REFINED AMORPHOUS SUGAR

By

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Abstract

This study was conducted to demonstrate a simple method for producing high quality refined sugar at low investment and running costs. Several factories using this process in Brazil were visited. The factory information presented in this paper was taken from one specific installation in the state of São Paulo in Brazil. The process studied includes the melting, clarification, decolourisation and crystallisation of the sugar. The results from the study show that at a relatively low cost it is possible to produce a high quality low colour sugar. The low investment cost is due mainly to the simplified process and the simplicity of the equipment, as well as the absence of the expensive pans, centrifugals, crystallisers and recovery section. One of the big advantages of this process is that it produces only one type of sugar and thus only one colour of sugar. The crystallisation process is rapid and at high temperature and atmospheric pressure. It does not yield any molasses, thus dispensing with a lot of tanks, pumps, piping, valves and structures. The drying process does not need an external heat supply. It uses the heat of the crystal. The crystal produced by this process is very small. This almost powder size crystal has the advantage that the large size surface to volume ratio lends to quick dissolving. Because of the simplicity of the process, automation is also simple and of low cost. Even though this is not a new process (principally only used in Portugal and Brazil), it will surely be of interest to potential, new refiners who are worried about investment costs.

Introduction

What we call in Brazil amorphous sugar is, in actual fact, not amorphous, but micro-crystalline sugar. Amorphous sugar exists in a glass form in sweets such as rock candy. But so as not to confuse things, we will continue to call it amorphous sugar in this paper.

The process to produce the amorphous sugar is really very simple (simpler than the more traditional methods of crystallisation). It consists of supersaturating the liquor into the labile zone (zone that allows spontaneous crystallisation to occur) and allowing it to crystallise spontaneously and completely. This crystallisation is not controlled. In this manner the maximum number of crystals is formed. Due to this large number of crystals, they are very small, as the sucrose molecules are totally consumed before any appreciable crystal size can be attained.

This process can be used with different purities, to give different end products. The lower the purity of the liquor, the greater will be the adherence of the molasses film on the crystal surface. These sugars have a 'soft' feel to the touch (soft sugars). The molasses film makes them 'sticky' and more difficult to dry.

In Brazil, some organic sugars are made this way, using raw evaporated cane juice instead of liquor. The end product is a dark chocolate coloured amorphous sugar. Even though the process is very much the same, this paper will deal with the higher purity, refined quality sugar.

The process to obtain the fine liquor will only be touched on briefly, as these are well known processes and common to any type of refinery.

Refined amorphous sugar

In Brazil, the main refined sugar consumed is the microcrystalline amorphous sugar. If you purify your liquor to a very high degree (almost 100 purity), there will be almost no molasses. The little molasses is divided over the very large surface area that the crystals have, thus yielding no liquid molasses. As most raw sugar in Brazil is a high quality mill white, with colours varying between 80 and 250 ICUMSA, it is not too difficult to reach this quality of liquor.
Liquor preparation

At the moment in Brazil, the most popular and efficient methods used are:

Melting

In Brazil, affination is not normally used due to the quality of the mill white used in the process. The sugar is dissolved to anywhere between 60 and 65°brix. For this purpose, sweet water from scum clarifiers can be used.

Clarification

The most common process is the well known phospho-flotation. The process uses a cationic surface agent that precipitates coloured bodies as well as other high molecular weight impurities. A floc is produced with phosphoric acid and lime (normally sucrate) aided by a polyacrylamide flocculant.

This floc is separated in a flotation clarifier using air dispersion. Colour reductions of up to 50% or more can be reached.

Filtration

Filtration through a deep bed filter is normally sufficient, care being taken not to allow clarifier floc to get through. The filtering cycle is normally limited by pressure. Some factories use pre-coat filters as an added safety measure.

Decolourisation by ion exchange resins

Ion exchange is probably the most popular decolouration method for various reasons. Both investment and running costs are relatively low (especially with automation). Regeneration is simple and cheap. Acrylic and styrenic resins are used with a tendency for up flow techniques.

With these processes, we can reach liquor colours in the range of 30 to 40 ICUMSA without great difficulty (Figure 1).
Concentration

The fine liquor is sent to the boiling section (Figure 2) where it is fed to a batch pre-heater. The pre-heater holds exactly the charge of the pan. The idea is that, as it waits to be drawn into the pan, it be heated up to or close to its boiling point, so as to shorten the boiling time to a minimum.

The pre-heater has a coil heat exchanger that uses 10 bar steam. The pre-heater is open to atmosphere via a tall vent. The exit valve and pipe that goes from the pre-heater to the pan is of a large diameter (25 to 30 cm) so as to be able to fill the pan in a few seconds. The pre-heater is situated just above the pan so that the feed is by gravity.

Fig. 2—Basic flow diagram of the amorphous sugar boiling.

The concentration (evaporation) is done in a coil pan at atmospheric pressure. It is a small pan that takes a charge of about 1,600 kg of liquor, of between 60 to 68°brix. The pan is similar to the pre-heater but with a larger surface area. It too uses 10 bar saturated steam. Typically, there are several independent coils. Originally, the coils were flat and independent to allow progressive heating as the pan was being filled. Nowadays the filling is very rapid, so the coils are all opened at the same time. Even so, the independent coils are still used, as this is a safe guard against possible leaks in the coils. Should a coil spring a leak, it can be isolated without having to interrupt the cycle.

The whole process between charging and discharging takes less than 10 minutes. It is important that this time be as short as possible to minimise colour formation as the temperatures are high. For the same reason, it is important that the invert sugar content be low (not more than 0.04%).

Rather than controlling the boiling process by density, supersaturation, or crystal formation, the process is controlled by temperature. The reason for this is that:

- Crystal formation does not take place in the pan.
- Final density is not reached in the pan.

When the masse is discharged, the crystallisation is started by shock due to the sudden cooling. The crystallisation starts during the fall by gravity between the pan and the beater. Thus it is important that we know that sufficient heat has been supplied to the masse so that the evaporation that continues in the beater is sufficient to render the crystals dry (thus the control by temperature).
If the density of the liquor is 68°brix, and the temperature very close to boiling, the cycle can be as short as 4 minutes (15 strikes per hour). At 65°brix the cycle can take up to 6 minutes. The liquor is heated to 127°C and immediately discharged.

The discharged masse falls directly into the ‘Beater’, much like a cake mixer (Figure 3). The beater has rotating paddles to ensure that the masse of forming crystals is kept loose, thus minimising agglomerations. The movement is also important to aid the vapours to escape easily.

Fig. 3—A view inside the beater shortly after discharge from the pan.

In the beater, a large amount of evaporation takes place, not only due to the added heat, but also due to the heat of crystallisation liberated by the crystals during their formation. The power needed in the beater is around 0.03 kw/kg final sugars at 30 r/min.

In a few minutes (normally about 6 minutes), the evaporation ceases even though the crystals are still quite hot. The sugar is now discharged from the beater and taken to a dryer. In the dryer, only cool air is blown through as the contained heat (in the crystals) is sufficient to terminate the drying process.

As can be imagined, there are a lot of fines and dust. These are due to both breakage, and to very small crystals that could not accompany the growth due to lack of free sucrose molecules at the end of the boiling cycle. Thus, the use of a cyclone separator and a water scrubber is necessary. Bag filters are also used in place of water scrubbers.

It is possible to work at lower temperatures and achieve some steam economy, if we used a reduced pressure in the pan (vacuum pan). One method used is to condense the vapours that leave the pan in the calender of an evaporator that receives the liquor before going to the pan, as shown in Figure 4.

With this scheme, we will have a steam economy by increasing the brix with pan vapours. In fact we would be working with a double effect evaporator, but with the liquor passing first in the low pressure vessel and second in the higher pressure. In this case, to ensure continuity, two pans should be used. (The pans work on a batch system).
Of course, working with this scheme, the investment would be higher due to the extra equipment (evaporator, condenser, water pump etc.) and to the fact that the pan would have to be stronger to withstand the reduced pressure.

Advantages of the amorphous process

1. Only one liquor boiling – thus always the same grade of sugar.
2. No molasses to contend with – fewer tanks, pumps, pipes etc.
4. Totally automatable with simple instrumentation.
5. Low investment costs due to:

Less equipment

As already mentioned, not having to deal with molasses, there is no need for molasses pumps, tanks, piping, valves etc. Nor is there need for a recovery section, thus eliminating recovery pans, crystallisers, centrifugals, pumps, tanks etc.
Simpler equipment

As the pan does not work under vacuum, it can be made of lighter material such as 3 to 4 mm plate. The crystallisers and centrifugals are replaced by the beater—an overgrown cake mixer that runs on low speed and low power.

Smaller equipment

As cycles are very short (about 6 minutes), there are at least 10 cycles per hour which makes it possible to use equipment about 15–20 times smaller than normal, if we consider that the conventional boiling time in a refinery can be about 2 hours. For example, a 1 m³ pan can produce 250 tonnes of sugar per day. To do this in a conventional system, you would need at least four 15 m³ pans and still rely on three more recovery pans.

Note that a 1 m³ pan delivers the equivalent of 1 m³ of massecuite (thick liquor) per batch. Charge and discharge take about 15 seconds.

The diagram in Figure 5 demonstrates visually the difference between the two types of refinery.

Fig. 5—Comparison between conventional and amorphous boilings.
Of course, to reach the same colour in an amorphous boiling as achieved in a conventional boiling, the liquor has to be of lower colour. This is because there is no change in colour between liquor and sugar.

Even though we have not drawn up costs of the two decolourisation processes, the difference is a lot less than the investment in pans, crystallisers and centrifugals needed for both refinery and recovery sections. Of course, the best solution is to start with a light coloured raw sugar (mill white by any appropriate process).

**Some typical parameters**

- Typical raw liquor colour: 150–200 ICUMSA
- Typical clarified liquor colour: 100–130 ICUMSA
- Typical fine liquor colour: 30–40 ICUMSA
- Volume: Heating surface in pan: 1 m³:25 m²
- Heating method: Coil calandria
- Heating steam: 10 bar saturated
- Liquor brix: 65 to 68%bx
- Discharge temperature: 127°C
- Typical cycle time in pan: 4 to 6 minutes
- Typical cycle time in beater: 6 to 8 minutes
- Typical crystal size: 0.33 mm
- Typical crystal CV: 47%
- Typical crystal pol: 99.40%
- Typical crystal purity: 99.56%
- Typical crystal humidity: 0.19% H2O
- Typical crystal colour: 30 to 40 ICUMSA at 420 nm

**Conclusion**

An amorphous sugar refinery is an attractive option for a would-be refiner. It produces a high quality refined sugar by an extremely simple process. Investment and operational costs are a lot lower than needed for a conventional refinery crystalline sugar product. The only difference between amorphous sugar and sugar produced by a conventional process is the size of the crystal.
SUCRE AMORPHE RAFFINE

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MOTS CLEFS: Amorphe, Raffinerie, Sucre.

Résumé

On décrit un système simple et peu coûteux pour produire un sucre raffiné de bonne qualité. On a visité plusieurs sucreries brésiliennes où ce système est utilisé ; on donne ici des informations provenant d’une sucrerie à Sao Paulo au Brésil. Le système comprend un bac de refonte, une clarification, une décoloration et la cristallisation du sucre. Les résultats obtenus montrent qu’il est possible de produire un sucre de bonne qualité et d’une couleur basse, à un coût avantageux. Le coût est réduit grâce à la simplicité du système et de l’équipement ; on ne sert pas de cuves, centrifuges, cristalliseurs et autres appareils coûteux. Un autre avantage est la production d’un seul type de sucre. La cristallisation est rapide et se fait à une forte température à la pression atmosphérique. On ne produit pas de mélasse, ce qui vise l’usage de bacs, pompes, etc. Le séchage du sucre se fait par la chaleur de cristal et donc ne demande pas de sources externes d’énergie. Le cristal est très petit, presque poudreux. Cela a l’avantage de causer une dissolution très rapide. Le contrôle et l’automation du système sont faciles. Le système est connu déjà (au Brésil et au Portugal) mais il devrait être intéressant pour les raffineurs qui font face à des coûts de production élevés.

AZÚCAR AMORFA REFINADA

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Resumen

Este estudio se practicó para demostrar un método simple para producir azúcar refinada de alta calidad con una baja inversión y costos de operación. Se han visitado diversas fábricas que usan este proceso en Brasil. La información de la fábrica que se presenta en esta ponencia se tomó de una instalación específica en el estado de São Paulo en Brasil. El proceso que se estudia incluye la afinación, clarificación, decoloración y cristalización del azúcar. Los resultados del estudio demuestran que con un costo relativamente bajo es posible producir un azúcar de color claro y alta calidad. El bajo costo de inversión obedece principalmente a los procesos simplificados y a la simplicidad del equipo, así como a la ausencia de costosos tachos, centrifugas, cristalizadores y secciones de recuperación. Una de las grandes ventajas de este proceso es que produce únicamente un tipo de azúcar y por lo tanto únicamente un color de azúcar. El proceso de cristalización es rápido y a altas temperaturas y presión atmosférica. No produce ninguna melaza y por lo tanto evita una gran cantidad de tanques, bombas, tuberías, válvulas y estructuras. El proceso de secado no requiere de ninguna fuente externa de calor. Utiliza el calor del cristal. El cristal producido mediante este proceso es muy pequeño. Este cristal de tamaño casi del polvo tiene la ventaja de que una superficie de gran tamaño con respecto al índice de volumen tiende a una rápida disolución. Debido a la simplicidad de este proceso, la automatización también es simple y el costo bajo. Si bien este no es un proceso nuevo (principalmente se ha utilizado exclusivamente en Portugal y Brasil), seguramente será de interés para refinadores potenciales o nuevos que están preocupados acerca de bajos costos de inversión.