REFEREED PAPER

OPTIMISATION OF RECOVERY HOUSE OPERATIONS AT HULETT REFINERY

MNCUBE FS[1], RAMBUKUS Z[2] AND MUZZELL D[1]

[1]*Tongaat Hulett Sugar, Technology and Engineering Group, Private Bag 3, Glenashley, 4022, South Africa*
[2]*Hulett Refinery, 444 South Coast Road, Rossburgh, 4072, South Africa*
fred.mncube@tongaat.com zyven.rambukus@tongaat.com dave.muzzell@tongaat.com

Abstract

Huletts Refinery (Hulref) normally boils two recovery massecuites, but can boil up to three recovery massecuites. Second crop runoff is a by-product that was previously sold for lysine manufacture to South African Bioproducts (SABP), a company which is no longer a regular customer. As a result, Hulref is using the Tongaat Hulett Sugar raw mills as an outlet for second crop runoff. This has put pressure on Hulref to optimise the recovery house pan floor operations to recover as much sugar as possible from the return syrup that enters the recovery house from the refinery. The colour of the remelted sugar stream from the recovery house back to the refinery is also a concern. The affinated sugar colours were much lower than those of the unaffinated sugar. This revealed that the bulk of the second crop sugar colour comes from the mother liquor film surrounding the crystal. Irregular crystal size is one of the contributors of poor purging of massecuite. Consequently, the colour of the sugar cured is high due to mother liquor adhering to the crystals. This highlighted the need to investigate the pan boiling practices at the recovery house. The number of cuts of the second crop boilings was reduced from three or more to two. Slurry graining was also introduced instead of the waiting method. Regular and larger crystals were obtained when slurry graining was adopted. This resulted in better purging of massecuite and consequently low second crop sugar colours. A centrifugal screen monitoring programme was instituted, which helped to quickly identify damaged screens for replacement. Water spray nozzles and a lube rod were installed in one of the machines. Low second crop syrup purities were achieved due to improved purging and effective use of centrifugal water.

Keywords: colour, purities, pan cycles, centrifugal screen, centrifugal water

Introduction

Hulref has been a regular supplier of high test molasses (HTM) to customers for raw sugar coating and other end uses. Only one boiling was being done at the recovery house and the first crop runoff used to manufacture the HTM. The market for this by-product no longer exists. Hulref now boils two crops and is using the Tongaat Hulett Sugar (THS) raw mills as an outlet for second crop runoff. The costs of transporting second crop runoff to the respective mills are very high. The combined colour of the recycle stream of melted sugar from the recovery house to the refinery has increased, and consequently powdered activated carbon is being used to reduce the colour of this stream.

Because Hulref's recovery house operations have been dormant for many years, a lot of valuable skill and experience in the operating staff was lost and is now slowly being regained. Good exhaustion in the recovery house does not achieve a high purity product. The difficulty arises from the presence of impurities such as polysaccharides and oligosaccharides. These impurities are co-crystallised with sucrose in the raw house. When they enter the refinery in the melt, they become concentrated during processing (Morel du Boil, 1995). Longer boiling times are experienced (Moodley *et al*., 1996) and elongated grains are present (Morel du boil, 1991). Despite the difficulties associated with exhausting the recovery house runoff, Moodley *et al*. (1996) managed to reduce the recovery house runoff purity at Malelane to 46%. These good results were achieved by using three boilings sequentially in a continuous pan.

A task team was formed to improve second crop exhaustion at Hulref. This paper presents some of the issues identified and their effect on exhaustion and colour of the recycle stream. The recovery house at Hulref has two 20 m^3 and two 40 m^3 batch pans, used for first crop (FC) and second crop (SC) boilings respectively.

Pan temperatures

Most of the pan boilers in the recovery house come from the main refinery pan house. Some practices that have crept from the pan house to the recovery house, such as boiling at high temperatures, may be good for high grade massecuites but not for recovery house boilings The recovery house pans were boiled at 25 kPa (abs), reportedly to reduce viscosity of the liquor and improve the crystallisation rate. A trial was performed in the recovery house where the pans were boiled at 20 kPa (abs) for a week. Samples of sugar and runoffs were taken and analysed for colour and viscosity, respectively. The results are displayed in Tables 1 and 2. The viscosity was determined using a capillary viscometer at 20°C as described by Lionnet and Pillay (2006).

Table 1. The effect of temperature on viscosity at 20°C.

Viscosity (mPa.S)		
	25 kPa (abs)	20 kPa (abs)
Return syrup	9.4	8.7
FC runoff	11.1	9.1
SC runoff	16.5	9.1

Table 2. The effect of temperature on colour.

Colour (IU)		
	25 kPa (abs)	20 kPa (abs)
Return syrup	6 335	9 688
FC runoff	12 281	21 590
FC sugar	1 644	1 439
SC runoff	58 110	40 001
SC sugar	6 154	3 429

The overall increase in viscosity from return syrup (RS) to second crop (SC) runoff for the pans boiled at 25 kPa (abs) is 75%. The viscosity for the pans boiled at 20 kPa (abs) increased by only 39%. The above strongly suggests that the higher temperature in the pan increases the viscosity of mother liquor. The polysaccharides in the recovery house streams are relatively concentrated compared to fine liquor. At high temperatures they tend to degrade and form high colour and viscous compounds. The pan temperature must be kept as low as reasonably possible to minimise polysaccharide degradation. Viscous massecuites do not cure easily (Rein, 2006) and high colour sugar is produced. This colour is recycled with the sugar and increases the melt colour. Activated carbon is being used to reduce the high colour of the recovery sweet water, but this is an extra cost. The average colour of the second crop sugar and second crop runoff boiled at 20 kPa (abs) is approaching half the colour of sugar and second crop runoff boiled at 25 kPa (abs). A correlation obtained by Wright *et al*. (1995) indicates a direct relationship between viscosity and molasses drainage in the centrifugal. These results confirm that finding, and also emphasise the importance of boiling the pans at lower temperatures.

Pan cycles

The pan boiling cycle for the SC massecuite was modified, whereas the FC boiling cycle was not changed in any way. The aim of adopting a new SC cycle was to minimise the number of cuts and improve crystal content without compromising the grain size. Numerous cuts reduce the crystal content of the massecuite. The number of sugar grains in a strike effectively halves after a 50:50 cut, although the grain size grows. The surface area/volume ratio decreases, which reduces the effective area for crystallisation and reduces the crystal content. A low surface area increases the chance of false grain formation. The false grain does not grow to the average size of the crystal in the pan, hence the massecuite eventually consists of mixed grain. The presence of false grain decreases centrifugal operation efficiency. The purging of this type of massecuite becomes extremely difficult as the small grains lodge themselves in the interstitial spaces between big grains and consequently clog the pathways through which mother liquor drains in the centrifugal (Rein, 2006). If the false grains are very small they pass through the centrifugal screen and increase the purity of the runoff.

The new cycle depicted in Figure 1 was run for a week only due to pan capacity constraints. The cycle was then changed to that shown in Figure 2. To improve the grain size of the SC sugar, the SC seed was prepared in the small pans (A/B). The seed was grained on RS and fed with FC runoff (Figure 1). This seed was split 50:50 to produce SC and third crop (TC) strikes.

The photographs in Figures 3 and 4 show massecuite boiled on seed prepared by utilising the cycles in Figures 1 and 2, respectively. The SC massecuite boiled from seed prepared in the A and B pans in Figure 1 has bigger and more uniform crystals compared to crystals boiled following the cycle in Figure 2. The crystal distribution (CSD) data of these massecuites is shown in Table 3. The crystals of SC massecuite boiled on FC footing cycle as per Figure 2 are small and have a higher CV, which implies bigger crystal size variation. The higher CV can also be due to poor circulation in the pan. The stirrer in the C pan was found to be turning in the wrong direction, thus disrupting the massecuite circulation pattern in the pan. This situation existed for both Figure 1 and Figure 2 boiling cycles. The elongation ratio of crystals boiled on

RS footing cycle as per Figure 1 is marginally higher than that of the crystals boiled on the FC footing. This could have been due to the increase of the oligosaccharide fraction (Morel du Boil, 1991) in the raw sugar at that time of the year.

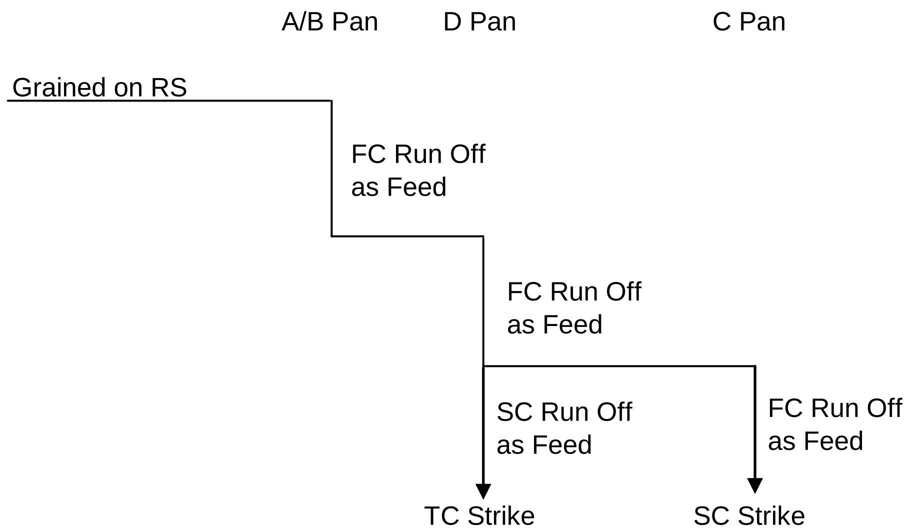


Figure 1. Seed preparation in small pans.

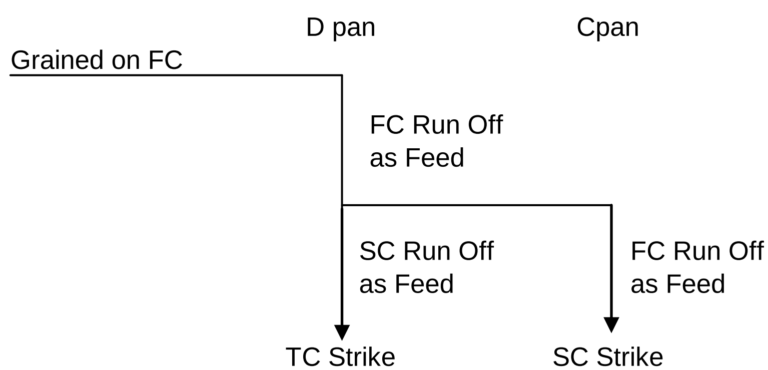


Figure 2. Seed preparation in large pans.

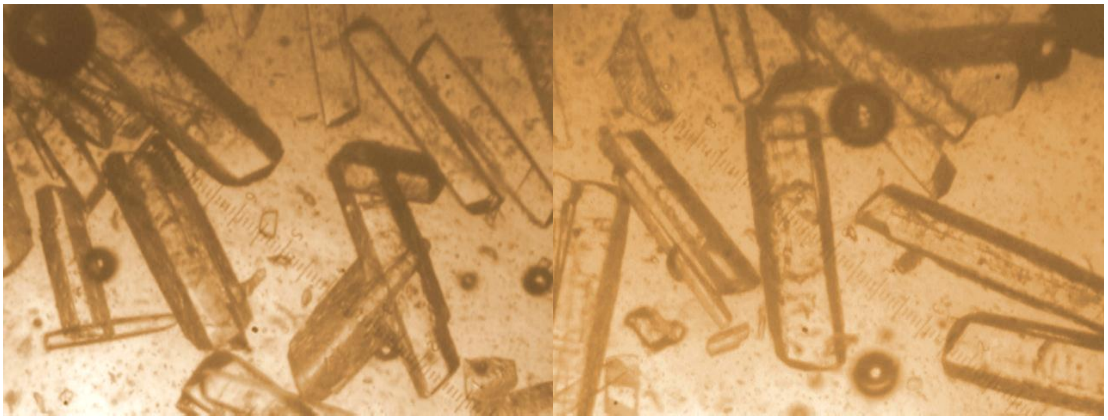


Figure 3. Massecuite (return syrup charge) boiled using cycle in Figure 1.

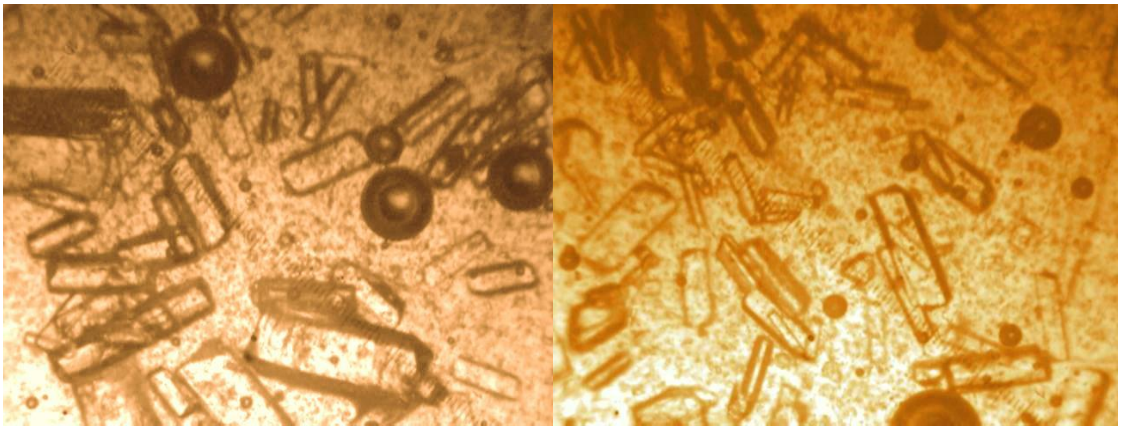


Figure 4. Massecuite (first crop charge) boiled using cycle in Figure 2.

Table 3. Crystal Size Distribution Data

Date	Size (µm)	Elongation ratio	CV%
25-11-11 (Figure 1 cycle)	795	4.0	30
18-11-11 (Figure 2 cycle)	348	3.2	47

The cycle in Figure 1 produced crystals with an average size of 795 microns. The coefficient of variation (CV) of these crystals was 30%. Low CV indicates a narrow spread of crystal size. Rein (2006) recommends a figure of 30%. The larger grain size has high voidage and makes it easy for the runoff to purge through. A drop in SC sugar colour was realised during this period. However, the second crop syrup purities did not drop. It was noticed during that period that the FC purities had increased. This resulted in a change of purity in the SC station.

The crystals in the massecuite boiled using the cycle in Figure 2 were small, with an average size of 348 microns. The CV of these crystals was also high. In terms of crystal size and quality, the cycle depicted in Figure 1 produced better results. Because of pan capacity issues, it was decided to carry on with this cycle (Figure 2) but to use slurry to grain the pans instead of the waiting method. The pan boiler has improved control over grain size and crystal content when slurry is used.

Slurry graining

From 14 December 2011, the seed for the SC boiling has been prepared using slurry graining. The cycle depicted in Figure 2 is now in use. The slurry is added at a ratio of 15 ml/m^3 of final massecuite (SC and TC). The previous graining technique consisted of concentrating until sugar grains were formed (waiting method). With the waiting method, a pan boiler has limited control of crystal content of massecuite as well as crystal size.

Table 4 below shows progressive CSD data of seed crystals from the time of graining up to the point where the seed was ready to cut for SC and TC massecuites. The crystal variation of this seed is low, with an average CV of 30%. Table 5 shows the CSD data of strike massecuites. The elongation ratio of the seed is lower than that of both SC and TC strike massecuites. This is expected since the strike massecuites are fed with FC and SC runoffs which have a higher concentration of oligosaccharides. The CV of SC and TC strike massecuites is higher than that of the seed due to the blinding of crystal faces and different growth rates (Morel du Boil, 1991, 1995). Rein and Msimanga (1999) found that the CV values get worse as the crystals grow in C massecuites in a raw factory. There are no fines that are observed in the SC and TC massecuite strike photographs (see Appendix 1), but very thin and long crystals can be seen which are due to the above mentioned phenomenon. The different elongation ratios are due to some massecuite being SC and some TC.

Table 4. Crystal size distribution of seed preparation data from graining.

Date	Time	Size (µm)	Elongation ratio	CV%
13-12-11	12:11	225	2.6	34
13-12-11	13:11	311	2.8	28
13.12.11	14:00	350	2.3	28

Table 5. Crystal size distribution of second crop and third crop strike crystals grained on slurry.

Date	Time	Boiling	Size (µm)	Elongation ratio	CV%
13-12-11		TC	583	4.2	34
13-12-11	23:25	SC	520	3.0	44
14-12-11	00:52	TC	520	4.1	46
14-12-11	13:30	TC	732	5.4	39
14-12-11	14:30	SC	364	2.7	49
14-12-11	18:30	TC	495	4.9	46

Figure 5 shows the crystals shortly after graining SC seed. Figure 6 shows the SC seed ready to be cut to boil SC and TC massecuites. The average size of the seed (350 µm) in Figure 5 is about the same as that of the strike massecuite in Figure 4 (waiting method), which is 348 µm. This implies that slurry graining produces larger crystals than the waiting method.

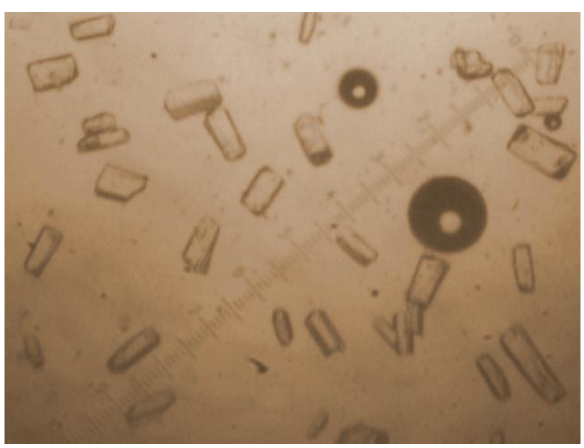


Figure 5. Crystals shortly after graining second crop seed.

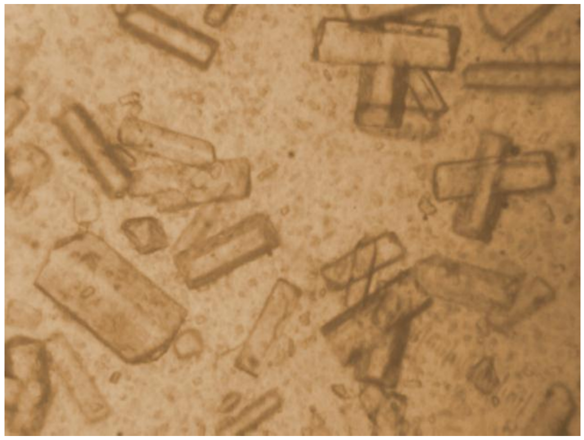


Figure 6. Final second crop seed crystals – slurry graining.

Performance

Exhaustion and SC sugar colour were used as yardsticks to gauge the performance of the second crop station (pans and centrifugals). The discontinuation of numerous cuts, boiling the pans at 20 kPa (abs), correction of the stirrer direction, centrifugal screen monitoring and centrifugal screen cleaning resulted in improved performance of the SC station. The number of cuts in SC boilings was reduced in week 29 and consequently a drop in SC crop sugar colour was realised (Figure 7) without compromising exhaustion. Towards the end of 2011 (week 36), the strike massecuites in pans C and D were both fed with SC runoff. Previously one strike was fed with FC runoff and the other with SC runoff (Figure 2). This modified cycle resulted in lower TC runoff purities and improved exhaustions. Continuous TC boiling can not currently be done, since SC and TC massecuites share the same crystalliser and centrifugals. A crystalliser and centrifugals that will be dedicated to the TC massecuites are currently being refurbished.

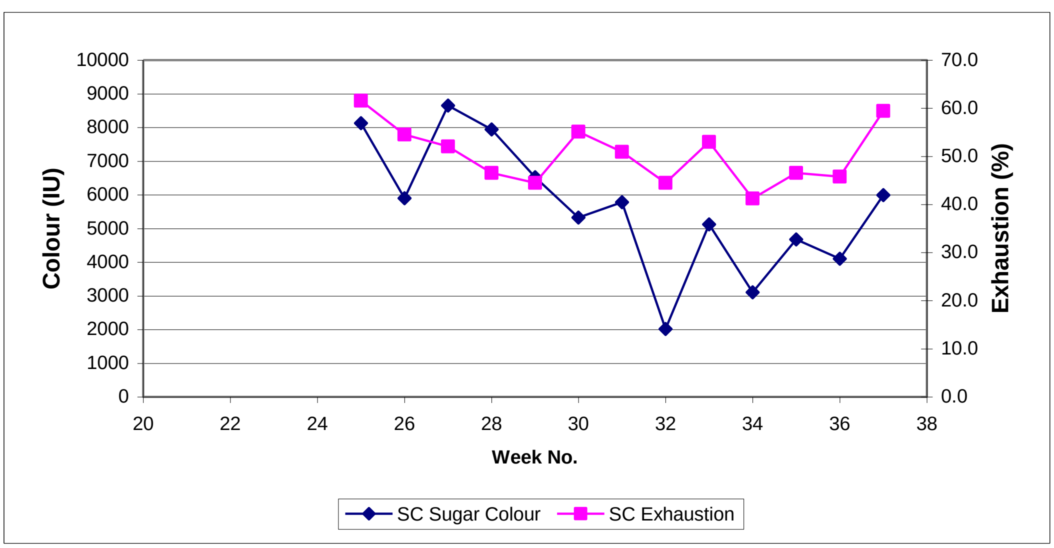


Figure 7. Impact of work done on second crop (SC) station on SC sugar colour and exhaustion.

Centrifugals

Hulref has seven continuous centrifugals in the recovery house; four are dedicated to curing SC massecuite (SC station) and the other three for curing the FC crop massecuite (FC station). At the time this investigation was done, only two centrifugals were operational for curing SC and TC massecuites; the other two were being repaired. Chrome/nickel screens with 0.06 mm width slots are used for both stations. Over time, the screens start to wear at the bottom of the basket, and if monitoring is poor, wearing continues until the screens break off at the base. The purities of the runoffs increase as the condition of the screens deteriorates.

A centrifugal monitoring procedure was implemented to ensure that the screens are checked at least once per day for holes and erosion of plating at the base of the screen. A criterion was that the screen must be changed when nickel plating wears off the base of the screen.

Spray washing was also introduced at the SC station to improve sugar colours. The previous method was to add water through nozzles in a water ring on the top of the feed funnel into the centrifugal. The initial runs showed a high curing purity rise of up to 7 units. Water flow was reduced to a point where acceptable SC sugar colour was achieved with a reasonable curing purity rise of less than 2 units (Rein, 2006).

Conclusion

This paper has covered the initial steps adopted to improve recovery house performance at Hulref. More work is currently being done to improve pan circulation, vacuum and centrifugal performance. These preliminary results have highlighted the importance of boiling the recovery house pans at lower temperatures, graining with slurry, and optimising pan cycles and centrifugal operation. The re-establishment of the lost pan boiling skills in the recovery house is an important factor in improving performance.

Acknowledgements

The authors would like to thank THS management for allowing this paper to be published. The co-operation received from pan boilers, Hulref Laboratory, TEG Laboratory and Hulref Services Department is highly appreciated.

REFERENCES

Lionnet GRE and Pillay M (2006). Applications of capillary viscometry in cane sugar factories, *Proc S Afr Sug Technol Ass* 80: 371-377.

Moodley M, Schorn and Singh I (1996). Off-crop refining at Malelane, *Proc S Afr Sug Technol Ass* 70: 189-194.

Morel du Boil P (1991). The role of oligosaccharides in crystal elongation. *Proc S Afr Sug Technol Ass* 65: 171-178.

Morel du Boil P (1995). Cane deterioration - Oligosaccharide formation and some processing implications. *Proc S Afr Sug Technol Ass* 59: 33-38.

Rein PW (2006). *Cane Sugar Engineering*. Verlag Dr A Bartens KG, Berlin, Germany.

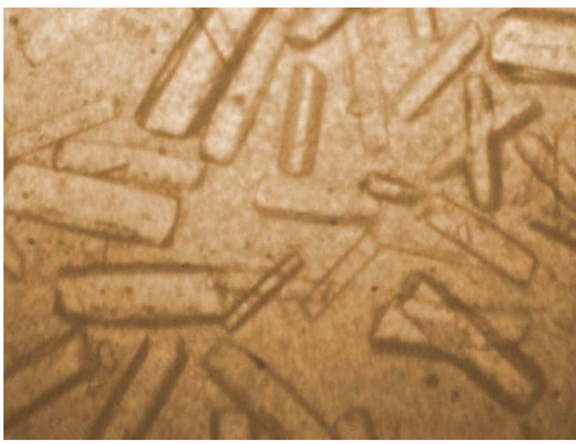
Rein PW and Msimanga MP (1999). A review of continuous pan boiling. *Proc S Afr Sug Technol Ass* 23: 124-136.

Wright PG, Broadfoot R and Miller KF (1995). A model of batch sugar centrifugal productivity. *Proc Aust Soc Sug Cane Technol* 17: 231-239.

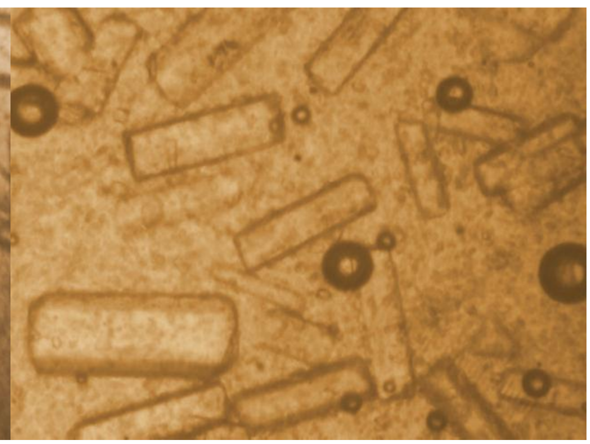
Appendix 1. Second crop and third crop massecuites - slurry graining.

14 -12-11 @ 13:30, TC

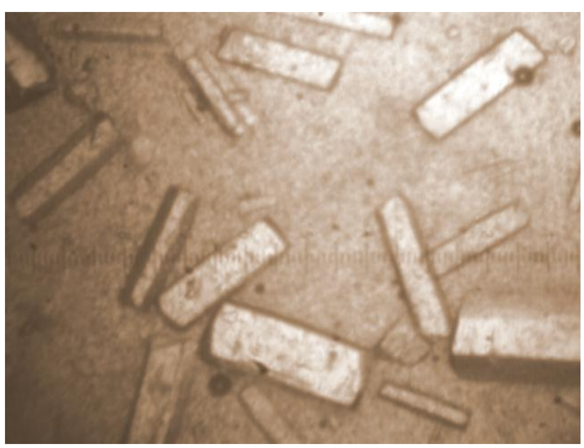
14-12-11 @ 18:30, TC



14-12-11 @ 23:25, SC



14-12-11 @ 00:52, TC



10-01-12@14:30, SC