although it increased press throughput.

Investigations of corrosion at the screen perforations in batch sugar centrifugal baskets

G. Schneider. *Zuckerind.*, 1986, **111**, 829 - 837 *(German)*.

Fatigue tests on corroded sections taken from centrifugal baskets are reported and a number of photomicrographs reproduced. The results of the investigations and of laboratory tests (using molasses and water from a sugar factory pit) on four different materials commonly used in the manufacture of baskets are discussed. Results indicated that the corrosion was associated with the formation of cracks at the perforations after a number of operational cycles and with defects in the form of ridges produced when the perforations were drilled during basket manufacture. The effect of massecuite as a cause of corrosion was found to be negligible, even where ion exchange processes had been used for juice treatment (earlier suggested as a major cause of corrosion); evidence of the unimportance of massecuite in this regard is the long life of centrifugal baskets in a factory where refining is also carried out.

Sugar refining

Electrostatic methods to separate bone char from granular carbon: preliminary report

M. A. Godshall, L. C. Weiss, M. A. Clarke and G. Perret. *Proc. 1984 Sugar Processing Research Conf.*, 266 - 283.

Because of differences in the properties of the two adsorbents, granular carbon is lost at a greater rate than bone char in mixtures of the two during service and regeneration, and separation of the two is needed so as to determine the loss and hence how much carbon must be added to make up to the required proportion. The water separation procedure currently used has some problems, particularly carry-over of one adsorbent into the other because of overlap of bulk density and particle size (the major factors contributing to separation). However, because of differences in the chemical composition of the two components, a difference in electrical properties may also be assumed, and attempts to separate mixtures into their component parts in an electric field are reported. Two techniques were tested: use in an A.C. field of an electric grid covered with a dielectric sheet especially developed by Masuda & Matsumoto for electrodynamic control of charged dust particles[1], and separation in a D.C. field using various configurations of electrodes. The A.C. system proved promising, with carbon being largely ejected from the electric panel and bone char remaining on it, although particle size and char composition complicated the separation. The D.C. method, using a stainless steel ball electrode suspended over a bowl-shaped electrode with a hole in the centre leading to a trap, also gave promising results, with the amount of bone char entering the trap being governed by particle size and voltage. Because of the effect of particle size on both methods, preliminary sieving is recommended.

Procedure for calculating the technological conditions for raw sugar processing

R. Ts. Mishchuk and V. A. Shul'ga. *Sakhar. Prom.*, 1986, (8), 23 - 25 *(Russian)*.

A method is described for calculating the molasses yield from a 3-strike scheme based on recycle of up to 80% of the *B*-massecuite to the *B*-pan and preferable use of high *A*-massecuite purity (e.g. 98.55).

Energy economies in the refinery by utilizing and/or recompressing vapours from continuous boiling linked with high- vacuum continuous crystallizers

J. Cuel. *Ind. Alim. Agric.*, 1986, **103**, 669 - 675 *(French)*.

At Nantes, the temperature of standard liquor is raised by vapour at 0.35 bar abs from a continuous *A*-pan (installed in 1980/82 to replace *A*- and *B*-pans) in a plate heat exchanger followed by concentration from 65/66° to 72.5°Bx in a flash tank operating at a vacuum of 680/700 mm Hg. Light syrup off char is heated in another plate heat exchanger with vapour at 1.35 bar and is then concentrated with *A*-pan vapour at 0.35 bar in a flash tank. The vapour from the light syrup flash tank together with that from the *A*-pan that is not used for standard liquor concentration is fed to a stato-compressor from which the compressed vapour at 1.3 bar and 106°C saturated temperature (after desuperheating) is recycled to the light syrup heat exchanger and the *A*-pan. Two continuous vacuum crystallizers are also incorporated in the new scheme. The patented stato-compressor used is a multi-tube ejector in which the supersonic steam jet generated is so controlled that there is no energy loss from shock waves; to achieve this, the mixing section is provided with a screw-controlled variable-geometry neck. Calculations show that the new scheme consumes only 25% of the steam requirement in a highly efficient refinery operating with a conventional 3-strike system.

Automation of a process for raw sugar remelt liquor preparation

A. A. Kutateladze and V. V. Kovalenko. *Sakhar. Prom.*, 1986, (10), 31 - 33 *(Russian)*.

Details are given of a system for raw sugar remelting in two tanks in series at a sugar factory refining raws; level, temperature and Brix are automatically controlled.

Calculation of yield in cane raw sugar refining

E. Gutknecht. *Lebensmittelind.*, 1986, **33**, 223 - 224, 228 *(German)*.

Various formulae for calculating white sugar yield and molasses sugar are reviewed. A modified form of the Lyle formula, the s-j-m formula and that of Cecil give the same results provided the ideal molasses purity of Lyle is used; however, the value is considered too low for East German conditions. The s-j-m formula is very easy to use but bases molasses formation only on the non-sucrose content in the raw sugar and requires the use of true purity. A formula for calculating the "refining value" (RV) of cane raw sugar includes both the non-sucrose content of the sugar before refining and some of that formed during refining; it takes the form

$$RV = 100 \{S_{crs} - [(NS_{crs} + V/2)\, p_m/(100 - p_m)]\} /S_{crs} - V$$

where S_{crs} and NS_{crs} = sucrose and non-sucrose contents in cane raw sugar, respectively, V = refining losses and p_m = molasses purity.

Cane sugar production systems: current and future

M. A. Clarke. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 1 - 4.

Changes in the sugar market in 1970/85 and the direct production of high-grade white sugar from cane juice are discussed and systems for its manufacture listed. The Blanco Directo process and deep bed filtration are briefly described and reference is made to the significance of the back-end refinery. Also mentioned are syrup clarification and direct-consumption brown sugars. Future developments are examined.

1 *Dechema-Monographien*, 1974, **72**, 3 - 11.

Laboratory studies

The chemistry of iron in the sugar refinery

R. Riffer. *Proc. 1984 Sugar Processing Research Conf.*, 231 - 251.

Investigations on iron contamination of soft sugar are reported. Iron may enter a product in contact with metal surfaces, while liquors can readily pick up iron during treatment with bone char. Iron accelerates darkening of liquors and sugars, acting as an oxygen carrier for autoxidation while also affecting soft sugar appearance and flavour as well as liquor viscosity. While iron was eliminated from a soft sugar liquor sample by a chelating resin, iron was rapidly acquired from char, apparently because of the high affinity of complexing groups in the non-sugars for iron. The formation of inorganic and organic complexes of iron is examined, and the crucial role played by phosphate is discussed — it acts as antoxidant by complexing iron, but also appears to convert iron complexes to polyvalent forms that are more readily removable by adsorbents; however, low levels of phosphate are desirable in liquors to be treated by char and perhaps by anionic resin because polyvalent anions inhibit decolorization. Soft sugar components that could cause darkening are considered, particularly phenols, and the effects of certain additives on colour development described. A number of methods were tested in the laboratory for iron removal, including the use of chelating and ion exchange resins, addition of phosphate, adjustment of pH to 8 (which allows much of the iron to be removed as hydroxide in filtration, but also leads to the rapid generation of new colour) and the use of immobilized phosvitin (a phosphate-rich egg yolk protein used as adsorbent;) mention is also made of recent work on *Aquaspirillum magnetotacticum* which takes iron in solution and concentrates it as magnetite inside its cell wall. Excellent removal of iron by phosvitin was reported, even when tested on liquors of high iron content; the performance of the adsorbent was enhanced by acid treatment before use, because of the very high iron content of the protein. Methods for determining iron are described.

Analytical methods of measurement — a need for correspondence

S. A. Brooks and R. A. M. Pilgrim. *Proc. 1984 Sugar Processing Research Conf.*, 252 - 265.

While the sensitivity of analytical instruments is constantly improving, the diversity of analytical methods necessitates ensuring that samples are prepared so that all methods of analysis monitor the same parameter. The importance of pretreatment of samples before atomic absorption of clarified juice and evaporator syrup for calcium determination is discussed; while atomic absorption had given results that indicated large quantities of Ca in the samples, only a slight calcium deposit formed on the evaporator tubes. Five methods of analysis were therefore carried out in addition to the standard EDTA titration method: ashing, preparation of Ca oxalate and permanganate titration, ion-selective analysis and oxalate precipitation followed by atomic absorption. Tabulated results for 21 samples showed that the values obtained by some of the methods (particularly ion-selective analysis of juices and atomic absorption of unashed syrup) differed significantly from those given by the standard EDTA method, although the data failed to show any correlation that deviated significantly from unity; however, the sample sizes were small, and similar correlations for 50 - 100 observations would show significant deviation. Values given by the oxalate precipitation/atomic absorption method showed no significant difference from the EDTA values for juice or syrup, while atomic absorption of ashed samples showed no significant differences for juice. The effectiveness of using ion-selective analysis for untreated samples as a rapid method of Ca determination in syrup was demonstrated.

Colour tests and other indicators of raw sugar refining characteristics

M. A. Clarke, R. S. Blanco and M. A. Godshall. *Proc. 1984 Sugar Processing Research Conf.*, 284 - 302.

The series of analyses for cane juice colour developed by Smith & Gregory[1] has been modified and some additions made to it for application to raw sugar for evaluation of its refining properties. The tests were devised to give as much information as possible rapidly and simply and included determination of phenols (based on the molybdotungstate reaction and precipitation with 80% ethanol rather than sulphanilic acid and precipitation with 50% methanol), amino-N components, alcohol-precipitable material, colour at different pH values and iron (using the bathophenanthroline spectrophotometric method), although it was felt that the information obtained for a wide range of sugars and refining processes did not compensate for the time spent on iron analysis, although this is recommended where ion exchange resins are used. Total polysaccharides, invert sugar and ash were also determined. Details are given of the methods used, and tabulated results are discussed for 10 samples. The tests can be performed on a routine basis in 90 min and provide an indication of decolorization behaviour but are not intended to be an accurate analytical system. The predictions based on the tests were correct in 80% of the cases.

Application of GC analysis in the South African sugar industry

P. G. Morel du Boil. *Proc. 1984 Sugar Processing Research Conf.*, 303 - 315.

Application of gas chromatography to determination of boiling house recovery, compilation of factory balances and calculation of undetermined losses, evaluation of molasses exhaustion, calculation of molasses payment, etc. is described and some typical results obtained are discussed. (See also Schäffler & Morel du Boil: *I.S.J.*, 1985, **87**, 10A.)

A comparison of GLC and HPLC for the determination of sugars in final molasses

1 *Proc. ISSCT*, 1971, 1415 - 1425.

T. A. Chorn and A. Hugo. *Proc. 1984 Sugar Processing Research Conf.*, 331 - 349.

Comparison between GLC and HPLC for sucrose determination in cane mixed juice and final molasses showed that the latter technique gave higher values than the former in all cases, from which it was assumed that HPLC included other components with the sucrose peak. Reasons for the poor correlation between the two sets of data are given as: (1) inadequate resolution, which may be increased by transforming the components of interest by precolumn derivatization, although this would lead to greater complexity; (2) the influence of inorganic salts which may be removed by precolumn deionization; (3) the removal of insoluble solids by sample filtration before HPLC, while GLC requires no such sample pretreatment; the concentrating effect brought about by removal of the insolubles can be avoided by including an internal standard in the sample before filtration; (4) high colour of the sample where a differential refractive index detector is used with HPLC; decolorization with an appropriate resin before chromatography is advocated; and (5) the concentration of sugars in the mixed juice samples injected into the HPLC column where this exceeds 1.5% in 10 μlitres; this effect is attributed, at least in part, to a combined increase in colour, insoluble solids and inorganic salts. By adopting the various modifications mentioned, very good agreement was obtained for molasses sucrose, with a correlation coefficient of 0.99995; however, the fructose and glucose contents found by HPLC were below the GLC values. While it is difficult to prove which method gave the more accurate results, the authors' opinion is that HPLC underestimated the sugars. The importance of the temperature stability of the refractive index detector used in HPLC is mentioned; while stabilization was difficult, a better detector is probably available on the market.

Symposium on high-performance liquid chromatography in the sugar industry: a different aspect of high-performance liquid chromatography

A. M. Ho. *Proc. 1984 Sugar Processing Research Conf.*, 350 - 362.

After describing a basic HPLC system, the author discusses results of tests to determine the precision of the system used at Redpath Sugars Ltd. and the accuracy of sucrose, glucose and fructose analysis in an artificial syrup; comparison with the Lane & Eynon titration method for reducing sugars showed that HPLC gave a higher invert content, but the number of samples was small. The possibility of using HPLC as on-line process control means in the manufacture of invert syrup by acid hydrolysis of sucrose is discussed; since very rapid analysis is required (the results being passed directly to a process control computer), a unit such as a fast carbohydrates analysis column available on the market and capable of giving a result within 4 minutes is considered suitable. A system of valves for sample transfer to the HPLC system and the sequence of activation are described.

Symposium on high-performance liquid chromatography

R. F. Hutton. *Proc. 1984 Sugar Processing Research Conf.*, 363 - 378.

Possible applications of large-scale preparative chromatography (which is compared with analytical chromatography) are discussed, with mention of various aspects including packed beds, the positive effect of recycling on separation efficiency, and use of a refractive index detector. A pulsed amperometric detector for sugars is also mentioned.

Swelling of cation exchange resins in aqueous sucrose solutions

A. A. Ivanyuk, S. P. Vycherova and M. I. Barabanov. *Izv. Vuzov, Pishch. Tekh.*, 1986, (2), 23 - 26 *(Russian)*.

Tests showed that swelling of macroporous KU-23 cation exchange resin in both water and sucrose solutions was considerably greater than that of gel-type KU-2-8 in Mg^{++}, Ca^{++}, NH_4^+, H^+, and K^+ form, while the reverse was true for the resins in Na^+ form. Delay caused by sucrose in the evolution of heat in an almost saturated solution when dewatered resin was wetted was associated with unavailability of opposite-charged ions and active groups for solvation by sucrose hydrates. Since KU-2-8 has a greater exchange capacity per unit volume in a swollen state, it is preferred for factory processes.

Colouring matter inclusions in sucrose crystals

G. Mantovani, G. Vaccari, G. Sgualdino, D. Aquilano and M. Rubbo. *Ind. Sacc. Ital.*, 1986, **79**, 99 - 107 *(Italian, English)*.

Single crystals were grown in dilute beet and cane molasses, of 1.1 non-sugar:water ratios, in sealed glass vessels rotated at 5 rpm on a constant-temperature water bath at 60°C so that the crystals were able to fall freely as they grew. A stereoscopic microscope equipped with a camera was used to examine the crystals after they had been wiped with soft filter paper; colour photomicrographs are reproduced to demonstrate colouring matter inclusion at the different faces. In the cases of beet molasses, the p' faces were the first to be affected, followed by the d, c, r, and o faces as the growth kinetics increased; growing the crystals alternately at high and low supersaturation caused the occurrence of a sequence of coloured and colourless zones. The d, c and r faces were the first to be affected by colour inclusion in the case of crystals grown in cane molasses, while increase in supersaturation led to involvement of the p' faces. Again, alternate high and low supersaturation caused coloured and practically colourless zones. The rates of growth of the different faces are thought to be the most probable factor in colorant inclusion. (See also Mantovani *et al.*: *I.S.J.*, 1986, **88**, 84A.)

By-products

Agronomic values of filter mud and fly ash

D. I. T. Walker. *Proc. 3rd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1985, 4 pp.

The nutrient value of filter cake lies mainly in its phosphate content; it contains very little K and much of the N is unfavourable because of a high C:N ratio when the cake is fresh and becomes available only once the fibrous material has broken down. The nutrient composition of fly ash (based on analyses conducted in Australia) consists of significant quantities of K_2O and some phosphate, while N may be present at a useful level; however, crop responses to fly ash, although they have not been measured, are thought unlikely to be satisfactory. There is very little information on cane response to filter cake in Barbados, but the author uses the data obtained by Cooper & Idris[1] for Trinidad to show how application of 10 tonnes/acre of filter cake lightly incorporated in the furrow gave a higher yield response than triple superphosphate applied at an equivalent level of P.

The handling of filter cake and fly ash in the factories and some other options

M. Biddlestone. *Proc. 3rd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1985, 5 pp.

The filter cake from all six factories in Barbados is transported by truck for agricultural use, while at only two factories is the fly ash removed from the furnaces as a slurry and then transported to disposal sites after dewatering. The system used at Portvale for fly ash treatment is cumbersome, and a single-stage dewatering scheme would be of benefit; the possibility of combining dewatered ash with filter cake is suggested. Continuous in-line weighing of filter cake at all the factories would also be of advantage to both farmers and processors.

Utilization of light impurities of beet at Lokhvitskii sugar factory

V. E. Lanin *et al. Sakhar. Prom.*, 1986, (8), 47 - 49 *(Russian)*.

Details are given of the system used for separation of beet leaf trash, etc. which is then ground and transferred to the pressed pulp conveyor for eventual use as cattle fodder.

The feed and nutrient values of beet leaves

U. Beiss. *Die Zuckerrübe*, 1986, **35**, 254 - 256 *(German)*.

The value of beet leaves as fodder for ruminants or as K and N fertilizer is discussed.

Prospects of sugar cane by-products in Indonesia

M. Mochtar, K. Halim and T. Sudijanto. *Gula Indonesia*, 1986, **12**, (2), 49 - 51, 59 - 62, 64 - 73.

Cane by-products utilization is discussed in general and then with particular reference to Indonesia, including details of some feasibility studies.

Feeding for productive ewes

G. Macleod. *British Sugar Beet Rev.*, 1986, **54**, (3), 26 - 27.

Advice is given on the feeding of molassed beet pulp to breeding ewes. Incorporation of the pulp in rations before grass growth is adequate has been shown to increase the weight of twin lambs by 1.5 - 2.0 kg at weaning.

Possibilities of using enzymes of the fungus *Penicillium roqueforti* in the fermentation of molasses wort for yeast production

J. Kwasnik. *Pr. Nauk. AE Wroclaw.*, 1985, (291), 121 - 124; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (16), Abs. 16 R396.

Results are reported of investigations on the use of enzymes, produced by *P. roqueforti*, in alcoholic fermentation of molasses and yeast growth. It was found that α-galactosidase contained in the mixture of enzymes allows only 50% cleavage of raffinose (1% solution) to sucrose and glucose. Because of this low hydrolysis efficiency and the prolonged hydrolysis time (approx. 5 hours), the enzymes indicated are not suitable for supplementary treatment of molasses.

Sugar cane press mud: a potential source of phytosterols, fatty alcohols, fatty acids and hard wax

B. K. Gupta, G. K. Gupta, J. L. Suri and C. K. Atal. *Res. and Ind.*, 1985, **30**, (2), 95 - 101; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (16), Abs. 16 R471.

A method has been developed for filter cake treatment with the aim of obtaining the title products. The chemical composition of filter cake samples from different sugar factories in the Punjab is discussed. Both soft and hard waxes and their mixtures have been isolated from filter cake and their physico-chemical constants determined. Saponification and subsequent separation using a solvent yielded sterols, fatty alcohols and fatty acids. Of the solvents used (diethyl ether, benzene, chloro- and dichloroethane), dichloroethane proved the best. It is shown that soft and hard wax should be isolated from filter cake separately. Saponification should be applied only to soft wax and then in a heterogeneous phase. Demineralization causes a 40 - 50% fall in filter cake mass and accumulation of the wax.

Prognosis of the quality of molasses as raw material for citric acid production

E. S. Mints and L. N. Mushnikova. *Povysh. Effektiv. Pr-va Pishch. Kislot*, 1985, 37 - 44; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (22), Abs. 22 R377.

Prediction of the quality of molasses for citric acid production by various methods (physico-chemical, microbial and biochemical) is reviewed and comparative evaluation made of the methods developed.

1 *Proc. 17th Congr. ISSCT*, 1980, 220.

Patents

UNITED STATES

Organosolv saccharification of bagasse

L. Paszner and P. C. Chang. **4,470,851.** February 9, 1982; September 11, 1984.

Bagasse is hydrolysed at 145 - 230°C with an aqueous acetone solvent mixture containing a small amount of an acid (0.1 - 0.001N sulphuric or hydrochloric acid) at <2% (<1%) by weight of the mixture, which is of >70% (80 - 90%) concentration. The cellulosic material is dissolved by this means and at least 90% of the available sugar recovered. The acetone forms stable complexes with the sugars and thus prevents their degradation while also facilitating their separation.

Histidine production

K. Araki and T. Kuga, *assrs.* Kyowa Hakko Kogyo Co. Ltd. **4,495,283.** April 7, 1983; January 22, 1985.

L-Histidine is produced by cultivation of a micro-organism belonging to the *Corynebacterium* or *Brevibacterium* genus (e.g. *C. glutamicum*) on a medium containing a suitable carbon source (fructose, glucose, sucrose, molasses, starch hydrolysate, etc.) at 20 - 40°C for 1 - 8 days.

Saccharide fatty acid ester for prevention or treatment of bloat in ruminants

R. Kawashima, A. Usagawa and T. Masuda, *assrs.* Mitsui Toatsu Chemicals Inc. **4,496,547.** December 20, 1982; January 29, 1985.

A fatty acid ester of a disaccharide such as sucrose in a mixture with a fatty acid salt in a weight ratio between 90:10 and 10:90 (3 - 97% sucrose ester and 97 - 3% fatty acid salt) prevents or treats bloat in ruminants caused by ingesting large quantities of legume pasture or feed concentrate.

High-fructose syrup

K. W. R. Schoenrock, T. H. Henscheid and H. G. Rounds, *assrs.* Amalgamated Sugar Co. **4,501,814.** July 21, 1980; February 26, 1985.

A high-fructose syrup is produced by liquefaction of starch with alpha-amylase and subsequent saccharification with soluble glucoamylase to a DE of 50 - 70 followed by removal of undissolved solids and treatment with soluble or immobilized glucoamylase to DE 90. After adjustment of the pH to 8.0 - 8.5, possibly using MgO, the syrup is isomerized with glucose isomerase. Ion exchange may also be used to remove the impurities from the hydrolysate, and saccharification carried out to a DE greater than 95.

Corn syrup purification with active carbon

J. E. Urbanic, of Pittsburgh, PA, USA, *assr.* Calgon Carbon Corp. **4,502,890.** November 8, 1982; March 5, 1985.

Active carbon having an iodine number of at least 1200 (at least 1400) and an average carbon size of 0.4 - 4.0 mm is used to decolorize and purify a starch hydrolysate containing 97% dextrose plus maltose, maltotriose and higher saccharides at a flow rate through the column of 20.8 ml/min, equivalent to a contact time of approx. 30 min. The treatment yields a syrup containing e.g. 98.5% dextrose and 1.5% maltose at 20 - 25 (45 - 50) g/g active carbon.

Increasing glucose isomerase production

B. E. Whitted and G. Boguslawski, of Elkhart, IN, USA, *assrs.* Miles Laboratories Inc. **4,510,247.** February 9, 1983; April 9, 1985.

The production of glucose isomerase is increased by a bacterium *(Flavobacterium arborescens* or *Escherichia coli)* which is grown at pH 7 and 30°C in an aqueous nutrient medium containing 0.1% glucose oxime and 0.2% of a carbon source other than glucose, e.g. xylose, arabinose or lactose.

High-glucose syrup production

R. P. Rohrbach, M. J. Maliarik and T. P. Malloy, *assrs.* UOP Inc. **4,511,654.** May 31, 1983; April 16, 1985.

A syrup containing 94% (97.6%) glucose is obtained from a feedstock [e.g. starch of low DE (5 - 25) pretreated with alpha-amylase] by treatment with immobilized amyloglucosidase or beta-amylase at 45 - 70°C, 1 - 1000 psi, a residence time ranging from approx. 4 min to 1.6 hr and a liquid hourly space velocity of 2 - 50; the contact time is adjusted by correlation between the last two parameters, and conversion is 50 - 85%. The partially hydrolysed mixture from the enzymatic treatment is passed through an ultrafiltration membrane and the permeate of high glucose content recovered, while the residual material is recycled to be mixed with partially hydrolysed mixture or for further enzymatic treatment.

Alcoholic fermentation

N. Y. Chen and J. N. Miale, *assrs.* Mobil Oil Corporation. **4,515,892.** October 28, 1983; May 7, 1985.

During fermentation of a sugar as obtained from sugar cane, the level of alcohol is maintained at a preset maximum of 2% (5%) by weight of solution (above which the fermentation process is inhibited) by intermittent or continuous withdrawal for adsorption on a resin in the form of a hydrophobic crystalline aluminosilicate zeolite having a silica:aluminium ratio greater than 12 (50 -100) and a constraint index of 1 - 12. The ethanol is desorbed by stripping with a carrier gas and is then brought into contact with a dehydration catalyst to provide water and an aliphatic organic intermediate product comprising olefins. The water is separated and the product then treated with adsorbent as above to yield gasoline boiling range products and by-product gas which may be used for the desorption stage.

Semi-crystalline fructose

C. E. Schollmeier, of Decatur, IL, USA, *assr.* A. E. Staley Manufacturing Co.

4,517,021. October 28, 1983; May 14, 1985.

A free-flowing, semi-crystalline fructose product of <2% moisture content and containing >60% (>75%) by weight crystalline fructose and <25% (<35%) amorphous fructose is obtained by mixing an aqueous fructose syrup [containing preferably 60 - 93% (70 - 80%) (85 - 91%) by weight of a saccharide, of which approx. 85 - 100% (88 - 95%) by weight is fructose, 2 - 8% glucose and 2 - 8% polysaccharides] with a crystallization initiator in a weight ratio to the syrup of 5:1 - 40:1 (7:1 - 15:1) (10:1); this initiator is a free-flowing, particulate solid capable of absorbing the syrup and both inducing crystallization in the metastable phase and serving as carrier for the fructose to allow crystallization and drying. Since it is intimately mixed with the syrup and becomes part of the solid product, it should be edible and pleasant to taste; while most starches and sugars are suitable, a fructose solid, preferably containing >85% fructose by weight and > 60% crystalline fructose, is more suitable, especially since it is convenient to recycle some of the final product as initiator. The mixture is brought into contact with air at an initial 50 - 80°C and a final relative humidity of <20% for 12 - 48 (15 - 24) hours.

Alcoholic fermentation

D. W. Tedder, of Marietta, GA, USA, *assr.* Georgia Tech. Research Corporation. **4,517,298.** September 21, 1983; May 14, 1985.

For production of ethanol or butanol, a feedstock such as beet, cane or molasses is continuously fermented with a suitable micro-organism (a *Candida* sp., *Saccharomyces* sp., thermophilic bacterium, etc.) in water. The liquor is continuously withdrawn for extraction from it of a low-level alcohol using an organic extractant capable of hydrogen bonding with water or alcohol, e.g. an alkyl or aromatic alcohol, a carboxylic acid or an ether, but preferably a mixed isomer of tridecanol, and a chemically stable hydrophobic solvent, e.g. an aliphatic hydrocarbon such as dodecane, kerosene, gasoline or diisopropylbenzene, that is completely miscible with the extractant. The alcohol is subsequently separated from the solvent by conventional distillation or evaporation.

Seed sugar production

P. W. van der Poel, of Prinsenbeek, Holland, *assr.* CSM Suiker BV. **4,518,436.** September 13, 1983; May 21, 1985.

Seed crystals are produced by cooling in a pan provided with a stirrer (but having no heat element). A concentrated sugar solution is brought to 1.12 - 1.20 (1.16) supersaturation, at which point a suspension is added at 1.8 - 2.2% by volume of the total feed; this suspension comprises milled sugar of 8 - 12 (5 - 20) µm in isopropanol. The feed is then cooled from 75 - 100°C (82 - 87°C) (85°C) to 75 - 85°C at a rate of 0.4 - 1.0°C (0.6°C) per min during 10 - 30 (17 - 25) min at 60 - 80 centibar pressure. The pan feed is mixed by means of a circulation pump in a circuit which also includes a heat exchanger. When the seed crystals have grown to 100 µm the unsaturated solution is discharged to the heat exchanger for dissolution of fines by steam and is reintroduced into the pan for growing to 200 µm, the supersaturation being maintained at 1.12 - 1.20 by pressure and temperature adjustment. In trials, the process yielded grain having an average size of 0.64 mm as against 0.58 mm in conventional seed boiling, a conglomerates content of 13.7% compared with 81.8% and an ash content of 0.007% against 0.0118%.

Glutamic acid production

M. Yoshimura, Y. Koyama, K. Goto, S. Inoue, S. Ikeda and H. Yoshii, *assrs.* Ajinomoto Co. Inc. **4,529,697.** March 15, 1983; July 16, 1985.

L-Glumatic acid is produced by aerobic fermentation of a suitable carbon source, e.g. glucose, sucrose, cane molasses or starch hydrolysate, with a micro-organism such as *Brevibacterium lactofermentum*, *B. flavum*, *Corynebacterium glutamicum* or *C. acetoacidophilum* at 30 - 38°C and pH 6 - 8 for 20 - 80 hr. A glutamic acid yield of 52.5% was obtained from cane molasses after 36 hours' cultivation of strain AJ 11796 of *B. lactofermentum* at 31.5°C and pH 6.5 - 8.0.

Sucrose recovery from molasses

R. W. Neuzil and R. L. Fergin, *assrs.* UOP Inc. **4,533,398.** October 24, 1983; August 6, 1985.

Sucrose is separated from betaine and mineral salts, particularly KCl, and recovered from beet or cane molasses by adsorption on activated granular carbon in a countercurrent moving bed or simulated moving bed at 20 - 200°C (20 - 100°C) and a pressure in the range from atmospheric to approx. 500 psig (atmospheric - 250 psig). The sucrose is then desorbed with an aqueous alcohol solution of 10 - 70% concentration by volume, and the desorbent flushed from the carbon with water before treatment of further molasses.

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press water. Diffusion losses, under Hungarian conditions, are reduced by more than 0.1% by recycling of more than 60% of press water; 75% is recovered in white sugar yield and 25% in molasses.

Removal of colouring matter in the sugar house by adsorption with calcium carbonate (E. Bara-Anyos, K. Vukov and K. Hangyál)

Formation of colour at the sugar end has been examined. It can be stated that the amount of colouring matter increases about threefold and that of colour bodies of high molecular weight increases fivefold during process at the sugar end. With regard to the fact that colour bodies of high molecular weight are mainly included in the crystal, a procedure was sought by which their quantity can be lowered efficiently. The lime-carbonic acid process is such a method, whereby the colour of solutions is reduced by 60 - 70% and about 95% of the colour removed is of high molecular weight. Applying this colour removal process to affined after-product sugar - raw sugar syrups, the purified syrups are, in respect of their colour, at least of the quality of intermediate product sugar syrups, and in this way can be added directly to first product boiling even when processing thick juices of low quality (purity < 90).

PROCESS TECHNOLOGY

Sugar crystallization from beet juices and molasses using the hydrate freezing process*

By Patrick J. Wrobel and James A. Heist
(Heist Engineering Corporation, Wilmington, NC, USA)

Introduction

Freeze crystallization processes are described elsewhere[1] and offer great design flexibility to meet varying application needs. The process under study for eutectic crystallization of beet sugar juices is the hydrate process. It requires the use of the following equipment, connected as illustrated in Figure 1:

(1) A crystallizer vessel where a refrigerant is mixed directly with the juice. The refrigerant boils as it absorbs heat from the juice, and water in the juice crystallizes as it loses heat. The solution becomes more concentrated and sucrose supersaturation increases, causing sucrose crystallization.

(2) A crystal separator-washer where the ice and sucrose crystals are separated by gravity. The individual crystals are then washed, the ice with pure water and the sucrose with another liquid. The washed crystals are drained and filtered or centrifuged to remove the wash liquid.

(3) A melter where the ice crystals are melted by heat exchange whereby the refrigerant vaporized in the crystallizer is condensed.

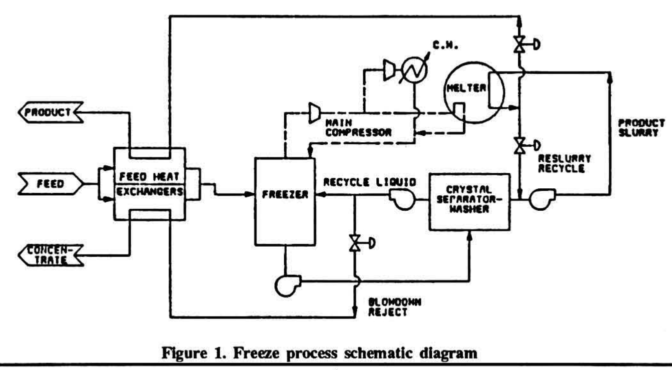

Figure 1. Freeze process schematic diagram

(4) A refrigeration system that is a direct-contact heat pump, compressing vapours produced in the crystallizer to a temperature where they will condense to melt the washed ice crystals. A heat rejection loop is also included to "pump" excess heat in the system to cooling water.

In crystallization from beet sugar juices we assumed a boiling process in which white sugar is produced in a first stage with recycling of crystals from the second and third stages to the first stage for recrystallization. The basic

* Presentation to the American Society of Sugar Beet Technologists, 1987, here supplemented with material prepared by the authors in conjunction with collaborators at American Crystal Sugar Co., Moorhead, MN, and the US Dept. of Energy, Washington, DC.

1 Heist: *Chem. Eng.*, 1979, **86**, (10).

equipment outlined above is reproduced in each stage, with the sugar from the first stage going to granulators and that from the second and third stages moving back to the preceding stage. The detailed process diagram was presented in our report[2] to the US Dept. of Energy (DOE).

Phase equilibria

The basis for the hydrate crystallization process is modification of the conventional water-sucrose solid-liquid equilibria, demonstrated in Figure 2. The solubility of sucrose is not affected significantly by temperature, as shown by the vertical line on the right.

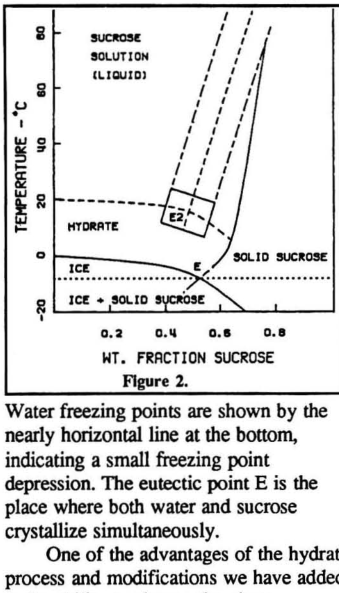

Figure 2.

Water freezing points are shown by the nearly horizontal line at the bottom, indicating a small freezing point depression. The eutectic point E is the place where both water and sucrose crystallize simultaneously.

One of the advantages of the hydrate process and modifications we have added is the ability to change the phase equilibria. The details are disclosed in a patent application. The effect is as shown by the curves to the left of and above the normal equilibria sucrose and ice curves.

Hydrate crystals of ice form when certain materials, gases under normal conditions, are added under pressure to water solutions in the temperature range 0 - 30°C. The crystallization temperatures of hydrates in sugar solutions are shown by the upper horizontal curve; the position of this curve depends on the hydrating agent that is used. The solubility of sucrose in water solutions is also affected by the choice of hydrate agent and other chemical modifications to the solution, as shown by the second nearly vertical line. Again, the location of the line depends on the hydrate agent and chemistry employed.

The intersection of the two altered equilibria curves defines the eutectic crystallization conditions, the point E2 at which the hydrate crystallization process operates. Laboratory tests have confirmed that operations in the following ranges produce eutectic crystallization:

Temperature: 7 - 12°C
Sucrose concentration 40 - 50 % by weight
Viscosity 40 - 80 cp

Equipment performance bases

Most of the operations in freeze crystallization are well understood and adequately modelled. There are a few parameters that are unique to each application, thus requiring testing in the laboratory and then in pilot plants. Feasibility analyses at each stage of the development program must estimate these parameters in order to assess the decisions on program continuation. It is these estimates that create uncertainty in decisions to commit further resources to development.

Performance criteria for hydrate freeze crystallization process components are detailed in the DOE report[2] and are summarized in Table I. The applications criteria that remain to be substantiated, and the basis for their estimation, are discussed below:

Sucrose crystallization kinetics - The hydrate freeze crystallization process operates 70°C below the temperature of the vacuum pan and 40°C below that of cooling crystallizers in the factory. Crystallization rates can be expected to be significantly slower in the hydrate process but there are no data to quantify the effects. Kinetic data from the literature have been extrapolated and an average growth rate, independent of super-saturation level, has been estimated and used as a basis for estimating growth rates in the hydrate process. The rate is given by

$$10^{-0.003704\,(12.5-T)\,-6.777} \times 500/\mu$$

where the rate is in cm/sec of major axis growth, T is the temperature in °C and μ the viscosity in centipoises. Growth rates in the intermediate and low cryst-allizers were estimated at 33% and 6%, respectively, of those in the white pans.

Sucrose crystal purity - An inherent

2 *Ann. Rpt., Contract No. DE-AC07-83ID12442* (Office of Industrial Programs, US Dept. of Energy, Washington, DC), 1984.

Table I. Process design criteria

1	Application			
1.1	Conventional factory, straight house, six months campaign without juice storage, northern location, with frozen and unfrozen beets			
1.2	Beets:	Slice rate	200 tons/hour	
		Sugar content	13.5%	
1.3	Juice:	Production	122% on beets	
		Purity	87%	
1.4	Sugar recovery:		81% from 87% juice purity	
2	Equipment performance			
2.1	Crystallizers			
	Ice production rate		100 lb/hr-cu.ft.-hr	
	Crystal residence time, hr		Sucrose	Ice-hydrate
		Stage 1	2	1
		Stage 2	4	2
		Stage 3	12	4
	Crystal product size, microns		Sucrose	Ice-hydrate
		Stage 1	800	300
		Stage 2	500	250
		Stage 3	300	200

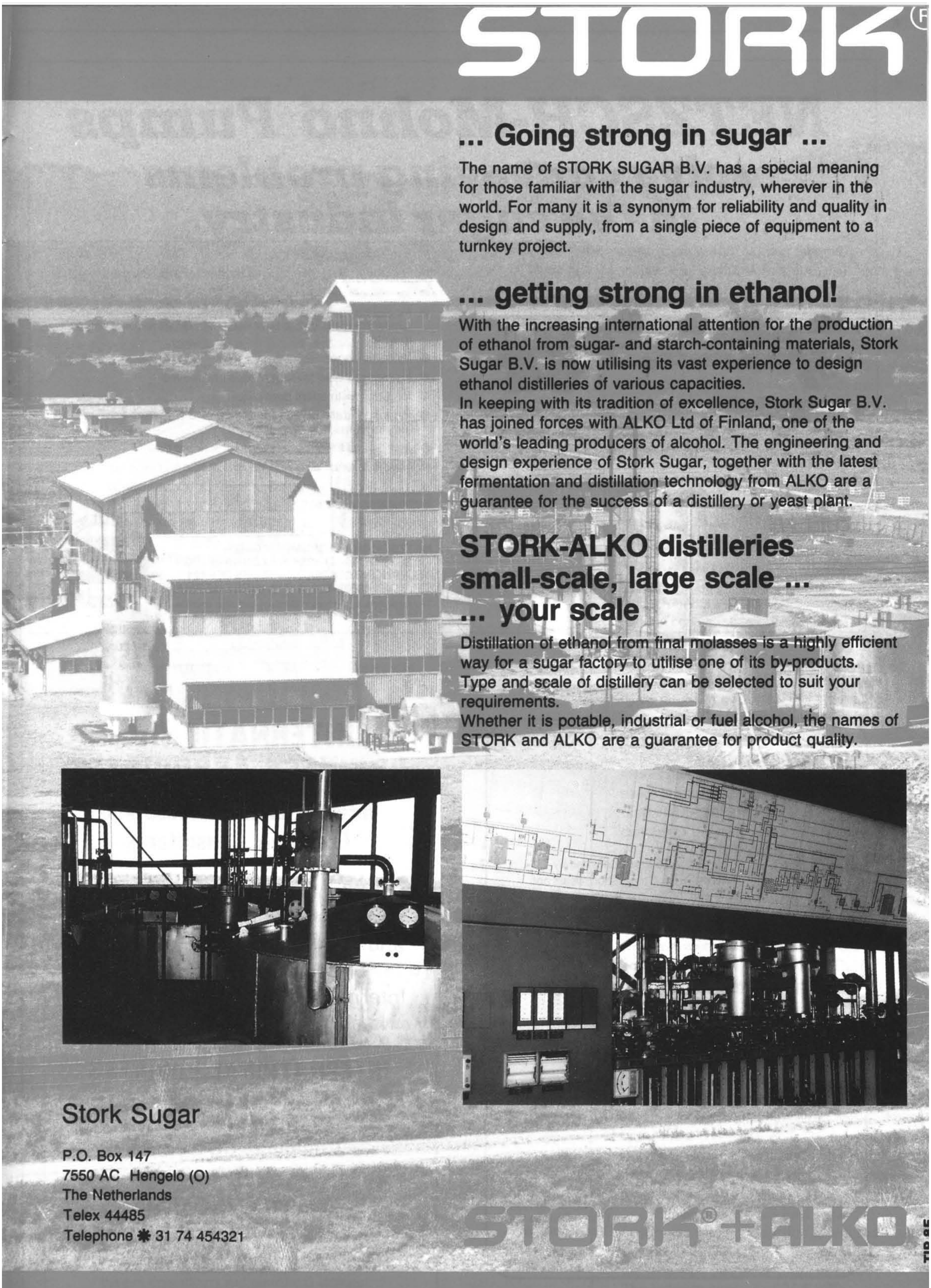
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Table I - continued

2.2	Wash and drain columns			
	Maximum ice washing rate, lb/hr-sq.ft.			
	Stage 1	300		
	Stage 2	275		
	Stage 3	225		
2.3	Heat exchangers	*Size*	*Material*	*Type*
	Feed exchanger	3520 sq. ft.	Aluminium	Plate
	Ice melter	14550 sq. ft.	C steel/ 90-10 CuNi	Shell & Tube
	Heat rejection condenser	2310 sq. ft.	C steel Admiralty	Shell & Tube
	Molasses stripper reboiler	1750 sq. ft.	304 SS	Shell & Tube
	Molasses stripper condenser	400 sq. ft.	304 SS	Shell & Tube
	Melt stripper reboiler	6000 sq. ft.	C steel 90-10 Cu Ni	Shell & Tube
	Melt stripper condenser	2300 sq. ft.	C steel 90-10 CuNi	Shell & Tube
	Granulator	10 ft dia. × 30 ft long	304 SS	Rotary kiln
	Granulator condenser	4050 sq. ft.	Aluminium	Fintube
2.4	Pumps			
	Capacities defined by mass balance and layout			
	Efficiencies	<5 h.p., 60%		
		>5 h.p., 70%		
	21 pumps, 15 constant speed, 6 variable speed			
	Sizes	11 under 5 h.p., 19 under 15 h.p. 1 each at 20 and 40 h.p.		
	Materials	304 SS, Casings and wetted parts		
2.5	Compressors			
	Oil-free centrifugal (pres. ratio < 2) or reciprocating cyclonic, washed entrainment separators on the suction to all compressors			
	Size, h.p.	1 each at 10, 15, 175, 200 and 450 h.p.		
2.6	Centrifuges			
	Continuous solid-bowl scroll-type with internal liquid pumps, 60 psig operating pressure.			
	Sucrose capacities:	Stage 1	46,385 dry pounds/hr	
		Stage 2	54,320 dry pounds/hr	
		Stage 3	14,000 dry pounds/hr	
3	General			
3.1	Materials of construction			
	Vessels	lined carbon steel		
	Piping	304 stainless steel or lined carbon steel		
3.2	Utilities			
	Steam at 42 psig saturated			
	Instrument air, dry and oil-free			
	Cooling water, 80°F or below			
	Electricity at 4160 V from factory substation			
3.3	Layout			
	Fits on four floors, within the space currently occupied by the pan crystallizers and centrifugal stations.			

assumption in this work is that the exclusion of impurities from the sucrose crystals produced in the hydrate process will occur as in pan boiling so that the same crystal purity and sugar recovery will be obtained.

Molasses losses - Sugar recovery from molasses is limited by slow growth rates and high viscosities. Because of the less viscous juices with the hydrate process, the recovery of sugar from molasses may be somewhat greater than in pans.

Steam and energy reduction

The hydrate freeze crystallization process affects the heat and mass balance in two ways: (1) no steam is needed in the pans for crystallization, and (2) the load on the evaporators is reduced because the juice is concentrated only to 40°Bx, determined by the reduced sucrose solubility with the hydrate process.

Full advantage of this change is taken only if the vapours that were used in the pans are no longer generated in the first place. This has implications on the source of those vapours. Evaporator vapours are no longer needed in the pans, so less expansion steam is fed to the first effect, and no expansion steam goes directly to the pans or for any heating.

A new heat balance was prepared using these guide lines; it showed that the effect was to reduce steam consumption by 600 pounds per short ton of beets. This corresponds to reducing primary energy feeding the boilers by 0.8 to 1.05 million B.Th.U., without reducing cogeneration of electricity. In factories where the heat transfer equipment has sufficient area to operate at the reduced steam production, the pans are eliminated and vapours from the first two or three evaporator effects actually have greater productivity because of larger pressure drops and lower juice concentrations. The juice heaters perform as well or slightly better because of the higher vapour temperatures.

For an average US beet sugar factory the steam production is reduced by 40%. In the more efficient factories the reduction can be as much as 50%. The industry average of 24.5 kWh generated per ton of beets processed can be obtained at a steam rate of 35 - 40% on beets, even with 400 psi boilers. US factories will be able to cogenerate to meet their electricity needs even when the hydrate freeze process is installed. The need for higher pressure boilers and turbo-generators in individual factories will require case-by-case analysis.

Study program

The development of the freeze crystallization study program was initially visualized as having four stages: (1) feasibility testing and analysis, (2) continuous laboratory demonstration, (3) pilot plant testing, and (4) commercial demonstration. The first was carried out some five years ago and the second began in 1983, results being reported in 1985[3].

In 1985 Heist Engineering designed and the OIP sponsored the construction of a pilot plant. The process vessels are 2 feet in diameter in this plant and the nominal capacity is 300 pounds per hour of water removed as ice. The sucrose crystallization capacity is a function of the juice concentration, with a maximum of 200 pounds per hour. Details of flows and process configuration of the pilot plant appear in Figure 3. Ice-hydrate and sucrose crystals are generated in the crystallizer and pumped as a 15% by weight slurry to a separator-growth column. In the latter column the ice floats up through the liquid in the vessel and the thick juice is recirculated through the bottom of the vessel. As sugar crystals grow to a suitable size they settle out into the bottom of this tank. Thin juice feed enters the top of the growth separator tank and flows in counter-current to the rising ice crystals, producing better conditions for additional growth of the ice.

As the ice reaches the top of the growth column it is pumped with a recycled thin juice stream to the wash column. In the wash column a porous plug of ice is formed, juice is filtered away through screens and the residual juice is washed from the surface of the ice. The ice plug is propelled to the top column where it is scraped into a reslurrying chamber. The clean slurry is then melted in a shell and tube heat exchanger. Since the ice formed in the hydrate contains about one-third refrigerant, as the ice melts the refrigerant is released and a decanter is used to separate the immiscible liquids. The small residual dissolved refrigerant is stripped in a vacuum stripper, compressed and sent back to the crystallizer.

Design features

There are several unique designs incorporated into this facility. First, the combination of operating pressures,

3 Cleary *et al.*: *Paper presented to Amer. Soc. Sugar Beet Tech.*, 1985.

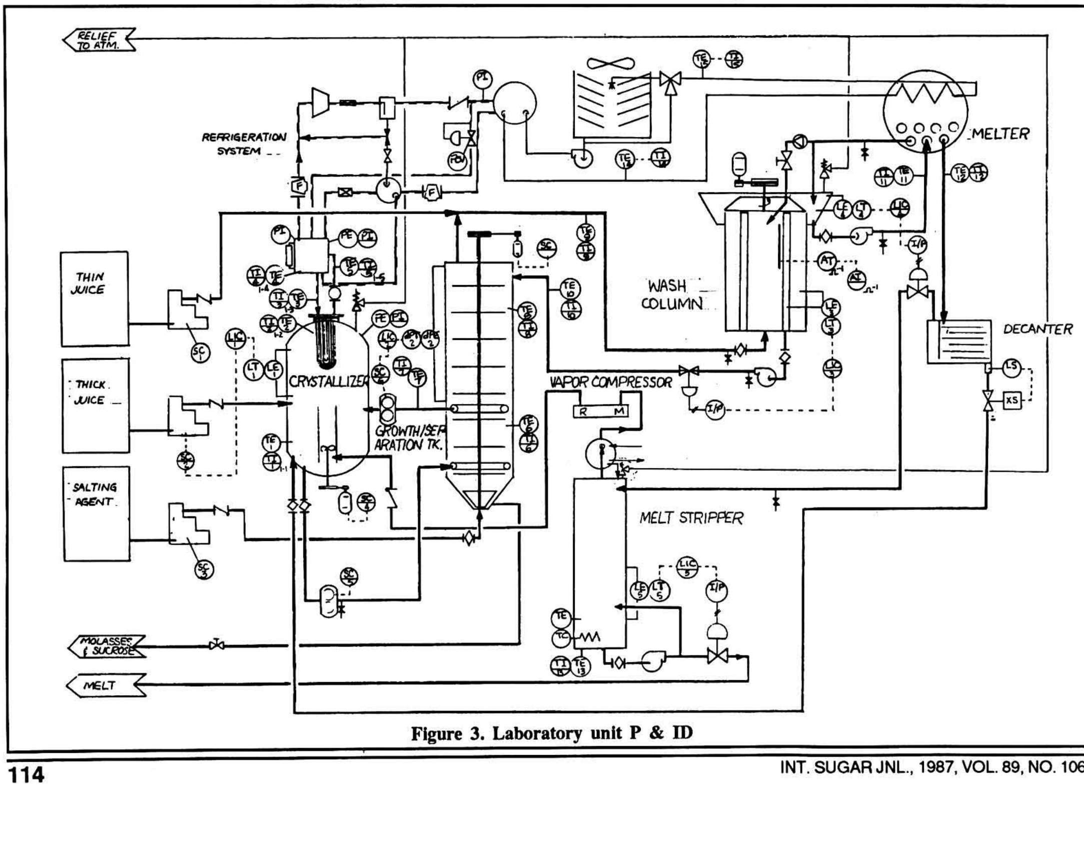

Figure 3. Laboratory unit P & ID

compression requirements and vapour characteristics encountered with a hydrate freezing process are different from those required in conventional freezing and refrigeration applications. Equipment appropriate to such a small pilot plant is very expensive at best, and may not even work. Therefore, the decision was made to use a condensing coil in the crystallizer, condensing directly the refrigerant boiling out of the slurry. This allows a conventional closed-cycle refrigeration compressor to be used to cool the coil.

This was also the first use in a crystallization-from-the-melt application where a gravity separator is used to separate two crystals produced simultaneously. The objective in this program was to develop a vessel that would perform the separation with near perfection.

A sample collection system was tied into each of the vessels in the plant. The collection system incorporated a degassing column, a viewing microscope and a permeability column. The degassing column is to remove refrigerant before the sample is removed from the system. The microscope allows viewing and estimation of crystal size continuously during testing. The permeability cell is a device used to measure the permeability of a pack of porous solids, and yields direct design data for the wash column as well as a weighted average crystal size.

Test results

The most significant achievement of this test program was demonstration of the phase equilibria on which sucrose crystallization by hydrate freezing is based. During this program sucrose was crystallized from simulated white pan liquors at temperatures ranging from 5 to 10°C (40 to 50°F). Sucrose concentration varied from 36 to 42% by weight and the solution viscosity under crystallization conditions varied from 60 to 80 cp.

Hydrate-ice crystal growth kinetics were also found to be very favourable in these tests; permeability data showed average crystal sizes in excess of 300 microns and microscopic examination showed some crystals in excess of 500 microns.

Of historical note, three previous hydrate freeze crystallization process plants have been constructed, all for seawater desalination[4,5,6]. None of these plants operated with a high degree of success, attributed by the developers to a variety of causes. Undoubtedly, a major cause in all three plants was the very small ice-hydrate crystals that were produced, reported to be in the 20 to 40 microns range[4].

The eutectic separator/growth column proved an effective device for separating sugar and ice-hydrate crystals. Ice fractions in this vessel were higher than was expected (for reasons outlined below) and there was some concern that the sugar might be trapped in the ice and be transferred to the wash column. Sampling and analysis did not show any sign of this occurring.

On the whole, the work done in this program confirms the potential that the hydrate freeze process has for concentrating and crystallizing sugar juices. However, additional details have to be worked through before the process can be carried into larger equipment or incorporated into a sugar factory. Testing to date has identified areas where further development is needed, as outlined below.

In all of the tests where sugar was crystallized, the sugar crystals remained small throughout. Even with seeding the initial sizes seemed largely in the 10 micron size. Over several days of testing they would grow to about 100 microns, but indications are that many new crystals were nucleating at the same time. This can be attributed to either of two causes: (1) excessive secondary nucleation caused by mechanical forces in the crystallizer and transfer pumps; or (2) high rates of primary nucleation in comparison to crystal growth kinetics on the crystals already in the slurry.

In the current pilot plant there is a mechanical agitator that adds about 0.1 h.p. per cubic foot of volume. This relatively high energy addition is necessary to mix the refrigerant and juices to enhance heat transfer. Testing with an open-cycle refrigeration system, in which hot refrigerant is flashed in the vessel to induce a more gentle agitation, should indicate whether secondary nucleation is the culprit.

As noted above, the ice fraction in the growth tank was higher than had been expected. In this plant we found that operating pressures were significantly higher than in the bench work we had done previously. This effectively raises the crystallizing temperature in clathrate formation, but it also makes the ice more dense because more hydrating agent is included in the crystal lattice. With an open-cycle refrigeration system there will be more control over operating pressures, which should thin the ice in this area and make it easier to reslurry into the wash column.

Wash column stability was a problem in these tests as in previous hydrate and secondary refrigerant processes. However, we attribute the problem not to small hydrate ice crystal size but to free refrigerant in the wash column. Specifically, free refrigerant harms operation in at least two ways: (1) it is a dense liquid that blocks the necessary flow of process liquid through the ice pack, and (2) if it vaporizes it acts to flood the column, pushing the process liquid above it up through the column; this also creates crevasses in the pack, which destroys its ability to distribute wash water uniformly to clean the ice.

Several alternatives have been proposed to overcome this, including stripping the slurry before it reaches the wash column and precooling thin juice as feed, and adding it in the slurry to the wash column at such a temperature that it rapidly absorbs the refrigerant in new hydrate crystal growth. This is addressed below.

Molasses recovery process

The results of the work to date suggest that from one-third to two-thirds of the sugar in molasses can be recovered

4 Williams *et al.*: *Rpt. US Dept. of Int., Office of Saline Water R & D*, 1968, (373).
5 Garrison *et al.*: *ibid.*, 1986, (368).
6 Anon.: *ibid.*, 1964, (90).

directly by this process. The logic goes something like this:

(a) Sugar solubility is significantly reduced by the hydrate freeze process;

(b) The hydrate process has a small effect on the solubility of the impurities;

(c) The thinning effect of the hydrate process will have a very beneficial effect on sucrose crystallization kinetics in low raw massecuites and molasses;

(d) Therefore, much of the sugar in molasses should be recoverable by the hydrate freeze process.

Phase equilibria calculations show that, when molasses is fed to the hydrate freeze process, about one-third of the sugar will crystallize before any ice formation. The raffinate that would be produced by this action alone is shown in Table II. Carbonate salts will be much less soluble at the temperatures involved in hydrate freezing, and will precipitate as the sugar crystallizes.

Table II. Molasses composition (weight fractions)

	Straight houses	Hydrate raffinate
Sucrose*	0.50	0.395
Amino acids	0.11	0.140
Inorganic N	0.01	0.013
Ash	0.12	0.121
K	0.08	0.102
Na*	0.03	0.013
Mg/Ca*	0.01	0.006
Organic acid	0.06	0.076
Invert sugar	0.01	0.013
Raffinose	0.01	0.013
Water*	0.18	0.229

* Materials that crystallize during hydrate freeze processing

Another benefit of the molasses recovery process would be production of seed for the current pan crystallizers. There is sufficient sugar in the molasses that recovery of even one-third would provide more than adequate seed as long as the seed crystals are over about 2 microns in size. Crystals probably have to approach 100 microns before they can be fractionated efficiently. A 100 ±10 micron stream of seed crystals would have at least two benefits in a factory: (1) the relatively large seed crystals will result in a smaller residence time in the pans than now, thus increasing their capacity, and (2) the crystals being produced should have a greater uniformity, thus reducing the screening load and subsequently the load on the melter and white pans.

In this scheme, sugar that is recovered beyond the need for seed would be melted and recycled to the white pans with thick juice from the pretreatment processes.

In a factory slicing 200 tons of beet per hour, the molasses flow is about 20,000 pounds per hour of which approximately half is sucrose. Ice hydrate production would be not more than 2000 pounds per hour, with 3500 to 7000 pounds per hour of recovered sucrose. In a factory operating just 3000 hours a year, there is obviously a large incentive to recover the sugar.

Economics

In most factories this molasses recovery scheme can be implemented with payback times of 1 year or less. The economics are summarised in Table III for a factory slicing 200 tons per hour and recovering 38% of its molasses sugar with a yearly operation of 2600 hours.

Table III. Molasses recovery economics

Costs	
Capital	$ 2 million
Annual O & M	
Electricity	$10,000
Labour	$40,000
Supplies	$20,000
Maintenance	$30,000
Molasses value	$730,000
Annual cost	$830,000
Credits	
Sugar	$2,035,000
Molasses	$453,000
Raffinate	$90,000
Pan capacity	-
	$2,578,000

A 50% contingency is included in capital costs to allow for processing that is not yet defined, such as filters to separate the sugar crystals from the molasses. Labour costs are predicted on a full-time operator servicing only this equipment. Supplies include refrigerant make-up, spare parts and replacements.

Determining the value of the molasses being diverted to the recovery process and the sugar-depleted molasses that results was done in the following way: "normal" molasses value is taken as $60.00 per ton, the value of non-sucrose molasses solids is taken as $20.00 per ton, the recovery plant is charged full value for all of the molasses it takes, and molasses returned from the recovery plant is valued at $60.00 per ton for that with a full sugar value and at $20.00 per ton for the sucrose-free portion, termed the raffinate in the table.

In projecting the recovery of sugar from molasses and the resulting economics, no credit is taken for increased factory capacity that might result from lower loading on the pans.

R & D plans and needs

The continued development of hydrate freeze crystallization for sucrose falls into two main areas: phase equilibria testing and equipment development.

Phase equilibria - The goals of phase equilibria testing are to develop the solubility of sucrose in various purity molasses under the conditions of the hydrate process and to measure solution physical properties under those conditions. This can be done in the pilot plant but is cumbersome at best. We are developing a new equilibrium cell that will allow us to obtain the data in a more expeditious manner.

Equipment development - The immediate goal of this phase of work is to improve the operation and reliability of the pilot plant, by making the changes outlined above. Specifically, these are to:
(1) install an open-cycle refrigeration system, feeding hot condensed refrigerant into the crystallizer that will flash and provide agitation,
(2) install a slurry stripper and a feed pre-chiller so that free refrigerant in the wash column can be avoided, and
(3) conceive, design and develop suitable sugar recovery equipment for removing the crystallized sucrose and separating it from the remaining juice and refrigerant.

Once these changes are made to the current pilot plant it should be able to produce a sufficient quantity of recovered sugar crystals for evaluation by the industry.

The next stage in equipment development will be implementation of this process on a larger scale, with a scale-up of 10 to 20 times the size of the current pilot plant. This will be approximately the size needed for molasses recovery, and about 1% of the size needed for processing the full juice stream in a factory slicing 200 tons of beet per hour.

Summary

A program has been under study for some years on the application of the hydrate freeze crystallization process to the separation of sugar crystals from beet juice and molasses. An account is given of the basis of the process and the benefits possible through reduction of steam and energy usage. Results of a two-year pilot plant process are described, with a discussion of the impact that the process can have on factory operations (increased sugar yield, improved sugar quality, automated/ continuous operation). Plans for continuing development of the process are presented.

Acknowledgement

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PROCESS TECHNOLOGY

The new liquid sugar process at the Vauciennes factory*

By J. Foucart and J. Paleos

Introduction

This paper describes experience obtained with the new liquid sugar process applied since January 1983 at the Vauciennes factory in France. Also further development trends are discussed, based on the idea of using the stored thick juice as a raw material to produce various products throughout the whole year.

The Vauciennes company commenced sugar production in 1853. For many years part of the thick juice was stored to produce crystalline sugar in the refinery after the campaign. Liquid sugar production started in 1953; then, as today, the product was non-inverted sucrose.

By 1980 the plant was processing 450,000 tonnes of beets per year during a campaign averaging 67 days. Of the thick juice produced, 20% was stored for treatment after the campaign. The liquid sugar was originally produced by remelting a No. 2 white sugar (12 - 15 EEC points). In spite of the fact that the syrup thus produced was processed through a mixed-bed ion exchange unit, the results, in particular the colour, were not always satisfactory. Obviously, a No. 1 sugar could have been used, but this would have resulted in a higher production cost of the liquid sugar.

The new process

In 1975 Applexion started development work with the Vauciennes factory to produce liquid sugar directly from thick juice. The problem at first glance did not seem to be particularly difficult. Starting from a thick juice of a certain purity the corresponding non-sugars could be eliminated by a classical demineralization system followed by a polishing unit.

In principle this is true; however, a number of questions had to be answered, all of which related to the definition of a system which could give consistent quality and, in particular, consistent organoleptic properties of the product.

Development work involving time-consuming pilot plant multi-cycling work was necessary. This development work lasted seven years, during which the following questions were answered:

(a) How many columns should be used in series in one chain?
(b) What resin should be used in each column?
(c) What is the influence of thick juice quality on a given system?
(d) What should be the dimensions of the system?
(e) How should regeneration be optimized?
(f) What was the optimum treatment of spent regenerants?

The results of this pilot plant work defined the system which has been in operation at Vauciennes since 1983. It consists of a number of parallel chains depending on the dimensioning in each particular case. Each chain has the following columns in series: Cation I, Anion I, Cation II, Adsorbent I, Anion II, Evaporation to 67°Brix, Mixed bed, Adsorbent II and Sterilization filter.

Since the product is liquid sucrose the demineralization takes place at 10°C to minimize inversion. The regenerants used are sulphuric acid, ammonia and a small quantity of sodium hydroxide.

* *Paper presented to the 28th Tech. Conf. British Sugar plc, 1986.*

The thick juice to be treated has the following characteristics:

Purity	92 - 93
Concentration	67°Brix
Colour	3500 - 4500 ICUMSA units
Hardness	15 ppm (all the thin juice is decalcified)

The liquid sugar produced has the following values:

Purity	99.9
Concentration	67°Brix
Colour	less than 10 ICUMSA units

The regenerants from the cationic and anionic resins are mixed and concentrated in falling film evporators to produce the following by-products:

(a) A crystalline fraction consisting mainly of potassium and ammonium sulphates which is sold as fertilizer,

(b) A liquid fraction (67° - 70° Brix) containing the organic and nitrogenous non-sugars which is sold as animal feed.

The energy for the concentration of the spent regenerants is obtained by mechanical recompression, since electrical energy in France is not expensive. In other countries a multiple effect evaporation may be preferable.

Economic considerations

At the time of the decision to implement this process, a capacity increase of 25% of the plant was also planned, with the corresponding investment for the crystallization equipment. The investment for the complete liquid sugar plant was higher than that for the crystallization equipment.

The return on the difference in investment can be calculated from the values of the additional sugar produced owing to the non-sugars elimination, from the difference in operating cost and the value of the by-products.

At this point it has to be emphasised that the data presented relates to the specific conditions of the Vauciennes plant. For example, in another case, a larger liquid sugar production may be more advantageous, or the fuel economy may be different for the same quantity of production.

(A) *Additional sugar produced*: From beets containing 16.00% sugar and 1.30% juice non-sugars, i.e. a total of 17.30% soluble solids (purity = 92.5) is produced sugar and molasses containing 1.95% sugar on beet and the 1.30% non-sugars on beet, corresponding to a purity of 60.0. The sugar produced is thus 16.00 - 1.95 = 14.05% on beet.

When the ion exchange process is applied all the non-sugars are removed; thus the sugar produced is 16.00% on beet. The net additional sugar produced is: 16.00 - 14.05 = 1.95% on beet.

From the above, the additional sugar production for the two cases can be calculated:

(a) the original additional sugar production was from 20% of 450,000 tonnes beets: 450,000 × 0.2 × 1.95% = 1755 tonnes;

(b) the present liquid sugar/crystal production is from 40% of 520,000 tonnes of beet, i.e. 520,000 × 0.4 × 1.95% = 4056 tonnes.

(B) *Operating costs*: From the actual production costs of liquid sugar it has been determined that this equals the crystallization cost at Vauciennes. Therefore the additional benefits for the extra sugar produced are (a) savings in energy consumption, and (b) sales of by-products.

The saving in energy consumption has been calculated from the actual differences in fuel purchased before and after the use of the ion exchange process, for the same quantity of liquid sugar produced. The fuel consumption was 2,000 tonnes less per year; the price of fuel being 1300 FF/tonne, the resulting energy savings is 2.6 million French Francs.

The fertilizer and animal feed fractions produced from the spent regenerants are sold for 500 FF/tonne each. The daily production of fertilizer and animal feed fractions are 6 tonnes and 8 tonnes respectively. Thus, for 250 days, income is 6 × 250 × 500 (= 750,000 FF/year) plus 8 × 250 × 500 (= 1,000,000 FF/year); the total revenue from the by-product sales is 1,750,000 FF/year.

The production cost of the liquid sugar at Vauciennes is presently 0.33 FF/kg, since there is no production during the week-ends. This cost is expected to be reduced to 0.22 FF/kg if the production becomes continuous. The production cost of the crystal sugar produced in one strike from the liquid sugar is estimated at 0.22 FF/kg.

Production schemes

Up to the end of 1984 the production scheme was as follows:

(a) *During the campaign* the thick juice was divided into three parts: crystallization (3 strikes), liquid sugar (Applexion process), and thick juice storage for treatment after the campaign.

(b) *After the campaign* the stored thick juice was divided into two parts: crystallization (3 strikes), and liquid sugar (Applexion process).

During 1985 the production scheme was changed. This change consisted of introducing a new process scheme into the liquid sugar line. Basically what was done was to introduce a one-strike crystallization into the liquid sugar line after the evaporation of the treated thick juice and before the final polishing. Thus the new production schemes were as follows:

(a) *During the campaign* the thick juice is divided into three parts: crystallization (3 strikes); "liquid sugar" → evaporation → crystallization (1 strike) → mother liquor → polishing → liquid sugar; and thick juice storage for treatment after the campaign.

(b) *After the campaign* the whole stored thick juice is treated as follows: "liquid sugar" → evaporation → crystallization (1 strike) → mother liquor → polishing → liquid sugar.

In the period after the campaign no molasses is produced. The advantage of the new scheme is that it gives a higher crystallization yield and obviously excellent sugar quality (2 - 4 EEC points). For the time being the available crystallization equipment at Vauciennes is being used and gives a 55% yield.

Modern crystallization equipment should increase the yield to 70% and decrease crystallization time to less than one hour. As mentioned above, the crystallization cost in this process is estimated at this factory at 0.22 FF/kg.

All the sugar produced in this crystallization is used to make cubes. It is planned that, when the production becomes continuous over the week-ends, cubes will be produced during the week and crystal sugar will be made during the week-end.

At that time the total production of liquid and crystal sugar from the new process scheme will become 38,000 tonnes/year (dry solids).

The new liquid sugar process scheme with crystallization is: Thick juice → Cation I → Anion I → Cation II → Adsorbent I → Anion II → Evaporation → Crystallization (1 strike) → Mother liquor → Mixed bed → Adsorbent II → Sterilization → Liquid sugar.

Possible future trends

One of the interesting points of the above is the fact that at least part of the Vauciennes production takes place throughout the whole year.

Although the advantages of extending the working period should be obvious, most beet sugar plants seem unable to find a way to work economically throughout the whole year. This may be true if one considers only the production of crystal sucrose.

At least in the case of the Vauciennes factory, producing liquid sugar and crystal sucrose over the whole year has proved to be economical. This does not mean that the same approach could be adopted in all plants but this example should at least provide the necessary motivation to investigate alternative systems!

It is interesting to consider other steps for transformation of the sucrose liquid sugar into other products which could be produced throughout the whole year, especially in view of proposed EEC regulations according to which chemicals produced from sucrose will be able to use quota sugar, with restitution virtually to world price, as raw material for this transformation. For example, pure glucose monohydrate produced from sucrose should have a lower production cost than that made from starch. Further transformation to sorbitol or mannitol is possible with quite attractive profit margins, making even small production quantities interesting.

Summary

This paper describes the experience obtained over recent years at the Vauciennes factory. The process, developed by the Applexion Company, uses ion exchange resins and produces high purity liquid sugar (sucrose) directly from thick juice throughout the whole year. One of the important features of this process is that it has no waste effluents for disposal. The effluents are concentrated to produce two saleable by-products : a fertilizer fraction and an animal feed fraction. Using this process the capacity of the Vauciennes plant was increased from 6000 tonnes of beets per day to 8000 tonnes of beets per day. A further development has been the application of a new crystallization scheme, which uses the liquid sugar, to produce a high quality product (3 - 4 EEC points). The mother liquor from this crystallization is passed through an ion exchange unit for polishing to produce the liquid sugar. Further developments are based on the idea of using thick juice as raw material for producing a variety of products throughout the whole year.

Facts and figures

China sugar crop areas[1]

China has taken the unprecedented step of publishing estimates of planted area for 1986 by crop. These include 977,000 hectares of sugar cane, against 965,000 ha in 1985, and 526,000 hectares of sugar beet, against 560,000 ha in 1985.

Molasses animal fodder plant in Australia[2]

A $A1 million factory will be built in Bundaberg this year to manufacture a range of animal feed products from molasses and other sugar wastes. The Sydney-based firm, Molasses Products Corporation, will use new membrane technology to desalinate molasses and use Australia's first large-scale continuous microwave ovens to produce dehydrated molasses for the domestic market and for export to Japan, South-East Asia and the US.

Guyana sugar production, 1986[3]

The state-owned Guyana Sugar Corporation reports that production in 1986, totalling 245,440 tonnes, was the highest since 1983. In 1985 Guysuco produced 243,000 tonnes. In noting that, from all indications, the industry's financial performance has improved considerably, the Corporation's Chairman has assured the country's 26,000 sugar workers that their jobs are not in jeopardy as a result of cuts in US import quotas which will reduce US imports of Guyanese sugar from 20,592 tonnes in 1986 to 10,920 tonnes this year.

Hungary sugar production, 1986/87[4]

Drought sharply cut Hungary's 1986 sugar beet harvest but dry conditions led to a record sugar content, according to the official MTI news agency. The 1986 crop was 3.58 million tonnes compared with 4.07 million tonnes the year before, but sugar output from Hungarian processing plants was 454,000 tonnes, with a further 30,000 to 32,000 produced in Yugoslav factories, against 483,000 tonnes in 1985/86. This corresponds to a record 130 kg of sugar per tonne of beet. Hungary's beet area is set to meet only domestic demand as low world prices make exports uneconomical.

Expansion of Cuban alcohol manufacture[5]

An alcohol distillery with a capacity of 500 hl per day, built near Central Amancio Rodríguez in the province of Las Tunas, is nearly completed. The distillery will produce several types of alcohol from sugar cane residues and about 80% of the production is to be exported. Cuba has currently 13 distilleries with a production in 1986 estimated at 1.3 million hl. A program for its extension and for the construction of distilleries of this type would allow an increase of Cuban alcohol capacity to some 2 million hl per year.

New Chinese cane sugar factory[6]

A new cane sugar factory having a capacity of 6000 tcd, is shortly to go into operation at Meishan, in the Panyu region of Guangdong province.

1 *World Commodity J.*, 1986, **9**, (4/5), 10.
2 *Australian Canegrower*, 1986, **8**, (11), 5.
3 *Latin American Commodities Rpt.*, January 15, 1987.
4 *Reuter Sugar Newsletter*, January 9, 1987.
5 F. O. Licht, *Int. Molasses Rpt.*, January 16, 1987.
6 *Zuckerind.*, 1987, **112**, 174.

Mauritius sugar statistics, 1986[7]

	1985	1986
	tonnes, tel quel	
Opening stocks	336,875	267,306
Production	706,839	645,797
Consumption	37,731	36,863
Exports		
Belgium	1,345	108
Canada	43,750	0
Egypt	10,800	0
Finland	13,300	0
France	69,410	83,207
Holland	3,060	1,659
India	12,485	0
Italy	0	1,35
Morocco	28,000	0
UK	414,287	428,574
US	12,556	23,924
USSR	14,700	0
Other countries	1,256	678
Total	624,949	539,502
Surplus in storage	469	137
Closing stock	380,565	336,875

Dominican Republic sugar meeting[8]

A meeting of sugar producing nations and exporting firms in the Dominican Republic at the begining of February broke up without reaching agreement on raising world sugar prices to 9.00 US cents/lb. Trade sources said the meeting was attended by representative from Brazil, Cuba, the Dominican Republic, Sucres & Denrées S.A., E. D. & F. Man Ltd., and an observer from a major EEC refining company. A clash of interests made an agreement impossible, according to trade sources.

New Bangladesh sugar factory[9]

A new sugar factory went into operation in mid-December in the Narshingi district of Bangladesh, 70 km north of the capital Dacca. It was built with a credit of 64 million Danish crowns raised by DDS of Copenhagen and will process 300 t.c.d. to produce 30 tonnes of sugar per day. It is to replace the Deshbandu factory, erected in 1934.

Australia sugar exports, 1986[10]

Australia's raw sugar exports in calendar year 1986 totalled 2.698 million tonnes, up from 2.64 million tonnes in 1985, according to the Sugar Board. Refined sugar exports were 12,000 tonnes, up from 10,000 tonnes in the year before. Destination of raw sugar exports included Canada with 552,000 tonnes, Japan with 514,000 tonnes, China with 443,000 tonnes, Malaysia with 380,000 tonnes and South Korea with 314,000 tonnes. Shipments to the Soviet Union, which did not take any Australian sugar in 1985, totalled 159,000 tonnes while Singapore took 135,000 tonnes, New Zealand 102,000 tonnes and the USA 99,000 tonnes. Australian sugar production in the 1986/87 crop year reached 3.44 million tonnes, raw value, virtually unchanged from the year before.

Italy sugar production, 1986[11]

From the beet area of 275,000 hectares (225,000 ha in 1985), the 39 Italian sugar factories sliced a total of 14,470,000 tonnes of beet (9,285,800 tonnes) to produce 1,710,000 tonnes of white sugar (1,244,276 tonnes).

Haiti sugar industry restructure[12]

The Haitian government has introduced a number of reforms including a plan to restructure the sugar industry which includes abandonment of the unprofitable Dabone sugar factory which has a crushing capacity of 3000 tcd. Of the remaining factories one is of 3600 tcd and the other two 1100 tcd each. Production in the 1985/86 season was 41,000 tonnes, down from 57,000 tonnes in 1984/85, but it is expected to rise to 55,000 tonnes in 1986/87.

Thailand sugar exports, 1986[13]

	1986	1985
	tonnes, raw value	
Bangladesh	60,935	18,628
Brunei	1,655	467
Bulgaria	62,725	0
China	307,191	911,281
Hong Kong	819	11,753
India	78,064	104,227
Indonesia	15,630	0
Japan	377,342	312,343
Korea, South	483,672	204,892
Malaysia	171,608	79,403
Maldives	1,031	0
Nepal	16,257	9,210
New Zealand	20,810	0
Pakistan	54,905	22,518
Papua-New Guinea	18,956	0
Singapore	2,245	1,358
Sri Lanka	89,341	30,013
US	21,910	33,985
USSR	250,143	37,818
Vietnam	12,520	0
Other countries	1,655	3,108
	2,049,414	1,781,004

Australia-Malaysia sugar agreement[14]

Under a new agreement, Australia is to supply Malaysia with 400,000 tonnes of sugar, spread equally over 1988 and 1989. The sales are an extension of those covered by previous agreements.

Indonesia's faltering sugar expansion[15]

Indonesia's sugar output is likely to be 1.8 million tonnes, raw value, this year, unchanged from 1986 and well below government's 1987 forecast of 2.5 million tonnes, according to the US Embassy in its agricultural survey. The Embassy said that Indonesia's move into self-sufficiency in 1984 may have been short-lived, and it will be recalled that Indonesia bought 162,500 tonnes of raw sugar on the world market in late 1986.

Polish sugar industry modernization program[16]

Last year, as a result of modernization, the Polish sugar industry's daily slicing capacity was raised by 4000 tonnes and in 1987 11,000 million zloty is to be allocated for further projects, mainly to modernize power equipment, replace machinery and to construct the country's first silo. This is designed to hold 15,000 tonnes of sugar and construction at the Gora Slaska factory will start this year. A citric acid factory at Raciborz is to be expanded this year, raising annual output from 700 to 1500 tonnes.

Solid fructose manufacture[17]

A. E. Staley Manufacturing Co. expects to open on June 1 its plant in Lafayette, Indiana, for manufacture of crystalline fructose. Annual production capacity will be 50,000 short tons per year. The company plans to offer the food-grade fructose under the name "Crystar" in 50 and 100-lb bags and bulk containers for 35-40 cents/lb, f.o.b. Lafayette. The product is not seen as a table-top sweetener but will be targeted at the powdered beverage, dry breakfast cereal and dry mix desert markets.

Malawi sugar exports, 1986[18]

Exports of sugar from Malawi were reduced to 93,496 tonnes, raw value, in 1986 from 142,588 tonnes in 1985. Major destinations were Zaire which took 25,359 tonnes (14,663 tonnes in 1985), the EEC with 16,525 tonnes (20,748 tonnes), and Mozambique with 7045 tonnes (2381 tonnes in 1985). Exports to unknown destinations amounted to 43,367 tonnes (39,788 tonnes in 1985) and in 1985 there were exports of 24,173 tonnes to Portugal and 36,838 tonnes to the US, neither country receiving sugar from Malawi in 1986. White sugar was a much higher proportion in 1986, viz. 29,072 tonnes or 31% of the total exports, against 14,322 tonnes or slightly more than 10% in 1985.

7 *Mauritius Sugar News Bull.*, 1986, (12).
8 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 68.
9 *Zuckerind.*, 1987, **112**, 173.
10 *Czarnikow Sugar Review*, 1987, (1758), 30.
11 *Zuckerind.*, 1987, **112**, 173.
12 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 100.
13 *I. S. O. Stat. Bull.*, 1987, **46**, (2), 48.
14 *Australian Canegrower*, 1987, **9**, (1), 4.
15 *Financial Times*, March 3, 1987.
16 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 113.
17 *Reuter Sugar Newsletter*, February 25, 1987.
18 *I. S. O. Stat. Bull.*, 1987, **46**, (2), 33.

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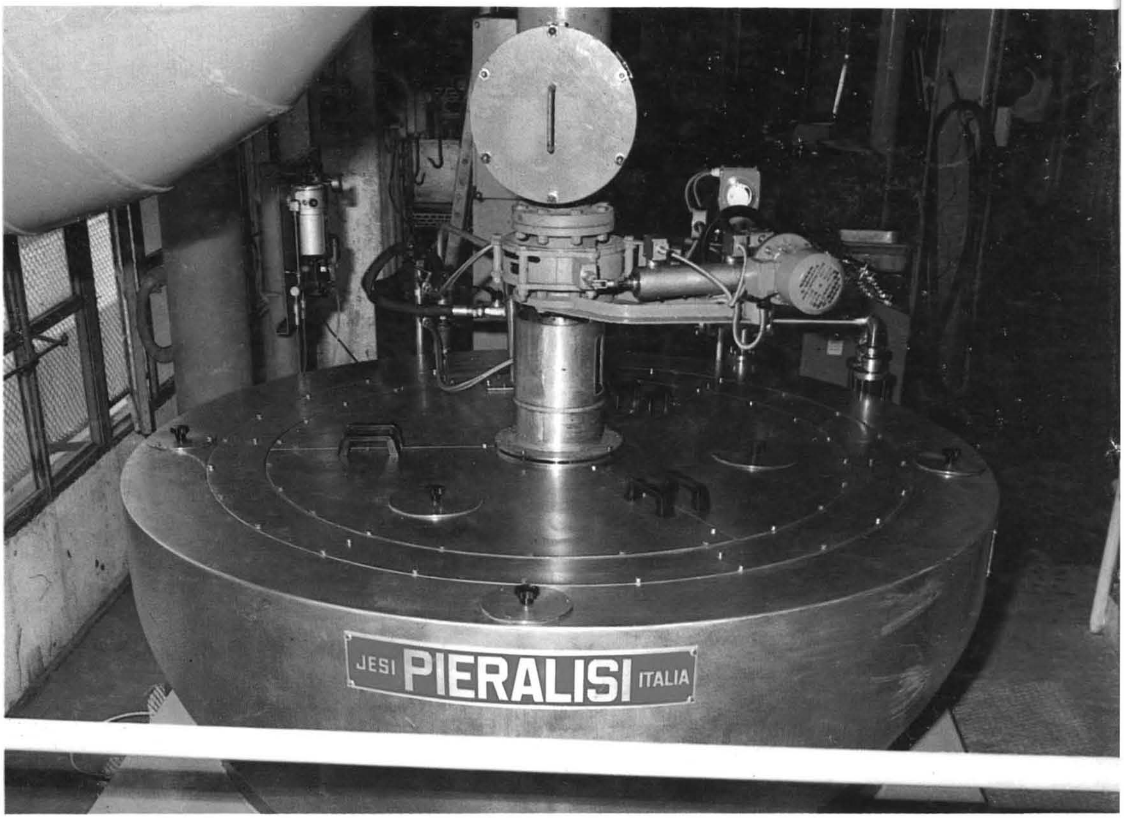
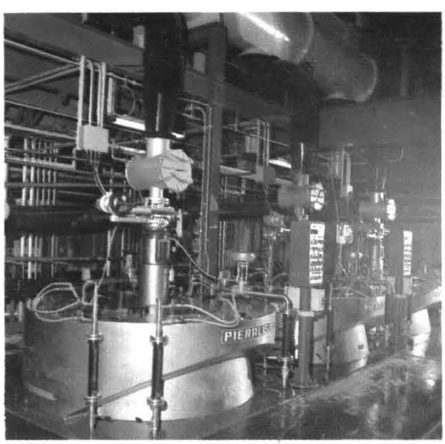
PIERALISI
CONTINUOUS CENTRIFUGALS





Specially designed for a sugar refinery wanting to step up production and cut running and maintenance costs, the **SCP-C5** is the biggest continuous centrifugal for treating sugar massecuite available today.
The **SCP-C5** is equipped with programmable logic control equipment and with special devices for the formation of artificial massecuite in the centrifugal and of Bx-controlled syrup.
The machine body and the basket are made entirely of stainless steel.
The oil-mist system is used for lubrication.
The **SCP-C5** – a truly great machine – has joined the Pieralisi family of centrifugals for the treatment of beet floating waters and carbonation juices.

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