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BACK TO BASICS: YOUR GUIDE TO SUGAR REFINING EXCELLENCE

E. M. I. Sarir - Carbo Solutions International LLC
ABSTRACT

Most sugar refineries understand the type of impact for continuous improvement initiatives that can have on bottom lines.

However, attaining this business value is a journey, not a destination.

Good manufacturing practices are steps taken to ensure maximum profitability and minimum losses.
Today, refineries are spending more time and attention to improve their conversion costs.

This means energy, maintenance and chemical usage are constantly being improved by focusing on:

- Yield and sugar loss
- Energy costs
- Chemical costs
- Continuous improvement
- Benchmarking
YIELD & SUGAR LOSSES
Sugar yield refers to the % white sugar made from raw sugar.

It could range from 95% to 98% depending on the raw sugar quality and the design and operation of the sugar refinery.

For this presentation, we shall focus on molasses losses only, because it represent the major part of sugar loss in a stand-alone refinery.
So, let's look at molasses because it is the biggest loss for a sugar refinery.

The main constituents of refinery molasses are:

- Water 20%
- Sugar 55%
- Red Sugar 11%
- Ash 10%
- Non sugar 4%
## YIELD & SUGAR LOSS

### Origin of the main constituents of refinery molasses:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>20%</td>
</tr>
<tr>
<td>Sugar</td>
<td>55%</td>
</tr>
<tr>
<td>Red Sugar</td>
<td>11%</td>
</tr>
<tr>
<td>Ash</td>
<td>10%</td>
</tr>
<tr>
<td>Non sugar</td>
<td>4%</td>
</tr>
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</table>

These originate from the raw sugar
Here are the molasses results of two refineries, one better than the other.

We shall compare them in the next slide.
The TOTAL SUGAR is what we lose to molasses and is the main index to monitor.

The next index which gives a good idea of molasses exhaustion is the ash content.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>62.6</td>
<td>53.6</td>
</tr>
<tr>
<td>Reducing Sugar</td>
<td>10.9</td>
<td>14.0</td>
</tr>
<tr>
<td>Total Sugar</td>
<td>73.4</td>
<td>67.6</td>
</tr>
<tr>
<td>Purity</td>
<td>75.5</td>
<td>61.3</td>
</tr>
<tr>
<td>RS</td>
<td>13.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Ash</td>
<td>4.2</td>
<td>7.1</td>
</tr>
</tbody>
</table>
Factors that affect final molasses purity.

- Raw sugar quality
- Process design
- Operations
- Controls

In the next few slides will clarify the above points
The use of VHP sugar has reduced the amount of massecuite processed by the recovery house.

Below are typical raw sugar analysis info:

<table>
<thead>
<tr>
<th>Raw Sugar Type</th>
<th>LP</th>
<th>VHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Polarization</td>
<td>98.00</td>
<td>99.30</td>
</tr>
<tr>
<td>% Ash</td>
<td>0.3</td>
<td>0.12</td>
</tr>
<tr>
<td>% Red. Sugar</td>
<td>0.50</td>
<td>0.13</td>
</tr>
<tr>
<td>Color (ICUMSA)</td>
<td>3000 +</td>
<td>1500</td>
</tr>
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RAW SUGAR QUALITY

The superior quality of VHP over LP sugar ensured the elimination of the affination process in many factories.

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The quality of VHP vs LP sugar results in the reduction in massecuites, and finally, the quantity of molasses generated.

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<thead>
<tr>
<th>Raw Sugar Type</th>
<th>LP</th>
<th>VHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Massecuite</td>
<td>33%</td>
<td>7%</td>
</tr>
<tr>
<td>B Massecuite</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>C Massecuite</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Molasses % Sugar</td>
<td>3.5%</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

As the sugar quality is improving, the amount of molasses is reduced.
YIELD & SUGAR LOSS

PROCESS DESIGN

The conventional sugar refinery design requires 6-7 crystallization stages and a return of recycle sugars to the front end.

<table>
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<th>Purity</th>
</tr>
</thead>
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<tr>
<td>Jet 1</td>
<td>98.5</td>
</tr>
<tr>
<td>Jet 2</td>
<td>96.6</td>
</tr>
<tr>
<td>Jet 3</td>
<td>93.3</td>
</tr>
<tr>
<td>Jet 4</td>
<td>87.9</td>
</tr>
<tr>
<td>A molasses</td>
<td>77.7</td>
</tr>
<tr>
<td>B Molasses</td>
<td>66.0</td>
</tr>
<tr>
<td>C Molasses</td>
<td>59.5</td>
</tr>
</tbody>
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The technique is basically successive squeezing, removing sucrose at each stage.
It can be seen that the mother liquor (Molasses) purity drops across each crystallization stage.

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PROCESS DESIGN

The crystallization process usually takes place in batch pans.

Different purities require different duration, for example refinery C-massecuite takes 5-8 hours.

A batch is discharged into a strike receiver from where it is centrifuged in continuous centrifugals.
YIELD & SUGAR LOSS

PROCESS DESIGN

Continuous centrifugals are well designed to separate crystals from viscous slurries.

They can also handle separation of small crystals due to the thin film separation method.
OPERATIONS

Continuous centrifugals require careful adjustments to control sugar and molasses purities.

Too much water will result in high molasses purities, and too little water will result in color recycle.
Fortunately, today’s optical equipment are available to automatically adjust the sugar color.

These machines are constantly adjusting the wash water to achieve the required sugar color.

The risk of over washing or under washing is eliminated.
YIELD & SUGAR LOSS

CONTROLS

The control of the molasses losses is conducted by the following:

- Final molasses analysis
- Weighing of molasses

It is important that the molasses be sampled in a representative manner.
ENERGY COST
Energy is required in a refinery in two forms:

- **Electrical**
- **Heat (In the form of steam)**

Most sugar factories have a co-generation plant where HP steam is produced to power a steam turbine and exhaust steam provides the heat energy.
The main area for energy efficiency is in the reduction of both electrical and heat energy consumption.

Since 80% of the energy is used for evaporation and crystallization, it stands to reason to focus here.
ENERGY COST

Since most of the sugar refining processes is conducted in the liquid phase, much water is added to the raw sugar. This has to be evaporated using steam.

The main options for reducing the steam usage in a sugar refinery are:

• Multi Effect Evaporation
• Continuous Pan Boiling
• Mechanical Vapour Recompression
ENERGY COST

MULTI EFFECT EVAPORATION

Using the Rilleaux principle, one ton of steam can evaporate $x$ tons of water when employing $x$ effects.

The use of low $dT$ falling film evaporators has made it possible to have at least two to three effects in a sugar refinery.
Continuous pans have a low hydrostatic head, thus requiring lower pressure steam.

This is well matched with the previous idea of employing multiple effect evaporators by using bled vapour to power a continuous pan.

For example, a batch pan needs calandria steam temperature of 120 deg C, whereas a continuous pan calandria can manage with a sub-atmospheric pressure steam of 90 deg C.
Vapor recompression is employed to recover low-grade waste heat from vapour.

It is cheaper to compress vapour into a higher-pressure steam, than it is to generate it from water.

It lends itself to continuous pans because continuous pans have a low-pressure requirement for its calandria.
CHEMICAL COST
Chemicals are used in the following unit operations in sugar refining:

- Utilities
- Clarification
- Decolorization
- Crystallization

We shall be focusing on these two operations.
Sulfur has long been eliminated as a chemical for clarification in most modern sugar refineries.

The main process for clarification are:

• Phosphatation
• Carbonatation

Both have advantages and disadvantages when it comes to chemical costs.
CHEMICAL COST

Phosphatation plants are low capital cost installations, but they require more costly chemicals compared to carbonatation.
CHEMICAL COST

Carbonatation only requires lime and flue gas, however, it is a high capital and maintenance cost process.

Both require cationic colorants to deal with high color sugar.

It has been shown in many previous reports that the use of decolorants are cost effective due to the lower sugar recycling caused by excessive wash water.
CONTINUOUS IMPROVEMENT
Often, the use of simple tools help focus employees to improve the performance of a station.

For example, the collection of membranes provide a visual indicator of sediments in sugar products.
Another example, the collection of hourly refined sugar samples provide a visual indicator of the sugar quality.

Operators soon acquire an eye for sugar color and adjust quickly, long before the lab results are posted.
There is no substitute for visual inspection.

A set of faulty centrifugal nozzles can undo the good work of the crystallization station.

Operators need to schedule regular inspections on the internals of each machine as required.
Here is one nozzle that is blocked.

This would result in high color sugar on the belt and reported by the laboratory.

Operator will increase the wash time to decrease the average sugar color.

This excessive washing results in significant yield losses.
Benchmarking is a very useful tool to improve performance.

The most effective way is to compare performance between similar types of refineries.

In the absence of such arrangement, a refinery would benchmark itself against its previous performance.
Typical benchmarking data is shown below per metric ton refined sugar output RSO

- Total Energy (Mjoules) / Ton RSO
- Power (KW*h) / Ton RSO
- Water consumption liters/Ton RSO
- Steam consumption T/T RSO
- Sugar loss % of raw sugar (%)
- Labor prod. MT RSO/ employee
- Molasses % RSO
- And many others as needed
CONCLUSION & RECOMMENDATION
This report focused on the following main issues concerning sugar refining:

- Yield and sugar loss
- Energy costs
- Chemical costs
- Continuous improvement
- Benchmarking
It is clear that going back to basics is the first step to achieve world class manufacturing.

The quest for excellence is a journey and not a destination.

In all cases, employee involvement is key to their motivation, and an optimum combination of man and machine delivers the best result.
Thank You for your attention

Gracias
Merci Beaucoup
Grazie
ありがとう
Kiitos
Danke sehr
Obrigado

CSI Clients

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