EVALUATION OF STAINLESS STEEL LASER-CUT CENTRIFUGAL SCREENS

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Abstract

Tests were carried out with stainless steel laser-cut screens at Illovo and Sezela Sugar Mills. The objective was to compare the performance of the laser-cut screens with that of conventional ones. Significantly higher C-massecuite throughput (up to 22%) and lower final molasses purities were attained with laser-cut screens. Other benefits are discussed.

Introduction

The screens commonly used in continuous centrifugals, for low grade curing in the South African Sugar Industry, are made from a base of nickel. These conventional screens are produced by the chemical etching and electro-deposition process and are subsequently chromium plated. While these screens serve the industry well, experience has shown that the chrome layer flakes off exposing the relatively soft nickel to the corrosive action of the molasses and the abrasive action of the sugar crystals. This accelerates the wear of the slots on the screen causing increased loss of sugar to molasses.

Stainless steel laser-cut screens are sheets of stainless steel containing millions of tiny tapered slots. Each screen is accurately perforated by a patented laser process to specific dimensions and open areas. Slot widths are available between 40 and 200 microns while material thickness is usually 200 microns. High open area ratios (up to 12%) are available. Great flexibility in screen shape and design is offered. The following are the features of laser-cut screens claimed by the manufacturers.

- The screen has a hard chromium surface coating. Unlike nickel based screens this does not flake off to expose relatively soft nickel. This contributes to the long life of the laser-cut screens.
- The screen slots are tapered and have very sharp, hardened working edges and high relief angles which achieve high separation efficiencies and prevent clogging.
- The screen has smaller slots and tougher material which prevents enlargement and stretching of the slots over the backing screen.
- The screen is considerably more resistant to damage by foreign objects or lumps.
- Screens damaged by foreign objects can be repaired by soldering, or the damaged segment can be replaced.
- The laser screen contains about four times more slots per equivalent open area than the conventional screen.
- There is no need for matched sets as screens are of uniform thickness. Centrifugals run smoothly and segments are replaceable.

Apart from the above mechanical benefits, the laser screen has been claimed to have:

- Reduced sugar loss to molasses.
- Reduced screen blinding.
- Reduced downtime.

Due to these potential benefits it was decided to carry out tests to verify these claims and to determine other benefits of the laser-cut screen.

Experimental procedure

Tests were carried out over three seasons to compare conventional and laser-cut screens. Since the results of the two preliminary tests done at Illovo sugar mill were very encouraging a comprehensive test was done at Sezela sugar mill in conjunction with the SMRI. One set of laser screens (L1) was used for the tests at Illovo and the other two sets (L2 and L3) were used at Sezela. These screens were tested against conventional type screens known as types A, B, C and D in this paper. The details of the various types of screens used and the test durations are shown in Table 1. The technical screen data are shown in Table 2.

Table 1

Screen types and test duration

Test No	Season	Location	Centrifugal types	Laser screen		Conventional types			
				Set	Duration	A	B	C	D
					Weeks	Weeks			
1	1991/92	Illovo	Western	L1	22	16	6	-	-
2	1992/93	Illovo	States	L1	28	12	16	-	-
3	1993/94	Sezela	BMA	L2	23	-	-	8*	-
			K1100	L3	25	-	-	8*	4

* These screens lasted an average of 8 weeks.

Table 2

Screen data

	Laser-cut screen	Conventional screen type			
		A	B	C	D
Illovo % open area	6,5	9	10	-	-
Sezela % open area	7,5	-	-	6,5	7,5
Slot length (mm)	0,9	2,8			
Slot width (mm)	0,06	0,06			
Screen thickness (mm)	0,20	0,28			

Fitting of laser-cut screens

Stainless steel laser-cut screens are stronger but slightly thinner, by 80 microns, than conventional screens. It was therefore essential to follow the supplier's instructions when fitting the screens, to prevent them from flying out during operation, due to inadequate clamping.

Final molasses and C-sugar purity

Catch samples of final molasses and C-sugars were taken every hour from each centrifugal that was under test. The samples were composited over 24 hours and the composites were sub-sampled to make weekly composites for purity analysis by the SMRI. C-massecuite nutsch samples were also composited weekly for analysis at the SMRI. The daily composite samples were analysed by Illovo.

Capacity determinations

The method and procedure adopted for capacity determination have been described by Vermeulen *et al.* (1986). It is based on a pol balance and requires the measurement of the molasses flow.

Screen lifespan

For each screen records were maintained of the dates installed and replaced as well as all downtime.

Screen slot wear

Screens were removed at intervals and at the end of the season for slot measurements at the SMRI. New screens were also sent for slot measurements for comparative purposes.

Conditions of screens

All the screens were inspected twice a week.

Results and Observations

Final molasses purity difference

The results from the two laser screens were averaged and compared to those from the conventional screens. There were no statistically significant differences between the results from the two machines fitted with laser-cut screens.

The results of the 1993/94 Season (Test 3) are summarised in Table 3 and the weekly data are plotted in Figure 1. The results obtained from the analyses done at Illovo were very similar to those of the SMRI (molasses purity difference 0,22). The molasses purity difference for the two types of screens is shown in Figure 1 for the test done at Sezela (Test 3).

Table 3

Conventional versus laser screens: SMRI weekly results

	Conventional screens	Laser-cut screens	Difference	t value	Remarks
Sugar purity	82,00	82,20	0,20	−0,08	Not significant
Molasses purity	36,10	35,90	0,20	4,47	Significant at 95%
Purity rise	1,83	1,63	0,20		

The results in this figure indicate that the molasses produced by the centrifugals with laser-cut screens was nearly always lower in purity than that from the conventional screens. Statistical tests (t-test) showed that the molasses purity difference was significant at 95%.

Capacity difference

The capacity data for the two types of screens tested in the 1993/94 season at Sezela are summarised in Table 4.

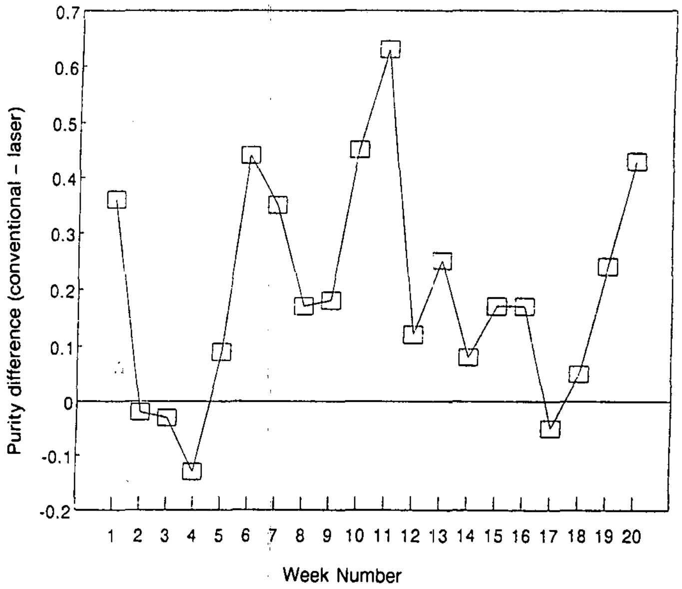

FIGURE 1 Final molasses purity difference, (conventional - laser), plotted against week number.

The results indicate that the laser-screen enabled a higher massecuite throughput (significant at 95%). Due to the difference in the open area of the screens further comparisons were done involving screens of equivalent open area. The results are given in Table 5.

Table 4

Capacity for C-massecuite: Conventional Versus Laser Screens

	Conventional screens	Laser-cut screens	Difference	t value	Remarks
% Open area	6,5	7,5	-	-	-
Capacity (kgh^{-1})	3 781	4 842	1061	8,2	Significant at 95%

Table 5

Conventional (Type D) versus laser-cut screen (Set L3)

Screen type	Capacity kgh^{-1}	% open area
Laser-cut screen	4298	7,5%
Type D screen	3369	7,5%
Difference	929	

From Table 5 it can be noted that the laser-cut screen still had a higher capacity than the conventional type screen although both screens had the same percentage open areas. The increased capacity is probably a reflection of different slot dimensions.

The capacity difference for the two types of screens is shown in Figure 2 for the test done at Sezela (Test 3). From this figure it can be seen that the massecuite throughput has been consistently higher throughout the season for the centrifugals with laser-cut screens than that with conventional type screens (mean difference 1 061 kgh^{-1}).

Screen lifespan

The lifespans of the various screen types are shown in Table 6. This abnormally high lifespan for the conventional screens

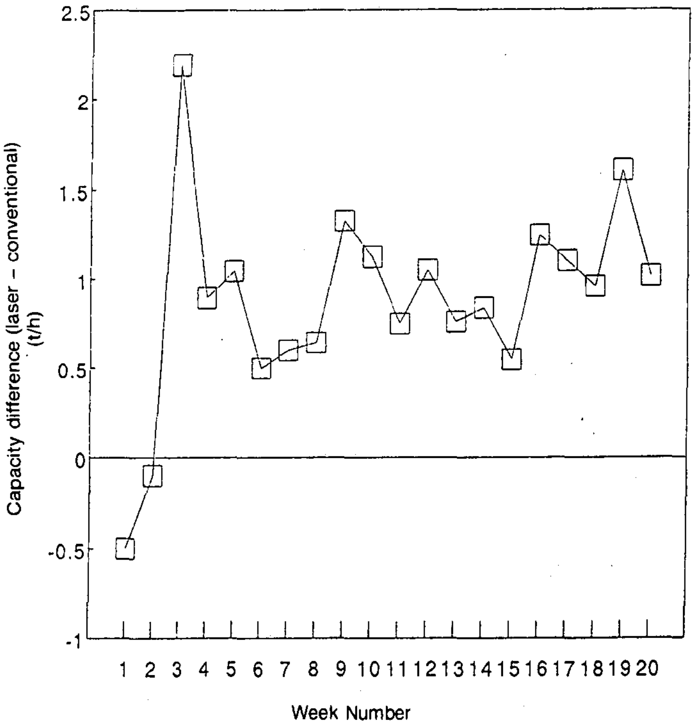

FIGURE 2 Capacity difference (laser-conventional) plotted against week number.

(normally 1300 hours under local conditions) was due to the low throughput because of the very highly viscous C-massecuites. One set of laser-cut screens lasted the first two seasons giving a total service of 7 200 h (50 weeks). The two sets of laser-cut screens, tested in the 1993/94 season, lasted in excess of 4 000 h and are still good for re-use next season. A total of 10 sets of conventional screens has been tested against the three sets of laser-cut screens.

Table 6

Screen types and usage (hours)

Season	Laser-cut screen	Conventional screen type				
		A	B	C	D	Number replaced
1991/92	3168	2304*	858	-	-	2
1992/93	4032	1716	2288*			2
1993/94	4010	-	-	1346	460	6

Screen slot wear

The results of the slot measurements for Test 2 and Test 3 are shown in Tables 7 and 8. These tables show that there was a progressive increase in the average width of the conventional type A screen while the average width of the laser-cut screen changed very little.

Conditions of screens

Laser-cut screens

It was observed that these screens developed relatively few dents compared to the conventional screens. The screens appeared to be clean at the back and showed no evidence of scaling. Therefore chemical cleaning of these screens was not necessary. However, washing the screens with hot water at least once a shift, was necessary to dislodge the dirt from the slots.

Table 7

Results of slot analysis of laser-cut and Type A screen (Test 2)
Laser-cut screen

Slot data in microns	New	9 wks	20 wks	50 wks	Slot width % increase
Width	55	48	53	56	Negligible
Std dev	9	9	7	-	-
Length	884	857	857	880	-
Std dev	56	81	77	-	-

Table 8

Type A conventional screen

Slot data in microns	New	9 wks	16 wks	Slot width % increase
Width	47	69	74	57%
Std dev	14	9	15	-
Length	2922	2895	2873	-
Std dev	65	77	77	-

The screen tested in the Western States Centrifugals lasted 7 200 hours (50 weeks). This set had a few dents and one small hole. This was probably caused by a foreign object during boil-off. One segment was cracked in three places. After careful inspection it was concluded that the crack was possibly due to metal fatigue. It was evident that the screen had reached the end of its service life.

The two sets of screens tested in the K1100 C-centrifugals at Sezela also had a few dents but no holes. They are still suitable for further use. The small screens in the accelerating cone showed minimum wear of the chrome surface layer.

Conventional screens

The conventional screens had visual evidence of wear on the screen surface. The formation of scale at the back of the screens in the K1100 centrifugals warranted chemical cleaning. Each set of screens was chemically cleaned at least twice. The chrome layer from the small screens in the accelerating cone had flaked off extensively and the screen surface was severely worn. The extent of wear on this screen was far greater than that on the basket screen.

Conclusions

The following benefits of the laser-cut screens have been confirmed:-

- The first set (L1) of screens lasted 50 weeks and the other two sets (L2 and L3) lasted 23 and 25 weeks respectively and are still suitable for further use. This long life offers advantages of reduced downtime and lower screen fitting costs.

- The screens produced lower final molasses purities throughout the season. The gain of 0,2 unit in final molasses purity, achieved by the two laser screens, resulted in a net saving of R63 000 for the duration of the test (25 weeks). This excludes labour savings. If all the centrifugals at Sezela had laser screens then a saving of 202 tons of sugar would be achieved based on the same purity drop. This would have resulted in a net saving of R160 000 for the season. On an industrial basis this represents a saving of R2,6 million per annum.
- Higher capacities were achieved. The reduced screen blinding, due to the fully divergent shape of the slot, enabled the machines to maintain capacity.
- Artisan's time was saved due to the reduction of screen changes and the reduced frequency of cleaning the laser screens.

From the calculations in Appendix 1 it can be seen that the laser-cut screen not only pays for itself but that additional savings could be achieved. Because of these advantages the use of laser-cut screens is considered justifiable despite their high initial cost.

Acknowledgements

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(Insert Appendix 1)

Appendix 1

Calculation of financial gain for 1993 season

1. Data Used

Sugar pol	99,41
Sugar moisture	0,25%
Sugar purity	99,66
Mixed juice purity	80,51
Tons pol in mixed juice	168442
Tons pol in filter cake	114
Tons pol undetermined	2712
Pol to sucrose ratio (F Mols)	0,9370
Pol to sucrose ratio (MJ)	0,9886
Bix of final molasses despatched	80,51

2. *Assumptions*

The laser screens in all the C-centrifugals produce final molasses purity of the same purity as that of the two laser screens tested.

All the laser screens last at least one season.

3. *Calculations for all centrifugals with laser screens*

	Conventional screens	Laser screens	Gain
Number of centrifugals	12	12	
Nett tons sucrose	167 526	167 526	
Mixed juice purity	80,51	80,51	
Sugar purity	99,66	99,66	
Final molasses purity	36,10	35,90	−0,20
Nominal BHR	86,49	86,61	+0,12
Sucrose loss F molasses	13,51	13,39	
Tons sucrose recovered	144 893	145 094	
Tons sugar	145 753	145 955	+202
Tons sucrose in final molasses	22 633	22 432	
Tons final molasses	72 967	72 722	−245

	All laser screens
1. Tons sugar saved	202
	Rands
2. Mill door price of sugar: R1 295 per ton	
3. Value of sugar saved	251 590
4. Less final mols not produced (245 tons @ R141 per ton)	34 545
	227 045
5. *Less:* cost of laser screens 4 @ R15 000 = 60 000 8 @ R 7 000 = 56 000	116 000
	111 045
6. *Add:* savings on conventional screens 4 × 3 = 12 @ R2 000 = 24 000 8 × 3 = 24 @ R1 000 = 24 000	48 000
Annual saving	159 945

NB These savings do not take into account the increased capacity achieved by the Laser-cut Screens and the maintenance costs of the Conventional Screens.