BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA

Mill Technology Division

FACTORY SCALE TRIALS WITH LASER PRODUCED STAINLESS STEEL SCREENS

BINGERA MILL - 1987 SEASON

by

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1. INTRODUCTION

The Australian sugar industry uses chrome-nickel screens in the low grade continuous centrifugals which process C massecuite. These screens are normally replaced once or twice during the progress of each crushing season due to corrosion problems, and this, coupled with the increased loss of sugar in molasses experienced as the screens become more worn, results in a serious, ongoing operating cost for mills.

In an effort to develop a more acceptable alternative to the above fugal screens, BSES approached the CSIRO Division of Manufacturing Technology in Sydney in June 1986 to ascertain the feasibility of manufacturing screens from stainless steel by the use of laser drilling techniques. The outcome of these preliminary discussions was that two screens (one slotted, and the other with round holes) were produced from 300 µm thick 302 stainless steel sheeting using laser technology.

The performance of these two CSIRO laser cut screens was subsequently evaluated in a series of comparative trials against the standard Cr-Ni screen. This work was carried out at the Chemical Engineering Department of the University of Queensland during March 1987, using a pilot scale experimental centrifugal and a mixture of molasses and sugar crystals as the feed material. The results obtained indicated that the capacity and performance of the laser cut stainless steel screens were similar to those achieved with the chrome-nickel screen. No significant difference in behaviour was evident between the slotted screen and the one with round holes.

With these encouraging results from the pilot scale tests, the next logical step was to extend the work to the factory scale by installing a set of laser cut screens in a full size production machine. This was done at Bingera Mill during the 1987 crushing season.

The main objective in the tests carried out at Bingera was to compare the performance of two adjacent, similar, BMA K1000 centrifugals, one of which was fitted with a new set of standard Cr-Ni screens, and the other with a set of laser cut screens manufactured by CSIRO. Initially, the screens in this latter machine comprised six stainless steel segments and two segments produced from commercially pure titanium. However, the two titanium segments tore along the trailing edges several days after installation, and were subsequently replaced with stainless steel segments.

Aspects of particular interest in these factory scale trials included :

- Screen capacity i.e. maximum massecuite throughput that each machine could handle while still producing sugar of acceptable purity.
- Change in purging efficiency as throughput was altered.
- Molasses purity rise experienced with each machine.

It was also necessary to obtain quantitative information concerning the decline in performance of each set of screens as the hours of operation were extended. To study this aspect, trials were conducted on each machine at regular intervals over a period of approximately ten weeks of operation.

This report presents the results of the above work, which was carried out at Bingera Mill during September to November, 1987. It does not include the results of screen corrosion tests carried out at the University of Queensland or open area measurements made by CSIRO before and after the trials. The performance of the laser cut stainless steel screen installed in the loading pot of one of the Bosco fugals at Tully Mill during 1987 season will also be considered separately.

2. SCREEN SPECIFICATIONS

The general specifications of the laser cut screens studied in this programme were as follows :

- Material of construction : 316 stainless steel
- Screen thickness : 200 µm
- Slots approximately 60 µm wide and 750 µm long
- About 6.0 per cent open area

These specifications are similar to those of the chrome/nickel screens currently in use in the industry. The two screens manufactured from commercially pure titanium had the same slot profile as the stainless steel units but were 50 µm thicker.

3. EQUIPMENT AND TRIAL PROCEDURE

The continuous low grade fugal station at Bingera comprises five BMA K1000 machines and one BMA K1001. Massecuite is received from the crystallisers through a large distribution manifold located above the fugals. Resistance heaters provide the only reheating capability after the crystallisers.

The main objective in this work at Bingera was to compare the performances of two identical machines situated side by side, one being fitted with a new set of chrome-nickel screens and the other with a set of laser cut screens produced by CSIRO. The machines selected for this purpose were Nos. 1 and 2 (both BMA K1000's) located at the right-hand end of the fugal stage. The general layout of these two trial machines, massecuite distribution system, etc. is illustrated in Figure 1.

Initially, the screens installed in No. 1 fugal comprised six stainless steel segments and two segments produced from commercially pure titanium. However, these latter two segments became torn along the trailing edges

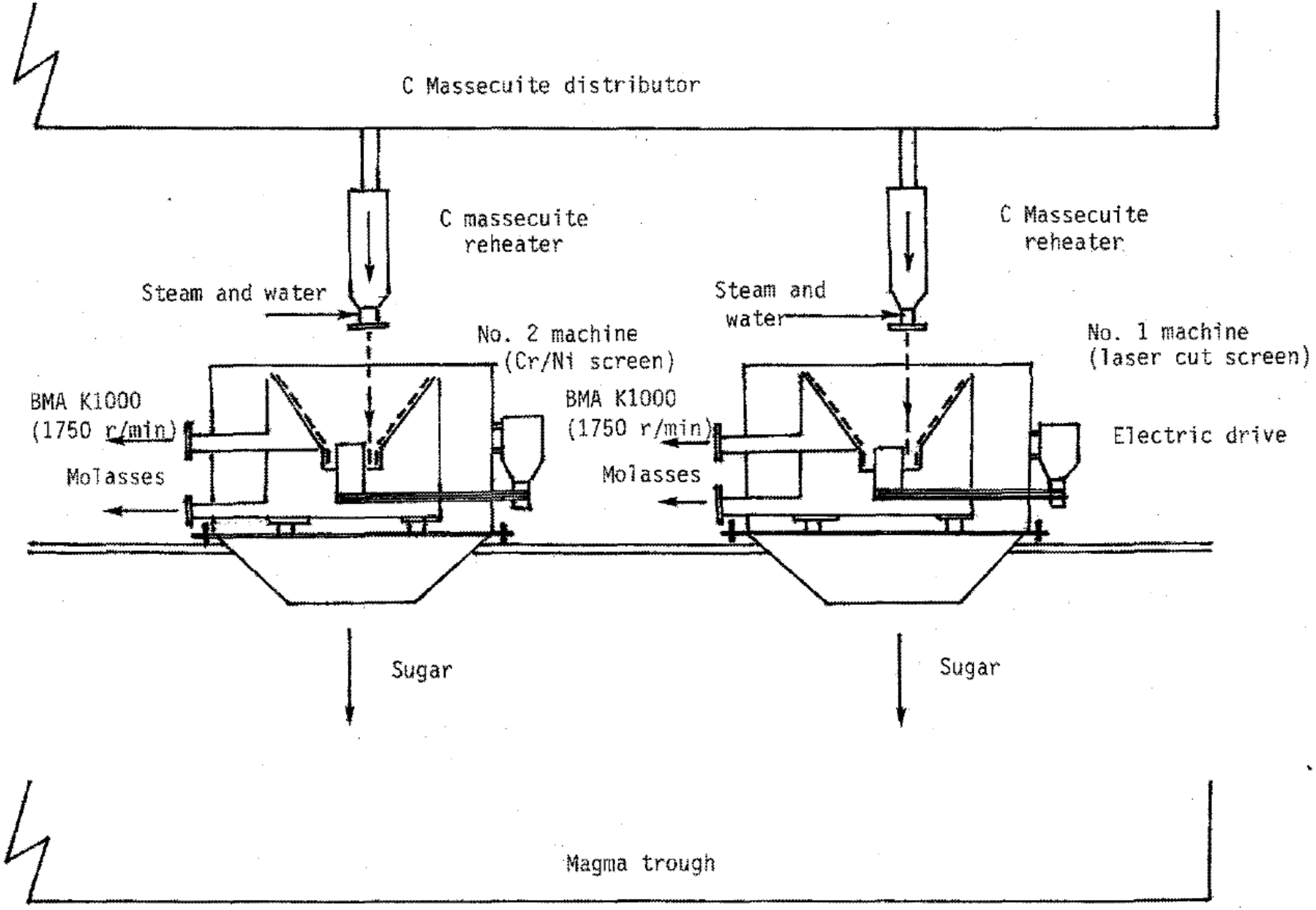

FIGURE 1 - Schematic arrangement of test equipment

several days after installation and were replaced with two stainless steel segments. The entry of foreign objects (such as nuts, pieces of welding rod, lumps of hard massecuite etc.) via the feed system also necessitated further screen replacements over the remainder of the crushing season. Details regarding the screen changes made in No. 1 machine over the duration of these trials are set out in Table I.

TABLE I

Screen replacements in No. 1 machine

Date	Hours of operation	Event
September 9	Nil	6 stainless steel and 2 titanium screens installed.
September 16	88	2 Titanium screens damaged and removed.
September 18	88	Titanium screens replaced by 2 stainless steel screens. (Nos. 9 and 10)
September 28	217	Screen segment No. 4 damaged and replaced by new No. 11 or 12 segment.
November 3	690	Screen segments 5 and 9 damaged. Replaced by repaired No. 4 segment and new No. 12 or 11 segment.
November 10	765	Screens removed from No. 1 machine
November 12	765	Screens installed in No. 3 machine

Note : The chrome-nickel screens in No. 2 fugal were not damaged by foreign objects during the above period.

The performance of the two sets of screens in Nos. 1 and 2 fugals was assessed on five separate occasions over a period of more than 1 000 hours operation. Details regarding the timing of these tests were as follows :

TABLE II

Timing of fugal tests

Trial No.	Date	Hours of operation*	
		Laser cut screens	Cr-Ni screens
1-3	September 21	94	155
4-6	October 6	281	373
7-9	October 20	477	567
10-12	November 5	544	755
13-16	November 18	659	862
End of season		836	1 044

Note : In the case of the laser cut screens, each of the eight segments has a different history with regard to usage. The 'hours of operation' quoted for these screens in the above table are weighted averages for each trial period. By the end of the season, some segments of screen had actually been in use for 1 010 hours.

The general approach taken in comparing the performance of the two sets of screens was to set steam and water usage on the two test machines at the same level and then adjust the massecuite feedrates to the two fugals to give roughly the same sugar purity. In each series of trials, three such comparisons were made at different levels of purity.

Operating data recorded for the two machines in each trial included :

- Massecuite, molasses and water temperatures (°C)
- Steam pressure (kPa)
- Water usage ($L.min^{-1}$)
- Motor load (A)
- Molasses flow - vertical and main gauzes ($t.h^{-1}$)

Samples of C sugar and molasses from both gauzes were obtained from each machine in all fifteen trials. A composite sample of massecuite being supplied to the fugals was taken in each series of trials. Portion of this material was subsequently used to obtain a sample of pressure filtered molasses.

In all, a total of 100 samples of massecuite, molasses or sugar was obtained in the fifteen trials carried out in this project. The pol and brix of each of these samples were determined by chemical staff at Bingera Mill, and portions of all samples were forwarded to the Chemical Engineering

Department at the University of Queensland for the determination of dry substance, and of sucrose by high performance liquid chromatography.

The formulae used to calculate the massecuite rate, purging efficiency, crystal content and molasses purity rise are given in Appendix III.

4. RESULTS AND DISCUSSION

The results of the trials carried out at Bingera are presented in Appendixes I and II. Appendix I gives the more important operating conditions and performance parameters recorded in each trial, while Appendix II lists the results of all analyses carried out by the University of Queensland.

The composition of the material being handled obviously has some influence on screen performance. A brief summary of the range of conditions encountered is therefore presented below :

	Range	Average
% Sucrose	53.0 - 60.6	57.4
% Dry substance	89.6 - 91.7	90.5
True purity	58.6 - 66.1	63.4
Temperature (°C)	42 - 59	50.2
Crystal content (%)	20.9 - 32.1	28.1

It may be seen that the average crystal content of the massecuite at Bingera (28.1 per cent) was much lower than in most other factories. This was due to the inadequate reheating facilities available, and the consequent necessity for heavy dilution of the massecuite with molasses to ensure fluidity of the material between the crystallisers and the fugals. The average massecuite temperature (50.2°C) was reduced considerably by the low values recorded in Trials 1-3 (42 - 48°C) which unfortunately had to be carried out shortly after a weekend shutdown when the material was still quite cold. The average temperature for the remaining twelve tests, which were all carried out after the massecuite had completely warmed up, was 55.4°C.

The various aspects of interest in this project (screen capacity, purging efficiency, molasses purity rise, etc.) are discussed separately in the following section of the report.

4.1 Screen capacity

The capacity of screens used in continuous centrifugals (i.e. the maximum massecuite throughput they can handle while still producing sugar of acceptable purity) is obviously an aspect of great significance with regard to both overall performance and the economic viability of the screen. The normally accepted capacity rating of a BMA K1000 fitted with chrome-nickel screens is about 4-5 $t.h^{-1}$ of massecuite, and it was important that the laser cut stainless steel screens trialled at Bingera were able to match or better this figure.

In the first series of trials carried out on 21-9-87, both No. 1 and No. 2 machines (laser cut and chrome-nickel screens respectively) appeared capable of achieving an acceptable purging efficiency at massecuite rates up to at least 5 $t.h^{-1}$. At higher throughputs, the screens were unable to cope with the high molasses flow, and lumps of unpurged massecuite were discharged with the sugar leaving the basket.

In subsequent trials (particularly those carried out on 5-11-87), it was observed that No. 1 machine could not handle more than about 3 $t.h^{-1}$ before suffering a severe decline in purging efficiency. This decline in performance of No. 1 machine was thought to be due either to some change in the feed system (e.g. a poorly aligned feed probe) or to gradual blockage of the slots in the laser cut screens. No change in the performance of No. 2 machine (chrome-nickel screens) was evident at this stage.

To establish the cause of this problem, the laser cut screens were removed from No. 1 machine and installed in No. 3 machine (also a BMA K1000), which seemed to possess a better feed probe and a more reliable supply of massecuite (being located immediately below one of the inlets to the distributor). The following series of trials carried out on 18-11-87 demonstrated that the laser cut screens in No. 3 fugal were capable of handling almost 7 $t.h^{-1}$ of massecuite and still producing an acceptable sugar purity of about 90 per cent. The chrome-nickel screens in No. 2 machine were also capable of matching this high standard of performance achieved in these final trials carried out at Bingera. It therefore appears that the reduction in performance of the laser cut screens when installed in No. 1 fugal was not due to blockage of the screens, but was attributable to difficulties with the feed system available in this machine.

On the basis of the above observations, it must be concluded that the working capacities of the two sets of screens were similar, and that this aspect should present no obstacle in the future development and viability of laser cut stainless steel screens.

4.2 Purging efficiency

Purging efficiency is an important indicator of centrifugal performance, and is defined as the percentage ratio of impurities leaving in molasses to impurities entering in massecuite. If it becomes too low, an intolerable load can be placed on the pan stage due to the excessive recirculation of impurities in magma. Such a situation has often necessitated an interruption to crushing until the bottleneck has been cleared.

The influence of massecuite feedrate on the purging efficiency achieved by the laser cut and chrome-nickel screens is illustrated in Figure 2. In each case, there was a decrease in purging efficiency as throughput was raised, the regression equations being as follows :

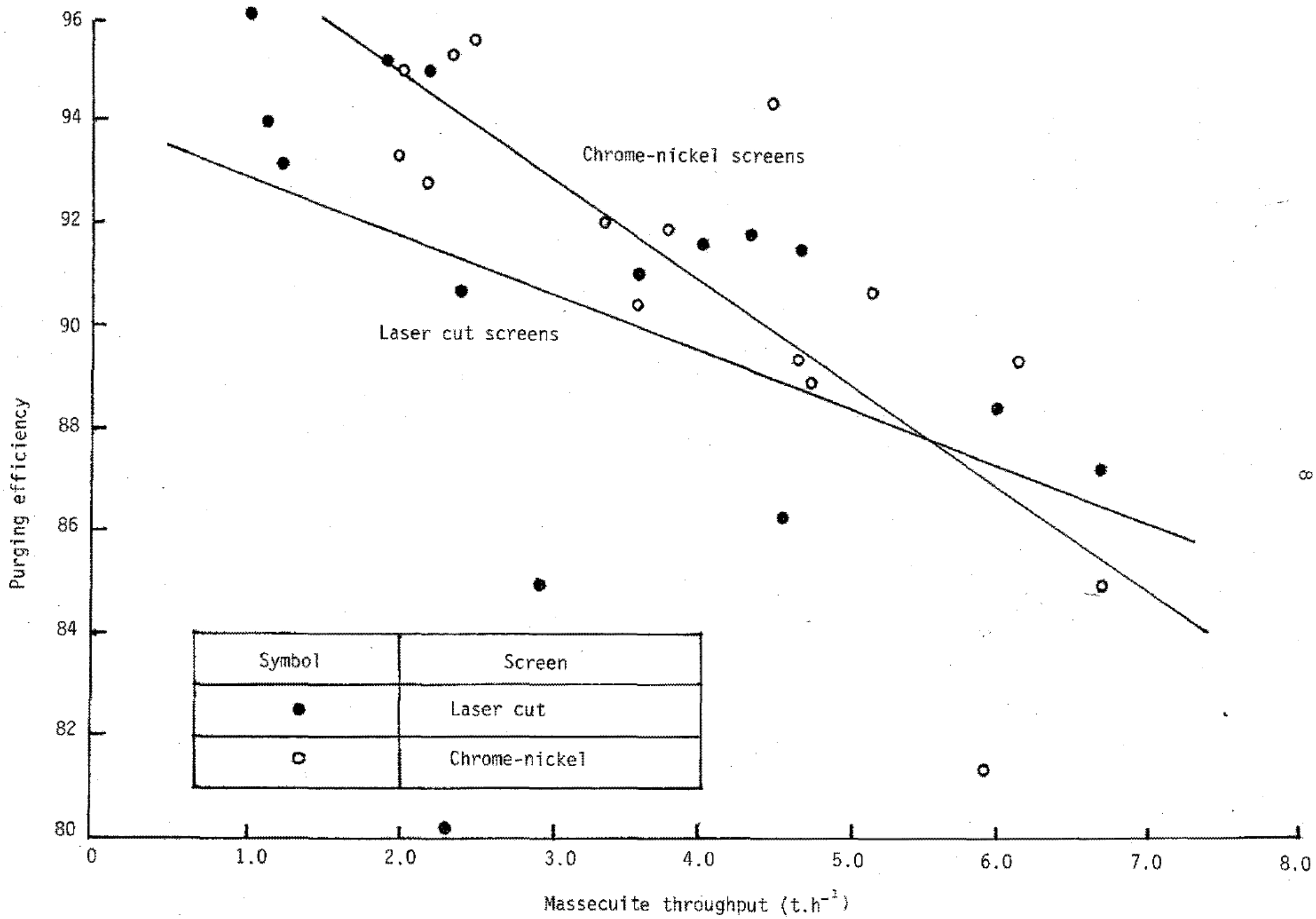

FIGURE 2 - Effect of massecuite throughput on purging efficiency

Laser cut screens

$$\text{P.E.} = 93.754 - 1.0254\ M \qquad (n = 15,\ r^2 = 0.1580)$$

Chrome-nickel screens

$$\text{P.E.} = 98.986 - 2.0315\ M \qquad (n = 15,\ r^2 = 0.6562)$$

where P.E. = Purging efficiency
M = Massecuite feedrate ($t.h^{-1}$)

These correlations are based on the results of all 15 trials carried out i.e. 12 trials with the laser cut screens installed in No. 1 fugal, together with the three trials completed after the screens had been transferred to No. 3 fugal. If one looks at only the first 12 trials, the correlations obtained were as follows :

Laser cut screens

$$\text{P.E.} = 94.977 - 1.6616\ M \qquad (n = 12,\ r^2 = 0.1439)$$

Chrome-nickel screens

$$\text{P.E.} = 100.26 - 2.5015\ M \qquad (n = 12,\ r^2 = 0.6617)$$

It may be seen that although the correlations obtained for the chrome-nickel screens were better than those for the laser cut screens ($r^2 \simeq 0.66$ compared with $r^2 \simeq 0.15$), the purging efficiencies achieved by the two sets of screens were basically of the same order. At a typical massecuite throughput of 5 $t.h^{-1}$, the levels of performance achieved by the two systems were in fact almost identical. It must therefore be concluded that the purging efficiency achieved by the laser cut stainless steel screens in these trials at Bingera was quite satisfactory and, as was the case with screen capacity, should present no problems in future installations.

4.3 Molasses purity rise

During the fugalling process, the loss of sucrose in final molasses may become inflated due to a number of factors. If the massecuite has a high fine grain content, or if the screens have become badly worn, a direct loss of crystal through the slots in the screen may occur. The excessive usage of steam or spray water also causes increased crystal dissolution, leading to higher sucrose losses across the screen. This obviously has a major influence on performance, and it has been estimated that, for a typical factory crushing say 400 $t.h^{-1}$ of cane, an increase of one unit in final molasses purity leads to a loss of approximately $50 000 per season.

The method normally used to monitor sucrose losses due to the fugalling process is to measure the molasses purity rise across the screen. This is defined as the difference in purity between that of final molasses and that of the mother liquor associated with the massecuite entering the fugal.

The influence of massecuite throughput on molasses purity rise across the laser cut and chrome-nickel screens is illustrated in Figure 3. For each case, the purity rise decreased gradually to a constant value as the feedrate was raised. This behaviour was already well known from previous work, and is due to the increased filtration effect which occurs as the thickness of the crystal layer on the screen builds up as the feedrate increases. The regression equations for the two lines of best fit shown in Figure 3 were as follows :

Laser cut screens

$$P = 4.561 + 1.354\ M - 6.277 \log_e M \qquad (n = 12,\ r^2 = 0.687)$$

Chrome-nickel screens

$$P = 6.103 + 1.083\ M - 6.154 \log_e M \qquad (n = 12,\ r^2 = 0.650)$$

where P = Purity rise
M = Massecuite feedrate ($t.h^{-1}$)

It should be noted that these correlations exclude the results of Trials 1-3, which were carried out shortly after a weekend shutdown when the massecuite had not reached normal operating temperature.

Both correlations were reasonably good ($r^2 = 0.687$ and 0.650), and it is clear that a lower purity rise (i.e. less sucrose lost in molasses) was obtained with the laser cut screens than with the chrome-nickel screens. The benefit achieved with the laser cut screens appears to range from about 0.5 unit of purity at a feedrate of 5 $t.h^{-1}$ to approximately 1.0 unit at a feedrate of 2-3 $t.h^{-1}$. The only explanation which can be offered for this superior performance of the laser cut screens is that the chrome-nickel screens wore very rapidly after installation, and this would have led to a greater loss of grain through the slots in the screen.

4.4 Effect of screen usage on performance

It is well known that the performance of chrome-nickel screens deteriorates rapidly as they become corroded after installation. The increased loss of grain through the slots that is experienced when this occurs necessitates replacement of the screen so that two or three set of screens are used each crushing season. It was therefore of considerable importance to establish whether the laser cut stainless steel screens exhibited a similar behaviour or maintained a more uniform standard of performance with increasing usage.

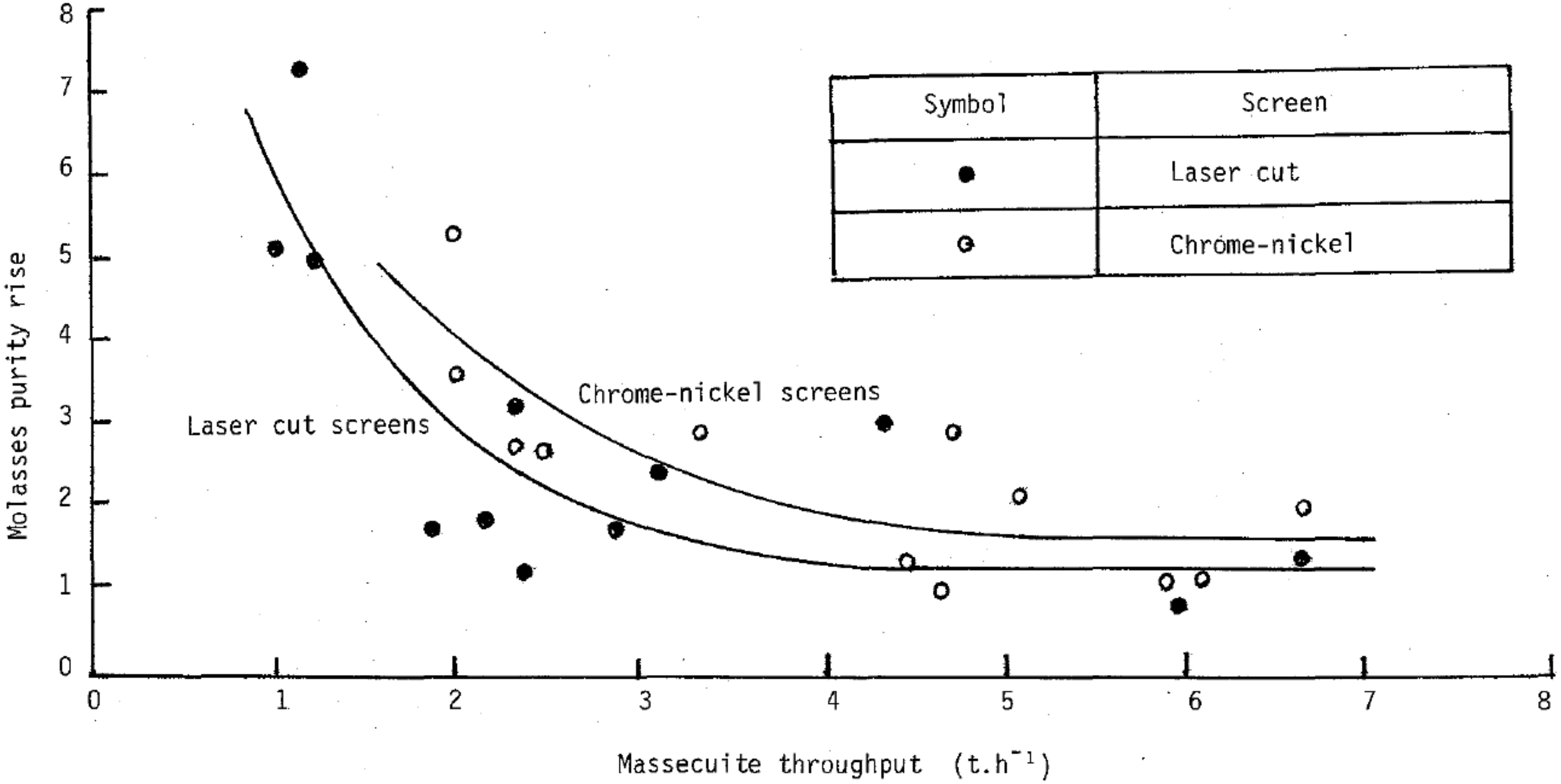

FIGURE 3 - Effect of massecuite throughput on purity rise

The results of some trials which were designed to provide information on this aspect are illustrated in Figure 4. In each test, the massecuite throughput was approximately 2.5 $t.h^{-1}$, and similar steam and spray water usage was maintained on both machines. No results are available for the final series of trials (carried out on 18-11-87 when the laser cut screens were installed in No. 3 machine) because, in this case, the main objective was to operate at as high a feedrate as possible.

It may be seen from Figure 4 that the purity rise during the first 400 to 500 hours of operation was much lower with the laser cut screens than with the chrome-nickel screens (1.0 unit compared with about 2.5 units). The initial purity rise for the chrome-nickel screens when they were brand new may well have been lower, but corrosion and the resulting decline in performance probably occurs very soon after installation.

After about 400 hours of use, the molasses purity rise experienced with the chrome-nickel screens appeared to increase steadily from about 2.5 units to 5.0 units at 750 hours. There was also some indication of a decline in performance of the laser cut screens after about 500 hours, and it is unfortunate that more results are not available to confirm whether this was the case. However, in spite of the limited data available, it does appear that the stainless steel screens do not deteriorate as rapidly as the chrome-nickels and therefore possess a distinct advantage in this regard.

5. CONCLUSIONS

The results of these factory scale screen trials have been very encouraging. There was no significant difference in performance of the laser cut stainless steel and chrome-nickel screens with regard to either screen capacity or purging efficiency. However, the laser cut screens achieved a lower loss of sucrose (molasses purity rise of 1.2 units compared with 1.9 units at a typical feedrate of 4 $t.h^{-1}$), and did not deteriorate in performance with increasing usage to such a marked extent as the chrome-nickels. The future acceptance and success of these screens in the sugar industry appears to be assured because of their superior performance, and also because it is likely they will have a longer working life than the chrome-nickel screens presently in use. This latter aspect is to be the subject of a separate report by CSIRO.

6. ACKNOWLEDGEMENTS

Thanks are due to the staff of Bingera Mill, whose interest and cooperation throughout this project was greatly appreciated.

P.G. Atherton,
Head, Mill Technology Division.

12th January 1988

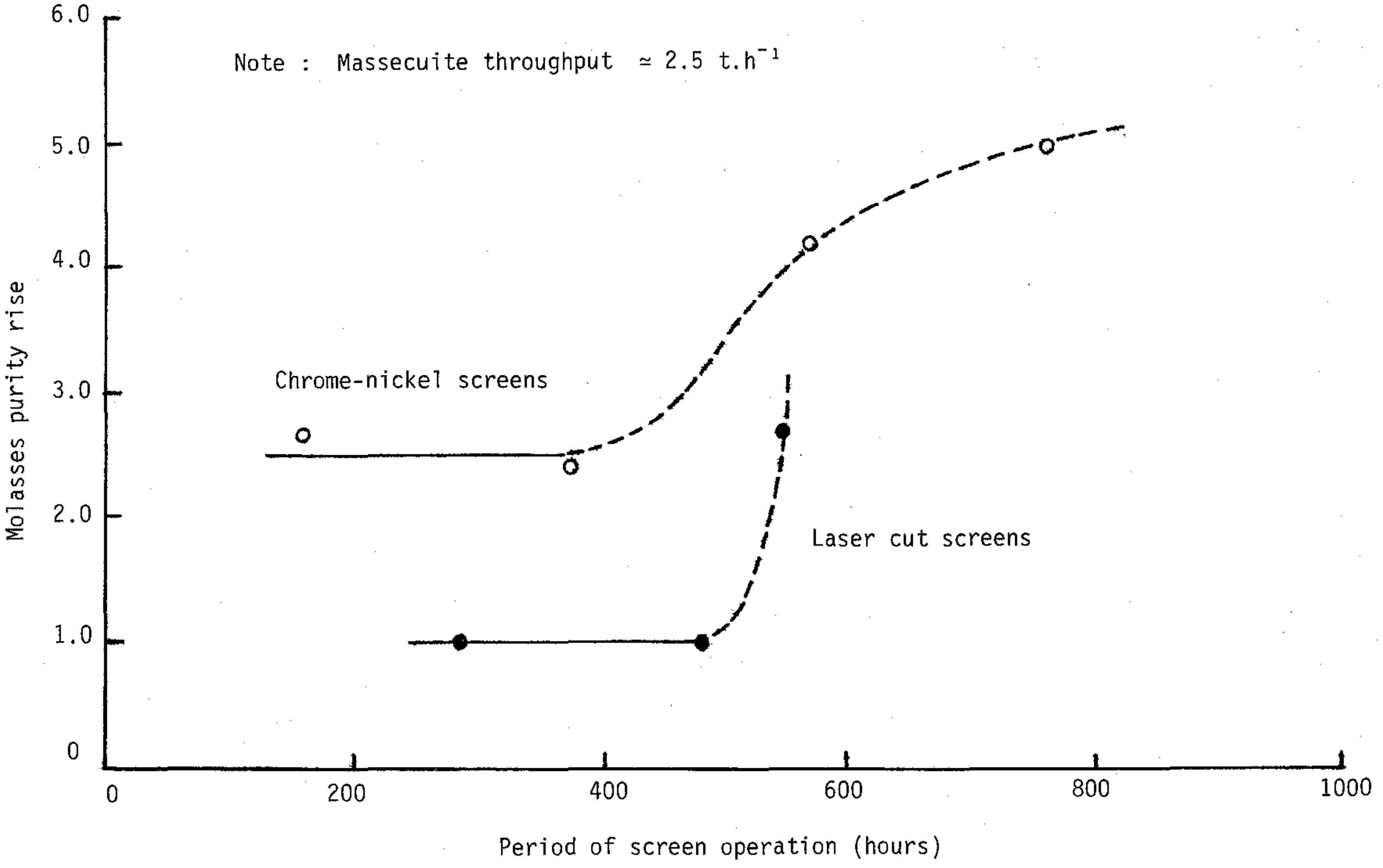

FIGURE 4 - Change in purity rise with screen age

APPENDIX I

Results of screen trials

Trial No.		1		2		3	
Date		21-9-87		21-9-87		21-9-87	
Fugal No.		1	2	1	2	1	2
Fugalling conditions	Massecuite temperature (°C)	42	45	46	46	47	48
	Water temperature (°C)	57	57	60	60	59	59
	Water usage ($L.min^{-1}$)	5.3	5.3	5.3	5.3	5.3	5.3
	Motor load (A)	32	30	38	30	29	18
Massecuite	Throughput ($t.h^{-1}$)	3.99	3.76	4.58	3.54	1.92	2.14
	Crystal content (%)	29.3	29.3	29.3	29.3	29.3	29.3
Molasses temperature (°C)	Bottom gauze	49	45	53	47	54	45
	Main gauze	40	44	43	45	47	33
Molasses flow ($t.h^{-1}$)	Bottom gauze	2.52	2.63	2.72	2.37	0.39	1.85
	Main gauze	0.54	0.19	0.54	0.19	1.50	0.01
	Total	3.06	2.82	3.26	2.56	1.89	1.86
Fugal performance	Sugar purity	92.0	92.1	91.8	91.2	92.9	92.4
	Purging efficiency	91.6	91.9	91.0	90.4	94.1	92.8
	Molasses purity rise	+0.2	+0.6	-1.1	-0.4	+5.1	+2.5

NOTE : These trials were carried out only eight to ten hours after the start of crushing.

No. 1 m/c - Laser cut stainless steel screens
No. 2 m/c - Cr/Ni screens

APPENDIX I
(continued)

Trial No.		4		5		6	
Date		6-10-87		6-10-87		6-10-87	
Fugal No.		1	2	1	2	1	2
Fugalling conditions	Massecuite temperature (°C)	56	52	54	53	53	53
	Water temperature (°C)	57	57	57	57	57	57
	Water usage ($L.min^{-1}$)	4.8	4.8	4.8	4.8	4.8	4.8
	Motor load (A)	32	30	31	29	28	27
Massecuite	Throughput ($t.h^{-1}$)	2.17	2.46	1.88	2.29	1.00	2.00
	Crystal content (%)	20.9	20.9	20.9	20.9	20.9	20.9
Molasses temperature (°C)	Bottom gauze	53	52	54	51	48	50
	Main gauze	54	52	45	51	39	40
Molasses flow ($t.h^{-1}$)	Bottom gauze	0.88	1.88	0.62	1.98	0.21	1.96
	Main gauze	1.08	0.32	1.11	0.13	0.94	0.02
	Total	1.96	2.20	1.73	2.11	1.15	1.98
Fugal performance	Sugar purity	91.5	91.9	91.9	91.5	91.2	90.4
	Purging efficiency	95.0	95.6	95.2	95.3	96.1	95.0
	Molasses purity rise	+1.8	+2.6	+1.7	+2.7	+5.1	+3.6

APPENDIX I
(continued)

Trial No.		7		8		9	
Date		20-10-87		20-10-87		20-10-87	
Fugal No.		1	2	1	2	1	2
Fugalling conditions	Massecuite temperature (°C)	58	59	57	57	56	56
	Water temperature (°C)	59	59	59	59	59	59
	Water usage ($L.min^{-1}$)	5.3	5.3	5.3	5.3	5.3	5.3
	Motor load (A)	28	28	27	27	30	34
Massecuite	Throughput ($t.h^{-1}$)	1.12	3.32	1.22	1.97	2.36	4.62
	Crystal content (%)	27.7	27.7	27.7	27.7	27.7	27.7
Molasses temperature (°C)	Bottom gauze	52	52	50	47	55	54
	Main gauze	40	45	42	-	47	55
Molasses flow ($t.h^{-1}$)	Bottom gauze	0.27	2.65	0.14	1.85	0.78	2.82
	Main gauze	0.93	0.07	1.08	nil	1.07	0.59
	Total	1.20	2.72	1.22	1.85	1.85	3.39
Fugal performance	Sugar purity	90.9	91.0	91.2	91.2	90.4	89.4
	Purging efficiency	94.0	92.0	93.2	93.3	90.7	89.3
	Molasses purity rise	7.3	2.9	5.0	5.3	1.2	1.0

APPENDIX I
(continued)

Trial No.		10		11		12	
Date		5-11-87		5-11-87		5-11-87	
Fugal No.		1	2	1	2	1	2
Fugalling conditions	Massecuite temperature (°C)	54	54	55	53	54	52
	Water temperature (°C)	60	61	61	61	62	62
	Water usage (L.min^{-1})	5.3	5.3	5.3	5.3	5.3	5.3
	Motor load (A)	34	33	32	31	31	36
Massecuite	Throughput (t.h^{-1})	3.09	4.69	2.88	4.43	2.32	5.91
	Crystal content (%)	30.7	30.7	30.7	30.7	30.7	30.7
Molasses temperature (°C)	Bottom gauze	55	53	56	53	56	53
	Main gauze	48	54	47	54	46	54
Molasses flow (t.h^{-1})	Bottom gauze	1.23	2.09	0.94	2.75	0.55	2.76
	Main gauze	0.95	1.31	1.04	0.51	1.07	0.88
	Total	2.18	3.40	1.98	3.26	1.62	3.64
Fugal performance	Sugar purity	88.2	89.8	87.5	94.6	84.2	85.6
	Purging efficiency	86.3	88.9	84.9	94.4	80.2	81.3
	Molasses purity rise	2.4	2.9	1.7	1.3	3.2	1.1

APPENDIX I
(continued)

Trial No.		13		14		15	
Date		18-11-87		18-11-87		18-11-87	
Fugal No.		3	2	3	2	3	2
Fugalling conditions	Massecuite temperature (°C)	56	57	58	58	58	58
	Water temperature (°C)	58	59	60	58	60	60
	Water usage ($\mathrm{L.min^{-1}}$)	5.3	5.3	5.3	5.3	5.3	5.3
	Motor load (A)	35	34	40	37	32	32
Massecuite	Throughput ($\mathrm{t.h^{-1}}$)	5.97	6.10	6.65	6.67	4.30	5.07
	Crystal content (%)	32.1	32.1	32.1	32.1	32.1	32.1
Molasses temperature (°C)	Bottom gauze	53	58	56	58	51	58
	Main gauze	53	57	55	57	53	56
Molasses flow ($\mathrm{t.h^{-1}}$)	Bottom gauze	0.43	1.23	1.22	1.37	0.35	0.88
	Main gauze	3.78	2.91	3.34	3.03	3.02	2.74
	Total	4.21	4.14	4.56	4.40	3.37	3.62
Fugal performance	Sugar purity	90.6	91.1	89.6	88.0	92.4	91.8
	Purging efficiency	88.4	89.3	87.2	84.9	91.8	90.6
	Molasses purity rise	0.8	1.1	1.4	2.0	3.0	2.1

NOTE : Laser cut screens have been switched from No. 1 to No. 3 machine in an effort to achieve a higher throughput.

APPENDIX II

Analytical results

Trial No.	1		2		3	
Date	21-9-87		21-9-87		21-9-87	
Fugal No.	1	2	1	2	1	2
C massecuite						
Sample No.	1	1	1	1	1	1
% Sucrose	57.1	57.1	57.1	57.1	57.1	57.1
% DS	89.6	89.6	89.6	89.6	89.6	89.6
True purity	63.7	63.7	63.7	63.7	63.7	63.7
Cyclone molasses						
Sample No.	2	2	2	2	2	2
% Sucrose	39.3	39.3	39.3	39.3	39.3	39.3
% DS	85.3	85.3	85.3	85.3	85.3	85.3
True purity	46.1	46.1	46.1	46.1	46.1	46.1
C Sugar						
Sample No.	3	4	9	10	15	16
% Sucrose	89.2	89.2	88.3	87.0	91.7	91.5
% DS	97.0	96.9	96.2	95.4	98.7	99.0
True purity	92.0	92.1	91.8	91.2	92.9	92.4
Molasses - bottom gauze						
Sample No.	5	7	11	13	17	19
Flowrate (t.h^{-1})	2.52	2.63	2.72	2.37	0.39	1.85
% Sucrose	33.2	35.0	33.9	34.1	41.6	32.9
% DS	71.8	74.8	75.4	74.8	62.1	67.7
True purity	46.2	46.8	45.0	45.6	67.0	48.6
Molasses - main gauze						
Sample No.	6	8	12	14	18	20
Flowrate (t.h^{-1})	0.54	0.19	0.54	0.19	1.50	0.01
% Sucrose	35.1	33.9	34.8	35.0	30.7	37.4
% DS	74.7	73.8	76.0	74.6	64.8	73.9
True purity	47.0	45.9	45.8	46.9	47.4	50.6
Molasses - total flow						
Flowrate (t.h^{-1})	3.06	2.82	3.26	2.56	1.89	1.86
% Sucrose	33.5	34.9	34.0	34.2	32.9	32.9
% DS	72.3	74.7	75.5	74.8	64.2	67.7
True purity	46.3	46.7	45.0	45.7	51.2	48.6

APPENDIX II
(continued)

Trial No.	4		5		6	
Date	6-10-87		6-10-87		6-10-87	
Fugal No.	1	2	1	2	1	2
C massecuite						
Sample No.	21	21	21	21	21	21
% Sucrose	53.0	53.0	53.0	53.0	53.0	53.0
% DS	90.5	90.5	90.5	90.5	90.5	90.5
True purity	58.6	58.6	58.6	58.6	58.6	58.6
Cyclone molasses						
Sample No.	22	22	22	22	22	22
% Sucrose	40.2	40.2	40.2	40.2	40.2	40.2
% DS	87.0	87.0	87.0	87.0	87.0	87.0
True purity	46.2	46.2	46.2	46.2	46.2	46.2
C Sugar						
Sample No.	23	24	29	30	35	36
% Sucrose	88.5	89.0	89.6	89.5	90.7	89.6
% DS	96.7	96.8	97.5	97.8	99.4	99.1
True purity	91.5	91.9	91.9	91.5	91.2	90.4
Molasses - bottom gauze						
Sample No.	25	27	31	33	37	39
Flowrate ($t.h^{-1}$)	0.88	1.88	0.62	1.98	0.21	1.96
% Sucrose	38.1	38.2	38.6	36.9	43.1	35.5
% DS	79.0	78.2	79.4	75.6	74.8	71.5
True purity	48.2	48.8	48.6	48.8	57.6	49.7
Molasses - main gauze						
Sample No.	26	28	32	34	38	40
Flowrate ($t.h^{-1}$)	1.08	0.32	1.11	0.13	0.94	0.02
% Sucrose	34.8	38.4	34.0	38.1	30.6	42.7
% DS	73.1	78.3	71.5	77.1	61.7	75.2
True purity	47.6	49.0	47.6	49.4	49.6	56.8
Molasses - total flow						
Flowrate ($t.h^{-1}$)	1.96	2.20	1.73	2.11	1.15	1.98
% Sucrose	36.3	38.2	35.6	37.0	32.9	35.6
% DS	75.7	78.2	74.3	75.7	64.1	71.5
True purity	48.0	48.8	47.9	48.9	51.3	49.8

APPENDIX II
(continued)

Trial No.	7		8		9	
Date	20-10-87		20-10-87		20-10-87	
Fugal No.	1	2	1	2	1	2
C massecuite						
Sample No.	41	41	41	41	41	41
% Sucrose	57.9	57.9	57.9	57.9	57.9	57.9
% DS	91.1	91.1	91.1	91.1	91.1	91.1
True purity	63.6	63.6	63.6	63.6	63.6	63.6
Cyclone molasses						
Sample No.	42	42	42	42	42	42
% Sucrose	41.5	41.5	41.5	41.5	41.5	41.5
% DS	87.0	87.0	87.0	87.0	87.0	87.0
True purity	47.7	47.7	47.7	47.7	47.7	47.7
C Sugar						
Sample No.	43	44	49	50	55	56
% Sucrose	90.4	89.2	90.6	90.7	89.6	88.4
% DS	99.5	98.0	99.3	99.5	99.1	98.9
True purity	90.9	91.0	91.2	91.2	90.4	89.4
Molasses - bottom gauze						
Sample No.	45	47	51	53	57	59
Flowrate ($t.h^{-1}$)	0.27	2.65	0.14	1.85	0.78	2.82
% Sucrose	47.9	38.2	50.4	37.2	39.5	38.4
% DS	73.5	75.5	72.8	70.2	79.7	78.9
True purity	65.2	50.6	69.2	53.0	49.6	48.7
Molasses - main gauze						
Sample No.	46	48	52	54	58	60
Flowrate ($t.h^{-1}$)	0.93	0.07	1.08	nil	1.07	0.57
% Sucrose	31.8	39.5	32.4	-	34.9	38.0
% DS	61.7	75.5	64.5	-	71.9	77.8
True purity	51.5	52.3	50.2	-	48.5	48.8
Molasses - total flow						
Flowrate ($t.h^{-1}$)	1.20	2.72	1.22	1.85	1.85	3.39
% Sucrose	35.4	38.2	34.5	37.2	36.8	38.2
% DS	64.4	75.5	65.5	70.2	75.2	78.7
True purity	55.0	50.6	52.7	53.0	48.9	48.7

APPENDIX II
(continued)

Trial No.	10		11		12	
Date	5-11-87		5-11-87		5-11-87	
Fugal No.	1	2	1	2	1	2
C massecuite						
Sample No.	61	61	61	61	61	61
% Sucrose	58.5	58.5	58.5	58.5	58.5	58.5
% DS	89.8	89.8	89.8	89.8	89.8	89.8
True purity	65.1	65.1	65.1	65.1	65.1	65.1
Cyclone molasses						
Sample No.	62	62	62	62	62	62
% Sucrose	40.6	40.6	40.6	40.6	40.6	40.6
% DS	86.3	86.3	86.3	86.3	86.3	86.3
True purity	47.0	47.0	47.0	47.0	47.0	47.0
C Sugar						
Sample No.	63	64	69	70	75	76
% Sucrose	83.0	84.1	81.2	90.9	79.7	82.3
% DS	94.1	93.7	92.8	96.1	94.6	96.2
True purity	88.2	89.8	87.5	94.6	84.2	85.6
Molasses - bottom gauze						
Sample No.	65	67	71	73	77	79
Flowrate (t.h^{-})	1.23	2.09	0.94	2.75	0.55	2.76
% Sucrose	38.2	38.7	37.4	37.2	39.5	38.4
% DS	77.1	77.2	76.6	77.5	76.8	79.8
True purity	49.5	50.1	48.8	48.0	51.4	48.1
Molasses - main gauze						
Sample No.	66	68	72	74	78	80
Flowrate (t.h^{-})	0.95	1.31	1.04	0.51	1.07	0.88
% Sucrose	36.4	37.6	36.0	38.9	34.7	37.8
% DS	74.0	75.9	74.2	78.7	70.5	79.2
True purity	49.2	49.5	48.5	49.4	49.2	47.7
Molasses - total flow						
Flowrate (t.h^{-})	2.18	3.40	1.98	3.26	1.62	3.64
% Sucrose	37.4	38.2	36.7	37.5	36.3	38.3
% DS	75.7	76.7	75.3	77.7	72.3	79.7
True purity	49.4	49.9	48.7	48.3	50.2	48.1

APPENDIX II
(continued)

Trial No.	13		14		15	
Date	18-11-87		18-11-87		18-11-87	
Fugal No.	3	2	3	2	3	2
C massecuite						
Sample No.	81	81	81	81	81	81
% Sucrose	60.6	60.6	60.6	60.6	60.6	60.6
% DS	91.7	91.7	91.7	91.7	91.7	91.7
True purity	66.1	66.1	66.1	66.1	66.1	66.1
Cyclone molasses						
Sample No.	82	82	82	82	82	82
% Sucrose	41.7	41.7	41.7	41.7	41.7	41.7
% DS	87.2	87.2	87.2	87.2	87.2	87.2
True purity	47.8	47.8	47.8	47.8	47.8	47.8
C Sugar						
Sample No.	83	84	89	90	95	96
% Sucrose	87.1	88.7	86.0	84.7	88.6	89.3
% DS	96.1	97.4	96.0	96.2	95.9	97.3
True purity	90.6	91.1	89.6	88.0	92.4	91.8
Molasses - bottom gauze						
Sample No.	85	87	91	93	97	99
Flowrate (t.h^{-1})	0.43	1.23	1.22	1.37	0.25	0.88
% Sucrose	36.7	38.6	37.7	39.0	37.7	38.3
% DS	76.3	78.8	77.0	78.9	75.0	77.6
True purity	48.1	49.0	49.0	49.4	50.3	49.4
Molasses - main gauze						
Sample No.	86	88	92	94	98	100
Flowrate (t.h^{-1})	3.78	2.91	3.34	3.03	3.02	2.74
% Sucrose	36.9	39.3	38.5	40.0	37.6	39.6
% DS	75.9	80.5	78.1	80.0	73.9	79.2
True purity	48.6	48.8	49.3	50.0	50.9	50.0
Molasses - total flow						
Flowrate (t.h^{-1})	4.21	4.14	4.56	4.40	3.37	3.62
% Sucrose	36.9	39.1	38.3	39.7	37.6	39.3
% DS	75.9	80.0	77.8	79.7	74.0	78.8
True purity	48.6	48.9	49.2	49.8	50.8	49.9

APPENDIX III

Relationships used in evaluating fugal performance

The various formulae used in calculating massecuite rate, purging efficiency, crystal content and molasses purity rise were as follows :

$$\text{Massecuite} = (\text{molasses rate})\frac{DS_{fm}}{DS_{mc}}\left[\frac{TP_{mag} - TP_{fm}}{TP_{mag} - TP_{mc}}\right]$$

$$\text{Purging efficiency} = \frac{(TP_{mag} - TP_{mc})\ (100 - TP_{fm})}{(TP_{mag} - TP_{fm})\ (100 - TP_{mc})} .100$$

$$\text{Crystal content} = \left[\frac{TP_{mc} - TP_{pfm}}{100 - TP_{pfm}}\right] DS_{mc}$$

$$\text{Molasses purity rise} = TP_{fm} - TP_{pfm}$$

where :

TP = true purity
DS = dry substance
mc = massecuite
mag = magma
pfm = pressure filter molasses
fm = final molasses

APPENDIX IV

Definitions

APPARENT

The word apparent is applied to figures and analyses based on brix and pol, as distinct from dry substance and sucrose, for example, apparent purity. Brix and pol analyses are still used by many mills for factory control purposes, and unless a specific instance arises where pol and brix have to be divorced from sucrose and dry substance, the term 'apparent' is often omitted.

BRIX

The brix of a solution is the concentration (in g solute per 100 g solution) of a solution of pure sucrose in water, having the same density as the solution at the same temperature. If refractive index be adopted as an alternative basis of comparison the value derived should be termed refractometer brix.

Obviously, for solutions of pure sucrose in water, the brix is equal to the dry substance, but in the presence of soluble impurities this may not be, and usually is not the case. Although gases and insoluble solids in suspension may alter the density of a solution the term brix refers exclusively to soluble solids.

CRYSTAL CONTENT

The percentage by weight of crystalline sugar present in a massecuite, magma or similar material.

CYCLONE PURITY OF MOLASSES

The purity of the mother liquor extracted from a sample of massecuite. The mother liquor sample is usually obtained by a pressure filtration process and is referred to as pressure filter molasses or PFM.

DRY SUBSTANCE

The weight of material remaining after drying the product examined under specified conditions, expressed as a percentage of the original weight. The determination of dry substance represents an attempt to measure the total solids, both soluble and insoluble, or, in the absence of insoluble solids, the total soluble solids. The degree of accuracy achieved depends upon the constitution of the sample and the drying technique.

MAGMA

A mixture of sugar crystals with a liquid such as syrup, juice or water.

MASSECUITE

The mixture of sugar crystals and mother liquor discharged from a vacuum pan. Massecuites are classified according to descending purity as first, second, etc., or A,B, etc.

MOLASSES

The mother liquid separated from a massecuite. It is distinguished by the same term as the massecuite from which it was extracted.

POL

The pol of a solution is the concentration (in g solute per 100 g solution) of a solution of pure sucrose in water having the same optical rotation as the sample at the same temperature. For solutions containing only pure sucrose in water, pol is a measure of the concentration of sucrose present; for solutions containing sucrose and other optically active substances, pol is the algebraic sum of the rotations of the constituents present.

PURGING EFFICIENCY

A term indicating centrifugal performance. It is the percentage ratio of impurities leaving in molasses to the impurities entering in massecuite.

PURITY

Two classes of purity - apparent and true purity - are recognised. Ideally, purity is the percentage of sucrose in the total solids in a sample. The purities mentioned above are derived as follows :

$$\text{Apparent purity} = \frac{\text{pol} \times 100}{\text{brix}}$$

$$\text{True purity} = \frac{\text{sucrose} \times 100}{\text{dry substance}}$$

The term purity alone generally signifies apparent purity.

SUCROSE

The pure chemical compound with the formula $C_{12}H_{22}O_{11}$. This is commonly referred to in the industry as pure cane sugar.

SUGAR

The crystals of sucrose, together with any adhering molasses, as recovered from the massecuites. The various grades are commonly identified in terms of the grade of massecuite processed, or in terms of the avenue of disposal of the sugar - so : A sugar, C sugar, shipment sugar.

VISCOSITY

The viscosity of a fluid is a measure of the internal friction of a fluid in motion. The unit of dynamic viscosity is the pascal second (Pa.s) which is the viscosity of a fluid for which a tangential force of one newton applied over an area of one square metre produces a laminar flow with a shear rate of one reciprocal second. For a newtonian liquid the viscosity is constant at all shear rates. For a non-newtonian liquid, viscosity will vary depending on shear rate.