

SOUTH AFRICAN C-MASSECUITES: CRYSTAL SIZE DISTRIBUTION AND ITS EFFECT ON CENTRIFUGAL LOSSES

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Abstract

The results of a two-year crystal size survey of C-masseccutes from the industry are summarised. The importance of the crystal size distribution on the physical losses of small crystals through the centrifugal screen and its contribution to overall centrifugal losses and molasses exhaustion are discussed. A recommended crystal size for C-masseccutes is given.

Introduction

Surveys on the performance of C-centrifugals² carried out in the 1980-81 and 1981-82 seasons showed that the molasses purity rise at centrifugation was high. It was also evident that the passage of small crystals through the screen slots accounted for a large part of the purity rise and at the time, this physical loss was estimated to be two points or more of molasses purity on average across the industry.

Because of the importance of this loss, recommendations were made for the implementation of an industrial survey of the crystal size distribution of C-masseccutes as the first step of an investigation in the size optimisation of the C-crystal population. In accordance with this plan the Sugar Milling Research Institute purchased a Kontron MOP Videoplan in 1983, which is a semi-automatic, computerised video-type particle size analyser. Using this analyser, a monthly crystal size survey of C-masseccutes from the industry has been carried out during the last two seasons.

In conjunction with this survey a more specific centrifugal investigation was carried out in the 1984-85 season at a number of mills to determine the effect of the crystal size distribution of C-masseccutes on the centrifugal losses.

In this paper the results of this size survey are summarised and the findings of the centrifugal investigation are discussed.

Particle Size Analyser

The crystal size measurements were made on an image analysis system consisting of the following main components:

- Zeiss microscope;
- monochrome TV camera (Sharp Model IT — 35 CZ);
- Kontron MOP Videoplan particle analyser which is made up of a 64 Kbyte computer and monitor, a digitizer tablet and a keyboard;
- video overlay module allowing the synchronisation of the video camera and the computer signals from the digitizer tablet;
- printer (Microline 82 A model).

The measurements were made at a 75:1 magnification and crystals smaller than 20 microns wide were excluded from the data.

Procedure

Industrial crystal size survey

On a fixed date of every month every mill sent to the Sugar Milling Research Institute a small sample (about 200 ml) of C-masseccute taken at the centrifugal inlet. The masseccute was conditioned with sucrose-saturated glycerol in a 1:1 ratio before being placed on the slide glass for size measurement. The length

and width of the crystals were measured. For each masseccute about 400 measurements were found to be sufficient to remove practically all variation in the mean and standard deviation due to the number of observations. The data were computed into a number distribution. The relative mass distribution was obtained by assuming that the third dimension of the crystals was equal to its width.

C-Centrifugal investigation

The bulk of the tests was carried out at three mills Darnall (DL), Union — Co-op (UC) and Illovo (IL) at two week intervals for most of the 1984-85 season. Similar data were also collected at many other mills on an irregular basis. The test consisted of measuring the molasses purity rise at a centrifugal under normal operating conditions (ΔP_T) and under "dry run" conditions (ΔP_p) with the wash water and steam additions cut off. For each test a crystal size measurement of the C-masseccute and of the "dry run" molasses was carried out. The apparent purity rises across the machines were measured relative to the purity of the nutsch molasses in the feed. The target purity difference of the factory C-molasses for each test (and of a few nutsch molasses samples) was determined as per the recommended method¹.

The "dry run" purity rise (ΔP_p) is a measure of the physical losses caused by the passage of small crystals through the centrifugal screen slots. The operational loss (ΔP_o) caused by crystal dissolution by washing in the centrifugal is equal to ($\Delta P_T - \Delta P_p$) so that

$$\Delta P_T = \Delta P_p + \Delta P_o$$

At the end of each test a thorough visual inspection of the centrifugal screens was carried out.

Results

Industrial size survey

The results of the survey carried out over the last two seasons^{3,4} are summarised in Table 1. The mean width of the crystal population is based on a number distribution and the elongation factor is the ratio of the mean length to the mean width.

TABLE 1
 Industrial monthly C-crystal size survey
 (Seasons 1983-84 and 1984-85)

	Mean width (microns)	Elongation factor	% Total crystal smaller than 120 microns	
			by number	by mass
Season 1983-84				
July	107	1.7	—	—
August	104	1.7	69	33
September	98	1.7	74	37
October	98	1.7	76	38
Season 1984-85				
June	103	1.6	67	24
July	107	1.6	67	27
August	110	1.7	65	29
September	111	1.6	61	22
October	122	1.7	55	16
November	129	1.8	50	14
December	131	1.7	47	12
January	121	2.0	56	17

During the 1984-85 season many mills increased the size of their C-crystal population as exemplified by the DL results shown in Figure 1, in which the size distribution by number and mass is expressed on a cumulative basis.

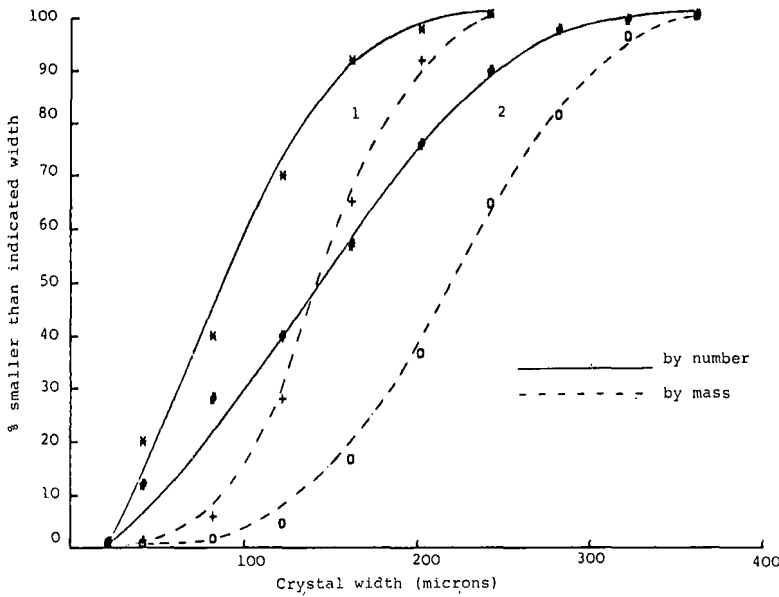


FIGURE 1 Crystal size distribution of two DL C-masseccutes. Masseccuite 1 mean width 98 microns
Masseccuite 2 mean width 144 microns

Crystal size distribution of the physical loss

As part of the centrifugal investigation 22 samples of "dry run" molasses, mainly from DL, UC and IL were analysed for the size of their crystals. The average size distribution of the crystals which passed through the screens (physical loss) is illustrated in Figure 2.

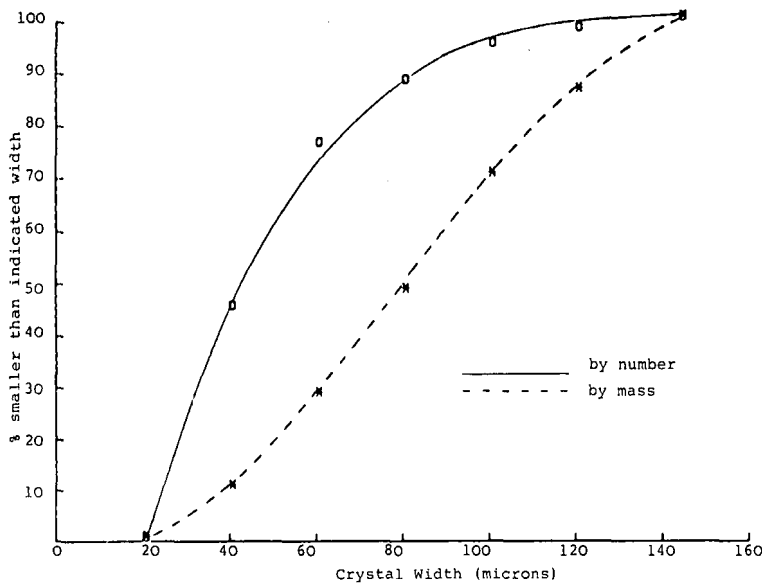


FIGURE 2 Size distribution of crystals in dry run molasses (physical loss).

The contribution of the different sizes of crystal to the mass loss is given in Table 2.

TABLE 2
The contribution of different crystal sizes to the physical loss

Crystal width (microns)	Percent total physical loss
20 - 40	10
40 - 60	18
60 - 80	20
80 - 100	22
100 - 120	16
120 - 140	14

Based on the above results 120 microns has been chosen as a practical "cut off" size for defining a small crystal in a C-masseccuite.

Mass content of small crystals in C-masseccutes

It was found that a bigger mean crystal size would reduce the quantity of small crystals expressed as a percentage of the total crystal content of the masseccuite. The relationship between the two parameters is given by the following equation which is shown graphically in Figure 3.

$$\ln(M_{sc}) = 24,28 - 4,55(\ln W_c)$$

$$(r = -0,97, n = 51)$$

where M_{sc} = mass content of small crystals expressed as a percent of total crystal content

W_c = mean crystal width in microns

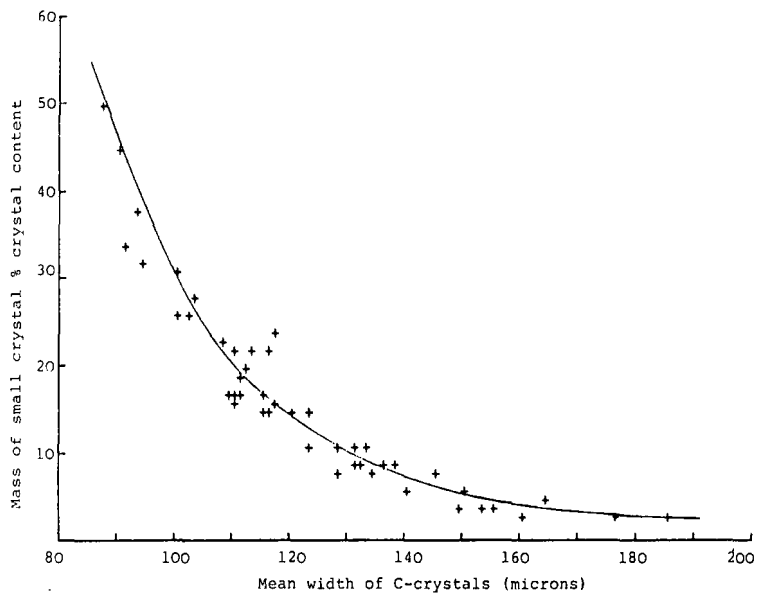


FIGURE 3 Content of small crystals in C-masseccutes of different crystal sizes.

Effect of the quantity of small crystals in a C-masseccuite on the centrifugal losses

Based on twenty-nine sets of data obtained during the centrifugal investigation it was found that a direct relationship existed between the percentage mass content of small crystals (M_{sc}) in a masseccuite and the molasses purity rise (ΔP_T) across the centrifugal as expressed by the following equation:

$$\Delta P_T = 1,25 \ln(M_{sc}) - 0,15$$

$$(r = 0,80, n = 29)$$

The relationship is illustrated in Figure 4.

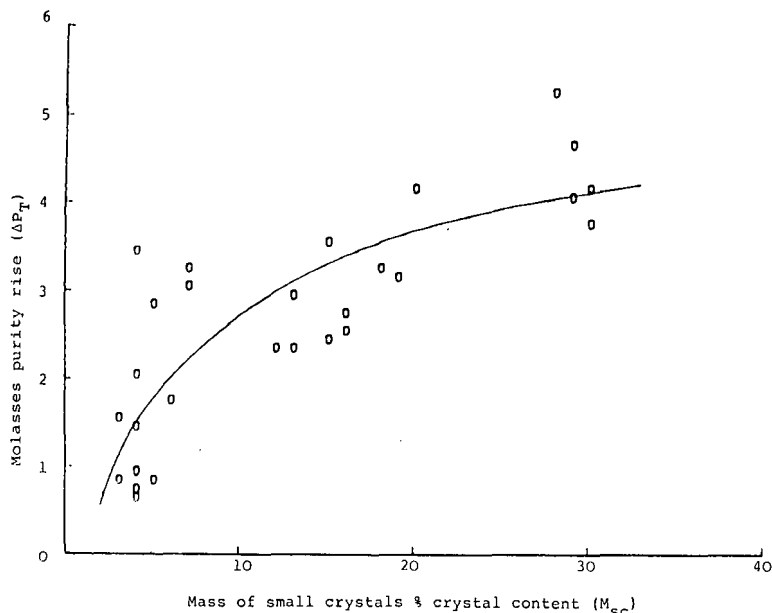


FIGURE 4 The relationship between the molasses purity rise (ΔP_T) and the content of small crystals (M_{SC}) in the C-masseccuite.

Influence of the physical loss on the molasses purity rise at centrifugation

There was good agreement between the total molasses purity rise (ΔP_T) and the purity rise resulting only from the presence of small crystals in the molasses (physical loss: ΔP_P). The relationship, illustrated in Figure 5, is given by the equation

$$\Delta P_T = 1,03 \Delta P_P + 0,59$$

$$(r = 0,89, n = 43)$$

In the above equation 0,59 represents the molasses purity rise due to sucrose dissolution under general operating conditions at a C-sugar purity of about 82°.

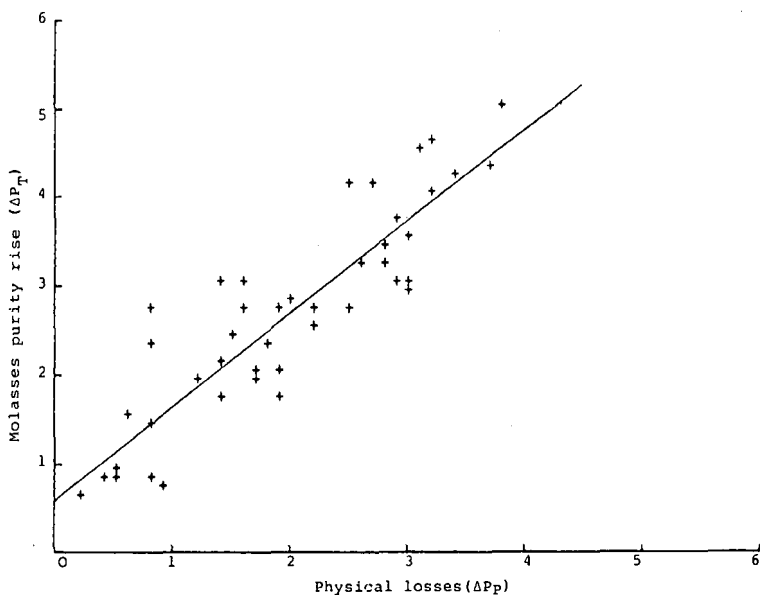


FIGURE 5 The relation between the molasses purity rise (ΔP_T) and the physical losses (ΔP_P).

Centrifugation losses and molasses target purity difference (TPD)

In general the molasses purity rise across the centrifugals (ΔP_T) was found to have a direct influence on the TPD as shown in Figure 6, the relationship being as follows:

$$TPD = 1,15 \Delta P_T - 0,72$$

$$(r = 0,79, n = 23)$$

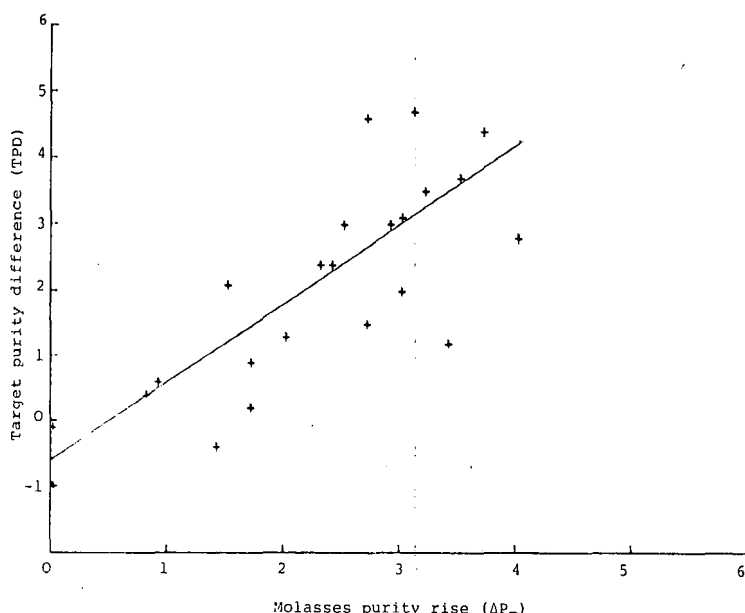


FIGURE 6 The relation between the target purity difference (TPD) and the molasses purity rise (ΔP_T) across the centrifugals.

In this connection it is worth noting the TPD results obtained on 4 nutsch molasses samples from different mills given in Table 3.

TABLE 3
Target purity difference of Nutsch molasses

Mill	Date	TPD Nutsch molasses	TPD final molasses (corresponding week)
DL	22/11/84	-1.1	+1.2
	13/12/84	-0.2	+1.7
NB	12/12/84	+0.5	+4.2
UK	11/12/84	-0.4	+2.1

The above results are an indication that if it were not for the molasses losses at centrifugation the industry TPD would be about nil, especially when it is realised that the nutsch molasses themselves contain a fair amount of small crystals.

Discussion

The loss of small crystals in the final molasses by passage through the screen slots during C-masseccuite centrifugation has been cause for concern for many years. It would appear that the industry, in its endeavour to maximise the final molasses exhaustion by producing C-masseccuites of low purity at high brix has, for practical reasons, reduced the C-crystal size, overlooking the detrimental effect that this policy could have on the centrifugal losses, when carried to extremes.

The size survey of the last two seasons has confirmed that the crystal size of the average C-masseccuites was very small. During the 1984-85 season, however, many mills made a serious effort to increase the size of their C-crystal population and by October 1984 a marked improvement was noticeable (see Table 1). In December 1984 the industrial average crystal width was 131 microns which is about 30 per cent bigger than the previous season's average and the content of small crystals in the C-masseccuites as a percentage of the total crystal content had dropped from 35 to 12 per cent.

As mentioned earlier, small crystals in this report are defined as being less than 120 microns wide. This is based on the crystal size distribution of the physical loss (see Figure 2), which also

showed that despite the nominal width of the screen slots being 60 microns no less than 70 per cent of the sucrose loss is caused by crystals wider than 60 microns (see Table 2).

In general, the physical loss of small crystals in the molasses was found to account for most of the total purity rise across the centrifugal as shown in Figure 5. In confirmation of our previous findings², the operational losses, that is the losses resulting from crystal dissolution on washing, were found to be relatively small at 0,6° purity under normal factory operation at a C-sugar purity of 82 to 83°.

As a logical consequence to the above findings, the quantity of small crystals in the C-massecuite was found to influence directly the molasses purity rise across a C-centrifugal (see Figure 4).

Finally, the molasses TPD and the molasses purity rise at centrifugation were found to be directly related (see Figure 6). Considering the large number of factors that are known to influence the TPD, it is remarkable that this statistically significant trend has been obtained. This is a firm indication of the prime importance of the centrifugal losses and therefore of the crystal size distribution of the C-massecuities on the overall C-molasses exhaustion performance.

Conclusions

The crystal size distribution of the C-massecuite, through its influence on the centrifugal losses, is of prime importance to the overall final molasses exhaustion performance. In spite of the marked increase in crystal size which was effected in mid-

season 1984–85, it is felt that the average industrial size is still too small and a minimum mean crystal width of 150 microns is recommended, which would greatly reduce the mass content of small crystals in the C-massecuities (see Figure 3). It is also felt that the elimination of physical losses at centrifugation would result in TPD approaching zero or less at most mills, provided the pre-centrifugal exhaustion performance can be maintained at its present level. In this regard, pan boiling control becomes of critical importance for the production of a bigger crystal without massive formation of false grain.

Acknowledgements

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