# CRYSTAL BREAKAGE IN CONTINUOUS B-CENTRIFUGALS

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**Abstract**

Since B-sugar is used as a footing for A-sugar boilings, an investigation was undertaken aimed at reducing breakage of B-crystal occurring in continuous centrifugals. Comparisons were made of B-sugar cured in batch and continuous centrifugals and between B-sugar cured in conventional centrifugals and in machines with large diameter monitor casings. It was established that most crystal breakage occurs when the crystal impacts the monitor casing. The reduction in breakage obtained with larger diameter casings has been measured.

## Introduction

The 3-boiling partial remelt system has been generally adopted in the South African sugar industry for the manufacture of VHP sugar. This requires that B-sugar be used as a footing for A-boilings. The major problem associated with the use of continuous B-centrifugals is the high degree of crystal breakage which occurs, with the result that the B-magma used as a footing in A-pans has a poor size distribution. In order to try to improve matters, the first step on taking a B-magma into an A-pan is to melt out all the small crystal. This procedure helps to some extent, but the net result is that the A-boiling is still started with a wide range of crystal sizes, making it more difficult to produce an A-sugar with the right size specification. Equally serious however is the fact that the time taken to melt out the small crystal represents wasted A-pan capacity, and moreover this procedure is wasteful of steam. There is incentive therefore to try to produce a magma for A-boilings which can eliminate this step.

Various schemes involving magma classification have been tried in various places but with little success. Most attempts therefore have been aimed at trying to reduce the breakage in the centrifugal rather than classify the sugar produced. There has been some disagreement as to whether the major part of crystal breakage occurs as the crystals progress up the screen or on impact as the crystals fly off the screen and impact the casing of the machine. Fives-Cail Babcock first marketed machines with large diameter casings to reduce velocity on impact. However, in order to reduce breakage on impact, the casing has to be made considerably larger than normal. In the case of A-boilings where the crystal size is around 0,65 mm, an FCB machine with a 1 m diameter basket in a 5 m diameter casing was installed and tested (De Robillard and Journet[1]). It was found that breakage was almost negligible at 1 200 rpm, i.e. a tangential velocity at the basket edge of 57 m/s, but that breakage and lump formation increased at higher rotational speeds.

The Australians have reported some work on crystal breakage (Swindells & White[2,3]). Crystal breakage is reported to occur mainly on impact as the crystal hits the monitor casing, with very little occurring as the crystals roll up the centrifugal screen. They have shown that if the crystal velocity hitting the monitor casing is less than about 10 m/s, the breakage of crystals is negligible. The velocity at which the crystal hits the casing is dependent on the casing diameter and the crystal size. Smaller crystals will hit the monitor casing at a considerably lower velocity than larger crystals. In addition, with lower purity sugar, there is less chance of breakage on impact.

With the advent of continuous A-pans, there is even more incentive to try to produce a B-magma with a uniform grain size. This could enable the requirement for the initial batch A-boiling to be dispensed with entirely.

All the B-centrifugals in South African sugar factories which used to be batch machines have now been replaced with continuous centrifugals, since they are easier and less costly to operate and maintain. Until recently Triangle Sugar Limited in Zimbabwe operated some batch B-machines and this provided the opportunity for comparative measurements to be made between B-massecuite cured on batch and continuous machines to establish the extent of crystal breakage. At the same time, an attempt was made to establish whether crystal breakage occurs on the screen or only on impact with the casing. The results of these tests are reported in this paper.

A single large diameter casing (3 m diameter) was installed on a BMA K850 machine at Darnall in place of its normal 1,75 m diameter casing. Testwork was done on this machine to establish the extent of reduction in crystal breakage. Subsequently, B-machines at Maidstone and Triangle have been installed with modified casings with a view to reducing the crystal breakage. Some results obtained at these mills are also presented.

In order to measure crystal breakage, a new method had to be derived for measuring crystal size of B-crystal. A system for washing of B-sugar prior to sieve analysis was developed to do this.

## Experimental details

### *Preparation of samples for crystal size measurement*

Massecuite samples were centrifuged in a small laboratory centrifuge at 1 500 rpm for 7 minutes, washed with 50 ml of sugar saturated 95% methanol and then centrifuged for a further 7 minutes. B-sugar samples, as well as sugar separated in the laboratory centrifuge from massecuite, were then affinated by mixing 1 kg of the well-mixed sample with 667 g of a saturated sugar solution. This was thoroughly mingled and centrifuged for 2 minutes at 1 500 rpm, washed with 50 ml of sugar saturated 95% methanol and centrifuged for a further 7 minutes.

### *Measurement of crystal size and size distribution*

The procedure for washing and screening the sugar is given in the Appendix.

Because B-sugar is generally smaller than A-sugar, 65 and 200 mesh sieves were added to the nest of screens normally used for A-sugar analysis (16, 28 and 42 mesh screens). Specific Grain Size (SGS) was calculated, and mean aperture (MA) and CV of the sugar were determined by plotting the size distributions obtained on log normal paper. This was found to give a better fit to the distribution than normal probability paper.

For some of the later tests, sugar sizes were obtained using the Kontron MOP Videoplan particle size analyser belonging to the SMRI. Mean crystal length and breadth were obtained.

### Comparison of batch vs continuous machines

Triangle had both batch and continuous B-machines in operation. The batch machines were used for producing magma and continuous centrifugals for B-sugar to remelt. Thus a test was set up to measure the difference in B-sugars. In addition, a small opening (150 mm × 100 mm) was cut in the monitor casing of a BMA K850 continuous machine and B-sugar, which passed through this opening, was collected as far away as possible, thus simulating the case of zero or low velocity impact.

While it was initially thought that the same massecuite was fed to the batch and continuous machines, it appeared in fact that the massecuite was taken off the B-crystallisers at different points. There also appeared to be a difference in colour in the massecuite going into the two different banks of centrifugals, and so samples of massecuite feeding each bank of centrifugals were obtained as well.

The sugar which passed through the small opening was collected on a piece of plastic sheeting. Initially it was thought that there would be classification of sugar particles, and that only the larger particles would reach the vertical plastic and smaller crystals would fall onto the floor. This did not happen as all sugar was collected on the plastic sheet. The plastic monitor "casing" was at a distance of 2,7 m from the centre line of the centrifugal or equivalent to a 5,4 m diameter casing. In practice, this would of course be unrealistic, but the object was to go beyond the point where impact breakage would occur.

The results are given in Table 1.

For massecuite cured on a batch centrifugal, the changes in SGS and fines obtained for Runs 2 and 4 are surprisingly high since, although one would expect the washing process in the machine to have some effect, some small grain would also go through the screen into the molasses. Another anomaly is that the grain size of the sugar in B-massecuite feeding the batch centrifugals was significantly larger than that to the continuous machines. It is perhaps unfair to look at percentage increase in fines only.

The most significant result of the whole test is that the sugar which went through the opening showed little change in fines, while the increase in fines on the standard K850 was 78%. This would strongly indicate that very little damage occurs on the screen and that the major part of breakage occurs on impacting the monitor casing.

At the same time that these tests were done, purity rises were measured on the machines. It was found that the purity rise on the batch machines was considerably higher than that on the continuous machines, perhaps indicating that more dissolution of sugar occurred in the batch machine. Sugar purities were also measured and varied in an apparently random fashion between 86 and 98 purity.

### Effect of large diameter casing on crystal breakage

A BMA K850 centrifugal was modified at Darnall to have a 3 m diameter casing. It was also equipped with a "skirt" which, when in place, gave the machine an effective diameter of 2,5 m. This was done since it was intended to investigate the effect of casing diameter on crystal breakage. Part of the testwork was also aimed at establishing whether crystal size had any effect on sugar crystal breakage.

Testwork consisted of taking samples of massecuite feeding the modified and unmodified machine adjacent to it, as well as sugar samples from each of the machines and measuring the crystal size. The results are shown in Table 2.

**Table 2**
**Comparison between the 2,5 m and 3,0 m modified centrifugal casing and the standard machine at Darnall**

| Diameter (m) | No of pairs of data | Machine | SGS (mm) | % SGS Increase | % Fines (< 65 mesh) | % Fines Decrease |
|---|---|---|---|---|---|---|
| 1,75 | 4 | Standard | 0,152 | | 58,6 | |
| 2,5 | | Modified | 0,167 | 9,9 | 48,5 | 17,2 |
| 1,75 | 4 | Standard | 0,145 | | 64,3 | |
| 3,0 | | Modified | 0,157 | 8,3 | 55,8 | 13,2 |

Unfortunately these results were carried out at the end of the season and massecuites were not analysed as these proved difficult to centrifuge. Nonetheless, the results of this investigation showed that the SGS of the sugar from the modified machine was always greater than that from the standard K850 centrifugal. More fines were produced by the standard machine in all cases than by the modified machine.

No apparent effect of diameter, whether 2,5 or 3 m, was evident from these tests. Massecuite quality varied quite significantly during the test period, as can be seen from average values of SGS and % fines.

A second series of tests was undertaken at Darnall the following season, this time taking samples of massecuite at the same time as sugar was sampled from the standard and modified centrifugals. Thus the total amount of crystal breakage as well as the difference between the 2 machines could be assessed. Again tests were done with and without the 2,5 mm diameter skirt in place. Results are given in Table 3.

**Table 1**
**Results of B-sugar size analyses on Triangle sugar samples**

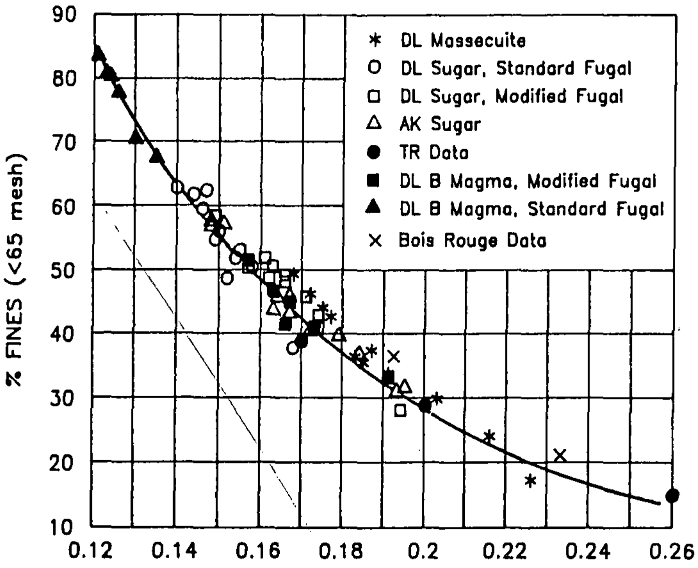
| Sample | SGS (mm) | | | | % Fines (< 65 mesh) | | | | % Reduction in SGS | | | | % Increase in Fines | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run No. | | | | Run No. | | | | Run No. | | | | Run No. | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| *Batch Tests:* | | | | | | | | | | | | | | | | |
| Massecuite | - | 0,251 | 0,252 | 0,267 | - | 16,2 | 17,8 | 14,0 | | | | | | | | |
| Centrifugal sugar | 0,206 | 0,227 | 0,251 | 0,239 | 23,7 | 21,9 | 16,6 | 19,4 | - | 9,6 | 0,4 | 10,5 | - | 35,2 | −6,7 | 38,6 |
| *Continuous Tests:* | | | | | | | | | | | | | | | | |
| Massecuite | 0,224 | 0,226 | 0,226 | 0,194 | 24,4 | 23,2 | 24,5 | 35,0 | | | | | | | | |
| Sugar through opening in casing | 0,217 | 0,192 | 0,226 | 0,195 | 26,6 | 35,8 | 22,4 | 33,6 | 3,1 | 15,0 | Nil | Nil | 9,0 | 54,3 | −8,6 | −4,0 |
| Standard continuous centrifugal sugar | 0,146 | 0,174 | 0,171 | 0,166 | 57,8 | 44,7 | 41,2 | 46,9 | 34,8 | 23,0 | 24,3 | 14,4 | 136,9 | 92,7 | 68,2 | 34,0 |

These results showed that even with the larger diameter casing, crystal breakage is not eliminated, but is certainly reduced relative to a standard machine. SGS drops by about 10% in the large casing machine, but by about 20% in the standard machine. The fines level of about 36% in crystal in the massecuite increases to about 48% in the large casing machine, but to about 54% in the standard machine. Again no difference between a 2,5 m or 3 m casing is evident from these results.

An effect of crystal size is evident in the results. A greater reduction in SGS occurs when the massecuite crystal SGS value is higher. In the standard machine, a larger B-sugar leads to more crystal breakage, so that attempts to get the A-sugar size up by boiling a larger B-sugar are made very difficult. The larger diameter casing improves matters significantly, as is evident from looking at the range of SGS values in Table 3.

A plot of % fines against SGS is shown in Figure 1, for crystal in massecuite and B-sugar produced in the standard and modified machines for all the data obtained in this study. The data all seem to follow the same relationship, suggesting that there is no particular pattern of breakage other than a general size reduction.

**FIGURE 1** Relationship between SGS and fines for B-sugar in massecuite and from B-centrifugals.




Subsequently some additional K850 centrifugals were installed at Maidstone, and the opportunity was taken to install them with larger casings, and dedicate them to production of B-sugar for B-magma. Since two machines were being installed, a single large casing surrounding both centrifugals was installed, a sketch of which is shown in Figure 2. The casing shape was changed, and with this arrangement, average distance between the edge of the basket and the casing was increased, with the width of the casing kept at 3 m. A short vertical baffle was installed between the two machines so that one of the baskets can be removed while the other is still in operation. The pan boilers at Maidstone report that it is not necessary to wash the magma from the new installation, whereas this was previously essential.

**FIGURE 2** Sketch of modified casing installed around B-centrifugals at Maidstone.

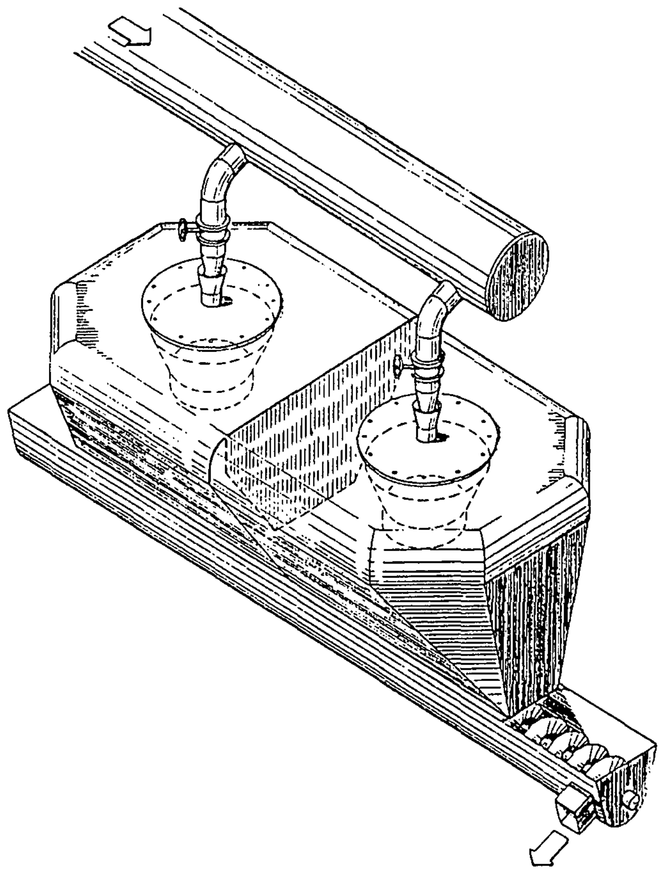


**Table 3**

**Size analysis of B-sugar in massecuite compared with sugar produced in standard and modified (3 m casing) B-centrifugals**

| Test No. | Case D (m) | SGS (MM) | | | Fines % | | | % Decrease | | % Increase in Fines | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MCTE | STD | MOD | MCTE | STD | MOD | STD | MOD | STD | MOD |
| 1 | 3,0 | 0,183 | 0,158 | 0,162 | 36,6 | 50,7 | 49,0 | 13,7 | 11,5 | 38,5 | 33,9 |
| 2 | 3,0 | 0,175 | 0,150 | 0,163 | 44,3 | 56,4 | 50,9 | 14,3 | 6,9 | 27,3 | 14,9 |
| 3 | 3,0 | 0,203 | 0,155 | 0,166 | 30,1 | 53,4 | 48,4 | 23,6 | 18,2 | 77,4 | 60,8 |
| 4 | 3,0 | 0,191 | 0,149 | 0,171 | 34,0 | 55,1 | 46,0 | 22,0 | 10,5 | 62,1 | 35,3 |
| 5 | 3,0 | 0,187 | 0,144 | 0,174 | 37,6 | 62,2 | 43,1 | 23,0 | 7,0 | 65,4 | 14,6 |
| 6 | 3,0 | 0,177 | 0,140 | 0,149 | 42,9 | 63,2 | 58,8 | 20,9 | 15,8 | 47,3 | 37,1 |
| 7 | 3,0 | 0,216 | 0,152 | 0,174 | 24,3 | 48,9 | 41,1 | 29,6 | 19,4 | 101,2 | 69,1 |
| 8 | 2,5 | 0,172 | 0,146 | 0,161 | 46,5 | 59,9 | 52,2 | 15,1 | 6,4 | 28,8 | 12,3 |
| 10 | 2,5 | 0,168 | 0,147 | 0,166 | 49,6 | 62,8 | 49,5 | 12,5 | 1,2 | 26,6 | −0,2 |
| 12 | 2,5 | 0,185 | 0,154 | 0,157 | 35,7 | 52,1 | 50,6 | 16,8 | 15,1 | 45,9 | 41,7 |
| 15 | 2,5 | 0,226 | 0,168 | 0,194 | 17,5 | 38,0 | 28,3 | 25,7 | 14,2 | 117,1 | 61,7 |
| Average | | 0,189 | 0,151 | 0,167 | 36,3 | 54,8 | 47,1 | 19,7 | 11,5 | 58,0 | 34,7 |
| Max Value | | 0,226 | 0,168 | 0,194 | 49,6 | 63,2 | 58,8 | | | | |
| Min Value | | 0,168 | 0,140 | 0,149 | 17,5 | 38,0 | 28,3 | | | | |
| Range | | 0,058 | 0,028 | 0,045 | 32,1 | 25,2 | 30,5 | | | | |

Triangle Sugar decided to scrap their old batch machines curing B-sugar. They installed a similar arrangement to Maidstone with three machines installed in a combined casing. The opportunity was taken to collect samples of B-sugar from the batch B-machines before they were scrapped and from the continuous machines with the large casing. These were compared with a sample from conventional continuous machines. Measurements of sugar sizes are shown in Table 4.

**Table 4**

**Measurements of B-sugar crystal size from different machines at Triangle**

| | SGS | % Fines (< 65 mesh) | MA (mm) | CV | SGS Decrease % |
|---|---|---|---|---|---|
| Sugar from Batch Centrifugal | 0,26 | 15,1 | 0,37 | 43 | - |
| Continuous Centrifugal (large monitor casing) | 0,20 | 29,1 | 0,28 | 52 | 23,1 |
| Continuous Centrifugal (small monitor casing) | 0,17 | 39,1 | 0,22 | 68 | 34,6 |

In this case significant breakage of crystal is evident even with the larger casings. Since the average crystal size is slightly larger in this case than the Darnall data, breakage can be expected to be greater and the difference between large and standard casing is also more pronounced.

Prior to the design of the new Felixton mill, a visit was paid to Bois Rouge in Reunion, where continuous FCB A- and B-machines were operating. Both had large diameter casings, and samples of A- and B-sugar produced as well as A- and B-massecuite were taken. The massecuites were centrifuged in the laboratory and the samples were brought back to South Africa for analysis, following the procedure in the Appendix. The results are given in Table 5.

**Table 5**

**Measurements of sugar size on samples from Bois Rouge, Reunion**

| | SGS (mm) | MA (mm) | % Fines | | SGS Decrease % |
|---|---|---|---|---|---|
| | | | (< 28 mesh) | (< 65 mesh) | |
| A-massecuite | 0,616 | 0,74 | 30,3 | - | |
| A-sugar | 0,533 | 0,66 | 45,4 | - | 13,5 |
| B-massecuite | 0,233 | 0,27 | - | 21,1 | |
| B-sugar | 0,193 | 0,24 | - | 36,1 | 17,2 |

Although only one set of samples was taken, it is clear that significant breakage of A-sugar occurs. This is in conflict with the Illovo results (De Robillard and Journet[1]), but the Illovo centrifugal had a 5 m diameter casing, whereas the machine at Bois Rouge had only a 4 m diameter casing.

The B-machines were FCB 1000's, with a 3 m diameter casing. A reduction in SGS of 17% is evident, greater than the change in SGS obtained at Darnall, but less than that measured at Triangle with larger B-crystal.

The new mill at Felixton incorporated BMA K1100 centrifugals for B-sugar. Some of these were installed with 3,2 m casings, instead of the standard 1,9 m. Although the basket diameter is larger (1 100 mm), the speed of rotation is slightly lower at 2 000 rpm. The peripheral speed is higher at 115 m/s compared to the K850 (98 m/s).

A series of samples of sugar from machines with the 3,2 m casing and the standard casing were taken. In this case, length and breadth of the crystals were measured using the Kontron particle size analyser and the values were compared with crystal size in the massecuite before curing. Results are shown in Table 6.

**Table 6**

**Measurements of B-sugar size at Felixton. Number of data points = 6.**

| | Average Length (L) (mm) | Average Breadth (B) (mm) | Average (L + B)/2 (mm) | L/B | % Decrease in (L/B)/2 |
|---|---|---|---|---|---|
| Sugar in massecuite | 267 | 152 | 210 | 1,8 | - |
| Sugar - 3,2 m casing | 176 | 103 | 141 | 1,7 | 33 |
| Sugar - std. machine | 135 | 85 | 110 | 1,6 | 48 |

In this case a much larger drop in average crystal size is evident. However the Kontron method gives a mean size weighted by number, compared with sieving which gives a mean size weighted by mass, so the larger decrease in size is not unexpected.

Inspection of the data in Tables 3 to 6 indicates that the reduction in crystal size is dependent on crystal size, with a larger degree of breakage evident with larger crystals. In addition, the 3 m casing appears to lead to a smaller reduction in average crystal size (only about 60% of the reduction seen in standard machines). It is clear that for South African B-massecuites, a casing larger than 3 m is required if breakage is to be eliminated entirely.

### Effect of centrifugal speed on crystal breakage

The speed at which the centrifugal rotates will determine the speed at which the crystal leaves the basket. At a rotational speed of 2 200 rpm and a basket diameter of 850 mm, the tangential velocity at the top of the basket is 98 m/sec. The speed of rotation will therefore also affect the speed at which the crystal impacts the casing.

One of the B-centrifugals at Amatikulu was modified by slowing down its speed from 2 100 rpm to 1 800 rpm. Samples of sugar were taken from each machine, and SGS and fines were measured. Although there did appear to be a difference, no statistically significant difference could be established. In fact all data points obtained fell on the same correlation obtained for the Darnall data shown in Figure 1.

### Effect of breakage of B-sugar on A-sugar size

An assessment of the effect of breakage of B-sugar on the A-sugar produced was made at Darnall. The mill was able to use B-magma based on sugar from either the standard centrifugals or the centrifugal with the large diameter casing.

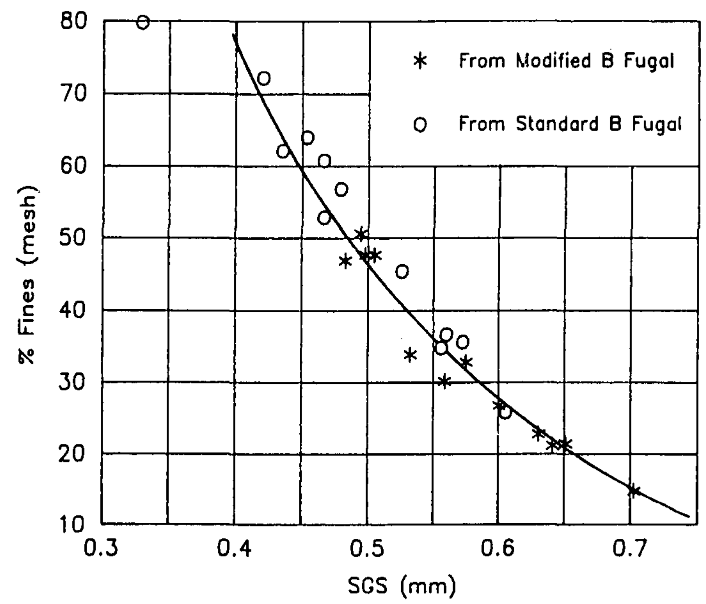
The SGS and fines in magma as well as the corresponding A-seed and A-massecuite were measured (Table 7).

These results show clearly that the magma made using sugar from the modified machine is larger by about 33%. This size difference follows through to the A-seed and the A-massecuite. In the A-massecuite, the crystal size difference is about 16%. Fines (based on material < 28mesh in the case of A-sugar) tends to be related to average crystal size. The data of Table 7 are plotted in Figure 3. As in the case of B-sugar, crystal size of A-seed and A-massecuite shows a similar relationship between SGS and fines.

**Table 7**
**Effect of large diameter B-centrifugal casing on crystal size in magma, seed and A-massecuite**

| Sample | 3 m Diameter casing | | | Normal casing | | |
|---|---|---|---|---|---|---|
| | SGS (mm) | % Fines | | SGS (mm) | % Fines | |
| | | < 28 mesh | < 65 mesh | | < 28 mesh | < 65 mesh |
| No. 1 Magma | 0,157 | 99,8 | 51,8 | 0,135 | 99,2 | 67,8 |
| A-seed | 0,531 | 33,9 | 2,5 | 0,435 | 62,3 | 3,1 |
| A-massecuite | 0,702 | 15,0 | 0,4 | 0,559 | 36,4 | 1,0 |
| No. 2 Magma | 0,167 | 99,9 | 45,2 | 0,130 | 99,4 | 70,7 |
| A-seed | 0,503 | 47,8 | 1,7 | 0,454 | 64,1 | 1,9 |
| A-massecuite | 0,573 | 32,8 | 1,1 | 0,573 | 35,7 | 0,8 |
| No. 3 Magma | 0,191 | 99,7 | 33,4 | 0,124 | 99,7 | 80,4 |
| A-seed | 0,558 | 30,1 | 1,9 | 0,466 | 60,6 | 1,8 |
| A-massecuite | 0,650 | 21,5 | 0,5 | 0,606 | 25,7 | 0,9 |
| No. 4 Magma | 0,173 | 99,4 | 41,3 | 0,126 | 99,3 | 77,8 |
| A-seed | 0,482 | 46,9 | 2,3 | 0,329 | 79,7 | 7,4 |
| A-massecuite | 0,599 | 26,9 | 0,9 | 0,466 | 52,9 | 2,4 |
| No. 5 Magma | 0,163 | 99,5 | 46,9 | 0,123 | 99,6 | 80,8 |
| A-seed | 0,497 | 47,7 | 1,8 | 0,420 | 72,1 | 2,6 |
| A-massecuite | 0,641 | 21,3 | 0,5 | 0,525 | 45,5 | 1,2 |
| No. 6 Magma | 0,166 | 99,7 | 41,7 | 0,121 | 99,5 | 83,6 |
| A-seed | 0,493 | 50,7 | 1,7 | 0,479 | 56,7 | 1,6 |
| A-massecuite | 0,630 | 22,7 | 0,7 | 0,555 | 35,2 | 1,3 |
| Average Magma | 0,170 | - | 43,4 | 0,127 | - | 76,9 |
| A-seed | 0,506 | 42,9 | - | 0,431 | 65,9 | - |
| A-massecuite | 0,633 | 23,4 | - | 0,547 | 38,6 | - |

**FIGURE 3** Relationship between SGS and fines for sugar in A-seed and A-massecuite, originating from B-sugar produced in standard and modified centrifugals.




## Conclusions

This study has shown that crystal breakage occurring in continuous centrifugals occurs almost exclusively when the sugar impacts the casing of the machine. Breakage of crystal due to the crystals rolling up the screen (if it occurs at all) could not be detected in the measurements obtained.

Increasing the casing size of a BMA K850 from 1,75 m to 3 m leads to a significant reduction in breakage, resulting in a larger average grain size with less fines. The larger casing leads to a lower reduction in average crystal size, being only about 60% of the average size reduction in a standard machine. Alternatively, the crystal produced with a larger diameter casing gives an average crystal size 10-30% larger than crystal from a standard machine. Crystal breakage is greater with larger size particles.

Work done at Darnall showed that crystal size in magma sent to A-boilings was larger by about 33% from a larger diameter casing machine. The difference in grain size follows through to crystal in A-massecuite, and facilitates achieving the required average crystal size and fines specifications for VHP sugar, thus promoting A-pan capacity.

## Acknowledgements

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### APPENDIX

**Measurement of crystal size distribution**

(a) *Washing of sugar*

1. Weigh out approximately105 g of sugar which has been sub-sampled, using the sample splitter, into a dry 250 conical flask fitted with a strainer stopper.
2. Add 100 ml of 90% methanol, saturated with sugar, to the sample and shake for 2 minutes.
3. Soak for 1 hour, shaking for 2 minutes every 15 minutes.
4. Filter off methanol under vacuum.
5. Add 50 ml of 95% methanol, saturated with sugar, shake for 2 minutes and filter as above.
6. Repeat the washing with 95% methanol three more times.
7. Add 50 ml of ether, shake for 1 minute and filter as above.
8. Repeat the ether washing 3 more times.
9. Allow to dry.

(b) *Sieve analysis*

1. Clean and weigh a nest consisting of 16, 28, 42, 65 and 200 mesh Tyler sieves.
2. Add approximately 100 g of dry sugar.
3. Shake for 10 minutes and then re-weigh the sieves.

*Calculations:*

(a) *Specific Grain Size (SGS)*

(i) Express the mass of each fraction as a percentage of the total mass and multiply by the corresponding factor.

| Mesh Number | Factor |
|---|---|
| 16 | 9,2 |
| 28 | 13,1 |
| 42 | 21,9 |
| 65 | 36,9 |
| 200 | 83,0 |
| Pan | 191,0 |

(ii) Add the products and multiply the reciprocal of this sum by 1 000 to get the SGS in mm.

(b) *Percentage fines*

Add together the percentage sugar retained on the 200 mesh sieve and the percentage sugar in the pan.