RECENT EXPERIENCES WITH DIFFERENT TYPES OF CONTINUOUS CENTRIFUGAL SCREENS

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Abstract

Results of observations made at some Tongaat-Hulett mills with continuous centrifugal screens over the last two seasons are presented. Particular note is made of the slot width and the variation in width between new and used screens. Comparisons are made between the service lives of various screens and the criteria used for determining the life. Both electroformed chromium plated nickel and laser cut stainless steel screens are considered.

Introduction

Continuous centrifugals are used for all low grade curing in South Africa. Screens for these machines are expensive and have a limited life due to the heavy duty to which they are subjected. The performance of the screens plays a very important role in the prevention of sugar loss. In the past different standards, often very subjective, were applied at each Tongaat-Hulett mill for deciding when screens should be changed. To gain more insight into the factors influencing screen life, measurements of slot sizes of both new and used screens were taken over the past two seasons.

Outline of manufacturing process

An outline of the way electroformed screens are made is shown in Figure 1. The required screen image is first drawn. This is reduced and multiplied either photographically or by computer aided design. A large photographic film is then made of the image. A chrome plated metal cylinder is polished and coated with a photosensitive layer. An exposure is made to ultraviolet light. The exposed layer is washed off and the remaining emulsion baked hard. The plate is then etched to form U shape depressions which extend down and under the emulsion. The emulsion is then removed and the depressions filled with resin. The cylinder is polished smooth to form the matrix. A nickel screen is then electroformed to the required thickness onto the rotating matrix by applying current through an electroplating solution. The screen is then peeled off the matrix. The flat or sugar side is polished and the screen is then hard chrome-plated on both sides.

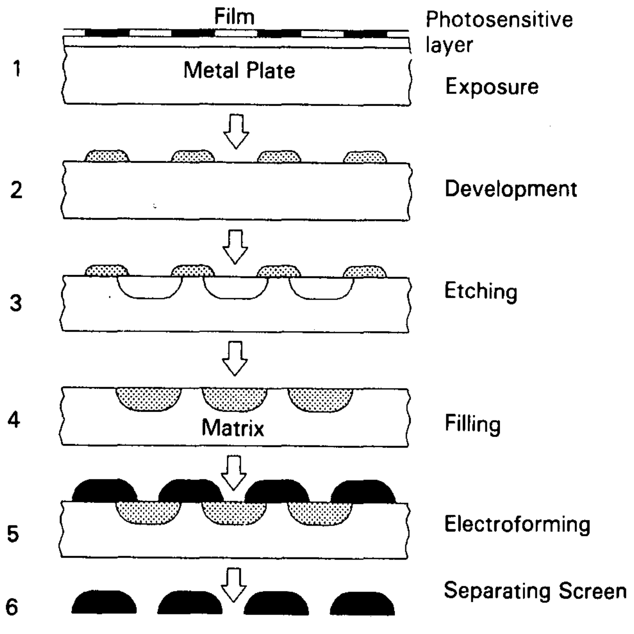
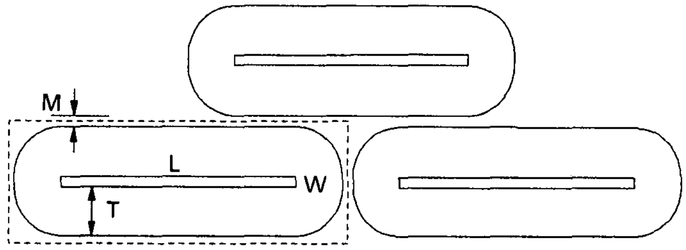


FIGURE 1 Outline of single sided electroforming process

The percentage open area of the screen is the main factor affecting the molasses drainage and hence throughput of the screen. This method of single sided electroforming imposes a constraint on the open area for a given thickness. The following calculation (Figure 2) shows this relationship for the type of matrix where the gap "M" is the same on both the width and length axes (Balco, Fontaine and Rototechnik). Veco screens have a slightly longer gap between the slots on the length axis.



$$\text{Area of slot} = L \cdot W$$

$$\text{Area associated with one slot} = (L+2 \cdot T+M)\,(W+2 \cdot T+M)$$

$$\therefore \text{\% open area} = \frac{(L \cdot W)}{(L+2 \cdot T+M)\,(W+2 \cdot T+M)} \times 100$$

Where: L = length of slot
W = width of slot
T = thickness of plating
M = width of original exposed matrix

FIGURE 2 Variables used for the calculation of % open area

The graph in Figure 3 shows this relationship for 0,06 and 0,09 mm slot width screens and at 1,8 and 2,8 mm slot lengths. It can be seen that for a given slot width, the slot length does not have a marked effect on the % open area. The % open area for 0,06 mm wide slots therefore is limited to about 7% for 0,3 mm thick screens, and 5% for 0,4 mm screens.

Balco and Veco make "Balcoflux" and "Vecoflux" screens that are electroformed on both sides and therefore have 10 to 15% open areas. These screens are at present approximately 2,5 times the price of standard screens.

The following types of screens are currently available from the four local suppliers:

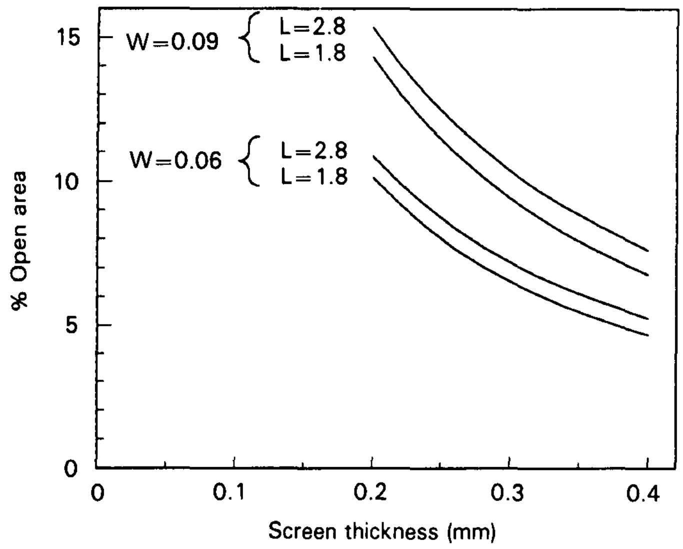


FIGURE 3 Relationship between % open area and screen thickness for different slot widths and lengths

Table 1

Availability of screen types from local suppliers for 0,06 mm slot width screens (slot length × screen thickness).

	Balco	Fontaine	Rototechnik	Veco
Standard	2,2 × 0,3	2,8 × 0,32	2,2 × 0,32 2,8 × 0,28	2,2 × 0,3 2,8 × 0,3
" " –flux	2,2 × 0,35+			2,2 × 0,3
Heavy duty	2,7 × 0,35 1,5 × 0,35			2,2 × 0,4

Screen prices have not been quoted as they are all very comparable for a given type of screen. Comparisons are also influenced by fluctuating exchange rates.

Screens are supplied with slot lengths from 2,2 to 2,8 mm and width 0,06 or 0,09 mm, although only one Tongaat-Hulett mill uses 0,09 mm screens for B duty. Screens are nominally 0,3 mm thick, but Balco and Veco supply thicker screens, namely the Balco RMS which is 0,32 to 0,38 mm thick and the Veco 400 which is nominally 0,4 mm.

Laser cut screens are made by cutting the perforations on stainless steel by a patented laser process to the required width and length. The slots are slightly V shaped with a sharp edge on the sugar side. The screen that was tested at Amatikulu had slots nominally 0,06 mm wide and 0,65 mm long cut into 0,2 mm thick stainless steel. The open area was approximately 12%.

Criteria for assessing screen life

Tongaat-Hulett Sugar as yet does not have fixed criteria for assessing when a screen should be changed. Apart from obvious damage such as holes and tears, different mills use different criteria. Recently the slot width has been considered the main criterion for screen performance. Unfortunately this is not easy to measure routinely in the factory. In the 1989 season four of the Tongaat-Hulett mills participated in a trial where slot dimensions of both new and used screens were measured at the SMRI. Both length and width of 100 slots were measured near the edge of each screen using the Kontron measuring instrument.

The Kontron is an image analysis system that has a video camera attached to a microscope. The video signal appears on a PC screen, where software allows an operator to measure distances by using a digitiser tablet. A line is left on the screen after a measurement has been made between two points. This measurement is automatically recorded after each click of the digitiser button. The instrument was originally bought to measure sugar crystals on a slide, and the microscope support required for this purpose unfortunately prevents the camera from reaching into the central areas of the screen.

Most of the mills take regular samples of molasses. These samples are examined for crystal content under a microscope. If there is much crystal present, then the purity rise is also checked and a decision is made whether to change the screen or not.

Foreign matter such as welding rod stubs, nuts and bolts often damage screens. These enter the process from the maintenance of the plant particularly after the off crop. These usually damage screens by making holes in them.

Results of slot measurements

A batch of 15 new Rototechnik screens was measured to assess the uniformity of the slots. This information was then given to the manufacturer for improving the quality control. A plot of the average slot width and maximum and minimum limits of these measurements is shown in Figure 4.

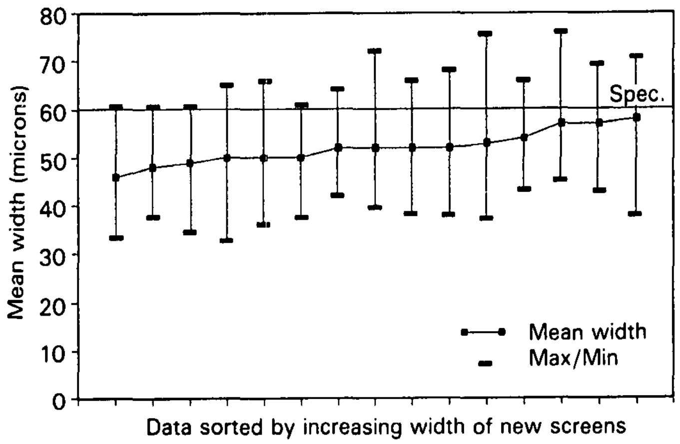


FIGURE 4 Variation in slot width in a batch of new Rototechnik screens

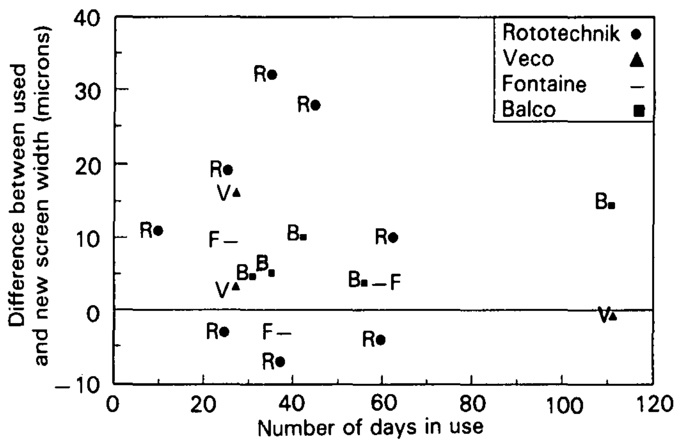


FIGURE 5 The increase in slot width (used – new) as a function of the number of days in use

The slot sizes of forty-nine other screens were measured new and after a period (not necessarily at the end of their lives). The average difference between the slot widths is plotted against the number of days in service. Unfortunately a record was not kept of the specific type of screens these were. A subsequent test at Maidstone on Veco 400 (heavy duty screens), gave an average slot width increase of 11 microns after 132 days of service. Heavy duty screens are approximately double the price of standard screens.

From Figure 5 it can be seen that there is not much correlation between slot width increase and screen life. It must be borne in mind that most of the screen wear occurs above the clamp ring where the massecuite first encounters the screen, an area which the Kontron cannot reach.

It was observed by the SMRI that certain slots on Rototechnik screens had a dumbbell shape. The slot width measurements of the last nine samples of both new and used screens were therefore measured in the centre and at each end of the slot. The average statistical data for these nine tests are shown in Table 2. These were all Rototechnik screens and had been used from 81 to 105 days. The lasercut screen had barrel shaped holes as seen in Table 3.

Table 2

Average of three position results of nine sets of measurements for Rototechnik screens (all readings in microns).

Position	Min	Max	Mean	SD	CV%	%<60	%>60
New screens							
At one end	72	102	87	7	8	0	100
At centre	52	82	67	7	11	23	77
At other end	73	105	87	7	8	0	100
Used screens							
At one end	64	130	94	14	15	1	99
At centre	49	107	73	12	17	27	73
At other end	65	130	93	13	14	1	99

Table 3

Average of three position results of four sets of measurements for Lasercut screen.

Age/Position	Mean	SD	CV%
New screens			
At one end	57	12	20
At centre	76	11	14
At other end	62	10	16
Used: 121 days			
At one end	48	8	16
At centre	64	8	13
At other end	55	9	16
Used: 133 days			
At one end	45	10	21
At centre	46	9	15
At other end	51	10	19

Figure 6 shows the comparison of an average slot from new and used Rototechnik screens and new Lasercut screens. The difference in shape is apparent.

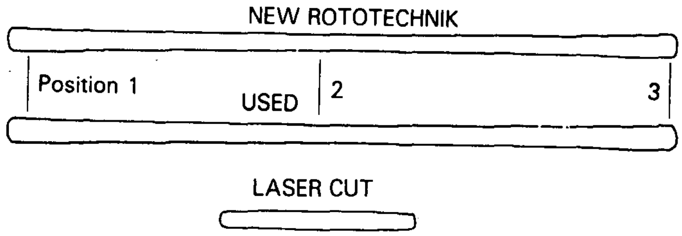


FIGURE 6 Diagram illustrating the dumbbell effect of some new and used Rototechnik screens as opposed to the barrel shape of new lasercut screens

Factors affecting screen life

Some factors effecting screen life are discussed below:

1. **Adherence of chrome layer.** The chrome layer is from 0,010 to 0,015 mm thick. It is usually thicker on the sugar face. The loss of the hard chrome has the most detrimental effect on screen life. The chrome does not appear to wear down but comes off in patches. If a patch is next to a slot then the nickel forming the edge of the slot wears away rapidly, widening the slot. The reasons for the chrome coming off are:
   - Poor original manufacturing process conditions. Chrome plating is a delicate operation and manufacturers must regulate the current, temperature and bath conditions to the most exact control.
   - Stress fracture. Chrome is very hard and resists stretching. Screens less than 0,03 mm thick are easily bent especially in the hollows of the backing screen and the chrome peels off.
   - Electrolytic action. There appears to be some electrolytic reaction that removes chrome. This is observed on the non-sugar side of screens after a somewhat short time, even on 0,4 mm screens. The chrome is also usually removed from the overlapping section where there is no massecuite flow. This does not appear to be caused by erosion as the underlying nickel remains unaffected.
   - Peeling. Chrome does not adhere completely to nickel. Where a spot is bare, the adjacent chrome plating is undermined and tends to peel off, enlarging the patch.

2. **Thickness of screen.** Apart from the detrimental effect of bending causing the chrome layer to fracture, the bending of screens against the backing screen causes the slots to widen in the hollows, thereby causing more sugar to be lost. This is especially so for screens under 0,3 mm thick. Furthermore if a screen is made thinner than the manufacturer's intended specification, then it is an indication that the slot width will also be correspondingly wider. This has been observed at Darnall where varying mass, thickness and slot width of new screens were well correlated. It is now standard practice in the Tongaat-Hulett mills to weigh new screens for comparative records.

3. **Foreign objects.** Any hard object is likely to make a hole or tear a screen, particularly if it is thin. Up to 40% of screens can be damaged in this way. Old screens are usually used at the start of a new season until off-crop debris has cleared from process.

4. **Lasercut screens.** These screens stand up very well to abrasion and enlargement of holes. The test measurements done in 1989 at Amatikulu that are shown in Table 3, show that the slots actually became smaller (no doubt due to fouling), and there was very little sign of wear and no denting. In this trial however not enough massecuite could be fed to the test machine. In 1990 an attempt was made to test this screen at the same flowrate as the Cr-Ni screens. The screens needed to be cleaned with EDTA. With clean screens approximately 80% of the Cr-Ni screen flow rate was achieved but this flow rate soon dropped off after one to two weeks, when a further clean was necessary. This required the removal of the screen. The kink caused by the clamp ring was inadvertently flattened after each removal. This repeated bending and straightening of the base of the screen caused the screen to tear in this area and the trial was abandoned. Stainless steel needs to be heated before flattening out kinks. The kink caused by the clamp ring should be left and a method found for replacing the screen in the exact location that it was.

Conclusions

1. For the commonly used single sided electroformed screens with slot widths of 0,06 mm, the open area is limited by the manufacturing process to about 7% for 0,3 mm thick screens, and 5% for 0,4 mm screens.
2. Quality control of screens can be improved if there are specific measurements made by users and these are fed back to manufacturers.
3. The commonly used types of screens have lives of from 10 to 25 weeks of service. Thicker screens last longer. Lasercut screens show promise because of their hardness and potential long life if the fouling and cleaning problem can be solved.
4. The type and design of backing liner cane have considerable effect on the screen life. The harder lasercut and thicker Cr-Ni screens are not as dependent on close-pitched support as are 'normal' screens.
5. The Kontron is a valuable tool for measuring slots. Its usefulness could be enhanced if the microscope and light source were separated by a long beam so that measurements could be made in the centre of screens.

Acknowledgements

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