MILLING AND OVERALL PERFORMANCES

By Th. FOURMOND

There are 2 factors which govern the extraction of sucrose and its recovery:

(*a*) The fibre content of the cane

(*b*) The purity of the juice.

Some sucrose will be immobilised by the fibre of the cane and the impurities of the juice, however efficient our milling and processing techniques may be. It, therefore, stands to reason that efficiencies of sugar mills ought to be expressed in terms of crystallisable sucrose rather than in terms of total sucrose.

At present, the only formula available for expressing the total work performed by the sugar mills is the Overall recovery. However, this formula is merely a quantitative expression, as mill Extraction and Boiling House Recovery are closely related to the fibre content of the cane and to the purity of the juice. In other words, the Overall Recovery does not express the efficiency of the work as cane of low fibre content and of high purity juice is bound to yield a higher Overall Recovery than cane of high fibre content and of low purity juice.

In order to judge the quality or efficiency of the work performed by the milling and processing departments, we have to resort to the "Lost absolute juice per cent Fibre" and to the "Boiling House Performance" respectively. As those two figures cannot be linked up, we are at a loss to express the Overall Performance of sugar mills by a formula which would express both quality and quantity at the same time and directly as a percentage of the maximum obtainable in practice.

If to calculate the efficiency of the Boiling House, we adopt the arbitrary principle (Winter & Carp's hypothesis based on practical results) that one part of non-sucrose will immobilise so much sucrose, there is no reason why we should not apply the same principle to the milling process by assuming that so much absolute juice shall be retained by 100 fibre of the cane. We could, therefore, determine the quantity of crystallisable sucrose available in the cane, according to the fibre content of the cane and to the purity of the juice, and from which, the milling and overall performances could be calculated.

Obviously, we will have to assume a reasonable target for milling efficiency, which shall have to be based on practical results. For instance, we do know that some Natal mills have achieved a performance equivalent to some 30 lost absolute juice per cent fibre in the 1957-58 crushing season. We could, therefore, fix the target, at present, at 30 lost absolute juice (until such time when this efficiency will be surpassed) and endeavour to calculate the corresponding crystallisable sucrose available at such an efficiency.

It would be rather difficult, if not impossible, to determine or calculate theoretically, the sucrose extraction corresponding to an efficiency of 30 lost absolute juice per cent fibre. However, from practical results, we do find that there is a rather close correlation, irrespective of milling efficiency, between sucrose and juice extractions as clearly shown by the following figures which represent the averages of all Natal mills.

	Lost absolute juice per cent Fibre	*Sucrose extraction*	*Juice extraction*	*Difference*
1954	44.08	92.40	91.58	+0.82
1955	45.46	92.32	91.51	+0.81
1956	42.08	92.93	92.10	+0.83
1957	40.91	93.36	92.56	+0.80
1958	42.26	92.87	92.02	+0.85
AVERAGE... ...				+0.82

To prove that the correlation is close, irrespective of milling efficiency, we shall quote the figures of some mills with milling performances differing, widely.

Mill	*Lost absolute Juice per cent Fibre*	*Sucrose extraction*	*Juice extraction*	*Differences*
Z.S.M.	52.2	89.80	88.92	0.88
Gledhow...	51.7	91.40	90.60	0.80
Natal Estates ...	31.2	94.50	93.67	0.83
Renishaw	31.1	94.60	93.91	0.69
Chakas-Kraal ...	42.0	93.20	92.48	0.72
Melville	49.6	91.50	90.73	0.77

As can be seen, the difference between sucrose and juice extraction is more or less constant, irrespective of milling efficiency.

We can, therefore, assume that, at the present standard of our milling technique, sucrose extraction is always higher than juice or brix extraction and can be approximated at +0.80 per cent. Should our milling technique improve and show a bigger difference, this present factor of 0.80 could be adjusted.

If this school of thought is correct, then it is easy to calculate the expected sucrose extraction (corresponding to an efficiency expressed as lost absolute juice per cent fibre) according to the fibre content of the cane. The purity of the juice being known, the crystallisable sucrose can be determined and from which the milling and overall performances would be calculated.

Juice extraction, equivalent to a performance of 30 absolute juice per cent fibre can be theoretically calculated in the following way:

$$\left\{ \frac{(100-F)-\frac{(F\times 30)}{100}}{(100-F)} \right\} \times 100$$

Where F = actual fibre per cent of the cane

∴ Expected sucrose extraction at 30 lost absolute juice per cent fibre, which we shall call exp. E, is equal to juice extraction at 30 lost absolute per cent fibre + 0.80.

Calculation of crystallisable sucrose available at 30 lost absolute juice per cent fibre.

A = Tons brix extracted at 30 lost absolute juice per cent fibre.

$$= \text{Tons brix in cane} - \frac{\text{Tons fibre} \times 30 \times \text{brix absolute juice.}}{10{,}000}$$

B Tons sucrose extracted at 30 lost absolute juice per cent fibre.

$$= \frac{\text{Tons sucrose in cane} \times \text{Exp. E}}{100}$$

C = Tons non sucrose extracted at 30 lost absolute juice per cent fibre.

$$= A - B$$

D = Purity of extracted juice at 30 lost absolute juice per cent fibre.

$$= \frac{B \times 100}{A}$$

F = Corresponding factor as rendered by Winter & Carp's.

G = Tons non-crystallisable sucrose extracted at 30 lost absolute juice per cent fibre.

$$= C \times F$$

∴ H = Tons Crystallisable sucrose available at 30 lost absolute juice per cent fibre.

$$= B - G$$

I = Tons crystallisable sucrose in mixed juice as calculated by usual method of S.M.R.I.

J = Tons crystallisable sucrose in sugars as calculated by usual method of S.M.R.I.

∴ Milling performance =

$$\frac{\text{Tons crystallisable sucrose in mixed juice} \times 100}{\text{Tons crystallisable sucrose available at 30 lost absolute juice per cent fibre.}}$$

$$= \frac{I \times 100}{H}$$

The boiling house performance is calculated in the usual way as recommended by the S.M.R.I.

∴ Overall performance =

$$\frac{\text{Tons crystallisable sucrose in sugars} \times 100}{\text{Tons crystallisable sucrose available at 30 lost absolute juice per cent fibre.}}$$

$$= \frac{J \times 100}{H}$$

∴ Milling, boiling house and overall performances are figures which express efficiency directly as a percentage of the maximum obtainable in practice. In other words, these figures are at the same time qualitative and quantitative, hence absolute.

Let us apply these formulae to Empangeni's, Tongaat's, Natal Estates' and Renishaw's figures for 1957-58 crushing season with a view to finding out if they are of any value to enlighten us about efficiencies of sugar mills.

	Z.S.M.	*Tongaat*	*N. Estates*	*Renishaw*
Fibre per cent cane	16.74	14.46	16.29	16.48
Lost absolute juice per cent fibre	51.3	33.9	29.6	30.4
Mill extraction	90.70	94.82	95.17	94.48
Milling performance	95.83	98.92	100.30	99.41
Purity mixed juice	86.0	86.0	85.5	84.7
Boiling house recovery...	88.60	91.28	90.66	90.19
Boiling house performance	95.80	98.60	98.90	98.50
Overall recovery	80.36	86.55	86.29	85.29
Overall performance	91.80	97.53	99.20	97.92

In the light of such figures, we find that Natal Estates has achieved the best efficiency in both milling and processing, thus ensuring the best overall performance although Tongaat shows a higher boiling house and overall recoveries. Renishaw comes second best although Tongaat shows a higher mill extraction and overall recovery. Judging by the recovery standard, one would think that Natal Estates has recovered (86.29 − 80.36) = 5.93 per cent more sucrose than Z.S.M. However, the performance standard shows that Natal Estates actually recovered (99.20 − 91.80) = 7.40 per cent more sucrose than Z.S.M.

Applying these formulae for the whole sugar industry since 1954 we find that:

	1954	*1955*	*1956*	*1957*	*1958*
Fibre per cent cane	16.03	15.74	15.81	15.38	15.92
Lost absolute juice per cent fibre	44.08	45.46	42.08	40.91	42.26
Mill extraction	93.40	92.32	92.93	93.36	92.87
Milling performance	97.20	97.02	97.68	97.94	97.70
Purity mixed juice	85.86	85.96	85.49	85.10	84.46
Boiling house recovery...	90.04	90.51	89.79	90.43	89.49
Boiling house performance	97.43	97.92	97.44	98.45	97.84
Overall recovery	83.20	83.56	83.44	84.42	83.11
Overall performance	94.71	95.00	95.18	96.42	95.59

The efficiency of the Natal sugar mills has been progressing steadily, reaching its peak in 1956-57. Judging by the recovery standard, one would conclude that the 1958-59 season was the lowest. However, the performance standard shows that it is second best and that +0.88 per cent more sucrose was recovered than in 1954-55.

This could be quite misleading to the layman if he had to correlate mill extraction with fibre content of the cane and boiling house recovery with the purity of the juice. With efficiencies expressed as milling, boiling house and overall performance, even the ordinary layman will understand that the higher the figure, the higher is the efficiency as they express efficiency directly as a per cent of the maximum obtainable in practice.

Is there any necessity, then, to formulate such expressions as milling, boiling house and overall performance? Some sugar technologists may consider that "lost absolute juice per cent fibre" and "boiling house performance" are good enough data to express the efficiencies of the sugar mills. However, if we consider that the entire staff of the sugar mills and

those connected with the sugar industry, in some way or other, are not necessarily sugar technologists, then we must admit the milling, boiling house and overall performances, being figures which express efficiency directly as a percentage of the maximum obtainable in practice, are far more logical and easier to understand as they express quality and quantity at the same time.

Furthermore, we all expect a clearer definition of millable cane in the near future. When a practical method for the determination of the fibre content is available for the analysis of individual cane consignments, the value of cane can then only be defined as "crystallisable sucrose available in the cane" and shall be determined according to the fibre percentage of the cane and the purity of the juice.

Therefore, for all these reasons, it would appear that there is some justification in introducing such expressions as milling and overall performances in our chemical control.

Summary

The author suggests that formulae such as milling and overall performances be introduced in our chemical control to express the efficiencies of sugar mills.

Such formulae, based on crystallisable sucrose, have an absolute value as opposed to the *mill* extraction and overall recovery, which, being based on total sucrose, have only a relative value as the fibre of the cane and the impurities of the juice will immobilise some of the sucrose of the cane.

From practical results, he proves that there is a close correlation, irrespective of milling efficiency, between sucrose and juice extractions, and the expected sucrose extraction, calculated from such a school of thought, makes the determination of crystallisable sucrose available quite easy and accurate.

REFERENCES

Summaries of Chemical Laboratory Reports of South African Sugar Factories—1954 to 1959.

Mr. Perk pointed out that sucrose extraction and juice extraction are not directly related. He said that the chief engineer of a factory was interested in the performance of his mills and therefore required the lost absolute juice per cent fibre figure, while the process manager was interested in the boiling house efficiency. He could not see that producing this overall picture was therefore of much value.

Mr. Fourmond replied that while the engineer might not be interested in overall performance, nevertheless mill extraction, being closely related to fibre per cent cane, he thought that it would be valuable to convert lost absolute juice to mill extraction. He said we now used the figure overall recovery and therefore he could not see why we should not use an overall performance figure, which has an absolute value. The overall figure is the most valuable one to all concerned in the Industry as it represents the true efficiency of a sugar mill.

Mr. Beesley said that we were dealing with two different processes. In the boiling house we were endeavouring to separate sucrose from non-sucrose and therefore the Boiling House Performance figure which is based on these two quantities, has a certain validity. However in milling we were endeavouring to separate sucrose from fibre and our endeavours inevitably resulted in the extraction of non-sucrose as well but not to a controllable extent. Hence he objected to the use of a fixed difference between brix and sucrose extraction when the relationship between the two was as far as he knew, wholly beyond the control of the man in charge.

Mr. Fourmond said that brix-sucrose relationship depended on the purity of the juice. The steps leading to the calculation of the milling performance are confusing as brix is taken into consideration. It was, nevertheless, a true reflection of milling efficiency, even if expressed in terms of total sucrose. To prove it, one has to divide the actual mill extraction by the expected sucrose extraction as per suggested formula and it will be found that milling efficiency, thus expressed in terms of total sucrose, is the same as the milling performance's figure.

Mr. Beesley repeated that he did not think the difference between brix and sucrose extraction was a controllable quantity.

Mr. Fourmond said that sucrose extraction had to be correlated with fibre and the more sucrose one extracted the more brix one would extract as well. He said that in judging the performance of the mill we must look at how much sucrose was recovered from that which was available actually in the cane. The determination of crystallisable sucrose available is necessary for the calculation of the overall performance which, as already explained, is the most important figure to express efficiency. This is most valuable for both technical and financial control.

Mr. Beesley repeated that he could not agree to the use of a performance figure (for milling) which was based on a relationship that was uncontrollable. In support of this statement he quoted the difference between brix and sucrose extraction for four mills for the 1957 season. All these mills gave figures very close to 30 Lost Absolute Juice per cent Fibre yet the differences were 0.56, 0.92, 0.50 and 0.52.

Mr. Fourmond said that such differences as Mr. Beesley had mentioned could be explained by the

nature of fibre. Whereas trash would increase the fibre, where a lot of mud was concerned, then this was a different matter. One found the boiling house efficiency was higher on the South Coast than it was on the North Coast. Was this due to more efficient working or was it due to the cane? Comparing yearly figures one found that the boiling house efficiency varied without any change in technique. This must be due to the nature of the impurities in the juice. He had worked on various figures showing a milling loss of 30 per cent. In general, studying the figures, he had found an average of 0.8 per cent between brix extraction and sucrose extraction.

Mr. van Hengel doubted that the milling performance figure suggested, was a more practical formula than Lost Absolute Juice per cent fibre.

Mr. Antonowitz said that possibly only one sugar factory in South Africa would be interested in calculating crystallisable sugar in cane and that was Umfolozi, which used a similar formula (or modification), to evaluate cane. He asked Dr. Douwes-Dekker if his formula modifying the Umfolozi formula was in any way similar to that outlined by the author.

Dr. Douwes-Dekker replied in the negative.

Mr. Fourmond said the millers were interested in buying crystallisable sucrose and not total sucrose, therefore the value of cane should take into consideration both fibre and purity of the juice. If cane value was based on crystallisable sucrose, the quality of cane delivered at the mills would improve automatically with the result that efficiency and throughput would go up, corresponding to a shorter crushing season. The farmers would also score as they would be carting less fibre and impurities. It would definitely contribute to bring down the cost of sugar production.

Mr. Thumann said the comparison from mill to mill was in some countries made by the Reduced Extraction figure. The fibre per cent of the cane was something which was eliminated in the account in such a formula. If one had a hard cane with hard internodes extra power would be required as compared with low fibre cane. He supported Mr. Fourmond's idea that there should be an overall figure such as suggested by Mr. Fourmond. He had never known in any other countries boiling house recoveries to vary from week to week as they did in South Africa. He thought that a paper such as this might lead to further papers which would lead to a better system than the one we have now.