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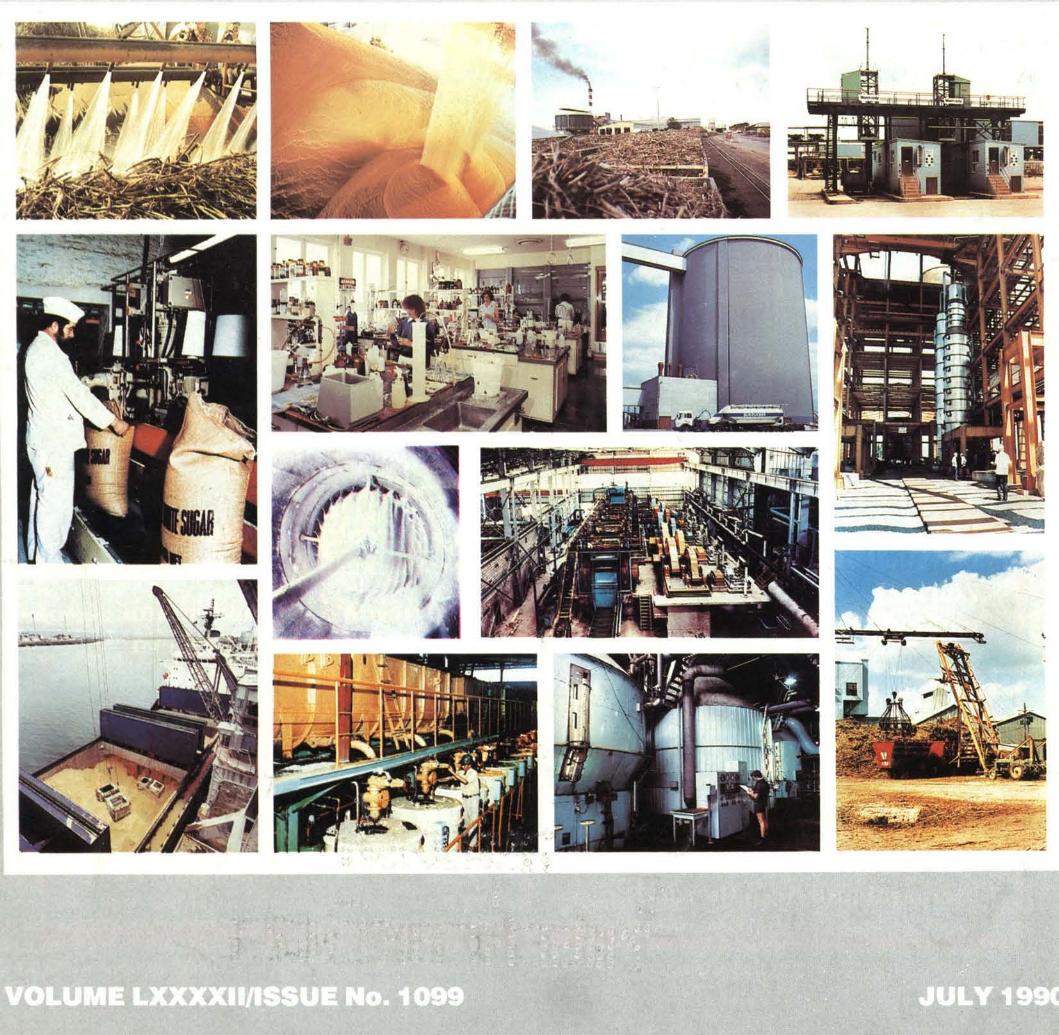

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News and views

World sugar prices

After reaching their highest levels for eight years in March, sugar prices consolidated during April, with little activity. Prices tended to ease, owing to the continuing absence from the market of large buyers and a perception that they would not soon return. In addition there were offers of Brazilian white and raw sugar, and a slightly greater availability from that country was forecast. The London Daily Price for raw sugar, which started the month at $373.60 per tonne had fallen to $359.60 by April 17 but gradually recovered to $369.40 on April 25. The mood of the market was then changed by the announcement of an increase in the US sugar import quota and the LDP rose to $385 on April 27, falling back slightly to end the month at $382.60.

The quota does not affect availability of sugar, however, and the rise was shortlived. In the absence of bullish news, the estimate by E. D. & F. Man of the sugar balance showing a reduced deficit was sufficient to bring about a further slide in prices. The LDP fell to $354.60 on May 8 whereupon Mexico bought sugar and the price rose to $360.40. Lack of business thereafter, and a series of estimates and announcements of higher production levels than previously expected brought about a recognition that the supply situation was not as tight as had been expected earlier in the year and the LDP gradually sank, to end the month at $337.20 per tonne.

In contrast to raw sugar prices during April, the London Daily Price for white sugar was remarkably stable and in fact increased slightly during the month, from $448 to $462 per tonne. During May, however, it was affected by the raw sugar values and, although subject to small recoveries when purchases occurred, the LDP(W) drifted gradually downward, to end the month at $431.50.

EEC farm prices agreement[1]

The twelve European Community agriculture ministers reached an accord on 1990/91 farm prices on April 27. They agreed to freeze intervention prices in ecu terms for most products for another year. For sugar, the intervention price was subjected to a 0.1712 % reduction so that the intervention price for white sugar was reduced from 531 to 530.1 ecu/tonne and that for raw sugar from 440.2 to 439.4 ecu/tonne. The monthly storage cost reimbursement was raised, however, from 4.8 to 5.2 ecu/tonne.

A new UK green rate of 1 ecu = £0.779553 was fixed, giving an effective rise in sugar prices of 10.5% in sterling terms. Revaluation of the West German and Spanish green rates to DM2.34113 and Ptas. 153.498 result in effective price cuts of around 1% in terms of these currencies. Changes in the green currencies of other member states will produce a sugar price cut of 0.2% for Belgium, Denmark and Holland and increases of 1.8% for France and Ireland, 2.3% for Italy, 4.9% for Portugal and 9.8% for Greece.

The farm price accord has been described as a "holding agreement" in preparation for further hard bargaining in the Uruguay Round of trade talks under the GATT, due to end in December. As part of a GATT agreement, the EEC may find itself obliged to consider lowering sugar prices. Now that the farm prices have been fixed for 1990/91, attention will turn to the Commission's proposals for the 5-yearly review of the sugar quota system and related measures.

World sugar production estimates, 1989/90[2]

The crop year covered by F. O. Licht's estimates run from September to August inclusive and this company's third assessment for 1989/90, published in May, includes many figures which will be definitive. By comparison with the second estimate[3], output is now set 1.2% higher at 107.7 million tonnes, raw value, and is 1.7% higher than output in the previous crop year. This is less than might have been expected from the higher level of world prices and it seems that producers have not responded in the form of either area or capacity expansion, probably because of uncertainty over the future of the world sugar market. Three factors are identified by Licht as throwing major doubt on this future, viz. the revolutionary upheavals in Eastern Europe with the likely end result of more efficient sugar industries in this area, the future of the Brazilian alcohol economy, and the possibility of a successful end to the Uruguay round of the GATT.

The muted response is understandable but creates the risk of another price boom which cannot be in the long-term interest of the industry. In spite of the rise in production, the situation remains tight.

Most of the beet crop estimates are unchanged from the previous figures and the total is given as 39,047,000 tonnes against 39,112,000 tonnes earlier and 37,575,000 tonnes in 1988/89. The difference is largely owing to reductions in the figures for Turkey and the UK, partly offset by an increase in the Chinese beet sugar crop estimate from 780,000 to 850,000 tonnes (which still reflects. However, a drastic fall from the 1,172,000 tonnes of 1988/89). Major changes in Western Hemisphere cane sugar crops include falls of 150,000 tonnes in the estimate for Cuba and 250,000 tonnes for Mexico offset by increases of 100,000 tonnes for Argentina and 271,000 tonnes for Brazil. African figures are little changed but in Asia substantial changes have raised the total estimate by almost 1,300,000 tonnes. These include 400,000 tonnes more for China's cane sugar crop, 960,000 tonnes more for India (bringing the estimate to 11,500,000 tonnes) and 110,000 tonnes more for Pakistan, partly offset by a fall of 75,000 tonnes for Thailand. The total cane sugar estimate is 68,686,000 tonnes, up from the earlier estimate of 67,342,000 tonnes but little more than the 68,325,000 tonnes of 1988/89.

From what is known about the 1990/91 crop, it may be concluded that

1 *The Sugar Situation* (E. D. & F. Man), 1990, (468), 3 - 4.
2 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 263 - 272.
3 *I.S.J.*, 1990, **92**, 57.

production will rise by some 3 to 5 million tonnes, sufficient to cover additional demand, according to Licht, but not to allow any significant addition to stocks already precariously low. "In other words, even without any major crop shortfalls supplies will remain fairly tight, indicating that the downward potential of prices is limited, especially as there is significant pent-up demand in countries which cannot afford to buy at current prices. Any major price fall will bring these countries into the market, providing a floor to prices. On the other hand, if production should fall short of current expectations, prices must be expected to move higher. Nevertheless, those same developing countries which would probably enter the market if prices were to fall will also provide a ceiling as they will trim their purchases as prices rise".

World sugar balance

The third and latest estimate of the world sugar balance has been published by F. O. Licht GmbH[4] for the crop year to August 1990 and the figures are reproduced below. The considerable rise in production slightly more than covers consumption and the statistical disappearance of sugar (the difference between reported imports and exports), so that the final stock figure is virtually unchanged, both numerically and as a proportion of consumption.

	1989/90	1988/89
	tonnes, raw value	
Initial stocks	29,132,000	32,785,000
Production	108,550,000	104,635,000
Imports	28,601,000	29,716,000
	166,283,000	167,136,000
Consumption	107,856,000	108,000,000
Exports	29,254,000	30,004,000
Final stocks	29,173,000	29,132,000
" "		
% Consumption	27.05	26.97

Morocco sugar industry deregulation[5]

The Government of Morocco is committed to make a number of reforms to the sugar industry in that country including measures to bring about a greater level of involvement from the private sector. Some privatization has taken place with both of the sugar factories in the Doukkala region now under private ownership; it is reported that the new owners plan to invest some $1,100,000 on modernizing and expanding the processing capacity of one of the two.

High support prices for growers of beet and cane, together with a purposely low range of retail prices to consumers for sugar has involved the Government in large expenditure on subsidies which have amounted to around $80 million in each of the past two years. This level is expected to decline this year as the Government continues its program of reducing subsidies by increasing retail prices.

In 1989 sugar consumption amounted to 783,000 tonnes, raw value, and Morocco produces almost two thirds domestically with 400,000 tonnes from beet and more than 100,000 tonnes from cane. Consumption growth has consistently outstripped improvements in domestic production aimed at reaching self-sufficiency. This year, producer support prices have been increased slightly, but this is more by way of covering higher input costs than providing growers with true incentives to expand the crop.

US sugar import quota rise

The size of the US sugar import quota jumped by nearly 10% on April 27 after a surprise announcement by the US Department of Agriculture raising the total allotment by 250,000 tonnes, raw value. The rise, the fourth since September 1989, reflects US manufacturers worries that, with domestic stocks low, supplies would be dangerously inadequate in the third quarter of the year, especially since some suppliers may not have sugar available. The US also reinstated Nicaragua to the quota program, taking the opportunity to signal the Bush Administration's benevolence on the day that Mrs. Violeta Barrios de Chamorro was installed as the new president. The total quota, for the period January 1, 1989 to September 30, 1990, amounts to 2,834,865 tonnes. Details of individual quotas are given below:

	tonnes, raw value
Argentina	112,630
Australia	217,401
Barbados	18,336
Belize	28,813
Bolivia	20,955
Brazil	379,798
Canada	28,813
Colombia	62,864
Congo	17,305
Costa Rica	49,758.5
Dominican Republic	460,997
Ecuador	28,813
Fiji	23,490
Gabon	17,305
Guatemala	125,727
Guyana	31,432
Haiti	17,305
Honduras	47,490.4
India	20,955
Ivory Coast	17,305
Jamaica	28,813
Madagascar	17,305
Malawi	26,067
Mauritius	31,390
Mexico	17,305
Mozambique	34,051
Nicaragua*	54,328
Panama	75,024
Papua New Guinea	17,305
Paraguay	17,305
Peru	107,392
Philippines	413,850
St. Kitts	17,305
El Salvador	71,034.1
Swaziland	41,908
Taiwan	31,432
Thailand	36,670
Trinidad	18,336
Uruguay	17,305
Zimbabwe	31,432

* Nicaragua's sugar import quota allocation includes 50,190 tonnes, raw value, which had previously been embargoed and allocated to other countries.

Finnish sugar factory to close

Finnsugar is closing the Naantali sugar factory from the 1990/91 campaign. Transfer of its beet supply to other factories at Salo and Turenki will extend the campaign in Finland from its present 50 days to 70 days in 1991/92.

4 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 281.
5 *Czarnikow Sugar Review*, 1990, (1797), 79 - 80.

Steam economy and cogeneration in cane sugar factories

By Joan M. Ogden*, Simone Hochgreb* and Michael Hylton**

Introduction

Most cane sugar factories have been designed to be energy self-sufficient, with sugar as the primary product. A bagasse-fired cogeneration system, made up of "medium" pressure boilers (1.5 - 2.0 MPa or 225 - 300 psi) plus small steam driven turbo-alternators, provides all the steam and electricity needed to run the cane mills and factory, leaving little surplus bagasse. With sugar as the main product and bagasse as a "free" fuel, there has been little economic incentive to save bagasse by factory energy efficiency improvements. In fact, bagasse-fired boilers have been designed to be somewhat inefficient, so that excess bagasse does not accumulate and become a disposal problem.

With the recent trend toward diversification in the cane sugar industry, a growing number of factories are manufacturing one or more by-products (such as alcohol or cogenerated electricity for export to the utility grid) in addition to sugar and molasses. In a factory with several products, each of which requires a certain amount of energy (or bagasse) to manufacture, energy efficiency (both in the conversion of bagasse to useful energy and in the utilization of energy within the factory) can become much more important.

In this paper, we discuss some implications of energy efficiency improvement for a raw sugar factory with a cogeneration system. We have considered two types of bagasse-fired cogeneration systems, which potentially offer much higher electricity production than those found in most sugar factories today: (1) high pressure condensing-extraction steam turbine systems, and (2) steam-injected gas turbines run on gasified bagasse.

In this paper "high pressure" (4.0 - 8.0 MPa) refers to boiler pressures typical of condensing-extraction steam turbines. "Medium pressure" refers to steam used for cane mills, which equals the boiler pressure in most sugar factories today (1.5 - 2.0 MPa). "Low pressure" refers to mill and turbo-alternator exhaust steam used in the process (0.2 - 0.3 MPa).

High pressure or condensing-extraction steam turbine (CEST) cogeneration systems are now used in a few cane sugar factories[1,2] and are being considered for several others[3]. As has been demonstrated in Hawaii and Réunion, when small medium pressure turbo-alternators are replaced with a high pressure CEST system, the total electricity production can be increased from about 20 kWh/tc (just enough to run the factory) to perhaps 70 - 120 kWh/tc. Thus, in addition to making sugar, about 50 - 100 kWh/tc becomes available for export to the utility grid. With a CEST cogeneration system, there would be an incentive to improve factory steam economy: any fuel (or equivalent steam) saved in the sugar process would become available for generating additional export electricity[2].

In a gasifier/steam injected gas turbine (GSTIG) system, bagasse would be gasified to form a low BTU gas, which fuels a gas turbine[4-6]. Steam would be raised for the mills and the process in a heat recovery steam generator (HRSG), which utilizes the hot exhaust gases leaving the turbine. Any steam not needed for the factory could be injected into the combustor to boost the electrical output of the system. As with the CEST system, the lower the factory steam demand, the higher the electrical output. While GSTIG systems are not commercially available at present, they could be developed within the next several years. Similar systems are being developed for use with coal in the US[7]. Linked with this development, biomass-fired systems could be commercialized within about three years[8]. GSTIG systems are of interest because they could potentially produce up to 200 kWh/tc of export electricity, about twice as much as high pressure steam turbine systems[5,6]. However, GSTIG systems could not provide quite enough process steam to supply the average cane sugar factory. Thus, some factory steam economy measures would be desirable when using these systems.

Our motivations for studying factory steam economy in raw cane sugar factories with cogeneration are twofold: to boost the export electricity production from a particular type of cogeneration system, and to widen future cogeneration options for the cane sugar industry to include the more efficient GSTIG systems. With these goals in mind, we have assessed several steam-conserving retrofits incorporating commercially available process equipment: waste heat recovery heat exchangers which utilize hot condensate for juice heating, falling film evaporators, and continuous vacuum pans. In the 1970's, these technologies were widely adopted in oil-dependent process industries with large evaporation energy requirements (such as the beet sugar, pulp and paper, and dairy industries) to reduce fuel costs[9]. With the emphasis on by-products and process steam economy, they are beginning to appear in the cane sugar industry as well[10,11].

Although we have focused on cogeneration, the energy efficiency improvements discussed may also be of interest to factories with other by-products which require energy (or bagasse) for their manufacture.

Increased cogeneration output through improved factory steam economy

(A) Electricity and steam production in

* Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544, USA

** Sugar Industry Research Institute, Factory Technology Division, Kingston, Jamaica.

1 Kinoshita: *Private communication*, 1987.
2 "24.65 MW bagasse-fired steam power plant demonstration project", *Commission of European Communities Report* EUR 10390 EN/FR, (1986).
3 Ronco Consulting Corporation and Bechtel National Inc.: "Jamaica Cane/Energy Project Feasibility Study" (US Agency for International Development, Washington, DC, USA), 1986.
4 Larson & Williams: *Amer. Soc. Mech. Engineers Report*, 1986, (86-GT-47), 9 pp.
5 Larson *et al.*: *I.S.J.*, in press.
6 Idem: *Princeton University Center for Energy and Environmental Studies Report*, 1987, (217), 103, pp.
7 Corman: "System analysis of simplified IGCG plants". (General Electric Company, Schenectady, NY, USA), 1986.
8 Idem: *Paper presented at workshop on biomass-gasifier steam injected gas turbines for the cane sugar industry*, (Arlington, VA, USA), 1987.
9 Rosenblad: *Private communication*, 1986.
10 Töbe: *Sugar y Azúcar*, 1987, **82**, (4), 36 - 40.
11 Bourzutschky: Private communication, 1987.

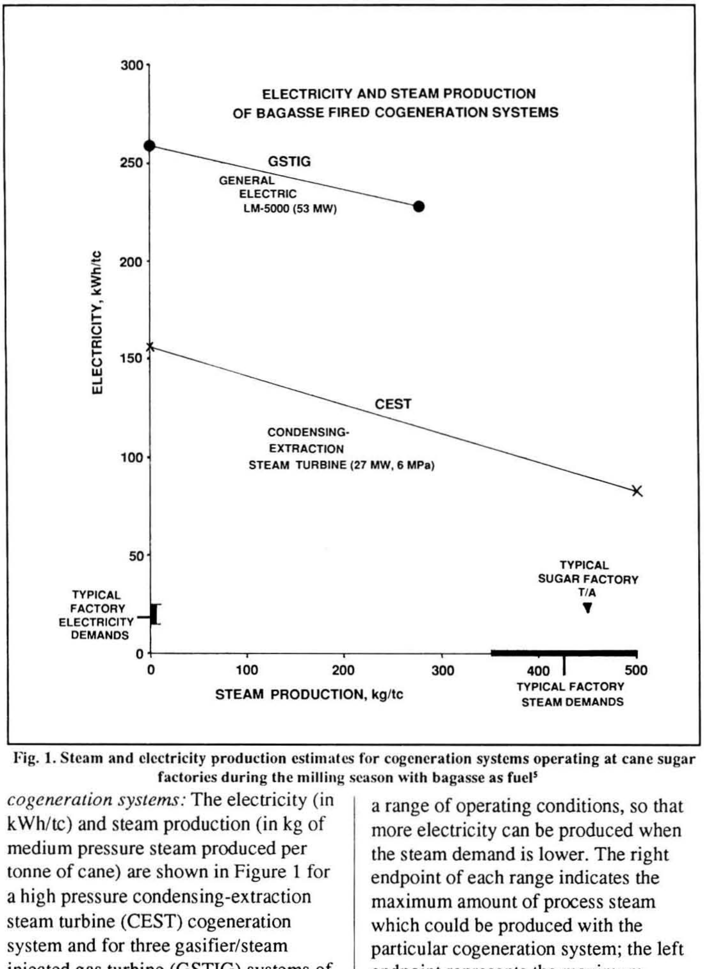


Fig. 1. Steam and electricity production estimates for cogeneration systems operating at cane sugar factories during the milling season with bagasse as fuel[5]

cogeneration systems: The electricity (in kWh/tc) and steam production (in kg of medium pressure steam produced per tonne of cane) are shown in Figure 1 for a high pressure condensing-extraction steam turbine (CEST) cogeneration system and for three gasifier/steam injected gas turbine (GSTIG) systems of various sizes[5,6]. Steam and electricity demands characteristic of most raw cane sugar factories today[12] are shown as ranges of values along the x and y axes of the graph. We have also plotted the steam and electricity production in a typical medium-pressure steam-driven turbo-alternator (MPTA) sugar factory cogeneration system.

For both CEST and GSTIG cogeneration systems, the steam and electricity production can be varied over a range of operating conditions, so that more electricity can be produced when the steam demand is lower. The right endpoint of each range indicates the maximum amount of process steam which could be produced with the particular cogeneration system; the left endpoint represents the maximum electricity production, which would occur when the process steam production is zero. In Figure 1, we have calculated the steam and electricity production at each endpoint and assumed that the electricity production increases linearly with decreasing steam demand[6,12].

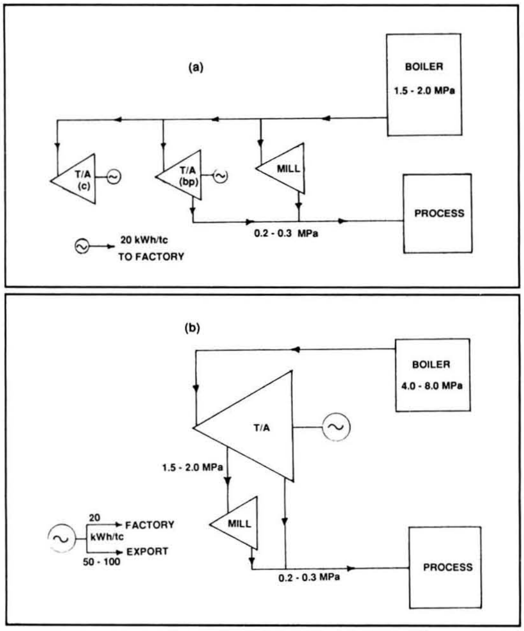
Comparing typical factory demands with the output of the cogeneration systems, we see that the CEST can easily meet the steam demands of the average raw sugar factory (350 - 500 kg/tc), while producing about 100 kWh/tc, roughly five times as much electricity as a small turbo-alternator system in a typical factory. While the GSTIG produces about 200 kWh/tc or twice as much electricity as the CEST system, the maximum steam production possible with the GSTIG systems is only about 270 - 300 kg/tc. The GSTIG system would not be able to supply all the process steam needs without some factory steam economy measures.

(B) Integrating a cogeneration system with a cane sugar factory: Examples of how a raw sugar factory could be integrated with a cogeneration system are shown in Figure 2 for three cases: a conventional factory with small medium pressure back-pressure and condensing turbo-alternators; a conventional factory with a CEST system; and a hypothetical steam conserving factory with a GSTIG system.

Electricity and steam supply and demand in a conventional raw sugar factory are illustrated in Figure 2a. In most raw cane sugar factories, steam is raised at 1.5 - 2.0 MPa in a medium pressure boiler. About 200 - 250 kg/tc of medium pressure steam is used to drive small back-pressure mill turbines; an additional 150 - 250 kg/tc goes to run one or more small back-pressure or condensing turbo-alternators, which produce just enough electricity for the factory (about 15 - 25 kWh/tc) , but none for export. The 350 - 500 kg/tc of low pressure exhaust steam (saturated steam at 0.2 - 0.3 MPa) from the mill turbines and turbo-alternators is then utilized for process heat (e.g. juice heating, evaporation and crystallization of sugar).

Variants of a CEST system with a conventional sugar factory are shown in Figures 2b and 2c. In a CEST cogeneration system, steam is raised in a high pressure boiler at 4.0 - 8.0 MPa, and passes through a condensing extraction steam turbine. About 200 - 250 kg/tc of medium pressure steam is extracted

12 Hugot: "Handbook of cane sugar engineering" (Elsevier, Amsterdam) 1986, 1166 pp.



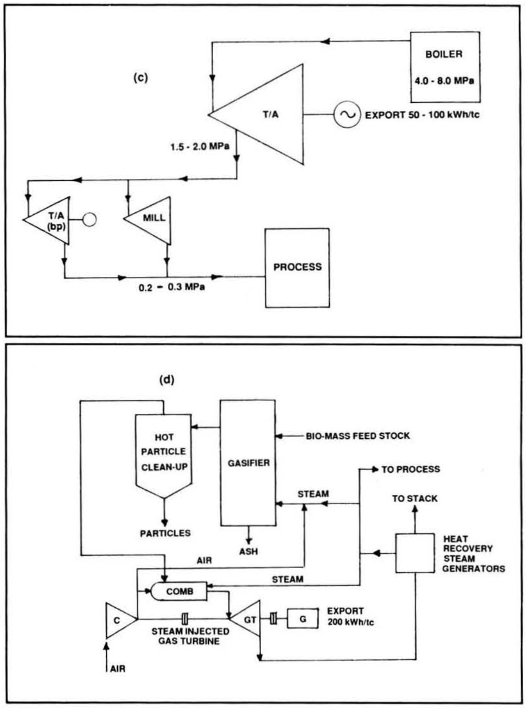


Fig. 2. A sugar factory with a cogeneration system: (a) conventional steam turbine, (b) high pressure steam turbine – two extractions, (c) high pressure steam turbines – one extraction, (d) gasifier/steam injected gas turbine system

from the turbine at 1.5 - 2.0 MPa for use in the mill turbines. The additional low pressure steam needed for process (150 - 250 kg/tc) can be supplied directly from the large steam turbine via a second extraction at 0.2 - 0.3 MPa (Figure 2b). The turbine supplies electricity to both the factory and for export. Alternatively, in the case of a retrofit, enough medium pressure steam can be extracted to run the mills plus the existing back-pressure turbo-alternators, which then provide exhaust steam for process as before and some of the factory electricity (Figure 2c). With either scheme, the export electricity production is about the same, perhaps 50 - 100 kWh/tc.

An example of how a GSTIG cogeneration system could be integrated with a sugar factory is sketched in Figure 2d. We have assumed that the factory process steam demand has somehow been reduced to less than 270 - 300 kg/tc. In the case shown, all the steam raised in the heat recovery steam generator (HRSG) is at medium pressure, and the existing back-pressure turbo-alternators may be used to generate a small amount of electricity for the factory. The export electricity would be about 200 kWh/tc.

(C) Export electricity production as a function of process steam demand in a raw cane sugar factory: Subtracting the factory electricity demand from the total electricity production (including both CEST or GSTIG and any electricity generated in the existing turbo-alternators), the electricity available for export to the grid can be calculated as a function of process steam demand.

Let us take as an example our base case, which is modelled on the Monymusk factory in Clarendon, Jamaica. The steam and electricity demands assumed for this factory are listed by end-use in Table I[13]. The first column gives electrical demands based on the existing factory, which uses small medium pressure steam turbo-alternators. The second column assumes that the old medium pressure boilers have been replaced by a new CEST cogeneration system (as in Figure 2c), thereby reducing the factory electricity demands from 19.4 kWh/tc to 12.9 kWh/tc. This assumption is based on preliminary measurements at Bernard Lodge factory in Jamaica[14], which suggest that the factory electricity demand can be cut by perhaps one-third, if the fans and pumps from the old boiler are replaced by a new CEST or GSTIG system. Of course, the CEST or GSTIG systems will also have fans or pumps, but this electricity use has already been included in the overall production curve in Figure 1.

13 Blanchard: Private communication.
14 Baldwin & Finlay: *Paper presented to Jamaican Assoc. Sugar Tech.*, 1987, in press.

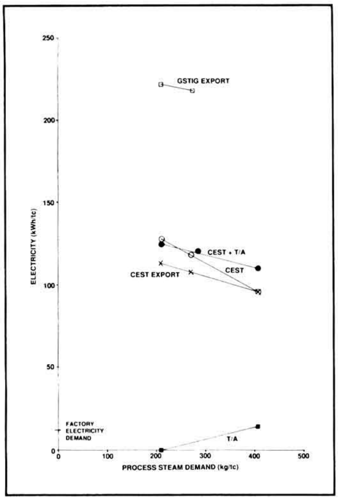


Fig. 3. Export electricity production as a function of process steam demand

If we could reduce the low pressure steam demand in the evaporators, vacuum pans and juice heaters, less exhaust steam would be needed. Thus, the amount of medium pressure steam extracted from the CEST would be reduced and the electrical production of the CEST system would increase by about 0.146 kWh per kilogram of steam saved, as shown in Figure 1.

If the low pressure steam demand exceeds the amount of exhaust available from the mill, some medium pressure steam would be sent through the existing back-pressure turbo-alternators. As the low pressure steam demand decreased, the electricity contributed by the turbo-alternators would also decrease. Thus, the total electricity production would increase more slowly than that in the CEST alone. The electricity production in the turbo-alternators is assumed to be about 0.07 kWh/kg medium pressure steam (see Appendix 1). If the low pressure steam demand could be reduced so that it just equalled the mill exhaust, the electricity production from turbo-alternators would be zero. Subtracting the factory electricity demand from the total, the export electricity can be found as a function of process steam demand (Figure 3). For our base case, for each kilogram of process steam saved, about 0.076 kWh of extra export electricity is produced.

For a high pressure steam turbine cogeneration system, the potential exists to boost in-season export electricity production significantly by factory steam economy. For example, if the process steam demand were reduced from 500 to 400 kg/tc, an extra 10.5 kWh/tc of electricity could be exported to the utility grid. For a factory crushing 175 tonnes of cane per hour (tch), this would mean an extra 1.84 MW of exportable electric power in the season, more than a 10% increase. If the season is 210 days long, and the factory runs 23 hours per day, the revenue over one season is about US $500,000, assuming that the electricity is worth $0.06/kWh.

Moreover, decreasing the factory low pressure process steam demand below 270 - 300 kg/tc means that the more electrically efficient gasifier/gas turbine cogeneration systems could potentially be used, and still meet factory process steam demands. Sugar factory steam economy widens the choice of future cogeneration systems to include those with very high electrical efficiency.

Opportunities for conserving factory steam

From Table I, we see that the evaporators, juice heaters and vacuum pans are the largest users of low pressure process steam. In this section we describe commercially available process equipment which could save energy at each of these steps.

Juice heaters: Present practice is to use shell-and-tube juice heaters heated with bled vapour from the evaporator (Figure 4a). In most factories, raw juice is heated in several stages with vapour bled from the evaporators (or sometimes with low pressure exhaust steam). Shell-and-tube heat exchangers are used, with the bled vapour condens

Table I. Process steam and electricity uses in the Monymusk sugar factory*

	Existing factory†	With external CEST cogeneration system
Medium pressure steam (1.37 MPa, 250°C)		
Total m.p. steam used	477 kg/tc	420 kg/tc
Cane mills	209 kg/tc	209 kg/tc
Medium pressure steam turbines		
Back-pressure	211 kg/tc	211 kg/tc
Condensing	57 kg/tc	-
6% Losses in mills and turbines	29 kg/tc	25 kg/tc
Total l.p. exhaust available	401 kg/tc	395 kg/tc
Low pressure steam (Mill and turbine exhaust, 0.2 MPa, 120°C, saturated)		
Total l.p. steam used	392 kg/tc	392 kg/tc
Evaporator		
Total	337 kg/tc	337 kg/tc
Bled to vacuum pans	98 kg/tc	98 kg/tc
Bled to juice heaters	90 kg/tc	90 kg/tc
Direct to vacuum pans	43 kg/tc	43 kg/tc
3% l.p. steam losses	12 kg/tc	12 kg/tc
Electricity demand		
Total electricity demand	19.4 kWh/tc	12.9 kWh/tc
Electricity production		
Medium pressure steam turbines	19.4 kWh/tc	14.8 kWh/tc

* Source: based on simulation by John D. Blanchard, Clarendon Sugar Holdings, Monymusk, of the Monymusk factory operating at a crushing rate of 175 tonnes of cane per hour

† Steam driven mills; Robert type 4-effect evaporator; medium pressure back-pressure and condensing turbo-alternators; and discontinuous vacuum pans

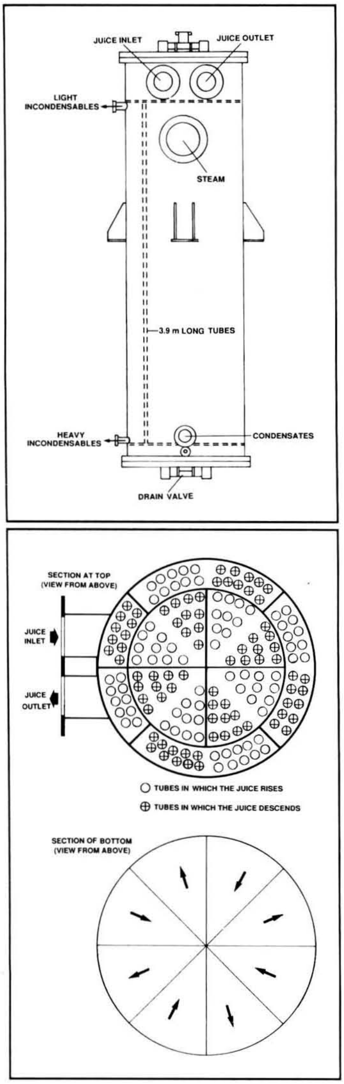


Fig. 4. Juice heaters: (above) shell-and-tube juice heaters, (below) plate-and-gasket juice heaters[12]

ing on the hot side and juice heated on the cold side. Clarified juice heaters also typically use vapour bled from the evaporator.

Other options include using hot condensate from the evaporator and vacuum pans for juice heating. By using the plentiful hot condensate from the evaporator and vacuum pans (which has an average temperature around 100°C) a large part of the juice heating could be done and some steam could be saved. In many cane sugar factories, the pure portion of the condensate (i.e. that derived from condensed exhaust steam) is returned to the boiler as feed water. In these factories, it may or may not be more efficient to send the pure condensates directly to the boiler, rather than using them first to heat juice.

This trade-off involves a number of factors, which depend on the factory design. For example, consider two options: (1) pure condensate is sent directly to the boiler at 90°C; (2) pure condensate is used first for juice heating and then sent to the boiler at 40°C. If the boiler produces steam at 6.0 MPa and 480°C, the total enthalpy change is (3373 – 167) = 3206 kJ/kg for 40°C feed water, and (3373 – 377) = 2996 kJ/kg for 90°C feed water. The energy required to make steam is about 7% higher with 40°C feed water than with 90°C feed water. Depending on how much of the 7% energy difference must be provided by burning extra bagasse (some feed water preheating may be done with boiler flue gases in an economizer stage), and how much process steam would be saved, using the pure condensates for juice heating en route to the boiler may or may not result in less fuel consumption overall.

The heat contained in the impure condensates (those derived from juice vapours, i.e. from 2nd and later evaporator effects) is generally not recovered in sugar factories today. Depending on the evaporator and vacuum pan operating temperatures, the impure condensates could contain as much or more heat than the pure condensates, and could accomplish at least some and possibly all of the juice heating. If desired, it would be possible to utilize the pure condensates as for the boiler, and the impure condensates for juice heating.

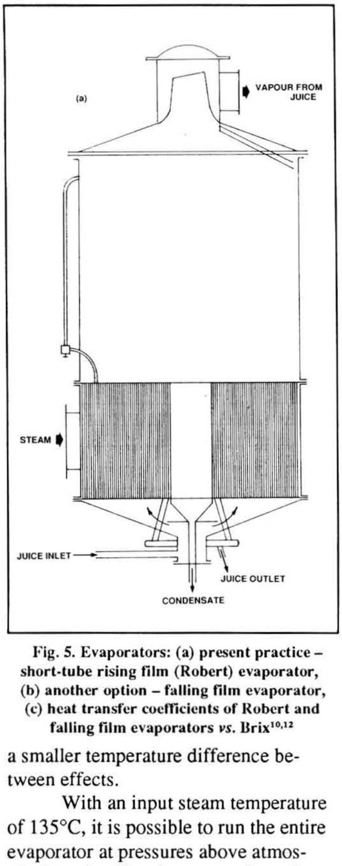
In a falling film evaporator, the exhaust steam consumption (and therefore the pure condensate production) would be lower than in a Robert evaporator. Less boiler feed water would be needed, and the impure condensates would be hotter and more plentiful than in a Robert evaporator. Thus, more energy would be available from impure condensates for juice heating.

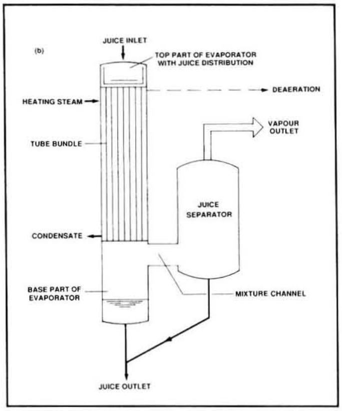
Either plate-and-gasket or shell-and-tube type heat exchangers could be used for juice heating with hot condensate. Plate-and-gasket heat exchangers (Figure 4b) have higher heat transfer coefficients than shell-and-tube heat exchangers (see Appendix 2). As the heat exchanger areas would be reduced, they are likely to be more compact and less expensive. The pressure drop would be similar to that of the shell-and-tube type heat exchangers.

In a plate-and-gasket heat exchanger, it is important to remove any large particles from the juice which could clog the narrow space between the plates. Experience in the beet sugar industry indicates that it should be possible to screen potentially troublesome coarse particles[11]. Another possible application for plate-and-gasket heat exchangers is for heating clarified juice.

Evaporators: In most cane sugar factories at present, forward-feed, multiple-effect, short-tube rising film (or Robert) evaporators are used (Figure 5a). Vapour is bled from the first two effects for juice heaters and vacuum pans. The first one or two effects run at slightly above atmospheric pressure, with the later stages running at less than atmospheric. Vapour from the final stage of the evaporator is fed into a barometric condenser to maintain a pressure gradient throughout the system. The heat transfer coefficients vary with the Brix as shown in Figure 5c.

Falling film evaporators (Figure 5b) are often used as energy savers in the beet sugar, pulp and paper and dairy industries, and are being studied for use in the cane sugar industry[10,11]. They have the advantage of higher juice flow velocity and higher heat transfer coefficients (Figure 5c) and can therefore run at





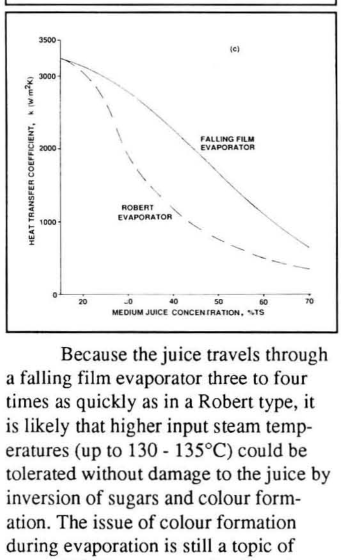


Fig. 5. Evaporators: (a) present practice – short-tube rising film (Robert) evaporator, (b) another option – falling film evaporator, (c) heat transfer coefficients of Robert and falling film evaporators *vs.* Brix[10,12]

a smaller temperature difference between effects.

With an input steam temperature of 135°C, it is possible to run the entire evaporator at pressures above atmospheric and utilize the vapour from the later effects for juice heating and vacuum pans. Vapour bleeding from later effects rather than from the first effect makes better use of the multi-effect configuration and reduces the overall steam consumption of the evaporator. Moreover, the condensate from the effects is quite hot (100 - 125°C) and in many cases could do all the juice heating. In existing factories with steam driven mills, the mill exhaust back pressure is already set and it may not be possible to produce exhaust steam at 135°C. However, even with exhaust steam at 120°C, it should be possible to run three or even four effects of a falling film evaporator under pressure.

Because the juice travels through a falling film evaporator three to four times as quickly as in a Robert type, it is likely that higher input steam temperatures (up to 130 - 135°C) could be tolerated without damage to the juice by inversion of sugars and colour formation. The issue of colour formation during evaporation is still a topic of research[15]. However, results from the falling film evaporator operated at the Sugar Industry Research Institute in Jamaica indicate no problems with colour formation at these temperatures.

Vacuum pans: In discontinuous pans, the thick syrup or massecuite is boiled down one batch at a time, in several stages or strikes. Because of the water added in washing, molasses dilution and agitation, it takes about 1.2 - 1.7 kg of steam to evaporate 1 kg of vapour from the massecuite in each pan. Steam consumption values reported in the literature[12] range from 120 to 170 kg/tc, depending on the design of the vacuum pan.

The steam load varies greatly in individual discontinuous pans. When the syrup is introduced into the pan, evaporation proceeds very quickly and the steam demand is high. Then the steam demand of the pans drops, owing to the increased massecuite Brix. This variation is a disadvantage with cogeneration where constant steam loads are desirable.

Continuous vacuum pans have the advantage of lower steam consumption and constant steam loads, and are coming into increasing use[12]. Agitation can be done with the incondensable gases vented from the pan, or with a little extra steam. Hugot[12] estimates that the steam consumption for a continuous pan should be about 25% less than for a discontinuous pan.

Steam economy case studies – factory balances and preliminary economics

Simplified model of the cane sugar factory

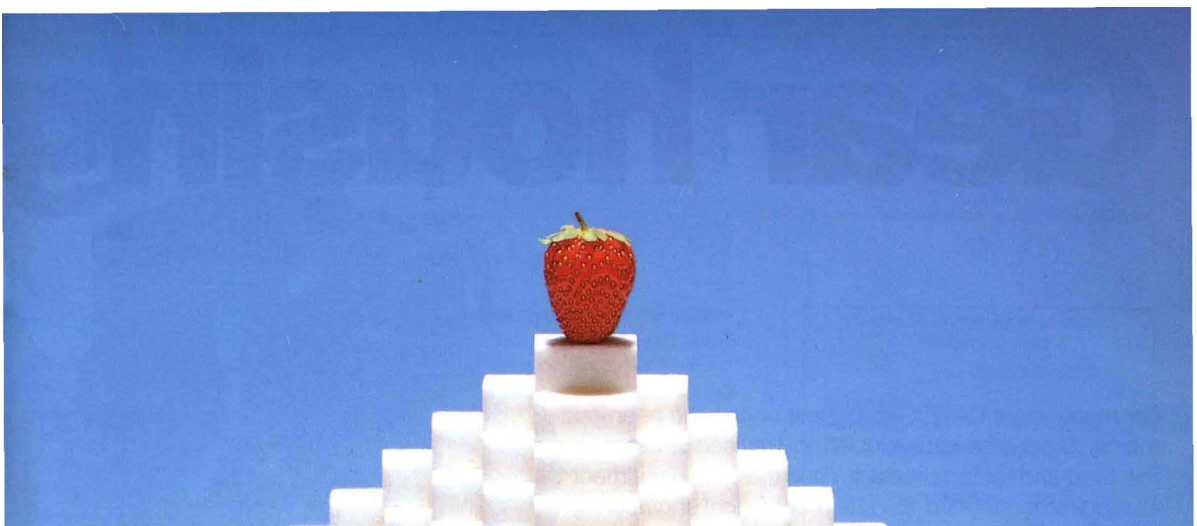
To study the effect of steam economy retrofits, we have used a simplified model of the cane sugar factory. The equations and assumed values used in our calculations are given in detail in Appendices 1-4. We have summarized the main features below:

(1) *Steam consumption in steam driven cane mill turbines and back-pressure turbo-alternators*

We have used steam consumption numbers for the mills and back-pressure turbo-alternators based on detailed calculations by engineers at Monymusk[13].

These values are tabulated in Appendix 1. As a check, we have also computed the expected steam consumption, as a function of steam inlet and outlet conditions, based on simplified formulae from Hugot[12]. As suggested by Hugot, we have assumed steam losses at 6% in the mills and back-pressure turbo-alternators.

15 Sangster: Private communication, 1987.



(2) *Juice heater calculations*

We have carried out juice heating calculations for two types of heat exchangers (shell-and-tube and plate-and-gasket), and considered heating with both bled vapour and condensate. The equations for counter-current heat exchangers and the values assumed for heat transfer coefficients and approach temperatures for the various cases are given in Appendix 2. In calculating the necessary heat exchanger areas, we have assumed a 10% heat loss in the juice heaters.

(3) *Evaporator calculations*

First, the evaporator configuration is specified (type of evaporator, number of effects, area of each effect, connection to juice heaters and vacuum pans), as well as the exhaust steam pressure and temperature, the incoming juice temperature and mass flow, the juice Brix entering and leaving the evaporators, and the condenser variables. Then the vapour temperature is input for each effect (alternatively the pressure or the heat transfer coefficient can be specified), and an initial guess is made at the amount of vapour bleeding needed for juice heating and vacuum pans. The heat and mass balance equations (Appendix 3) can then be solved to find the mass flows of steam and juice. After finding the mass flows, the juice heating calculations are repeated, and the whole sequence is iterated until a self-consistent solution is obtained. We have checked these calculations with those of a more sophisticated computer program[13] and obtained generally good agreement, to within about 5%. Low pressure steam losses of 3% are assumed in the process.

(4) *Vacuum pan calculations*

We have based our estimates of steam use in discontinuous vacuum pans on those at Monymusk, assuming a value of 137 kg/tc (Appendix 4). For continuous vacuum pans, we have assumed that the steam consumption is reduced by 25% from its present value at Monymusk to 103 kg/tc. The continuous vacuum pan heating surface areas required are calculated from tables in Hugot[12].

Retrofit case studies

In this section, we present four case studies of steam economy retrofits of a raw sugar factory (modelled on Monymusk factory in Jamaica) with a CEST cogeneration system. In each case, we have calculated the factory steam and mass flows, and the heating surface areas of retrofit equipment (condensate juice heaters, falling film evaporators and continuous vacuum pans). Using the capital costs for process equipment given in Table II, the total cost of each retrofit is estimated.

Table II. Summary of process equipment costs

	Installed cost, $ US
Juice heaters (a)	
Shell-and-tube	$75 - 100/m^2
Plate-and-gasket	$100 - 150/m^2
Evaporators (b)	
Short-tube rising film	$300 - 500/m^2
Falling film	$300 - 500/m^2
Vacuum pans (c)	
Discontinuous	$500/m^2
Continuous	$500/m^2

Sources:
(a) APV Crepaco: Heat transfer hand-book"
(b) A. Rosenblad (Rosenblad Evaporators Inc.): private communication
(c) Based on the assumption that vacuum pans cost about as much as evaporators per unit heating area, which was confirmed with industry experts. Where a range is given, we have used the higher value when estimating retrofit costs.

Once the factory steam demand is known, the export electricity production can be found from Figure 3. The extra export electricity with the retrofit is then calculated relative to the base case. Assuming an average grinding rate of 175 tonnes of cane per hour, a 210-day, 23 hour/day season, and an electricity price US $0.06/kWh, the extra electricity revenue (due to decreased process steam demand) and the simple payback time for each retrofit are computed. These results are summarized in Table III and Figures 6 - 9.

(1) *Base case conventional raw sugar factory* (Figure 6)

Our base case is a conventional raw sugar factory modelled on the Monymusk factory in Jamaica. A description of the existing factory equipment and operating conditions[13] was used as input to our sugar factory model, and the mass and heat flows were calculated, as shown in Figure 6. Our estimates of the mass flows matched those of a more sophisticated modelling program (Table I[13]) to within about 5%. The process low pressure steam demand including turbine losses is 405 kg/tc.

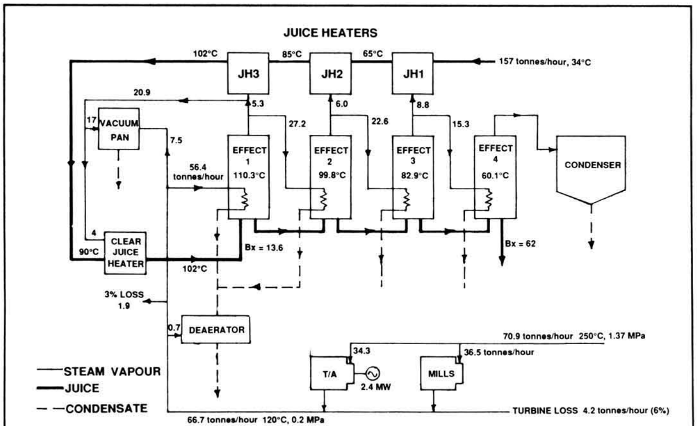


Fig. 6. Conventional factory based on the Monymusk factory in Jamaica (Case 1, Table III)

Table III. Comparison of steam economy retrofits for a 175 tch raw sugar factory crushing 23 hr/day during a 210-days season

Case	1 Present Monymusk with CEST	2 With condensate juice heater	3 Quadruple falling film evaporator	4 Quintuple falling film evaporator
Factory demands				
Medium pressure steam, kg/tc:	405	359	313	258
Mills	209	209	229	229
Turbo-alternators	196	150	84	29
6% loss	–24	–22	–19	–15
Low pressure steam, kg/tc:	381	337	294	242
Evaporator	322	308	279	231
Direct to vacuum pans	43	43	43	0
3% loss	11	10	9	7
Electricity, kWh/tc	12.8	12.8	12.8	12.8
M.P. steam saved, kg/tc	-	46	92	147
Retrofit cost, US$				
Juice heater	-	147,000	144,800	56,700
Falling film evaporator	-	-	2,400,000	2,400,000
Continuous vacuum pans	-	-	-	622,000
Total	-	147,000	2,544,800	3,078,700
Total electricity for export, kWh/tc	94	97.5	101.0	105.2
Extra electricity for export, kWh/tc* (relative to Case 1)	0	3.5	7.0	11.2
Extra electricity revenue, US $/season (relative to Case 1)	0	177,000	354,000	568,000
Simple payback time for retrofit (seasons)	-	0.8	7.1	5.4

These results are based on the model of the sugar factory described in Appendices 1-4.

* Assumes that a CEST cogeneration system is used, that an extra 0.076 kWh of export electricity is generated for each kg of medium pressure steam saved and that electricity is worth US$0.06/kWh.

(2) *Condensate heat recovery for juice heating* (Figure 7).

In this case, we estimated the process steam demand, assuming heat is recovered from the condensate for juice heating. If all the condensate is used for heating, the overall steam demand is reduced from 405 kg/tc to 358 kg/tc. If a plate-and-gasket heat exchanger is used, the heating surface area required is 979 m^2 and the cost is $ 147,000; for a shell-and-tube type the area is 1957 m^2, and the cost $196,000. The extra electricity production is 600 kW, the revenue per season is about $177,000 and the payback time is about one season.

If only the impure condensate is used for heating, the medium pressure steam demand is reduced to 389 kg/tc. The heating surface area of a plate-and-gasket juice heater is 238 m^2, the cost is $37,500, the extra electricity production is 213 kW, the extra revenue per season is $62,000 and the payback time is less than one season.

In these cases, condensate juice heaters can reduce the low pressure steam demand by 4 - 12%.

(3) *Quadruple-effect falling film evaporator with condensate juice heating* (Figure 8)

In this case, a quadruple effect falling film evaporator is installed, and condensate is used for juice heating. The overall medium pressure steam consumption is reduced to 313 kg/tc, a saving of about 23%. The saving occurs largely because the first two effects are run under pressure, so that vapour for

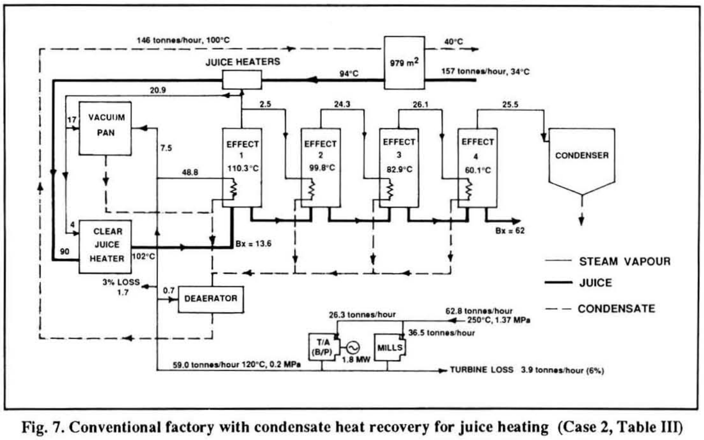


Fig. 7. Conventional factory with condensate heat recovery for juice heating (Case 2, Table III)

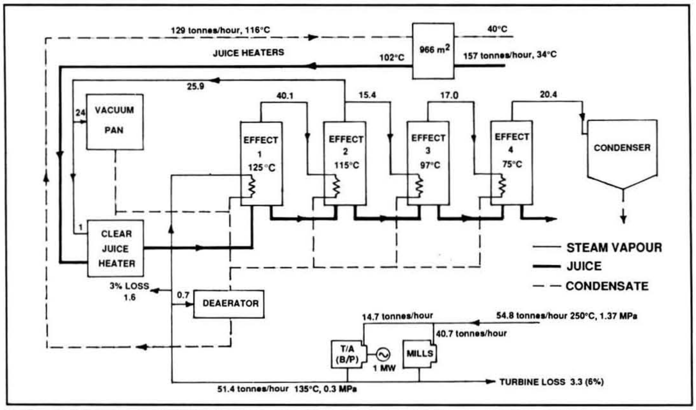


Fig. 8. Quadruple effect falling film evaporator with condensate heat recovery for juice heating (Case 3, Table III)

the vacuum pans is bled from the second effect, rather than using first effect vapour or exhaust steam. In addition, no vapour bleeding for juice heating is required. The area of the evaporator is 4800 m²; that of the juice heater is 970 m². The total cost is about \$2.5 million. The extra export electricity production with a CEST system is 1225 kW (an increase of about 10%), the extra revenue is \$355,000 per season, and simple payback time is 7.2 years. This case is interesting, because it could perhaps be used with the highly efficient GSTIG cogeneration system, and still meet the factory steam demands.

(4) *Quintuple-effect falling film evaporator with condensate juice heating and continuous vacuum pans* (Figure 9)

For greater steam economy, a quintuple-effect falling film evaporator with condensate juice heaters and continuous vacuum pans could be installed. The total area of the evaporator is 4800 m². The steam required is reduced to 258 kg/tc with this design, a saving of 36%. The total retrofit cost would be about \$3.1 million dollars. The extra export electricity would be 1960 kW (an increase of 12% as compared to case 1), the extra revenue would be \$574,000 per season, and the simple payback time would be 5.4 years. The GSTIG cogeneration system could also be used with this factory design.

Conclusions

Using commercially available process equipment it appears to be possible to reduce the overall steam use in a raw sugar factory to about 250 kg/tc. If a high pressure condensing-extraction steam turbine cogeneration system were present, the payback time of the various steam economy retrofits considered would be between one and six seasons for electricity selling at US\$0.06/kWh. For the CEST cogeneration system the export electricity production was increased by up to 15% by steam economy. Steam conserving designs also make bagasse gasifier/gas turbine cogeneration systems a future possibility for use in the cane sugar industry. The export electricity from these systems could be about 200 kWh/tc or twice the amount possible with CEST systems today.

Acknowledgements

The research reported here was undertaken with support from the Office of Energy of the US Agency of International Development, Washington, DC, as part of its Jamaica Cane/Energy Project.

The generous help of the engineers at Monymusk, particularly John Blanchard, is much appreciated. The authors would also like to thank Helmut Bourzutschky, Francisco Correa, Jack Keppeler, Charles Kinoshita, Eric Larson, José Roberto Moreira, Axel Rosenblad, Ian Sangster, Earl Smith, Robert Socolow and Robert Williams for useful discussions and comments during this work.

Summary

With the recent trend toward diversification in the cane sugar industry, a growing number of factories are producing electricity for export to the utility grid, in addition to sugar and molasses. In this paper, we discuss energy efficiency improvements as a

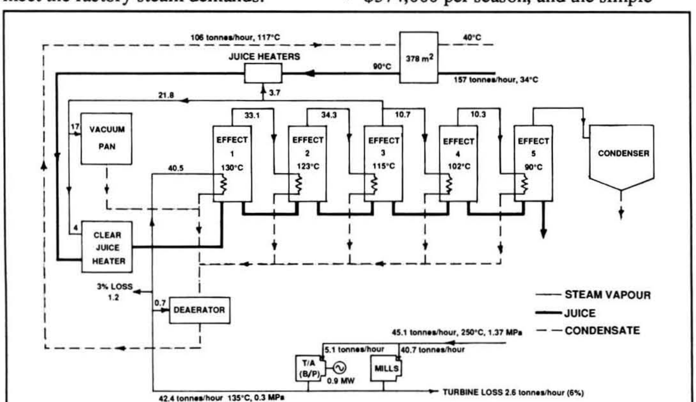


Fig. 9. Quintuple effect falling film evaporator with condensate juice heating and continuous pans (Case 4, Table III)

way of increasing electricity production in a raw cane sugar factory with a cogeneration system. We have considered two types of advanced bagasse-fired cogeneration systems: (1) high pressure condensing-extraction steam turbine systems of the type used in some factories in Hawaii and Réunion, and (2) steam-injected gas turbines run on gasified bagasse (these systems, which could be commercialized within a few years, could produce about twice as much export electricity as a high pressure condensing-extraction steam turbine, but would require some steam conservation measures in the factory).

We have written a computer program to calculate factory balances for several steam-conserving designs incorporating commercially available process equipment: waste heat recovery heat exchangers which utilize hot condensate for juice heating, falling film evaporators, and continuous vacuum pans. Our results indicate that the process steam use could be reduced to less than 300 kg per tonne of cane milled, boosting the electrical output of the steam turbine cogeneration system by up to 20% and making the highly efficient gas turbine systems a future option for the cane sugar industry.

Economía de vapor y co-generación en las fábricas de azúcar de caña

Con la tendencia reciente de diversificar la industria del azúcar de caña, varias fábricas están produciendo electricidad para exportar a la red de servicios, además de azúcar y melazas. En este trabajo, nosotros discutimos el mejoramiento en la eficiencia energética como una manera de aumentar la producción de electricidad en una fábrica de azúcar crudo de caña con un sistema de co-generación. Hemos considerado dos tipos de sistemas avanzados de co-generación alimentados por bagazo: (1) sistemas de turbinas a vapor de condensación y extracción a alta presión del tipo usado en algunas fábricas en Hawaii y Réunion, y (2) turbinas a gas inyectadas con vapor que funcionan con bagazo gasificado (estos sistemas, que podrían ser comercializados dentro de unos pocos años, podrían producir el doble de la electricidad exportada por la turbina a vapor de condensación y extracción a alta presión, pero requeriría ciertas medidas para la conservación del vapor en la fábrica).

Hemos escrito un programa de computación para calcular los balances de fábricas de varios diseños de conservación de energía incorporando equipo de procesamiento disponibles comercialmente: intercambiadores de calor para recuperación de calor que utilizan condensado caliente para el calentamiento de jugos, evaporadores de película descendente, y tachos de vacío continuos. Nuestros resultados indican que el uso de vapor en el proceso podría ser reducido a menos de 300 kg por tonelada de caña molida, incrementando la producción eléctrica del sistema de co-generación de turbina a vapor en hasta un 20% y hacer de los sistemas de turbinas a gas altamente eficientes una futura opción para la industria del azúcar de caña.

Economie de vapeur et génération d'énergie avec vente au réseau dans les sucreries de canne

Avec la tendance récente vers une diversification dans l'industrie du sucre de canne, un nombre croissant d'usines produisent, à côté du sucre et des mélasses, du courant électrique pour l'exporter vers le réseau. Dans cest article nous discutons des améliorations pouvant être apportées à l'efficience en matière d'énergie et qui peuvent constituer une voie pour produire davantage de courant dans une sucrerie vendant du courant au réseau. Nous avons considéré deux types de systèmes avec combustion de bagasse: (1) un système mettant en oeuvre un turbine à vapeur sous pression élevée opérant en condensation-extraction (du type utilisé dans quelques usines à Hawaii et en Réunion) et (2) des turbines à gaz avec injection de vapeur opérant sur de la bagasse gazéfiée. Ce dernier système, qui pourra étre commercialisé dans peu d'années, pourra produire presque deux fois plus de courant exportable qu'une turbine à vapeur à haute pression opérant en condensation-soutirage. Son utilisation exigera cependant certaines mesures d'économie de vapeur dans les usines.

Nous avons écrit un programme d'ordinateur qui calcule les bilans des usines pour différents projets pouvant conduire à une économie de vapeur et comprenant des équipements disponibles sur le marché: des échangeurs de chaleur pour récupérer des calories perdues et utilisant du condensat chaud pour réchauffer les jus, des évaporateurs à descendage et des appareils à cuire continus. Nos résultas indiquent que la vapeur utilisée dans le processus pourrait être réduite à moins de 300 kg par tonne de canne travaillé. Ceci rehausserait de plus de 20% la quantité d'électricité de la turbine à vapeur dans un système de cogénération. De ce fait les systèmes de turbine à gaz à haute efficience deviennent une option d'avenir dans l'industrie du sucre de canne.

Appendix 1. Steam consumption in cane mill turbines and factory turbo-alternators

We have based our estimates of cane mill and turbo-alternator steam consumption on results of a sugar factory modelling program by Blanchard applied to the small steam turbines at Monymusk[13]. For various conditions this program gave the resultswhich appear in Table A.1.1.

We have compared these numbers with estimates of steam consumption in the cane mills and turbo-alternators derived from Hugot[12]:

$$Q_{gen} = 3600/[(h_{in} - h_{out})\ n \times pm \times pg \times pr]$$

$$Q_{mill} = 3600/[(h_{in} - h_{out})\ n \times pm \times pmg]$$

where:

Q_{gen} = steam consumption in kg

ISJ Abstracts

Cane sugar manufacture

Evaluation of the cone-mesh type of bagasse blower chamber in stationary and transitory mode

P. Pacheco B. and R. Lesme J. *Ingenería Energética*, 1985, **6**, (2), 172 - 174 *(Spanish)*.

Studies have shown that the cone-mesh chamber permits continuous feeding of bagasse into a pneumatic transport system and gives a continuous flow of bagasse. Maximum flow of material and air flow are related exponentially by an equation which has been calculated, and the time required to reach maximum flow is between 20 and 50 seconds.

Economies of size in the Louisiana sugar cane processing industry

B. A. Chapman and R. D. Christy. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 22 - 29.

A survey of the industry in Louisiana from 1967 to 1985 shows how the number of factories has fallen while the average crushing rate per factory has increased. The economic implications of this change were examined in a study of size economies as a measure of economic efficiency. Empirical results of the analysis suggest that, on average, processing companies have operated with increasing returns from 1979, indicating an improvement in average company efficiency as it grows and pointing to the future possibility of fewer and larger factories. As current and future tech nologies allow for increasing returns, factories could be expected to increase output in an attempt to reduce unit costs and maintain or improve their competitive position. Those factories unable to take advantage of greater output may find themselves in a weakening position. The process of adjustment of the industry and the rate at which it proceeeds will be largely governed by the domestic demand for refined sugar in the USA and by the raw sugar price; a decrease in either of the last two factors would possibly cause yet further concentration of processing.

Turbidimetric evaluation of novel clarification schemes and evaporation

G. A. Adongo and S. J. Clarke. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 109 *(Abstract only)*.

Turbidimetric measurements can be very informative in studies of sugar factory performance, in particular for clarifier operation and raw sugar quality. Techniques for determination of turbidity have been cumbersome, but modern instruments can greatly reduce the time and effort involved. The refractive index (and therefore Brix) of a solution has a major effect on the measured turbidity value. The residual turbidity of clarified juice is a useful measure of the removal of suspended material. Several novel clarification schemes involving anionic and cationic polymers and surfactants have been studied. Cationic polymers can be very effective in reducing turbidity, and comparative data are given for several chemical treatments of juice. Evaporation of juice to syrup causes formation of suspended material, e.g. calcium salts related to scaling. Changes in turbidity through the evaporator were measured on pilot-scale equipment at Audubon Sugar Institute and at three factories. These and results for other factory streams are described.

Short-term/long-term computer application for the sugar industry

E. Alfonso and R. Valdes. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 109 *(Abstract only)*.

As in many industries, over the past 20 years the introduction of computers in the sugar industry has been viewed with mixed feelings. The use of programmable controls has been quickly accepted; the ability to change a control scheme quickly without component replacement is a very desirable characteristic of these systems. The addition of "smart" components capable of interactive control through the use of communication paths has opened up a wider field. These pathways allow for soft wiring between the intelligent systems which can be reconfigured to allow for any change in even the most complex scheme without the need to rewire a component. Economically this is a welcome advantage, for a technician can rapidly modify a system with a configuration terminal without ever having to make a physical change, saving on downtime and labour cost.

Parameters for vacuum pan automation

G. L. Aleman. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 109 *(Abstract only)*.

The success or failure in the automatic operation of any process equipment depends mostly on the proper selection of the parameters to be monitored and/or controlled. The author aims to highlight those parameters essential in massecuite boiling and to develop the necessary communication between people experienced in the art of boiling and personnel having knowledge of instrumentation and modern technology.

Evaluation of the performance of a forced-feed roller on the seventh mill at Atlantic Sugar Association

J. F. Alvarez, H. Cardentey and A. Pacheco. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 110 *(Abstract only)*.

The efficiency of the forced-feed roller is measured against that of other types in terms of imbibition and % pol in bagasse, and theoretical performance is compared with actual results. The benefits of the roller are evaluated as wel! as problems during its operation.

Computer model to assess the economic value of a sugar cane variety

S. J. Clarke and S. B. Milligan. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 110 *(Abstract only)*.

A computer model was developed to estimate sugar and molasses output from a typical factory for non-standard cane varieties. The program, written in BASIC and SAS languages, assumes the operation conditions for a standard variety: a fixed mill fibre throughput, fixed evaporator load and boiling house efficiency, and values for syrup Brix, molasses Brix and imbibition % fibre. The standard cane composition may be from commercial operations or from the breeding program. The model permits comparison of varieties of different fibre, juice Brix and juice purity levels in terms of sugar and molasses production per tonne of cane per day. Use of the program in conjunction with relative harvesting, transportation and factory costs allows computation and comparison of the economic value of different varieties.

Crown wheel removal from bagasse roller

G. Delaune and J. Theriot. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 110 *(Abstract only).*

Information is reviewed and compiled on the effects of milling without crown wheels on the bagasse rollers. Discussed are details of performance before and after removal of the crown wheels at Breaux Bridge Sugar Cooperative.

Monocast nylon mill bearing liners

K. McGrew. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 111 *(Abstract only).*

Results and analysis of plastic inserts installed on quarterbox bearings of the bagasse roller at Breaux Bridge Sugar Cooperative are presented. Industrial plastics are becoming more popular in areas of intensive wear, heat or corrosion. Evaluations and assessment are based on one crop year. Further results were to be accumulated during the 1988 harvest.

Microprocessor control structures for raw sugar factories

W. Keenliside. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 111 *(Abstract only).*

The implementation of digital control in cane sugar factories requires an understanding of the structures and architecture available for control systems. The methods available for control systems are described and the different areas within a sugar factory are shown that can be linked together to provide both process control and operational decision making. Methods of constructing a hierarchy for the control equipment is developed and different options are presented.

Improving the performance of low-grade crystallizers

Y. Oubrahim, M. Saska and M. Garcia. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 111 *(Abstract only).*

Various policies of operating low-grade crystallizers and their effects on molasses exhaustion are discussed. Comparison is made between continuous and batch operation, and three ways of reducing the massecuite viscosity (dilution with water, dilution with molasses, and temperature control with no dilution) are eval-uated in terms of their effects on sugar loss. Factors limiting the flow of heavy massecuites, such as the elevation between crystallizers and the cross-sectional area of the connectors, are briefly discussed.

Cane knives choke protection

A. L. Perera. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 111 *(Abstract only).*

A description is given of a new approach to the protection of cane knives and cane carriers against chokes due to cane overfeeding, stones or any large piece of metal, chain, etc. carried along with the cane. The system consists of a set of electronic speed switches that could be set at a desired speed according to the particular conditions or preferences of each installation. A magnetic pick-up senses the signal from a small spur gear (previously attached to the free end of the cane knives shaft) and sends it to the speed switch through a digital tachometer for a continuous read-out of knife speed and easy adjustment.

Preparing cane with an electronic governor

L. R. Zarraluqui. *J. Amer. Soc. Sugar Cane Tech.*, 1989, **9**, 112 *(Abstract only).*

A secondhand, two-stage condensing steam turbine without governor, built in 1950, was installed in the summer of 1984 at Okeelanta sugar factory as replacement for a wrecked turbine that used to drive the first set of cane knives in a 12,000 tcd tandem. Because of major differences between design and local conditions, the turbine needed to be re-rated by means of an engineering study. A solid-state electronic governor was selected as a retrofit for the turbine as one of a number of options. The governor proved to be extremely precise and very reliable and to be capable of providing the prime mover with considerable stability. Over the period of four harvests during which some 6 million short tons of cane were processed, there was no downtime as a result of governor failure, despite the fact that the governor requires little, if any, maintenance. Details are given of the re-rating procedure and of the governor and its characteristics.

Reinforced plastic as an engineering material for equipment and piping in the sugar-alcohol sector

M. Labronici. *STAB*, 1987, **5**, (3), 54 - 57 *(Portuguese).*

The properties of polyester and vinyl resins, used with fibre reinforcing, are discussed and the applicability of Derakane materials produced by Dow Química do Sul Ltda. for the handling of liquids (cane juice to molasses and alcohols to vinasse) in the Brazilian sugar and alcohol industries is described. They possess the advantage of corrosion resistance and so greater life than steel in tanks and piping.

Analysis of sucrose losses in delayed cane

J. L. Bouza F., M. Guevara M. and J. M.

León C. *Centro Azúcar*, 1987, **14**, (1), 3 - 7 *(Spanish)*.

Two methods of calculating sugar losses in cane and their application to harvested green and burnt cane are described. The adverse effect of delay in processing is discussed, and particular attention is called to the situation at cleaning centres where burnt cane is chopped into billets and then stored for some time under fluctuating climatic conditions such as night cold and dampness followed by strong sunlight.

Investigation of the effect of cane juice treatment with steam for settling purposes

N. Martínez A., B. Cabrera, P. Fabregat P., P. M. Nemirovich and A. P. Nikolaev. *Centro Azúcar*, 1987, **14**, (1), 26 - 30 *(Spanish)*.

Treatment of juice with saturated steam at 130 - 140°C for 1 sec increased the settling rate and juice quality and reduced the mud volume in clarification experiments. Best results were obtained at a steam:juice ratio corresponding to a temperature difference of 2.5 - 5.5°C.

Dynamic simulation of a crystallizer

M. C. L. López Z. *GEPLACEA Bull.*, 1990, **7**, (1), 6 pp.

The dynamic behaviour of a crystallizer was simulated using a program based on mass and energy balances as well as crystal content and size distribution. The equations used in the model are presented and their functions described, and the effects of various factors analysed. It is shown that under optimum conditions as derived from the model the daily yield could be increased by about 37%.

Study on continuous fluidized bed drying of bagacillo

M. A. Boizán J., R. Novoa C. and V. F. Frolov. *Centro Azúcar*, 1987, **14**, (1), 31 - 36 *(Spanish)*.

The kinetics of fluidized bed drying of bagacillo were studied in a large number of experiments using a conico-cylindrical unit supplied with hot air from a compressor. Statistical evaluation of the data is discussed and a mathematical expression presented for calculation of the average final moisture content of the bagacillo.

Heat transfer in continuous fluidized bed drying of bagacillo

M. A. Boizán J., R. Novoa C. and V. F. Frolov. *Centro Azúcar*, 1987, **14**, (1), 37 - 43 *(Spanish)*.

The mathematics of the process in the fluidized bed unit used for experimental drying of bagacillo (see preceding abstract) are discussed and expressions obtained for calculation of the coefficient of total heat transfer between the hot air and the fluidized particle bed.

Study on filtered juice clarification using surfactants

M. de Lourdes C., J. Sabari O., R. González C. and L. Ramos S. *Centro Azúcar*, 1987, **14**, (1), 44 - 49 *(Spanish)*.

Tensol was added at 8 and 10 ppm and Talosep A-5 at 2, 4, 8 and 10 ppm on Brix to juice of 10 - 12°Bx. Results of clarification showed Talosep A-5 to be superior to Tensol (but not significantly so) in terms of mud volume, impurities removal and clear juice colour.

Preliminary study of the sulphitation process with industrial cane juices

N. Vargas P., R. García L. and R. Santana M. *Centro Azúcar*, 1987, **14**, (1), 50 - 54 *(Spanish)*.

Comparative experiments were conducted on mixed juice treatment by conventional liming to pH 7.5 and heating to 96 - 98°C as against sulphitation followed by liming to pH 7.5 but without heating. Results showed that the sulphitation/liming system gave lower juice colour, ash, Mg and phosphate contents, faster settling and a smaller mud volume but a higher Ca content than the conventional system.

Cane juice liming with a mixture of calcium hydroxide and sodium carbonate

I. Wong P., A. Sanchez R. and R. Santana M. *Centro Azúcar*, 1987, **14**, (1), 55 - 60 *(Spanish)*.

By comparison with liming using only Ca hydroxide, a mixture of Ca hydroxide and Na carbonate to give a juice of the same pH increased the settling rate, gave a lower mud volume and less scale in the tubes of a 4th evaporator effect.

Method of calculating the dimensions of pipeline mixer systems

T. Prieto F. and A. Márquez S. *Centro Azúcar*, 1987, **14**, (1), 61 - 65 *(Spanish)*.

A mathematical equation for calculation of the length:diameter ratio of a baffled pipeline mixer was evaluated by experiments in which malachite green was used as tracer in the mixing of water and ammonium nitrate. The results are applicable to juice liming systems or mixing of other sugar factory liquid materials.

Optimum conditions for juice purification by alternating current

M. J. Castro F., I. Díaz A. and F. Pérez S. *ATAC*, 1987, **46**, (1), 13 - 17 *(Spanish)*.

Under optimum conditions of mixed juice purification by electrolysis using various pairs of electrodes, a purity of 99 was obtained as against 98 when the juice was limed and heated; electrolysis also gave a much lower attenuation at 420 nm and lower concentrations of organic acids, proteins, amino-acids, dextrans, starch, reducing sugars and calcium. The optimum conditions were a current density of 94 A/m^2 and a residence time of 27 min.

Proposal of technological change and material balance at Argelia Libre sugar factory. I

I. Galbán D., P. Anzardo P., J. Buriánek and R. Rodríguez E. *CubaAzúcar*, 1987, (Jan./Mar.), 3 - 8 *(Spanish)*.

Analysis of the processing scheme used at Argelia Libre sugar factory was aimed at establishing the causes of an inadequate white sugar quality and an excessive final molasses purity. Two basic defects in the system were found to be responsible: high *A*-molasses is transferred to the buffer syrup tank while there is no control on *B*-molasses purity. Modifications to the scheme are outlined with the help of a flow diagram.

Characteristics of sucrose-mother liquor crystal systems. I. Parameters defining the composition of the mixture

J. Buriánek and A. C. Hernández. *CubaAzúcar*, 1987, (Jan./Mar.), 20 - 25 *(Spanish)*.

Optimum separation of crystals and mother liquor in the vacuum pan, crystallizer and centrifugal is examined mathematically, whereby the composition of the sucrose-mother liquor mixture is shown to be dependent on the mother liquor composition, ratio of the crystal to the non-crystal component and on the crystal content. The composition of the mixture was calculated for 112 combinations of the three parameters (but this was not possible in the case of another 15 combinations) for use in optimization.

Corrosion of steel caused by juice in evaporators

R. Monduí and T. Llanes. *CubaAzúcar*, 1987, (Jan./Mar.), 26 - 30*(Spanish)*.

Corrosion of carbon steel tubes in evaporators was investigated over a period of 100 days. Examination of the effects of various parameters showed that a fall in Brix and pH and a rise in temperature promoted corrosion, while flow rate also had a marked effect, while the chemical composition of the steel had no major influence. Evaporator cleaning with acetic acid could allow steel tubes to replace copper ones.

Obtaining 30% surplus bagasse by reducing the steam consumption in raw sugar manufacture. I

D. U. Leal, P. Friedman and A. Valdés. *ATAC*, 1987, **46**, (2), 17 - 26 *(Spanish)*.

A modified scheme for juice heating, evaporation and boiling is described that would reduce steam consumption by 17 - 25% by comparison with conventional systems and allow a 30% surplus of bagasse for paper production.

Wetting by cane juice of the usual metal surfaces in heat transfer equipment

M. E. Castellanos, R. González and M. Derivet. *ATAC*, 1987, **46**, (2), 27 - 32 *(Spanish)*.

The wetting of copper, aluminium and stainless steel surfaces by juices of 20 - 60°Bx as well as pure sucrose solution at 60° and 100°C was examined in the presence of three surface-active agents at concentrations of 100, 300 and 500 ppm. The results demonstrated the advantages of the surfactants in increasing the wetting capacity but also showed that their performance was markedly affected by juice impurities. Al showed the greatest response to the action of the surfactants, while stainless steel was the most responsive to wetting.

Effect of cropping and crushing seasons on recovery of sugar

N. N. Potty, P. S. Kumar, K. C. Chandy and J. M. Kuriakose. *Indian Sugar*, 1989, **39**, 559 - 561.

Examination of the effects of the date of starting and duration of the crushing season on sugar recovery, based on data from 1948 to 1988, showed a steady decline in recovery as crushing was delayed from September to November.

Cane separation - its integration in the conventional sugar industry

H. C. C. Bourzutschky, E. Wittwer and J. Badiuk. *Zuckerind.*, 1990, **115**, 111 - 116.

The principles of the Tilby cane separation process are explained and its advantages over conventional processing demonstrated by calculations which show higher raw sugar yields and (because of a higher purity syrup) lower molasses losses and yields despite higher losses in extraction and clarification. The auxiliary equipment needed for a complete process line is listed. Developments described include the small-scale factory erected in Jamaica[1] and a proposed autonomous syrup plant based on an annual cane processing capacity of 136,000 tonnes which could overcome the major problem experienced with the process, namely inability to recover all the crystallizable sugar. The possibility of applying the process to the production of partially inverted syrups and by-products utilization of the separated cane are briefly discussed.

Water

S. J. Clarke. *Sugar Bull.*, 1990, **68**, (5), 14, 17.

The significance of waste water BOD and sugar content is discussed. While some streams at Louisiana factories contain very little sugar, most would not comply with official requirements; the sugar contents in cane wash and condenser waters in 1989 corresponded to BOD levels of several hundreds of ppm. Where condenser water is used for cane washing, the water from the cane table will contain much sugar and, if recycled, it will need to have its BOD stabilized and its pH raised to avoid odour and corrosion problems. A particular problem arises with slurried filter cake, characterized by a low volume and a very high BOD. A secondary filtration system to recover the sugar is considered the best solution; pilot plant tests at one factory some years ago indicated a possible 80% sugar separation and 50% reduction in the weight of material to be transferred. Combining fly ash slurry with clarification mud (allowing the ash to act as filter aid) has given acceptable results and could best be used for the secondary filtration and the residual material applied to the soil in canefields.

1 Bourzutschky & Ricketts: *I.S.J.*, 1989, **91**, 48A.

Beet sugar manufacture

Pulsation regeneration of a filtration surface

Ya. O. Kravets, A. I. Kolomiets and L. P. Zarudnev. *Puti Intensif. Protsessov Sveklosakh. Proizv.*, 1989, 99 - 107; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1455.

Methods of regenerating filtration surfaces were investigated on the basis of the performance of existing filters. A method of pulsation regeneration of filtration surfaces is described in detail. Various methods of generating pulsations in a filter are examined, and results are given for an experimental filter and an experimental filter station with a fixed mud layer and pulsation regeneration. It is shown that valve-type pulsators are superior to hydraulic and rotary types. Recommendations are given on the use of pulsations to regenerate filtration surfaces, and the design differences between a modified filter manufactured by the Progress Works at Berdichev and a Sh1-PFF filter are discussed.

Sugar extraction from molasses by ion exchange chromatography

P. P. Zagorodnii, N. I. Zharinov, N. S. Fedorova and S. P. Vycherova. *Puti Intensif. Protsessov Sveklosakh. Proizv.*, 1989, 127 - 138; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1459.

Results are given of trials on a bench unit for sugar recovery from molasses by ion exchange chromatography using KU-2-4Kh cation exchange resin in Ca^{++} form. Mathematical relationships have been established between, on the one hand, product parameters and the molasses fraction and, on the other, the various factors affecting separation performance. Recommendations are given on optimum process conditions and some problems are noted which need solving before the process is introduced into the industry.

Evaporation of juices in the presence of perlite filter aid

L. M. Bochko, L. P. Buketova and A. V. Savostin. *Sakhar. Svekla*, 1990, (1), 38 - 39 *(Russian)*.

At a sugar factory supplied with limestone of high (up to 6.2%) silicate content, 63% of the scale In the 4th evaporator effect consisted of silicates and other constituents not soluble in HCl. Following successful laboratory experiments, the scale was removed after the end of the 1988/89 campaign by water blasting after boiling out with sodium carbonate and then with NaOH. Perlite filter aid in the form of a finely dispersed powder has a high thermal stability and particles that act as supplementary nuclei for vapour formation (thus intensifying juice heating), is inert to juices and is highly abrasive; added to evaporator juice at 0.01% on beet it was found in tests to reduce scale formation and allowed the evaporator to operate to the pressure limit of 2.9 atm for 50 days as against only 10 - 20 days in previous years. A warning is given not to use perlite sand in which the particles have closed pores and so would not have the desired supplementary heat transfer properties.

The ACWW-1000 centrifugal in a factory scheme

D. P. Oleinik and G. V. Pan'ko. *Sakhar. Svekla*, 1990, (1), 39 - 40 *(Russian)*.

The performances of five Polish ACWW-1000 continuous centrifugals at Yagotin sugar factory over a period of 10 years are discussed. The machines are used for *B*- and *C*-massecuites and affination and have a maximum speed of 1470 rpm. They are considered superior to Soviet FPN-1251-LZ batch machines as regards noise, vibration and massecuite quality requirements, but the need for water application to the screen beneath the massecuite layer (because of a low separation factor) causes increase in molasses losses by 0.1 - 0.2% on beet in low-grade working (although it has little effect with *B*-massecuite); however, the continuous centrifugals give a better sugar quality than the batch machines and are easy to service and maintain.

Modernization of tower diffusers

N. N. Pushanko, A. A. Seregin, G. M. Sliva, V. N. Kuchar, S. A. Balakan and A. S. Dmitrash. *Sakhar. Svekla*, 1990, (1), 40 - 42 *(Russian)*.

Details are given of modifications to the design of the flights on the vertical shaft of Soviet tower diffusers, made necessary by inadequate performance and rapid wear; the new flights are of asymmetrical design, with the cross-sectional area at the end where it is attached to the shaft being greater than at the other end. The number of flights was reduced and that of the fixed baffles on the column wall increased. Data from seven factories showed that the modification increased diffuser capacity by 10 - 30% and reduced the sugar losses in pulp by 15 - 70% and electricity consumption by 35 - 40% while also lengthening the life of the transport system components.

A plant with differential jet extractor

A. L. Ignatenkov, I. M. Fedotkin and G. I. Myl'nikov. *Sakhar. Svekla*, 1990, (1), 43 - 44 *(Russian)*.

The design of the multi-tray unit for extraction of juice from beet fragments and leaf trash by spraying with water described previously[1] was modified and tests were conducted at a solids feed rate of up to 15 kg/min after premixing in a screw crusher. The extractor was heated with live steam to give a temperature of 60 - 65°C. Although a draft of 140 - 180% was achieved at 14 - 15 kg/min feed rate, and a juice was obtained having a sugar content of 5.9 - 7.5% at pulp losses of 1.06 - 1.60%, longitudinal mixing was not as good as at feed rates of 6 - 8 kg/min and the results were poorer than in earlier laboratory tests. The problem can be overcome by using a vane pump instead of a centrifugal pump to feed the solids.

The effect of certain factors on preliming figures

D. V. Ozerov, A. R. Sapronov and A. M.

1 Ignatenkov *et al.*: *I.S.J.*, 1989, **91**, 121A.

Gavrilov. *Sakhar. Svekla*, 1990, (1), 45 - 47 *(Russian)*.

Investigations of colloid coagulation and mud dehydration during preliming showed that rapid coagulation was undesirable since the resultant open-structured mud retained some of the liquid phase which could not be completely removed by holding the pH at its optimum for a given time or by heating. Comparison of three variants of the process at the same range of raw juice purity (79 - 88.4) and constant temperature (40°C) showed that lowest mud volume and colloid content and improvement in filtration and settling were obtained by mixing recycled 2nd carbonatation mud at 0.5% Ca carbonate by weight with 0.4% CaO at 500 rpm and, once an optimum pH of 10.9 was achieved, reducing the speed to 14 rpm to provide laminar mixing and maintaining the pH constant for 12 min during which the temperature fell to 35°C. The Ca^{++} and OH^- ions caused marked dehydration as a consequence of their exchange whereby K^+ and Na^+ in the Ca carbonate micelles (formed when there were insufficient Ca^{++} ions and having a negative charge) were replaced by the less hydrated Ca. (The slow rate at which these exchange reactions usually take place increases with increase in the Ca hydroxide concentration). There was a gradual fall in the zeta-potential of the colloids which, with laminar mixing and reduced temperature, permitted the energy barrier preventing coagulation to be overcome.

Investigation of beet knife durability

A. E. Rudyk, M. S. Stechishin and V. A. Kulikov. *Sakhar. Svekla*, 1990, (1), 47 - 48 *(Russian)*.

Case-hardening by nitriding was used for beet slicer knives which were then examined for anti-corrosion and wear properties by comparison with knives electro-plated with titanium nitride and chromium after normal use throughout a campaign and in tests in which they were exposed to the corrosive effects of buffered citric acid and sodium phosphate solution as well as raw juice. The case-hardened knives were found to have a longer life and to give better quality cossettes than the original untreated steel knives. The electroplated knives had better anti-corrosion properties than the untreated knives but flaked and chipped as a result of impact and corrosion of the surface below the plating, so that they were not recommended.

Molasses desugaring by ion exchange chromatography

K. P. Zakharov, P. P. Zagorodnii, N. I. Zharinov, N. S. Fedorova and S. P. Vycherova. *Sakhar. Svekla*, 1990, (1), 48 - 50 *(Russian)*.

Experimental sugar recovery from molasses by ion exchange chromatography using KU-2-4 sulpho-cationic gel in Na^+ form is reported. The molasses was first diluted to 40 - 45°Bx, delimed with soda ash if the lime salts content exceeded 0.1% on Brix and filtered, after which it was added to a 30-litre column at 10% on resin volume through which it flowed at 0.2 vol/vol/hr at 80 - 85°C. An average 88.3% of the initial sugar content (23.3%) was recovered at a purity of 69.9; after evaporation, this fraction could be used for low-grade boiling.

Silo for bulk storage of sugar

I. G. Pomazan, V. A. Bulda, Yu. S. Skorina, V. S. Vovchenko, L. S. Vilents, A. Ya. Pritsker and V. M. Shevchenko. *Sakhar. Svekla*, 1990, (1), 50 - 52 *(Russian)*.

A metal cylindrical white sugar silo of 20,000 tonnes capacity is described and details given of its erection, conveying and distribution equipment and of the procedure used for charging and reclaiming the sugar.

Continuous deliming of 2nd carbonatation juice

M. I. Egorova, V. V. Spichak, V. O. Shtangeev, L. I. Vodolazov and L. N. Fastova. *Sakhar. Svekla*, 1990, (1), 53 - 55 *(Russian)*.

Continuous deliming was tested with KU-2-8 cation exchange resin in Na^+ form which was then regenerated by passing a 4% solution of 40% NaOH in delimed 2nd carbonatation juice through the column with KU-2-8 resin in Ca^+ form until the eluate contained no more than 0.5% CaO by weight. Results for a model 2nd carbonatation juice of 13°Bx, 11.25% sugar content and 0.345 - 0.411% CaO content by weight showed a reduction to 0.01% CaO at a flow rate of 10 m/hr through a counter-current column 50 mm in diameter and 850 mm high and containing 1 litre of resin.

Cavitation treatment of ammoniacal condensates

A. F. Nemchin, E. A. Shoikhet and S. A. Esikov. *Sakhar. Svekla*, 1990, (1), 55 - 57 *(Russian)*.

A multi-stage supercavitation vessel in the form of a venturi tube housing cavitators (horizontal conical sections with discs) was used in tests on ammonia removal from condensate. The condensate was pumped up to nine times through the vessel at 90 - 95°C and then through a degasifier. Up to 94% deammoniation was achieved by passing the condensate seven times at 20 litres/sec through a three-stage vessel having a length:diameter ratio of 2 for the straight section. The energy consumption was 1.2 $kW/hr/m^3$.

Purification by carbonatation of pulp press juice

G. Pezzi. *Ind. Sacc. Ital.*, 1989, **82**, 215 - 220 *(Italian)*.

In some campaigns, because of economic constraints, sugar factories operated by Eridania Zuccherifici Nazionali SpA have had to operate diffusers at a throughput which is above the rated level, with drafts that have often been restricted, so that the pressed pulp has yielded a juice rather than water; this has resulted in higher losses and problems in the treatment of the press liquid for use in diffusion. Experiments at two factories showed that carbonatation of the press liquid increased purity, while increasing the pressure applied to the pulp increased Brix and pol but failed to have any further significant effect on purity and caused a marked increase in colour. The carbonatated liquid had a purity about 10 - 12 units lower than that of thin juice and contained much more lime salts. The question of whether to recycle the treated liquid to diffusion or use fresh water is discussed.

Empirical equations for the heat transfer coefficients in evaporators

P. Hoffman. *Zuckerind.*, 1990, **115**, 104 - 109 *(German).*

Because of considerable differences between the true evaporator heat transfer coefficients in Czechoslovakian sugar factories and theoretical values calculated by means of conventional formulae, new equations were developed using multiple correlation analysis. These equations gave a better reflection of conditions in the factories, and comparison of calculated and true values showed better agreement. Further work should be directed at improving evaporator performance.

Automation strategies

K. Kuhn. *Zuckerind.*, 1990, **115**, 121 - 124 *(German).*

In a discussion of computerized automation of factory operations the view is expressed that performance and competitiveness will depend more on personnel than on equipment and technology, the argument being that the same level of technology will be available to all factories and that therefore the operator skills will be the major variable.

Treatment of sugar factory waste water - a major contribution to environmental protection

U. Gutteck. *Lebensmittelind.*, 1989, **36**, 248 - 250 *(German).*

The role played by waste water recycling and re-utilization in reducing the fresh water requirements of a sugar factory and environmental pollution is discussed and the four major water circuits in a factory are examined: the boiler feedwater, condensate, mixed condensate and flume/wash water circuits. Four basic techniques for waste water treatment (spraying on agricultural land, anaerobic treatment with activated sludge, aerobic treatment with activated sludge and oxygenation in storage basins) are assessed and their investment and operational costs, electricity consumption and space requirements indicated for the same size of sugar factory. It is stressed that, regardless of the choice of system, the most cost-effective approach is the avoidance of unnecessary water contamination by e.g. careful handling of beet to minimize the amount of sugar entering the flume/wash water, separation of juice components from vapour and dry disposal of carbonatation mud.

Process for treatment of sugar factory waste water

J. Danowski and R. Soszynski. *Lebensmittelind.*, 1989, **36**, 251 - 252 *(German).*

A Polish-designed waste water treatment process at Hodonin sugar factory in Czechoslovakia involved heating with a mixture of evaporator and pan condensates to 33°C followed by continuous fermentation for 2.5 days in an open horizontal vessel with labyrinth-type flow and recirculation by pump. The temperature difference across the fermenter was up to 4°C at a sub-zero ambient temperature and with a strong wind. The mud discharged with the water was stored and recycled to the anaerobic stage. After the first stage of a two-stage activated sludge treatment with aeration (with a high-load mud in the first and a low-load mud in the second stage), the mud was regenerated in a conditioning vessel and any excess transferred to a storage basin or to the water awaiting heating and anaerobic treatment. Despite an overall reduction in BOD_5 of 98.7% at a daily throughput of 3600 m^3 and an initial BOD_5 load of 4 kg/m^3, the process had two major drawbacks: high heat losses in the fermenter at an air temperature below −10°C (reheating of the water led to pasteurization of the recirculated mud) and deposits of Ca carbonate in the pipelines and pumps resulting from contact between the condensate and hot untreated waste water having a high Ca salts concentration. These disadvantages were eliminated in a similar plant in which a closed vertical fermenter was used with plate-type settling tanks in the upper section for biogas withdrawal; juice was retained for 13 hr and not recycled when heat losses were low. Overall BOD_5 reduction was 99% at a daily load of 7.7 tonnes and nominal throughput of 2322 m^3.

Driver-operated weighbridges: an update

P. Leaton. *British Sugar Beet Rev.*, 1990, **58**, (1), 35.

In the system tested for beet delivery at York sugar factory, a barrier at the entrance to the weighing platform rises to allow a vehicle to be driven onto the platform and lowers once the truck is parked correctly (if it is not completely on the platform, light beams are broken and the weigher will not operate). The driver places his delivery permit in a slot in the weighbridge window and his read-only identity card (a blue disc bearing a serial number) in the reader slot; the disc rolls down the entry slot chute and is read while in motion. Grower details are displayed on a screen for the driver to check, and if he is satisfied with the details he presses an accept button which triggers the printing of a ticket. Having obtained this ticket, the driver leaves the platform and an induction loop in the exit ramp opens the barrier for the next truck to enter. The scheme has proved highly successful and is likely to be introduced at other British Sugar factories.

Sugar refining

Rheological study of concentrated liquors in a refinery

R. Marrero A., F. O. Fragoso C. *ATAC*, 1986, **45**, (5), 25 - 29 *(Spanish)*.

A study of the rheological behaviour of liquors of 47.3 - 63.4% soluble solids contents at 55, 60, 65 and 70°C showed that they had constant viscosities for different angles of slope of flow rate and thus behaved as a Newtonian fluid. Viscosity increased with % soluble solids and with fall in temperature; the effect of temperature rise on viscosity reduction was greater with a higher soluble solids content, and increase in viscosity under the effect of the higher soluble solids was greater where the temperature fell.

Characterization of the liquors used in refined sugar crystallization

L. Carrazana R. and M. Mazorra M. *Centro Azúcar*, 1986, **13**, (4), 20 - 22 *(Spanish)*.

B-sugar melted in sulphitation syrup and used for refined sugar boiling was found to contain 20 - 60 ppm SO_2 and even more where the *B*-massecuite was poorly purged; however, the liquor impurities, including SO_2, did not affect sucrose solubility.

Study of the filtrability of different refinery liquors

Z. S. de la Calahorra, J. L. D. Rodríguez and M. Salinas. *Centro Azúcar*, 1987, **14**, (1), 12 - 15 *(Spanish)*.

The filtrabilities of raw sugar liquors as determined at one Cuban sugar factory and four refineries are discussed.

Reducing undetermined sucrose losses

I. F. Bugaenko and A. A. Yasin. *Sakhar. Svekla*, 1990, (1), 57 - 58 *(Russian)*.

In refining of cane raw sugar, liming may be responsible for a major part of the total unknown sugar losses which increase with temperature rise and process time. Raw and low-grade sugar is typically remelted and limed together with recycled green syrup from *A*-massecuite which contains approx. 0.1% reducing sugars; however, carbonatation tests showed that almost all the reducing sugars in the green syrup undergo degradation without liming which it should therefore bypass, thereby decreasing the amount of sucrose exposed to heating at high alkalinity and so reducing losses.

Statistical process control. Practical aspects

T. E. Wilson. *Sugar J.*, 1989, **52**, (5), 16 - 18.

See *I.S.J.*, 1990, **92**, 6A.

Strict operational control: the first step towards energy rationalization in refined sugar production

M. E. de la Paz and D. U. Leal. *ATAC*, 1987, **46**, (1), 18 - 23 *(Spanish)*.

Processing at two Cuban refineries was examined with the aim of finding reasons for excessive energy consumption. Remedies include strict control of Brix, reduction in dilution of various products (where viscosity has to be decreased it is better to use heating), avoidance of undesirable temperature loss in pipelines, tanks and processing equipment, and raising the evaporator syrup Brix to as high a level as is practical.

The bacterial count in sugar and the influence of moist storage conditions

G. Müller. *Lebensmittelind.*, 1989, **36**, 253 - 255 *(German)*.

Details are given of the types and numbers of micro-organisms found in 23 samples of white sugar, 20 of them from East Germany and 3 from Cuba, obtained from a sugar-processing food plant. Only one of the samples met requirements in respect of all the categories of micro-organism studied (although mesophilic anaerobes are omitted from the East German Standard TGL 3070/01 and the limits for osmophilic yeasts and fungi apply only to liquid sugar). Sugar that had been stored in sacks contained extremely high levels of each category of micro-organism; it was completely caked together and had a colour varying from grey to dark grey or from yellow to a brownish yellow. Samples of the two types of sack used showed signs of dampness.

Investigation of water-soluble polyelectrolytes at Petrovsk No.2 sugar factory/refinery

L. G. Vorona, V. V. Mank, V. F. Chernenko, T. A. Mikhailik, R. Ts. Mishchuk, T. K. Panchuk, Yu. F. Tsyukalo and V. I. Shul'ga. *Dokl. Kiev. Tekhnol. Inst. Pishch. Prom.*, 1989, 12 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (5), Abs. 5 R1485.

Laboratory and factory tests were conducted on decolorization using VPK-101 water-soluble polyelectrolyte of syrups intended for refined sugar boiling. The dependence of polyelectrolyte consumption on syrup quality and of decolorization efficiency on Brix were established. The feasibility of replacing powdered active carbons with the polyelectrolyte was demonstrated.

An introduction to TSC's sugar refineries

S. Y. Hsiung. *Taiwan Sugar*, 1989, **36**, (6), 22.

Reference is made to Hualien and Peikang refineries which are attached to existing sugar factories and started operations in 1989 with the aim of meeting customer requirements for a better quality white sugar than hitherto available in Taiwan and in greater quantity. Both refineries produce granulated white sugar, a high quality special sugar, small packaged special sugar and invert syrup. Peikang has a daily remelt capacity of 500 tonnes of raw sugar while Hualien processes 300 tonnes/day.

Laboratory studies

Enzymatic sensors. Tests on electrodes for industrial purposes

-. Comtat. *Ind. Alim. Agric.*, 1989, **106**, 1121 - 1123 *(French).*

Tests were conducted on a number of commercial enzymatic electrodes for determination of glucose and L-lactic acid. Glucose was determined in pure solution in the presence or absence of sucrose, in beet raw and thin juice and in syrups, while L-lactate was determined in beet raw juice. A Boehringer kit was used as reference method. Results, which are tabulated, showed that the three models provided with a glucose oxidase membrane performed satisfactorily on pure glucose and where 15% sucrose was present, but only a Tacussel Glucoprocesseur coped in the presence of 60% sucrose; the other models were a YSI 27 and a Seres Enzymat. Their performances on factory juices and syrups differed, with the YSI 27 giving the poorest performance and failing to give reliable readings below 10 mg/litre while the other two models gave values down to 1 mg/litre; the repeatability of the Enzymat was poor. The YSI 27 gave satisfactory results in L-lactate determination and was better than the Enzymat or an AL 7 (marketed by Setric); it is considered more adaptable to routine control of fermentation in diffusion and is easier to use than the AL 7, while the Enzymat suffers from rapid ageing of the membrane. At present, none of the biosensors is suitable for on-line application.

Mass transfer in pure sucrose solutions

V. Maurandi. *Zuckerind.*, 1989, **114**, 976 - 979.

Mass transfer in concentrated sucrose solutions is discussed on the basis of dimensionless correlations to describe the main parameters at 20 - 70°C, particularly the effects of stirring and crystal size. In general, an increase in crystal size was accompanied by an increase in the minimum angular velocity of a stirrer to provide uniform dynamic distribution of suspended crystals, in the terminal slip velocity between crystals and mother liquor and in the mass transfer coefficient. The difficulty of correctly evaluating the order of magnitude of the thickness of the diffusion boundary layer is discussed.

Effect on the linearity of the flame ionization detector of the use of pure oxygen

J. A. Sales and C. O. Mariano. *Bol. Técn. Copersucar*, 1987, (37), 3 - 7 *(Portuguese).*

Fusel oil analysed at the Copersucar Technical Centre by gas chromatography showed varying results from those recorded by a similar method employed at a factory/distillery. Analysis of a synthetic mixture of alcohol showed that the factory's results were in error. The factory instrument used pure oxygen in the flame ionization detector and experiments showed that this reduced the linearity of response; use of a synthetic air containing 21% of oxygen, in a ratio of 10:1 with hydrogen gave a 2:1 proportion of O to H and resulted in improved linearity as well as cost saving.

Some parameters for measuring the juice deterioration in sugar cane

Anon. *Ind. Azuc.*, 1987, **92**, (1040), 28 - 32 *(Spanish).*

Correlation between juice pol, reducing sugars content and factory sugar yield % on the one hand and dextran content on the other was better in each case than that between the three parameters and juice acidity which, however, can be measured routinely.

Effect of adding carbon on pol determination in final molasses

A. Rodríguez A., F. A. Fernández A. and I. M. Aguilar V. *ATAC*, 1986, **45**, (6), 17 - 22 *(Spanish).*

In tests on the use of active carbon to reduce the colour of final molasses samples using the modified Jackson & Gillis IV method, it was found that the pol fell as the amount of carbon increased; this was attributed to adsorption of some of the sucrose by the carbon. However, up to 0.5 g carbon gave a difference that was no greater than the experimental error and did facilitate polarimetry.

Automatic systems and on-line analysers in the sugar factory

G. Marchetti. *Ind. Sacc. Ital.*, **82**, 221 - 234.

The range of differences in green syrup pol and refractometric Brix measurements made by 13 analysts is indicated and sources of error and how to correct them are discussed. A major improvement results from the use of automatic sampling and on-line analysers. Details are given of an on-line near infrared system and of an automatic MSD#1 laboratory doser which converts volumetric to gravimetric analysis and has given pol measurements for juice, green syrup and molasses in close agreement with values obtained by conventional polarimetry; it can be interfaced to a computer or to a refractometer. The NIR system can be used for Brix and pol measurement as well as for inorganic cation and anion analyses, pectin determination in raw juice, etc.

A simple method to measure colloids in sugar cane juice

S. D. Borawake, A. Kumar and S. J. Jadhav. *Bharatiya Sugar*, 1989, **15**, (2), 17 - 18.

The pH of a 10-ml sample of screened primary juice or of clear juice is adjusted to 3 with dilute HCl. The colloids are precipitated by adding 14 ml of ethanol and 0.7 ml of diethyl ether and filtered through Whatman No. 41 paper followed by oven drying at 70°C for approx.1 hr to constant weight. Reproducibility is 0.2%. Results for a number of samples from which an average 23.2% of colloidal material was removed gave an average concentration of 5.6% in raw juice and 4.3% in clear juice.

By-products

Hydrated ethyl alcohol: non-corrosive fuel

T. Arai, E. A. Alvarenga, J. A. R. Leme, J. N. de Vasconcelos and C. A. Correa. *Brasil Açuc.*, 1987, **105**, (1), 3 - 12 *(Portuguese)*.

A survey is presented of the development of non-corrosive fuel alcohol production, developed jointly by IAA/Planalsucar and by USIMINAS, presenting the latest results of corrosion tests carried out both with circulation equipment and in road tests of vehicles.

Continuous nitrogen complementation in the alcohol fermentation process

F. J. Ribeiro, J. C. Lopes and S. E. Ferrari. *Brasil Açuc.*, 1987, **105**, (1), 26 - 30 *(Portuguese)*.

Addition of nitrogen in the alcohol fermentation process is fairly common in Brazilian alcohol distilleries, mainly as a single dose at the beginning of the season to increase yeast cell production. Studies at the distillery of Usina Jaboticabal showed that continuous N addition resulted in higher fermentation efficiency, productivity and yield as well as higher cellular viability in the yeast, and should therefore be adopted.

Development of an alcohol-based chemical industry

L. O. Galvez. *GEPLACEA Bull.*, 1990, 7, (1), 2 pp.

An initial scheme for the development of a cane- and sugar-based chemical industry in Cuba is outlined, including: ethanol and other fermentation products; sucrose esters and resins; furfural and furfural derivatives from bagasse; acetic acid as a raw material for herbicide manufacture; products from cellulose; biomass pyrolysis, gasification and liquefaction products; products from lignin; recovery of products from residues occurring in the various processes; and wax recovery from filter cake for use directly or as an intermediate.

Some alternatives for the disposal and use of acid and alkaline waste from washing processes in raw sugar factories

H. Manso and R. Morera. *CubaAzúcar*, 1987, (Jan./March), 14 - 19 *(Spanish)*.

Methods described for treatment and use of the HCl- and NaOH-containing waste from juice heater and evaporator cleaning include bagacillo predigestion for use as animal fodder, recovery of the HCl for subsequent domestic use and neutralization and solids removal in settling tanks before discharge into the sea.

Ethanol potential of sugar and fodder beet

K. Bürcky. *Zuckerrübe*, 1989, **38**, 314 - 315 *(German)*.

Experiments over three years revealed a close relationship between beet sugar content and fermentation ethanol productivity; no preferential tendency for fermentation was found among varieties. Alcohol yield, calculated on the basis of 0.68 litres per kg of sucrose, could average 5500 litres/ha in West Germany, with a possible 10,500 litres/ha where both the sugar content and beet yield were high.

Ethanol fermentation of beet molasses by a yeast resistant to distillery waste water and 2-deoxyglucose

K. Moriya, H. Shimoi, S. Sato, K. Saito and M. Tadenuma. *J. Ferment. and Bioeng.*, 1989, **67**, 321 - 323; through *S.I.A.*, 1990, **52**, Abs. 163.

A flocculant killer yeast, *Saccharomyces cerevisiae* strain H-1, which was selected for ethanol fermentation of beet molasses, has a tendency to lose its viability in the fermented broth. Through acclimatization of strain H-1 in distillery waste water (DWW), a strain resistant to DWW, W-9, was isolated. Acclimatization of this strain in a medium containing 150 ppm 2-deoxyglucose permitted isolation of a strain, M-9, which was resistant to 2-deoxyglucose and hence was expected to give an improved ethanol yield. In laboratory tests on fermentation of beet molasses media, strain M-9 gave better results than the parent strains. The maximum ethanol concentration obtained was 107.2 g/litre, in a medium containing 23% (w/v) total sugars. However, the maximum ethanol yield of 92% was obtained at 21% total sugars. The concentration of residual sugars (mainly sucrose and fructose) after fermentation was about 2.8%, lower than with either of the parent strains. A problem not yet solved is that, when strain M-9 is used in repeated batch fermentations, it loses its ability to flocculate in a beet molasses medium.

A strain for manufacture of compressed yeasts

S. Ts. Kotenko and B. I. Dalgatova. *Pishch. Prom.*, 1989 (10), 48; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (3), Abs. 3 R1314.

A new yeast strain, *Saccharomyces cerevisiae* V-503, has been developed by laser treatment of Strain 73. It has superior biochemical and technological properties for application in baking. Cultivation for biomass production was conducted at 29 - 30°C and the molasses medium had a pH of 4.8 - 5.0 and a dry solids content of 17.5%. The pressed yeasts had a pale straw colour and a friable consistency with an acceptable yeast smell and the following biotechnological properties: a rising strength of 49 min, maltase activity of 55 min, zymase activity of 40 min, a stability greater than 12 days, an acidity of 300 ppm acetic acid and a moisture content of 73%.

Activation of yeast metabolism by finely dispersed metallic iron in cultivation on sugar industry wastes

T. I. Nushtaeva and V. S. Alenivech. *Tez. Dokl. Nauch. Konf.: Rats. Ispol'z. Prirod Resursov Sibiri*, 1989, 24 - 25; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (3), Abs. 3 R1322.

The possibility is demonstrated of increasing the rate of metabolic processes of yeasts in the presence of finely dispersed iron obtained by electrically exploding a conductor wire in an argon atmosphere. Since the structure, chemical composition and properties of finely dispersed metal powders alter as a function of the process parameters involved in their production, the effect of iron powders obtained by various methods on biosynthesis of yeast biomass substances was investigated. The powders used were obtained by the method described above, by crushing chips and by thermally degrading azides. Iron filings and industrial carbonyl iron were used as controls. Beet molasses was used as one of two feed media. The powders were introduced into yeast cultures with which the media were inoculated so as to give an initial yeast cell content of 20 - 25 million. Cultivation was carried out at a constant 28°C. The powder obtained by exploding the wire in argon had a predominantly stimulating effect on biosynthesis of ethanol and lipids by comparison with the other powders and increased CO_2 liberation but had no essential influence on the size of the yeast cells.

Citric acid from cane molasses

N. Ya. Novotel'nova, R. A. Yurchenko and T. T. Shevtsova. *Pishch. Prom.*, 1989, (10), 40 - 41; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (3), Abs. 3 R1331.

Citric acid solutions obtained by fermentation of Cuban cane molasses at Smelyansk and Leningrad citric acid plants were examined and details given of the technological properties of the molasses. Analysis of the physico-chemical parameters of Ca citrate and of the pH of the medium and basic citric acid solution obtained from beet molasses showed the need to introduce corrections in the cane molasses scheme and basic process parameters to allow for properties of the impurities. Crystalline citric acid obtained from the cane molasses conformed to the standard without recrystallization.

Effect of molasses wort concentration on the progress of alcohol fermentation at reduced pressure

Z. Janiszyn, E. Dziuba and G. Sovkowicz. *Przem. Werm. i Owoc.*, 1989, **33**, (5), 4 - 6; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (4), Abs. 4 R1398.

An investigation was conducted on the dynamics of ethanol formation and on the physiological state of yeasts of *Saccharomyces cerevisiae* strain 30 in batch fermentation of molasses wort having a dry solids content of 200, 250 and 300 g/litre at atmospheric pressure and at a reduced pressure and a temperature of 30° and 35°C. Fermentation at the reduced pressure was more rapid than at atmospheric pressure, and vacuum fermentation of molasses media of higher sugar concentration proceeded at an optimum rate without any adverse effect on yeast physiology.

Beating the dunder problem

Anon. *Australian Canegrower*, 1989, **11**, (4), 19 - 20.

Before 1970, vinasse from Sarina distillery (which produces alcohol from molasses) was piped to local saltwater creeks, causing permanent pollution and eliminating all marine life. In 1971, when CSR Ltd. acquired the distillery, the vinasse was sprayed over the land; while this allowed fish to return to the creeks, it proved inadequate because it could not cope with the effects of heavy rain during tropical wet seasons. Utilization of the vinasses as fertilizer by cane farmers increased until, by 1988, all the vinasse resulting from a season's processing was being used, although the wet season problems remained unsolved; the recommended dosage rate of vinasse containing 8 - 10% solids was approx. 13 m^3 per ha. Adoption of the Biostil process of ethanol fermentation in 1989 allows less water to be used, thus greatly reducing the volume of vinasse but maintaining the nutrient concentrations and allowing it to be held in existing storage dams, the depth of which is being increased to ensure no seepage even with very heavy rain. The increase in vinasse concentration has been accompanied by a 35% reduction in distillery steam consumption (based on alcohol yield). Problems associated with vinasse availability and price are mentioned.

Importance of cane bagasse in pulp and paper production in Mexico

J. M. R. Rodríguez. *GEPLACEA Bull.*, 1990, **7**, (2), 2 pp.

It is estimated that Mexican sugar factories use 80% of the total bagasse as fuel and that no more than 15% of the total is utilized for pulp production; the amount of pulp used in paper manufacture fell from 13.2% in 1980 to 8.8% in 1989 despite an annual growth in paper production of 4.2% per year. The number of bagasse pulp plants fell from seven in 1980 (with a total annual output of 272,400 tonnes, representing 37.2% of total pulp production in Mexico) to four in 1989, with a production volume of about 257,000 tonnes which accounted for 32.5% of the total. Reasons for the current situation and possible remedies are indicated.

Immobilization of dextransucrase on benzoyl cellulose as a support

Z. Petronijevic, S. Jovanovic and R. Nesic. *J. Serbian Chem. Soc.*, 1990, **55**, 145 - 151.

Dextransucrase immobilized on benzoyl cellulose having a desired degree of acylation (brought about by altering the cellulose:benzoyl chloride ratio) was incubated for 15 min with sucrose solution (200 g/l) at 30°C. Results showed that all supports with an acylation degree of at least 2.9 had a marked inhibitory effect on the enzyme, while a degree of 2.53 meq/g proved the most favourable; at pH 5.4 and 23°C this gave a dextran yield > 20 units/g.

Table A.1.1.

Steam inlet		*Steam outlet*		*Mills*	*Turbo-alternators*
P_{in} (MPa)	T_{in} (°C)	P_{out} (MPa)	T_{out} (°C)	Steam used (kg/tc)	Steam used (kg/kWh)
1.37	250	0.20	120	209	14.0
		0.25	127	233	15.9
1.9	270	0.20	120	177	11.9
2.5	360	0.20	120	129	10.2

steam/kWh electricity out at generator terminals

Q_{mill} = steam consumption of mill in kg steam/kWh mill power

n = average turbine thermodynamic efficiency
= 0.7 - 0.72 (back-pressure of 0.149 - 0.396 MPa)
= 0.65 for mill turbine (two-stage)

h_{in} = enthalpy of steam in (kJ/kg)

h_{out} = enthalpy of steam out (kJ/kg)

pm = mechanical efficiency of turbine = 0.985

pg = efficiency of generator
= 0.94 - 0.985

pr = efficiency of generator gearing
= 0.97 - 0.985

pmg = efficiency of gearing for mill
= 0.85

These formulae do not consider part load performance, which can affect the steam consumption significantly.

Steam conditions and quantities, calculated assuming the following values for Monymusk (pm = 0.985, pg = 0.9625, pr = 0.9775, n = 0.70 for back-pressure turbo-alternators; pmg = 0.85, n = 0.65 for mills), are given in Table A.1.2.

Table A.1.2.

Steam inlet			*Steam outlet*			*Turbo-alternator*	*Mills*	
P_{in} (MPa)	T_{in} (°C)	h_{in} (kJ/kg)	P_{out} (MPa)	T_{out} (°C)	h_{out} (kJ/kg)	Q_{gen} (kg/kWh)	Q_{mill} (kg/kWh)	Steam used (kg/tc)
1.37	250	2930	0.20	120	2707	24.9	29.7	208-267
			0.31	135	2727	27.4	32.7	229-294
1.9	270	2953	0.20	120	2707	22.5	26.8	187-241
2.0	316	3060	0.20	120	2707	15.7	18.5	129-167
			0.31	135	2727	16.7	19.6	137-176
2.5	360	3149	0.20	120	2707	11.3	13.3	94-122

The actual power consumption in the mills is difficult to estimate *a priori*. We have calculated a range for the mill steam consumption, assuming that the average mill power consumption lies in the range 7 - 9 kWh/tc. Given the uncertainty in these numbers, we have used the estimate in Table A.1.1 for mill steam consumption where available. For the case where P_{in} = 1.37 MPa, P_{out} = 0.31 MPa, we have assumed that mill steam consumption is 229 kg/tc. The turbo-alternator steam consumption is also taken from the estimates in Table A.1.1.

Appendix 2. Juice heater calculations

Juice heater areas and inlet and outlet temperatures can be estimated if the heat transfer coefficients, approach temperature and heating fluid temperature and pressure are known.

From energy balance for a counter-current heat exchanger:

$$m_{jin} \times C_{pj} (T_{jav}) \times (T_{jout} - T_{jin}) = m_s \times [h(T_{sin}) - h(T_{sout})]$$

where:

m_{jin} = mass flow of juice

C_{pj} = specific heat of juice at a certain temperature and Brix (see Appendix 3 for formula)

T_{jav} = average juice temperature

T_{jout} = outlet juice temperature

T_{jin} = inlet juice temperature

m_s = mass flow of steam (or hot condensate)

T_{sin} = inlet temperature of steam (or hot condensate)

T_{sout} = outlet temperature of steam (or hot condensate)

$h(T_{sin})$ = enthalpy of steam (or hot condensate) at inlet

$h(T_{sout})$ = enthalpy of steam (or hot condensate) at outlet

If the approach is known (the temperature difference between the exit steam and the inlet juice, T_{appro}), then we can solve for T_{sout}

$$T_{sout} = T_{jin} + T_{appro}$$

and for T_{jout}

$$T_{jout} = T_{jin} + m_s \times [h(T_{sout}) - h(T_{sin})] / [m_{jin} \times C_{vpj} (T_{jav})]$$

The heat exchanged is given by:

$$Q = U \times A \times LMTD \times f(LMTD) = m_s \times [h(T_{sout}) - h(T_{sin})]$$

where:

U = heat transfer coefficient

A = heat exchanger area

$$LMTD = [(T_{sin} - T_{jout}) - (T_{sout} - T_{jin})] / \ln[(T_{sin} - T_{jout})/(T_{sout} - T_{jin})]$$

f(LMTD) = heat exchanger correction factor = 0.8 - 0.99

Solving for the heat exchanger area gives:

$$A = m_s \times [h(T_{sout}) - h(T_{sin})] / [U \times LMTD \times f(LMTD)]$$

In our juice heater calculations we have assumed the values of heat transfer coefficients U (Watts/°C/m^2)given in Table 2.1.

The range of values reflects the influence of fouling. We have used the lower value of the heat transfer coefficient in figuring heat exchanger areas.

Approach temperatures, T_{appro}(°C), are given in Table 2.2.

Table 2.1.

Type of juice heater	*Source of heat* Vapour or steam	Condensate
Plate-and-gasket heat exchanger	2500-4000 (a)	2000-4000 (a)
Shell-and-tube heat exchanger	600-1300(b)	1000-2000(a)

Table 2.2.

Type of juice heater	*Source of heat* Vapour or steam	Condensate
Plate-and-gasket heat exchanger	6-10 (a)	6-10 (a)
Shell-and-tube heat exchanger	7,15,18,20 (c)	6 - 10 (a)

Sources:

(a) APV Crepaco : "Heat transfer handbook", HTH-586

(b) Hugot[12]

(c) These are approximate approach temperatures corresponding to effects 1, 2, 3, and 4, assumed for the shell-and-tube juice heaters at Monymusk, which utilize vapour bled from the evaporator; they are based on Hugot's values[12] and on factory simulations[13]

Appendix 3. Evaporator calculations

Assuming no heat losses, the equations for mass and heat flow in the effect "i" of a forward feed evaporator with N effects are:

Mass conservation:

Sugar: $m_{jo} \times X_o = m_{ji} \times X_i$, i = 1, N

Water: $m_{ji-1} - m_{ji} = m_{vi} + m_{vbi}$, i = 1,N

Energy balance:

$$m_{vi-1} \times HFG(T_{vi-1}) = (m_{vi} + m_{vbi}) \times HFG(T_{vi}) + m_{ji} \times C_{pj} \times (T_{ji} - T_{ji-1})$$

(Condensing vapour) = (evaporation from juice) + (juice heating)

Heat exchange:

$$Q_i = U_i \times A_i \times (T_{vi-1} - T_{ji}) = m_{vi-1} \times HFG(T_{vi-1})$$

Boiling point rise:*

$$T_{ji} = T_{vi} + BPR$$

$$BPR = 2.5 \times fX_i \times (0.3 + fX_i)\,[1 - 0.54 \times P_{vac}/(190.5 - P_{vac})]/(1.036 - fX_i)$$

where: $P_{vac} = 76 - P_{vi} \times 760$, P_{vi} in MPa, $fX_i = X_i/100$

Specific heat of juice:*

$$C_{pj}(X_i) = 1.0 - (0.6 - 0.0018 \times T_{ji}) \times X_i/100$$

Barometric condenser:

$$(m_w + m_{vN}) \times HG(T_w + DT_c) = m_w \times HG(T_w) + m_{vN} \times HFG(T_{vN})$$

(condensed water) = (input water) + (condensing vapour)

where:

m_{ji-1} = juice flow into effect "i"

T_{ji-1} = temperature of juice flowing into effect "i"

X_{i-1} = Brix of juice flowing into effect "i"

C_{pj} = specific heat of juice at a certain temperature and Brix

BPR = boiling point rise of juice at a given Brix and temperature

T_{vi} = vapour temperature in effect "i"

P_{vi} = vapour pressure in effect "i"

m_{vi-1} = mass flow of vapour into steam side of effect "i"

m_{vbi} = vapour bled from effect "i" to juice heaters or vacuum pans

U_i = heat transfer coefficient of effect "i"

A_i = heat exchange area of effect "i"

T_w = temperature of water into barometric condenser

m_w = mass flow of water into barometric condenser

DT_c = temperature difference between condenser inlet water and outlet condensate

HFG = enthalpy of vaporization

HG = enthalpy of water

For Monymusk, we have assumed the following values for the heating surface areas[13]:

Effect	Area, m^2
1	1998
2	1129
3	844
4	836

* E. Hugot[12]

Appendix 4. Vacuum pan calculations

The total vapour to be evaporated in the vacuum pan is:

$$m_{vtot} = m_{jN} \times (1 - X_N/X_f) = m_{jo} \times (X_o/X_N) \times (1 - X_N/X_f)$$

where:

m_{jN} = mass flow of juice out of last effect of evaporator

X_N = Brix out of last effect = 60-70

X_f = final Brix of massecuite = 94-96

m_{jo} = juice flow into first effect of evaporator

X_o = Brix of juice into first effect of evaporator

Then, assuming that the amount of juice is about equal to the amount of cane crushed, Hugot quotes steam consumption of about

$$m_s = (1.2 - 1.7) \times (X_o/X_N - X_o/X_f)/(1 - V_{Ploss}) \text{ kg steam/tonne cane}$$

where:

V_{Ploss} = heat loss in vacuum pans = 10 - 20%

Assuming V_{Ploss} = 20%, X_o = 13, X_N = 65 and X_f = 96°Brix, then the steam consumption is about

m_s = 100 - 140 kg/tc,

continued on page 146

Rheological studies of massecuites and molasses

By R. Broadfoot and K. F. Miller
(Sugar Research Institute, Mackay, Queensland, Australia)

Continued from page 116

Rheological measurements on massecuites

Massecuites were prepared by mixing a known proportion of raw sugar crystals (of mean aperture 0.62 mm and 35% coefficient of variation, by sieving) into molasses which had been concentrated in the laboratory pan. The same bulk supply of final molasses was used as for the viscosity measurements on molasses. For each massecuite the crystal content was 30% by weight on massecuite.

The rheology of the massecuites was studied with the Brookfield viscometer using No. 7 spindle and with the pipeline viscometer using tubes L1, L2 and L3. The "Power Law" model provided a good fit to the flow curve data and values of the "Power Law" parameters so determined are given in Table V. Two of the massecuites were extremely viscous (having mother molasses of high dry solids content) and these showed flow characteristics approaching Newtonian behaviour. In the case of sample MS3, which contained a large quantity of entrapped gas, the flow curves for each tube of the pipeline viscometer showed two distinct straight-line regions, with a tendency towards Newtonian behaviour at the higher shear rates. Ness[13] has reported similar observations in massecuites containing significant quantities of gas.

The values of flow index for the massecuites and for molasses which have comparable dry solids content to that of the mother liquor were compared and this showed that the flow behaviour was largely unchanged. However, the comparison is confounded by differences in the range of shear rate and the presence of gas in the massecuite samples.

The flow curves for massecuite samples MS2 and MS3 showed considerable divergence between the curves for

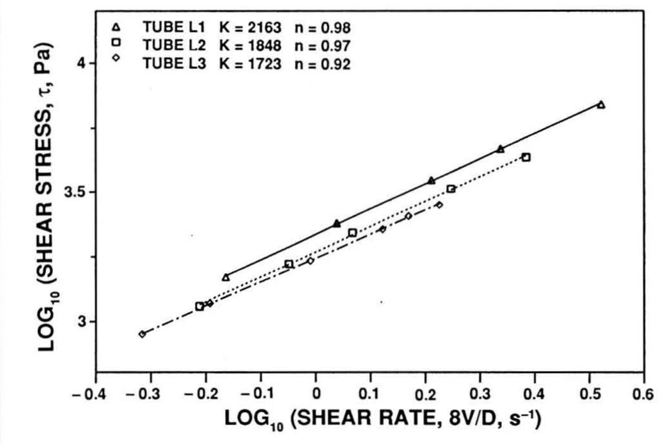


Fig. 7. Flow curves for massecuite sample MS2 using the pipeline viscometer

13 *Proc. 1st National Conf. on Rheology* (Melbourne, Australia), 1979, 47 - 50.

Table V. "Power Law" parameters for massecuite samples

Sample	Mother molasses dry substance	Temperature of measurement, °C	Brookfield viscometer with spindle 7: K, Ns^nm^{-2}	n	Shear rate* range, s^{-1}	Pipeline viscometer: Tube	K, Ns^nm^{-2}	n	Shear rate* range, s^{-1}
MS1	82.5	50	73.1 (at 48°C)	0.79	1-10	L1	45.9	0.92	3-24
						L2	45.2	0.93	2-22
MS2	88.9	50	$\mu_{apparent}$+ = 5720 Pa.s at 49°C			L1	2163	0.98	0.7-3
						L2	1848	0.97	0.6-2
						L3	1723	0.92	0.5-2
MS3	89.8	50	$\mu_{apparent}$+ = 7040 Pa.s at 49°C			L1	4456	0.87	0.5-2
							4269	1.01	2-3
						L2	3112	0.76	0.4-1
							3425	0.97	1-2
						L3	2469	0.86	0.5-0.9
							2497	0.89	0.9-1.1

Notes:(1) The mother molasses was prepared from the bulk supply of final molasses and was 43.5 purity
(2) Each massecuite sample contained 30% crystal by weight on massecuite
(3) Entrapped gas content in samples MS1, MS2 and MS3 was estimated at 4, 5 and 10% by volume on gas-free massecuite, respectively

* Uncorrected shear rate
\+ Single measurement of apparent viscosity. Brookfield RVT viscometer at upper torque limit

the different tubes (differing length) due to the influence of pressure loss associated with the tube ends. This resulted in higher consistency values for the shorter tubes. Figure 7 shows the flow curves for massecuite sample MS2. Flow index values were largely independent of the tube L/D ratio. Similar observations on the influence of tube dimensions on the consistency and the flow index values for massecuites were made by Ness[2].

Correction for end effects in pipeline viscometry

The flow curves for the massecuite and molasses samples using tubes of different length have shown higher consistency values for the shorter tubes (see Tables III to V). This occurs because the measured pressure drop (P_m) across the tube is not totally available to overcome the shear stress at the wall (τ) corresponding to fully developed laminar flow. An additional pressure loss, representing the sum of frictional pressure losses at the entrance and exit of the tube and a head loss corresponding to the exit kinetic energy must be provided. In this section a technique is developed to correct for these additional pressure losses and so provide a better estimate of the rheological properties of the material.

Using the procedure developed by Sarmiento *et al.*[14], to correct for the entrance and exit pressure losses a plot of $DP_m/4L$ versus D/L for constant values of shear rate has been prepared for each sample. For this correction procedure tubes of different length but the same diameter are used for each analysis. Figure 8 shows the data for massecuite sample MS2. For each shear rate the true wall shear stress for fully developed flow is given by extrapolation of the lines of constant shear rate to a D/L value of zero. For a time-independent non-Newtonian fluid such as massecuite or molasses a single flow curve based on the true wall shear stress will exist for all tubes (pipes) regardless of the diameter or length.

Using the value of true wall shear stress (τ) obtained for each shear rate an estimate has been made of the number of velocity heads consumed in the tube entrance and exit from the relationship

$$P_m = 4\tau L/D + K_{head} V^2 \rho/2 \qquad (1)$$

where K_{head} = number of velocity heads corresponding to the pressure losses in the entrance and exit of the tube, V = average velocity in the tube, and ρ = density of the material.

The work of Hooper[15,16] indicates that, for laminar flow, the loss of head due to tube entrance and tube exit is given by:

$$K_{head} = K1\, Re_{tube}^{-1} D_{res} D^{-1} + 2 \qquad (2)$$

where K1 = a constant, dependent on the profile of the tube entrance, Re_{tube} = Reynolds number for flow inside the tube, and D_{res} = the diameter of the reservoir (i.e. the chamber at the entrance of the tube).

The first term of expression (2) represents the pressure loss in the tube entrance and the quantity "two velocity heads" is the kinetic energy loss at the tube exit. The pressure loss at the entrance is very much greater than the kinetic energy loss.

Hooper[16] indicates that, for a rounded tube entrance, a value of 50 for factor K1 is appropriate and for a square tube entrance a value of 160 should be used. This factor should be constant for tubes of similar entrance profile.

For the pipeline viscometer used in the tests (D_{res} = 0.15 m) the average values of K1 which were determined for the range of shear rates studied are given in Table VI.

Table VI. Average values of tube entrance factor K1

Sample	Tube type	Average Re_{tube}	Mean value of K1
F1	S	0.7	19
F2	S	0.4	10
M3	S	0.2	2
M5	S	0.1	20
M6	S	0.01	8
M7	S	5×10^{-4}	7
M8	S	4×10^{-6}	4
MS1	L	0.01	(No result)
MS2	L	3×10^{-5}	23
MS3	L	1×10^{-5}	54

Generally the test data showed lower values than those suggested by Hooper[16] for a rounded entrance profile, probably because the entrance of each viscometer tube was very well rounded, having a radius of curvature of 5 mm.

For the test data a constant value of K1 was not obtained and, in general, massecuite or molasses samples with significant quantities of entrapped gas (samples F1, F2, MS2, MS3) showed higher values. It may be that the pres-

14 *Ind. Eng. Chem. Process Des. Dev.*, 1979, **18**, 746 - 751.
15 *J. Chem. Eng.*, August 24th, 1981, 96 - 100.
16 *ibid.*, November 7th, 1988, 89 - 92.

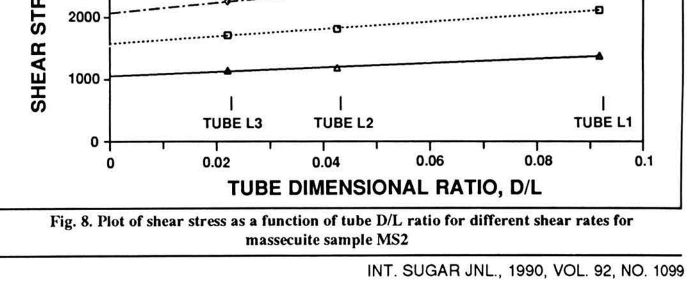
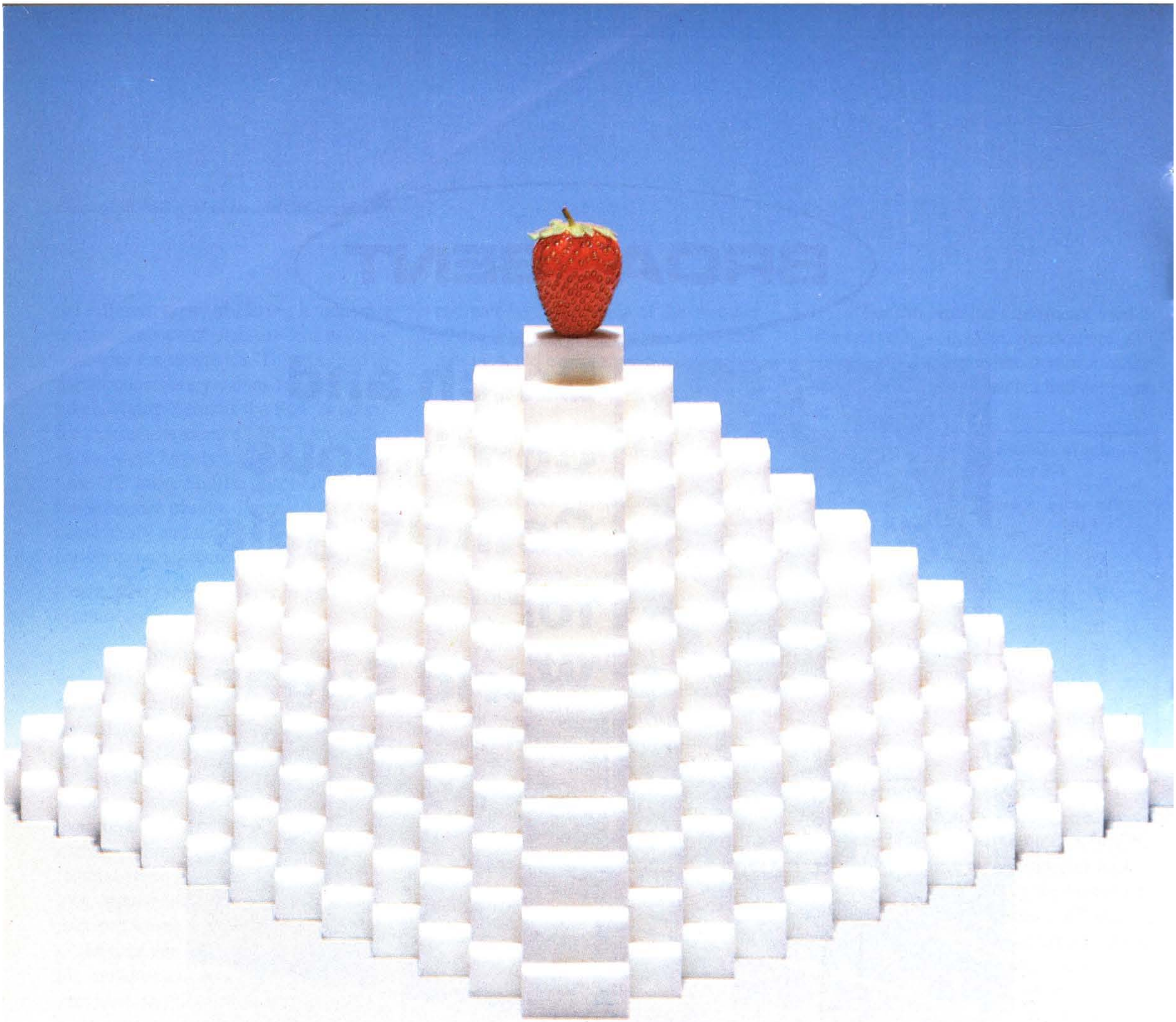


Fig. 8. Plot of shear stress as a function of tube D/L ratio for different shear rates for massecuite sample MS2



ence of a dispersed phase (gas or crystal) results in a higher pressure loss at the tube entrance. For the degassed molasses samples the average value of K1 was 8 and this appeared to be largely independent of the Reynolds number.

It is proposed that, for pipeline viscometry, a correction for the pressure losses associated with the tube entrance and exit should be subtracted from the measured pressure to obtain the estimate of the frictional pressure loss for fully developed flow. It is derived in Appendix A from expressions (1) and (2), that, for a "Power Law" fluid, the ratio of the sum of the pressure losses at the tube ends to the frictional pressure loss at the tube wall is given by:

$$K1\ D_{res}/64L$$

This ratio is independent of the tube diameter and the fluid consistency, flow index, velocity and density. Thus, using this relationship and an estimated value for the entrance profile factor K1 a simple correction to the value of the measured pressure differential can be made to provide an estimate of the pressure loss for fully developed flow. The consistency and flow index values can then be determined using the standard procedure outlined in Table I.

For a well rounded tube entrance a value for K1 of 8 seems appropriate for molasses but a higher value (e.g. 20 to 30) should be used for massecuites or molasses containing entrapped gas. Further assessment of this factor and the variables which influence its value is desirable.

For the pipeline viscometer used in this study the analysis shows that tubes with a L/D ratio greater than 35 are required if the pressure losses at the tube ends are to be limited to less than 10% of the total pressure differential. This value of L/D ratio holds for both degassed molasses samples (with tube S) and for massecuites (with tube L). For molasses samples containing significant quantities of gas the minimum L/D ratio should be at least twice that for degassed molasses if the relative influence of the pressure losses at the tube ends is to be limited to a similar magnitude.

Because of the relative importance of the pressure losses at the tube ends in the estimation of the consistency and the simplicity of the procedure required to correct the measured pressure differential for these losses, it is recommended that the correction is included in the analysis of pipeline viscometry data.

Conclusions

Rheological studies were made on molasses samples covering a range of temperatures, dry solids and gas contents. Massecuite samples were also studied but over a restricted domain.

For molasses the Brookfield-SSA rotating cylinder viscometer gave reasonable predictions of the rheological properties for pipeflow situations. The consistency values obtained from the Brookfield and pipeline viscometers were not significantly different statistically, although some large individual differences were obtained. Generally, the Brookfield rotating cylinder viscometer indicated more pseudoplastic flow behaviour for a particular molasses sample than did the pipeline technique. This was shown by the lower values for flow index with the rotating cylinder method, particularly at higher temperatures. The Brookfield results generally gave the closest agreement with pipelines of low length to diameter ratio.

The viscosity of molasses varies with temperature, with samples of higher dry solids content being more sensitive to changes in temperature. The presence of entrapped gas caused a large change in the molasses flow properties e.g. 13% gas content increased the consistency by 40% and produced greater pseudoplastic flow behaviour.

The pipeflow method requires that a correction for the pressure losses at the tube entrance and exit is made if a single flow curve, independent of the tube diameter and length, is to be obtained.

The pressure loss for the tube ends is calculated in terms of the number of velocity heads and a relationship is derived to estimate this. It is recommended that the correction be made because, even with tubes with L/D ratios of 35, the pressure loss at the tube ends is estimated at 10% of the total pressure differential.

Summary

The rheology of molasses and massecuite samples has been studied using a Brookfield rotating cylinder viscometer and a pipeline viscometer. The results have provided a good fit to the "Power Law" model for non-Newtonian fluids. For the molasses samples the rotating cylinder viscometer has indicated more pseudoplastic behaviour than the corresponding measurements with the pipeline viscometer. Consistency values determined by the two methods were comparable, with closest agreement being obtained with pipelines of low length to diameter (L/D) ratio. Measurements on degassed molasses have shown increased sensitivity of the viscosity to changes in temperature for molasses of higher solids content. Pipeline viscometry showed a divergence of flow curves for tubes of the same diameter but different length owing to the effects of pressure loss at the tube entrance and exit. A procedure has been proposed to correct for these losses and to allow the true wall shear stress for fully developed flow to be estimated from measurements with a single pipeflow tube.

Estudios reológicos de masas cocidas y melazas

La reología de muestras de melazas y masas cocidas ha sido estudiada usando un viscosímetro rotatorio cilíndrico Brookfield y un viscosímetro de conducción. Los resultados han mostrado una buena correspondencia con el modelo de "Ley de Potencia" para fluidos no-Newtonianos. El viscosímetro rotatorio cilíndrico ha mostrado para las muestras de melazas una conducta más pseudoplástica que las mediciones correspondientes con el viscosímetro de conducción. Valores consistentes determinados por los dos métodos fueron

comparables, con una concordancia mejor cuando se usan conductos de baja relación entre longitud y diámetros (L/D). Las mediciones en melazas desgasificadas han mostrado una sensibilidád de la viscosidad a cambios de temperatura en los casos de melazas con alto contenido de sólidos. La viscometría de conduccíon mostró una divergencia en las curvas de flujo para tubos del mismo diámetro pero diferente longitud debido a los efectos de pérdida de presión entre la entrada y la salida del tubo. Se ha propuesto un procedimiento para corregir estas pérdidas y permitir que el verdadero esfuerzo cortante de las paredes, en un flujo completamente desarrollado, sea estimado a partir de mediciones con un tubo único de conducción.

Etudes de la rhéologie des massecuites et des mélasses

On a étudié la rhéologie d'échantillons de mélasses et de masse-cuites. A cet effet on a utilisé un viscosimètre Brookfield à cylindre rotatif et un viscosimètre à tube. Les résultats furent en bonne concordance avec le modèle "Power Law" pour des fluides non-Newtoniens. Dans le cas des mélasses, le viscosimètre à cylindre rotatif a indiqué un comportement plus pseudoplastique que ce ne fut le cas dans les mesures effectuées au viscosimètre à tube. Les valeurs de consistance furent comparables dans les deux méthodes. Les meilleurs résultats furent obtenus avec des tubes caractérisés par un faible rapport longueur sur diamètre (L/D). Des mesures sur des échantillons dégazés ont – pour des mélasses à brix élevé – fait apparaître une sensibilité accrue de la viscosité vis-à-vis de modifications de température. Suite aux effets de chute de pression à l'entrée et à la sortie du tube, on notait pour le viscosimètre avec tube des divergences dans les courbes d'écoulement pour les tubes d'un diamètre identique mais de longueur différente. On propose une méthode qui permet d'introduire une correction pour ces pertes de pression. Ainsi on peut – à partir de mesures avec un seul tube – évaluer le véritable "shear stress" le long de la paroi pour plein débit.

Rheologische Studien über Füllmassen und Melassen

Ein Brookfield-Viskosimeter mit rotierendem Zylinder und ein Rohrleitungsviskosimeter wurden zu Studien der Rheologie von Melassen- und Füllmassenproben angewendet. Die Ergebnisse waren in guter Übereinstimmung mit dem Modell des Exponentialgesetzes für Nicht-Newtonsche Flüssigkeiten. Bei den Melassenproben wies das Brookfield-Viskosimeter mehr Pseudoplastizität als das Rohrleitungsviskosimeter auf. Beide Methoden gaben fast gleiche Konsistenzwerte, mit der besten Übereinstimmung bei Rohrleitungen mit einem kleinem Länge-Durchmesserverhältnis. Messungen von entgasenen Melassen zeigten erhöhte Empfindlichkeit der Viskosität auf Temperaturänderungen bei höheren Feststoffgehalten. Eine durch Rohrleitungsviskosimetrie gefundene Abweichung der Fliesskurven für Rohrleitungen mit gleichem Durchmesser aber unterschiedlicher Länge war auf die Einflusse eines Druckverlustes am Rohrleitungseintritt und -Austritt zurückzuführen. Eine Verfahrensweise wurde vorgeschlagen zur Berücksichtigung dieser Verluste und zur Ermittlung der tatsächlichen Wandscherspannung bei vollentwickeltem Fliessen an Hand Messungen bei einer Einzelfliessrohr.

APPENDIX A

Ratio of the sum of the pressure losses at the entrance and exit of the tube to the pressure loss for fully developed laminar flow

For the laminar flow of fluid in a tube the measured pressure loss can be subdivided into two categories, *viz*. the frictional wall loss for fully developed laminar flow and pressure and energy losses at the tube entrance and exit.

$$P_m = 4\tau L/D + K_{head} V^2 \rho/2 \qquad (1)$$

where $K_{head} = K1\ Re_{tube}^{-1} D_{res} D^{-1} + 2 \qquad (2)$

(Refer to the text for nomenclature).

The kinetic energy loss at the tube exit is equal to two velocity heads. In practice the magnitude of the losses at the entrance of the tube is several times greater than this. Thus

$$K_{head} \approx K1\ Re_{tube}^{-1} D_{res} D^{-1} \qquad (3)$$

The ratio of the pressure losses at the tube ends (ΔP_{end}) to the pressure loss due to fully developed laminar flow (ΔP_{wall}) is

$$\Delta P_{end}/\Delta P_{wall} = K1\ D_{res} V^2 \rho/8\ Re_{tube} \tau L \qquad (4)$$

For a "Power Law" fluid the shear stress at the wall, τ, (see Table I) is

$$\tau = K[(3n + 1)\ 8V/4nD]^n \qquad (5)$$

and the Reynolds number for flow in the tube[3] is given by

$$Re_{tube} = D^n V^{2-n} \rho [4n/(3n + 1)]^n / 8^{n-1} K \qquad (6)$$

combining (6) and (5)

$$Re_{tube}\ \tau = 8V^2 \rho \qquad (7)$$

Substituting (7) into expression (4) gives

$$\Delta P_{end}/\Delta P_{wall} = K1\ D_{res}/64L \qquad (8)$$

continued from page 142

depending on the design of the vacuum pan. Measured steam consumption in vacuum pans is quoted by Hugot as 120 - 165 kg/tc. The value measured for Monymusk[13] is 137 kg/tc.

We have assumed, as indicated by Hugot, that a continuous pan would use about 25% less steam than a discontinuous pan. We assume a value of 103 kg/tc. For sizing continuous pans, we have used the table from Hugot[12].

New books

Electricity usage in the sugar industry: opportunities for reducing the demand

Eds. U. Curdts and H. Eichhorn. 97 pp; 21.0 × 29.7 cm. (Verlag Dr. Albert Bartens, P.O. Box 380250, D-1000 Berlin 38, Germany.) 1989. Price: DM 59 plus postage.

A symposium on the subject of electrical energy in the sugar industry was held by the German Sugar Technologists Association (VDZ) at its General Assembly on May 10, 1988. The papers were published separately in *Zuckerindustrie* but have now been assembled in a single volume and are in both German and English. The symposium looked at the problem of imbalance between power and steam which has arisen owing to the much greater thermal efficiencies achieved in the beet sugar industry; in Germany, thermal energy requirements have been halved in the past twenty years. Technical advances in electricity generation and usage, as well as careful study of the power consumed in different areas of sugar manufacture have revealed marked differences and potential for savings. The papers included are "The outlook for energy use and processing technology in sugar manufacturing" by K. E. Austmeyer; "Energy connection and combined heat and power in sugar manufacturing and pulp drying" By P. Valentin; "Topical problems in power distribution systems" by L. Zentgraf, "Network disturbances in case of capacitors reactive power compensation and harmonic oscillations in electrical networks" by B. Schneider; "Approaches to variable speed drive motors" by B. Göckel; "Employment of variable speed three-phase A.C. drive motors in the sugar industry" by H. Herold; "Electric power consumption in unloading, storing and preparing sugar beet and for flume and wash water treatment" by U. Curdts; "Optimization of electric power savings in the sugar house" by H. Weidner and "Electric power consumption of mechanical dewatering and thermal drying of pulp" by C. Voss. Well printed and bound, this *Proceedings* will be of great interest especially to electrical engineers in both beet and cane sugar industries.

Sugar Year Book 1988

Anon. 335 pp; 9.5 × 13.5 cm (International Sugar Organization, 28 Haymarket, London SW1Y 4SP, England). 1989. Price: £15.00.

This small volume is as usual crammed with statistics of sugar production, consumption and trade in 128 countries, 41 of them members of the International Sugar Agreement at the time of going to press in July last. The figures are mostly provided by the governments of the countries concerned, extracted from statistical publications, or in some cases estimated. They are on a calendar year basis except where otherwise stated, and are expressed as tonnes, and as far as possible in terms of 96° raw sugar. Comparative figures are given for 1981 or 1982 to 1988 inclusive. This is the 42nd edition of the Yearbook and, like its predecessors, is printed in small but clear type. As an authoritative collection of statistics, in a highly convenient format, it is to be highly recommended.

Sucrose: nutritional and safety aspects

Eds. G. Vettorazzi and I. Macdonald. 206 pp. (Springer-Verlag, Berlin) 1988. Price: £21.50.

This book, part of the International Life Sciences Institute series of human nutrition reviews, has two main sections. The first is a group of summaries on such topics as chemical and physical data on sucrose, production, uses, occurrence, metabolism and kinetics in animals and man, biochemical, health and safety aspects, evaluations, conclusions and recommendations. As well as literature reference lists after each chapter, the second section provides a bibliography of about 2500 references, with a list of selected books, all on nutrition and safety of sucrose.

Cane sugar. The small-scale processing option

R. Kaplinsky. 229pp; 21.0 × 29.7 cm. (Intermediate Technology Publications, 103/105 Southampton Row, London WC1B 4HH, England.) 1989. Price: £25.00.

This book includes the papers presented at the conference on small-scale sugar processing organized by the Intermediate Technology Development Group in 1987[1]. It is introduced by Mr. Kaplinsky and Ian McChesney of ITDG who discuss the involvement of the Group in promotion of small-scale sugar processing, especially in Africa, and this is followed by a series of summaries of the papers and their full texts. We have carried abstracts of these papers but the book includes photographs and diagrams which our abstracts could not include. The book provides an interesting account of a type of sugar manufacturing operation very different from that carried out by the bulk of our readers.

Hawaiian sugar manual, 1989

Anon. v + 29 pp; 15.2 × 23.0 cm. (Hawaiian Sugar Planters' Association, 99-193 Aiea Heights Drive, Aiea, HI 96701, USA.) 1989.

This small booklet is an up-to-date record of the Hawaiian sugar industry, produced by its principal organization. Officers and the 1989 Board of Directors are listed and details given of the Aiea and Washington offices of the Association, as well as the names, addresses and chief executives of the 13 Hawaiian sugar companies. After a short history of sugar in Hawaii, tabulated details are provided of total and harvested cane areas in 1988, and sugar production and yields per acre for the 13 companies and the United Cane Planters' Cooperative. 928,195 short tons of sugar was produced from a harvested area of 78,861 acres. An account is given of the 1988 season and a table of cane and sugar data from the 1908/09 season to that of 1988. Another table provides records of raw

1 *I.S.J.*, 1987, **89**, 225 - 226.

sugar prices, numbers and wages of employees since 1940, and it is noted that the sugar companies currently employ approximately 6100 people of whom more than half are field workers. Articles provide information on the HSPA, the Experiment Station, and the C&H sugar refining company. The second section of the booklet is concerned with the US sweetener industries – cane, beet and corn – and the legislation governing them, while the third section discusses world sugar production, trade and consumption, with information on the world sugar market and sugar surplus, the International Sugar Agreement and the General Agreement on Tariffs and Trade. The booklet closes with a glossary of sugar terms.

Operações unitarias na produção de açucar de cana

248 pp; 16 × 23 cm. (Livraria Nobel Editora, Brazil) 1989.

This book is a translation into Portuguese of "Unit operations in cane sugar production" by Dr. John H. Payne, under the sponsorship of the Brazilian Sugar and Alcohol Technologists Association, STAB. The translation and conversion from British to metric units were by Sr. Florenal Zarpelon of Usina Açucareira Ester S/A., and the printing and publication in soft-cover form was coordinated by Prof. J. P. Stupiello. Further information on the book may be obtained from Sr. Zarpelon at Usina Ester, Cosmópolis, SP, Brazil 13150.

Modernisation of Indian sugar industry

Ed. J. K. Gehlawat. 336 pp; 15.5 x 23.7 cm. (Arnold Publishers India Pvt. Ltd., AB/9 Safdarjung Enclave, New Delhi, India 110029). 1990. Price: Rs. 300.00.

A very successful Seminar was held at the Indian Institute of Technology, Kanpur, under the auspices of the Indian Institute of Chemical Engineers during March 26 - 27, 1988. A total of 40 papers were presented covering a wide range of topics under the general heading of modernization, discussing recent introductions in cane milling equipment, juice treatment, heat transfer, energy conservation and co-generation, etc., as well as the better use of waste materials to obtain by-products. Most of the book is taken up by the text of these papers while also included are a foreword by Professor M. M. Sharma, Director of the Department of Chemical Technology in the University of Bombay, a preface by the Editor, the inaugural address by the Director of the National Chemical Laboratory in Pune, a valedictory address by the Sugar Industry Secretary of the UP State Government, a keynote address by the former head of the Department of Chemical Engineering of the National Sugar Institute in Kanpur, and a list of participants in the Seminar. Abstracts of the papers will appear in this Journal in due course.

The making of a sugar giant: Tate and Lyle 1859 - 1989

P. Chalmin. 782 pp; 15.0 x 22.7 cm. (Harwood Academic Publishers, P.O. Box 786, Cooper Station, New York, NY 10276, USA.) 1990. Price: $95.00.

This book is a slightly shortened version of the author's thesis which won him his doctorate in history from the Sorbonne University in Paris. Originally in French, it has been very well translated by Erica Long-Michalke, and the author acknowledges his debt to the subject company who provided access to their archives, as well as to many others who helped his work. It provides introductory chapters on the world sugar economy from the end of the 18th Century and the international sugar trade, especially in London; on British sugar policy up to 1914; and on sugar refining in Great Britain in the 19th Century. The main story commences with chapters on Henry Tate & Sons, and Abram Lyle & Sons, their origins and entry into and progress in the sugar refining business. After years of strong foreign competition, the first World War provided an opportunity to strengthen the sugar refining industry in Britain and led to the postwar merger which gave rise to Tate and Lyle. After some years of adaptation, the firm's growth resumed by both horizontal development, leaning to a quasi-monopoly of refining, and vertical development, with investment in raw sugar production in the West Indies and elsewhere as well as barge and road transport facilities for raw and refined sugar. Investments were made in beet sugar factories, but had to be divested with the formation of the British Sugar corporation in 1936. The Second World War saw a very different situation from the first yet, in spite of a much reduced throughput and operational difficulties, the firm prospered. When the Labour Party achieved power in 1945 it started to nationalize what it considered key industries and that of sugar refining was one on the list. Tate & Lyle fought an energetic and successful battle to prevent this and remained in private hands. But the danger led to a policy of increasing overseas investments which have turned the British company into a multinational group. Chapters describe the history of Tate & Lyle ventures in the West Indies, Africa and Canada, as well as its shipping and engineering activities, and the venture into European Sugars. The changes in the interests and development of the group since 1965 are described, with chapters on commodity trading, glucose and high fructose syrup, agribusiness and sucrochemistry. A final section discusses the changes which took place in the period from 1980 (when the thesis was written) to 1989 when the English translation was made. It records the way in which the Group has changed under the chairmanship of Neil Shaw who has turned the company from a somewhat paternalistic enterprise into a highly decentralized, profit-oriented, modern structure with greater responsibility for management, elimination of fringe activities away from the main business of sweetener manufacture, and evolution into an Anglo-American business. The book is provided with a comprehensive set of notes to the various chapters and an extensive bibliography and index.

Facts and figures

Poland campaign results, 1989/90[1]

The sugar beet harvest in Poland for the 1989/90 campaign amounted to 14.4 million tonnes, up 2.1% from the previous crop. The beet yield fell from 34.1 to 34.0 tonnes/hectare, however. Sugar production amounted to 1,716,000 tonnes, white value, up 2.2% from the 1,679,000 tonnes produced in the 1988/89 campaign.

New alcohol distillery in Brazil[2]

In December last a 100-member cooperative was formed in the municipality of Rondon in north-east Paraná state and will invest $5 million in a new distillery to convert 200,000 tonnes of sugar cane per year into 118 million litres of alcohol, beginning in the 1990/91 harvest.

Rumanian sugar production expected to fall[3]

Rumania expects to produce only half of its sugar needs of 600,000 tonnes in 1990 and will have to import sugar. In 1989 production was 600,000 tonnes and the industry is capable of producing 680,000 tonnes. However, the post-revolutionary transfer of land to private farmers has disorganized agriculture and this is blamed for the shortfall.

Seminar on newsprint from bagasse[4]

The Cuba-9 Research Centre and UNIDO are convening an international seminar on newsprint from bagasse, to be held in October 1990 in Havana. Discussions will focus on the technical and commercial quality of viable processes, demonstration and discussion of the Cuba-9 technology, and presentations by manufacturers of machinery and equipment with experience in newsprint and other types of paper from bagasse. Its objective is to assist governments and industries in adopting investment decisions through discussions aimed at achieving optimum technological and economic benefits.

Colombian sugar production and exports

With an increase in sugar production of 11.7% over 1988, Colombia took full advantage of the increase in world market prices in 1989. Its total sugar production of 1,523,323 tonnes, raw value, allowed exports to rise to 323,240 tonnes, raw value[5], from 242,983 tonnes in 1988 and only 96,009 tonnes in 1987. The principal destination was the USA, which took 286,664 tonnes of raw sugar, while Haiti took 12,000 tonnes and Mexico 6392 tonnes. In addition Colombia supplied 11,613 tonnes of white sugar to Haiti, 2156 tonnes to Mexico and 2961 tonnes to the Dutch Antilles. Foreign earnings rose 32.8% above those of 1988, reaching $102 million. A combination of efficient cane and sugar producers, together with the richness of the soil and the Colombian climate have contributed to bringing the country into the position of the most productive country in terms of cane per hectare destined for centrifugal sugar manufacture at a cost among the lowest in the world.

Alcohol production by extractive fermentation

Alcohol production by fermentation consists of using a micro-organism — a yeast or bacterium — to convert simple sugars to ethyl alcohol in an aqueous medium, traditionally in either a batch fermenter or in a continuous stirred-tank fermenter. The problem with this type of process is that alcohol is toxic to the fermentation organism and, as the alcohol concentration rises, the reaction rate decreases. This phenomenon, known as end-product inhibition, reduces productivity and prevents concentrated feeds being employed, resulting in long fermentation periods and large amounts of water processing in the downstream alcohol recovery. One solution to end-product inhibition is to remove the toxic alcohol as it is produced and this is the basis of the extractive fermentation process (EFP). A biocompatible water-immiscible solvent is sparged through the broth during fermentation, removing the alcohol. The solvent is then separated from the aqueous phase using a continuous centrifuge and sent to a single-stage flash vapourization unit where the alcohol is vapourized under vacuum at about 120°C. Since the solvent has a much higher boiling point it remains liquid and is returned to the fermenter in a closed loop. The alcohol vapour, meanwhile, flows to a condenser and is collected.

A demonstration unit for the EFP has been assembled and successfully operated at Queen's University, Kingston, Ontario, Canada. With this system, a concentrated substrate of 500 g/litre of glucose has been successfully fermented with over 90% conversion. Furthermore, 67% w/w alcohol has been achieved in a single-stage flash vapourization unit operating at 120°C and a vacuum of 24 inches of mercury. It is believed that near azeotropic alcohol is possible with further fine-tuning of the system. An important feature of the EFP is the separation of the micro-organism cells in a continuous centrifuge and recycling to the fermenter to keep their concentration high. Since the process depends on the return of live cells, the pumping involved must be non-injurious and the materials of construction must be resistant to the solvent used. This requires the use of inert materials such as polytetrafluoroethylene, polypropylene, silicone or stainless steel. Also the solvent can act as a lubricant and cause hoses to slide off connectors. ProMinent Fluid Controls of Canada have supplied pumps to the Department of Chemical Engineering in Queen's University which answer these requirements and also allow fine-tuning since the motor is adaptable to analogue control by a 4-20 mA signal.

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 145.
2 *Sugar y Azúcar*, 1990, **85**, (2), 17.
3 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 145.
4 *GEPLACEA Bull.*, 1990, **7**, Sugar Inf. - 1.
5 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S131.

Tanzania sugar production increase[6]

The island of Zanzibar, an autonomous region of Tanzania, will increase sugar production to 12,000 tonnes in 1990 from 6000 tonnes in 1989. This improvement is attributed to favourable weather, a UN agriculture development program and the rehabilitation of the island's sole sugar factory. Zanzibar and its sister island Pemba imported 22,000 tonnes of sugar in 1989.

Panama import quota for the US restored[7]

The Panama portion of the 1989/90 sugar import quota, totalling 69,312 tonnes, was restored by the US as of January 30, 1990. This was in response to a Presidential finding that civilian control and democracy were in the process of being restored and that the current government is cooperating with the United States in its anti-drug initiatives.

Finland sugar production, 1989/90[8]

In the recent campaign, the four sugar factories in Finland sliced 1,056,449 tonnes of beets to produce 124,752 tonnes of white sugar, 22,418 tonnes of raws and 5466 tonnes, raw value, of low-grade sugar, as well as 43,547 tonnes of molasses.

New sugar terminal in Cuba[9]

Cuba's eighth terminal for the export of sugar is under construction about 500 km east of Havana; it is expected to start operation in 1991. The terminal will be able to handle a million tonnes per year of raw sugar, 900,000 tonnes of white sugar in bags and also 180,000 hectolitres/year of alcohol derived from sugar cane.

Dominican Republic sugar exports, 1989[10]

Exports of sugar by the Dominican Republic last year totalled 437,757 tonnes, tel quel. The major destination was the USA with shipments of 258,511 tonnes, while the next largest outlet was the USSR with 103,120 tonnes. About two-thirds of all shipments were by the private La Romana milling group and some one-third was from the state milling group, the CEA.

Réunion sugar companies merger[11]

The Sucrerie du Nord-Est company, who operate the Beaufonds sugar factory in Réunion, have agreed to buy the Sucrerie-Distillerie du Gol from Société L. Bernard, reducing the number of sugar companies on the island to two. The combined company will produce 120,000 tonnes of sugar per year. The merger will further concentrate control of Réunion sugar production in local hands since Société L. Bernard had been owned by a Paris-based company.

British Society of Sugar Cane Technologists

The 1990 Annual General Meeting of the BSSCT took place on April 11 in London. No alternative nominations having been received, the existing officers were elected for a further term. The technical session heard four papers on sugar industry coverage in CAB abstracts, by Dr. K. K. S. Bhat, on rodent control in sugar cane by Dr. M. Rampaud, on resin decolorization at Thames refinery by R. H. Lixenfield and M. R. T. Low, and on cane mechanization by G. Williamson.

Philippines sugar exports, 1989[12]

Exports of raw sugar from the Philippines in 1989 totalled 193,673 tonnes, all of which went to the US, as in 1988 when 143,578 tonnes were exported.

Portugal sugar refineries merger

The amalgamation took place on January 1, 1990 of two Portuguese sugar refining companies: SIDUL (Sociedade Industrial do Ultramar S.A.) and SORES (Sociedade de Refinadores de Santa Iria S.A.). The new company is Alcantara Refinarias Açucares S.A. and its main office is at Quinta do Ferral, 2685 Santa Iria de Azoia, Portugal.

Drought effect on Thailand sugar crop[13]

A severe drought has damaged more than 275,000 hectares of farm land in the north, north-centre and south of Thailand and it has been reported that some factories in the affected areas may have to stop crushing for lack of cane. The cane sugar content is disappointingly low and production in 1989/90 is now estimated to be 3.5 million tonnes, well below the previous season's outturn of more than 4 million tonnes. Reduction in the Thai crop will coincide with further rapid growth in consumption.

Mauritius sugar statistics[14]

Sugar production in 1989 totalled 568,301 tonnes, tel quel (601,831 tonnes, raw value), against 634,224 tonnes, tel quel, in 1988. Exports amounted to 636,223 tonnes, tel quel, against 652,452 tonnes in 1988. The principal destinations were the UK which took 501,104 tonnes (454,292 tonnes in 1988), the USSR with 44,700 tonnes (0), the US with 20,611 tonnes (10,310), Portugal with 18,000 tonnes (18,000), Canada with 15,058 (60,077), Morocco with 14,000 tonnes (14,350), France with 11,088 tonnes (12,137), Italy with 4398 tonnes (4316), Holland with 3004 tonnes (2442), Belgium with 1549 tonnes (1953) and Switzerland with 1219 tonnes (797). In 1988 China took 48,350 tonnes (0 in 1989) and Finland 25,050 tonnes (0).

New Pakistan sugar factories[15]

At least six sugar factories are to come on stream in the near future and Pakistan's 46th factory, which commenced

6 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 148.
7 *Czarnikow Sugar Review*, 1990, (1793), 25.
8 *Zuckerind.*, 1990, **115**, 145.
9 *AIN (Cuba) news agency report*, March 15, 1990.
10 *Czarnikow Sugar Review*, 1990, (1793), 25.
11 *Amerop Newsletter*, 1990, (196), 13.
12 *I.S.O. Stat. Bull.*, 1990, **49**, (4), 28.
13 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 159, 168.
14 *Mauritius Sugar News Bull*, 1989, (12).
15 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 167.

trial operations this season, is by far the biggest in the country. The Brothers Sugar Mill is located at Chunian in the Punjab and it is expected to produce about 100,000 tonnes of sugar in the coming season.

Belgian sugar factory closure[16]

The Escanaffles sugar factory, erected in 1872, has been closed. Its capacity was 4000 tonnes/day and its beet supply will be taken up by the Frasnes factory which belongs to the same group.

Belize sugar exports, 1989[17]

In 1989 Belize exported 83,325 tonnes of raw sugar against 84,647 tonnes in 1988. The EEC received 45,962 tonnes last year, the US 23,214 tonnes and Canada 14,149 tonnes, against amounts of 44,860, 20,586 and 19,201 tonnes, respectively , in the previous year.

Reduced Cuban crop estimate

The official Cuban newspaper *Granma* has acknowledged that, owing to poor weather and reduced mechanical cutting of cane because of mechanical failure of equipment, Cuban sugar production will be lower in 1989/90 than in the previous season, when output reached 8.2 million tonnes, raw value[18]. Since the crop began in November, official newspapers have repeatedly voiced concern over the delays and stops in cutting and crushing. The rain in late February and March reduced milling to 60% of capacity from 92% previously[19] and analysts have reduced their estimates of sugar production to between 7.2 and 7.9 million tonnes. Persistently short of raw sugar to meet its export commitments, Cuba bought just under two million tonnes of sugar in February from the French trade house Sucres et Denrées for delivery to the Soviet Union.

Fiji sugar production, 1989[20]

Fiji's four sugar factories crushed more than four million tonnes of cane to produce 460,602 tonnes of sugar in the 1989 season and set several new crushing records. The overall average for all factories was 1025 tonnes per hour, compared with 972 tonnes in 1988. The installation of a new single-tandem mill with three crushers at Rarawai, and a diffuser and new evaporator at Lautoka are almost completed and are expected to improve mill efficiency, throughput and operating hours.

New Surinam sugar project[21]

The Secretary of the Indonesian Sugar Council was to lead an official delegation to Surinam to discuss further plans for the construction of a factory for production of sugar for export to the EEC.

Singapore sugar imports, 1989[22]

Imports of sugar into Singapore fell to 195,369 tonnes, raw value, in 1989 from 232,468 tonnes in 1988. Both figures were higher than the 182,256 tonnes imported in 1987. In all three years some 70% was as raw sugar – mostly from Australia – and the rest white sugar, mostly from Malaysia.

Sugar project for Namibia[23]

Lonrho plc has signed a joint venture investment contract with the new government of Namibia for a $150 million sugar project in the north of the country. Subject to feasibility studies, the project should produce 60,000 tonnes of sugar a year after about $2^1/_2$ years, rising to 100,000 tonnes after about 5 years. The scheme will meet Namibia's local sugar consumption of 40,000 tonnes a year, leaving a surplus for export.

St. Kitts sugar crop reduction forecast[24]

The economy of St. Kitts is based largely on its sugar industry which employs one-quarter of the labour force and is a major export earner. In the wake of hurricane Hugo, the 1990 sugar cane harvest is forecast to yield some 18,000 tonnes, well down on the 1989 crop. As part of its development strategy, the government is attempting to restructure the sugar industry and also promote diversification so as to reduce dependence on a single crop, as well as reduce food imports.

Argentina sugar production, 1989[25]

The sugar factories processed 9,999,000 tonnes of cane in the 1989 season, to yield 848,000 tonnes of white sugar and 96,000 tonnes of raws. The fall in production was the result of a devastating drought in late 1988 that continued in 1989. No sugar cane was utilized for the fuel alcohol program which has been completely suspended. No beet sugar was produced, owing to financial problems suffered by the country's only beet sugar factory. Sugar production will probably increase in the 1990/91 season as a result of good weather during the 1990 growing season, but total production will still remain below that of 1988/89 because of a reduction in the planted area.

Swaziland sugar exports, 1989[26]

	1989	1988
	tonnes, raw value	
Canada	142,224	115,674
China	0	49,062
EEC	196,427	191,052
Malaysia	0	28,912
Mozambique	7,684	4,102
Sri Lanka	8,114	0
USA	36,053	11,960
USSR	12,407	0
Zaire	255	0
Unknown	3,629	3,084
	406,793	403,846

New Indian sugar factories[27]

Five new cooperative sugar factories, originally scheduled to be set up in the 8th Five-Year Plan period, are to be built this year at Dasuya in Hoshiapur district,

16 *Zuckerind.*, 1990, **115**, 221.
17 *I.S.O. Stat. Bull.*, 1990, **49**, (2), 4.
18 *GEPLACEA Bull.*, 1990, **7**, (3), Sugar Inf. 1.
19 *Reuter Sugar Newsletter*, February 28, 1990.
20 *Reserve Bank of Fiji Rpt.*, 1990, (5).
21 *Indonesia Development News*, 1990, (3).
22 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S146.
23 *Public Ledger*, March 23, 1990.
24 *ABECOR Country Rpt.*, April 1990.
25 F. O. Licht, *Int. Sugar Rpt*, 1990, **122**, 222, 257.
26 *I.S.O. Stat. Bull.*, 1990, **49**, (4), 32.
27 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 297.

Patran in Patiala district, Mehal Kalan in Sangrur district, Bhata Kalan in Bhatinda district and Masitan in Kapurthala district. All will be of 2500 t.c.d. capacity.

Cuba sugar exports, 1989[28]

	1989	1988
	tonnes, raw value	
Albania	23,655	33,906
Algeria	190,314	162,458
Angola	9,659	43,984
Brazil	149,144	0
Bulgaria	308,382	295,656
Cambodia	0	1,083
Canada	168,451	111,890
Cape Verde	4,879	0
China	889,173	1,399,439
Czechoslovakia	159,142	170,712
Dominican Republic	0	1,172
EEC	68,025	39,192
Egypt	38,518	50,375
Finland	744,750	12,529
Germany, East	357,174	338,676
Ghana	12,939	17,734
Indonesia	26,424	13,663
Iraq	40,239	66,845
Japan	205,059	372,469
Korea, North	30,170	30,361
Libya	44,369	12,533
Malaysia	84,414	55,641
Mexico	67,610	0
Nicaragua	10,699	21,720
Pakistan	0	39,016
Peru	29,379	0
Poland	58,384	0
Rumania	266,368	200,412
Sri Lanka	13,009	0
Sweden	11,473	0
Switzerland	3,205	2,975
Syria	65,040	26,733
Tunisia	73,332	24,458
Uganda	15,174	8,675
USSR	3,468,906	3,307,504
Venezuela	109,715	103,623
Vietnam	12,498	8,856
Yugoslavia	18,104	0
Other countries and unknown	4,229	3,932
Total	7,112,005	6,978,222

Turkey sugar imports[29]

The Turkish Sugar Corporation has bought about 254,000 tonnes of refined sugar for delivery before August. In the subsequent 12 months it is expected to buy about 400,000 tonnes, representing the difference between consumption and estimated production which is set at 1,350,000 tonnes. It must be assumed that the Turkish sugar industry will take steps to boost production and it is hoped that nearly 400,000 hectares will be sown to sugar beet this year. Based on the average sugar yield, this area should provide 1.8 million tonnes of sugar, enough to meet requirements.

Indian sugar consumption estimates[30]

White sugar consumption in India is estimated to rise to 13,273,000 tonnes from 10,400,000 tonnes during the 8th Five Year Plan period, corresponding to an annual increase of 5%. By 2000 A.D. consumption is likely to reach 16,940,000 tonnes. Consumption during 1988/89 was estimated at 9.9 million tonnes.

El Salvador sugar expansion[31]

Sugar production for 1989/90 is set at 205,000 tonnes, raw value, up from 189,023 tonnes in 1988/89[32]. Of this amount, 163,300 tonnes is as white sugar for domestic consumption, and 41,700 tonnes as raw sugar for export. In 1990/91 production is expected to reach 263,000 tonnes, of which 87,000 tonnes will be for export.

Mexican technology aid for Venezuela bagasse paper[33]

Kimberley Clark de Mexico S.A. de C.V. has signed a contract with Consorcio C.A. Venezolana de Pulpa y Papel (VENEPAL) to provide technical assistance for the production of pulp from bagasse. The Venezuelan company, a leader in the cellulose/paper industry of Venezuela, is currently developing an ambitious expansion program for its operation.

Mauritius investment by Lonrho[34]

The UK-based multinational Lonrho is to invest $846,000 in its sugar factories in Mauritius. A refinery section is to be added at the Britannia sugar estate, to be operational by the end of 1990 with an installed capacity of 12,000 tonnes. New facilities are being installed at Mon Tresor to generate electricity from bagasse to feed into the grid all year round instead of only during the crushing period.

USSR/Cuba sugar agreement[35]

Under an agreement signed in April, Cuba will export 4.4 million tonnes of sugar to the USSR this year in exchange for industrial equipment.

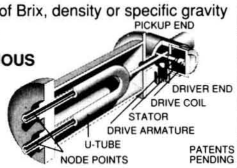
East German sugar industry reconstruction[36]

The East German Halle sugar combine is to be converted into a joint stock company, Deutsche Ostzucker AG, and an extensive rationalization and modernization program is planned which will require foreign partners and credit. The current 43 factories are to be replaced by 7-8 new sugar factories, located in traditional beet growing areas but with daily slicing capacities of 8000 - 10,000 tonnes of beet. It is hoped to have the first of these new plants operating by 1993.

PERSONAL NOTES

We regret to report the death of **Professor Andrew VanHook** at the age of 82. An academic, he nevertheless was well known among practical sugar technologists for his work on sugar crystallization and he presented many contributions to sugar literature as well as participating in the work of American and international sugar technologists groups, and especially ICUMSA and the US National Committee. He will be missed by his many friends around the world.

28 *I.S.O. Stat. Bull.*, 1990, **49**, (3), 9 - 10.
29 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 234.
30 *Indian Sugar*, 1990, **39**, 735.
31 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 237.
32 *I.S.O. Stat. Bull.*, 1990, **49**, (4), 11.
33 *Amerop Newsletter*, 1990, (197), 11.
34 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 295.
35 *Prensa Latina news agency report*, April 19, 1990.
36 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 234, 255.



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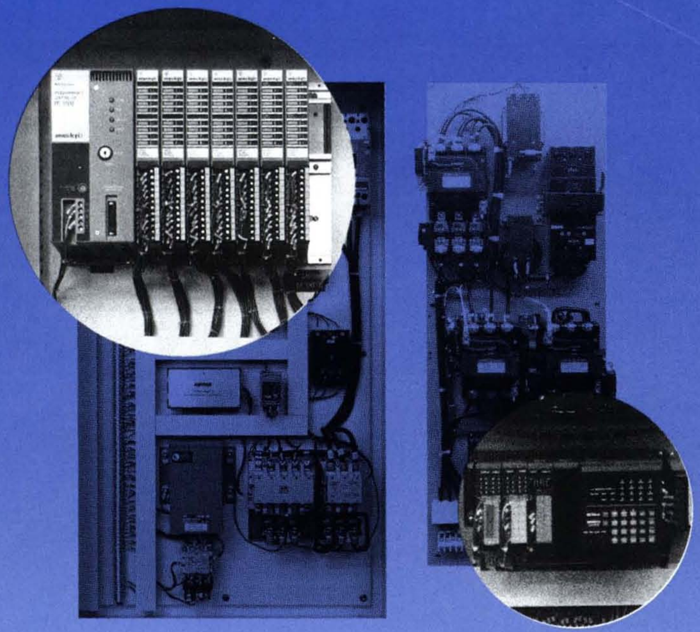

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