A PRELIMINARY REPORT ON A CONTINUOUS C PAN

By W. S. GRAHAM and D. J. RADFORD
The Tongaat Group Ltd.

Abstract

The reasons for selecting a continuous pan for C massecuite boiling and preliminary experiences with the unit are described. Although the throughput of the pan has been lower than had been anticipated the exhaustion obtained appeared to be comparable with that achieved using batch pans. Further evaluation and optimisation of the pan are necessary before a final assessment is possible.

Introduction

Before the installation of the continuous pan, the pan floor at Tongaat Sugar factory consisted of 12 x 28,5 m³ pans. Six were used to boil A massecuite, two were used for B and three for C massecuite with one pan used to make B and C seed and occasionally to boil a low grade strike. In order to be able to handle the estimated future factory output it was necessary to increase the pan floor capacity. Further, many of the existing pans were approaching the end of their useful life.

Tongaat believed that the successful application of continuous pans in raw sugar factories was possible and this would result in many advantages over large batch pans. These advantages include:

(1) A steadier steam demand by the pan floor. This would lead to steadier operation of the evaporators especially the Kestners from which the steam would be taken.

(2) A steady water demand by the condensers and a lower peak demand thus saving on the required pump house capacity.

(3) Being simpler to automate fully than a batch pan.

(4) Less attention being required from the pan boiler and the results obtained being less dependent on the skill of the pan boiler.

(5) The high heating surface/volume ratio with the low massecuite head, which should give better circulation and improved crystallisation in the pan.

The major disadvantage associated with continuous pan boiling is the large coefficient of variation in the sugar produced. In white pans, producing sugar to be made into cubes, this has been claimed as an advantage but for raw sugar which will be affinated prior to refining the regularity of the grain is of considerable importance. Because the magnitude of the coefficient of variation of A sugar produced in a continuous pan under the local conditions was not known it was decided to play safe and consider the pan primarily for C boilings, with provision to test it subsequently on A boilings.

Because all the C sugar produced in the factory is remelted the CV of this sugar is not so important. The most essential requirement is that there should be no crystals present which would pass through the screens of the continuous centrifugals. It was also desirable not to have many very large crystals as this would reduce the surface on which crystallisation could take place and would therefore reduce the potential exhaustion of the massecuite. It was decided that a continuous pan fed with seed which could be grown to meet the minimum size requirement before feeding to the continuous pan, would ensure no loss of crystal in the final molasses, provided the pan was suitably controlled to prevent the formation of false grain. The amount of work done on the seed prior to injection into the pan could be varied, if necessary, to ensure that the exhaustion of C massecuite would not be inferior to that obtained under normal batch pan operation. These two safeguards made the decision to install a continuous pan for C massecuite boiling relatively free of serious risk.

The largest commercially available pan, the Fives Cail Babcock (FCB) 64 m³ was selected. FCB insisted on manufacturing the pan in France and it was shipped to Tongaat in four sections which were welded together in situ. It is probable that FCB would consider the local manufacture of any future pans.

Description of plant installed

The pan shell is a horizontal cylinder made of mild steel 11,9 m long by 3,80 m diameter. It is fitted with two mild steel plate type calandrias which extend from either end of the pan almost to the centre (Fig. 1). Each consists of 33 elements with the deepest 1 160 mm in the centre and arranged as depicted. The elements as well as the headers are fitted with partitions which ensure a positive flow of steam through each element as indicated. Both the incondensible gases and the condensate are withdrawn from the lower compartments of the headers. The incondensible gases may be vented either to atmosphere or into the pan. The latter connections allow the pan to be boiled with negative steam pressure thus permitting the selection of a wider range of throughput.

The entrainment prevention system shown in Fig. 1 consists of a baffle mounted below the take-off dome and a vapour directional change into the main vapour pipe.

The pan is divided into 15 compartments. The central element forms the major part of the longitudinal partition below the massecuite surface and a plate, 1,5 m high, is mounted on top of it. Similar transverse plates extend downwards and fit loosely between the elements. The connections between compartments are openings about 100 mm x 750 mm in the plates forming the partitions underneath the calandria. The high partitions above the calandria are necessary to prevent splashing of massecuite from one compartment to another.

Conductivity electrodes in 3 compartments were necessary for control of the pan with the system supplied. Tongaat requested that electrodes be fitted to all compartments so that the pan settings could be more precisely optimised.

The pairs of electrodes consisted of rods (300 mm x 10 mm) mounted in parallel 100 mm apart. Each electrode was mounted in a PTFE assembly which fitted together with O ring seals and steam channels within the assembly were provided to blow steam around the electrodes. These electrodes were not entirely satisfactory.

The kind of flowmeter usually supplied by FCB was of the variable orifice type consisting of a flap which lifted according to the molasses flow and which was magnetically coupled to a pointer. Experience at Quartier Français factory in Reunion showed that these meters were prone to clogging and required frequent cleaning.

This type of meter was installed in each of the main supply lines to the pan but Tongaat designed and installed V notch weirs in the lines to the individual compartments to indicate these flows and these have proved to be satisfactory. Further, steam lines were installed on the V notch weir boxes. These were used both for cleaning the sight glasses and for injection of steam with the feed when desired.

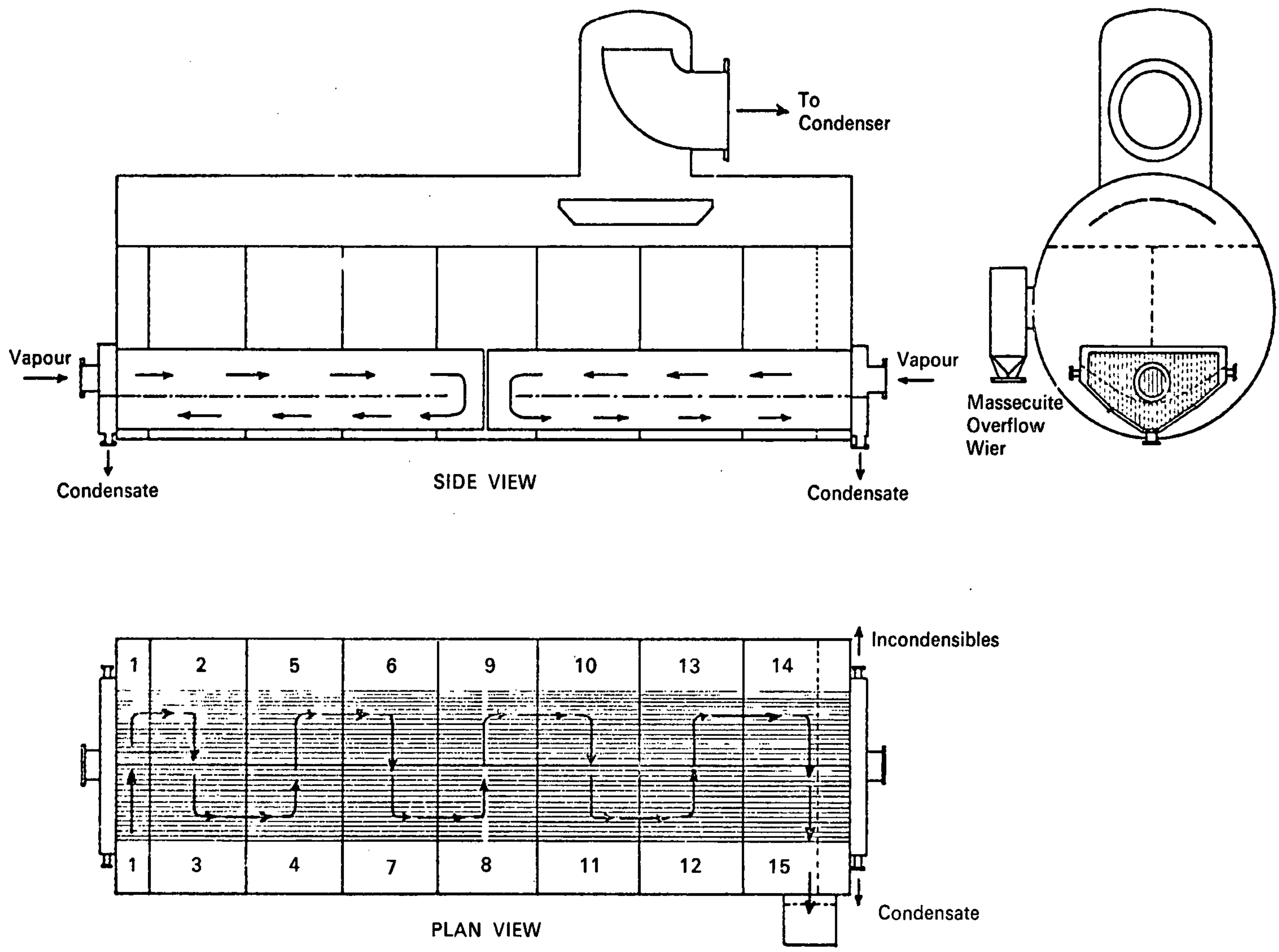

FIGURE 1 General arrangement of pan.

The sampling devices (Fig. 2) fitted to each compartment could extract samples of up to 250 cm^3. Each consisted of a glass flask with ground glass flange which was held by suction against the rubber gasket glued to the sampling device.

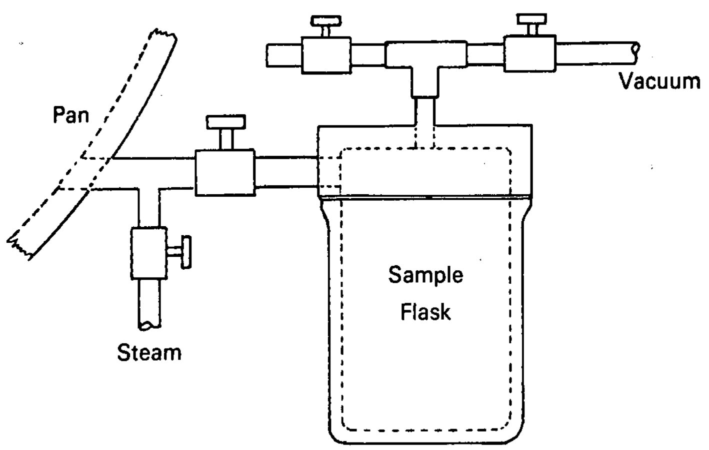

FIGURE 2 Sampling devices.

When the flask was under vacuum the valve to the pan was opened allowing massecuite to flow into the flask. When sufficient massecuite had been collected the valve to the pan was closed, the vacuum line valve then closed and the vacuum breaker valve opened.

The sample was adequate to allow pol and brix analyses to be carried out. In the earlier compartments of the pan, samples could be obtained quickly (1–2 minutes) but in the last stages the sampling time was sometimes 15 minutes or more. A larger inlet pipe would have overcome this slow rate of sample collection.

It was found in practice that the heavy glass flasks were prone to breakage. A suitable alternative was found to be ME 106, a type of polythene which is a white translucent material through which the level of sample can be readily discerned.

Seed was pumped into the first compartment from a stirred holding tank by a thyristor controlled variable speed lobe pump.

All compartments could be fed with B molasses or water while compartments 1-10 could also be fed with A molasses.

Three separate feed liquor manifolds provided with automatic control valves allowed—

A molasses to be fed to compartments 1-10
B molasses to be fed to compartments 1-13
B molasses to be fed to compartments 13-15

Each compartment had a manual control valve and the feed entered through a single pipe flush with the wall of the pan under the 4th element from the outside.

A manually adjustable weir at the outlet of compartment 15 controlled the massecuite level in the pan. The massecuite passed through a barometric sealing leg into a sump from which it was pumped to the crystallisers. The sump overflowed into the suction of the belt driven massecuite pump with a capacity in excess of that required.

Although provision had been made to select different pumping speeds by changing the pulley ratios this facility was not used. The pumps were driven with 7,5 kW electric motors.

Two drains for emptying the pan were provided with 350 mm butterfly valves which have proved to be satisfactory. The launder into which they discharge was fitted with a flap which allowed the pan steamings to be diverted to the molasses tank.

The condenser was designed by Tongaat and is shown in Fig. 3. The vapours are taken to the bottom of the unit and flow counter current through the descending water stream. Excess water from the perforated plates overflows serrated weirs around the circumference of each tray thus allowing the water level to build up to ensure an even flow through all the perforations.

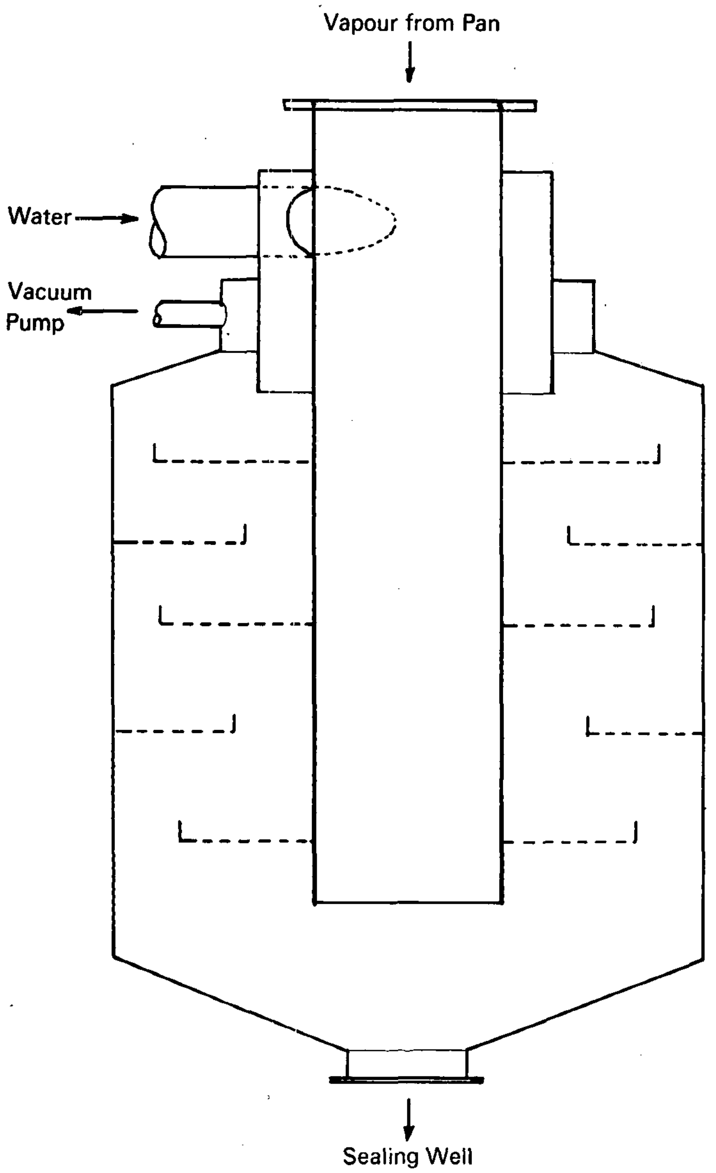

FIGURE 3 Condenser.

The liquid ring vacuum pump had a capacity of 27 m^3 per minute at 10 kPa abs. and was driven by a 45 kW electric motor.

Pan controls

A butterfly control valve in the common line feeding steam to the two headers maintained a constant predetermined steam pressure.

Constant vacuum in the pan was obtained by an absolute pressure controller which actuated a control valve in the water line to the pan condenser.

For the control system advocated by the pan suppliers electrodes were necessary in only 3 compartments. The signal from one of the compartments being fed with A molasses would actuate the control valve on the line supplying molasses to the A manifold, the signal from one of the compartments being fed with B molasses would actuate the control valve on the line supplying molasses to the main B manifold while the signal from the electrodes in compartment 15 actuated the control valve on the line feeding the last 2 (or 3) compartments.

The system for control of the brix and temperature of the A and B molasses is depicted in Fig. 4. Molasses from the main molasses storage tank at a brix of 75–78° was pumped through a thermostatically controlled shell and tube heater to the pan supply tank which was level controlled. Excess molasses was recycled into the pump suction.

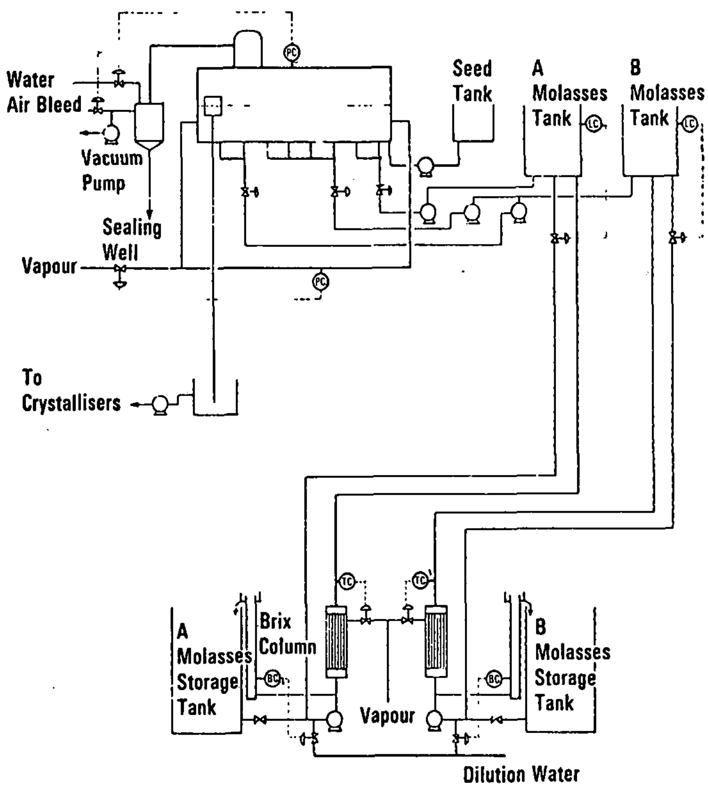

FIGURE 4 General flow diagram.

A bleed from the pump discharge was fed continuously to a brix column which measured the brix by the differential pressure between a column of molasses and a column of water at the same temperature. Brix was automatically controlled by adding water to the inlet of the pump.

To minimise the need for close operator attention to the pan, alarms for high and low conductivity were provided with the three conductivity controllers supplied by FCB. In addition, an annunciator alarm was installed to indicate failure of vacuum control, tripping of the seed pump, molasses pumps, massecuite pump and rising level in the massecuite sealing well.

Pan modifications

When the pan was first commissioned it was soon apparent that it performed well below its guaranteed capacity. The problem was investigated by two technologists from FCB who suggested various modifications which were carried out by Tongaat personnel.

The first changes made had little apparent effect on the pan performance. They were as follows:

(1) Lowering the Gestra steam traps from a point about 150 mm below the pan to a level about 4 m below the pan.
(2) Installation of steam baffles to give better steam distribution in the calandria headers.
(3) Installation of condensate drains and incondensible gas vents on the upper compartments of the headers.

Three steam jiggers were then fitted to each compartment near the centre baffle and an appreciable improvement in pan capacity resulted. However, it was apparent that the steam distribution was not very even so further modifications were made.

The jiggers were fitted with crosspieces, each with 13 x 5 mm holes in order to distribute the steam more evenly. Further, the molasses feed inlets were fitted with distribution pipes 1 300 mm long with 8 x 10 mm holes in each. These brought the feed nearer to the centre of the pan, viz. between the 6th and 7th elements as well as distributing it over a larger area. Steam pipes were also connected to the feed lines to permit the addition of a mixture of steam and molasses to the pan.

The vacuum controller was satisfactory for normal operation but if the steam were shut off, the vacuum in the pan increased, thereby cooling the massecuite. Consequently an automatic air bleed on the pump suction was incorporated to prevent this happening.

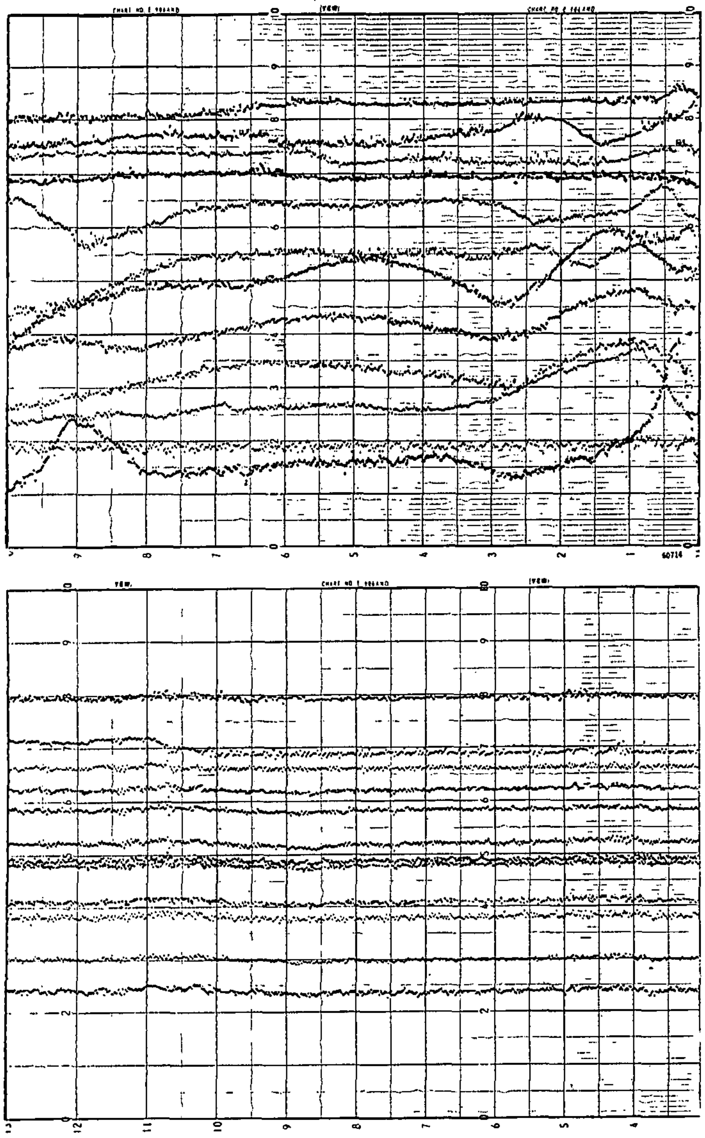

FIGURE 5 Charts of conductivity.

The chart recorder monitoring conductivities of the twelve compartments not used for control revealed the inadequacy of the control system supplied on the pan molasses feed system (Fig. 5). Tests were carried out by Tongaat staff to control the feed to individual compartments using modified Philips Plastomatic PD temperature controllers. These were used to control Saunders valves fitted on the individual lines feeding the compartments. These controllers proved to be entirely satisfactory as is shown in Fig. 5.

Since cleaning the pan involved boiling water in it the incorporation of a valve in the massecuite discharge pipe was found to be necessary.

Pan operation

To start the continuous pan, a sufficient quantity of a suitable footing to cover the calandria plates and fill the sump of the sealing leg was prepared in a batch pan. Partially boiled C massecuite with a purity of about 60 was considered to be satisfactory. The vacuum was set to the desired level and the weir raised to its maximum height. Steam was then opened to the calandria and the pan operated as a batch type unit. As the conductivities of the compartments reached the desired levels the feed was switched to automatic control and steam opened to the jiggers. When the pan started to overflow the discharge weir, it was slowly dropped until the desired weir level was reached. Only when the massecuite started overflowing was the seed pump started. The setting of the seed pump was adjusted to give the required quantity of seed as judged from inspection and analysis of the massecuite in the pan.

The seed used was similar to that used as footing for batch pans and had a grain size of 0,08 – 0,10 mm.

Once the pan was settled down it was not necessary to make further adjustments unless it was desired to change the throughput rate. The major control on throughput was effected by varying the steam pressure on the calandria.

To shut the pan down for a short period the weir was set to its lowest setting to minimise the quantity of massecuite in the pan, the seed pump stopped, the weir then raised to maximum setting and the brix of massecuite reduced prior to shutting off the steam and feed and breaking the vacuum.

The maximum length of stop under these conditions was about 40 hours. When the pan was restarted the contents started to swell while vacuum was being raised. This was due to a certain amount of decomposition with gas formation. This foamy mass was most quickly broken down by opening steam on the jiggers.

In order to empty the pan the seed pump was stopped, the weir raised to maximum height setting and the pan operated as a batch unit using only B molasses as feed to reduce the purity of the contents. When massecuite started to overflow the weir, all compartments were brixed up before stopping the pan and discharging the contents through the drains to the massecuite pumps.

Results and performance

(a) Initial performance

A summary of data obtained prior to fitting the jiggers is shown in Table 1.

TABLE 1

Performance of the continuous pan before modifications

Pan vacuum, kPa abs.	10
Calandria steam pressure, kPa gauge	20
Massecuite flow, th^{-1}	8,2
Massecuite ref. purity	49,2
Massecuite ref. brix	97,3
Nutsch purity on strike	36,3
B molasses ref. app. purity	42
B molasses brix	69,0
Seed flow, th^{-1}	3,3
Evaporation rate, kg $m^{-2}h^{-1}$	4,33

At this time 3 x 28,5 m^3 batch pans were handling about 11 m^3 h^{-1} of similar massecuite. Since the 64 m^3 continuous pan was rated as equivalent to 133 m^3 batch pan capacity the pan was performing far below its design capacity. The evaporation rate was obviously very low and because of this the modifications noted above were made.

(b) Performance after modifications

Subsequent to the various modifications the pan has boiled all the C massecuite from the factory crushing 310 tons cane per hour but the optimum capacity and the conditions governing its capacity have still to be established on a quantitative basis. However, for a few days after starting the pan from scratch evaporation rates of 7 to 8 kg $m^{-2}h^{-1}$ were measured but within a few weeks this dropped to between 5 and 6,5 kg $m^{-2}h^{-1}$ and stayed at this level for the remainder of the season (approximately 12 weeks in which the pan was stopped once for 40 hours but never emptied). This latter evaporation rate corresponded to a massecuite production rate of 9 to 12 th^{-1} compared with 6,5 to 9,1 th^{-1} obtained on the 27 m^3 continuous pan at Quartier Français as reported by Riviere and Pithois[1].

Comparative massecuite consistency data obtained by the S.M.R.I. for C massecuite at two Reunion factories and for some South African factories (Fig. 6) suggests that the difference in pan boiling rate is not associated with the high viscosity sometimes claimed for South African low grade products.

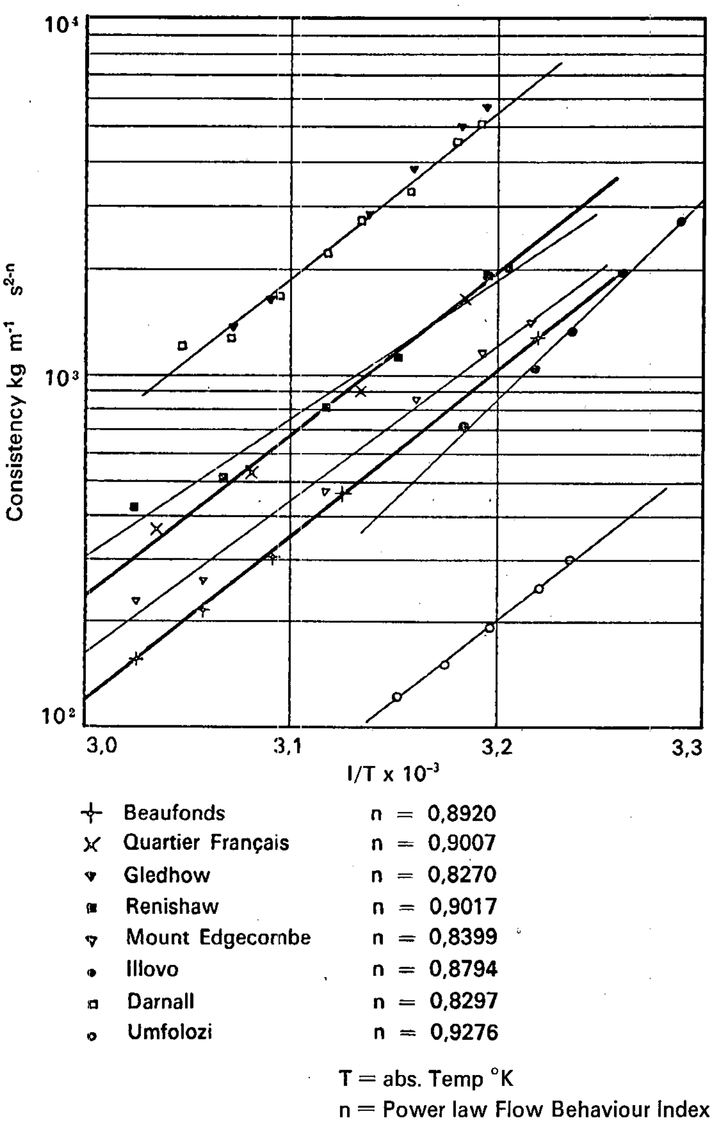

FIGURE 6 Massecuite consistency data.

(c) Exhaustion of massecuite

The quality of the massecuite produced in the continuous pan appeared to be similar to that from a batch pan except that the continuous pan massecuite showed a larger variation in crystal size. At the end of the season both massecuites contained appreciable amounts of elongated grain but earlier in the season there was no elongated grain in the massecuite from the continuous pan.

The data in Table 2 compares the actual and target purities of final molasses obtained in 1975 when batch pans were used with that of the corresponding period in 1976 when all the massecuite was boiled in the continuous pan.

TABLE 2

Comparison of actual and target purities of final molasses

Final molasses	1975			1976		
	Oct	Nov	Dec	Oct	Nov	Dec
True purity	39,84	39,70	37,44	40,39	39,65	37,81
Target purity	39,76	40,11	39,73	39,96	39,92	37,83
Difference	0,08	−0,41	−2,29	−0,43	−0,27	−0,02

From this data it was concluded that the exhaustion obtained with the continuous pan was similar to that obtained with the batch pans.

(d) Fouling of the pan

The cleaning schedule for the pan has yet to be established but after nearly seven months of operation there has been no evidence of hard scale formation on the elements.

After the first four weeks' operation and prior to any of the modifications having been carried out the pan was emptied and cleaned by boiling with water. The elements appeared to be completely clean at this stage.

After the twelve week run following the modifications mentioned above and with only a single stop when the pan was not emptied, appreciable build up of massecuite on the partitions and even on the shell and other unheated surfaces below the massecuite boiling level had occurred. After boiling with water the heating elements had a layer of soft scale easily removed by light brushing whilst there was a considerable quantity of loose scale in the bottom of the pan. The analysis indicated that it was largely rust and charred sugar.

It seems likely that periodic cleaning of the pan will be required, possibly once every 4 to 6 weeks.

Conclusions

From experiences to date with a FCB 64 m^3 pan boiling C massecuite it appeared that:

(1) The capacity of this pan was appreciably lower than had been anticipated.

(2) The exhaustion achieved was comparable with that obtained under similar conditions using batch pans.

(3) Control of the pan following the modifications described was such that steady conditions with consistent results could be obtained with very little operator attention.

(4) Scaling of the elements was not a serious problem and manual cleaning by brushing should be adequate.

REFERENCE

1. M. Riviere and P. Pithois (1976). Application of the continuous vacuum pan to third strikes. Sugar y Azucar Dec 1976 Vol 71 No. **12:** 48-52, 58.