VISCOSITY AND CRYSTAL SHAPE AT ILLOVO SUGAR LIMITED

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Abstract

The results of a survey of final molasses viscosity and C-crystal shape which was carried out at the mills of Illovo Sugar Limited over the last three seasons are presented and the main trends are discussed.

Introduction

In South Africa the molasses exhaustion performance is assessed by means of the Target Purity Difference (TPD) of the molasses. The TPD is basically the difference between the actual molasses purity and a target purity which is statistically based and assumed to be the lowest achievable in practice.

The TPDs of the final molasses in the mills of Illovo Sugar Limited (ILS) vary quite widely between mills and seasons. There is regular reference to good 'TPD mills' and good 'TPD years'.

The reasons for those TPD changes, which are equated to the performance of the crystallisation station, go mostly unexplained - in spite of the many fancy ideas which are put forward every season.

In order to throw some light on to the matter it was decided to measure on a weekly basis the viscosity of the final molasses of all the ISL mills as well as the crystal size and shape in the C-massecuites. These parameters were chosen because of the important effect they are expected to have on molasses exhaustion; *i.e.* viscosity by its influence on crystallisation and centrifugation characteristics and crystal shape because of its effect on crystal loss across the centrifugals screens. It is assumed of course that low viscosity and low crystal elongation are desirable features in sugar processing.

In addition they are parameters which are, for all intents and purposes, beyond the control of the operating staff, being mainly dependent on the properties of the incoming juice. The survey is also an attempt to quantify and compare subjective terms such as 'gumminess', 'stickiness' and 'needle grains' which have long been used in the sugar world.

The survey, believed to be the first of its kind in the sugar world, was carried out in the last three seasons (1992-1994) with the assistance of the Sugar Milling Research Institute (SMRI). The results are presented and discussed in this paper.

Procedure

Contributing mills

Out of the seven mills of ISL, only five, PG, UF, GH, NB and SZ, are considered in this report. The other two mills, Illovo and Umzimkulu, did not operate or processed little cane during the 3-year period because of the drought which was prevailing in South Africa. The survey is based on a total number of molasses and massecuite samples amounting to nearly 1000.

Viscosity of final molasses

The measurements were carried out by the SMRI on weekly composite samples, using a Brookfield viscometer. All the measurements were made at 30°C, firstly on the molasses at actual dry solid and secondly at 74 % dry solids, after dilution with water, which now allows for direct comparisons. Finally, the consistency ('viscosity' at three or more rotational speeds, for non-Newtonian fluids) was measured, but for simplicity the term 'viscosity'is used here. All the results are in Pa.s. for molasses at 74% dry solids and 30°C.

The assumption has been made that the differences found at 74% dry solids and 30°C will persist at operating levels of dry solids (80-85%) and temperatures (40-65°C). The validity of this assumption is being investigated by the SMRI. For discussion in this paper all the weekly data have been converted to monthly averages.

Crystal shape of C-massecuites

The crystal population of a weekly catch sample of C-massecuite from each mill was measured by the SMRI by means of a Kontron Image Analyser. The average crystal width and length (both in μm) and elongation ratio (ER) which equals length/width of each massecuite were recorded. As with the viscosity, the weekly data have been converted to monthly averages.

Results

At the outset it must be mentioned that all three seasons under review were not totally 'normal' in the sense that they were drought-affected with lower than normal cane production and juice purity. See Table 1.

Table 1

Mixed juice purities at ISL mills during seasons 1992-1994 (up to November).

	Season			
Mill	1992	1993	1994	Mill average
PG	84,0	85,4	85,1	84,8
UF	85,5	84,7	85,3	85,2
NB	86,8	84,8	87,1	86,2
GH	82,3	80,5	82,7	81,8
SZ	80,8	80,4	82,9	81,5
Season average	83,9	83,2	84,7	

Viscosity

The average season viscosities for the five mills for the 1992, 1993 and 1994 seasons are shown graphically in Figure 1. It is evident that there was a progressive increase in viscosity over the three seasons with Noodsberg and Sezela the higher and Umfolozi and Pongola, the two northern mills, the less viscous. The results also indicate the wide differences

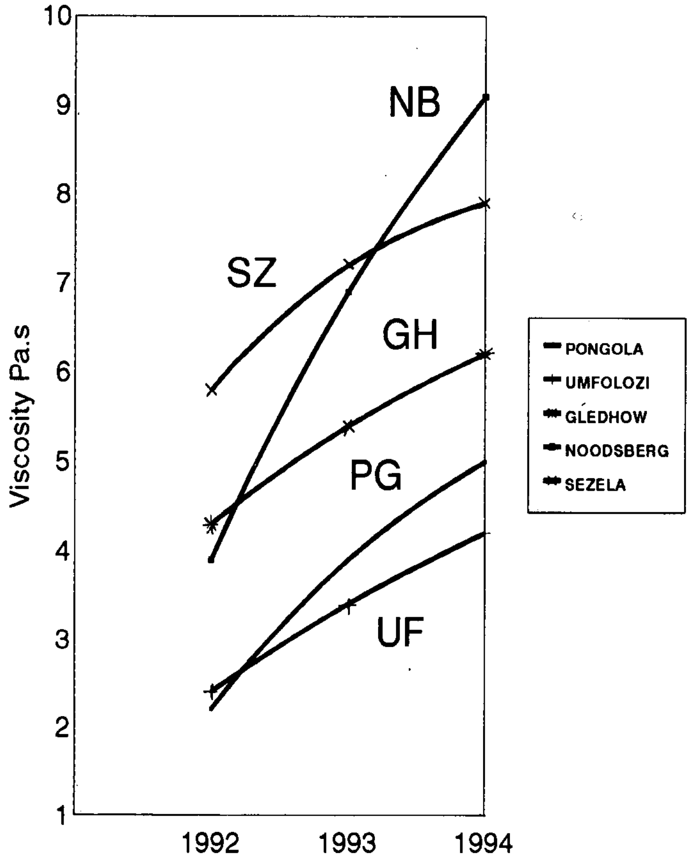

FIGURE 1 Average seasons viscosities of final molasses at ISL.

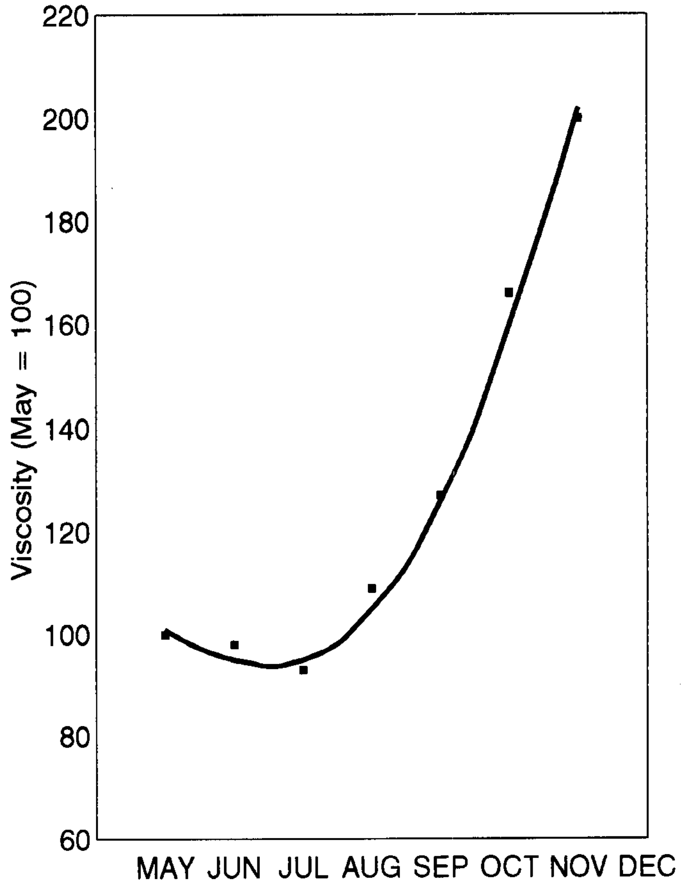

FIGURE 2 Average monthly viscosity at ISL (basis - May = 100).

in viscosity within the group, ranging from about 2 Pa.s at Pongola and Umfolozi in 1992 to 9 Pa.s at Noodsberg in 1994.

On a monthly basis the viscosities ranged, over the three seasons, from a low of 1,6 Pa.s (Umfolozi: June 1993) to a high of 13,8 Pa.s (Noodsberg: November 1994), *i.e.* a nine-fold difference. It is worth noting that the increase in viscosity in 1994 took place in spite of a general improvement in juice purity. (See Table 1). It is also interesting that Noodsberg with the highest juice purity in the ISL group is also the one recording the highest viscosity.

An explanation for these apparently contradictory effects was sought in cane freshness. However an examination of the ethanol content of the mill mixed juices (the level of ethanol in juice is considered to be an indication of cane freshness) showed no indication of a change in cane freshness over the three seasons.

The seasonal change in viscosity for the group, expressed as the average of all five mills over the three seasons, is shown in Figure 2 (basis is May viscosity equals 100%). It shows a slight drop of 7% from May to July followed by a steady rise over the following months to November when the viscosity is exactly double its May value.

Crystal shape

The average elongation of the C-crystals for the three seasons is shown in Figure 3.

Generally speaking there is no major change on a yearly basis although Gledhow and Sezela did show an improvement in 1993. Umfolozi has the lowest (best) elongation ratio at just less than 1,5 and Noodsberg the highest (worst) ratio at 2,1–2,3. This means that Noodsberg suffers the disadvantage of having the most elongated crystal population in ISL while Umfolozi is favoured with a 'more square' crystal.

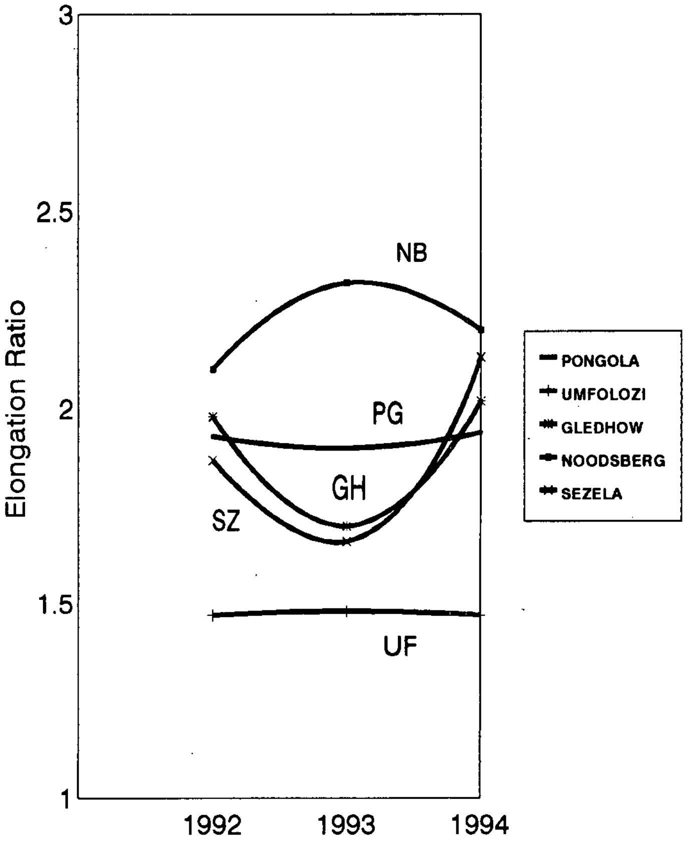

FIGURE 3 Average season elongation ratio of C-crystals at ISL.

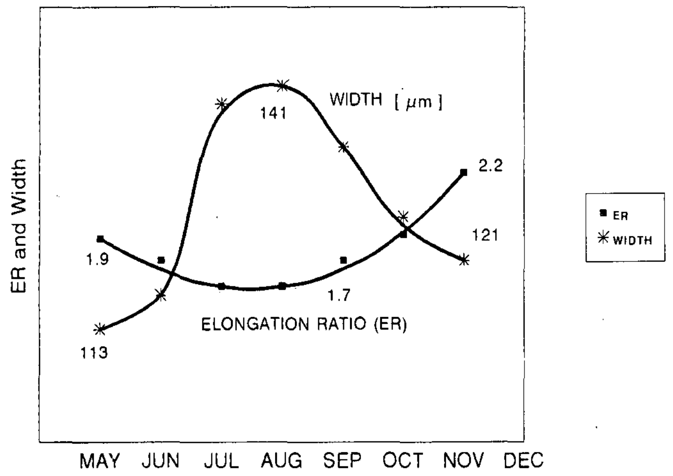

FIGURE 4 Monthly elongation ratio and width of C-crystals at ISL.

The trend in crystal shape during a season (based on the five mills over the three seasons) is illustrated in Figure 4. As with viscosity there is an improvement in crystal elongation in the first three or four months of the season followed by a steep increase (1,72 to 2,24, *i.e.* an increase of 30%) in the period September to November. Figure 4 also shows the change in crystal width during the season and it is clear that there is a correlation between the ER and the crystal width with the recommended crystal width of 140-150 m, (Jullienne, 1985), being only achieved in July and August when the ER is at its lowest.

This correlation between the width and the elongation of the crystal is surprising in that width ought to be a parameter controllable by normal process operations. It is possibly an indication that the corrective action which is applied to achieve the desired crystal width is either not severe enough or is ineffective.

TPD of final molasses

The trend in TPD during the three seasons under review is shown in Figure 5. It is clearly evident that there has been a strong downward trend over the three years and it is interesting to note that this improvement in molasses exhaustion took place against a background of increasing viscosity (see Figure 1).

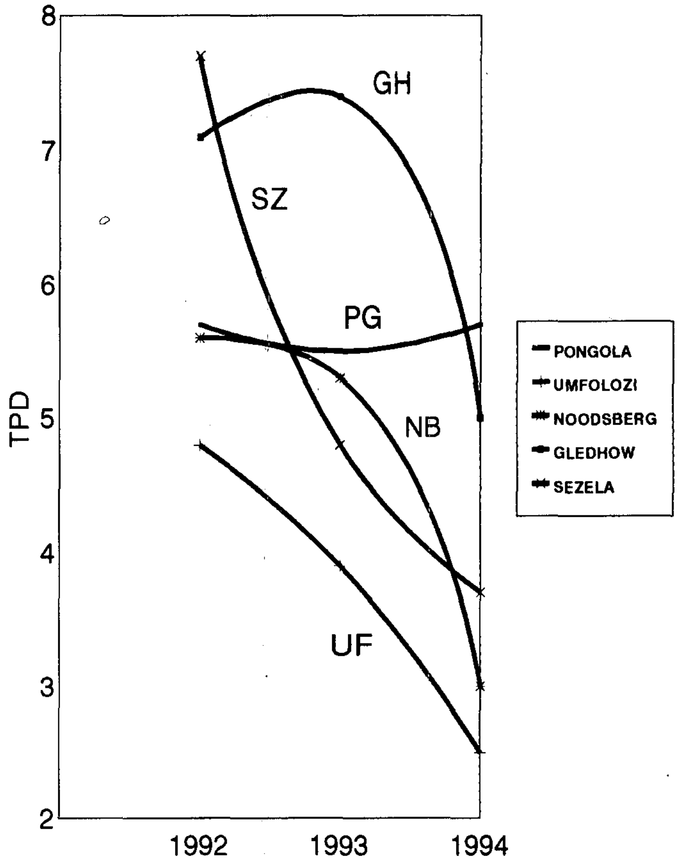

FIGURE 5 Average season TPD of final molasses at ISL.

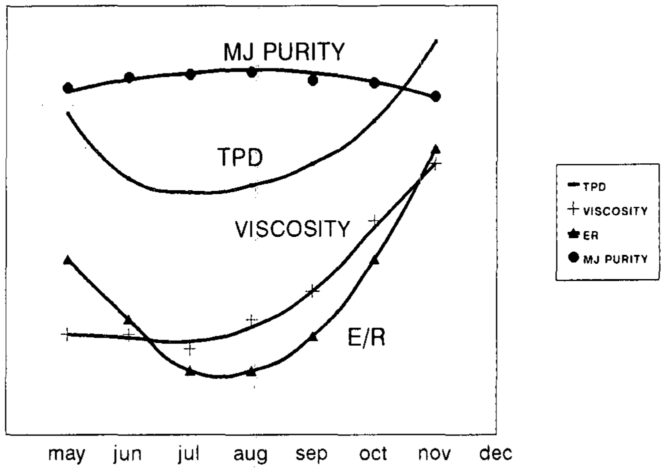

FIGURE 6 Monthly trend in mixed juice purity, TPD, viscosity and elongation Ratio.

Discussion

The survey has shown that important differences in molasses viscosity and C-crystal shape, both likely to have a marked bearing on molasses exhaustion, do exist in the mills of ISL. In fact, of all the commonly measured product characteristics, viscosity is possibly the one showing the widest range of variation.

Umfolozi has by far the most desirable characteristics (lowest viscosity and ER) with Noodsberg having the worst which possibly goes some way towards explaining their respective TPD performances over the three seasons.

As evident in Figure 6 the data show that the seasonal level of both the viscosity and elongation ratio, not unexpectedly, follow the seasonal mixed juice purity pattern and is in good agreement with the seasonal changes in TPD.

However in spite of those strong relationships on a seasonal basis, it is important to note that, because of the two contradictory cases described below, the data are far from proving that molasses exhaustion performance can be explained in terms of juice purity, molasses viscosity and ER. Contradiction number one is Noodsberg which, with the highest purity of mixed juice in the group, produces the most viscous molasses and elongated crystals and the highest TPD. It is worth noting that this phenomenon is also common with colour. The second contradiction is the 1994 season which recorded an increase in molasses viscosity in spite of an improvement in juice purity but still produced the lowest molasses TPD of the three seasons.

This is an indication that the type and concentration of the substance/s responsible for bad crystallisation characteristics do vary between mills and seasons. It is speculated that they are not linked directly to the purity of the juice and that it is purely coincidental that their seasonal changes follow the mixed juice purity pattern. Studies carried out at the SMRI (Morel du Boil, 1991) have identified oligo-saccharides as the main contributors to crystal elongation. However, very little is known about the factors which affect viscosity under local conditions and a fundamental study appears to be necessary.

Acknowledgements

Thanks are due to the Sugar Milling Research Institute, Durban, for carrying out all the analytical work for the survey.

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