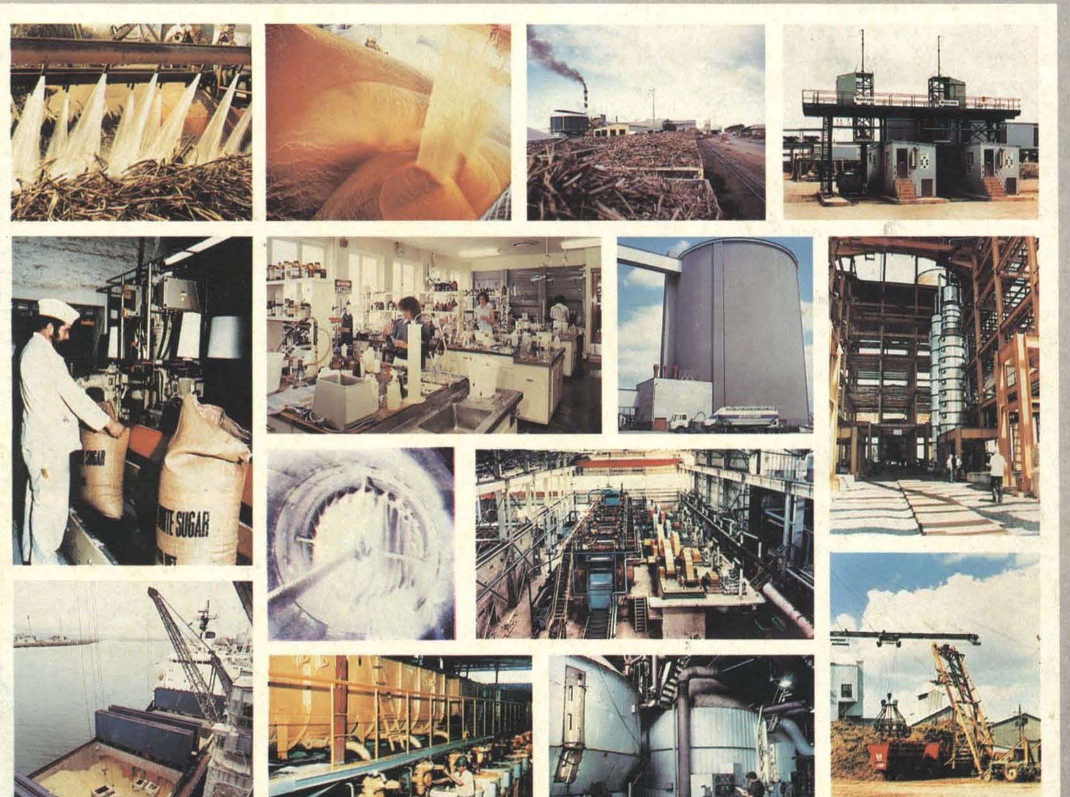
INTERNATIONAL SUGAR JOURNAL



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News and views

World sugar prices

The market started to slide during the first half of December owing to the lack of buying interest and postponement of agreed sales, as well as the announced possibility of more sugar available from Brazil. The London Daily Price for raw sugar fell from $348 on December 1 to $328.40 on December 12 and then stabilized at around $330 until December 21. Sentiment turned bearish, without any specific cause and the LDP dropped to $311 and then $308 but rallied to end the year at $321 per tonne. Reports of frost damage in Texas and Florida, purchases by Pakistan, negotiations by Mexico for imports following frost damage and reports that the Cuban crop was behind schedule all combined to bring the LDP up from $320.20 on January 1 to $350.40 on January 17. The announcement of an increase in the US supply quota had already been expected and so did not bring a further increase and prices remained fairly stable until January 25 when the LDP rose to $357.20 and then to $360.60 before falling back to end the month at $348.

White sugar had been the commodity in demand during the period and it was not surprising, therefore, that the premium over raws increased steadily during December when the LDP(W) started at $385 (a premium of $37) and ended at $380 (a premium of $59). The premium continued to rise during January, reaching a peak of $90.50 on January 15 but then began to fall to a level of $67.80 on January 25 after which it recovered partly, to end the month at $78.50, when the LDP(W) reached $426.50.

Turkey sugar situation[1]

Inflation pressures have led to price increases in Turkey and over the past year there have been three major rises in sugar prices. The wholesale price of granulated sugar rose from 600 lira to 790 lira per kilo in June 1989, to 910 lira the next month and at the beginning of December a further rise to some 1140 lira per kilo took place, making an increase of 90% in six months. Until a few years ago, the government subsidized sugar prices to consumers and more recently this policy has given way to one where the higher costs of inputs to production and farming are passed on to the consumer.

This is likely to have an impact on consumption which will also be affected by another poor level of domestic production this season. In 1988/89 it had been hoped that an area of 390,000 hectares would be planted to beet but farmers found beet prices disappointing and the beet area only amounted to 317,000 ha. Very dry conditions and rising prices of various inputs also reduced crop prospects and final production in 1988 barely exceeded 1.4 million tonnes, raw value.

The area was increased to 350,000 ha for 1989 but again the weather was dry and recovery in output was not as much as had been hoped for at 1.52 million tonnes. After crops of 1.7 - 1.8 million tonnes, production fell in 1986/87 to some 1.4 million tonnes when low world prices and export commitments to Iran and Iraq resulted in imports of some 225,000 tonnes in 1987. With higher world prices the option of importing sugar to meet the indicated deficit of around 100,000 tonnes will be more difficult.

Brazilian sugar export ban lifted

Bureaucracy in Brazil has been holding up exports of sugar from that country and have threatened Brazil's US supply quota. The sugar was due under contracts signed as long ago as 1984 but CACEX, the foreign trade department of the Banco do Brasil, has been fighting the proposals for months and had obtained an injunction against shipment on the grounds that it was illegal to export sugar under the cost of production. A court dismissed the injunction and ordered CACEX to issue export licences, whereupon an earlier agreement reached with five trading houses for shipment of around 150,000 tonnes of sugar could have taken place.

CACEX went back to the courts and got a ruling that the contracts were illegal but this has now been overturned[2]. Part of the shipments was sugar destined for the US under Brazil's supply quota. No sugar has arrived from Brazil since May and the US has been increasingly concerned over the failure to meet delivery dates set. The US Trade Representative had threatened to reallocate 125,940 tonnes of the quota (which had been due for delivery before December 31, 1989) if shipment had not started by February 5.

US sugar policy and the GATT

After the GATT panel report in May which accepted Australia's claim that the sugar import quota system was inconsistent with US obligations under the agreement, the US stated that it was intended to conform with the panel's finding. No action has been announced in the interim and towards the end of 1989 growers were indicating that they might not be able to survive GATT liberalization of world trade in sugar. A USDA study predicted that multilateral liberalization would result in a 69% cut in sugar prices and 42% drop in the quantity produced by the US industry. The Department assured the industry that it would protect commodities like sugar through a tariff rate quota, according to a vice-president of the Hawaiian Sugar Planters' Association, however, such quotas permitting imports of normal US needs with a prohibitive tariff above that amount[3].

At a meeting of the International Sugar Organization's Market Evaluation, Consumption and Statistics Committee at the end of November, the US representative presented a paper on his country's sugar policy and asserted that the US was under absolutely no obligation to make any changes whatsoever in its domestic sugar policy, although a review of policy so as to implement the panel's finding was still under way. The US Trade Represent-

1 *Czarnikow Sugar Review*, 1989, (1791), 173.
2 *Public Ledger's Commodity Week*, February 3, 1990.
3 *Reuter Sugar Newsletter*, November 6, 1989.

ative was reported[4] on January 20 as stating that it was expected that the review would be finished before the end of the GATT Uruguay Round of discussions on trade liberalization in December 1990.

The US has proposed under the Uruguay Round that all support measures should be converted to tariffs and that these should be eliminated over a period. This has met opposition from other countries and groups such as the EEC who seek a gradual reduction of existing support measures. The Round is supposed to be finalized by the end of 1990 but there is a wide difference between the positions taken up and a great deal of compromise will be needed if success is to be achieved. There seems to be little hint of such compromise and there are very many factors which may be taken as indirect support measures although not recognized as such by the parties concerned and their elimination or conversion to tariffs would be very difficult.

Sugar prices and HFS production

A study has been made, for discussion by the International Sugar Organization's Market Evaluation, Consumption and Statistics Committee, to seek better informed knowledge of the connection between sugar prices and HFS consumption. This relationship has been a source of debate, with extreme arguments that there is total dependence (i.e. that HFS would lose its market share but for high domestic support prices for sugar) and that sugar prices have no influence on production of HFS (because the latter is cheaper than sugar). Mathematical models were set up, including lag effects of prices, and applied to circumstances in several countries. Three main conclusions were drawn from the results of the study: (1) particular peaks in sugar prices were not solely responsible for expansion of HFS consumption, which was shown to depend on a range of past prices; (2) there does not appear to be a strong technical division between the shares of sugar and HFS in the sweetener market where, for some uses, the two are highly competitive and the price of sugar can affect the growth of HFS usage; and (3) HFS consumption growth in the US is not solely a function of the level of protected domestic sugar prices.

EEC farm price proposals[5]

The EEC Commission's farm price proposals were published on December 20, 1989. In common with nearly every other sector of the CAP, it is proposed that sugar prices be frozen for the 1990/91 marketing year. On their own, the price proposals appear to be the least controversial for many years, and they have been presented earlier than in any other year during the 1980's. They therefore stand a good chance of being agreed to fairly promptly by the Council of Ministers.

However, the agromonetary proposals could delay agreement, as they have done in recent years. The "green rate" proposals suggest national currency price rises in six member states but unpopular price cuts in West Germany and Spain. The continuing strength of the West German mark against other EMS currencies and the consequent threat of an EMS realignment, could place an added strain on the farm price negotiations.

The whole sugar policy will be up for review in 1991, with many schemes expiring at the end of the 1990/91 marketing year, while many others are long overdue for a critical review, for example, raw sugar refining aids, regionalization amounts and national subsidies.

US sugar supply quota

Frosts at the turn of the year affected the cane crops in Florida and Texas, although the Louisiana crop had been harvested for the most part and was unaffected. The freeze damage led to reduced sugar estimates and a lower than expected beet sugar output plus non-arrival of sugar from Brazil led to a tight sugar supply position within the United States. Following representations from the Sweetener Users' Association, the USDA increased the sugar supply quota by 325,000 tonnes, raw value, with effect from January 18. Panama's previously reallocated quota amount of 30,557 tonnes has been restored and is included in the current allocation of 69,312 tonnes which for the moment remains suspended and is not allowed to be shipped. The increases and the new quotas, which apply to the period January 1989 to September 1990, are as follows[6]:

	Increase	New quota
	tonnes, raw value	
Argentina	11,829	104,160
Australia	22,833	201,054
Barbados	1,926	16,957
Belize	3,026	26,646
Bolivia	2,201	19,379
Brazil	39,888	351,238
Canada	3,026	26,646
Colombia	6,602	58,136
Congo	1,855	16,070
Costa Rica	5,858.5	49,758.5
Dominican Republic	48,416	426,331
Ecuador	3,026	26,646
Fiji	2,476	21,737
Gabon	1,855	16,070
Guatemala	13,204	116,272
Guyana	3,301	29,068
Haiti	1,855	16,070
Honduras	5,754	47,490.4
India	2,201	19,379
Ivory Coast	1,855	16,070
Jamaica	3,026	26,646
Madagascar	1,855	16,070
Malawi	2,751	24,127
Mauritius	3,301	29,036
Mexico	1,855	16,070
Mozambique	3,576	31,490
Panama	38,514	69,312
Papua New Guinea	1,855	16,070
Paraguay	1,855	16,070
Peru	11,279	99,316
Philippines	43,464	382,729
St. Kitts	1,855	16,070
El Salvador	8,191.5	71,034.1
Swaziland	4,401	38,757
Taiwan	3,301	29,068
Thailand	3,851	33,912
Trinidad	1,926	16,957
Uruguay	1,855	16,070
Zimbabwe	3,301	29,068
Specialties	0	1,815
Total	325,000	2,584,865

4 *Public Ledger's Commodity Week*, January 20, 1990.
5 E.D. & F. Man: *The Sugar Situation*, 1990, (464), 3.
6 *USDA News*, January 16, 1990.

Start-up of beet waste water treatment plants

By Dr. S. R. Pickin
(International Biochemicals U.K. Ltd., Slough, Berks., England)

For some UK beet sugar factories, the establishment of the National Rivers Authority means even more stringent control of waste water discharge and the possibility of severe costs or penalties should final effluent fail to meet consent standards. The seasonal nature of beet processing dictates that the effluent treatment plant operates in phase with production from October to April and then remains largely inactive for the remainder of the year.

Whilst this pattern brings yearly respite from the potential headaches of maintaining acceptable levels of effluent discharge, it often imposes problems of starting-up the biological treatment plant effectively in preparation for each new campaign. A typical aerobic plant includes holding/balancing lagoons, an aeration tank and a settling tank or clarifier from which clean final effluent is discharged to a watercourse or main drainage. The essential biological action takes place with the application of oxygen to the effluent in the aeration tank, often by use of powerful mechanical agitators. In all such systems, it is the presence of a resilient and vigorous population of active micro-organisms – the "biomass" – which degrades the waste matter and is the key to successful waste water treatment.

When sugar beet processing comes to a halt in March or April, the effluent treatment plant continues to treat any waste water held in lagoons until this is used up. The following season, conventional practice is to "re-activate" the system by running the aeration tank agitators for as much as a month before the start of processing. Generally, there will be an adequate volume of residual organic matter and accumulated rainwater to supply the aeration tank and at least give the appearance of readiness for the new influent from the factory.

Unfortunately, there is no guarantee that this practice will ensure the timely re-establishment of an effective biomass. The following treatment problems are common in this industry and they usually stem from a biomass that is ineffectual at best:

* High ammonia levels in final effluent.
* Excessive filamentous growth in the treatment plant leading to poor sludge settlement and unacceptable solids content in the final effluent.
* Poor BOD/COD removal because of inefficient degradation of influent components such as starches and celluloses.
* Inability to cope with peak organic or hydraulic loading.

Fortunately there exists a more scientifically controlled method of biomass start-up for seasonally operated or completely new plants. InterBio (UK) Limited are specialists in the application of biotechnology to industrial waste water treatment, starting "purpose-designed" biomass populations or, by augmentation, giving new life and vigour to a failing or ailing biomass.

InterBio's range of Biolyte systems are produced by isolating the most efficient and voracious micro-organisms for degrading a span of target waste components, adapting and stabilizing them and vastly multiplying the resulting strains. The resulting products take the form of dry granular material which is easily rehydrated and applied, easily stored for future use and quite harmless to man and the environment.

Each of these specially formulated microbial products is designed to deal with a particular spectrum of biological effluents treatment problems. Following diagnosis of a given problem, including on-site and laboratory analysis, the microbial products can be applied singly or in combination over a phased dosing program.

The solution or attempted solution of effluent treatment problems by methods such as restricting/modifying the plant influent or re-engineering the plant itself, are invariably costly and disruptive. In this context, biomass start-up or augmentation as outlined above can be highly cost-effective. It is also fast-acting with improvement in final effluent quality being achieved within a period of weeks, in many cases.

The recommended campaign start-up of a beet sugar effluent treatment system with Biolyte microbial strains involves a dosing program commencing ten days before the start of the campaign. The aeration tank should be filled with effluent from the holding lagoons and continue to be fed with effluent over this initial period. This method can achieve substantial power savings as well as establishing a tailor-made biomass because the agitators need be run for only ten days compared with the typical thirty days of conventional start-up practice.

Another negative factor in beet sugar process effluent treatment is the weather; the biomass is required to perform vigorously in the least conducive temperatures throughout the winter months. Cold conditions are particularly inhibiting for the nitrifying micro-organisms necessary to reduce effluent ammonia levels. Biolyte characteristics designed to alleviate this and the other common problems mentioned earlier, are outlined below.

Biolyte NC200 contains selected ammonia-oxidizing micro-organisms which quickly establish themselves within the biomass. Dosing of high-ammonia effluent with NC200 ensures that an active population of nitrifiers is present right from the start of the campaign and that ammonia content standards are met.

Excessive filamentous growth is suppressed by Biolyte MX10, a formulation of microbial strains which encourages the growth of good floc-forming bacteria, improves sludge settlement and ensures good final effluent clarity.

Poor BOD/COD removal is countered by the Biolyte CX70 formulation, which includes a combination of micro-organisms species selected for their ability to degrade starch, pectin, cellulose and a wide range of sugars. An effective biomass is established soon after application, increasing BOD/COD removal efficiency and improving sludge settlement characteristics.

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Treatment of waste water from molasses processing industries and sugar factories

By Lennart Huss and Fernando García Pascual

For the past 15 years the waste waters from the sugar industry have been treated with anaerobic processes of varying design. During this time the treatment efficiency has improved, making higher and higher reductions of organic impurities possible. The first anaerobic treatment plants at Spanish sugar mills were installed at the ACOR plants in Valladolid and Olmedo in 1985. At the same time it was decided to erect a plant at the SGAE "Carrion" sugar factory in Monzón de Campos. This plant, which treats water from the molasses distillery and the sugar factory, was started up in 1986. At the EBRO sugar factory in Venta de Baños a plant was started up in 1988, and in 1989 the fifth anaerobic plant for sugar factory waste water was started up the at the CIA Salamanca sugar factory. This report will present the results from the plants at Venta de Baños and Carrion.

The Venta de Baños sugar factory

This sugar factory, which processes sugar beets during October - January, has a capacity of 4500 tonnes per day and it is planned to extend this to 6000 tonnes a day. The capacity of the installed Anamet plant will still be sufficient after this extension. There is a molasses distillery at the sugar factory with a capacity of 70,000 litres 100% ethanol per day. The slop from this distillery is evaporated and the condensate from the evaporation is sent to the treatment plant together with waste water from the sugar factory. The distillery is operated about 300 days a year, and thus the Anamet plant treats waste water from only the distillery when the sugar factory is not in operation. By feeding part of the slop from the distillery to the waste water without evaporation, the concentration of organic pollutants (COD) in the waste water can be increased. By converting these into methane gas which is burnt in a steam boiler, energy is produced which can be used for production of steam for alcohol distillation and evaporation of the slop.

Design of the treatment plant

The Anamet plant is designed for a waste water flow of 3600 m^3/day, having a COD load of 27,000 kg/day and a COD/BOD_5 ratio of 1.5, to produce a purified effluent having a BOD_5 content of 30 mg/litre.

The process design of the plant is shown in the flow sheet in Figure 1. In principle the plant consists of one anaerobic and one aerobic totally mixed biological treatment stage, each provided with a sludge separation system and recirculation of biological sludge. The biogas produced is burnt in the factory steam boiler.

The plant is designed with all reactor vessels in steel and with circular tanks to make the plant cost efficient. All tanks are connected in series with the anaerobic reactor furthest back and the aerobic final sedimentation at the front. The volume of the anaerobic reactor is 6750 m^3. A lamella sedimentation unit for the anaerobic sludge, with a sedimentation area of 315 m^2, is used. The volume of the aerobic reactor is 2000 m^3 with an oxygen transfer capacity of 50 kg O_2/hour. The final sedimentation is in a normal horizontal flow clarifier with an area of 215 m^2.

Result

The plant was started up during the 1988 sugar campaign. The organic load measured as COD appears in Figure 2.

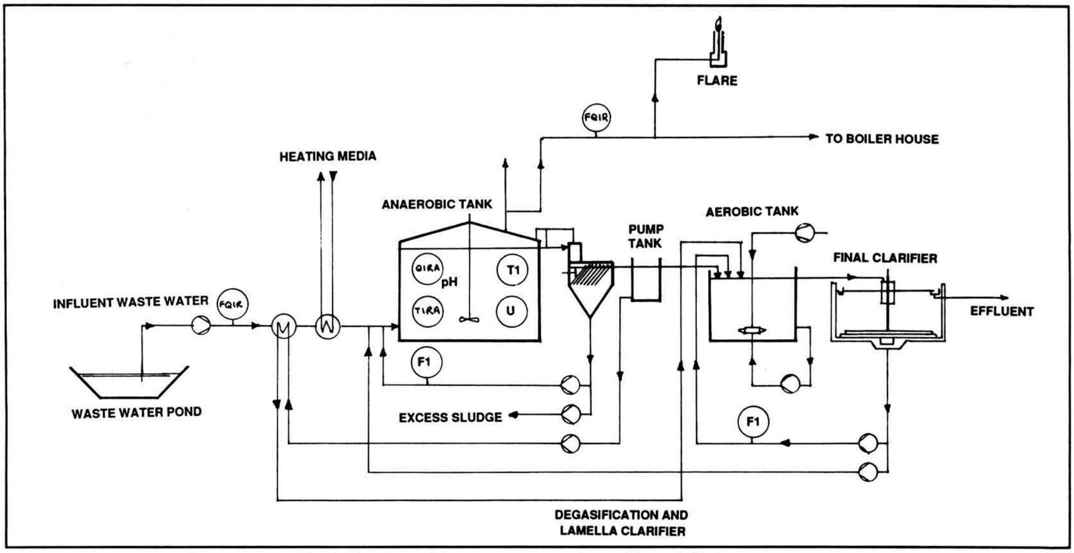

Fig. 1. Flowsheet of Anamet treatment plant at Venta de Baños

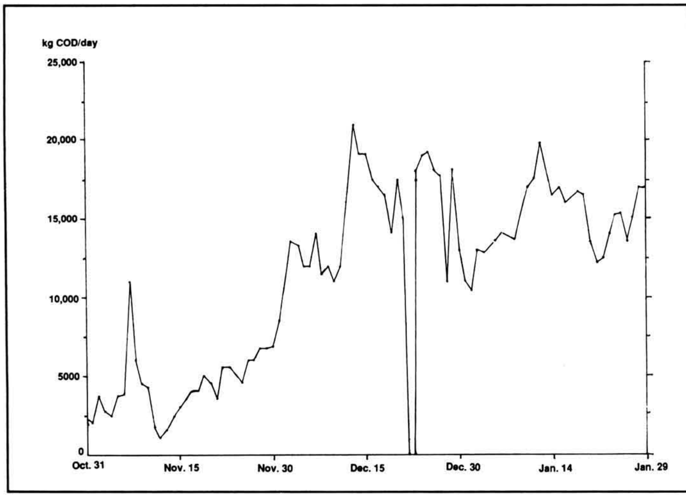

Fig. 2. Organic load at Venta de Baños, 1988/89 campaign

After about 1 month's low load during the first start-up phase, the normal load for the campaign – about 15 tonnes COD/day – was reached.

The results reached at this load are shown in Figure 3. A COD reduction of 96% was reached in the anaerobic stage and a total COD reduction of 99% was reached after the anaerobic and aerobic treatment. Very few BOD_5 measurements were made at the plant. The measurements during the performance test period on January 20, 1989 showed the following results:

	mg/litre BOD_5	Reduction, %
Influent	3750	–
Effluent anaerobic sedimentation	95	97.5
Effluent aerobic sedimentation	10	99.7

The biogas production reached the theoretical value, about 0.35 Nm^3 CH_4/kg COD reduced, with a methane concentration in the biogas of about 70%. Lime is used in the beet flume and wash water to keep the pH at a sufficiently high level. This results in high concentrations of Ca^{++} in the waste water, about 500 - 1160 mg/litre. Much of this calcium is precipitated in the anaerobic stage as $CaCO_3$, reducing the content of Ca^{++} in the waste water to about 250 mg/litre. The precipitated $CaCO_3$ accumulates in large quantities in the anaerobic sludge, of which it comprises 70 - 75%, the remainder being organic matter. By the accumulation of biomass during the first campaign also the calcium sludge accumulated to the effect that, at the end of the campaign, a TSS content of 24.9 g/l was reached out of which 6.1 g/l was VSS. The anaerobic reactor is equipped with a roof-mounted, mechanical agitator, hanging from a free-swinging shaft with one impeller at the surface and another just above the bottom of the tank. By this unique mixing design sludge deposits in the reactor can be avoided in spite of the high content of $CaCO_3$ in the sludge.

The results achieved at the sugar factory compare very well with those from other installations e.g. the Südzucker factory at Zeil, where COD reduction of 99% and a BOD reduction of 99.9% are obtained.

The Carrion sugar factory and distillery

In 1986 an Anamet plant of a somewhat special design was installed at the Carrion sugar factory and distillery. The waste waters treated include that from a molasses-based distillery with a daily capacity of 55,000 litres 100% ethanol produced from 195 tonnes of molasses as raw material. The distillery is in operation 200 - 300 days a year, depending on the market situation for ethanol. The sugar factory, having a capacity of 3000 tonnes of beets/day, is in operation from October to January. The waste water from the sugar factory is stored in ponds close to the factory

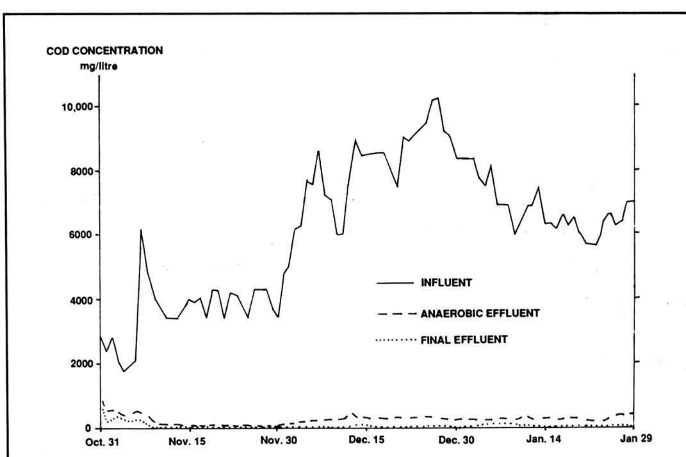

Fig. 3. COD concentration at Venta de Baños, 1988/89 campaign

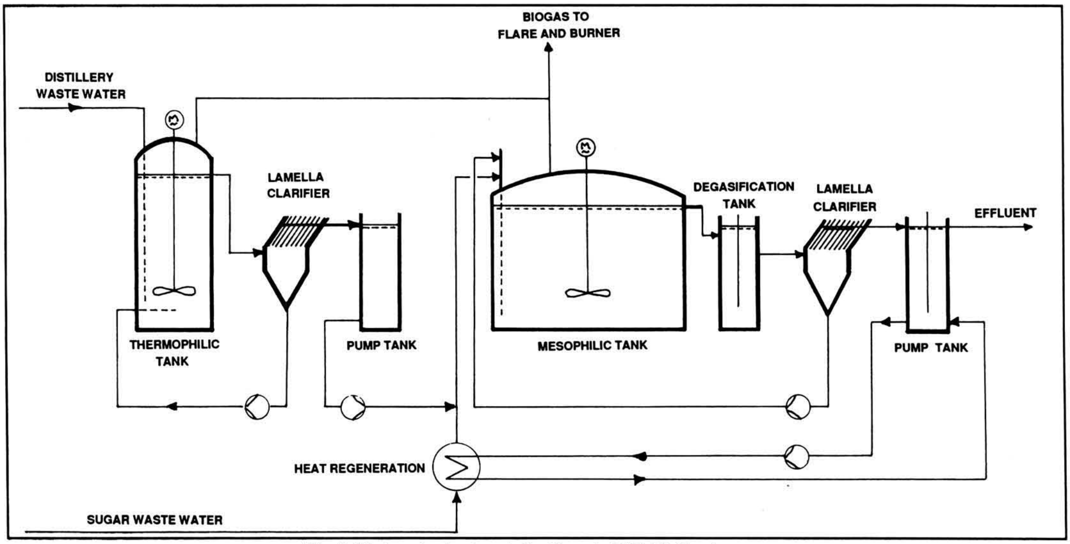

Fig. 4. Waste water treatment plant layout at CGAE, Carrion

area and is fed to the waste water treatment plant all the year round. Waste water characteristics that this treatment is designed for can be seen in Table I.

Design of the Carrion plant

The extended waste water treatment plant at Carrion consists of two anaerobic stages connected in series, the first stage thermophilic and the second stage mesophilic. An extension of the plant with a subsequent aerobic stage will take place during 1990. The anaerobic stages are both designed as totally mixed anaerobic reactors with top-mounted agitators and with lamella sedimentation for separation of biological sludge. The lay-out can be seen in Figure 4. The thermophilic reactor is fed with waste water from the distillery only, while that from the sugar factory is fed to the mesophilic reactor. The volumes of the two reactors are 3500 m^3 and 7900 m^3, respectively.

The temperature of the slop is controlled by heat exchanger in the distillery to 55 - 58°C. The temperature of the factory waste water is controlled by recovery heat exchange from the effluent. The reason for treating the distillery waste first in a thermophilic anaerobic process and then in an anaerobic mesophilic process is to achieve a maximum reduction of organic material. The thermophilic stage also works as an acidification step before the mesophilic treatment.

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Table I.

		Distillery	Sugar factory	Total
Flow	m^3/day	500	1250	1750
	m^3/hour	21	52	73
COD	kg/day	42500	2500	45000
	mg/litre	85000	2000	25700
BOD_5	kg/day	30500	1500	32000
	mg/litre	61000	1200	18300
N	mg/litre	<7500	<500	<2500
SO_4^{--}	mg/litre	<6150	0	<1760
Temperature, °C		80	>0	–

Table II.

COD load average	40 tonnes/day
Methane gas production	15,000 - 20,000 m^3/day
Gas yield	0.4 m^3 CH_4/kg COD added
Chemical consumption	0.5 l conc. HCl/m^3 slop + micronutrients

	COD kg/m^3	BOD kg/m^3	COD reduction, %	BOD reduction, %
Influent	85	63	–	–
Effluent thermophilic	68	–	20	–
Effluent mesophilic*	8	3	71	85

* Dilution with sugar factory waste water 2.1:1

Waste water treatment in a sugar factory

By C. Naehle
(Süddeutsche Zucker-AG, Mannheim, Germany)

Introduction

The main difficulty encountered by the beet sugar industry in the cleaning of the waste water is that the latter is produced only for a short time, i.e. during the campaign. The amount of the flume-wash water stream in a sugar factory depends on climatic conditions, which means on the dirt carried by the beets into the factory.

The amount of waste water in a sugar factory has been reduced in recent decades from 15 m^3 to 0.8 m^3 per tonne of beets by the introduction of closed circuits, for example the use of condensates instead of fresh water for the extraction step.

The water treatment techniques in use are biological in nature and so it is necessary that at the beginning of the campaign the biological treatment plant is already adapted to the water to be cleaned. Several technologies for the treatment of waste water in a sugar factory are available today. First of all, however, it is necessary to separate the water streams with high pollution from those with low pollution.

The highly polluted waters are the decanted flume water, the beet wash water, the waste water from the ion exchangers and several cleaning waters from the factory. The highly polluted water streams with COD contents of several thousand mg per litre can be treated anaerobically. The technology of anaerobic waste water treatment in the sugar industry has undergone a tremendous development during the last decade. Sixteen anaerobic plants are operating the West German sugar industry, four of them in Südzucker factories. Different systems are employed but the main one is the sludge contact process.

The less polluted waste waters include the surplus condensate or excess condenser water in cases where condensate has been used to fill up the condenser water circuit. These are usually treated only aerobically either by lagooning or in activated sludge plants. The other water streams of a sugar factory, such as cooling water or sealing water are normally not polluted with organic substances and they should not be treated biologically.

Anaerobic treatment

The biological degradation of organic matter is carried out in three steps. In the first step, organic acids such as propionic acid, carbon dioxide, hydrogen and other low molecular weight substances like alcohols, are produced. This phase is called acidification. In the second step the products from the first are converted to acetic acid. This is the acetogenic phase. In the third step – the methanogenic phase – the bacteria produce biogas from the acetic acid formed, carbon dioxide and hydrogen. These different phases are shown in Figure 1.

In a sugar factory the first acidification step takes place in the lagoons which are used for the sedimentation and storage of the earth. During the acidification here the pH is uncontrolled and falls from 11 to about 6. The waste water after the acidification contains mainly acetic, propionic and butyric acids. It also contains lactic acid to an extent depending upon the residence time in the acidification stage.

The second and third steps of the anaerobic treatment occur in an anaerobic plant. Figure 2 shows schematic diagrams of various anaerobic treatment processes.

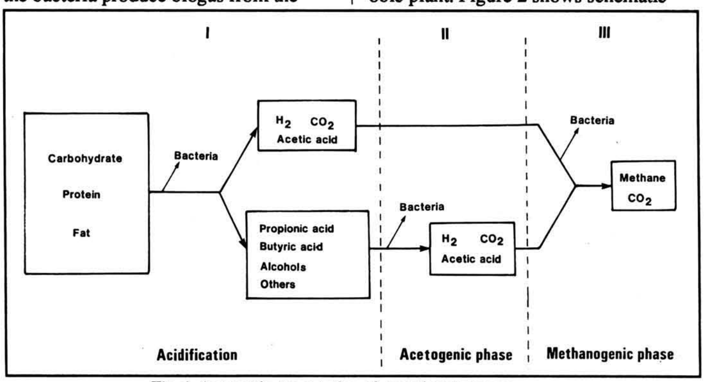

Fig. 1. Anaerobic degradation of organic substances

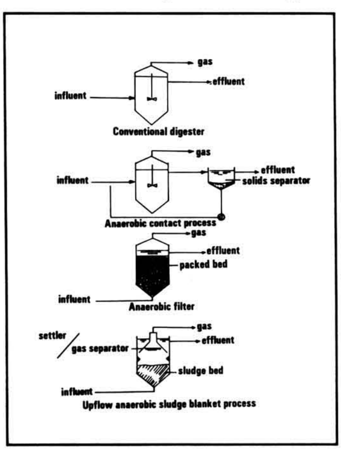

Fig. 2. Schematic diagrams of various anaerobic treatment processes

The plants installed in the West German sugar industry work mainly according to the contact process. Such a plant consists of a methane reactor or digestion tower, a degassing unit and a sludge clarifier. The mixing in the digestion tower is carried out by mechanical stirrers or through injection of biogas. The degassing unit is equipped with a stirrer and in many cases with a vacuum pump.

The sludge clarifier consists of a simple settling tank or a plate settling tank. The plate settling clarifier can either be incorporated directly into the top of the digester or it can be installed outside of it. Figure 3 is a schematic

Paper presented to Int. Sugar Conf. (Killarney, Ireland), 1989.

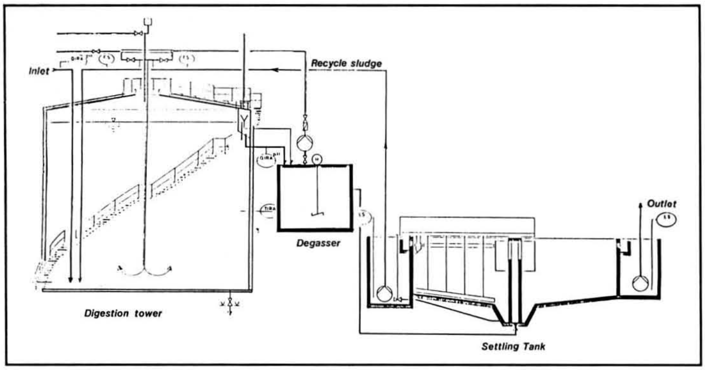

Fig. 3. Anaerobic waste water treatment plant at Offstein factory

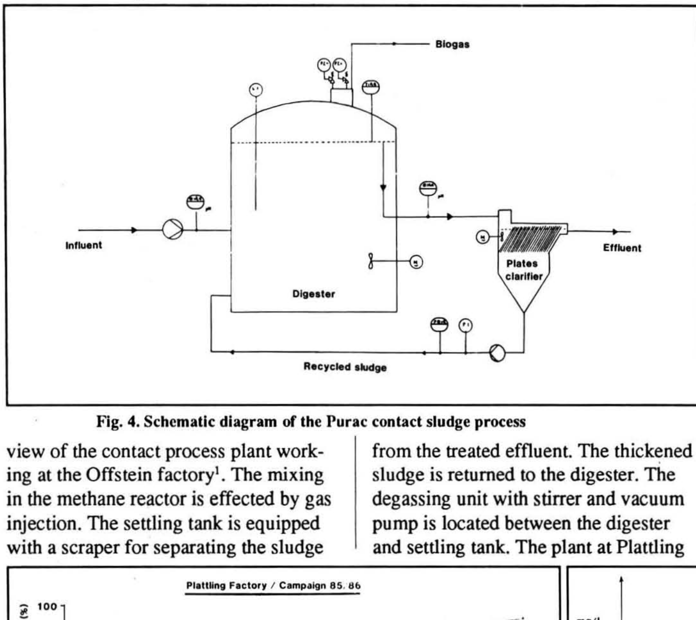

Fig. 4. Schematic diagram of the Purac contact sludge process

view of the contact process plant working at the Offstein factory[1]. The mixing in the methane reactor is effected by gas injection. The settling tank is equipped with a scraper for separating the sludge from the treated effluent. The thickened sludge is returned to the digester. The degassing unit with stirrer and vacuum pump is located between the digester and settling tank. The plant at Plattling factory is similar to that at Offstein.

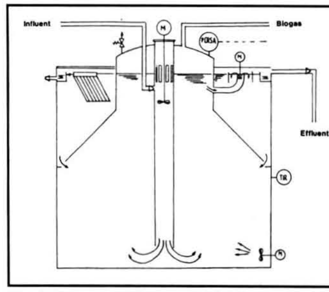

Fig. 5. Schematic diagram of the Sulzer contact sludge plant

Figure 4 shows a contact process plant with a plate settling tank situated outside the digester. The mixing of the methane reactor is effected with mechanical stirrers, similar to the plant shown in Figure 5, in which the plate settling clarifiers are integrated in the top of the digester. This is a new type of anaerobic plant built by Sulzer. Such a plant has been working at the Regensburg factory since the 1988 campaign.

An anaerobic plant can be started either with adapted sludge from another such plant or with municipal digested sludge. In the second case an adaptation period of approx. four weeks is necessary to reach an efficiency better than 90%. The reason for the necessity of adaptation is that the bacteria in the municipal sludge are not able at first to degrade the propionic acid.

Figure 6 shows the efficiency of COD degradation (weekly averages) at the plant in Plattling during the first

1 Schiweck *et al.*: *I.S.J.*, 1985, **87**, 232 - 238.

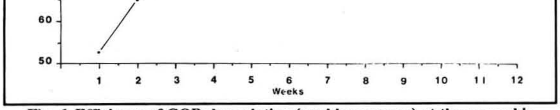

Fig. 6. Efficiency of COD degradation (weekly averages) at the anaerobic plant of the Plattling sugar factory

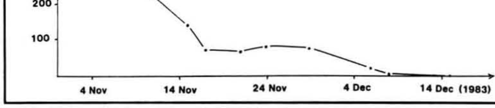

Fig. 7. Propionic acid content in the effluent (anaerobic treatment plant at the Offstein factory)

campaign, while Figure 7 shows the degradation of propionic acid at the Offstein factory during the start-up in the first campaign.

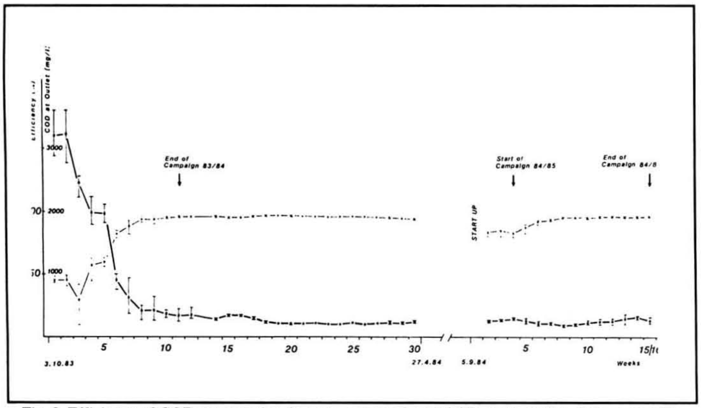

Fig. 8. Efficiency of COD degradation (weekly averages) and COD at the outlet of the anaerobic waste water treatment plant at Offstein factory

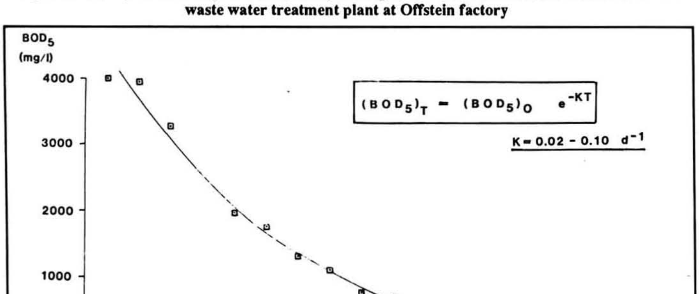

Fig. 9. Waste water treatment by lagooning at the Gross-Gerau factory

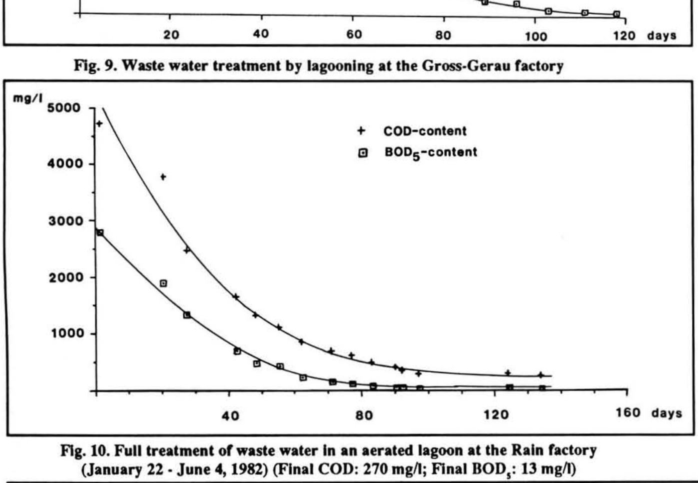

Fig. 10. Full treatment of waste water in an aerated lagoon at the Rain factory (January 22 - June 4, 1982) (Final COD: 270 mg/l; Final BOD_5: 13 mg/l)

The anaerobic process is very stable, if the working conditions are uniform. So it is necessary that the process temperature is kept constant at about 35°C. The pH is normally self-regulated in the process, because the buffering capacity in the waste water is very high; about 2000 mg $CaCO_3$/litre. Addition of alkali is necessary only if the waste water pH is so low as to depress the process pH under 7.

After the adaptation of the sludge the COD degradation efficiency of an anaerobic plant with uniform working conditions is higher than 90%. Between campaigns the sludge can be stored in the plant itself. Figure 8 shows that the restart with the stored sludge occurs without problems.

With the anaerobic process a specific sludge loading of 2.0 - 2.5 kg COD per kg organic matter per day can be attained[2]. The most important aspect of the anaerobic technique is the sludge separation, because the amount of suspended matter in the effluent, i.e. the sludge loss, should not be higher than the production of new sludge, which amounts to about 5 kg organic matter per kg COD degraded per day.

The sludge clarifier should be designed for an upward flow rate of 0.2 to 0.25 m/hr, irrespective of the type of clarifier. This has been found to give a good quality effluent.

A special characteristic of the waste water in a West German sugar factory is its high calcium content. The reason is that flume water is treated with lime in order to control bacterial growth, to improve the settling of dirt in the mechanical decanters and to maintain the quality of washed beets during storage. It is known that calcium is precipitated as calcium carbonate in the system. This is the reason why an efficient mixing system has to be installed in the digester to avoid the formation of deposits.

The specific biogas production in the anaerobic treatment of waste water is about 0.4 m^3 per kg COD degraded. The content of methane in the biogas is about

2 Nähle: *Zuckerindustrie*, 1984, 109, 19 - 27.

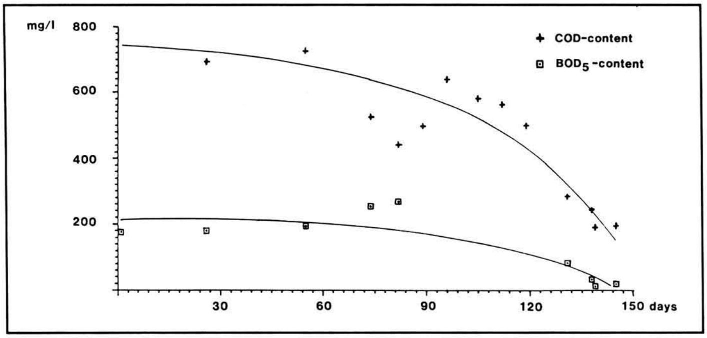

Fig. 11. Aerobic post-treatment of anaerobically treated waste water by lagooning in a sugar factory (February 22 - July 18, 1984) (Final COD: 196 mg/l; Final BOD_5: 18 mg/l)

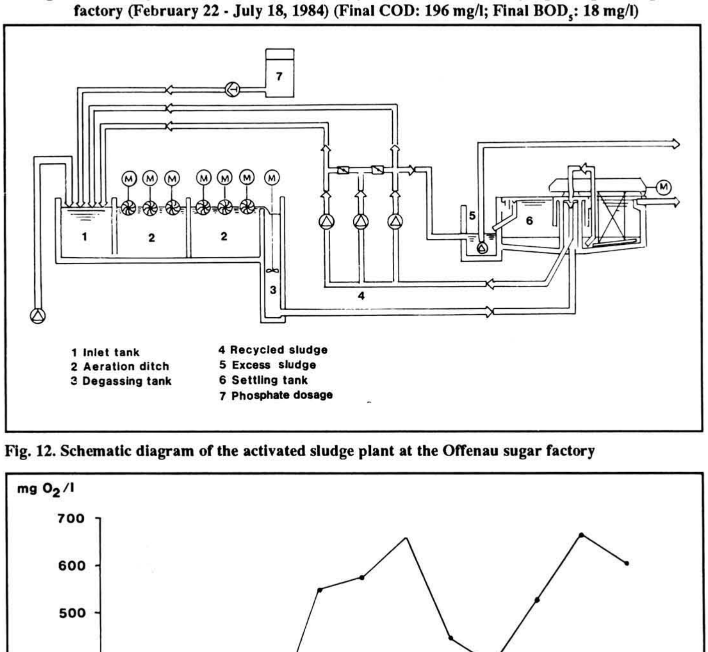

Fig. 12. Schematic diagram of the activated sludge plant at the Offenau sugar factory

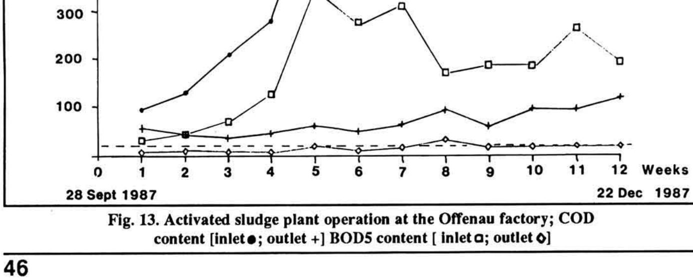

Fig. 13. Activated sludge plant operation at the Offenau factory; COD content [inlet ●; outlet +] BOD5 content [inlet □; outlet ◇]

70 to 80%. Usually the biogas produced is used either in the boiler house or at the pulp drying station.

Following the anaerobic treatment the waste water is usually treated aerobically. This aerobic post-treatment can be carried out in aerated lagoons or in an activated sludge plant. The aerobic treatment often includes the purification of excess condensate or condenser water.

Aerated lagoons

Treatment by lagooning is the oldest waste water purification technique of the sugar industry. Lagoons offer great ecological safety because their volumes are so large they can always store any amount of waste water in each campaign.

Lagoons are used in the sugar industry for the full treatment of the waste water and for the post-treatment of anaerobically digested water[3]. The COD and BOD_5 reductions obtained in aerated lagoons are very high, in fact amounting to about 90% for the COD content and about 97% for the BOD_5 content.

The reduction of the pollution can be described as an exponential function (Figure 9). Purification in aerated lagoons depends mainly on the temperature, the kind of waste water and the oxygen content. The value of the degradation constant K ranges from 0.02 to 0.10 d^{-1}. Figure 10 shows the degradation curve for the full treatment of waste water in a lagoon at the Rain factory in 1982.

The aerobic purification of anaerobically treated water is shown in Figure 11. The characteristic of the degradation curve is different, because the easily degradable substances of the waste water have already been eliminated in the anaerobic plant.

To avoid mal-odour in the full treatment of the waste water, it is necessary that the aeration facility in the lagoon should be in accordance with the oxygen requirements, i.e. according to the pollution (COD content) level. The

3 Nähle & Pellegrini: *Korrespondenz Abwasser*, 1989, (1), 57 - 60.

ISJ Abstracts

Cane sugar manufacture

Chemicals in sugar manufacture: new trends

D. P. Kulkarni. *Bharatiya Sugar*, 1989, **14**, (8), 29 - 30, 33.

Chemicals used in sugar manufacture are reviewed, including: biocides employed as cane mill disinfectants; magnesium oxide, settling aids (particularly polyacrylamides) and surface-active agents used in clarification; amylase to remove starch and dextranase to eliminate dextran; scale and corrosion inhibitors employed in evaporators as well as scale-removal agents such as sulphamic acid and ethylene diamine tetraacetic acid (EDTA) as chelating agent; surface-active additives such as manganous sulphate in boiling; and miscellaneous chemicals applied in equipment cleaning and boiler water treatment.

Electronics and control systems in the sugar industry

M. Bharadwaj. *Bharatiya Sugar*, 1989, **14**, (8), 35, 37, 39 - 40.

The advantages of electronic instrumentation and control systems and the reluctance of operators in Indian sugar factories to adopt them are discussed. Some factors relating to automation are examined, including the requirements of staff needed to operate and maintain the systems.

Availability of natural gas in India and its use in sugar factories for cogeneration and bagasse fibre saving for the paper industry

D. P. Sharma. *Bharatiya Sugar*, 1989, **14**, (8), 59 - 60, 65, 67.

See *I.S.J.*, 1990, **92**, 2A.

Use of spiral trough tubes in heat exchangers

K. Wang, T. Li and Q. Lin. *Sugar J.*, 1989, **52**, (2), 13 - 15.

Experiments on clarified juice heating with steam are reported in which one of two heaters (A) was fitted with smooth copper tubes while the other (B) had tubes with an outside concave spiral trough so that the inside had a spiral protruberance with a pitch of 25 mm and a trough depth of 1 mm. Results showed the heat transfer coefficient in B to be 50 - 200% greater than in A where scaling caused a much more rapid fall in the value. There was less scale in B and it was friable and hence easily removable. Pressure drop in B was only slightly greater (0.01 - 0.06 MPa) than in A. In B the juice was heated from 96.7 - 106.7°C to 104.6 - 116.45°C. The mechanism of juice and heat flow along the spiral tube is analysed.

Specialized equipment and chemicals produce VLC sugar

S. Quaiyoom. *Sugar y Azúcar*, 1989, **84**, (8), 18 - 19, 22.

In a process for VLC (Very Low Colour) sugar manufacture, flocculant is mixed with juice before clarification; the juice enters a preflocculator tangentially so as to create a swirling motion with low shear action. Solids such as bagacillo are removed by screening. After clarification, the juice is evaporated and then transferred to a micronizer where air is drawn in and the bubbles that form are broken into micro-bubbles to turn the syrup into an emulsion. The flocs and solid impurities attached to the bubbles are removed by flotation in subsequent clarification with polymer. The process is expected to give a sugar of 120 - 250 ICUMSA colour units and a turbidity of 20 - 50 ICUMSA units.

Factory research in South Africa

Anon. *Ann. Rpt. Sugar Milling Research Inst.*, 1988/89, 8 - 15.

The effect of tops and trash on cane milling: The effects of four different cane harvesting treatments on factory performance were determined in experiments which showed that by far the best boiling house recovery (91.3%) was obtained (i) when the cane was burnt and topped before delivery, while 87.5% was achieved with burnt, untopped cane which, however, gave approximately the same *A*-sugar colour (872 ICUMSA units) as in (i) while the hourly cane throughput was 190 as against 180.6 tonnes. Where cane was unburnt but topped the boiling house recovery, sugar colour and cane throughput were 84.4%, 1284 units and 140 tonnes/hr, respectively, while the corresponding values for unburnt, untopped cane were 83.7%, 1784 units and 127 tonnes/hr. Higher costs resulting from transport and crushing of unburnt, untopped cane are mentioned.

Diffuser operating conditions and performance: A survey of five diffusers having hourly capacities equivalent to 150 - 400 tonnes of cane showed that over 70% of the sugar was extracted from cane during the first 16 - 20 minutes of diffusion. More acetic acid than lactic acid was formed, the latter being produced mainly in the central part of the diffusers while acetic acid was formed chiefly in the front and back ends and in the press water. Severe corrosion was found in those units operating at a low pH; on the other hand, it was previously found that a high pH could lead to formation of acetic acid by hydrolysis of bagasse.

Washing in centrifugals: Investigations on both laboratory and factory scales showed that it was practical to replace *A*-centrifugal wash water with 65°Bx evaporator syrup at 60°C to obtain VHP sugar; in the factory, the syrup wash of 6 - 8 sec was followed by a 1-sec steam or hot water wash, and no difficulties were experienced in handling the sugar before and after drying. Although a longer wash was required with the syrup than with water, *A*-massecuite exhaustion was about 1 unit higher because of the reduction in crystal dissolution in the centrifugal; this also reduced energy consumption and the equipment needed for crystallization, while the amount of water to be evaporated in the pans fell by about 1.4 tonnes/hr in the average South African factory. Some modifications are required to the wash water piping to accommodate syrup, but the same spray nozzles may be used.

Sucrose degradation in molasses: The pH of final molasses at two factories with high undetermined losses was found to be lower than at other factories; heating molasses samples for 48 hours at 70°C revealed a pH-dependent stability of molasses sucrose and showed that in most cases the sucrose loss through heating could be reduced by raising the pH before heating.
Chemical colour removal in raw sugar manufacture: In decolorization tests with a number of chemicals, bentonite was found to be economically unjustifiable for juice and syrup clarification; sulphitation proved to be the most economical means of colour removal, with the cost effectiveness of the various sulphur compounds in the following decreasing order: sulphur dioxide > sodium bisulphite > sodium hydrosulphite > sodium sulphite. In the raw house, however, the cost of using these chemicals was greater than the colour penalty applied to export sugar and was greater than the cost of decolorization in a refinery.
The quantities and fate of nitrogen entering sugar factories: A procedure developed for total N determination was used to measure the N content in weekly composite samples of mixed juice from South African factories. The content varied from factory to factory and was strongly influenced by the suspended solids content in the juice. The loss of total N experienced across a factory was attributed to the removal of solid material during clarification and to losses in the form of ammonia during evaporation and crystallization; over 50% of the amino-N found in mixed juice was lost or converted to other nitrogenous compounds.
A transducer for measuring mill roller lift: While the linear variable differential transformer (LVDT) measures displacement by using a magnetic core sliding on the axis of three magnetically coupled coils to produce an output voltage that is proportional to displacement, it is not generally suitable for application in a cane mill environment and is rather expensive. However, a SMRI-designed mill lift transducer based on the LVDT has a linearity and accuracy 1% of the reading; it has a measuring range of 50 mm and an output signal of 4 - 20 mA, and particular attention has been paid to its rugged construction and sealing.
Kinetic investigations into the hydrolysis of acetyl groups in bagasse: Acetic acid produced from bagasse during diffusion as a result of overliming is volatilized during evaporation and may cause severe corrosion of piping and of vacuum pan calandrias. The effects of pH and temperature on bagasse hydrolysis were determined in a laboratory diffuser; results showed that a unit increase in pH caused a 9-fold increase in the acetate ion concentration which rose by 2.6 times as a result of a 10°C rise in temperature. A mathematical model of diffusion was of help in predicting acetate formation under defined conditions of pH, temperature and residence time. Acetyl hydrolysis was insignificant if the juice was not limed.
Bagasse dewatering: Determination of the moisture content in pressed bagasse samples from a number of factories confirmed that cane variety and nature of the bagasse as well as mill settings and operation affect moisture removal.
Energy management: A steam balance computer program developed by SMRI for an IBM microcomputer provides means for calculation of desuperheat water, condensate flashing, boiling point elevation, vapour recompression and return bleed parameters. The effectiveness of the program was assessed by carrying out a theoretical steam balance for all South African sugar factories using input data available on file at the SMRI. The program is offered for sale to sugar companies some of whom are already using it in their energy management campaign.

How to care for your pH system - the critical part

M. M. Bharadwaj and P. Sohoni. *Bharatiya Sugar*, 1989, **14**, (9), 25 - 27, 29 - 30.

Sampling of a process stream and factors to be considered in general as well as in particular regard to mixed juice and syrup are discussed and advice given on maintenance of a pH measuring system, including explanations of the role played by the various components.

A computer control system for cane juice sulphitation pH control

Y. C. Hsiao, C. H. Chen, H. M. Chen and M. D. Huang. *Taiwan Sugar*, 1989, **36**, (3), 13 - 16.

See *I.S.J.*, 1989, **91**, 115A.

Cane juice clarification by the action of open steam

N. Martinez, P. Fabregat, L. D. Bobrovnik, P. M. Nemirovich and A. P. Nikolaev. *Izv. Vuzov, Pishch. Tekh.*, 1989, (2), 120 - 121 *(Russian)*.

Experiments at four Cuban sugar factories showed that treatment of juice with 7 - 8 × 10^{-2} kg of steam/kg at a pressure of 0.65 - 0.80 MPa and a temperature difference of 5 - 6°C increased the settling rate by 50 - 60% in subsequent clarification and gave a clear juice of greater transparency and of lower Ca, Mg, phosphate and colour content; the colloid content fell by 40 - 50% by comparison with untreated juice while the clarification efficiency rose by 50 - 60%. At a greater steam usage than given above there was increased sucrose hydrolysis with a resultant rise in the reducing sugars content as well as an undesirable degree of dilution.

Reverse osmosis concentration of mixed juice

D. Hsu. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 46 - 47.

In a study of mixed juice concentration by reverse osmosis, repeated cleaning of the ZF 99 membrane with NaOH and a detergent at a higher temperature of 65°C (as against 40°C originally recommended by the manufacturers, Paterson Candy International Ltd.) failed to reduce the permeate conductivity to below 2.5% of the feed conductivity although it increased the permeate rate to an acceptable level of 48 litres/hr/m²; in fact, there was evidence that repeated cleaning caused further deterioration of the membrane rather instead of restoring it to its original efficiency, so that it would not be suitable for juice concentration, and there will be no further RO experiments until a membrane of higher resistance to fouling is available.

Simultaneous concentration and de-ashing of clarified juice by nanofiltration

D. Hsu. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 47 - 48.

Rapid advances in manufacturing techniques have enabled semipermeable membranes of a much more uniform pore size to be made for e.g. the separation of salts from sucrose; these nanofiltration membranes have a sucrose rejection rate ranging from 9% to >99% and a monovalent ion rejection rate of <70%. Since the ash in juice is mostly K^+ and Cl^-, the membranes can be used for simultaneous removal of water and ash, and certain membranes able to withstand temperatures of 100°C or higher could possibly be used to treat clarified juice. Laboratory experiments at 40°C showed a significant drop in permeate rate only during the first two hours, while typical sucrose and ash rejection rates were 99.4% and 41.6% with losses of 0.01% and 1.36% per pass, respectively, at 600 psig, and corresponding values of 99.2%, 34.8%, 0.02% and 1.46% at 500 psig; there was little or no permanent fouling of the membrane.

Molasses de-ashing by electrodialysis and by counter-diffusion

D. Hsu and B. J. Somera. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 48 - 49.

Tests on molasses exhaustion after electrodialysis showed that, although treatment led to a fall in purity, this decrease was significantly lower than that predicted by calculation; moreover, the difference between the true and theoretical purities increased significantly with the level of de-ashing. The difference between the two sets of values could have been due to a possible effect of electrolyte such as sulphuric acid (used in the electrode compartments and possibly entering the molasses during de-ashing) on sucrose solubility. Another method of molasses de-ashing, counter-diffusion, consumes much less energy than electrodialysis and does not introduce any foreign substances into the feed, although it is characterized by a higher trans-membrane sucrose loss.

Biocide test at the McBryde Sugar Company factory

K. M. Onna and W. K. Hashimoto. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 49.

Midland Laboratories' PCS 6001 (a biocide containing 15% each of sodium dimethyldithiocarbamate and disodium ethylenebisdithiocarbamate plus 70% inert material) was added to knifed cane at 6.2 ppm and to last mill juice at 11.6 ppm (on prepared cane weight) on alternate days. Statistical analysis of the results showed that treatment increased the purity of filtered juice and syrup and less so that of clarified juice, while any effect of 1st expressed juice and mixed juice purity was considered non-significant.

Laboratory simulation of *B*-magma boiling

B. J. Somera and T. Moritsugu. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 55 - 56.

Comparison of factory and laboratory data for boiling on a syrup and on a *B*-magma demonstrated the superiority of the *B*-magma system over the syrup system and showed better colour of *A*-massecuite, *A*-sugar and raw sugar in the factory than in the laboratory. Projected values also showed how the factory pan performance could be further improved. A high correlation (r = 0.99) was established between crystal colour and massecuite colour; all things being equal, the greater the reduction in massecuite colour achieved by *B*-magma boiling, the greater will be the decrease in sugar colour.

Studies on extended storage of very-low-colour sugars

T. Moritsugu and S. Goya. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 56 - 57.

Results of studies on storage of VLC raw sugar for varying periods at the Honolulu terminal warehouse and at Aiea refinery warehouse are summarized; in general, it was found that sugars having acceptable deterioration factors may be stored safely for up to 6 months without loss of dry pol and with only a 10% increase in colour.

Energy saving in Hawaiian sugar factories

M. H. Bagley and C. M. Kinoshita. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1988, 62 - 64.

An examination of the energy efficiency of Hawaiian factories indicates the benefits of high-pressure boilers and turbogenerators to increase electricity generation while other suggestions relating to energy saving include: increasing boiler efficiency by better control of excess air, greater use of condensate as boiler make-up water (using pressurized feedwater heaters to prevent loss of heat through flashing and to improve the thermal efficiency of the steam cycle), avoiding the use of make-up steam (because of the reduction in available work when the steam is throttled), increasing evaporator capacity and lowering the pressure of the exhaust steam, controlling the evaporation rate in bled multiple-effect evaporators, preheating the juice going to the 1st evaporator effect, avoiding excessive pressure drops in steam lines, and raising the level of maintenance to reduce the time lost through mechanical failures.

Beet sugar manufacture

The next stage in organizing water/waste water management at Melno sugar factory

K. Marciniak. *Gaz. Cukr.*, 1989, **97**, 71 - 72 *(Polish).*

The introduction of biological treatment of waste water at Melno in 1986 was followed by the installation of Miniflox oxygenation units in a nearby lake fed by a river into which highly polluted effluent from the factory had been fed and ultimately had caused ecological problems. The improvement in the quality of the water in the lake at two depths is demonstrated by comparison of data from 1986 and 1988.

A combined process of extraction in a solid-liquid system

N. N. Pushanko, A. A. Seregin, V. N. Kukhar, S. A. Balakan and S. V. Rogal'skii. *Tez. Dokl. Konf. Tekhn. Urov. Predpriyat. Pererab. Prom. Gosagroproma Ukr. SSSR i Kach. Vypusk. Prod.*, 1989, (1), 59 - 60; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (15), Abs. 15 R1508.

A study was made of a combined extraction process consisting of heat treatment of the solid phase, squeezing to extract the liquid phase and continuation of extraction under optimum hydrodynamic conditions. A mathematical model of the process for a layer of cossettes describes the mass transfer process with an applied load and has enabled the relationship between degree of heat treatment of the solid phase, pressure gradient in the layer of cossettes and the coefficient of mass transfer to be established. On the basis of the investigations an industrial unit for sugar extraction from cossettes with intermittent pressing has been developed.

Dust explosion-proof mill for icing sugar manufacture

J. Lowinus. *Lebensmittelind.*, 1989, **36**, 171 - 174 *(German).*

An East German Rekord explosion-proof pinned-disc mill for icing sugar production is described; it is located in a pressure-proof housing provided with a star-type or screw feeder in a tube to limit the spread of shock waves. A vertical pressure-reducing pipe is also supplied with a tangential suction tube to remove any dust. The design is based on analysis of damage data from Nauen sugar factory where an icing sugar mill exploded.

Innovators' contributions

A. P. Parkhod'ko. *Sakhar. Svekla*, 1989, (4), 55 - 56 *(Russian).*

Amongst innovations described is a tray elevator for transfer of massecuite to the distribution trough. The trays, located on an endless chain in a 219-mm diameter tubular circuit, collect massecuite from a special chest as they pass through it at the bottom end of the system and take it to a height of 5 - 20 m where it is discharged; the arrangement is suitable for all types of massecuite and does not cause any crystal abrasion. It has been found that altering the direction of rotation of the blades of a horizontal trash catcher in a beet flume to accord with the beet flow greatly increases performance by comparison with counter-rotating blades. The benefits of converting a vacuum filter to a moving belt type at one factory included a 50% increase in throughput, improved filter cake sweetening-off and easier servicing.

Porous elements in massecuite boiling

I. M. Grinchuk *et al. Sakhar. Svekla*, 1989, (4), 56 - 59 *(Russian).*

Porous titanium or stainless steel elements covering the entire space below the calandria of a vacuum pan were designed to facilitate the blowing of steam up into the massecuite in order to increase its circulation; with injection of steam at 80 - 100 kg/hr, the active boiling time was reduced by 10% by comparison with conventional boiling, the crystal content rose by an average of 5%, crystal size distribution improved and sugar yield increased by 0.02% as a result of lower losses in molasses during purging.

Weigh feeders for sugar

A. L. Shoikhet, V. D. Novoseletskii, V. A. Zaets, A. I. Likhtser and M. A. Cherkasskii. *Sakhar. Svekla*, 1989, (4), 61 - 62 *(Russian).*

Information is given on weigh feeders used in Soviet factories for sugar bagging and for feeding sugar into bulk silos.

Operation of wet dedusters

B. P. Efanov, N. F. Bobrakov and M. G. Shumakova. *Sakhar. Svekla*, 1989, (4), 62 - 63 *(Russian).*

The performance of a cyclone used to separate dust from air discharged from a granulator was well below requirement, so that the dust content in the air in the sugar drying section was 150 - 200 mg/m^3 instead of 10 - 12 mg/m^3 as it should have been according to the official standards. The problem was solved by replacing the cyclone with a wet siphon type dust trap in which juice sprayed under pressure into the dust-laden air entrained the dust particles and was recycled to a tank for use in a melter.

Turbines for waste water aeration in storage basins

J. Kraska and A. Czmuchowski. *Gaz. Cukr.*, 1989, **97**, 88 - 89 *(Polish).*

The performance of a Polish-built M-500 aerator with modified impeller at Jawor sugar factory is reported. Over a period of 59 days starting on April 22, 1988, the average BOD_5 of 216,000 m^3 of waste water was reduced from 1700 to 44 mg O_2/dm^3; output of the aerator was 1 - 3 kg O_2/kWh.

Incondensable gases in sugar factory evaporators

H. Rokicki. *Gaz. Cukr.*, 1989, **97**, 89 - 91 *(Polish).*

Chromatographic analysis revealed much greater average quantities of incondensable gases (% on beet) in a quadruple-effect evaporator than values given in the literature for beet processing. Data are also tabulated for cane raw sugar processing at the same factory after the beet campaign; these indicate considerably higher amounts of incondensable gases (given as g/sec) in effects 2A, 2B and 3 when raw sugar and not beet was processed, while the quantity in the 4th effect was higher (at 0.006 g/sec) during beet processing.

Results of investigations on the metrological and operational features of vibratory flowmeters

T. Strzalkowski, L. Gutkowski and M. Turkowski. *Gaz. Cukr.*, 1989, **97**, 91 - 93 *(Polish).*

Tests on three versions of the vibratory flowmeter described earlier[1] are reported. While there were no other pipeline flowmeters available at the sugar factory (Chelmica) for comparison, the results showed that the test units reacted sufficiently rapidly to change in raw, thin and thick juice flow with an error throughout the campaign in the range ±0.95 - ±1.95%, depending on the diameter of the meter orifice; this was made up of a measuring error of ±0.1 - ±0.6%, an error of ±0.3% that was due to changes in the operating characteristics of the transducer and an error of 0.2 - 1.7% caused by mud deposited on the inner surface of the meter.

Is preventive maintenance guided by the potential costs of breakdown? A sugar factory investigation

H. Grothus. *Zuckerind.*, 1989, **114**, 629 - 633 *(German).*

Maintenance in line with the condition of equipment aims to minimize the potential costs arising out of component unavailability (used as a guide to preventive maintenance expenditure) and the costs of the maintenance itself. Analysis of the situation in a relatively large sugar factory (for which the cause and frequency of failure of major equipment and components are indicated) shows that for some components the costs of preventive maintenance are disproportionately high relative to the costs of breakdown and replacement.

Check for faults and minimize maintenance

D. Thoms. *Zuckerind.*, 1989, **114**, 633 - 638 *(German).*

A preventive maintenance scheme is outlined in which equipment is inspected for structural damage and/or defective operation and servicing is carried out only if faults are apparent. The sequence of measures and the reporting procedure are described for a sugar factory and the cost benefits indicated.

Foaming of carbonatation juice

T. Szekrényesy, T. Liktor, K. Hangyál and L. Dömötör. *Zuckerind.*, 1989, **114**, 639 - 644 *(German).*

An investigation of foam formation during 1st carbonatation showed that the amount increased with temperature rise in the range 60 - 90°C, subject to the effects of pH and gas flow velocity (increase in which caused excessive foaming). Although saponins were the major causes of foam formation, other chemical components also contributed, including sucrose. After removal of the surface layer of foam, there was a sharp fall in surface tension during the first 10 msec after creation of a fresh surface, whereas it took 10 min for equilibrium to be restored, from which it was concluded that components were present that diffused only slowly because of their relatively high M.W. Conditions for prevention of foaming are indicated. It is emphasized that, while no foam should form during carbonatation under normal conditions, it is easy to transgress the limits beyond which there is risk of foaming.

Beet quality: technological and economic values and a payment system

J. van den Hil and L. H. de Nie. *Zuckerind.*, 1989, **114**, 645 - 650.

Trends in beet quality in Holland over the last 20 years are analysed and the importance of tare as a qualitative parameter discussed. Evaluation of beet quality for payment is assessed, including dirt and top tare, K, Na and α-amino-N. Formulae for calculating molasses sugar on the basis of beet analysis are compared and the adverse effect of frost considered. Beet payment systems are discussed and details given of the scheme used by Suiker Unie.

A study of the effect of the size of active aluminium oxide granules on sugar solution decolorization

V. A. Loseva, V. V. Zueva and N. S. Belova. *Dokl. Voronezh. Tekhnol. Inst.*, 1989, 4 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (16), Abs. 16 R1438.

A study of the effect of the size of the granules showed that the decolorizing efficiency of the aluminium oxide was dependent on the surface area of the particles and fell with particle size; the best results were obtained with a fraction measuring 0.60 mm.

Antifoam/defoamer systems

K. K. Mitchell. *Sugar y Azúcar*, 1989, **84**, (8), 23.

In a system for foam prevention and elimination, anti-foam agent is injected into the intake side of a water booster pump where it is dispersed and thoroughly mixed. It is then pumped to a flow panel which incorporates flowmeters of varying capacity to allow a controlled amount of the anti-foam to be dosed to any given point in the factory. Benefits of the system are discussed.

Further experiences with continuous crystallization at Wabern sugar factory

G. Witte. *Indian Sugar*, 1989, **39**, 147 - 156.

See *I.S.J.*, 1988, **90**, 14A.

1 Turkowski: *I.S.J.*, 1989, **91**, 28A.

Refinery developments in the white sugar station at Carlow including pan seeding and MET vacuum cooling crystallization

M. E. Buckley. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 39 pp.

Since the 1986/87 campaign, two major additions were made to the equipment at Carlow with the aim of increasing yield and reducing massecuite quantity so as to permit: a 10% expansion in the beet slice (by removing a bottleneck in the middle-product station), achieve 8% reduction in fuel consumption (with the possibility of a further 7% decrease), efffect a more regular material flow and energy consumption patterns in the white end and maintain sugar quality standards. The new equipment consisted of a Selwig & Lange seeding system and a MET vertical vacuum crystallizer for *A*-massecuite. Details are given of the systems and of their performances; these led to an increase in 1st product crystal yield in 1988 that exceeded the level in the1986 campaign by more than 20%.

Further developments in extraction efficiency with a DDS diffuser

A. F. Johnsen and J. Thomassen. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 26 pp.

A stationary and a dynamic model of extraction in a DDS diffuser are described and their application to improvement in automatic control and performance of the diffuser station discussed; the need to control diffusion, beet conveying to the hoppers, slicing and changing of the knives as one integrated system is emphasized. The stationary model is based on Fick's first law of mass transfer of sugar in a homogeneous phase and is divided into three parts: (1) in which no diffusion takes place but the sugar-containing liquid on the surface of the cossettes is washed off; (2) in which sugar is transferred from the cossettes to the juice and it is assumed that all the sugar is replaced by an identical quantity of water so that there is no mass reduction, that there is homogeneous mixing, that there is the same concentration of sugar throughout the diffuser cross-section, and that no sugar is lost through bacterial activity; and (3) where press-water and fresh water are introduced and the exhausted cossettes are discharged. The dynamic model includes those factors affecting the juice-cossettes level; tests showed that the level at the 1st, 2nd and 3rd scroll bearings correlated with the scroll speed as a 1st order function with time lag. Details are given of an automatic system for replacement of beet knives and knife boxes installed in Danish factories. Implementation of the various improvements at Nakskov factory has, over the past 3 years, reduced juice draft by 5 - 7 units at a constant sugar loss and load or has decreased sugar losses by 0.07 - 0.09% on beet at constant load and draft.

Experiences with an interesting arrangement of a falling-film evaporator and continuous crystallization at Minerbio sugar factory in the 1988 campaign

C. F. Buja. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 12 pp.

A falling-film evaporator was installed at Minerbio sugar factory in Italy to concentrate Quentin molasses from 66° to 74°Bx before it is fed to the seed pans and thence to the BMA continuous evapo-crystallization tower installed at the same time as the evaporator. Details are given of both pieces of equipment and of their performances.

Possibilities and practical results of continuous pan boiling

E. D. Bosse. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 51 pp.

A brief survey is presented of continuous vacuum pans, including the BMA system available as a tower or as a horizontal arrangement of four units. The massecuite pump especially designed for the BMA vertical system is illustrated and details given of the design parameters for a tower having a white sugar massecuite capacity of 85 tonnnes/hr and of a cooling crystallizer for seed magma production. The automatic controls of the BMA tower used for white sugar boiling, the scheme used to clean the pan without the need to stop operations and low-grade boiling are described. Aspects of the BMA horizontal pan are outlined and performances of both vertical and horizontal types are discussed. The advantages of the systems are listed.

The utility of a factory sugar loss identification program reflecting variable sugar beet quality

S. E. Bichsel and L. Batterman. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 15 pp.

Molasses losses constitute approx. 75% of the total sugar losses in a factory and are a function of the quantity of soluble melassigenic non-sugars not removed during carbonatation and of inadequate molasses exhaustion. By establishing target purities for molasses and thin juice based on beet quality, it is possible to apportion blame and allow efforts to be concentrated on one or the other means of reducing losses. Application of this approach, with a microcomputer used to produce a loss allocation report with loss bar graphs, has highlighted the extent of losses caused by inadequate removal of impurities in carbonatation.

Modern technical trends in sugar crystallization

D. Schliephake and B. Ekelhof. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 24 pp.

The advantages of crystal seeding over slurry seeding are indicated and details are given of the Braunschweig seed magma system. The benefits of syrup washing (including increased crystal recovery and energy reduction) are also briefly discussed followed by a brief survey of continuous boiling systems and a description of flash cooling of massecuite in the "multistage ebullism tank" (MET). Details are given of a 3-massecuite boiling scheme for the production of EEC 2 white sugar with double-effect vapour utilization; the instrumentation and automatic control system are also described.

The Eemshaven sugar terminal

J. R. Boersma. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989.

The Eemshaven Terminal project arose from a requirement of Suiker Unie for additional storage space for sugar produced during the annual campaign. In an average year it had become necessary to find space for approx. 150,000 tonnes of export sugar. Eemshaven offered very direct access to the sea, it was near the Suiker Unie factory at Groningen, and grants were available for the project. An account is given of the terminal, with a discussion of the means of transporting bulk sugar, silo design development, construction and operation of the facility.

Experiences with cathodic corrosion protection in diffusion

R. Rosenqvist, H. Hallanoro and M. Ainali. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989.

A diffusion pH close to 5 has been shown in the literature to improve juice quality and pulp pressing properties. Such a low pH may, however, considerably increase corrosion in the diffusers. Corrosion theory is reviewed with special emphasis on electrochemical corrosion. The principle of cathodic corrosion protection is explained. Small- and full-scale corrosion prevention tests using the cathodic protection method in a carbon steel DDS diffuser are described. The results achieved indicate a possibility of over 90% reduction of corrosion with the applied method.

Questions of thermal energy management

E. Otorowski. *Gaz. Cukr.*, 1989, **97**, 105 - 110 *(Polish).*

For low-pressure ultrafiltration or reverse osmosis to be a suitable alternative to evaporation as a means of concentrating thin juice, energy consumed should not exceed 3.6 kWh per tonne of water removed. A number of other methods of reducing steam consumption in evaporation and throughout the factory are listed, and the advantages of vapour compression discussed. Various approaches based on this are examined and available equipment described.

Improving the filtrability of sugar syrups

L. A. Sapronova and G. A. Ermolaeva. *Izv. Vuzov, Pishch. Prom.*, 1989, (2), 53 - 56 *(Russian).*

Poor filtrability of some liquid sugars used in the production of non-alcoholic beverages was caused by dextran and colloids. Experiments to find suitable remedial measures are reported. Although heating at 85 - 90°C for 10 - 15 min in the presence of 0.01% (by weight of sugar) chitosan (a flocculant) dramatically improved the clarity of an affected 50% sugar solution, it failed to improve filtrability; however, up to 3-fold increase in filtrability was achieved by heating under the same conditions at pH 4.5 - 5.0 followed by centrifuging at a separation factory of about 2000. Addition of MgO at 0.5% on sugar reduced viscosity and the concentration of suspended particles, while subsequent centrifuging gave further improvement. Chloride of lime, aluminium sulphate and iron sulphate had no positive effect. On an industrial scale it is recommended to treat refractory syrups by heating for an optimum time at optimum temperature and pH (to be established initially) and then adding a suitable flocculant.

Optimum kinetic parameters of sucrose crystallization in a vacuum pan

M. I. Livshits and V. I. Tuzhilkin. *Izv. Vuzov, Pishch. Tekh.*, 1989, (2), 98 - 101 *(Russian).*

A method is described for calculation of the optimum crystal content in *A*-massecuite and of the optimum mean crystal size at the moment when crystal growth ceases during boiling. Equations are developed for boiling and centrifugalling, and calculations show how the optimum crystal content rises from 46.6 to 53.5% with increase in purity from 88 to 94 while the optimum crystal size increases from 0.35 to 0.70 mm (as a function of the ratio between pan content and heating surface area) and the optimum time to cessation of crystal growth ranges from 65 to 192 min.

Trends in the development of sugar crystallization. I. Batch crystallization

A. Vígh. *Cukoripar*, 1989, **42**, 50 - 56 *(Hungarian).*

A review is presented, with 35 references to the literature, of advances made in batch boiling and crystallization, including: the development of massecuite stirrers; automatic control schemes; measures to reduce the boiling time and steam consumption, including boiling *A*-massecuite from syrup of higher Brix and using modern approaches to seeding and footing preparation; magma schemes; and techniques such as massecuite precooling and precentrifugalling.

Trends in the development of the sugar industry

P. Wertán. *Cukoripar*, 1989, **42**, 57 - 60 *(Hungarian).*

Advances made in sugar factory equipment and processing and modern approaches to energy saving and environmental protection are surveyed, including centrifugals (drives and their control, rotary speed and batch *vs.* continuous machines), batch *vs.* continuous boiling, pulp drying (with mention of the BMA low-temperature system and other possible means of reducing steam consumption), waste treatment and disposal, and flue gas treatment and emission control.

Sugar refining

Refining research in South Africa

Anon. *Ann. Rpt. Sugar Milling Res. Inst.*, 1988/89, 11, 13.

Colour transfer during refined sugar boiling: Investigations of the transfer of colour from mother liquor to crystal during boiling in the SMRI pilot pan involved liquors purified by three different methods, namely (i) carbonatation followed by sulphitation, (ii) phosphatation followed by ion exchange and (iii) ion exchange on its own. A number of preliminary tests confirmed that results were comparable to those obtained under normal refinery conditions. These indicated significant differences in colour transfer (colour of affined sugar/ colour of feed) which depended on the clarification process used. Values of about 0.040 obtained for liquors from refineries using process (i) contrasted with those of the order of 0.10 for refineries using (ii). Sulphitation and ion exchange have been selected for further investigation, and work is also being carried out on colour formation during boiling.
The shipment of refined sugar in containers: Investigations into why unconditioned refined sugar in containers became wet during transport by sea to Cape Town showed that the temperature of the sugar at the loading stage was the single most significant causative factor. The sugar stayed dry if this temperature was <30°C but in most cases became wet if loaded when hot. The type of container (insulated as against single-walled, ventilated types) had no effect when the sugar was loaded when cold, but wet sugar occurred more often in the insulated container when loaded hot; this was attributed to the fact that, when hot sugar is loaded, the air surrounding it is also hot and can hold more moisture which can then migrate to certain areas within the container but cannot escape as through the ventilation holes in the other type. However, hot-loaded sugar in the ventilated container was found to be more susceptible to changes in atmospheric relative humidity and temperature whereas there was little fluctuation in R.H. or temperature in the containers when carrying cold sugar.

Integrated treatment of eluates from regeneration of decolorization units in a sugar refinery

L. Bento, J. Machado Santos and D. Hervé. *Ind. Alim. Agric.*, 1989, **106**, 573 - 578 *(French).*

While decolorization by ion exchange resin has a number of advantages over the use of active carbon or bone char, it has the major disadvantage of producing coloured effluent of high NaCl concentration. Details are given of a 2-stage process developed at Oporto refinery in Portugal which allows reutilization of the effluent for resin regeneration; Stage 1 involves pre-regeneration with a diluted solution during which the weakly anionic colorants are eluted, while Stage 2 consists of regeneration at a normal concentration of 8 - 10% to allow elution of the strongly anionic colorants. The two fractions are limed with 5% $Ca(OH)_2$ (v/v) and treated by carbonatation or phosphatation to give approx. 22% decolorization with Stage 1 effluent (of low NaCl concentration) and 60 - 70% decolorization with Stage 2 effluent of high NaCl concentration. The mixture of effluents is recycled after addition of salt to give a required concentration. Tests over 200 cycles with an initial syrup colour averaging 677 ICUMSA units showed an average decolorization efficiency of 73.3% with a strong anion exchange resin, while 87.3% decolorization was achieved with an initial syrup colour of 587 units and use of a weak and a strong anion exchanger. A special regeneration was carried out every 20 cycles. The resin life and decolorization efficiency were unaffected by the residual colour in the recycled effluent. Details are given of the operational parameters of a full-scale optimized scheme in which two regeneration cycles are each followed by rinsing to yield a low- and a high-density eluate which are recycled (the high-density eluate first being treated with lime) so that the only effluent discharged is one of 1 m^3/m^3 resin per regeneration which contains 25 g/litre NaCl, has an extinction (at pH 9) of 8600 at 420 nm and a pH of 9.5. A new decolorization process introduced incorporates a moderately basic anion exchanger (which adsorbs half of the colouring matter such as caramels and hexose degradation products) followed by a strongly basic anion exchange resin which gives a final syrup having a colour content of 75 ICUMSA units compared with 587 units initially, representing a decolorization efficiency of 87.3%.

Flexichevron entrainment separators in the sugar industry

Anon. *Ind. Alim. Agric.*, 1989, **106**, 642, 644 - 646 *(French).*

The performances of Koch Flexichevron entrainment separators in the pan station and triple-effect evaporator at Crockett refinery in the USA are discussed. The separators were in the form of stainless steel triple-pass zigzig baffles. The sugar content in the condensate from the pan station was reduced from 20 - 25 ppm to a maximum of 5 ppm and generally below 2 ppm, while that in the condensate from the evaporator fell from 30 - 100 ppm (sometimes 200 ppm) to an average of 2 ppm or less, with occasional increases to 5 - 7 ppm.

Application of powdered activated carbons

A. U. Dmitrenko, S. A. Brenman, L. V. Ogorodniichuk, N. D. Tereshchenko, E. P. Navrotskaya, V. I. Mikhailovskii and A. S. Sikorskii. *Sakhar. Svekla,* 1989, (5), 50 - 53 *(Russian).*

In experiments with refinery syrups, the decolorizing efficiency of Norit powdered active carbon added at 0.4% on Brix fell from 54.5% to 7.0% with increase in the total quantity of high molecular weight (HMW) compounds and colloids from 0.075% to 4.275% on Brix, the fall being particularly marked when the (HMW compounds + colloid) content exceed 0.5%. The same adverse effect was found in treatment of syrup from a beet sugar factory. Atomic absorption spectrophotometry showed that Na, Ca and Fe cations were removed from syrups by active carbon as constitutents of colouring matter and other organic non-sugars that underwent polymerization, from which it was concluded that conditions conducive to this structural change were optimum for decolorization. Since colouring matter, including HMW compounds and colloids, undergoes such changes in 2nd carbonatation, 0.4% carbon was added to filtered and unfiltered 2nd carbonatation juice followed by continuous mixing for 20 minutes and then cooling to a temperature in the range 50 - 90°C; pH_{20} remained practically unchanged at 9.2. At 50° and 60°C decolorization of the filtered samples was greater and at the higher temperatures lower than for the unfiltered juice. Treatment of unfiltered 2nd carbonatation juice and remelted *B*- and *C*-sugars with a suspension of fresh carbon at 0.1% on sugar and recycle of some of the spent carbon to 1st carbon juice settlers reduced the colour by 10 - 15% over a cycle of 7 days; increasing the carbon to 0.2% on the 8th day and to 0.4% on the 9th gave even better results.

An automated ion exchange plant

Ya. O. Kravets, G. V. Buzovetskaya, V. N. Eremenko, T. M. Mel'nichenko, V. V. Pimenov, V. V. Mazunin and V. A. Kashirskii. *Sakhar. Svekla*, 1989, (5), 53 - 55 *(Russian).*

Details with a flowsheet are given of an automatic refinery syrup decolorization plant which includes a single column in which AV-17-2P anion exchange resin is used as a two-bed system and regeneration with NaCl and NaOH takes place in a separate vessel. The system includes a syrup and water header tank, regenerant mixer, holding tanks, resin elution and eluate treatment vessels, pipelines for movement of the resin suspension, etc. The various process stages are described and results of tests on liquor and run-off treatment in a station of 13 resin columns discussed (a decolorization efficiency of 50 - 66% and total refinery sugar losses of 0.65% on weight of refined sugar compared with 1.61% using an older system).

Removal of sugar dust and citric acid from air

E. A. Shtokman, T. A. Skorik and E. K. Glazunova. *Sakhar. Svekla*, 1989, (5), 57 - 59 *(Russian).*

Investigations at Skidel' refinery showed that the amount of dust in the air in the sugar and citric acid drying sections was far in excess of the permissible limit of 10 mg/m³, with the bubble type wet dedusters used having efficiencies of only 56% and 63%. The properties of the dusts from the two products are tabulated. It was proposed to install a vertical foam/droplet type of deduster which the air enters via a lateral, downward sloping acceleration tube leading to a short horizontal throat provided with spiral orifices; this lies at the surface of water held in a frusto-conical section with a mud discharge port at the bottom. When the spinning dust-laden air meets the water it forms a zone of foam and droplets which trap the dust particles while the air follows an upward path through a diffuser surrounded by baffles and is vented to the atmosphere. The effect of residual sugar and citric acid concentration in the water on performance is discussed; at a concentration up to 15%, dust separation efficiency averages 99.7%.

Design and evaluation of a refined pan stirrer at Hulett refinery

M. G. S. Cox and P. R. Purdham. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 56 - 63.

A 5-bladed Kaplan-type stirrer tested in No. 2 pan provided with a ribbon-type calandria reduced colour formation and gave higher sugar yields than boiling without a stirrer. However, although it gave excellent thrust and flow characteristics at low speeds, at higher speeds it consumed much more power than a 4-bladed helical screw impeller which also gave a higher proportion of axial flow (the Kaplan type providing a mixture of axial and radial flow with back-mixing which made it more suitable for use in a No. 4 pan with a tubular calandria). The helical screw stirrer was more suited to a high-Brix massecuite of non-Newtonian behaviour and reduced crystal colour and conglomeration as well as the coefficient of variation at constant mean aperture while improving yield and heat transfer by comparison with an unstirred pan. It performed best at a speed of 147 rpm, a blade root angle of 42° and a tip angle of 14°. Excellent results were achieved with the Kaplan-type stirrer in the No. 4 pan at 60 rpm; it allowed low steam pressures to be used and gave a higher yield of sugar of lower colour.

Review of steps taken to improve *A*-massecuite exhaustion at Noodsberg

I. Singh. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 85 - 89.

A conventional 3-boiling is employed, with *B*-magma used as footing for *A*-massecuite and a raw sugar colour standard set at 1000 ICUMSA units. However, *A*-massecuite exhaustion fell as a result of reducing the colour by washing of raw sugar from another factory in order to maximize refined sugar throughput. Exhaustion was improved by: (1) increasing the Brix to 93° and thereby allowing a boiling time of 15 minutes as standard; (2) minimizing massecuite dilution by pan steamings; (3) installing a microcomputer for automatic boiling control based on conductivity; and (4) installing rotary and fixed cooling elements in the two banks of crystallizers. These various steps resulted in an average exhaustion of 68.9 and a purity drop of 19.1 in 1988 as against corresponding values of 62.0 and 16.4 in 1985 when the problem first occurred. The benefits of improved *A*-massecuite exhaustion are listed and possible means of giving still further improvements are indicated.

Laboratory studies

Trace components in sugars. VI. Quantitative determination of formic acid, acetic acid, propionic acid and butyric acid in sugars by GLC

S. Saito, T. Miki, H. Ito and M. Kamoda. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 61 - 67 *(Japanese).*

For the determination of the four acids named, 10 - 20% sugar solution was passed through a column of Dowex 50W cation exchange resin in Na^+ form and then through a column of Dowex 1 anion exchanger in Cl^- form which was washed with water until no sugar was detected in the washings. The organic acids adsorbed on the anion exchange resin were eluted with 80 ml of 1N NaCl and the eluate concentrated to dryness at 45°C under reduced pressure. The dried residue was dissolved in 5 ml of succinic acid dibutyl ester containing 0.8 µg/ml of *n*-undecane and the solution then heated at 100°C for 4 hours in the presence of Dowex 50W cation exchange resin in H^+ form to esterify the organic acids. After butyl esterification, 5 ml of *n*-hexane was added to the solution followed by passage through a filter paper. The filtrate was washed with NaCl solution and dehydrated with anhydrous sodium sulphate. The anhydrous filtrate was analysed by GLC. Recoveries were: formic acid 97.9%, acetic acid 105.2%, propionic acid 93.0% and butyric acid 96.1%.

Determination of nitrate in sugar beet by an enzyme method

T. Muratsubaki and K. Sayama. *Proc. Research Soc. Japan Sugar Refineries' Tech.*, 1989, **37**, 79 - 83 *(Japanese).*

An enzymatic method employing a Boehringer Mannheim kit (F-Kit Nitrate) gave an accurate measurement of nitrate in pressed juice after clarification with aluminium chlorate and filtration through Toyo filter paper No 5C. The results obtained were compared with values given by ion chromatography. The enzymatic method showed negative correlation between beet pol and nitrate content.

Determination of dextran in products of sugar manufacture

O. V. Chopik, I. V. Zakharova and S. S. Guseva. *Sakhar. Svekla*, 1989, (4), 59 - 61 *(Russian).*

A method for dextran determination has been developed on the basis of the difference between the total polysaccharide content in two parallel subsamples (5 ml press or raw juice heated to 80°C, filtered and cooled) to one of which is added dextranase. The sample is placed in a 100 ml graduated cylinder to which is added 0.3 - 0.4 g perlite and 3 ml 10% trichloroacetic acid; after mixing, 40 ml absolute alcohol is added and the sample stood for 5 min to allow a mud to form which is then separated by passage through a funnel lined with a glass fibre filter. The precipitate is washed five times with 80% ethanol and filtered. To 1 ml of the filtrate in a test tube is added 1 ml 5% phenol and 5 ml conc. sulphuric acid and the colour measured at 490 nm. To 5 ml of the same filtrate is added aqueous dextranase solution (made up of 1 ml Nitten DL-3 having an activity of 2000 units/g in 9 ml water) and the mixture heated at 55°C for 10 min, after which is added a further 0.5 ml dextranase solution; after mixing and holding at 55°C for 15 min, perlite and ethanol are added together with trichloroacetic acid (to eliminate the dextranase and thus prevent its interference with the colour reaction) and the same procedure followed as with the other subsample. The difference between the total polysaccharide content in subsample 1 and the residual content in subsample 2 as found from standard curves gives the dextran content; average recovery of added dextran was 99.7% (96.3 - 102.5%). Variants of the procedure for thick juice, molasses and raw sugar samples are outlined.

Electrochemical measurement of the degree of microbial infection of the contents in a trough-type diffuser

J. Dobrzycki, M. Ludwicki and S. Wawro. *Gaz. Cukr.*, 1989, **97**, 85 - 87 *(Polish).*

Laboratory and factory tests are reported on the measurement of the redox potential of juice as an indicator of infection in a DDS-type diffuser. A sensor patented by Dobrzycki *et al.* was used in the factory tests; it comprised a measuring and a depolarizing electrode as well as the porous diaphragm of an electrolytic bridge (containing 3% KCl solution) linking the interior of the diffuser with a reference electrode. A number of these sensors were installed at points in the diffuser and connected with the measuring transducer by an automatic contact switch. Comparison of results obtained for three sensors located at the head, tail and midpoint of the diffuser showed that the best correlation between the measured values and the degree of microbial infection was obtained for the midpoint sensor; this showed the greatest change in redox potential in company with a marked fall in the bacterial count after formalin dosing. Redox values in the range between –72 and 100 mV corresponded to bacterial counts of 10^4 - 10^5 per cm^3 of juice; increase in the microbial population beyond this upper limit caused negligible increase in the redox potential. The new system is seen as a suitable means of avoiding unnecessary overdosing of formalin.

Application of a new indicator to measure the reducing sugars content in a cultural liquid medium

C. L. Zhou and H. S. Cheng. *Food Ferment. Ind.*, 1988, (5), 41 - 45; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (17), Abs. 17 R1392.

In an investigation of the use of 2,4-dinitrophenol to determine reducing sugars in cultural liquid medium it was found that the results were in good agreement with values obtained using the classical Fehling method. The new method is simple and may be used for reducing sugars in other media.

By-products

Micrococcus bacteria in the technology of rum from sugar cane in the French West Indies

B. Ganou-Parfait, L. Fahrasmane, D. A. Celestine-Myrtil, A. Parfait and P. Galzy. *Microbiol. Alim. Nutr.*, 1988, **6**, (3), 273 - 277; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (17), Abs. 17 R1396.

Results are given of investigations on Gram-positive *Micrococcus* bacteria discovered during rum manufacture from sugar cane. On the whole the bacteria were found to multiply before alcohol fermentation. Their basic characteristic was the ability to accumulate acrylic acid, from which it is thought possible that they are the cause of the formation of some of the acrylic acid found in rum. The bacteria, which enter the cane from the soil, have an adverse effect on the quality of rum because of the considerable quantity of acrylic acid and traces of allyl alcohol in them.

Producing pulp and paper from sugar cane bagasse: a worldwide perspective

J. E. Atchison. *Sugar y Azúcar*, 1989, **84**, (9), 89 - 92, 94, 96, 98, 100.

A survey of bagasse pulp and paper manufacture includes: bagasse availability; potential uses of bagasse pulp; advances in bagasse storage and processing technology; depithing; continuous rapid pulping in a horizontal digester; wet bulk storage of bagasse; the Ritter biological pretreatment process for bulk storage of bagasse; the Bagatex-20 process for bagasse storage in large bales; manufacture of newsprint and major factors to be considered; new developments in reconstituted panel board for which a high degree of depithing is required, except in the case of insulation board; improvements in chemicals recovery; and the future use of bagasse for pulp and paper.

Make a success of pressed pulp ensilage

J. P. Vandergeten and M. Vanstallen. *Betteravier*, 1989, **23**, (244), 15 - 17 *(French)*.

For optimum beet pulp ensilage the pulp should be pressed to at least 22% dry solids and delivered to the farmer as soon as possible to avoid conversion of sugars into products other than lactic acid; should storage be necessary, a covered concrete area should be made available so as to prevent mixing with other types of pulp and deterioration caused by rain. The best results are obtained by ensiling within 24 hr of pressing and properly covering the silage. Advice is given on the best type of silo, its protection and dimensions.

The sugar beet - also a fodder plant?

W. C. von Kessel. *Zuckerrübe*, 1989, **38**, 268 - 272 *(German)*.

The utilization of beet by-products as animal fodder is discussed. Beet leaves are of particular importance because of their nitrogen content, so that they are of value as both animal fodder and then as fertilizer in the form of manure. The environmental problem of seepage from leaf silage is examined and the benefits of adding beet pulp pellets to absorb the excess moisture are assessed. The costs of leaf silage and the energy value of pressed and dried pulp are discussed.

Fodder from the Swedish Sugar Corporation

Anon. *Zuckerrübe*, 1989, **38**, 273 *(German)*.

Developments in the use of beet by-products as animal fodder in Sweden are described. Pressed pulp was found to give a higher milk yield and a higher milk protein content than grass silage while the milk fat content remained the same; the fibre in pulp in a 1:1 mixture with grass accelerated the breakdown of the grass. While addition of Betfor (a 1:1 molasses : pulp mixture) to silage has been practised for some years, a new beet fibre product, Natur-Ens, has been developed which, when added to silage, prevents seepage by binding the excess moisture. Experiments in 1988 showed that where silage had a dry solids content below 25%, addition of Natur-Ens at 20 - 45 kg/tonne increased the dry solids content by about 4% and the convertible energy by 0.5 MJ/kg dry solids, but caused a slight fall (1.2% by weight of dry solids) in the digestible raw protein content.

Contamination of industrial alcoholic fermentations by yeasts of the *Brettanomyces* genus

M. de Miniac. *Ind. Alim. Agric.*, 1989, **106**, 559 - 563 *(French)*.

Cases of contamination of *Saccharomyces cerevisiae* by *Brettanomyces intermedius* during alcohol fermentation are reported; it is considered highly probable that the contaminant reduces growth of *S. cerevisiae* by secreting acetic acid and is associated with a much slower fermentation than the controlled process, thereby causing a fall in alcohol production. Observations of the behaviour of the two yeasts on a molasses substrate showed that aeration favoured the growth of *B. intermedius* and acetic acid synthesis, while the contaminant was more resistant to acid conditions than *S. cerevisiae*. It is therefore recommended to limit the air feed rate to 0.5 vol/vol/hr and not to exceed an acidity (as sulphuric acid) of 2.5 g/litre.

Investigation of thermophilic methanization of molasses vinasse

Z. Kokuszko and S. Gwardys. *Zesz. Nauk. Technol. Chem.*, 1988, (41), 135 - 144; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (19), Abs. R1365.

It was found that in thermophilic methanization of molasses vinasse, the maximum load of organic matter in the fermenter may reach 4.2 g/dm^3 over a fermentation period of 10 days. Under these conditions, the biogas yield is 315 cm^3 per g organic matter or 20 dm^3/dm^3 vinasse.

specific power requirement ranges from 5 to 20 W/m^3.

From the economic point of view, aerated lagooning is comparable with conventional processes. The oxygen requirement in aerated lagoons varies between 1.3 and 1.5 kg per kg BOD_5 degraded. Aerated lagoons offer various advantages: they are easy to handle; they do not need any adaptation time; they do not produce excess sludge; and they cannot exceed the restricted limits, because lagooning is a batch process.

The possibility of odour emission and the risk of groundwater pollution by seepage are to be mentioned as possible disadvantages, however, while in aerated lagoons no noteworthy elimination of ammoniacal nitrogen has been observed.

Activated sludge process

In this process, the bacterial culture in the form of a floc (activated sludge) is fed with the waste water into an agitated, aerated tank. Agitation prevents the formation of deposits in the tank and homogenizes the mixture of bacteria and influent.

After a sufficient contact time, the mixed liquor of bacteria and water is fed to a final clarifier or secondary settling tank, in which the clarified effluent is separated from the sludge. The separated sludge is recycled to the aeration tank to maintain an adequate concentration of bacteria. The excess activated sludge is removed from the system.

In the West German sugar industry there are only twelve plants of this sort and not all of them purify anaerobically digested water. Figure 12 is a schematic diagram of the activated sludge plant at the Offenau factory. This plant treats a mixture of condensate and waste water from the aerated lagoons.

In Figure 13 the results of the COD and BOD_5 degradation (weekly averages) in the first campaign at Offenau are shown. In this plant a complete nitrification is obtained, so that the ammonia contents of the effluent is lower than 1 mg/l. Nitrification (Figure 14) is the term used for the bacterial process in which the ammoniacal nitrogen is oxidized to nitrite (reaction 1), and then to nitrate (reaction 2).

1) $$55\ NH_4^+ + 5\ CO_2 + 76\ O_2 \longrightarrow C_5H_7NO_2 + 54\ NO_2^- + 52\ H_2O + 109\ H^+$$

(Nitrosomonas)

2) $$400\ NO_2^- + 5\ CO_2 + NH_4^+ + 195\ O_2 + 2H_2O \longrightarrow C_5H_7NO_2 + 400\ NO_3^- + H^+$$

(Nitrobacter)

Fig. 14. Biological nitrification

The biological nitrification in an activated sludge plant depends on the temperature, the sludge loading, oxygen content and the age of the sludge in the plant. This means that the residence time of the sludge in the plant must be long enough to keep the slowly reproducing nitrifying bacteria in the plant.

The combination of anaerobic digestion and the activated sludge process for the post-treatment of the waste water is not very common in the West German sugar industry. In such a combination the highly polluted water is always treated in the anaerobic plant. The activated sludge plant often treats the anaerobically digested water together with excess condensate or excess condenser water, if condensate is used to fill the condenser water circuit.

The removal of the pollution by an activated sludge plant is higher than by aerated lagoons as a post-treatment technique. The COD content in the effluent is lower than 100 mg/l, the BOD_5 content being not higher than 10 mg/l. In most cases a high rate of ammoniacal nitrogen elimination is observed too.

In West Germany we expect a restriction of ammoniacal nitrogen content of all sorts of industrial waste waters. The municipal plants have to meet a limit of 10 mg NH_4-N/litre after 1992, the reason being that a high nutrient content (nitrogen compounds and phosphates) in the waste waters may in turn contribute to the pollution in the North Sea.

Stripping of ammonia

In the waste water of a sugar factory the greater part of the ammoniacal nitrogen orginates from the condensate. In the evaporation plant glutamine is saponified into ammonia and pyrolidone carboxylic acid. The ammonia is stripped out with the vapours and then appears in the condensate. Part of the condensate is used in the factory, for example for extraction, but the excess

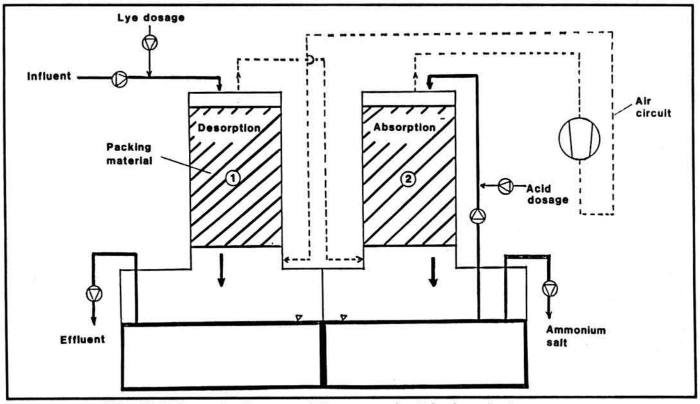

Fig. 15. Schematic diagram of the ammonia stripping plant

must be treated as waste water. In a sugar factory the ammonia can be removed before it appears in the waste water; this can be performed by stripping of dissolved ammonia from the condensate. We carried out trials in the 1985 campaign with a pilot plant designed for a flow rate of about 1 m^3/hr. Air was used as entraining gas. Ammonia stripping efficiency depends upon the pH, temperature and the air:water ratio (m^3/m^3). Figure 15 is a schematic diagram of the pilot plant. This consists of a stripping column, an absorption column, a closed circuit for the air and a circuit for the acid used. The column contains a packing material providing a large contact area between the liquid and gas phase.

After alkalization, condensate flows downwards through the packing material in the stripping column. Air is passed in countercurrent through the liquid phase. The air enriched with ammonia is blown upwards into the absorption column against a countercurrent flow of acid so that ammonia is eliminated from the gas phase, and the exhaust air is then re-used for stripping.

The trials were performed at various temperatures ranging from 50°C to 70°C. The target ammoniacal nitrogen content of the effluent was a maximum of 2 mg/l, which corresponds to a removal of about 99%. Figure 16 shows the content of ammoniacal nitrogen in the treated condensate in relation to the stripping temperature and the air: water ratio. The technology of ammonia stripping can be an optional adjunct to the activated sludge process in a sugar factory for maintaining the ammonia content in the treated waste water within required limits..

For the 1989 campaign Südzucker has built a stripping plant at the Offstein factory. The stripping technology will allow the aerobic treatment of the waste water by lagooning as practised up to now.

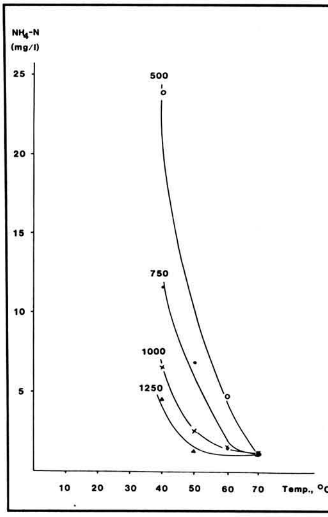

Fig. 16. Ammonia content in the effluent at different temperatures and air:water ratios (m^3/m^3)

Treatment of waste water from molasses processing industries and sugar factories

continued from page 42

Results

More than three years of operation of this plant have given a lot of experience, of which only a part will be summarized here. Both cane and beet molasses have been used in the distillery. The main difference in the treatment of the slops has been that cane molasses contains much less nitrogen and has a lower buffer capacity. This has created problems with low pH in the thermophilic stage but an excellent performance in the mesophilic step. For beet molasses-based slop the high nitrogen content must be controlled very thoroughly so that no toxicity from ammonia appears when the pH goes up in the waste water factory following good reduction of COD. The mixing of sugar factory waste water in the mesophilic step is essential for achieving a dilution of the ammonium concentration. Another method that has been successful has been to reduce the pH in the mesophilic reactor below 7.6 by addition of HCl.

Since the first start-up the distillery has had a number of quite long stops of 1 - 4 months. This has created problems with the activity of the sludge after such a long shut-down when reseeding has sometimes been necessary. The most probable reason is the toxicity of ammonia liberated during the shut-down when the pH in the sludge increased owing to high reduction of COD.

Analysis of COD and methane recovery in comparison with COD load has also created problems as there are components like betaine in the slop which will biodegrade anaerobically but not show up in a COD analysis. On the other hand, this has led to a much higher gas recovery than expected and the production of gas at normal COD load to the plant is 20,000 - 30,000 m^3/day. This gas is burnt in the factory steam boiler and it replaces 50% of the fuel oil in the distillery. The gas production is worth so much money that, at the current oil price, the investment in the treatment plant will be repaid within 4 - 5 years from the start-up. The operation conditions and the treatment results during a period of normal operation in July/August 1988 are shown in Table II.

Start-up of beet waste water treatment plants

continued from page 39

These examples are relevant to the field of beet sugar effluent treatment but cover only a part of possible application of microbial products. No two biological waste water treatment plants have identical characteristics or operational problems and each case requires detailed appraisal to achieve optimum results.

Biomass-fired steam-injected gas-turbine cogeneration for the cane sugar industry†

By Eric D. Larson*, Joan M. Ogden*, Robert H. Williams* and Michael G. Hylton**

Introduction

The study reported here was undertaken to assess the prospects for increasing the production of exportable electricity from sugar factories by the use of gas-turbine cogeneration systems, with residues from the cane as the primary fuel[1]. Gas turbines at sugar factories would represent a fundamental technological change, involving some risks, so their expected technical and economic performance must be far better than that of the commercially-established steam turbine before they could be considered for the sugar industry. To compare advanced gas-turbine and modern steam turbine cogeneration, a case study based on the Jamaican Monymusk factory was undertaken, with data drawn in large part from a study exploring the feasibility of installing a large condensing-extraction steam turbine cogeneration system at Monymusk[2].

Exporting electricity from sugar factories

Bagasse-fired cogeneration is familiar to the world's sugar industry, but few sugar factories generate excess electricity for export to national utility grids. A typical factory cogeneration system produces some 20 kWh of electricity per tonne of cane crushed (kWh/tc) – just enough to meet on-site demand. Such a system also leaves no excess bagasse, thereby avoiding disposal costs. A modern, large condensing-extraction steam turbine (CEST) cogeneration system, similar to that being considered for Monymusk and to those already installed at a few factories, e.g. in Hawaii[3] and Réunion[4], could export in excess of 100 kWh/tc, while meeting on-site energy demands. If steam-conserving process technologies widely used in oil-dependent industries like beet sugar and dairy products manufacture (e.g. condensate juice heaters, falling film evaporators, and continuous vacuum pans) were adopted at cane sugar factories, still more electricity (perhaps 25% more) could be exported to the grid. Furthermore, if an auxiliary fuel were used for power production in the off-season, the total electricity generation would be still higher – some 240 kWh/tc (Figure 1).

The biomass-gasifier steam-injected gas turbine (biomass-GSTIG) cogeneration system considered in the present study, if operated year-round at a "steam-conserving" factory would produce about 460 kWh/tc, or about double that for a CEST and 23 times as much as that produced at a typical sugar factory today (Figure 1).

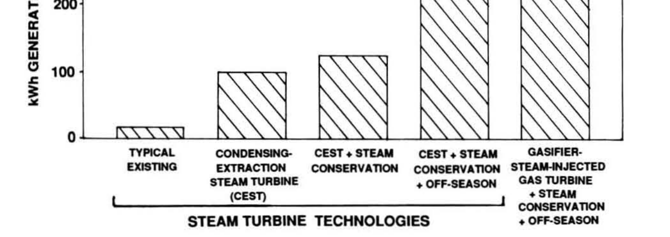

Fig. 1. Electricity generating potential of cane residue-fired condensing extraction steam turbine and gasifier steam-injected gas turbine cogeneration systems: The two right-most bars include the effects of reduced process steam demand and off-season operation with an auxiliary fuel[1]. Note that in all cases shown here the electricity production is referenced to the tonnage of cane processed during the milling season

GSTIG technology

The biomass-GSTIG system (Figure 2) would operate by converting the biomass feedstock into a combustible gas in a pressurized gasifier, which would be coupled to an aircraft-derivative steam-injected gas turbine. Some of the air from the gas turbine compressor would be used in the gasifier, and the combustible gas would be cleaned of particulates before burning it in a combustor with the balance of the compressor air. The hot turbine exhaust gases would raise steam in a heat recovery steam generator (HRSG); some of this steam would be required to operate the gasifier, and the rest could be used for process needs or for injection into the combustor. The injection of steam into the combustor leads to an increase in both power output and electrical efficiency. With steam injection,

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† The research reported here was supported by the office of Energy of the U.S. Agency for International Development, Washington, DC, USA. This paper appears in "Research in thermochemical biomass conversion: An International Conference" (Elsevier, London), 1988.

1 Larson *et al.*: "Steam-injected gas-turbine cogeneration for the cane sugar industry; optimization through improvements in sugar processing efficiencies". *PU/CEES Report 217* (Centre for Energy and Environmental Studies, Princeton University, Princeton, NJ), 1987.

2 Ronco Consulting Corporation and Bechtel National Inc.: Jamaica cane/energy project feasibility study, funded by the US Agency for International Develop ment and the Trade and Development Program, Washington, DC, 1986.

3 Kinoshita: Unpublished data from Hawaiian Sugar Planter's Association, Aiea, Hawaii, 1986.

4 Directorate-General of Information and Market Innovation: "24.65 MW bagasse-fired steam power plant demonstration project". (EUR 10390 EN/FR, Commission of the European Communities, Brussels), 1986.

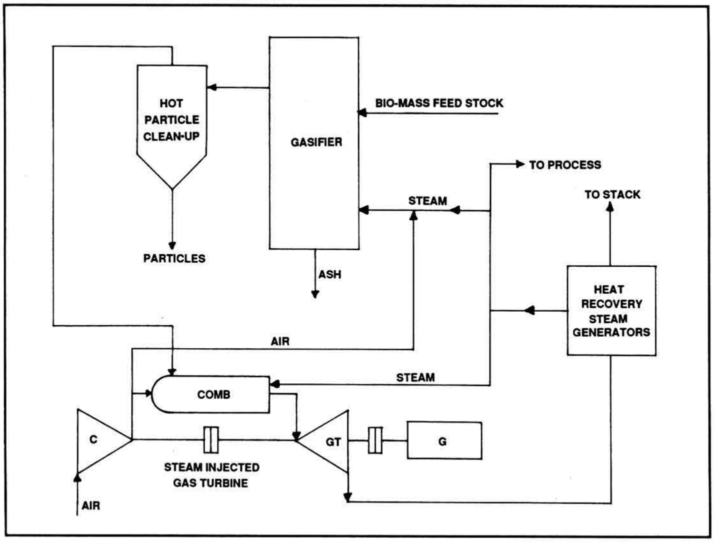

Fig. 2. Schematic representation of a biomass-gasifier steam-injected gas turbine (biomass-GSTIG) cogeneration cycle

the higher mass flow through the turbine expander increases power output. Higher efficiency is achieved largely because only a negligible amount of additional work input is required to pump the boiler feed-water to boiler pressure, avoiding the large amount of work required to compress a gaseous working fluid. Aircraft-derivative gas turbines are chosen for steam injection, because they are designed to accommodate turbine flows considerably in excess of their nominal ratings[5].

Steam-injected gas turbines fired with natural gas have been operating commercially in the United States for several years in cogeneration applications. This technology is attractive for cogeneration applications, because steam not needed for process can be injected to produce more power; under provisions of the Public Utilities Regulatory Policies Act (PURPA) in the US, the extra electricity can be sold to the utility at a reasonable price, thus extending the financial viability of gas turbine cogeneration to a wide range of variable steam-load applications[5]. (PURPA requires utilities to purchase cogenerated electricity at a price equal to the cost the utility could avoid by not having to supply that electricity otherwise.)

Steam-injected gas turbines fired with gasified coal (coal-GSTIG units) have been investigated by the General Electric Company (GE) in the US, with support from the Department of Energy (USDOE)[6], following the successful commercial demonstration of a gas-turbine steam-turbine combined cycle operating on gas derived from sulphur-bearing coal at the 100 MW Cool Water central station power plant in California[7]. [In a gas turbine/steam turbine combined cycle, the hot exhaust from a simple-cycle gas turbine is used to raise steam in a HRSG, which in turn is used to drive a condensing steam turbine, which augments the power production of the gas turbine. Industrial (not aircraft-derivative) gas turbines are most often used in combined cycles.]

Coal-GSTIG technology is largely transferable to systems based on biomass. In fact, the higher reactivity of biomass makes it inherently easier to gasify than coal[8]. Furthermore, most biomass contains no sulphur, obviating the need for, and additional cost of, the sulphur removal equipment. Thus, no new technology must be proven to use biomass in GSTIG systems[9]. In fact, by linking with the ongoing work on coal-GSTIGs, the commercialization of the biomass-GSTIG technology could be accomplished in about three years[9].

Performance/cost estimates of biomass-cogeneration technologies

Performance: Fuelled by bagasse during the milling season, both CEST and GSTIG cogeneration systems could produce variable amounts of electricity and process steam, as the simplified representation in Figure 3 indicates. To increase electricity production in a CEST, a greater fraction of the steam would be condensed rather than extracted; in a GSTIG, a greater fraction of the steam produced in the HRSG would be injected into the combustor. At any level of process steam production, a GSTIG unit would produce roughly twice as much electricity per tonne of cane as a CEST (Figure 3). However, the maximum level of process steam production for the GSTIG systems considered here is about 300 kg/tc, while the CEST could produce in excess of 400 kg/tc.

The total steam produced in the HRSG of a GSTIG would be in excess of 300 kg/tc. It is estimated, however, that the Lurgi-type gasifier considered here would require (primarily for cooling the bed) about 20% of the total steam production, which is based on the steam requirements when gasifying coal in this type of gasifier[6]. The gasification steam required with biomass may actually be lower, although sufficient testing with biomass feedstocks has not been carried out to determine this. An

5 Larson & Williams: *ASME J. Eng. for Gas Turbines and Power*, 1987, **109**, (1), 55 - 63.
6 Corman: "System analysis of simplified IGCC plants" (General Electric Company, Schenectady, NY, USA for the US Dept. of Energy), 1986.
7 Electric Power Research Institute: "Cool Water coal gasification program: fourth annual progress report AP-4832" (EPRI, Palo Alto, CA, USA), 1986.
8 Larson *et al.*: "Biomass gasification for gas turbine power generation", in "Electricity", Eds. Johansson *et al.* (Lund University Press, Lund, Sweden), 1989, pp 697 - 739.
9 Corman: "Integrated gasification-steam injected gas turbine (IG-STIG)" presented at Workshop on Biomass-Gasifier Steam-Injected Gas Turbines for the Cane Sugar Industry, (Washington, DC), 1987.

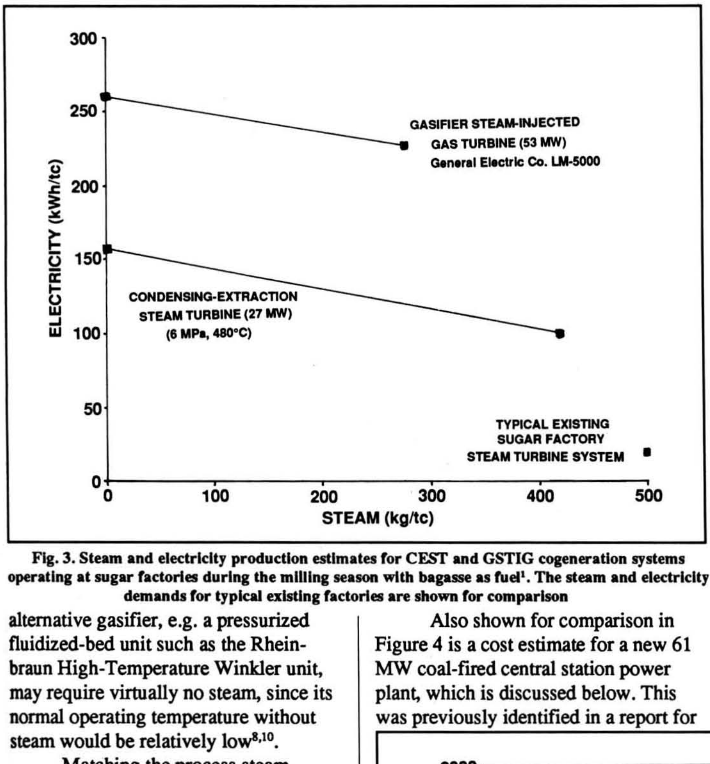

Fig. 3. Steam and electricity production estimates for CEST and GSTIG cogeneration systems operating at sugar factories during the milling season with bagasse as fuel[1]. The steam and electricity demands for typical existing factories are shown for comparison

alternative gasifier, e.g. a pressurized fluidized-bed unit such as the Rheinbraun High-Temperature Winkler unit, may require virtually no steam, since its normal operating temperature without steam would be relatively low[8,10].

Matching the process steam available from the cogeneration system with the steam demands at a sugar factory is discussed below.

Capital costs: Installed unit capital costs have been estimated for several sizes of CEST and GSTIG systems (Figure 4)[1]. (The United States GNP deflator has been used to express all costs in this paper in constant 1985 US dollars.) Unit costs are higher for CEST systems, and they have stronger associated scale economies. Unit costs for the GSTIG would be lower because of their substantially higher energy efficiency and reduced materials requirements (e.g. no condenser or cooling tower). In addition, scale economies would be weaker than for the CEST systems, since even in the larger sizes it is expected that shop fabrication, rather than field assembly, could be used extensively.

Also shown for comparison in Figure 4 is a cost estimate for a new 61 MW coal-fired central station power plant, which is discussed below. This was previously identified in a report for the Jamaica Public Service Company (JPS) as the least costly electricity supply expansion option for Jamaica[11].

Maintenance: Maintenance costs are a key consideration for gas turbines. They are widely believed to be relatively high, based primarily on the electric utility experience with peaking gas turbines. Indeed, with low capacity factors and repeated starts and stops, such units often have high per-kWh maintenance costs[12]. However, with the proper maintenance programs that accompany most gas turbines operating in baseload applications, the costs can be quite modest. For example, the Dow Chemical Company has operated several natural-gas-fired Pratt and Whitney FT-4 aircraft-derivative gas turbines (15 - 20 MW each) in cogeneration plants in the San Francisco area for some twenty years, with total maintenance costs averaging 0.2 - 0.3¢/kWh[12].

Minor maintenance of aircraft-

10 Bellin *et al.: Bioenergy 84*, 1985, 3, 65 - 72.
11 Montreal Engineering Company: "Least-cost expansion study" *Rpt. prepared for the Jamaica Public Service Co. Ltd.*, 1985.
12 "Workshop on steam-injected gas turbines for central station power generation" Eds. Larson & Williams (New Jersey Energy Conservation Laboratory, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, USA), 1986.

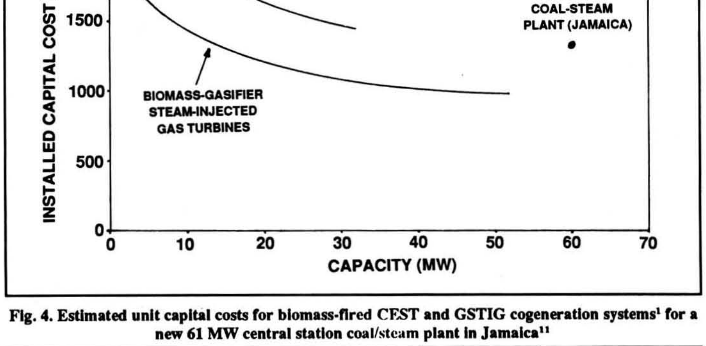

Fig. 4. Estimated unit capital costs for biomass-fired CEST and GSTIG cogeneration systems[1] for a new 61 MW central station coal/steam plant in Jamaica[11]

derivative gas turbines, upon which GSTIG systems would be based, is facilitated by the modular design of these engines originally developed to minimize down-time for aircraft. Major maintenance is typically done off-site, while a replacement engine continues to produce power. The replacement engines are often leased or purchased from manufacturers as part of a service agreement. In other cases, manufacturers provide innovative service contracts which guarantee delivery and installation of a replacement engine within a specified period of a major engine failure (e.g. 48 hours), which is made possible by the very compact nature of aircraft-derivative machines. Stationary gas turbines, including many aircraft-derivative units, are operating in industrial applications worldwide[1] with relatively low maintenance costs.

Table I provides a summary of the cost assumptions used in the financial analysis discussed in the next section. Maintenance cost estimates were based on previous studies and discussions with industry experts[1]. The operating labour estimates are based on employment data for power plants operated by JPS[11].

Table I. Cogeneration costs assumed in the financial analysis[1]

Cogeneration system	CEST	GSTIG
Capacity, MW	27	53
Unit cost \$/kW	1560	990
Total installed cost, 10^6\$*	42	53
Fixed maintenance, 10^3\$/year	660	1300
Variable maintenance, \$/kWh	0.003	0.001
Number of operating employees	24	55
Labour cost, 10^3\$/year	130	300

* If steam conservation retrofits are made at the factory, this cost would increase by $3.1 million (Table II)

Table II. Summary of factory end-use scenario[1,14]

Equipment/Retrofits	Cost, 1985 US$	Factory energy use: Steam, kg/tc *,** (Live)	Steam, kg/tc *,** (Exhaust)	Electricity† (kWh/tc)
Conventional factory:				
No retrofits	0	209	374	13.0
Steam-conserving factory:		209	209	13.0
Plate/gasket juice heater	100,000			
5-Effect falling film evaporator	2,400,000			
Continuous vacuum pan	600,000			
Total	3,100,000			

* Steam conditions are 1.4 MPa, 250°C for live steam and 120°C, saturated for exhaust steam

** For the conventional factory, it is assumed that the existing turbo-alternators are operated to produce all on-site electricity, in which case all of the cogenerated power would be exported, and all steam (374 kg/tc) would be supplied to the factory as live steam. For the steam-conserving factory, the turbo-alternators would be retired, and the cogeneration plant would supply on-site electricity needs

† With a new cogeneration system installed, the previously-existing boiler system (including fans, pumps, and other electrical ancilliaries), which accounts for approximately 1/3 of the electricity demand at a typical factory[15], would be shut down. The electricity demands shown here are with a new cogeneration system. Note that elsewhere in this paper, the electrical output of the CEST and GSTIG systems are specified as net of the cogeneration plant

Jamaican case study: A sugar producer's perspective

To explore the financial feasibility of exporting electricity, internal rates of return have been calculated for CEST and GSTIG cogeneration plants installed at hypothetical raw sugar factories.

Assumptions

Factory operation: The operation of the Monymusk factory, processing a nominal 175 tch during a 206-day season, was chosen as the basis for developing the hypothetical factory energy demands. Monymusk has operated for the last several years with an average cane throughput of 150 - 160 tch, which is below its rated capacity of over 200 tch, because of inadequate cane supplies and deteriorating factory equipment[13]. With World Bank supported rehabilitations to field irrigation systems as well as the processing plant, plans are to raise the throughput to 200 tch, or a total of over 755,000 tonnes per season, by 1990.

Two levels of sugar factory energy demands considered in this study are summarized in Table II and discussed in detail elsewhere[1,14]. The total steam requirement of 374 kg/tc for the "conventional" sugar factory is based on the performance of existing equipment at Monymusk. To utilize a GSTIG cogeneration system, which would produce a maximum of about 300 kg/tc of process steam (see Figure 3 and "Performance" above), equipment retrofits would be required at a typical factory to reduce steam demand. Decreasing steam demand would also permit a greater amount of electricity to be exported from the CEST. A "steam-conserving" factory considered here would utilize condensate juice heating, falling film evaporators, and continuous vacuum pans to reduce the steam demand to 209 kg/tc, or that available from the mill turbine exhaust (Table II).

Exported electricity price: In principle, the price a utility pays a cogenerator for electricity should reflect the cost the utility avoids by not having to supply that electricity itself, e.g. by building new capacity or operating existing plants. The lowest cost of alternative new central station electricity

13 "Jamaica Sugar Holdings, Ltd. corporate plan 1984 - 1989. (III) Monymusk factory and estate technical report." (Tate and Lyle Technical Services, Bromley, England), 1984.
14 Ogden *et al.: I.S.J*, In press.
15 Baldwin & Finlay: *Proc. 1987 Meeting Jamaican Assoc. Sugar Tech.*, in press.

Table III. Levelized fuel prices assumed for the Jamaica case study

Fuel	Price (1985 US$/GJ)
Bagasse (from Eletrobras report[16])	
As delivered from mills, 50% moisture content	0.00
Dried to 25% moisture	0.58
Baled, dried to 25% moisture and stored	0.78
Briquetted (12% moisture)	1.16
Pelletized (15% moisture)	2.02
Barbojo	
Baled, dried to 25% moisture, transported and stored*	0.97
Briquetted, transported and stored (12% moisture)**	1.35
Pelletized, transported, and stored (15% moisture)**	2.21
Residual fuel oil	
Low[17]	2.90
High	4.00
Distillate fuel oil	
Low[17]	5.40
High	7.50
Imported coal	
Low[17]	1.43
High[11]	2.08

* Estimated in the Ronco and Bechtel study[2]; the barbojo would dry in the field to roughly 35% moisture, after which it would be baled. It is estimated that it would have a moisture content of about 25% by the time it is used at the cogeneration plant

** Calculated as the cost of baled barbojo ($0.97/GJ, which includes transport and storage costs) plus the difference in cost between baling and either briquetting or pelletizing bagasse

supplies (including capital, fuel, and O&M charges) in Jamaica is estimated to be 5.0 - 5.8¢/kWh for a new 61 MW coal/steam plant. This assumes an installed cost of $1316/kW (which includes a portion of the costs of building a national coal-handling system), a heat rate of 12,030 kJ/kWh, a 66% annual capacity factor, an annual labour cost of $358,000, maintenance costs of 0.3¢/kWh, a discount rate of 12%, and a 30-year economic life[11]. Assumed coal costs are given in Table III.

Another set of cost estimates[2] for Jamaica are: 8.3¢/kWh for a new coal-fired steam-electric plant, 6.6¢/kWh for a new oil-fired steam-electric plant, and 8.7¢/kWh for a new oil-fired gas turbine plant. The cost of operating existing oil-fired plants (O&M and fuel only) in Jamaica is estimated to be 4.5 - 6.1¢/kWh, assuming a heat rate of 14,500 kJ/kWh and an O&M cost of 0.3¢/kWh[11]. The assumed costs of residual fuel oil are given in Table III.

Bagasse costs: During the milling season, a CEST unit would burn unprocessed (50% moisture content) bagasse, for which no cost is charged. For the GSTIG systems it is currently unknown what level of processing of the bagasse will be required for gasification. Five levels that are considered here, and their associated costs, are shown in Table III.

Costs of off-season fuel: Since a cogenerator would often need to operate year-round to earn an avoided cost that includes a capacity credit, several off-season scenarios are considered here.

The tops and leaves of the cane, "barbojo" in Jamaica, is assumed to be the off-season fuel for the base case, cost estimates for which are given in Table III. The harvesting and storage of barbojo for energy has not been done on a large commercial scale. However, field trials or small-scale operations have been conducted in Puerto Rico[18], the Dominican Republic[19], the Philippines[20], Mauritius[21], Thailand[22] and Florida[23], and tests are underway in Jamaica. In Puerto Rico, where extensive field trials with three varieties of cane have been carried out, an average of 660 kg of 50% moisture content barbojo were produced with each tonne of cane. (Left on the field after cutting, the barbojo dried from about 50% to 35% moisture within 6 days.) One approach being pursued in Jamaica[24] has been to focus on developing cane varieties that will retain most of their leaves through harvesting, with the

16 Eletrobras: "Aproveitamento energético dos residuos da agroindustria da cana- de-açúcar." (Ministry of Industry and Commerce, Brasilia, Brazil), 1986.
17 JPS projections to the year 2000, quoted by Ashby (Centre for Special Studies, PCJ Engineering, Kingston, Jamaica): *Personal communication*, 1987.
18 Phillips: "Cane crop residue for biomass fuel." (Agricultural Engineering Department, University of Puerto Rico, Mayaguez), 1986.
19 Vinas: *Paper presented at the Second Pacific Basin Biofuels Workshop*, Hawaii, 1987.
20 Varua: *ibid.*.
21 Deepchand: *I.S.J.*, 1986, **88**, 210 - 216.
22 Coovattanachai: *Personal communication*, 1987.
23 Eiland & Clayton: *Paper presented at the Amer. Soc. Agric. Engineers Winter Meeting*, Chicago, 1982.
24 Shaw: *Personal communication*, 1987.

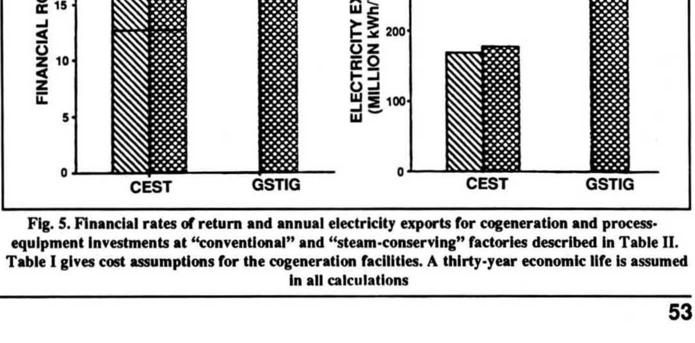

Fig. 5. Financial rates of return and annual electricity exports for cogeneration and process-equipment investments at "conventional" and "steam-conserving" factories described in Table II. Table I gives cost assumptions for the cogeneration facilities. A thirty-year economic life is assumed in all calculations

whole cane being transported to a central location where the barbojo and millable cane would be separated.

Initial trials in some cane growing regions indicate that increased weed growth and decreased soil moisture retention associated with barbojo removal are not serious problems there. Of greater concern appears to be potential damage to an emerging crop and soil compaction (particularly of clay soils, as in Jamaica) on ratooned fields during mechanical collection of barbojo. In any case, while some level of barbojo recovery appears feasible, longer-term studies are required to fully assess the agronomic effects.

Since barbojo recovery is unproven, a second off-season scenario is considered in which oil is burned during the off-season for the first five years of operation, followed by a switch to barbojo. The CEST systems would burn residual fuel oil, and the GSTIG would burn distillate fuel oil. The lower oil prices shown in Table III are assumed for operation during this five-year period, since these are the prices currently used[17] in JPS projections to the year 2000.

Results

Base-case: The annual exports of electricity and the estimated financial rate of return (ROR) for alternative cogeneration investments at factories with two levels of process energy demands are shown in Figure 5. The cogeneration systems considered here are sized for fuelling with the bagasse available from the processing of 175 tch: a 27 MW CEST or a 53 MW GSTIG. An investment in the CEST plant at a "conventional" factory is estimated to provide a ROR of 13 - 16%, if barbojo were the off-season fuel. With additional investments in process equipment required for a "steam-conserving" factory, slightly more electricity could be exported, but the ROR would be virtually unchanged (Figure 5), since the extra investment costs (Table II) would offset the extra electricity revenues. Investing in the GSTIG system (fuelled by briquetted bagasse and barbojo) and "steam-conserving" retrofits would provide an estimated ROR of 18 - 23%, and exports of electricity would be about double that for the CEST (Figure 5). (The Lurgi dry-ash gasifier, which is considered for the GSTIG systems analysed here, was originally designed to gasify chunks of coal. The biomass fuel, therefore, may need to be in a form similar to coal chunks. If an alternative gasifier were considered, e.g. a Rheinbraun High-Temperature Winkler fluidized-bed unit[10], less processing of the bagasse might be required, with dramatic impacts on cost.) The total tonnage of barbojo required for the off-season with the CEST would be about three-quarters of the total bagasse tonnage consumed during the milling season. For the GSTIG, bagasse and barbojo consumption would be comparable.

At the "steam-conserving" factory up to $23 of electricity revenue would be generated per tonne of cane crushed, if GSTIG cogeneration were used and if the electricity buyback rate were 5.0¢/kWh. Sugar revenues would equal electricity revenues for a sugar price of about 23¢/kg. For comparison, electricity revenues with the CEST would equal sugar revenues for a sugar price of about 11¢/kg.

Impact of alternative fuels: The "steam-conserving" case is chosen here to illustrate the impact of using alternative fuels. If less extensive processing than briquetting of bagasse and barbojo were required for the GSTIG, the ROR would increase from a range of 18 - 23% up to a range of 24 - 29% while, if pelletizing were required, it would fall to 11 - 16%.

For the scenarios in which oil is burned during the first five off-seasons, the ROR for the GSTIG would be 11 - 13%, while that for the CEST would be 10 - 12%. The ROR for the GSTIG falls relatively further from that for the base case since the GSTIG would burn distillate fuel oil, while the CEST would burn less costly residual fuel oil.

In a third scenario, the cogeneration system could be undersized relative to the in-season fuel supply, and excess bagasse stored for use during the off-season (after processing to permit long-term storage). In this scenario, about half as much electricity would be produced annually, and the ROR would be 14 - 18% for the GSTIG (using briquetted bagasse year-round) and 10 - 13% for the CEST (using baled, dried bagasse during the off-season[1]).

Results for smaller installations

The average cane processing capacity of sugar factories in Jamaica and many other countries is lower than 175 tch. Since there are scale economies associated with both the CEST and GSTIG technologies (see Figure 4), the ROR would decrease in both cases for cogeneration investments at smaller factories. However, because of its weaker scale economies, the financial advantage of the GSTIG relative to the CEST would increase with decreasing size. For a "steam-conserving" factory processing about 20 tch, the ROR would be 9 - 13% for a 5 MW GSTIG unit (fuelled by briquetted cane residues) and 3 - 5% for a 3 MW CEST (using less-processed cane residues)[1].

(to be continued)

* * *

International seminar on sugar and cane derivatives[1]

The Cuban Institute for Research on Sugar Cane Derivatives (ICIDCA), in conjunction with the Cuban Institute for Sugar Research (ICINAZ) and Tecnoazúcar, will hold a second International Seminar on Sugar and Cane Derivatives during April 10 - 13, 1990. Topics will include sugar technology, biotechnology, food and animal feed, treatment and use of wastes, development of bagasse agglomerates, and pulp and paper technology. The deadline for submitting papers has passed but further information may be obtained from the organizing committee at Via Blanca 804, Carretera Central, Havana, Cuba (Telex 511667, 511022).

1 *GEPLACEA Bull.*, 1989, 6, (11), Sugar Inf.-1.

Facts and figures

Alcohol manufacture support in Australia[1]

Hopes for the early development of an alcohol industry in Australia received support from a pledge by the National Party's Federal leader that the coalition government would not impose an excise tax on alcohol. The coalition's resources and energy policy would be to seek opportunities to use non-fossil fuels as alternative energy sources. The Chairman of the Queensland Cane Growers' Council, Harry Bonanno, has called on the Federal government to back an Australian alcohol industry based on sugar cane. He says such an industry would help to combat air pollution and would help reduce Australia's current account deficit.

French technical aid for the USSR[2]

France and the Soviet Union have agreed in principle on a $378 million agribusiness and farm cooperation scheme under which France will help to modernize Soviet production in the sugar and other sectors and will receive in return oil, wood and metals. France has set up a consortium of about ten companies to coordinate cooperation. Among them, Sucres & Denrées will modernize sugar factories in the Ukraine.

Oil/alcohol fuel pipeline in Brazil[3]

A 16-inch pipeline is to be built between Rio de Janeiro and São Paulo to transport oil and alcohol. The 200-mile pipeline, to be built at a cost of $70 million, will allow Petrobras to save an estimated $20 million per year in transport costs.

Cane varieties in Argentina[4]

A varietal census carried out in Tucumán showed that only two varieties accounted for almost two-thirds of the total area cultivated, viz. NA 56-79 with 37.2% and NA 63-90 with 24.4%. The same varieties only accounted for 25% of new plantings, however, and the areas devoted to other varieties such as Tuc 71-7, Tuc 77-42, Tuc 72-16 and NA 73-2596 are expected to increase in view of their excellent qualities. The average age of the cane fields in Tucumán is approximately four harvests although 20% are older than the 6th ratoon and require immediate replanting.

Irrigation project funding for Pakistan[5]

The Manila-based Asian Development Bank has approved an interest-free loan for Pakistan's agriculture system. A project to improve the country's farm irrigation system and raise output of sugar cane and other crops would receive a special drawing right equivalent to $118 million.

Chinese beet sugar production fall[6]

Because of a drop in area from 729,000 to 507,700 hectares, serious drought and pest attack, the total 1989 beet crop is estimated at 7.88 million tonnes, down from 12.16 million tonnes in 1988, according to the *Farmers' Daily*, and considerably less beet sugar is likely to come from the 1989/90 campaign.

Barbados sugar production, 1989[7]

The 1989 sugar crop in Barbados totalled 66,263 tonnes, which was 17,000 tonnes less than in 1988 and the lowest since 1931. The poor result is attributed to drought during the growing season, followed by too much rain.

Brazil's alcohol fuel problem[8]

Brazil recently imported 1500 million litres of methanol for incorporation with petrol into a mixture with ethanol whereby demand for the latter would be cut by 40%. Environmental groups in the country have been successful in persuading the Governor of Rio de Janeiro state to obtain a Federal court injunction against use of the methanol on the grounds that the government has not drawn up an environmental impact report to state that the methanol is not toxic when burnt as a motor fuel. The Energy Minister has said that the government had concluded after consultation that the mixture was viable from a health point of view, while the São Paulo Environment Secretary said that methanol produced less carbon monoxide than petrol. The methanol could be used in the chemical industry but the government is appealing against the court injunction. It is important to be able to cut the demand for alcohol so that more cane can be processed to sugar for export.

Denmark sugar industry rationalization

With the take-over in May 1989 of the cooperative company operating the Nykobing sugar factory, the Danish sugar industry is entirely in the hnds of the Danisco Group, which includes A/S De Danske Sukkerfabrikker, A/S De Danske Spritfabrikker and A/S Danisco. Turnover to the end of October 1989 was higher than expected. The sugar campaign started at the end of September and production is expected to reach approximately 490,000 tonnes, white value, or some 65,000 tonnes more than the allotted EEC production quota for Denmark. It is reported[9] that the smallest sugar factory in the country, Stege, with a slicing capacity of 5600 tonnes/day, is to be closed.

Sugar trading company ownership change[10]

Geneva-based Gill & Duffus S.A., the sugar trading division of Dalgety, the international food and agribusiness group, is being sold to a consortium of Japanese investors including Taiyo Gyogyo K.K. (40%) and Daitoh Trading Co. Ltd. (20%) as well as the management and directors (40%). The sale is

1 *Australian Canegrower*, 1989, **11**, (16), 2-3.
2 *Sugar J.*, 1989, **52**, (4), 18.
3 *Sugar y Azúcar*, 1989, **84**, (11), 9.
4 *GEPLACEA Bull.*, 1989, **6**, (10), Sugar Inf.-1.
5 *Amerop Newsletter*, 1989, (192), 11.
6 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 561.
7 *Financial Times*, November 29, 1989.
8 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 576.
9 *Zuckerind.*, 1989, **114**, 930.
10 *Agriculture Intl.*, 1989, **41**, (9), Supp. 14.

Sugar Industry Technologists Inc.

49th Annual Meeting, 1990

The 49th Annual Meeting of SIT will be held during May 6 - 9 at the Hyatt Regency Hotel in Vancouver, Canada, when BC Sugar will also be celebrating its 100th Anniversary. A program of technical presentations has been ass-embled with 13 papers ranging from bone char pipe kiln design to ion exchange to continuous centrifugals to chromatography, etc., while there will also be a symposium on methods of purification in cane sugar refining.

A separate program has been arranged for the ladies with a number of scenic tours.

Information and registration forms should be obtained from the Executive Director, Bruce Foster, P.O. Box 632, Ste. Thérèse de Blainville, Quebec, Canada J7E 4K3 (Tel.: +1-514-621-3524; Fax: +1-514-965-1121) as early as possible.

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conditional on receiving consent from the Ministry of Finance in Tokyo.

Alcohol production plans in Italy[11]

The Italian Government plans that the closed Comacchio sugar factory near Ravenna is to be converted into an alcohol plant.

Brazil sugar export quota, 1989/90[12]

Brazil has raised its sugar export quota by 76,752 tonnes to 731,752 tonnes, raw value. The sugar factories in the North/North-East will be allowed to produce but not export the sugar unless they meet 90% of the alcohol production quotas allotted to them.

Record sugar production in Greece[13]

According to information from Hellenic Sugar Industries S.A., sugar production in Greece has reached a new record level of about 370,000 tonnes, against the previous record set in 1976 of 355,000 tonnes and an initial estimate for the 1989 campaign of 330,000 - 350,000 tonnes.

New Indian sugar factory[14]

Dharani Sugars & Chemicals Ltd. is finalizing plans to establish a large sugar factory in Orissa at an estimated investment cost of 280 million rupees. The company was promoted by a group of non-resident Indians from the United States. The company, which has also promoted the most modern 2500 t.c.d. plant in India at Narayanapuram, adjoining the Rajapalayam-Tenkasi State Highway in Tamil Nadu, at a cost of 210 million rupees, will put up the Orissa plant by way of expansion. The project will be a replica of the Narayanapuram plant, which went on stream early in 1989.

Taiwan sugar production target[15]

A production target for the 1989/90 crop in Taiwan has been set at 550,000 tonnes, according to the Taiwan Sugar Corporation. This is marginally below the initial goal of 560,000 tonnes set for the 1988/89 season when output reached 615,000 tonnes. Sugar consumption in 1970 is expected to remain unchanged at around 500,000 tonnes. Taiwan has a US quota of 25,767 tonnes, raw value, which is permitted entry into the USA between January 1, 1989 and September 30, 1990. On an annualized basis, this represents an outlet of around 14,700 tonnes.

UK aid for the Guyana sugar industry[16]

An agreement to provide technical assistance to the state-owned Guyana Sugar Company to increase its production to 250,000 tonnes per year has been signed by Booker McConnell. Guyana will also reimburse Bookers an undisclosed sum for the payments due after the company's sugar operations were nationalized in 1970. The details of the agreement are to be worked out by June 1990. According to the agreement, Bookers will also help Guyana acquire new funds through loans and partial privatization of the company to domestic and foreign investors.

Costa Rica alcohol project[17]

Taking advantage of export incentives provided under the Caribbean Basin Initiative, the Costa Rican government has launched a project to produce fuel-grade alcohol derived from sugar cane for the US market. A Brazilian firm, Canaplan S.C. Ltda., has been awarded a contract to carry out a prefeasibility study for the alcohol-based chemical industry, to be undertaken by the Liga Agrícola e Industrial de la Caña de Azúcar (LAICA). In 1986, a plant designed to produce 240,000 litres/day of fuel-grade alcohol was completed in Punta Morales. However, the facility was shut down in 1987 owing to technical problems.

Italian agricultural expertise for the USSR[18]

The Ferruzzi Group and the Soviet Union have signed collaborative agreements involving Ferruzzi operations in chemicals and agro-industry and calling upon the group's expertise in technical and scientific research and in construction and engineering.

PERSONAL NOTES

In January **Owen W. Sturgess** retired from the Bureau of Sugar Experiment Stations of which he has been Director for many years. He has been replaced by **Dr. Colin C. Ryan** who has been serving as Assistant Director. Mr. Sturgess will, from July next, be Managing Director of Avonwel Pty. Ltd., sugar cane consultants, of P.O. Box 396, Indooroopilly, Qld., Australia 4068.

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11 *Zuckerind.*, 1989, **114**, 918.
12 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 576.
13 *Zuckerind.*, 1989, **114**, 932.
14 F. O. Licht, *Int. Sugar Rpt.*, 1989, **121**, 578.
15 *Czarnikow Sugar Review*, 1989, (1791), 173.
16 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 13.
17 *Amerop Newsletter*, 1989, (193), 13.
18 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 9.

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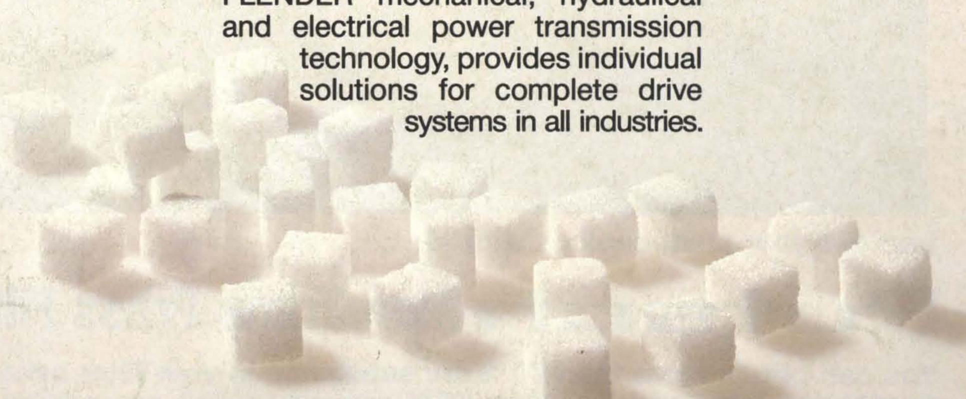

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