

# MOLASSES GRAINING AND THE MAGMA SYSTEM UNDER NATAL CONDITIONS

By C. L. STEYN

Due to the recent interest in graining on molasses and the magma system of boiling, it was felt that some notes on Umzimkulu practice would be of interest to the Natal Industry.

At Umzimkulu the molasses graining technique has passed the experimental stage and for the past two seasons has been standard practice, and, at no time (other than a few days at the commencement of the crop) has syrup, or material of more than 70° purity, been used for routine graining.

In 1948, due to a bottleneck at the A and B massecuite centrifugals and the high cost of additional machines, graining on molasses was tried in an endeavour to obtain a regular sugar crystal which would cure freely and thus increase capacity. This met with varying degrees of success, due to the human element, as good results could not always be reproduced. The pan-boilers, accustomed to syrup graining, found the greatest difficulty in optically assessing the graining conditions of dark coloured and more viscous molasses.

In 1952 a recording cuitometer was installed and a standard boiling pattern evolved by trial and observation. This standard now gives a uniform grain, free from conglomerates or smear, and the boilings can be reproduced with as little as  $\pm 0.01$  mm. difference in grain size between strikes.

The method of operation is as follows:—

The graining charge of A molasses of 68° purity and 70° brix is drawn into the pan and boiled down at highest vacuum, so that when concentrated, it will occupy one-third of the strike volume. When the conductivity reading reaches 68 mA., with the voltage regulator set at 4, the pan temperature is raised to 160° F. The conductivity rises with the temperature and then falls again, due to further concentration. When it again reads 68 mA. the charge is ready for seeding and 100 grams of sugar dust is rapidly drawn into the pan. (This dust is obtained by grinding coarse, conglomerate-free sugar to a fine powder in a pestle and mortar, the powder then being screened through 48 mesh and dried). The dust is mixed, weighed into several bottles and stored ready for use.

100 gm. dust gives a mean grain-size of  $0.30 \pm 0.01$  mm.

150 gm. dust gives a mean grain size of  $0.25 \pm 0.01$  mm.

on a finished C massecuite of 800 cu. ft.)

Boiling down is continued until the cuitometer reading is 55 mA., whereupon hot balancing water feed is started, and the conductivity held constant until the seed has developed (after 2 to 2½ hours). The balancing water is now gradually diminished and the temperature lowered to 145° F. At 35 mA. the water is shut off and feed of 54—55° purity B molasses commenced, the conductivity reading being kept constant until the pan is nearly full.

Approximately one hour before the pan is full, the temperature is again raised to 160° F. The strike is completed at this temperature and struck at 32 mA. This gives a C massecuite of 59—60° purity with a brix of  $97 \pm 1.0$ °. The overall time taken for one full stike is 8 to 9 hours.

A typical example of the condition of the massecuite at different pan levels is indicated by:—

| Pan Level       | Temp. °F | Vac. gauge ins. Hg | mA. | Bx.  | Purity |
|-----------------|----------|--------------------|-----|------|--------|
| Seeding ... ..  | 160      | 24                 | 68  | 90.0 | 67.5   |
| Balancing water | 160      | 24                 | 55  | 92.5 | 67.5   |
| ¼ pan ... ..    | 145      | 26                 | 36  | 95.5 | 61.2   |
| ¾ pan ... ..    | 140      | 27                 | 36  | 96.5 | 59.9   |
| Full ... ..     | 160      | 24                 | 32  | 97.5 | 58.8   |

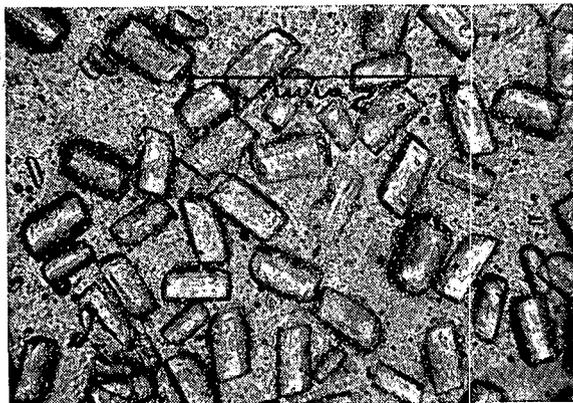
For the successful operation of this system it is essential to have complete control of the graining pan, (i.e. a regular steam supply and independent vacuum control), so that the boiling temperature may be fully controlled for both graining and boiling. A recording conductivity instrument, such as the Cuitometer, is also vitally important as a substitute for the eye, touch and memory of the pan boiler.

Seven years ago, when normal 3-boiling system with syrup grain for all three strikes was in use, the magma system, using C sugar mingled with A molasses as seed for the A and B strikes, was tried. This scheme gave a great deal of trouble and had to be abandoned for the following reasons:—

- (1) The original syrup grain was inconsistent—while some strikes were good, others were so full of conglomerate and smear that the subsequent use of this sugar as seed was unsatisfactory.
- (2) The C massecuite was cured to 80—85° purity and mingled with A molasses. The recirculation of so much non-sugars caused excessive viscosity.
- (3) The C magma was pumped to a storage crystallizer under the pan floor and the cold material

drawn up into the pan by vacuum. The result was frequent clogging of the suction pipe and time lost in the pan by having to heat the magma to boiling temperature.

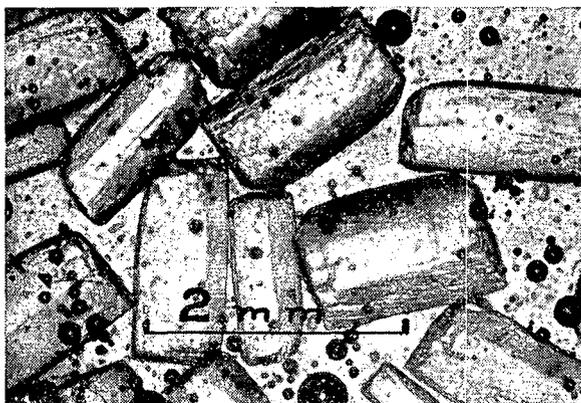
A modified magma system, using molasses grain-  
ing, was introduced last season and proved an out-  
standing success.



Typical Umzimkulu C massecuite  
(diluted with anhydrous glycerin)



Typical Umzimkulu B massecuite  
(diluted with anhydrous glycerin)



Typical Umzimkulu A massecuite  
(diluted with anhydrous glycerin)

Under this present system the C masse is cured and washed in the centrifugals to give a sugar of 95° purity which is then blended with syrup to form a magma of 87° brix and 89° purity. This is transferred by rotary pump to a storage vessel, fitted with heating tubes, on the pan floor. From here it is drawn into the B pan up to the one third mark and boiled up to the two thirds mark on syrup feed. Half of this is then cut to the A pan. The B pan is then fed with A molasses to make one B strike. The A pan is fed with syrup until full, whereupon half is cut back to the empty B pan and so two A strikes are made. Hence 200 cu. ft. of magma results in a total of 1800 cu. ft. of A and B massecuite.

Typical grain sizes for the three massecuites are:

C sugar crystal size—0.31 mm.

B sugar crystal size—0.60 mm.

A sugar crystal size—0.87 mm.

These sugars are illustrated by the photomicrographs shewn.

The introduction of the magma system at Umzimkulu has resulted in an increase in the volume of massecuite boiled per ton of sugar produced. This is illustrated by the following table:

|                             | 1951                                       | 1952  | 1953   |
|-----------------------------|--|---|--|
|                             | Three-boiling<br>system,<br>syrup<br>grain | Three-boiling<br>system,<br>molasses<br>grain | Three-boiling<br>magma<br>system,<br>molasses<br>grain |
| Mixed juice purity          | 84.96                                      | 86.60   | 85.09  |
| A Masse purity ...          | 82.10                                      | 86.80   | 86.04  |
| B Masse purity ...          | 70.30                                      | 74.40   | 76.41  |
| C Masse purity ...          | 61.24                                      | 59.80   | 59.30  |
| Final Molasses ...          | 40.94                                      | 39.04   | 40.24  |
| Cu. ft. Masse/<br>ton sugar | 55.93                                      | 51.53   | 54.06  |

It will be seen that the increase, in the comparison between the 1952 and 1953 seasons, amounts to about 5 per cent. on massecuite volume, some of which can be accounted for by the lower mixed juice purity in 1953. However, this increase in massecuite volume has presented no practical difficulties in the factory—in fact there has been a substantial increase in both pan and centrifugal capacity. This is due to the A and B strikes starting on a fully developed uniform grain footing, and to boiling higher purity massecuites, resulting in a sugar so free curing that the A and B centrifugal capacity has increased by 35 per cent. Whereas previously the eight 36" water driven centrifugals (used alternately on A or B massecuite) were working at full pressure throughout, now only four machines are used for A's and five and sometimes six for B massecuite. Two machines have been idle and lay dormant throughout the crop. From a bottleneck,

a position of increased capacity potential has been created.

Another advantage of the present system is that all the sugar bagged is from two high purity strikes, 73 per cent. from A massecuite of 86.04° and 27 per cent. from B massecuite of 76.41° purity, the C sugar being eliminated. The average pol of the mixed A and B sugars for the 1953 season was 98.28°.

In the older method sugar was bagged from three massecuites of 82.10°, 70.30° and 61.24° purity. The sugars were all mixed and the C sugars were small grained, sticky and of poor quality.

All massecuites are single cured.

The C centrifugals are 30" × 1300 r.p.m. machines, provided with a double gutter and manually operated cut-over to separate the wash from the final molasses. The wash of 48—52° purity is mixed with the B molasses. Unfortunately these machines are under capacity and so require an excessive amount of steam and wash water. This results in erosion of the crystals and so increases the final molasses purity.

This paper has been presented as a simple record of facts and performance obtained under practical factory conditions, and as such, may prove helpful to others. There is no doubt that the raw sugar produced is an ideal material for the refinery.

In conclusion I would like to thank Mr. Beesley of the Sugar Milling Research Institute for the massecuite photographs and for his efforts in computing the grain size of many samples of massecuite sent to him.

**Mr. Rault** (Chairman) said the papers read by the three new contributors to our congress had one common feature, namely, the crystallisation stage of sugar technology.

He welcomed Mr. Beesley from the S.M.R.I. staff, who had lately returned from overseas, and was adjusting outside practice to local conditions and reporting on his difficulties in this preliminary work.

Mr. Ducasse, an experienced sugar-boiler, had constructed a pan control instrument of a simple design for guiding the sugar boiler and had explained in a very lucid way the principle and the working of this instrument, which, in view of its cheapness, he hoped should be adopted not only on the vacuum pans but also in crystallisers to check dilution during cooling.

Mr. Steyn had given in great detail the results of his two years' experience in successfully practicing crystallising methods somewhat uncommon to South African factories. His contribution was welcome, as many South African factories are under capacity, due to the rapid expansion of the industry. He

claimed that at least one department, namely the centrifugal, could have its production capacity increased without large capital expenditure, by altering the crystallisation technique.

**Mr. Elysee** asked if Mr. Beesley proposed, in future work, to record not only crystal sizes, but also quantity or surface area of the crystals. As far as Mr. Ducasse's paper was concerned, he knew that Mr. Ducasse had worked for the past five years on his instrument. His contention was that a cuitometer could give false readings because of fluctuations in factory current. He asked if Mr. Ducasse could increase the current from his instrument in such a way as to produce a chart.

**Mr. Beesley** said that as far as crystal area was concerned, the control of the number of crystals present and the purity limits (massecuite to molasses) used, automatically defined crystal size and hence crystal surface area.

**Mr. Elysee** stated that he wanted to know what percentage of crystal would be desirable for a given massecuite volume.

**Mr. Beesley** replied that Gillett, in America, recommended about 46 per cent. crystal for C massecuites, and to obtain such a high percentage with reasonable crystal size it might be necessary to increase the massecuite purity to provide sufficient sucrose.

**Mr. Ducasse** said that by increasing the number of electrodes in parallel, the amount of current could be increased, but it was less trouble to look after one electrode than several. He demonstrated that it was possible when the reading became very low to step it up to give a higher reading. In the same way the current could be stepped up to record on a graph.

**Mr. Davies** said that he had tried to make C sugar magma, using A molasses rather than the high purity syrup used when making B massecuites, but he experienced considerable trouble until he diluted the molasses.

**Mr. Steyn** pointed out that when a C sugar was cured it was mingled with syrup and used as a developed seed footing for A and B massecuites.

**Mr. Davies** considered it a mistake to use syrup when making magma, when it was intended to boil a B strike from the magma.

**Mr. Elysee** supported Mr. Davies' argument.

**Mr. Beesley** said that Mr. Steyn used his C sugar as a footing for both A and B strikes. It would therefore be a mistake to use any molasses for this magma.

**Mr. Steyn** said that the addition of molasses only to the B strike presented practical difficulties. Not only would an additional storage vessel be required,

but the curing of the massequite would be slower, because of the resultant smaller grain size and lower purity. Under the magma system the purity of the B and C strike is predetermined. To obtain a C strike of 60° purity and using a graining charge of 68° purity A molasses, a feed of 55° purity B molasses is required; hence the B massequite uses, as footing, magma mingled with syrup and built up with A molasses to give a set purity of 76° for the strike, from which the run-off molasses of 55° purity is obtained. Therefore, to add molasses only to form a magma would result in too low a B molasses purity, which in turn would reduce the C strike to an undesirably low purity.

**Mr. De Froberville** queried the low purity of seeding charge used for C massequite.

**Mr. Steyn** explained that 68° purity molasses was used as the graining charge for the C massequite footing on which 55° purity molasses was fed to produce a finished massequite of 60° purity. On curing, the sugar from this massequite was blended with syrup to give a seed magma of 89° purity for the A and B strikes.

**Mr. Phipson** related that at Empangeni, mingling C sugar with first molasses, when using it as a footing for B massequites, was tried and this worked well.

**Mr. Rault** asked of the three contributors whether in view of their reliance on conductivity instruments, they would be prepared to take the proof stick away from the pan boiler and be guided entirely by the reading of such instruments in boiling a complete strike.

**Mr. Beesley** replied that Mr. Steyn had already reached that position.

**Mr. Steyn** confirmed this, stating that the proof-stick method had been dispensed with, and in fact, the proof-sticks on the pans had seized up for want of use.

**Dr. Van der Pol** said that it might even be possible to go as far as they did in Australia, where pan control instruments were used to automatically regulate the feed to the pans.

**Mr. Ducasse** said that as a practical pan boiler he was convinced that the proof-stick could be eliminated and that pan-boilers generally should be encouraged to use instruments.

**Mr. Davies** asked if Mr. Ducasse's instrument would be of real assistance when trouble was experienced in graining a pan.

**Mr. Ducasse** said the instrument gave better results than the finger and thumb method. The secret of pan boiling, in any case, was to know the correct degree of super-saturation. This was provided by the instrument. Differences in purity could be corrected by an experienced pan-boiler. He mentioned that they had on occasion experienced

greater trouble with 89° purity syrups than they did with 81° purity syrups.

**Mr. Steyn** said that Mr. Ducasse's idea of giving different readings for different purities to the pan-boilers, was largely overcome by the molasses graining technique and magma system. When once mastered, the molasses graining method is far simpler to control than syrup graining.

**Mr. Ducasse** said that allowances had to be made for varying purities. One could not use the same reading of the instrument for all purities. Another thing to be taken into consideration was the amount of syrup which was introduced in shock seeding.

**Mr. Beesley** pointed out that Mr. Ducasse used "shock" seeding as against Mr. Steyn's "true" seeding, which probably accounted for the difference in opinion and that in his experience "true" seeding and the magma system greatly simplified control.

**Mr. Rault** thought that the technique carried out by Mr. Steyn in provoking initial crystallisation on a comparatively low purity medium and building the crystal on progressively purer liquors, would be detrimental to colour, if he had to produce a high standard of consumption of white sugar. The usual washing at the centrifugals practised in white sugar factories, could only be effective if the greatest intensity of colour was on the outside layer of the crystal. This was not quite the case in the magma system, where the core of the large crystal had then formed in a very impure and coloured medium. When colour was of prime importance and judged by the impression on the eye, a small crystal size was very helpful, although centrifugal yield was adversely affected.

The coarser grain raw sugar from the magma system, helped the affination stage of the refinery. It was a distinct disadvantage for the appearance of a high quality white sugar.

**Mr. Ducasse** was very doubtful if there was such a thing as true seeding. In answer to Mr. Rault, Mr. Ducasse said that as far as white sugar manufacture was concerned, that was more dependent upon clarification than upon pan-boiling.

**Mr. Beesley** replied to Mr. Ducasse that his statements were not only based on experience in Natal, but also on that obtained in Australia, where it was a well-accepted practice. In answer to Mr. Rault he was not prepared to say that true seeding would be applicable to white sugar manufacture, but he hoped to carry out some tests on this in the coming season.

**Mr. Phipson** said that he had seen a white sugar boiled from a footing of C sugar mingled with syrup and the crystals definitely had a grey colour.

**Mr. Thumann** said that there was no difference in the quality of grain used for white sugar as compared with raw sugar, provided the right methods

of clarification were used. The only time he had seen the colour of a sugar affected was when it was grained on molasses. This was probably due to the coloration of the seed itself and not due to the material from which the sugar was built up.

**Mr. Rault** stated that in producing white sugar a fine crystal size was required and it was much easier to produce raw sugar.

**Mr. Steyn**, defending true seeding, said that the only thing that fixed the crystal size and quantity, was the number of grains of sugar dust introduced into the pan and not the quantity of syrup drawn in. True seeding was the only reliable method of getting reproducible seed grain.

**Dr. Douwes Dekker** said that many systems of boiling control had been tried in the past. Each had had its own advocates. The conductivity method had not always found much favour in the refining industry. A group of experts on boiling in the beet industry had, however, come to the conclusion some years ago that more attention should be paid to that method, and the conductivity method was now being seriously studied by the refining industry. Mr. Ducasse's principle would throw new light on the conductivity method and Dr. Douwes Dekker said he hoped that Mr. Ducasse's paper would draw the attention of sugar experts throughout the world.

**Mr. Davies** asked for an explanation of his experience that strikes made from a developed syrup seed footing did not shew a consistent final crystal size.

**Mr. Beesley** pointed out that the way in which a strike was boiled (light, heavy or erratic) had a bearing on the final crystal size and that without a pan control record it was difficult to know what the pan-boiler had done with the massequite.

**Mr. Davies** replied that even when the massequites were boiled under his supervision the crystal size still varied.

**Mr. Beesley** then enquired if Mr. Davies could say that the quantity of footing being drawn into the pan was always the same, as if this varied, the grain size would also vary.

**Mr. Davies** replied that the quantity of footing was the same, but he would not be prepared to say that the number of crystals was the same in each case.

**Mr. Rault** said that for optimum reproducible results, we would have to rely increasingly on instrument action without altogether neglecting the personal observation of the experienced sugar boiler.