

## MINIMISING SUCROSE LOSS IN FINAL MOLASSES: THE THREE LAWS OF MOLASSES LOSS

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### Abstract

Maximising sucrose recovery can also be viewed as minimising sucrose losses. From this perspective, since sucrose loss in final molasses is normally the largest component of the total sucrose loss, minimising sucrose loss in final molasses is vital to maximising sucrose recovery. A set of 'Three Laws of Molasses Loss' is proposed as a basis for guiding actions necessary to minimise the loss of sucrose in final molasses. The rationale behind each of the laws is described, along with how they relate to good operational practices. The three laws are also used as an aid to interpreting standard factory performance figures.

### Introduction

A clear and measurable objective is a primary requirement of any business venture. For the business to remain viable over the long term this must ultimately be a financial measure of profit. Unfortunately, measures of profit are of little value as an objective to guide the day-to-day or week-to-week operations in a sugar mill. This is particularly so because of the complexity of the division of proceeds system that effectively determines raw material cost and selling price.

A conventional raw sugar mill generally has high fixed costs (salaries and costs of installed capital) and low variable costs. The combination of this fact and the way that the division of proceeds system works is that profit can normally be maximised by first maximising cane throughput and then maximising sugar recovery from the cane. If the cane supply is limited and easily within the crushing capacity of the sugar mill (as is the case in many instances at present within the South African sugar industry) then the objective is simply to maximise sugar recovery from the available cane.

Maximising sugar recovery can be restated as minimising sucrose loss, allowing the loss to be broken down into a number of more specific components of the total loss. For a conventional raw sugar mill the components of the total sucrose loss are:

- sucrose loss in bagasse
- sucrose loss in filter cake
- sucrose loss in molasses
- undetermined sucrose loss (i.e. sucrose that is unaccounted for when completing a mass balance over the mill).

All of these components need to be minimised to maximise sugar recovery. The sucrose loss in molasses is particularly important because it is normally by far the largest of the four components of total loss (about double the other losses combined). Although sucrose lost in molasses is still available as a saleable product (as part of final molasses) the price of sucrose

sold as final molasses is of the order of only one tenth of the price of sucrose sold as product sugar.

### Why do we lose sucrose in molasses?

To understand sucrose loss in molasses it is useful to begin with a very brief summary of the major processes within a conventional raw sugar mill.

- Extraction of sucrose from the cane fibre to generate a juice which also contains the other soluble components of the cane that are not sucrose.
- Clarification of the juice by lime addition and settling.
- Energy efficient concentration of the juice, without crystallisation, to produce syrup.
- Crystallisation of the sucrose from the syrup by a combination of concentration and cooling.
- Separation of the crystalline sucrose from the mother liquor in which the crystallisation took place to yield sugar and molasses.

Although the conventional boiling house of a factory will have multiple stages of crystallisation and centrifugation (A, B and C), the ultimate products are raw sugar and final molasses.

This simple summary of sugar processing accentuates the following facts:

- All soluble non-sucrose in the cane juice should end up in final molasses (other than the very small amount that exists as impurity in raw sugar).
- Because crystallisation is used as the mechanism for separating the sucrose from the molasses, some sucrose will remain in the final molasses. There is also a lower limit below which the quantity of sucrose in molasses cannot be reduced and this is ultimately defined by the solubility of sucrose in the molasses.

### What should we do to minimise sucrose loss in molasses? The 'Three Laws of Molasses Loss'

With a clear understanding of why there will always be a loss of sucrose in molasses, it is possible to define what should be done to minimise this loss. Although at a detailed level this will require many specific actions, it is very useful to be guided by a set of fundamental laws or principles. The approach that is proposed in this paper is based on the 'Three Laws of Robotics' devised by Isaac Asimov, the famous science fiction author, to guide the design and manufacture of robots that were both useful and safe. These laws are:

**First Law:** A robot may not injure a human being or, through inaction, allow a human being to come to harm.

**Second Law:** A robot must obey orders given to it by human beings, except where such orders would conflict with the First Law.

**Third Law:** A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Asimov's laws embody the interesting concept that it is possible to derive sensible courses of action from a small, hierarchical set of fundamental laws – the validity of which he

investigated in numerous short stories. Applying this approach, along with an understanding of the factors that affect sucrose loss in molasses, it was possible to formulate the following Three Laws of Molasses Loss:

**First Law:** The quantity of non-sucrose in final molasses must be minimised because, at any given purity P, each unit of non-sucrose will take with it  $P/(100-P)$  units of sucrose.

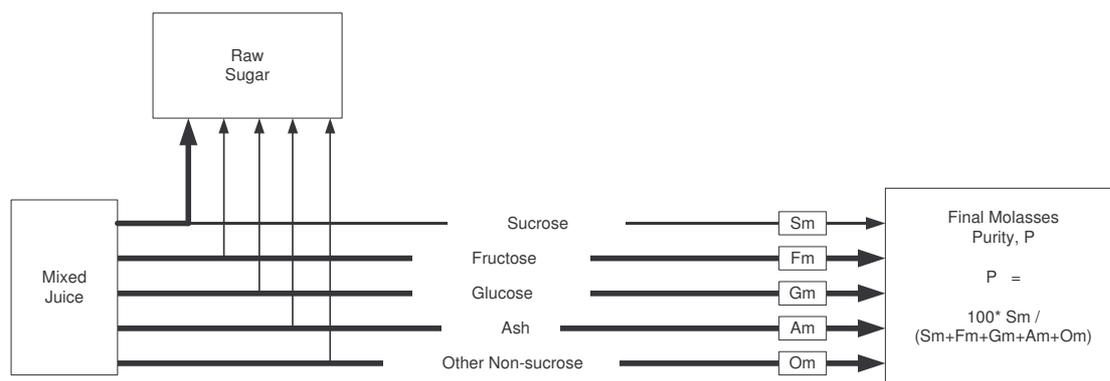
**Second Law:** The achievable final molasses purity or target purity must be kept as low as possible except where this would contradict the First Law.

**Third Law:** The actual final molasses purity must be reduced to as close to the target purity as possible (or even better, below) except where this would contradict the First or Second Law.

Although the application and implications of these laws is discussed in detail in this paper, the benefit of this approach (to this or any other aspect of sugar manufacture) will need to be tested over time.

### Understanding the Three Laws of Molasses Loss

To fully understand the Three Laws of Molasses Loss we need to delve deeper into detail, starting with an understanding of the soluble solids passing through the factory, based on the simple diagram in Figure 1.



**Figure 1. Soluble solids passing through the factory.**

In this representation, the non-sucrose soluble solids comprise fructose, glucose, ash and other non-sucrose. This combination of actual compounds (fructose and glucose) and pseudo-components (ash and other non-sucrose) is sufficient for a practical understanding of molasses loss. Ash approximates the soluble inorganic solids whilst other non-sucrose, which is determined by the difference between total dissolved solids and the sum of the other components, is usually made up of more complex organic molecules such as polysaccharides and proteins.

Clearly most of the sucrose entering in mixed juice leaves in the raw sugar, along with small quantities of each of the non-sucrose components. Approximately one tenth of the sucrose entering the factory in mixed juice leaves in the final molasses, along with most of the non-sucrose components.

The **First Law** is clearly evident from Figure 1. If there was no non-sucrose, there would be no final molasses and there would be zero loss of sucrose in final molasses. More specifically, for any given purity of molasses P, every mass unit of non-sucrose leaving in final molasses will take with it  $P/(100-P)$  units of sucrose. Thus, assuming a constant molasses purity, minimising sucrose loss in molasses is achieved by minimising the quantity of non-sucrose in molasses.

It might appear that the First Law needs to be overridden by common sense for the situation where any stream of less than 100% purity is diverted to effluent (since this will inevitably reduce the quantity of non-sucrose in final molasses). However, the First Law does still hold for its stated objective of minimising sucrose loss in molasses, and common sense indicates that this is an unwise action because the reduced loss of sucrose in molasses will be counterbalanced by an equal or greater undermined sucrose loss (except for the unusual situation of streams of lower purity than final molasses).

The **Second Law** arises from the use of crystallisation as the means for extracting sucrose from impure solutions. Crystallisation takes place from solutions that have been supersaturated (either by evaporative concentration or cooling) and stops when the solution reaches saturation. There are practical limits of the extent to which an impure solution can be concentrated and cooled, consequently there is a minimum quantity of sucrose that will always be lost in final molasses with every mass unit of non-sucrose. This minimum is commonly defined by a minimum molasses purity that can be achieved by crystallisation, usually termed 'target purity'. Rein (2007) reviewed a range of strategies from around the world that are used for estimating target purity. He makes a very strong case for the South African approach of basing target purity on an extensive set of standardised laboratory experiments that use accurate analytical procedures (most importantly measuring true sucrose rather than apparent sucrose or pol). He specifically supports the use of the South African formula for calculating Target Purity (Smith, 1995), viz:

$$\text{Target Purity (South Africa)} = 43.1 - 17.5 \times (1 - e^{-0.74 \times (F+G)/A})$$

Where  
 F = fructose % final molasses  
 G = glucose % final molasses  
 A = ash % final molasses (conductivity ash).

To minimise sucrose loss in molasses it is necessary to minimise the target purity. The plot of the target purity equation in Figure 2 shows that the target purity will be minimised when the ratio of  $(F+G)/A$  in final molasses is maximised.

Given the format of the target purity equation, mathematically there two actions that will both work to minimise the target purity:

- Maximise the quantity of fructose and glucose
- Minimise the quantity of ash.

In terms of Fructose and Glucose, the interaction between the first and second laws becomes rather subtle. A change in the quantity of fructose and/or glucose causes a change in the quantity of non-sucrose in final molasses that is counterbalanced by a change in the target purity of the molasses. Calculations of the magnitude of these two effects on the sucrose loss in final molasses indicate that they are approximately evenly balanced. The incentive of the

first law in this instance then becomes the benefit of reduced loading of non-sucrose on the capacity of the C-station (pans, crystallisers, reheaters and centrifugals).

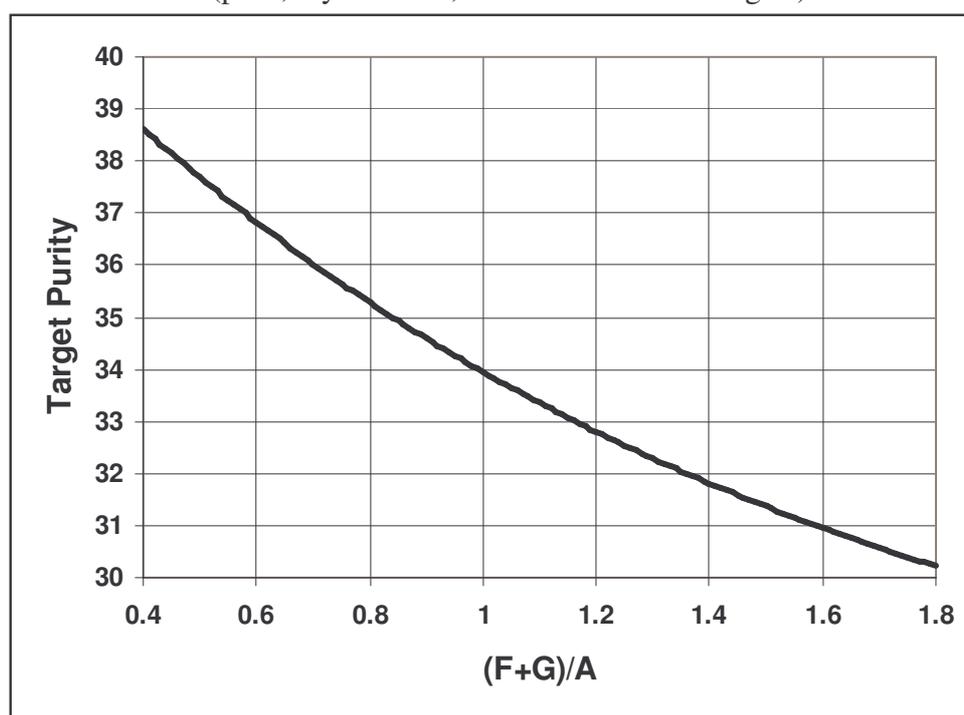


Figure 2. The influence of (F+G)/A ratio on Target Purity.

The **Third Law** is the obvious corollary to the Second Law; To minimise sucrose loss in molasses, the final molasses purity must be reduced down to as close as possible to the practical minimum defined by the target purity. A final molasses purity below the target purity, although unlikely, is even better.

### Applying the Three Laws of Molasses Loss

#### First Law

The quantity of non-sucrose in the factory must be minimised to reduce the mass of sucrose in final molasses. There are three broad approaches to achieving this.

- Selectively remove non-sucrose. Generally this is not possible in substantial quantities although it was one of the incentives for investigating exotic processes such as ethanolic precipitation of molasses (Robertson, 1978). Small quantities of soluble and colloidal non-sucrose are removed during conventional clarification so there is an added incentive from the perspective of sucrose loss in molasses to ensure good clarification. There is a possibility that some non-sucrose components can be degraded into volatile components that are removed during evaporation. Acetic acid and ethanol are normally found in evaporator condensates (having been volatilised from the juice) but the quantities are usually too small to be of practical significance and may in any event come from the degradation of sucrose.
- Do not add extra non-sucrose. Generally this is not an issue but can be important in factories using chemical cleaning. In this instance it is important not to contaminate

process streams with soluble inorganic solids from the chemical cleaning. This requires careful attention to ensure that all isolating valves associated with chemicals do not leak and that vessels are thoroughly flushed with water after a chemical clean.

- Do not generate non-sucrose by the degradation of sucrose. The break-down of sucrose into non-sucrose is a 'double whammy' because of the direct loss of the degraded sucrose (an increase in the undetermined sucrose loss), as well as the consequential increase in sucrose loss in molasses due to the increased quantity of non-sucrose in molasses. The most common form of sucrose degradation is inversion where the sucrose molecule is split into a glucose molecule and a fructose molecule. Low brix products in the front end of a raw sugar factory are most susceptible to sucrose inversion. Inversion rates increase as the pH decreases and temperature increases. High retention time of hot juice from a diffuser at a relatively low pH will encourage inversion of sucrose. This is the reason that draft juice tanks between the diffuser and the mixed juice scales have been removed in many factories. Poor distribution and uneven retention time in clarifiers will also increase sucrose inversion. Long retention times in first effect evaporators are particularly bad in terms of sucrose inversion. The impact of additional fructose and glucose on molasses losses is much less severe than for other non-sucrose components as discussed in the explanation of the second law. A special case is the re-introduction of a seriously degraded stream back into the factory, a situation that can arise if the products in floor sumps deteriorate due to bacterial action and are then recovered back into the factory process streams. Every effort should be made to avoid this situation by identifying and eliminating leaks, having small sumps that are sanitised with steam and/or bactericides and emptying the sumps frequently. If, however, the purity of the degraded stream is below the target purity of molasses, it should not be added back into the process.

### Second Law

The final molasses target purity must be kept as low as possible without increasing the non-sucrose in the factory.

- If the target purity of final molasses is as low as possible, then it becomes easier to achieve low final molasses purity and thereby reduce the sucrose losses in molasses. The target purity is governed by the F+G/A ratio; the higher the ratio the lower the target purity. According to Law 2, it is not acceptable to increase the target purity if it is in conflict with Law 1. Therefore, the target purity should not be reduced by increasing the non-sucrose. An increase in non-sucrose components of fructose (F) and/or glucose (G) through inversion of sucrose will reduce the target purity, but non-sucrose formation through sucrose inversion is not acceptable. However, non-sucrose reduction through removal of ash is advisable. Although only small quantities of ash are removed during clarification this is still an added incentive to ensure good clarification for the removal of colloidal solids, which would appear as other non-sucrose, and removal of phosphate as insoluble calcium phosphate. If pH correction is done with caustic soda solution, then the phosphate will remain behind as soluble Sodium Phosphate, which will increase the ash in solution.
- Do not destroy F+G and create other non-sucrose. Some fructose is destroyed during clarification and in the first effect evaporators because fructose is labile at high temperatures and some destruction will take place with the formation of other non-sucrose, albeit marginal. Reducing the retention time at high temperature can minimise fructose destruction. Glucose is destroyed when a Maillard reaction takes place. Conditions of high

brix and high temperature coupled with low purity will promote a Maillard reaction (Newell, 1979). The Maillard reaction is most prevalent in 'C' massecuite, although this reaction can start in an evaporator system if the temperature of syrup rises above 65°C. The key to minimising Glucose destruction is to control the temperature of the product and reduce it to as low as practically possible. During boiling under vacuum this is achieved by reducing the absolute pressure to as low as possible without adversely affecting processing conditions. The inability to achieve the necessary low pressures and temperatures is usually a result of one or more of the following factors: air leaks into the vacuum vessel, inefficient vacuum pumps, excessive pressure drops in the vacuum pipes, inadequate condenser performance and excessive injection water usage.

- Track the F/G ratio from mixed juice to final molasses. This value will normally decrease slightly through the evaporators (Schäffler *et al.*, 1985) as a result of fructose destruction. Thereafter the value will increase as the products move through the boiling house en route to final molasses because of the glucose destruction associated with the Maillard reaction. The F/G ratios in mixed juice and final molasses from 2005 to 2008 in the South African sugar industry in Table 1, reflect the approximate magnitude of glucose change across the factory where fructose destruction is deemed to be marginal. Individual factories can therefore gauge the relative extent of the Maillard reaction by comparing the F/G ratios in the mixed juice and final molasses for their centre.

**Table 1. Fructose, glucose and F/G ratios in mixed juice and final molasses from 2005 to 2008 in the South African sugar industry.**

Product	Year	Fructose %	Glucose %	F/G ratio
Mixed juice	2005	0.29	0.27	1.07
	2006	0.26	0.24	1.08
	2007	0.26	0.24	1.08
	2008	0.26	0.23	1.13
Final molasses	2005	7.5	5.2	1.44
	2006	7.3	5.2	1.40
	2007	7.3	5.3	1.38
	2008	7.1	5.2	1.36

The average destruction of glucose from mixed juice to final molasses in the South African sugar industry varied from 20-35% between 2005 and 2008. Individual factories can show greater or less destruction of Glucose over shorter periods.

If the main components of non-sucrose are expressed as a percentage of the total non-sucrose in mixed juice and final molasses, then the relative increase or decrease of each component between mixed juice and final molasses can be roughly gauged. This assumes that little if any non-sucrose is volatilised during processing operations and the non-sucrose removal with sugar is minimal. A spreadsheet that reflects these changes from mixed juice to final molasses can serve as a quick check on the extent of Maillard reaction in the factory. A reduction of Maillard reaction will reduce the upward escalation of the target purity (Table 2).

**Table 2. Non-sucrose components expressed as a percentage of the total non-sucrose in mixed juice and final molasses (2005-08).**

Product	Year	Fructose% N-Sucrose	Glucose% N-Sucrose	Ash % N-Sucrose	Other% N-Sucrose
Mixed juice	2005	15.85	14.75	27.87	41.53
	2006	15.20	14.04	28.65	42.11
	2007	15.20	14.04	29.24	41.52
	2008	14.53	12.85	28.49	44.13
Final molasses	2005	15.63	10.84	30.57	42.96
	2006	15.21	10.84	30.63	43.32
	2007	15.27	11.08	30.22	43.43
	2008	14.79	10.83	30.70	43.68

In three of the four years there is actually a marginal increase in Fructose from mixed juice to final molasses, which suggests that there is evidence of minor sucrose inversion; this, however, also supports the earlier statement that very small amounts of fructose are destroyed in the front end. However, the glucose reduces substantially, and there is a slight increase in ash and 'other' components of non-sucrose. The small increase in 'other' components can in part be due to the accumulation of breakdown products from the destruction of glucose in the Maillard reaction.

Destruction of glucose and the accumulation of some Ash will increase the target purity of final molasses, which is contrary to the recommendation of Law 2. Clearly attention must be given to minimising glucose destruction by minimising the Maillard reaction.

Do not add ash. Formation of organic acids that are neutralised with  $\text{Ca}(\text{OH})_2$  will produce soluble ash. This is not normally of concern in raw sugar factories but has been shown to be important in refineries (Cox *et al.*, 1990). Contamination with sodium hydroxide from chemical cleaning and/or the use of caustic solutions (either sodium hydroxide or waste chemical cleaning solutions) for neutralising fermented floor washings before returning them to process are further examples of procedures that will increase ash and increase the target purity of final molasses.

### Third law

The Third Law is all about improving final molasses exhaustion without increasing non-sucrose in the factory and/or reducing the target purity of final molasses. This is a complex topic and will be discussed only briefly here. Rein (2007) gives a useful summary of the 'Optimum operation of C stations'. Some of the important principles are based on the seminal work done in the late 1970s and reported on in the papers by Lionnet and Rein (1980) and Rein (1980).

The achievement of a low final molasses purity is achieved by a combination of the performances of the following processes in the C-station: seed preparation, massecuite boiling, cooling crystallisation, reheating and centrifugation. There is a close interaction between these processes and each needs to be optimised in conjunction with the others.

- Preparation of C-seed. C-seed is normally prepared in a batch pan. The purity of the C-seed needs to be approximately 65 to ensure the consistent production of a regular grain. It is common practice to grain a C-seed on A-molasses. On occasion it may be necessary to use a little syrup together with A-molasses to grain the C-seed pan to achieve the desired purity. It is essential to boil the C-seed at a low temperature to minimise Maillard Reaction and the creation of viscous by-products. The grain size of the C-seed is critical and must be sufficiently large to produce a final grain size in the C-masseccuite of >120 microns. The correct preparation of slurry is essential to achieve this (Ninela and Rajoo, 2006)
- Purity drop during C-masseccuite boiling. Good operation of C-masseccuite boiling not only achieves good crystallisation in the pan but sets up the conditions for crystallisation in the cooling crystallisers. Lionnet and Rein (1980) highlighted the critical importance of achieving high non-sucrose to water ratios in the masseccuite discharged from the pan. This is because it is water that is ultimately the cause of the loss of sucrose in molasses. Their experimental work confirmed this and their recommendation was that the high non-sucrose to water ratios were best achieved by very high masseccuite brixes rather than very low masseccuite purities.

The efforts to eliminate water from the masseccuite need to be tempered by the need to ensure that the rate of crystallisation is not too severely retarded. Thus, the masseccuite needs to be of a suitable consistency to boil, mix and flow, as well as having sufficient crystal surface area on which the crystallising sucrose can deposit. This led to the recommendation that masseccuite brixes should approach 98 and that masseccuite purities should be adjusted to achieve a crystal content of about 25% at the outlet of the pan (Rein, 2007). The appropriate masseccuite purity will change as the (F+G)/A ratio changes through the season and can be estimated by calculation, assuming appropriate purity changes over the crystallisers reheater and centrifugals. More recent factory experience has indicated that masseccuite brixes approaching 98 are counterproductive and a level closer to 97 is more effective (Ninela and Rajoo, 2006). This is probably because the lower non-sucrose to water ratio of the lower brix is more than compensated for by a higher crystallisation rate.

Good masseccuite circulation and good sucrose transfer onto the sugar crystals are both essential to achieve good pan exhaustion. Attention must be paid to feed system design to ensure even distribution of feed. Boiling at low temperatures is important to minimise the Maillard reaction that both destroys glucose (affecting target purity) and generates breakdown products that increase viscosity and impede crystallisation. Boiling temperatures of 63°C or below are recommended (Rein, 2007) and excellent C-masseccuite exhaustions have been achieved with temperatures below 60°C (Ninela and Rajoo, 2006). Vacuum systems and condenser arrangements must be efficient to achieve the low absolute pressures required to achieve these low boiling temperatures (usually around 10 kPa(a)). The brix profile during the boiling and the final brix of C-masseccuite at strike are also important items to consider. Recent experience indicates that the best performance is achieved with a brix profile over a C-masseccuite boiling that begins with a very gradual increase in brix for approximately the first third of the boiling, followed by a linear increase in brix over the rest of the boiling to achieve the desired brix at strike. The recommended brix profile will promote good masseccuite circulation and molasses exhaustion because the lower brix will have a lower viscosity.

- Purity drop on cooling. For any given massecuite discharged from the pan, good crystallisation is achieved by having crystallisers with sufficient retention time, good flow patterns (i.e. close approach to plug flow) and sufficient cooling. While increasing the residence time up to 48 h generally continues to reduce the molasses purity, the economic optimum is difficult to specify as it depends on the particular details of how the value of the extra sugar recovered is distributed (the division of proceeds system). Rein (2007) reports that, in South Africa, C-crystallisers are often installed to provide a residence time of 45 h. With this installed capacity a molasses purity drop of between 6 and 8 units can usually be achieved. Stirrer malfunction will lead to channeled massecuite flow and reduced purity drop in the mother liquor. Similarly high cooling water temperatures or no flow of cooling water will also reduce the purity drop. Since there is some evidence that very rapid cooling can promote the formation of very fine crystal that will dissolve out during reheating or washing in the centrifugals, rapid cooling is normally avoided by running the cooling water in a counter flow direction to the C-massecuite.
- Purity change on reheating. A small purity rise or purity drop is normally recorded across the reheater. A small purity drop should occur and if this does not happen it is normally an indication of a problem. There are two common reasons for a purity rise. The first and most serious is a water leak in the tubes in the reheater that results in crystal dissolution and molasses purity rise. This situation can be rectified by isolating the offending section in the tube bank, but will ultimately result in poor reheating and viscous C-massecuite being fed to the centrifugals. The second reason for a purity rise is the presence of very small false grain crystals or 'dust' (as it is often called) in the C-massecuite. The "dust" can be formed in the pan or in the crystallisers when spontaneous formation of false grain takes place as the brix increases and/or the massecuite temperature is reduced. The "dust" will easily dissolve when the C-massecuite temperature is increased in the reheater.
- Purity rise on curing. A purity rise is normally expected across curing because some sucrose crystal will always pass through the centrifugal screen holes and some crystal will be dissolved by the wash water. The key to improving final molasses exhaustion here is to minimise the sucrose loss through the screen and minimise the dissolution of sucrose. Procedures need to be developed for centrifugal screen cleaning, screen maintenance and screen replacement to ensure that the screens are always in the best possible condition. It has been shown that C-massecuite crystal width must be >120 micron on average to minimise passage of crystal through the 60 micron slots or holes in a centrifugal screen (Julienne, 1985). The more regular grain size will produce less small grain that can pass through the screen. Therefore it is critical to pay attention to crystal size and quality in the pan.

Easy separation of molasses from the crystal in the centrifugal will require less wash water to reach the desired C-sugar purity. To achieve this, the massecuite must have a low viscosity, which can be obtained if Maillard reaction is minimised in the pans. Low viscosity massecuite will have to be reheated to only about 58°C to get good separation of molasses from the crystal, while very viscous massecuites may need to be reheated to as high as 70°C to effect reasonable separation. Normally high viscosity massecuite also requires additional wash water to produce a reasonable quality of C-sugar. Clearly high viscosity massecuite will require additional wash water, resulting in further dissolution in the centrifugal.

Flash heating of the massecuite when it passes through the steam jacket located in the centrifugal feed will immediately increase mother liquor temperature and reduce viscosity. This heating is particularly important for low temperature and low viscosity massecuites where massecuite reheating is minimised.

Wash water should be impregnated into the massecuite using a 'lube rod' to improve crystal washing efficiency. If water is added via the ring spray at the feed cone of the centrifugal, the water does not mix well with the massecuite as it is normally expelled from the designated mixing area in the centrifugal before it has completed any effective 'washing' of the crystal.

### **Factory performance figures and the Three Laws of Molasses Loss**

Factory operations are guided by an understanding of performance figures and there are a few figures that relate directly to the Three Laws of Molasses Loss.

#### *Non-sucrose ratio*

The accuracy of this weekly ratio is normally dictated by the accuracy of the weekly factory stocktake since large measurement anomalies can occur here. The analyses are normally accurate enough not to be of concern. The non-sucrose ratio will give an indication of net non-sucrose formation or destruction between mixed juice and final molasses. It is advisable to use this ratio as a guide and to look at the trends over a period of about three weeks to nullify the effects of erroneous stocktakes. The normal accepted range of non-sucrose ratio is 0.98 to 1.03. Any results outside these limits warrant investigation, as they could adversely impinge on both the First and Second Laws of sucrose loss in molasses. If the ratio is regularly high it indicates non-sucrose formation, and if the ratio is always low it indicates non-sucrose destruction and the strong possibility of it affecting the target purity of final molasses.

#### *TPD based on final molasses analyses vs TPD based on MJ analyses*

If there is no destruction or formation of monosaccharides and ash between mixed juice and final molasses, then the F+G/A ratio will be the same for mixed juice and final molasses assuming that minimal quantities of fructose, glucose and ash are removed from the factory in the sugar. If the F+G/A ratio does not change from mixed juice to final molasses, then the target purity for mixed juice and final molasses will be the same. However, this is not normally the case and generally the F+G/A ratio will decrease from mixed juice to final molasses because some monosaccharide destruction (particularly glucose) will take place and this may cause the ash to increase marginally. The end result is that the target purity derived from final molasses analyses will be higher than the target purity derived from mixed juice analyses. Therefore, if the difference between the mixed juice TPD and the final molasses TPD is small at <0.2 units, it indicates that monosaccharide destruction between mixed juice and final molasses is minimal, while the converse applies for a large difference of >0.5. The difference in TPD for mixed juice and final molasses is merely an indication of a trend that has taken place in the factory and should not be regarded as an absolute measurement of non-sucrose change.

### **Conclusion**

Where the Three Laws of Minimising Sucrose Loss in Final Molasses are adhered to, a structured approach to optimising molasses exhaustion and reducing sucrose losses in molasses can be achieved.

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