SOME ASPECTS OF FACTORY OPERATION AT THE TONGAAT SUGAR COMPANY FACTORY

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A review of several of the operations carried out in a raw sugar factory has been presented. Proven solutions to some of the practical problems which were being experienced at the Tongaat Sugar Company factory are described, while mention is also made of some still unresolved practical difficulties which, it is hoped, will provoke fruitful discussion.

Trials with an Ultrasonic Electrode Cleaner

A commercially available ultrasonic electrode cleaner was tried on the electrodes which measured the pH of limed juice at its boiling point. The local representatives of the supplier had stated that the ultrasonic electrode cleaner could be used satisfactorily on boiling juices but it was only subsequent to its installation that the contrary opinion of a representative from the parent company in Europe was learned. It was explained that the electrode cleaner would prove unsatisfactory in liquids at boiling point because the energy imparted by the electrode cleaner would cause a vapour layer on the electrode surface, i.e. the liquid on the surface of the electrode was made to boil. This was borne out in practice.

The unit did show the anticipated benefit of keeping the electrodes clean but it also caused unexpected damage. In particular it caused the porous plug on the reference electrode to be dislodged and was the probable cause of some broken glass electrodes. Further, the sealing of the ultrasonic probe itself was unsuitable for the conditions of use.

The Distribution of Limed Juice to the Clarifiers

More than one type of commercial arrangement for the distribution of limed juice to the clarifiers had been tried at Tongaat without success when it was decided to design a plant to perform this important function. Incidentally, unsuccessful plant included vee-notch weirs and submerged adjustable gates.

The requirements of the plant were:—

(a) The proportion of the total factory flow of juice to each clarifier should be easily adjustable over a wide range (including zero, i.e. clarifier shut off).

(b) Once set, the ratios of the flows to each clarifier should be unaffected by variations in the total factory flow, i.e. the proportions to be independent of the total.

(c) The flow to each clarifier should be easily and accurately measurable at all flow rates.

Attaining these objectives was complicated at Tongaat by:—

(i) The wide variations in flow stemming from two different-sized milling trains which gave nominal crushing rates of 0, 120, 180 and 300 tons/hour, depending on what plant was running.

(ii) Wide variations of clarifier capacities, with two 24 ft. Dorr and four 22 ft. Bach clarifiers.

The above objectives have been successfully achieved under all conditions of operation in a relatively simple and inexpensive manner by distributing the juice from a quiescent tank through a series of adjustable Cippoletti weirs. Cippoletti weirs were chosen in preference to vee-notch weirs for two major reasons. First, the vee-notch form does not permit simple adjustment whilst retaining the proportionality condition (b) above. Secondly, the vee-notch discharge being proportional to $H^{2.5}$ suffers from a markedly bunched scale for large values of H, which means that precision of measurement is sacrificed at large flows.

An excellent weir form for the required purpose would be a suppressed rectangular weir for which the discharge Q is given by—

$$Q = 3.33\ LH^{1.5} \text{ in f.p.s. units}$$

where L is the length of weir and H the height of the free upstream liquid surface above the base of the weir. A series of such weirs with a common base level positioned round a tank would discharge in the ratio of their lengths. However, if a simple gate were introduced to adjust the length L of such a weir, its form would be changed immediately to that of an unsuppressed weir. With two end contractions the flow from a rectangular weir becomes $Q = 3.33\ (L - 0.1\ H)\ H^{1.5}$.

Apart from the more complicated calculation this implies, the property of Q being proportional to L for a given H has now been lost. This means that the ratio of the flows through different weirs would no longer be independent of the total flow. This was the problem which led to the selection of a Cippoletti weir form.

A Cippoletti weir is a trapezoidal weir whose side angle θ (Fig. 1) is selected such that the increase of length with height just compensates for the effect of the end contractions and the formula for such a weir reverts to the desired form of—

$$Q = 3.33\ LH^{1.5}$$

The angle θ for this property was determined by Cippoletti to be such that $\tan \theta = 0.25$.

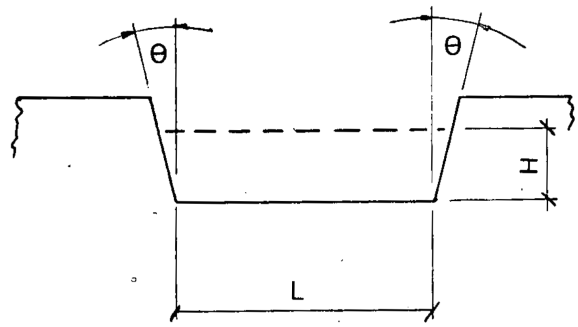

FIGURE 1: Illustration of a Cippoletti weir.

If Q is expressed in metric tons per hour while H and L are given in centimetres the equation for the flow of juice (S.G. 1.06) over a Cippoletti weir is—

$$Q = 0.06795 \times L \times H^{1.5}$$

The product $0.06795 \times H^{1.5}$ was calculated for different values of H and these values used to construct the (scale A) which indicated the height of juice above the weirs. Hence the product of this reading and the weir opening in centimetres read from another scale (scale B), gave the quantity of juice passing through the weir.

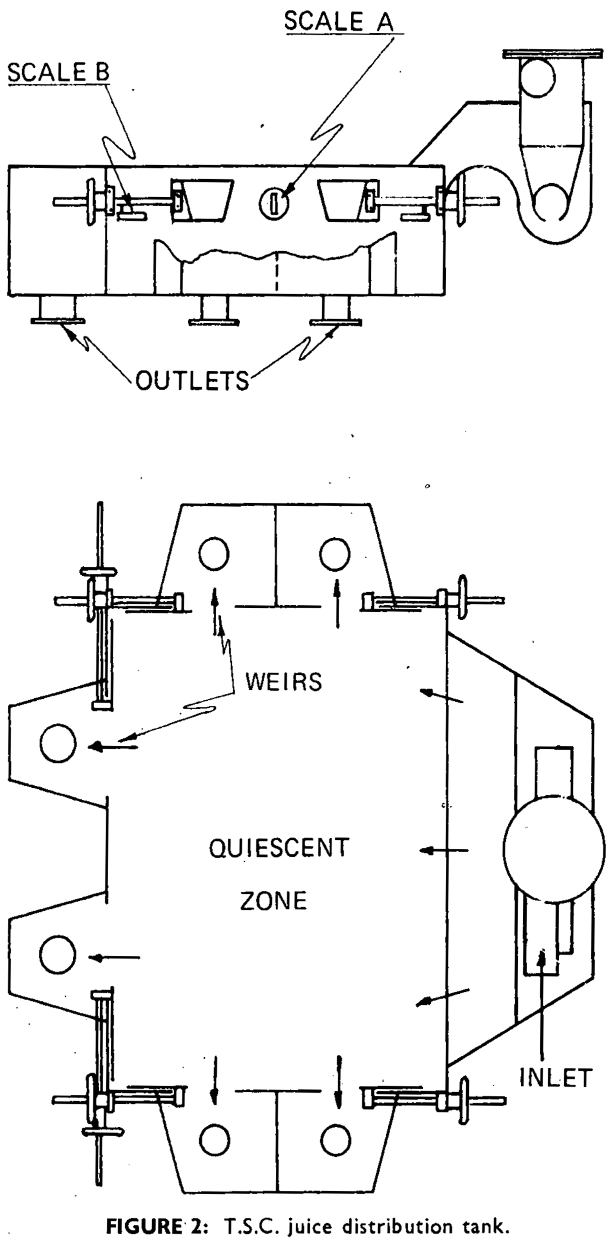

FIGURE 2: T.S.C. juice distribution tank.

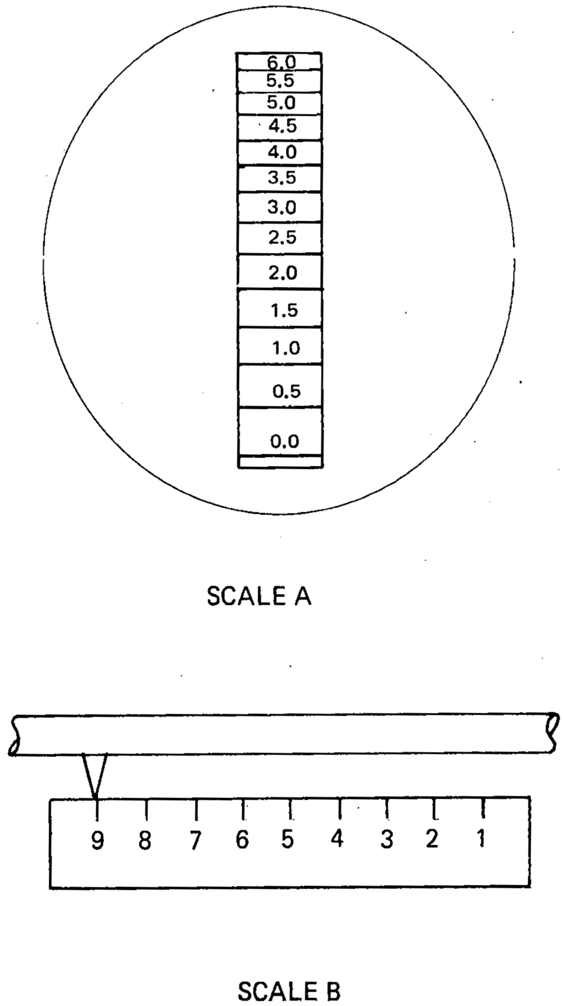

FIGURE 2A: Details of scales in Figure 2.

Details of appropriate H/L ratios, free ventilation and chamfered edges, etc., required in the design of such a box can be found in any standard hydraulics or engineering handbook. The arrangement of the Tongaat installation is depicted diagrammatically in Fig. 2.

A check on the accuracy of these weirs was made on a number of occasions by comparing the calculated flow through the weirs with the recorded flow from an orifice plate. The agreement was within 1–2%.

A problem which was found with the weir box was a build up of sand which was such in the latter part of the year that it was necessary to flush it out once per week. To facilitate this operation it is desirable to have the bottom sloping towards the drain outlet.

Clarifiers

Although all the heated juice at Tongaat passed through a suitable flash tank the Bach clarifiers had flash tanks which were attached to each unit. One of these had been removed a few years ago when some test work was being carried out on this clarifier and it had functioned satisfactorily since then without the flash tank. The other Bach flash tanks were removed during the past season and no problems have been experienced as a result. It should be mentioned that the emergency overflow of the Bach clarifier was located in its flash tank, but in view of the relatively large diameter of these clarifiers such an overflow was considered to be unnecessary under present circumstances. The main advantages of their removal were the reduction in maintenance and provision of extra space on the clarifier floor. It was noticed that the juice entered the clarifier at a slightly higher temperature after they had been removed.

T.S.C. operated two 24 ft. Rapidorr clarifiers and in the past it had been found that one of them had a marked tendency to retain caked mud in the mud compartments. A close study of the units was made in order to find the cause of the difference in performance. Two features that were noted were—

(a) different rates of rotation of the scraping gear; and

(b) juice take-off pipes in the one clarifier were set about 20 cm too low.

Although these two features were modified to bring the characteristics of the unsatisfactory clarifier into line with the better one it was not successful in achieving the desired improvement.

After seven weeks of operation in July/August the mud in the lower mud compartment had built up to the level of the inspection port. On the other hand, no significant mud build up occurred during the last 16 weeks of operation. Analysis of juice samples from this clarifier after a week-end shut-down showed a greater increase in R.S.R. than did any of the other clarifiers. Some comparative data of the R.S. ratios after a week-end shut-down were:—

5.26 and 7.12

6.36 and 10.16.

Juice Retention in Clarifiers

Trials run in Bach clarifiers at 55 and at 80 tons juice per hour seemed to indicate that there was less loss of sucrose with the lower retention time of 1.7 hours compared with 2.4 hours. This conclusion was based mainly on the change in R.S.R. from clarifier feed to clarified juice. As a guide to what happens in the clarifier it is suggested that this comparison is more meaningful than the change in R.S.R. from mixed juice to clarifier juice which is sometimes used as a rough indicator.

Filter Station

The retention of the filter station was known for some time to be low and attempts were made to improve it. These filters had been altered some years ago in such a way that the feed entered through two pipes in the bottom of the tray and the overflow was taken off from the one end instead of along the length of the filter.

Observations showed that the sprays were impinging too strongly on the cake and also delivering too much water. This resulted in erosion of the cake and dilution of the bagacillo/mud mixture in the filter tray. Consequently retention was being reduced in two ways, viz., by—

(a) washing off cake which had been picked up by the filter; and

(b) diluting the feed to the filter which has often been shown to result in lower retention.

New finer sprays were fitted and this did lead to improved results. Using water at a pressure of 3.8 bar absolute, these sprays delivered 200 ml/minute over a circle of diameter 20 cm when the spray was set 20 cm from the filter drum. However, it is still possible for the operator to add too much water on the top of the filter with the above-mentioned effects, but the answer to this is considered to lie in proper training of the operators.

A further aspect of filter operation which was examined was the setting of the cut off and application of vacuum to the panels of the filter drum. It was found that for a particular filter different panels appeared to cut off at different heights above the mud discharge point while some panels did not appear to break vacuum completely. It was only towards the end of the season that the cause of this unsatisfactory behaviour, viz. eroded or incomplete brass strips separating the panels, was found. The leaks occurred between the drum and the strip as well as on the screen side of the strip. Some leakage of vacuum also occurred on the strips sealing the ends of the panels. It is expected that the necessary attention to this will result in a further improvement in filter operation.

One other modification which seemed to have been well worth while was the fitting of steaming pipes along the length of the filter drums. These were set approximately 25 mm from the drum and consisted of 1.5 in. n.b. pipes with 1/16 in. diameter holes drilled at $\frac{1}{2}$ in. centres. These were used to steam-clean the filters using 7 bar gauge steam once every two days and examination has indicated that after a full season's operation the screen and compartment behind it were still in a satisfactory state of cleanliness for filter operation. Consequently it was not necessary to use the caustic soda cleaning treatment which had proved so successful on a previous occasion.

Pan Boiling

Attention is drawn here to one aspect of the operation of continuous centrifugals curing C massecuite, viz. the effect of irregular size grain. While a continuous machine can cope much more readily than a batch machine with a boiling containing all sizes of grain there can be appreciable loss of small crystals through the screen. Because of this, particular attention must always be paid to the grain regularity of the C boilings. At T.S.C. it was found that the regularity of boilings was not satisfactory and investigation showed that a major cause of this was the introduction of fine crystal in the B molasses and more especially in the wash from the double curing of C sugar. The presence of the exceptionally large quantity of crystal in the wash was a direct result of crystal breakage in the continuous C fore-curers. A very noticeable improvement was achieved by dissolving this grain through the use of thermostatically controlled silent steam blowers on the pan suction tanks.

Stirrers were also employed so that localized over-heating, which would cause caramelization, was minimized and also the feed to the pans was maintained at a uniform temperature. By heating the liquor in the suction tanks only, the amount of decomposition attendant on this practice was further minimized.

Discussion

Mr. van Hengel (in the chair): Tongaat uses steam blowers to improve the position regarding crystal in wash.

I think the present system of storage tanks for B-molasses should be reconsidered. These have been replaced at Mount Edgcombe by one large vertical tank, which pumps continuously to a blow-up tank and continuously overflows so that solution of fine particles is taking place.

It may be that the difference in reducing sugar ratio between limed and clarified juice should be investigated before the difference between mixed juice and clarified juice but what do these differences really convey to us?

Dr. Graham: A major reason why Tongaat operates as at present is the belief that decomposition can be minimised by holding molasses in storage at as low a temperature as is practicable.

Hence, only the molasses in the pan feed tanks is heated to dissolve fine grain.

The reducing sugar differences referred to are used as an indicator of chemical changes in the clarifier.

Dr. Matic: Is it the intention to measure pH at the boiling point of the juice?

Dr. Graham: No, because we do not know how to clean electrodes at boiling point with the ultrasonic cleaner.

The other problem is that the electrodes simply do not last, whether they are being cleaned or not.

Dr. Matic: Dr. Parker mentioned a German make of electrode which would stand up to these conditions.

Mr. Cargill: Did Tongaat solve the problem of differences in clarifier capacities?

Mount Edgecombe last year installed an automatic flushing system for their electrodes.

Dr. Graham: Although we have modified the clarifiers and are now using a reliable measuring device which controls the flow of juice, we are still having trouble and are getting an uneven build-up of mud.

Mr. Renton: Empangeni did at one stage introduce mechanical wiping of electrodes but this is no longer carried out.

Mr. Chiazzari: I am very interested in Tongaat's clarification system.

Regarding filter stations and the scaling up of the backing screens we have found that we cannot leave our screens for a week before cleaning them and we try and purge them every eight hours.

In connection with fine grain in wash, our centrifugals are fitted with a device operated by a timer, to feed water into the monitor casing.

By diluting the molasses in the casing, a smaller pump is required and much of the dissolving of fine crystal is affected.

We put low pressure vapour into our tanks and we seldom have trouble with microscopic grain coming back.

Dr. Graham: Our after-curers were continuous machines but we did not add water and often the wash looked more like massecuite than molasses.

Regarding our filters, an operator on each shift is responsible for two and he normally cleans one machine every second day.

In connection with clarification, the pH of the clarified juice is governed by two factors: (1) it should be minimum otherwise the quantity of final molasses is excessive; (2) we do not want an increase in reducing sugars from clarified juice to syrup, which is indicative of sucrose hydrolysis.

Mr. Bruijn: This morning we heard that the pH must not be too high because of decomposition of reducing sugars and because more molasses would be made.

Now we are told not to keep the pH too low because we will increase reducing sugars in the syrup.

There is no exact point where the one reaction stops and the other starts.

Dr. Graham: A compromise is necessary when deciding the pH at which the juice must be controlled. This value should be such that the destruction of both sucrose and reducing sugars is minimised.

Mr. van Hengel: The construction of our evaporators must be able to cope with the conditions which are optimum both ways and there is need for an intensive investigation.

Mr. Jullienne: Regarding bleeding of filters, it is important that they be properly cleaned at shut-down.