ABSTRACT

This short paper describes the performance of a new continuous centrifugal developed to handle all grades of massecuite. Dubbed the 'Superfugal', it is a very high capacity machine with low specific power requirements. No problems with respect to molasses purity rise and crystal breakage are evident. It is expected that one Superfugal could replace up to four batch fuggals currently used for shipment sugar production. On low grade, it should replace four commonly used continuous machines. Its versatility permits an attractive future option of a single, high grade - low grade fugal station for the whole factory. Current estimates suggest that a total of five Superfugals could service a 600 t/h factory. This, together with the potential for automation, should substantially reduce operating and maintenance costs.

INTRODUCTION

NQEA Australia Pty Ltd has developed an advanced technology continuous centrifugal for the sugar industry. The new 'Superfugal' design arises from developments licensed from BSES and the University of Queensland (Anon', Greig', Swindells').

The development has focused on providing a high capacity, continuous machine that would find application over the full range of sugars produced in the raw sugar factory and refinery. In addition to machine capacity, the key issues have been the elimination of crystal breakage and the minimization of molasses purity rise and power consumption.

Two prototypes were manufactured and tested before the first commercial machine was sold. At Kalamia Mill, the first prototype was commissioned for high grade service, processing both A and B massecuites. At Inkerman Mill, a second prototype was used for low grade separation trails.
The Superfugal prototypes incorporate the following features:

- A novel feeding arrangement which also acts as a rate control device and is amenable to automation.
- A static device which results in very low crystal breakage.
- Modified drainage ports to eliminate the 'teapot effect' discussed by Kirby and Greig.
- An improved basket geometry (which has been found to be similar for all massecuites).
- A direct coupled 90 kW motor which is totally enclosed and forced ventilated.
- Laser-cut stainless steel filtering screens.

**HIGH GRADE MASSECUITE SEPARATION**

**Installation and commissioning**

The Superfugal was installed on the end of the Kalamia Mill fugal station in line with the existing batch machines. With this installation A massecuite was fed directly from the side of the receiver, while B massecuite flowed to the machine via an 18 m length of 450 mm diameter hot-water-jacketed pipe. In both cases, the available massecuite head was often insufficient for the machine to run continuously at high rates for long periods.

Commissioning trials were carried out during the last two weeks of the 1988 crushing season and in September 1989. These trials covered the elimination of teething problems related to:

- Feeding (especially high crystal content massecuites),
- Wash water application,
- Crystal breakage device settings,
- Product sampling, and
- Mechanical reliability.

Steam is added to heat the feeding device and to heat the massecuite layer flowing on to the screen. The machine is fitted with three water sprays at different levels, which facilitate control of pol and moisture.

It was decided to operate in the speed range from 750 rpm to 1000 rpm, as in this range, high capacities could be achieved without compromising the sugar crystal size distribution. The main trial series focused on these two speeds, as they are...
close to the synchronous speeds or a pole and a pole induction motors. The main trial series was carried out during October and November 1989.

**Performance**

The NQEA superfugal was operated at up to 120 t/h on A massecuite and up to 80 t/h on B massecuite while producing 98 pol sugar. The capacity-sugar purity relationships shift according to massecuite properties. For typical Kalamia Mill material (Table 1), nominal capacities were of the order of 75 t/h on A massecuite and 45 t/h on B massecuite, based on 98 pol sugar production.

**TABLE 1. Typical high grade massecuite properties at Kalamia Mill.**

<table>
<thead>
<tr>
<th></th>
<th>Dry sub. (%)</th>
<th>True purity</th>
<th>Crystal content (%)</th>
<th>Crystal mean consistency @ 50°C</th>
<th>Crystal mean apertures (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A massecuite AV</td>
<td>90.8</td>
<td>87.8</td>
<td>52.4</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Range</td>
<td>89.0-92.0</td>
<td>84.7-90.9</td>
<td>44.8-60.0</td>
<td>0.7-1.7</td>
<td>0.73-0.85</td>
</tr>
<tr>
<td>B massecuite AV</td>
<td>91.4</td>
<td>82.2</td>
<td>48.6</td>
<td>6.1</td>
<td>0.75</td>
</tr>
<tr>
<td>Range</td>
<td>90.1-92.6</td>
<td>80.0-85.9</td>
<td>44.3-53.0</td>
<td>4.6-9.2</td>
<td>0.73-0.78</td>
</tr>
</tbody>
</table>

The sugar purity can be controlled by varying the flow rate of wash water at a given massecuite rate. The effect of wash water rate on sugar purity was both consistent and repeatable.

For A massecuite, the sugar quality can be controlled to 98 pol at a nominal wash rate of 1% on massecuite, or to 99 pol at a nominal wash rate of 3.5% on massecuite. VHP sugar (>99.4 pol) was produced at wash rates of greater than 6%.

For B massecuite, the sugar quality can be controlled to 98 pol at about 3% wash water, and to 99 pol at about 7% wash water. The performance of the superfugal varies according to massecuite properties and these results apply to the conditions encountered at Kalamia Mill.

There appeared to be no discernible benefit associated with increasing the basket speed from 750 rpm to 1000 rpm. It was observed that the color line is always very low on the screen (<20% up the basket) and under these conditions it is felt that washing would be the controlling mechanism rather than filtration, as is the case in low grade fugalling (Greig et al.). It would therefore be expected that
basket speed would have limited influence on the performance of a high grade fugal.

Crystal breakage

The Superfugal incorporates a static device designed to eliminate crystal damage from high velocity impacts with the machine's casing and from mid-air collisions on the flight path from the basket lip to the sugar chamber wall. Damage from mid-air collision can be very severe at high levels of polarization.

Grist analyses were carried out on sugar produced by the Superfugal and by Kalamia Mill's batch fugals. Sugars were sampled prior to the dryer, but after they had passed through a screw and elevator. Trials were conducted so that A or B sugars from either the batch fugals or the Superfugal could be sampled independently.

In the 1989 trials, the percentage fines produced by the Superfugal only marginally exceeded that produced by the batch fugals (factor of 1.09) when operating at 750 rpm.

At 1000 rpm, the Superfugal produced a significant increase in the proportion of fines in sugar. This was expected as the energy of the discharging crystals has increased by almost 80% from the value for a basket speed of 750 rpm. However, recent improvements to the crystal breakage apparatus have resulted in the Superfugal being able to produce high grade sugar of the same 'fines' content as that of a batch fugal.

Molasses purity rise

When comparing the purity rise on the Superfugal with that of the batch machines it was found that there was no significant difference in the molasses purity rise with both fugals producing 98 pol sugar. More recent evidence suggests that the continuous machine has a purity advantage over its batch counterpart and that this advantage increases as the target purity of the sugar increases.

Power consumption

Power consumption was monitored using an Easetering 'tong tester', which measures the line voltage and current for each phase, and the phase angle. The results showed that the power demand for the Superfugal, as-well-as being steady, was some 20% of the kWh per ton of massecuite used by the batch machines at Kalamia.
LOW GRADE SEPARATION

Installation and testing

The Superfugal at Inkerman Factory was installed on an existing staging in line with five Western States CC5 machines. Massecuite from the continuous crystallizers flows under gravity through a finned tube primary heater prior to distribution through individual secondary heaters to each fugal. A special finless type of heater was designed for the Superfugal, to cope with space limitations and with a very high secondary heating requirement.

An operating speed of 1440 rpm was selected for the main trial series, as this enables the use of a standard 4 pole induction motor for the direct drive arrangement. This speed is low enough to provide a significant reduction in the crystal discharge velocity from that of other machines, but high enough to provide a very high fugal capacity relative to other commercial machines.

Purging performance

A series of trials was carried out comparing the Superfugal and one CC5 machine operating simultaneously. The selection of the CC5 machine for trial was varied each day. The fugal station at Inkerman Mill was consistently producing quite high C sugar purities (>90 true purity). The Superfugal performed very well at C sugar purities over the range 85 to 95 purity. Typical C massecuite properties during the trial period are given in Table 2.

The Superfugal capacity average 3.7 times the capacity of the Western States CC5 machines. It should be noted that the throughput of the Superfugal was often limited by the available head, with the wash water flowrate reduced to match the sugar purity with that from the CC5. The 3.7 factor underestimates the true capacity advantage of the Superfugal as its actual capacity was well above the total amount of material being produced by the low grade station. As a typical example, the Superfugal processed 35 t/h of massecuite (I/W = 3.2, Temp = 58°C) at a C sugar true purity of 90.

TABLE 2. C massecuite properties at Inkerman Mill.

<table>
<thead>
<tr>
<th></th>
<th>Dry sub. (%)</th>
<th>True purity</th>
<th>Impurities to water</th>
<th>Crystal content (massecuite) (%)</th>
<th>Mother liq consistency (Pa s°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>90.2</td>
<td>64.8</td>
<td>3.6</td>
<td>36.8</td>
<td>35</td>
</tr>
<tr>
<td>Range</td>
<td>89.0-91.4</td>
<td>64.1-65.5</td>
<td>3.1-4.2</td>
<td>35.6-39.2</td>
<td>25-65</td>
</tr>
</tbody>
</table>
Molasses purity rise

The molasses purity rise was obtained for each trial on both the Superfugal and the CC5 machines. From the Superfugal it was generally lower than that from the CC5 machine. The average difference was just over 1 unit, with a range of ±0.8 unit.

Crystal breakage

Size distribution studies showed the crystal breakage to be significantly lower than that from the CC5 machine.

Power consumption

The specific power consumption of the Superfugal and of the CC5 fugals was compared. The energy requirement of the Superfugal is slightly lower than that of the CC5 fugal, the average difference being approximately 35%.

CONCLUSIONS

The NQEA Superfugal has been successfully demonstrated for the production of low grade and shipment sugars. The nominal capacity of the machine was 75 t/h A massecuite, 45 t/h B massecuite and 35 t/h C massecuite. Effective control of high grade sugar pol (from <98 Pol to VHP) was achieved by adjustment of wash water flowrates, while C sugar purity was also controlled by the wash water flowrate. VHP sugar was routinely produced from A massecuite. A static device substantially eliminates the crystal breakage problem that has prohibited continuous high grade fuggling in the past. The device is effective over the entire sugar pol range. High grade molasses purity rises were not significantly different from those of the batch machine when the Superfugal and the batch fuggals were producing the same brand of sugar. On low grade material the Superfugal had an average purity rise of 1 unit less than the other continuous fuggals at Inkerman (Western States CC5). The Superfugal’s specific power consumption is one-fifth that of its batch counterpart on high grade processing and some 35% below other continuous machines in use at Inkerman Mill when processing low purity massecuites.

FUTURE IMPLICATIONS

A viable alternative to the high grade batch fugal is now available. The performance of the new continuous centrifugal has not been matched or even approached by that reported by any other fugal, batch or continuous. Its superior performance...
is due to a combination of technical innovations, the benefits of which appear to be additive. Its advantage over the other commercial units cannot simply be explained by size-speed combinations.

The design feature allows versatility of application which is a further asset, with equally impressive results for low grade or high grade processing. Preliminary work suggests that this range of proven applications will extend to refinery requirements as well. This aspect has the obvious advantage of standardization of centrifugal equipment and associated ancillary gear.

The time may now be opportune for some reflection on the relatively recent batch to continuous low grade changeover. This resulted in some 20 different models of continuous fugals being supplied to Australian mills by nine different manufacturers. Some were designed to suit the characteristics of the material, some were not. The effect of this diversity on items such as supply of screens and other consumable items was immense.

An opportunity is now presented for the next changeover to be affected with standard size machines. They can also serve as replacements for existing low grade units as these are retired from service. Current estimates suggest that a 600 t/h factory could operate with a total of 5 Superfugals on a single stage processing A, B and C massecuites. The ease with which pol and moisture are able to be varied in the Superfugal, coupled with new techniques such as near infrared sensing, indicates strong potential to automate the whole fugal process.

CURRENT SITUATION

Since the testing of the prototypes, three machines have been sold to Queensland mills. All are operating routinely on high grade massecuite. Some teething problems have been encountered but are being overcome, and operational characteristics equal to those of the prototype are being achieved.

REFERENCES


**RESUME**

Ce papier décrit la performance d'une nouvelle centrifuge continue, qui peut traiter toutes les massecuites. Appelée la "Superfugal", cette machine a une capacité très haute mais consomme peu d'énergie. La pureté de la mélasse et le cassage des cristaux ne sont pas des problèmes. Une Superfugal pourrait remplacer jusqu'à 4 machines discontinues pour la production de sucre à exporter. Sur les massecuites de basses puretés, elle remplacerait jusqu'à 4 machines continues. Sa souplesse d'utilisation permettrait d'avoir une seule station centrifuge, pour toutes les massecuites de la sucrerie. On pense que 5 Superfugals pourraient suffire pour une sucrerie de 600 t/ha. Cela, avec la possibilité d'automatiser le système, devrait réduire les coûts d'opération et d'entretien.
RESUMEN

Este breve papel describe los resultados de una nueva centrifuga continua desarrollada para manejar todos los grados de masa Ace. Esta centrifuga bautizada "Superfugal" es una máquina de alta capacidad con bajos requisitos específicos de potencia. Los problemas con respecto al aumento en las purezas de miel final y daño al grano no son evidentes. Se estima que una sola de estas centrifugas podría reemplazar cuatro centrifugas tipo "Batch" usualmente usadas para producción de azúcar cruda. En tercera debe reemplazar cuatro centrifugas continuas usualmente usadas para este servicio. La versatilidad de este tipo de centrifuga permitiría la opción de tener una sola estación de centrifugas para todas las masacocidas producidas en un ingenio. Se estima que un total de cinco de estas Super-centrifugas puedan con la producción de una fábrica de 600 t/h. Esto combinado con el potencial de automatización, podría reducir substancialmente los costos de operación y de mantenimiento.