PERFORMANCE OF STAINLESS STEEL LASER-CUT CENTRIFUGAL SCREENS

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ABSTRACT

The performance of stainless steel laser-cut centrifugal screens in a sugar factory was compared with that of conventional chromium-nickel screens. The results showed that the laser-cut screens produced a lower molasses purity rise of about 1.3 units compared to conventional ones, leading to an increase of overall sugar recovery and substantial gain.

Keywords: molasses purity rise, massecuite throughput, operational loss and physical loss

RESUME

La performance des tamis des essoreuses en acier inoxydable, taillé au rayon laser, fut comparée à celle des tamis chrome-nickel du type conventionnel dans une sucrerie. Les résultats ont démontré que la mélasse produite avec les tamis en acier inoxydable était d'une pureté inférieure d'environ 1.3^{o} à celle obtenue avec les tamis conventionnels, améliorant ainsi la récupération générale du sucre et occasionnant des gains substantiels.

Mots clés: pureté de la mélasse, débit de la masse cuite, pertes opérationnelles et physiques.

INTRODUCTION

A new type of screen for continuous centrifugals is now available, made of chromium-plated stainless steel, with fine perforations formed by laser-beam. For low-grade continuous centrifugals, very narrow screen slots (typically 60 microns wide) are essential to prevent excessive loss of fine sugar crystals. Prior to 1988, virtually all screens were of chromium-coated soft nickel, which had some drawbacks (Crane & Patino, 1995). An inherent weakness of the chrome-nickel screen is the high susceptibility of the nickel base to corrosion by salts present in molasses. This leads to an increase in slot width as the chromium surface peels off progressively and results in an increased loss of sugar (Greig *et al*. 1984; Greig *et al*. 1985; Kelly *et al*. 1985). A solution to the problems associated with conventional screens was found via the laser-cutting of slots into stainless steel sheeting, and trials have shown that the working life of the laser-cut screens is at least three times that of the conventional chrome-nickel ones (Atherton *et al.* 1991).

The main features of laser-cut screens as claimed by the manufacturers are:

- The hard chromium surface-coating on the stainless steel base does not flake off easily.
- The screen slots are tapered and have sharp, hardened working edges and high relief angles to achieve high separation efficiencies without clogging.

- High resistance to enlargement of the slots due to hardened working surfaces, and resistance to damage by foreign objects. Screen damages may be repaired by soldering.
- Uniform thickness of the screens.
- Apart from the mechanical benefits, the laser-cut screen reduces sugar loss in molasses, screen blinding and downtime.

Investigations carried out by Vermeulen *et al.* (1994) confirmed that the above-named benefits could be derived from stainless steel laser-cut screens.

In Mauritius, the preliminary data collected at Britannia sugar factory showed that laser-cut screens produced final molasses of lower purity than the conventional ones. Since the results were very encouraging a comprehensive study was carried out at the sugar factory during the 1997 crop season to compare the performance of two BMA K850 continuous C-centrifugals, one fitted with conventional screens and the other with laser-cut screens.

EXPERIMENTAL PROCEDURE

The method adopted to evaluate the screens was to keep the C-sugar purity the same for both test machines so that the quality of the molasses produced by them could be effectively compared.

The specifications of the screens used are given in Table 1.

Table 1: Characteristics of the types of centrifugal screens

	Laser-cut	Conventional
Open area %	7.50	6.00
Slot length (mm)	0.90	2.20
Slot width (mm)	0.06	0.06
Thickness (mm)	0.20	--

Massecuite flow rate was estimated by collecting massecuite over a fixed period of time followed by weighing. Before a series of test runs were started, the screens and baskets were washed and inspected. Water at about 30^{o}C was used in the centrifugals and their flow rates were monitored by means of a cold water turbine flow meter. Since no account could be taken of steam addition, the latter was added from a high to low level basis

Sampling of products

Before each test run, a representative sample of C-massecuite was taken to: (i) separate the mother liquor using a Nutsch bomb equipped with 0.06-mm screen, (ii) analyse for viscosity, and (iii) for Brix, pol and purity determination. Once the operational variables were set, the centrifugals were run under steady conditions for 20 minutes, then the final molasses and C-sugar were sampled at regular intervals of 5 minutes over a period of 30 minutes. Each type of product was composited and well mixed. Sub-samples of Nutsch and final molasses and

C-sugar samples were analysed for Brix and pol to determine their direct purities. To make sure that the same C-massecuite was examined during the experiment, the viscosity of the C-massecuite was measured at the start and end of the daily tests.

Dry-run tests

Dry run tests were carried out to determine whether sugar losses were due to crystals passing through the screens (physical loss; **ΔPp**) or crystal dissolution during washing in the basket (operational loss; **ΔPo**). The centrifugals were operated at the same massecuite throughput but without the addition of water and steam, and the results were used to determine the molasses purity rise (**ΔPt**), the physical loss and the operational loss as follows (Jullienne, 1987):

$$\Delta Pt = \Delta Pp + \Delta Po$$

$$\Delta Pt = \text{final molasses purity} - \text{Nutsch purity}$$

$$\Delta Pp = \text{“dry run” molasses purity} - \text{Nutsch purity}$$

RESULTS AND OBSERVATIONS

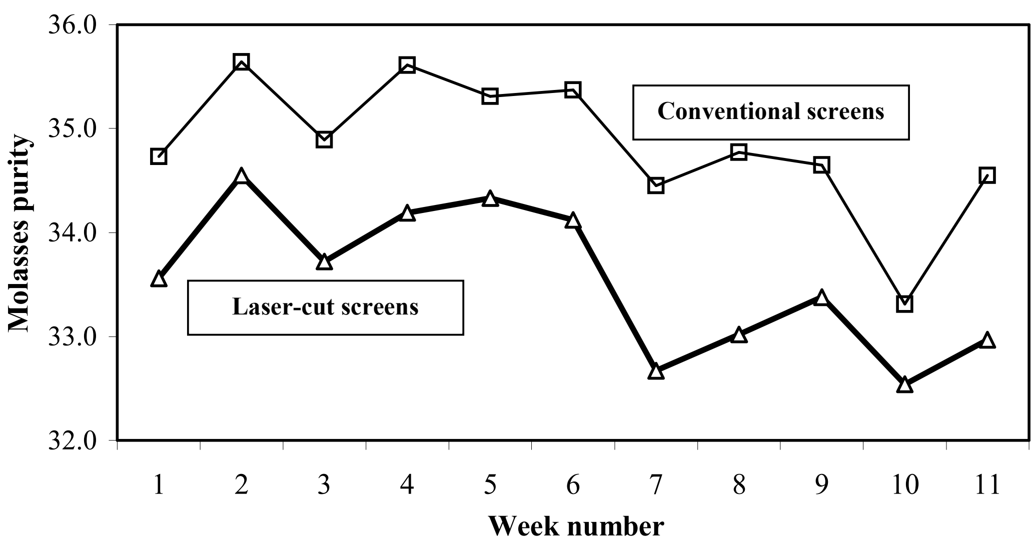
Final molasses purity difference

The results for 11 weeks of operation during the 1997 crop season are summarised in Table 2 and weekly data are plotted in Figure 1.

Table 2: Conventional versus laser screens: summary of 1997 crop results.

	Conventional	Laser-cut	Difference
Molasses purity	34.8	33.6	1.3

Figure 1: Final molasses purity (conventional v/s laser-cut screens)



As shown, the molasses purity produced by the BMA K850 centrifugal was always lower with laser-cut screens than with conventional screens.

Comparative tests

Tests were carried out at different C-massecuite throughputs with water and steam regulated to yield a C-sugar of around 85-86^{o} purity. The results obtained are shown in Table 3.

Table 3: Comparative tests.

Screen	Massecuite flow (kg/h)	C-sugar purity	Molasses purity	Purity rise
Laser-cut	971	85.6	34.5	2.1
	1115	86.2	34.0	2.2
	1476	85.5	35.1	2.7
Conventional	992	86.3	36.9	4.5
	1143	86.9	35.9	4.1
	1492	84.3	36.5	4.2

Again, the molasses produced by the centrifugal when fitted with the laser-cut screen was always of lower purity than when fitted with conventional screens by about 2.0^{o}. It was also noted that laser-cut screens helped in handling higher C-massecuite throughput whilst keeping molasses purity rise low.

Dry-run Tests

The mean results obtained for the dry-run tests are summarised in Table 4.

Table 4: Dry-run tests.

Screen	Purity rise	Operational loss	Physical loss
Laser-cut	2.7	0.4	2.3
Conventional	4.7	0.6	4.1

The operational loss for both screens was relatively small and purity rise was due in major part to the physical loss of small crystals in the molasses, which indicated the presence of a substantial amount of fine crystals in the massecuite. The effect of fine crystals passing through the screens was less with the laser-cut screen because the smaller slot area led to fewer crystals passing through.

Screen life-span and slot wears

In a normal crop season of about 120 days, at least two sets of conventional screens are required on each centrifugal, whereas the laser-cut screens had been used since the 1995 crop season, i.e. for two crop seasons before the study here reported. However, it should be pointed out that the laser-cut screens were not installed at the beginning of the crop as a precaution against impact by pieces of metal in the massecuite.

The laser-cut screens developed relatively few dents compared to the conventional screens, which showed visual evidence of surface wear. Furthermore, the laser-cut screens appeared to be clean at the back and showed no symptoms of the scaling shown by the conventional screens.

Economic implications

The cost of one set of conventional screens is about MUR 7 000 compared to MUR 80 000 for a set of laser-cut screens. As already mentioned, at least two sets of the nickel-chromium screens would be required for a crop season of about 120 days as opposed to one of the laser-cut set. Moreover, curing of C-massecuite with laser-cut screens produced molasses purity of about 1.3^{o} unit lower, is equivalent to a net gain of about MUR 647 000, as shown in Appendix 1.

CONCLUSION

Extensive tests have been carried out in several countries on stainless steel laser-cut screens for low-grade continuous centrifugals and results have shown that these screens help to save on sugar lost to final molasses, which is confirmed by the present study. The laser-cut screens have been used for three crushing seasons already and are still suitable for further use. Slot deformation was much more pronounced in conventional screens than laser-cut screens.

Although the laser-cut screens are tougher and more resistant, precautions should be taken against mechanical damage by foreign objects fed in with the massecuite. Stainless steel laser-cut screens are a cost-effective alternative to the chromium-nickel plated screens, and the derived benefits more than compensate for the higher purchase price of the screens.

ACKNOWLEDGEMENTS

The authors thank Dr L J C Autrey, Director of the Mauritius Sugar Industry Research Institute, and Mr J P Lamusse, Sugar Technology consultant, for reviewing the paper and Britannia sugar factory personnel for their collaboration.

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Appendix 1

Calculation of financial gain using data from Summary of Chemical Control Data 1997 and data from Target Purity Difference reports for the year 1997:

- Average dry matter % molasses : 81.2
- Mean true purity = (sucrose/dry matter)x100 : 39.9
- Tonnes cane crushed : 222 120
- Final molasses weight %cane @85^{o} Brix : 2.56

Total molasses produced = 222 120 x 0.0256 = 5686 tonnes

Sucrose % molasses = (39.9 x 81.2) / 100 = 32.40

Sucrose lost in molasses = (5686 x 32.40) / 100 = 1842 tonnes

Molasses purity gained = 1.3^{o}

If purity is reduced by 1.3^{o}, i.e., from 39.9 to 38.6

Sucrose % molasses = (38.6 x 81.2) / 100 = 31.34

Sucrose lost in molasses = (5686 x 31.34) / 100 = 1782 tonnes

Reduction in loss of sucrose = 1842 – 1782 = 60 tonnes

(Assuming that the price of 1 tonne of sugar is at MUR 12 000)

Financial gain in terms of sugar export = 60 x 12 000	= MUR 720 000
Less: cost of 1 set of laser-cut screens	= MUR 80 000
Less: cost of 1 set of conventional screens (used at start of the season)	= MUR 7 000
Add: savings on conventional screens (2 sets)	= MUR 14 000
Net gain	= MUR 647 000

(***Note***: maintenance costs of screens are not included and it is also assumed that one set of laser-cut screens last at least one crushing season)