CONTINUOUS LOW GRADE CENTRIFUGALS

Continuous low grade centrifugals cause an average decrease in boiling house recovery of the magnitude of 1%. This means a loss of about 3% of the sugar passing through them. There are no sensing devices to enable instrumented control, so machine operation is manual. Since this loss is of the same order as that in filter cake, it is proposed that it be routinely measured and reported.

INTRODUCTION

Two unit operations in a cane sugar factory are prone to sugar loss. These are milling and continuous low grade centrifugation. Both lose from 3 to 6% of the sugar entering their maws. The quantity loss in the mill, of course, is much greater because all the sugar in the cane is involved, whereas less than one-third of that sugar reaches the low grade centrifugal station. 

Technology is at hand to reduce losses in both of these operations. Loss at the cane station can be kept at the 2% level by diffusion. This option, however, is only economically viable for new or expanded operations. Loss at the low grade centrifugal station, on the other hand, can be reduced to close to zero by the use of batch machines. Continuous machines need constant attention to keep the loss under 3%, under most conditions. 

Control of continuous centrifugals is the most sensitive unit operation in processing. There is no instrumentation which enables sensing of the most important criterion of efficient operation — the increase in molasses purity taking place in the machine! Control is therefore manual, using the physical senses and judgment of the operator, based on some previously obtained laboratory analyses. In an incredible lapse, such figures rarely appear on routine reports.

The continuous low grade centrifugal has a built-in sugar loss potential not present in an automatic machine. This is because the design requires the use of water or steam or both to remove the molasses from the crystals, causing sugar to dissolve and pass into the molasses. An additional factor is that all
the crystals are exposed to sliding action on the screen and are ground and fractured, producing fines smaller than the screen perforation. In a batch centrifugal only a small number of crystals are fixed at the surface of the screen, and the build-up of a crystal blanket acts as a filter to prevent other fine crystals moving to the screen. This action, however, is detrimental if the massecuite contains fine crystals which can plug the interstices and prevent the flow of molasses.

The minimum loss factor in a continuous machine universally experienced is that corresponding to a purity increase of 1.5 points. The minimum is rarely maintained and reliable figures reported from various regions show a normal average of near two points. The loss in sugar that this will cause will depend upon the purities of the juice and the final molasses but commonly means close to 1% of the sugar entering the boiling house. But, since only a portion of the entering sugar enters the low grade station, the loss of sugar going through it may be over 3%.

In experimental studies molasses purity increases of five or even six points are often seen. These mean a loss of 2 to 3% of sugar mixed juice corresponding to 6 to 5% of low grade entering sugar. Control of such loss is of utmost concern, but trying to achieve such control is a frustrating exercise, representing the extreme of the trial-and-error approach. The multiple factors involved include massecuite viscosity, crystal content, crystal size, crystal uniformity, temperature, rate of feed, and quantities of water and steam. Any of these can change in short order. How can the operator control? He cannot. He can only try. For this reason, the continuous designation is doubly appropriate, it must receive continuous attention. Nowhere in processing can so much sugar be lost so quickly and with so little notice.

Continuous centrifugals are attractive because of their simplicity, low initial cost and low non-intermittent power consumption. Economic evaluation dictates that these advantages must overbalance a continuous anticipated sugar loss of 1% over the lifetime of the machine to justify installation. Economic justification for tolerating such a loss is scarce. To get some indication of the magnitude of this, consider the Hawaiian figures. Continuous machines came into the industry early in the 1960s and gradually took over the low grade station until, by the end of the decade, the conquest was almost complete. In the post-war period final molasses refractometer purities averaged 32-33. In the 1960s the purities started going up and reached a plateau in the 1980s with a decade average of 37.7. The decade figures are shown in Table 1.
TABLE 1. Hawaii industry averages.

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<th>Refractometer Pol Purity</th>
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<tr>
<td></td>
<td>Syrup</td>
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<tr>
<td>1960-69</td>
<td>85.3</td>
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<td>1970-79</td>
<td>86.6</td>
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<td>1980-89</td>
<td>86.7</td>
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In the 1980s only two factories were still using batch low grade centrifugals on about 10% of the industry production. I have been unable to find anything to account for the increase in final molasses purity except for the introduction of continuous low grade centrifugals. Cane quality improved and mixed juice and syrup purities increased, reducing the quantity of low grade material to handle. Considerable improvements in equipment were made in the meantime – such as new pans, crystallizers and instrumentation.

If the same level of molasses purity (33.2) obtained in the 1960s had been maintained in the 1970s, sugar recovery would have been 1.3% more. In the 1980s it would have been 1.7% more. The loss is factual; the reason subject to speculation but the use of low grade centrifugals is certainly contributing.

Facing the status quo it is imperative that losses of such size be monitored, contained and reduced. Experience had developed some techniques basic to such a program. These are covered in the following discussion.

**GENERAL OPERATING PRINCIPLES**

1. The massecuite shall be acceptable quality. Continuous centrifugals are sensitive to the properties of the massecuite so sugar boiling procedures should be directed toward producing a standard quality with respect to uniformity of crystal size, crystal content, molasses soluble solids and purity.

2. The temperature of the massecuite entering the fugal should be sufficiently high such that the viscosity of the massecuite is suitable for processing. If the temperature is higher than the saturation temperature of the molasses then dissolution will occur. This should be avoided.
Since saturation temperature are rarely measured routinely, a starting standard practice would be to heat in a massecuite heater to 55°C (5°C above the optimum minimum temperature in crystallizers of about 50°C), then bring the temperature another 3-5°C higher in the feed pipe to the centrifugals. With almost instantaneous heating it is possible to go above the saturation temperature 2 or 3°C momentarily without dissolving appreciable sugar. This can be done by “halo steam” as in Western States machines or with tubular heaters.

3. Machines should be run at maximum load at all times. This can be done by automatically maintaining constant level in the massecuite header to hold a constant feedhead and adjusting the valve. Maximum load ensure a more uniform and thicker covering of the screen giving more efficient removal of molasses and less fines passing through the screen. Also minimum lubrication water is necessary. This is illustrated in Figure 1 comparing the performance of laser-cut stainless steel screens with conventional chrome-nickel screens.

4. Use of water should be limited to that necessary for lubrication of the massecuite.

It is most effective, therefore, if added in the feed pipe. No water should be evident in the acceleration bowl after this addition.

5. Use of steam should be limited to that necessary to heat the massecuite.

6. Low grade sugar should be kept at the minimum purity acceptable. Quality of the sugar is of secondary importance to molasses purity, and so should not be a controlling factor.

CONTROL

As noted, there are no sensing devices or instruments to monitor the molasses purity increase across the machines. The only measure comes from periodic analyses of the molasses entering and leaving the machine. From observations taken at the time of sampling, experience then governs the control action taken by the operator. The appearance and feel of the sugar offer about the only instant guides to what is happening. In general the lighter the color and the drier the sugar, the greater the purity rise in the molasses.

To make such a manual control effective, correlating observations should be kept in chart form at each machine, because each has peculiar characteristics. Sugar samples should be taken periodically with a proof stick held in the basket discharge stream and adjustments can be made in the control options.

PROCEDURES

Routine procedures might be the following:

1. Record hourly in chart form for each machine.
   (a) Temperature of massecuite in header
   (b) Temperature of molasses
   (c) Feed load meter reading
   (d) Water rate
   (e) Steam rate
   (f) Color line (level in basket where sugar color changes)
   (g) Sugar color and consistency.

2. Record every 8 hours for each machine.
   (a) Analysis of molasses entering (from filtered massecuite)
   (b) Analysis of molasses leaving
   (c) Microscopic examination of molasses for sugar crystals
   (d) Examination of screens for damage.
3. Correlate massecuite quality with centrifugal performance. Abnormal factors to be noted are:
   (a) Brix and purity
   (b) Crystal size
   (c) Crystal content
   (d) False grain.

4. Adjust load, water, and steam to give a sugar appearance judged to give minimum molasses purity increase.

COMMENTS

1. The maximum load is governed largely by the consistency of the massecuite, so the sugar boiling and crystallizer operations must be coordinated with the centrifugals to reach optimum results.

2. Since feed to the machines is by gravity, it is necessary to maintain a uniform head in the feed tank to the header. This means that flow from the crystallizers must be controlled by a level sensor in the feed tank.

3. When starting up a machine all pipes and valves must be steamed to prevent lumps which can damage the screen.

4. If the massecuite is difficult to process because of high consistency the temperature should be raised rather than trying to use more water or steam in the basket. In fact increasing the massecuite temperature is a general help in operating provided it is not far above the molasses’ saturation point.

5. Screens are thin and easily damaged by sugar lumps as well as foreign material. Slotted screens are particularly vulnerable, as even small pressure indentations can increase the dimensions of the slots. Coarse woven backing screens permit large depression and large slot deformation. A recent study of wedgwire backing appears to offer a possible solution.

   Corrosion is a major cause of screen deterioration in chrome-nickel screens. The use of laser-cut stainless steel screens is promising.

6. When making changes in operational settings, bracket by over shifting and then come back, rather than using a creeping approach.
It is recommended that the continuous low grade centrifugal loss be a routinely reported figure along with loss in Bagasse, Final Molasses, Filter Cake and Undetermined. It is real, can be measured and is of the same order of magnitude as the loss in Filter Cake. Although the loss now appears in the Final Molasses figure it is not attributable to the conventional factors affecting final molasses purity.

REFERENCES

CENTRIFUGES CONTINUES EN BASSE PURERTE

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RESUME

Les centrifugues continues en basse purete causent en general une reduction de 1% en recouvrement. Cela represente une perte de 3% du sucre travaille par ces centrifugues. Le control des centrifugues reste manuel parce qu'il n'y a pas de capteurs pour alimenter l'instrumentation. Cette perte de sucre est plus ou moins de la meme grandeure que celle aux filtres. Elle devrait done etre mesure regulierement.
Las centrifugas continuas empleadas para masacocida final causan una disminución promedio de 1% en la recuperación de la fábrica. Esto representa una pérdida de alrededor de 3% de el azúcar que pasa por ellas. La operación de las máquinas es manual debido a que no existen sensores adecuados para establecer control automático. Ya que esta pérdida es equivalente a las perdidas en cachaza se propone aquí que sea regularmente medida y reportada.