TRIALS ON B.M.A. CONTINUOUS CENTRIFUGALS

By G. G. CARTER

The Tongaat Sugar Company Limited

The Tongaat Sugar Company installed 10 new B.M.A. K850 continuous centrifugals at the start of the 1969/70 season as a replacement for 19 obsolete batch type C machine used as forecurers.

The appreciable savings in maintenance and operational labour which were anticipated were realized, as well as lower final molasses purities.

This paper deals with the experience gained while operating these machines during the 1969/70 season and it must be stressed that these results are based on the difficult C massecuite conditions in S.A.

Description of the Machine

The B.M.A. K850 (Fig. 1) is a continuous machine comprising a vertically mounted conical basket spinning at 2,200 r.p.m. The angle of the cone is 35° and the top and bottom diameters are 850 mm and 360 mm respectively. The gravity factor is 2,265 measured at the top of the basket diameter, at full speed.

The drive is by means of a 30 kW electric motor mounted behind the centrifuge and connected to the basket spindle by means of five vee belts. The basket has no flywheel but requires a 10-minute wait to come to rest should the machine be switched off.

Lubrication of the two main bearings is done by a separate oil pump, which in case of failure switches off the main drive and a pilot lamp (see Fig. 1).

The distribution cone is elaborate and consists of an acceleration cup plus feed cone whereby the massecuite is both fed on to the screen and also lubricated with steam and water prior to the massecuite being purged on the screen.

The type of screen used for the curing of low-grade massecuite has slots 0.06 mm wide and 2.2 mm long and was composed of nickel with a hard chrome surface.

Massecuite was fed from a static finned reheater only capable of reheating 0.86 m^3h^{-1} per machine from 40°C to 55°C with water of 60°C. The unit was

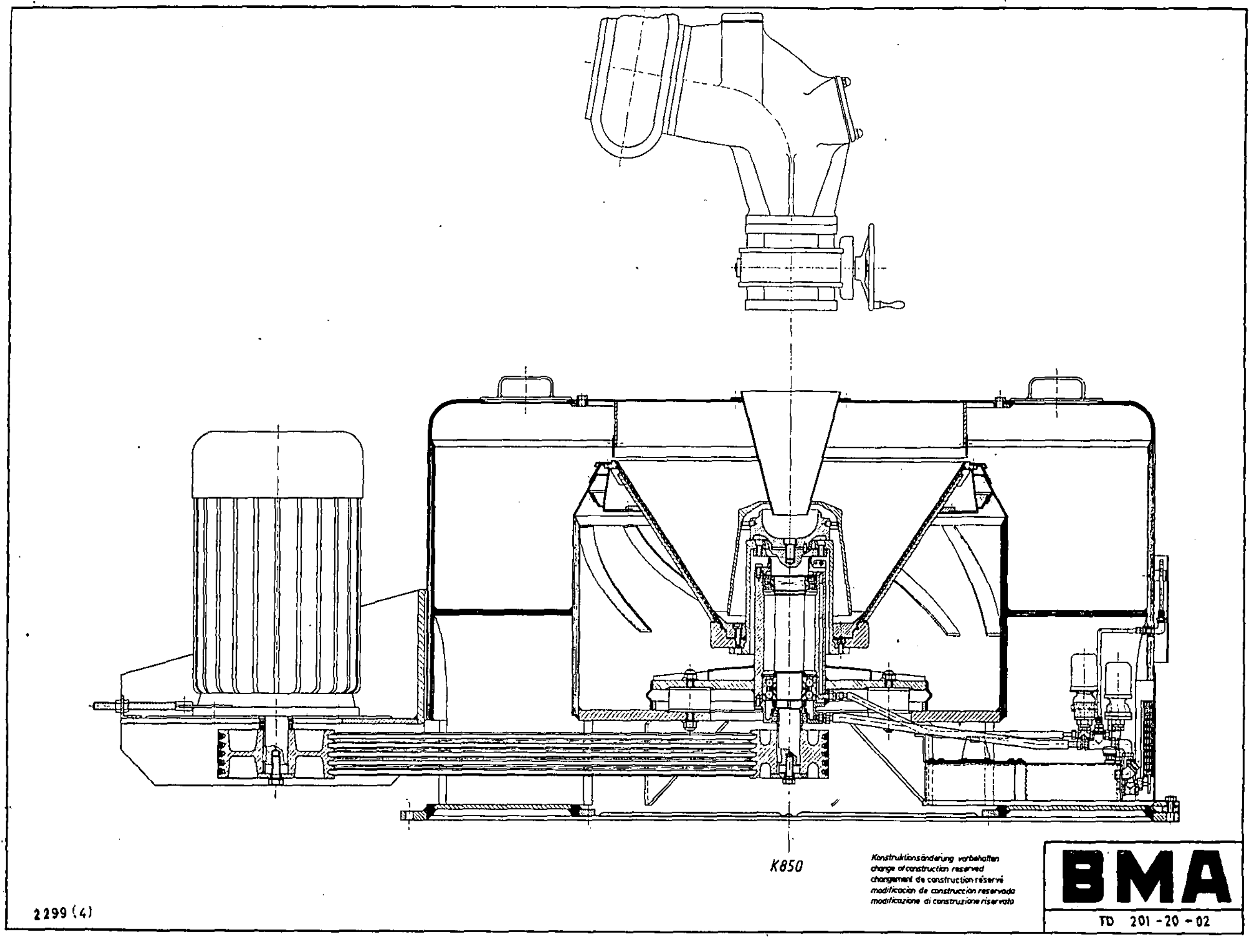


FIGURE 1

unsuitable for the quantity of massecuite to be reheated since the heating surface was well below requirements.

Massecuite flow from the reheater could be controlled by an automatic diaphragm valve. The controlling impulse comes from the power taken by the drive which is proportional to the feed rate. Because of fluctuations in the electrical supply to the machines these valves opened and closed *ad lib.* and were also electrically unreliable. The net result was that manual operation was adopted.

Wash water could be added through sprays at the apex of the basket as well as mid-basket whilst water could also be added inside the distribution cone to provide lubrication of the feeding massecuite (see Fig. 2).

Steam injection is provided inside the distribution cone to warm the massecuite (see Fig. 2).

Inspection of the sugar is possible on the top of the monitor casing and of the molasses by means of an inspection plate on the molasses drain.

Investigational Aspects

A programme of work was drawn up and the following points were studied:—

(a) The effects of the temperature and quantity of water and steam added in relation to the sugar quality and consequently machine throughput.

(b) The effects of the temperature and quantity of water and steam added in relation to the molasses purity.

(c) The effects of crystal size on the sugar and molasses purities.

(d) The effects of massecuite purity and its viscosity effects on machine throughput and molasses purity.

(e) The effects of massecuite temperature and its viscosity effects on machine throughput.

(f) The reliability of the machines with respect to screen life, electrical problems and component life, etc.

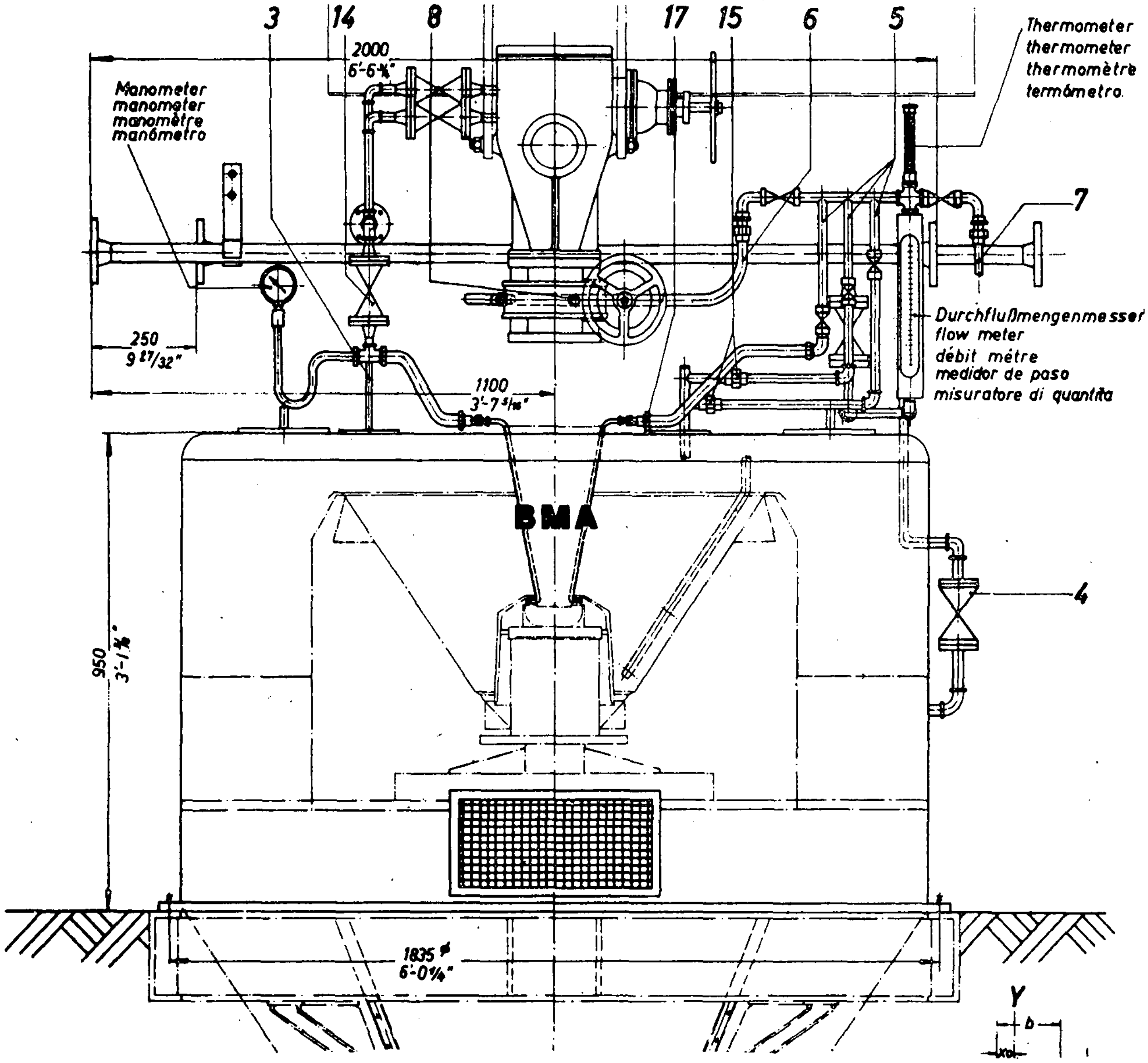


FIGURE 2

Results and Discussion

In compiling the results the average conditions from a series of experiments have been quoted and the various points dealt with in the order mentioned under investigational aspects.

(a) *Tests to see the effects of the quantity of water on sugar quality and molasses purity.*

1. From visual tests it was clearly seen that water added to the feed cone was essential to serve as a lubrication medium to the molasses film adhering to the sugar crystal and the sugar would not cure without it. The water which could be added by nozzles to wash the purging sugar on the screen was shown to wash the sugar through the screen if used in any quantity, or raised the final molasses purity, and consequently was never used.

2. An interesting feature of the tests was that the ratio of lubrication water to massecuite increased in a non-linear fashion as the throughput of massecuite was increased from 0.71 m^3 to the maximum which was of the order of 1.23 m^3h^{-1}. This is shown in Table I and Graph 1.

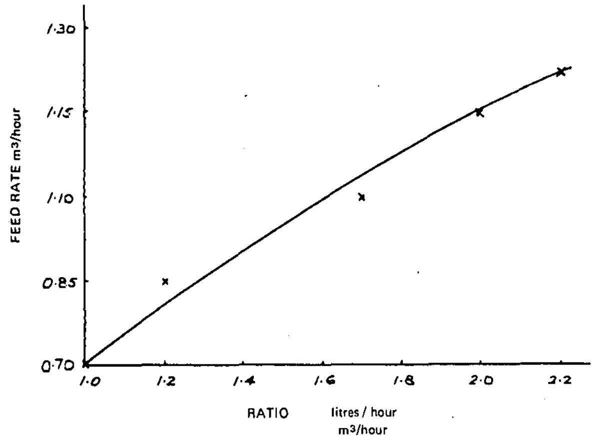
TABLE I

The effects of massecuite throughput on the amount of water needed to effect a sugar purity of ± †⁻.–.

m^3 of Mass. per hour	Amt. of water in litre/hour	Ratio of water Mass. *	Purity of C' sugar
0.72	26.0	1.0	86.7
0.87	37.0	1.2	85.8
0.99	60.0	1.7	84.7
1.15	81.0	2.0	84.8
1.23	94.5	2.2	84.3

* The ratio of water/mass. is calculated in this column using 0.72 cubic metres as a base.

The high ratio of water needed at the upper range of throughput resulted in a dilute molasses which was below the target refractometer brix of 86.0 set to prevent the operators adding too much water and thus washing excess sucrose into the final molasses.



GRAPH 1: Showing effects of massecuite throughput on the amount of water needed to produce a sugar of 85.0 purity.

3. The effects of the quantity of water on sugar purity and molasses purity were found to be such that:—

(a) A point can be reached where the sugar purity will not increase much above a certain level however much water is added.

(b) The excess water merely serves to dilute the molasses brix to below an acceptable level and increased the difference between nutsch and final molasses purity.

(c) The increase in difference between final molasses and its nutsch purity became most marked with rising use of wash water when the sugar purity exceeded a level of 85.0.

TABLE II

The effects at 0.92 m^3h^{-1} (constant throughput) of increasing the rate of water addition on sugar purity molasses brix and purity rise.

Rate of water addition in l/h	Sugar Purity	Molasses Brix	Rise in Nutsch difference
40.0	83.7	87.5	1.4
80.0	85.8	84.3	1.7
120.0	86.3	80.6	2.3
160.0	86.8	76.8	3.1

(b) *Tests to see the effects of water temperature on sugar quality and molasses purity.*

A series of experiments were conducted to see the effects of water temperature on sugar purity and the tests clearly showed that water at 80° C was better than at 60° C or 40° C in that less water at the higher temperature was needed to produce a superior quality C' sugar.

TABLE III

The effects of wash water temperature on the throughput and purity of C' sugar

m^3 of Mass per hour	Average Purity of C Mass	Temp. of the wash water °C	Purity of the C' sugar	Amount of wash water l/h	Molasses Purity
0.99	58.5	80	84.7	46	38.6
0.97	58.6	60	84.1	55	37.9
0.99	58.8	40	82.7	66	38.3

(c) *Tests to see the effects of steam on sugar quality.*

Steam, at Tongaat, was found to be necessary to improve the quality of sugar produced at throughputs above 0.72 m^3h^{-1}. Attempts were made to see what steam pressure was most beneficial. Whereas J. Chen and workers in Peru showed an improvement in sugar quality between 1 and 2 atmosphere steam, at Tongaat no difference could be detected and the lower pressure steam was used. The quantity of steam added was increased by using a 6 mm copper pipe instead of a 3 mm copper pipe and the generally hotter atmosphere gave visually improved sugar quality. It was further seen that the lower the purity of the massecuite the more beneficial was the steam in producing higher purity C sugar by most probably providing better viscosity reduction. This latter observation has not yet been confirmed by quantitative measurements. With increasing steam pressure a higher molasses purity can be expected.

(d) *Tests to see the effect of increased massecuite temperature on machine capacity and the quality of sugar produced.*

Results are seen in Table IV where the effects of purging massecuite at 50° C and 60° C are shown. It is seen that the machines are able to use less water/m^3 of feed at the same throughput and also can purge more massecuite at 60° C than 50° C. The rise in nutsch purity was, however, the same in both instances. This seems strange in the light of expected rise in molasses purity due to re-solution, but could have been disguised by the need for less wash water.

TABLE IV

Illustrating the effects of massecuite temperature on maximum throughput and water/feed ratio.

Massecuite Temp. °C	Massecuite Purity	Sugar Purity	Throughput in m^3	Molasses Nutsch Difference	Amount of water litre/hour
60	59.5	86.3	0.98	1.5	50.0
50	59.7	85.2	0.99	1.4	56.0
60	58.7	85.7	1.05	1.5	50.0
50	58.3	85.9	0.99	1.7	60.0
60	58.0	85.8	1.06	1.6	55.0
50	59.1	84.3	0.96	1.6	63.0

(e) *Tests to see the effect of massecuite purity on machine throughput and the quality of molasses produced.*

Massecuite purity was set at different levels during the season and it was seen that the general tendency was for the lower purity massecuite to take longer to purge, though at the start and finish of the season 56.0 purity (5:1 refractometer brix) massecuite was boiled and handled very well.

It is a known fact that the lower the third massecuite purity (at least to 55.0 (5:1 refractometer) the greater will be the probability of low molasses purity.

This was illustrated at T.S.C. where the purity of third massecuite was raised from 57.7 average for the period (8th June, 1969, to 14th June, 1969) to 58.8 for the period (15th June, 1969, to 21st June, 1969) and the molasses purity rose from 37.5 to 38.1. The following table shows the average molasses purity and its equivalent massecuite purity for the period of 42 weeks during the 1969/70 season.

Group	Number in Group	Average Nutsch Purity	Average Massecuite Purity
36.6—37.5	15	37.1	58.21
37.6—38.5	12	37.9	58.66
38.6—39.0	6	38.9	59.10
39.1—39.5	6	39.4	59.75

Similar results were found in tests conducted at Darnall as shown in the extract quoted below:—

"Massecuite Purity: This varied between 54.0 and 60.6. An attempt has been made to correlate massecuite purity with the nutsch purity to give an indication of whether a low massecuite purity leads to a potentially lower molasses purity.

In the first case, the nutsch purities were placed in the following groups:—

30.0—30.9
31.0—31.9
32.0—32.9
33.0—34.9

Each group was averaged with the corresponding massecuite purities and the following results were obtained:—

Group	Number in Group	Average Nutsch Purity	Average Massecuite Purity
30.0—30.9	9	30.65	56.65
31.0—31.9	19	31.62	57.05
32.0—32.9	12	32.31	57.60
33.0—34.9	9	33.63	59.17

In the second case, the massecuite purities were placed into groups, i.e.:—

Group	Number in Group	Average Nutsch Purity	Average Massecuite Purity
54.0—55.9	7	31.66	55.34
56.0—57.0	12	31.98	56.65
57.1—58.0	11	31.82	57.61
58.1—59.0	11	32.55	58.72
59.1—60.0	8	32.60	59.40

From these results, one can say that the lower the massecuite purity, the lower will be the nutsch purity. That is, the lower the massecuite purity the greater is the potential of the massecuite to yield a lower purity of final molasses."

(f) *Tests to see the effect of grain size on sugar and molasses purity from the continuous machines.*

During the course of the season tests were conducted on the C massecuite grain size in order to assess its effect on sugar purity and molasses purity.

At the beginning of the season the grain size was of the order of 0.29 mm in length and massecuites were full of false grain. This slowed purging and produced sugar with a low pol and molasses of higher than necessary purity. The effects of false grain are very pronounced on continuous machine molasses purity, more so than in a batch machine where the crystal bed filters out the false grain—giving, admittedly, a poor quality sugar.

Attempts were made to boil a larger grain but these merely served to reduce third-stage exhaustion since insufficient crystal was present so that a great amount of false grain still occurred.

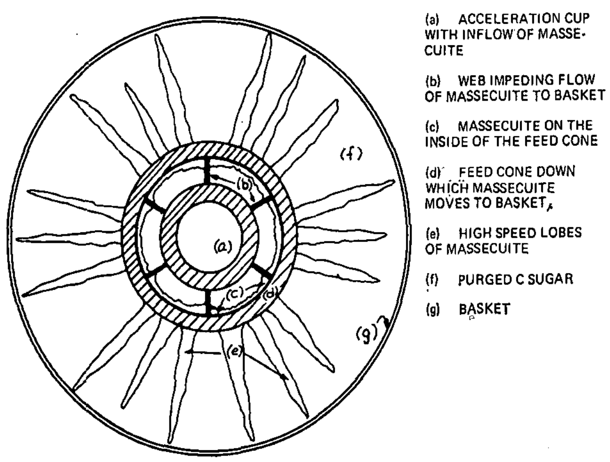
Consequently, boiling techniques were changed to give a massecuite with many nuclei so that the false grain was greatly reduced and the grain size, because of uniformity, still kept to 0.29 mm average. This grain gave improved curing and better quality sugar.

An interesting point which emerged was that the sugar produced by the continuous machines contained a lot of fine grain which, when made into a magma with B molasses, raised the purity of the wash from the after curers and caused more C strikes to be boiled. Double curing was thus abandoned and a noticeable improvement in third-stage recovery observed.

(g) *Tests made to observe the distribution pattern of massecuite being purged on the centrifugal screen.*

Using a stroboscope the distribution pattern of m/c on the screen of the machine was observed and the cause of many of the phenomena affecting the throughput of these machines seen.

The impeding effects of the distributor webs are such that lobes of massecuite under high pressure are sent up the basket at speeds which prevent satisfactory purging. Sketch No. 1 illustrates the pattern of these lobes on the basket.



SKETCH 1: Distribution pattern of massecuite on basket of B.M.A. centrifuge.

The effect of these lobes is to cause carry-over which contaminates the sugar with unpurged massecuite. This effect becomes greater as the throughput feeding these machines is increased. It also explains why there is a need for a greater ratio of water to massecuite feed so as to reduce the viscosity of molasses film adhering to the sugar to low limits and thus enable purging of the high-speed zones. A throughput of greater than 1.14 m^3h^{-1} resulted in a badly cured C sugar and 1.43 m^3h^{-1} was never attainable. This carry-over effect explains why it is best to operate these machines at $\pm$ 0.86 m^3h^{-1} as the amount of wash water needed to achieve any sugar pol is significantly less, meaning less chance of washing sucrose into the molasses. Also the quality of sugar produced is of a higher value meaning less recirculation. From the above discussion it is thus recommended for South African conditions that when purchasing these machines a capacity of 0.86 m^3h^{-1} be considered as optimum.

It should be mentioned that the supplier has elaborated a modified massecuite feeding device which underwent preliminary tests at Darnall last season, and a 30% throughput increase was experienced.

(h) *The mechanical and electrical reliability of these machines.*

A brief discussion of the mechanical features of the machine shows that structurally the machines appear well made with the exception that:—

(a) The feed distributor webs on five out of ten machines sheared, causing lost time of up to 24 hours for their repair.

(b) Controllers supplied by Siemens were fitted to each of the ten B.M.A. machines in order to obtain automatic control of the massecuite feed. The signal to the controller was the wattage drawn by the motor driving the centrifugal basket. Deviations from the set point effected the required opening or closing of the massecuite valve. The controller could be desensitized so that undesirable momentary fluctuations of up to 10% due to electrical interference would not alter the setting of the massecuite valve.

Experience showed that these controllers under Tongaat conditions were not satisfactory. This was due to voltage fluctuations exceeding 10% causing hunting of the control system.

It is appreciated that a technical solution can be found by, for example, installing a voltage stabilizer. Such an answer can, however, be expensive.

(c) The screens tended to blind due to the depositions in the screen slots of chrome deposits which were cleaned by placing the screens for two minutes in a flat bath of Hibitol and then washing with water and covering with a saturated solution of sodium carbonate. This problem is overcome by regular washing of the screens with hot water 3 times every 24 hours.

In order to check the screens a slide of molasses was taken once a shift and if high traces of sugar crystal were observed the machine was stopped to check for screen damage. The number of screens rejected because of being irreparably damaged during the season totalled eight. The screens were eroded at their base by massecuite impinging above the wearing ring. In order to prevent this it is necessary to skim the base of the acceleration cup, thus lowering the feed cone in relation to the wearing ring. The changing of screens takes 45 minutes.

Conclusions

The points which have emerged as being operationally desirable are:—

1. Steam of 1 bar absolute pressure should be provided through a 6 mm copper pipe to provide a good hot atmosphere for feeding in the massecuite.

2. Water at 80° C is best added via the distributor cup.

3. To ensure maximum sugar quality and minimum water addition (thus eliminating excess molasses dilution and consequential excess rise between final molasses and nutsch purity) the machines need to be run at $\pm$ 0.86 m^{3-1} until the feed arrangement is improved to eliminate the tongues of contaminating unpurged massecuite.

4. An operator is essential and needs to be supplied with information every hour on special notice boards. This information gives sugar quality (not below 85.0 purity) and molasses brix (of not less than 86.0 brix) thus ensuring minimum water usage and rise in molasses purity. The great advantage of continuous machines is that they afford the process manager the ability to control recycling since the C sugar quality can be varied within limits. The machines need constant operator attention to obtain the best results at all times.

5. If the massecuite could be fed hot (at 60° C), using very rapid reheaters to ensure minimum re-solution, then increased throughput and lower water usage can be expected.

These machines earned revenue by achieving savings as follows:—

1. Only one operator per eight-hour shift is required to work 10 continuous machines with savings in labour previously needed to operate 19 old batch-type machines, amounting to R21,000 per annum.

2. Savings in maintenance over the comparable number of batch-type machine are estimated at R3,000 p.a.

3. The earnings in revenue to Tongaat of these machines in one year has meant a gain in BHR of 0.8% which means additional revenue of some R80,000. This figure is high because of previous serious deficiencies in equipment. The earnings ability for a factory well equipped with fully automatic batch machines would be less.

The following table shows the massecuite purity and molasses purity which was obtained by the T.S.C. from 1962 to 1969 and shows dramatically the ability of the continuous machines in 1969 to cure a low purity third massecuite and its subsequent production of low-purity molasses.

Massecuite Brix	Massecuite Purity	Final Mol. Gravity Pur.	Year	Type of C Centrifugal
*97.2	*57.3	37.8	1969	Continuous
97.2	59.3	40.5	1968	Batch
97.0	58.6	39.8	1967	,,
97.4	59.6	41.2	1966	,,
97.8	59.5	41.1	1965	,,
97.1	59.8	40.5	1964	,,
97.3	59.9	40.0	1963	,,
96.6	60.3	40.9	1962	,,

* These two figures calculated from refractometer data using measured differences between refractometer and spindle brix. The difference in molasses purity between the 1969 year and the lowest year from 1962 to 1968 is 2.0%, which represents some 1.0% in BHR.

Acknowledgements

The author wishes to thank all those members of staff who assisted during the course of this investigational work and to also thank the Tongaat Sugar Company for permission to publish this paper.

Discussion

Mr. van Hengel (in the chair): I concur with the five points mentioned in the conclusion of your paper, except where it is stated that we must aim for the highest possible sugar purity.

Darnall has decided, unlike Tongaat, to maintain double curing even with continuous machines.

If we settle for a purity of C — sugar of 80, then it is possible from a normal massecuite purity to have a circulation of 130. This is not pure enough to go to the remelter — it must be double cured.

As plenty of water is necessary and some capacity is lost by trying to get higher purity sugar, I think that it is better to settle for a slightly lower sugar purity and to double cure it.

Mr. Carter: Our view is this. Why buy fifteen machines and use ten to produce sugar of 80 purity when you can use fifteen to produce sugar of 85 purity with a lower recirculation load?

When you purge to a high purity you will have more molasses to dispose of.

Mr. Chiazzari: If you double cure, the molasses is being circulated to the C-massecuite.

If you single cure, are you not returning the recirculation back to the raw sugar?

Mr. Carter: Yes, but we prefer to use as many machines as possible in order to get the minimum recirculation. We want to use all our machines to get the highest possible quality sugar.

Mr. van Hengel: The industry has spent a lot of money on the remelt system, which is designed basically to crystallise our first product out of the most pure surroundings — to get the best sugar. This object is defeated if we do not double cure, particularly as this system has presented no difficulties.

Mr. Archibald: Has Tongaat experienced building up of sugar in the machines? It has been so bad at Empangeni that the machines have tripped. We now stop and wash down one machine daily.

We have also had trouble with the massecuite impinging onto the screen.

I agree with Mr. Carter that constant operator attention is necessary to ensure smooth running of the machines.

Mr. Hulett: I wish to refer to the correlation between low massecuite purity and low molasses purity.

Before monthly averages are taken for massecuite and molasses purities, it can be seen that a very low purity molasses has been obtained from a high purity massecuite.

I feel we should put on a machine to drive a pan so that the same condition could be produced all the time and we might then be able to take a step forward in boiling C-massecuites.

Mr. Carter: On the basis of probability, when you boil a lower purity massecuite you will obtain a lower purity molasses.

It would be interesting to have mobility meters to indicate viscosities in our pans when boiling because of the different purities during the season.

Mr. Moor: Regarding the automatic controls for the massecuite feed. We were under the impression that they were operated from the amperage of the motor driving the centrifugal. But it is not purely an amperage control as it does take account of voltage fluctuations, but it becomes inaccurate under the conditions of voltage fluctuations such as sugar mills tend to have. However, the manufacturers are taking steps to correct this.