WHITE SUGAR MANUFACTURE AT ENTUMENI MILL

By R. A. CARTER

Evolution of Process

We have in past years received some very adverse criticism about the quality of our mill white sugars, because of the considerable variation in colour and grain size which often gave it a most unsatisfactory appearance. The management's declared policy was, therefore, to place quality first before quantity, as the time would soon be on hand when competition would be keen, and we had to place a good product on the market.

Objects of Process

Firstly to produce a good quality of sugar which would command top price in the Mill White category.

Secondly to have our sugar recognised as a quality product by the Industry.

Thirdly to show that it was possible to produce a mill white sugar direct from the cane, which would be suitable for all domestic purposes.

Comparative figures of analyses are shown in Table No. 1.

TABLE 1

	Colour Type	Colour Intensity	Turbidity	Conductivity	Ash	Moisture	Reducing Sugars	SO_2 p.p.m.
S.A.B.S. Refined	.025	.015	.030	60	.030	.06	.030	25
Entumeni Av. for Season	.008	.008	.085	72	.045	.07	.006	61
S.A.B.S. Mill White	.045	.040	.180	140	.100	.06	.030	70
Entumeni Remelting Period ...	.009	.009	.085	73.5	.046	.079	.005	63
Entumeni No Remelting	.006	.003	.087	66	.040	.063	.010	56
Entumeni Best Two Weeks	.008	.006	.070	60.75	.038	.06	.004	57
Entumeni 94 Purity Massecuite...	.009	.009	.112	77.1	.053	.06	.013	102

Clarification

The quantity of chemicals used for the season were as follows:

	Per ton Cane	Per ton Sugar
Lime	8.10 lbs.	68.36 lbs.
Sulphur	3.59 lbs.	30.30 lbs.
Phosphoric ...	0.60 lbs.	5.06 lbs.

The figures may seem to be excessive, and may in fact be more than is necessary for good clarification, but, under existing conditions, these quantities had to be maintained.

The juice from the mills is unfortunately not well screened, and a lot of Bagacillo comes into process. This tends to retard the settling rate of the juice due to flotation.

After leaving the scales, the juice is heated to 140°F. and then limed to more than 12 pH. The filtered juice is also returned at this stage and mixed in with the incoming juice from the mills.

From the pre-liming tanks the juice is pumped to the sulphur tower where it is sulphured to 3.5 to 4 gms. per litre, and thence to the correcting tanks where the phosphoric acid is added, and the juice finally tempered to 7.2 pH before boiling and settling. The settling tanks are the old type and juice is drawn off by means of siphon pipes. It is, of course, inevitable that a certain amount of precipitate is periodically drawn off and sent to the evaporators.

Syrup

This is kept at 32°-33° Be. The disadvantage here is, of course, the difficulty in settling the syrup at this concentration. There appears to be a definite limit to what can be achieved by ordinary clarification means, and the peak is reached in the last vessel of the evaporators, where, after a certain concentration, a considerable amount of impurities is precipitated in the form of scale.

If we could either centrifuge or filter our syrup, it is possible that a far better quality of sugar could be produced.

Mid-Sap Process

This was tried out on a small scale, the syrup taken from the second vessel of the triple effect, and was about 15° Beaume. This was treated with lime, sulphur and phosphoric and either settled or filtered.

The resultant liquor was very nice and clear, though no increase in purity was observed, and the sugar made therefrom in a small pan, capable of boiling about 1½ cubic feet of sugar at a time, was not of a sufficiently good quality to merit very much attention, though, perhaps, with more and better facilities, some very good results could be obtained.

Mother Liquor for First Massecuites

This consists of syrup with constant addition (while curing) of remelted second massecuite sugars and rich washings from the after-curers of the white sugar centrifugals.

Boiling of First Massecuite Strikes

These were grained and built up on mother liquor only, in a 10-ton pan.

Sufficient liquor was taken into the pan and concentrated to reach the pre-crystallization stage when the pan was about one-third full. Then, just prior to graining, about 4 ozs. of sodium hydrosulfite was added. After mixing this in, a pint of 30 per cent. phosphoric acid paste settled solution was drawn in.

The object of all this was to ensure that the mother liquor was as colourless as possible at the point of graining.

At this stage, a certain amount of sugar dust was added as shock seed, and the quantity of crystals formed was visually controlled by the pan boilers.

By doing this, we were sure of having a good clear nucleus to work on and the rest followed automatically.

Pans were only cut once, as we had to be careful about crystal size. Another point about graining was that we endeavoured to establish our seed at a fairly high temperature, say about 160° F. This seemed to ensure a very free sugar without any conglomerates.

Boiling of Second and Third Massecuite Strikes

The mother liquor in these instances consisted of first molasses and wash from the first massecuite fore-curers, with the addition of syrup bottoms.

The usual procedure was to reserve a tank for syrup bottoms and make at 50/50 mixture with first molasses. This was used for graining purposes. The graining method was similar to that employed for first massecuites, only no hydros or phosphoric was used, and rather more sugar dust.

Sufficient crystals were formed in this medium for as many as four strikes of second and third massecuites, but normally we cut to one pan for a third massecuite, then cut to a seed mixer for future use, and built up the mother pan for a second massecuite strike.

Centrifugals and Curing

The first massecuites are double cured. First they are cured in three 30″ water-driven machines and then washed in a magma with rich runnings from the after-curers, and finally cured in 3 × 30″ after-curers, washed and dried. These three machines have handled as much as fourteen tons of white sugar in eight hours.

The second massecuites are all single cured and the sugar washed in the centrifugals to ± 99° Pol. for re-melting purposes. For this purpose we have 2 × 30″ water-driven centrifugals, which cure up to seventy tons of sugar per week at peak periods.

The second massecuites cured very easily and only twice gave trouble—when a fresh strike was mixed in a crystallizer still containing some old massecuite.

The third massecuites are double cured, and here we have our biggest capacity, but, unfortunately, not enough speed, i.e. 3 × 36″ belt-driven machines as fore-curers, and 2 × 36″ machines as after-curers running at 960 r.p.m. This speed is not high enough to eliminate all the molasses from our third massecuite strikes, and we have to resort to steam in order to prevent too much exhaust molasses being returned to process in the third wash.

This third wash is kept in a separate tank, is of 60° purity and is used to top up the second massecuite strikes as well as for magma for third sugars.

With high speed machines here, we could drop the purity of our final molasses and put at least one per cent. on to our boiling house recovery.

The Remelting and its Effects.

The remelting of second sugars was almost automatic and proceeded with very little trouble. In all, we remelted 31,848 cubic feet of second massecuite sugars over a period of 17 weeks, i.e. 312 cubic feet per day. In addition to this, the washings from the after-curers of the first massecuite were added to the syrup.

From all this, an additional 30,340 cubic feet of first massecuite was boiled over the same period.

Therefore the proportions of first, second and third massecuites boiled over this period were as follows:—

60.2 : 22.6 : 17.2, (cured)

68.9 : 11.4 : 19.7, (bagged)

The proportion of second massecuite was bagged to facilitate supplied of Grade II sugars to local stores.

As this second sugar was, for most of the time, remelted in clarified juice by-passed from the pre-evaporators, a certain load was eliminated at this stage, and the extra syrup to the pans was in the region of 130 gallons per hour at 32° Beaume. This quantity was not sufficient to impair our work in any way.

A possible disadvantage to the final sugar quality may be caused by remelting in clear juice, because the scale, which would otherwise be precipitated out in the last vessel of the evaporators, is still retained in this juice.

The Purity Factor

This has always been an interesting factor in our work, and I think we still have a lot to learn about the relation of purity to final quantity and quality of the product.

Take, for example, the purity of our remelt, which is in the region of 94-95 per cent. This solution still contains the impurities which are normally precipitated in the last vessel of the evaporators as scale, while the syrup purity direct from the evaporators may be 88 or 89, but will be without the scale-forming precipitates. Perhaps this is why, when sugar was made chiefly from remelt, it was decidedly inferior in quality to that made from a mixture of remelt and syrup. (See Table No. 1 for comparisons).

This is an interesting feature which needs investigation and could, perhaps, lend substance to the contention that "It is not the 'quantity' of impurities that has such a bearing on the recovery and quality of the sugars, but rather the 'types' of impurities present in the juice."

General Observations

When comparing the production of white sugar with that of cargo sugars, it is very difficult to assess data accurately.

During the periods 3 and 4 in Table No. 2, we were unfortunate in breaking both crusher and mill rollers, which caused a decrease in the crushing rate and an increase in the moisture content of the bagasse.

In addition, the sucrose in the cane dropped, the yields of sugar from first massecuites went sky-high, the number of boilings of massecuites were considerably reduced and we were losing a lot of exhaust steam to the atmosphere.

Our figures for fuel consumption, are therefore, not by any means a true reflection of what might have been, because we could have produced much more sugar, had we been able to get it into the factory, for the amount of steam available.

After ceasing to produce white sugar, we were all prepared for some fantastically high boiling house recovery figure, but we were sadly disappointed because it just did not work out that way.

We used syrup to boost our first molasses purity, and because of the increased yields in sugar from first massecuites, we had a greater drop in first molasses purity. The actual drop was from 77 to 71.

It might be policy at this stage to build the third massecuites on syrup seed. As the export quota of sugar is now increased, we will have a better chance of working in this manner next season.

With modern equipment in the factories, such as continuous clarifiers, high-speed centrifugals and, of course, some means of purifying the syrup (particularly by centrifuging, if possible), it should not be beyond the bounds of possibility to produce an excellent quality of white sugar in our factories without forfeiting too much in recovery.

It would probably be advantageous to either remelt our second sugars in water or else remelt as usual, and return to the clarification station to mix in with the incoming juices from the Mill.

The undetermined losses are, of course, there as usual, but, from certain observations, it would appear that the main sources of these losses are in the initial stages of the process, particularly in the pre-liming stage, recirculation of filtered juice and the excessive heating in the pre-evaporator towards the end of the week, when working on 4 to 5 lbs. back pressure in the vessel itself.

Other losses, of course, must occur in the remelting process, but not to the extent we anticipated.

The only figure that causes real concern is the turbidity of 0.085. This is going to prove difficult to reduce. Apart from the remelt being in part responsible for this, there is also the possibility that our massecuite conveyor plays a big part in this matter, as all our massecuites are discharged through the same conveyor and a few grains of off-colour sugar in our sample could quite easily cause the turbidity to rise.

I am not going to comment on the figures given, as I feel they speak for themselves.

The one good feature about the way we have been operating at Entumeni is the extreme versatility of the process. If well laid out, with a special elevator for white sugar only, a change-over from production of low grades to white sugars, and *vice versa*, can be made at very short notice without unduly upsetting the normal routine of the factory.

Of special interest is the fact that the quality of the sugar made during the second period when remelting was stopped, was better than that made in the first period.

To my mind, the complete success of a venture of this kind must be based on the elimination of all the colloidal matter in the syrup, and I would like to take this opportunity of asking our engineering friends present here to-day to give the matter their consideration, and endeavour to produce the necessary equipment for this purpose.

Acknowledgments

For the ultimate success of our efforts, credit is due in the first place to the Experiment Station Staff at Mount Edgecombe, who in recent years have produced the necessary quality of cane. There is reason to believe that, when some of the newer varieties are available, the task of producing superior sugar will be still easier.

Also I would like to thank Dr. Douwes Dekker and his Staff for their assistance and their part in fostering new ideas and giving us a lot of useful information.

Thirdly, a great deal of credit must go to the pan-boilers at our factory for their whole-hearted efforts to "deliver the goods."

TABLE 2

	First Period 20/5/53 26/9/53	Second Period 27/ 9/53 24/10/53	Third Period 25/10/53 14/11/53	Fourth Period 15/11/53 28/11/53	Season to 28/11/53
Tons of Cane Crushed	38,354	7,641	6,061	3,822	55,878
Tons of Sucrose in Mixed Juice	5,088	1,025	767	475	7,355
Tons of Sugar Bagged	4,480	931	705	436	6,552
Tons of Sugar Made and Estimated	4,580	932	707	431	6,650
Commercial Sugar Recovery	90.02	90.93	92.18	90.74	90.42
Sucrose Recovery	89.52	90.25	90.87	89.23	89.71
Total cubic feet First Massecuite Bagged	151,886	25,588	16,785	9,857	204,116
Total cubic feet Second Massecuite Cured	57,080	9,774	6,598	4,780	78,232
Total cubic feet Second Massecuite Remelted	31,848	—	—	—	31,848
Total cubic feet Second Massecuite Bagged	25,232	9,774	6,598	4,780	46,384
Total cubic feet Third Massecuite Bagged	43,205	9,697	6,156	4,101	63,159
Total cubic feet First, Second and Third Massecuite Cured ...	252,171	45,059	29,539	18,738	345,507
Total cubic feet First, Second and Third Massecuite Bagged...	220,323	45,059	29,539	18,738	313,659
Tons of White Sugar Bagged	3,370	602	13	47	4,032
Tons of Other Grades Bagged	1,110	329	692	389	2,520
Total Sugar Bagged	4,480	931	705	436	6,552
Average Yields in lbs./cubic foot Bagged	40.67	41.32	47.73	46.54	41.78
Cubic feet of Massecuite per ton Sugar	49.18	48.40	41.90	42.98	47.87
Cubic feet of Massecuite per ton Sucrose Mixed Juice... ...	43.76	43.96	38.51	39.45	42.64
Cubic feet of Massecuite Made/Ton Cane	6.57	5.90	4.90	4.90	6.20
Purity of First Massecuite...	90.03	89.54	88.53	88.43	89.67
Purity of First Molasses	77.26	74.76	70.84	70.91	75.71
Purity of Second Massecuite	74.64	71.70	69.04	69.94	73.26
Purity of Second Molasses...	56.54	55.47	53.27	53.47	55.81
Purity of Third Massecuite	62.65	61.38	60.29	61.06	62.10
Purity of Third Molasses	41.64	41.44	41.05	41.44	41.54
Average Polarization of all Sugars	99.445	99.252	98.586	98.34	99.21

	Combined Periods (First and Second)	Combined Periods (Third and Fourth)	Season
Commercial Sugar Recovered	90.17	91.63	90.42
Sucrose Recovery	89.64	90.24	89.71
Purity of Mixed Juice	87.91	87.51	87.86
Average Yield/cubic foot Massecuite	40.78	47.15	41.78
Cubic feet Massecuite/per ton Sugar	49.04	42.42	47.87

STEAM AND FUEL CONSUMPTION

	First Period	Second Period	Third Period	Fourth Period	Season
Total lbs. Boiler Steam Flow	56,305,000	11,343,000	8,268,000	5,265,000	81,181,000
Tons Firewood used	1,642	342	226	120	2,330
Tons Bagasse used	13,568	2,735	2,115	1,419	19,837
Firewood at 35 per cent. Moisture. Dry Substance	1,067	222	147	78	1,514
Tons Dry Substance in Bagasse	6,928	1,367	1,039	692	10,026
Tons Dry Substance available as Fuel	7,995	1,589	1,186	770	11,840
Lbs. Steam/Ton Sugar	12,293	12,170	11,694	12,216	12,208
Lbs. Dry Substance/Ton Sugar	3,491	3,410	3,355	3,574	3,470
Lbs. Steam per lb. Dry Substance	3.52	3.57	3.48	3.42	3.52

	Combined Periods (First and Second)	Combined Periods (Third and Fourth)	Season
Lbs. Steam per Ton Sugar	12,278	11,892	12,208
Lbs. Dry Substance per Ton Sugar	3,477	3,438	3,470
Lbs. Steam per lb. Dry Substance	3.53	3.46	3.52
Fibre per cent. Cane	16.48	15.93	16.33

N.B.—*First Period:* Remelting of "B" Sugars. Washing in fore- and after-curers.

Second Period: No remelting, but washing in fore- and after-curers.

Third Period: Only 13 tons white sugar boiled in previous period. "A" molasses boosted with syrup for grain for "B" and "C" sugars.

Fourth Period: 47 tons white sugar. "A" molasses treated as in third period. No remelting.

Mr. Rault (Chairman) said that the author was not only turning out an excellent mill white sugar but was also setting an example which should be followed in clarifying the controversial term "quality" by applying more definite analytical standards as suggested by the South African Bureau of Standards. The appearance of a sugar to the naked eye, as against measurement by instruments and expression of the results in figures had not yet reached international finality, but in the near future at the June, 1954, Paris Congress, agreement amongst world sugar technologists was likely.

Using the methods of colour determination suggested by the South African Bureau of Standards he had come to the conclusion that the appearance of a refined sugar was influenced as much by the turbidity, as it was by the colour, of the solution of the sugar after filtering through a very tight filtering medium. If he were correct in this conclusion, perfect filtration in the factory was nearly as important as decolorisation, and this pointed to sulphitation-defecation factories being at a disadvantage.

He found it difficult to reconcile the drop in quality of sugar boiled from a large percentage of high purity remelt, as mentioned by Mr. Carter, with his own experience at Mount Edgecombe factory, where recrystallisation on high purity liquors was one of the main factors in improving quality.

Dr. Douwes Dekker said that the Entumeni sugar was characterised by a rather high figure for turbidity. As causes for the high turbidity, Mr. Carter had mentioned (*a*) finely suspended solids in syrup, and (*b*) non-sugars not deposited in the evaporator. It was, however, necessary to take actual quantities into account when these causes were discussed. Actually the amount of suspended matter taken out in the evaporator was very small. He did not think that using clarified juice which might have deposited matter on the tubes of the evaporator could make any difference to the final result as far as the quality of sugar was concerned. The amount of suspended matter in syrup was small relative to the amount produced during the boiling process. Therefore by centrifuging syrup no gain would really be made. He noticed that Mr. Carter was in the habit of introducing phosphoric acid paste into the pan when graining. It was likely that calcium phosphate might be included in the crystals while they were being formed and this might be the cause of some of the turbidity in Entumeni sugar. Also syrup bottoms were introduced into the B massecuites and they also could lead to a similar result of suspended matter persisting through to the sugar crystals.

Mr. Phipson asked if it would not be better to treat remelted sugar with lime and phosphoric acid and settle it or filter it. Would this not improve the turbidity of the sugar? Also, if he did not think it possible to introduce syrup and remelt sugar into the pan at the same time.

Mr. Carter said that the remelt was mixed in with the syrup. He asked Mr. Rault if he still reintroduced remelt into the raw juice and why he did this.

Mr. Rault replied that the only sugar remelted in raw juice was the third massecuite crystal, which although affined to 98/99° purity, was judged too coloured for reboiling to a refined sugar and was passed through the carbonation stage of clarification where it lost its identity and raised the evaporator thick juice purity one to two degrees. Sulphitation raws of 98° Pol. and over were similarly treated, due to their low filterability if not carbonatated.

The very light crystals purged from the 84/86° purity was also not marketed but washed to over 99° purity, remelted and brilliantly filtered through diatomacious earth and formed the nucleus of the refined sugar.

In this technique, recrystallisation, filtration and high degree of purification, contributed to the quality of the refined sugar, which was produced from the first boiling only. This was on similar lines to the beet granulated methods of crystallising from one "standard liquor" mixture of remelt sugars and thick juice from the carbonatation process. We have, however, gone a step further for safety on account of the variable cane juices of this country. We segregate the two filtered liquors, start graining on the purer and lighter liquor and only use thick juice at the later stage of crystallisation with the grain well advanced, so that colour concentration on the outer layers of the crystal can be more effectively washed away at the centrifugal stage.

Mr. Carter asked if anybody could prophesy that an aluminium compound might take the place of lime in clarification. If something like alumina could be used it would be possible probably to eliminate floc now present in the clarified juice.

Dr. Douwes Dekker feared the objection was the cost. He thought that our efforts should be directed towards decreasing and not increasing the amount of chemicals now used.

Mr. Carter said he was once a strong advocate for the cutting down of chemicals, but he must admit now that he was wrong. He regarded phosphoric acid as being essential.

Dr. Douwes Dekker pointed out that the phosphate content of our juices was very low and probably it was essential to add it. He was of the opinion that the best place to add phosphoric acid was just after the scales so that when lime was added calcium phosphate was formed immediately. The present method of adding phosphoric acid in the settling tanks was certainly convenient, but not necessarily the best way.

Dr. Van der Pol said that we should aim at reducing the amount of chemicals required to produce raw sugar and remelt it all. By a separate refinery process we would then produce a white sugar of excellent quality at comparable costs.

In answer to Mr. Carter he quoted figures showing that, as compared with the normal syrup produced, a special sample of syrup made by Mr. Carter, without the use of sulphur, showed superior results in all respects except colour. Since it is possible that the cause of possible refractoriness had not been analysed for, he had tried to isolate the compound responsible for the different properties of a defecation syrup. So far no definite conclusions have been reached.

Mr. Carter said that as far as he could see a raw sugar produced using clay, lime and phosphoric only could be remelted to produce a good quality of white sugar, when such liquor was passed through the ordinary clarification process again.