THE “PURITY LOSS” CONCEPT AS A SIMPLE MEASURE OF PROCESS EFFICIENCY

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ABSTRACT

In this paper a new concept of “purity loss” is discussed. It is the “virtual purity of molasses” conceived by Noel Deerr to calculate the reduced boiling house recovery for comparing boiling house efficiencies. The process of cane sugar manufacture is one of increasing the purity of the mixed juice solids to the desired purity of commercial sugar. This means the removal of maximum non-sucrose with minimum possible sucrose loss in the by-products and unknown losses in the overall operations. The sucrose loss per unit non-sucrose eliminated at every stage is a measure of the efficiency of the operation. This is indicated by the purity loss in that operation. For example, the purity loss in clarification is a measure of the clarification efficiency. The “purity loss” in the crystallisation process is indicated by the final molasses purity, while the extent of inversion, spillage loss of any material etc. is indicated by the purity of unknown losses. The method of calculation of “purity loss” at each stage from the factory data has been demonstrated. The “total purity loss” (virtual purity of molasses) can be calculated easily from the observed mixed juice purity and the boiling house recovery using Deerr’s SJM formula.

INTRODUCTION

The “purity loss” concept is an off-shoot of Noel Deerr’s SJM Formula for available sugar calculations. The raw material received into the process house in cane sugar manufacture, is the mixed juice of a certain purity (J) which is a measure of the proportion of sugar and non-sugar contained in it. The process is essentially one of refining a lower purity material into a higher purity product — sugar, and hence the main objective is to eliminate non-sugar at every stage until commercial sugar of the desired purity (S) is obtained. In the various operations such as clarification, filtration, evaporation, crystallisation etc. some sucrose is invariably lost along with the non-sucrose eliminated. So, the factor which indicates at what loss of sucrose every unit of non-sucrose is eliminated, is a measure of the process efficiency. Hence, the usefulness of the “purity loss” concept.

CALCULATION OF “PURITY LOSS” FROM SJM FORMULA

Let R be the observed boiling house recovery, J the observed mixed juice purity and Mv the “virtual purity of molasses” or “total purity loss”.

Then, \[ R = \frac{100 (J - Mv)}{J (100 - Mv)} \times 100 \]

Therefore, \[ Mv = \frac{100 J - JR}{10000 - JR} \times 100 \]
Decr's "virtual purity of molasses" is here more correctly designated as the "total purity loss" because it shows the real meaning of the concept. It is the actual purity of the total losses taking place in the entire process house and hence a correct measure of the sucrose loss per unit non-sucrose received in the raw material, i.e. mixed juice.

**CALCULATION OF "PURITY LOSS" FROM FACTORY DATA**

The 3 main sources of loss in cane sugar manufacture are as follows:
1) Losses in clarification process through the filtercake;
2) Losses in crystallisation process through the waste molasses;
3) Unknown losses by inversion of sucrose, spillage of material, etc.

The purities of these different losses and the "total purity loss" can be calculated from data collected from a factory as shown in the following example:

*Data taken from the Manufacturing Report*

<table>
<thead>
<tr>
<th></th>
<th>Brix</th>
<th>Pol</th>
<th>Purity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mixed juice</td>
<td>15,99</td>
<td>13,11</td>
<td>81,99</td>
</tr>
<tr>
<td>2. Clear juice</td>
<td>16,45</td>
<td>13,52</td>
<td>82,19</td>
</tr>
<tr>
<td>3. Final molasses</td>
<td>92,74</td>
<td>29,29</td>
<td>31,56</td>
</tr>
<tr>
<td>4. Mixed juice % cane</td>
<td>88,10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Final molasses % cane</td>
<td>3,90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Filtercake % cane</td>
<td>2,68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Pol % filtercake</td>
<td>1,16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Sugar recovery (ESG)</td>
<td>10,28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Boiling house recovery</td>
<td>89,01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CALCULATIONS**

1) **Brix in MJ % cane**

\[
\text{Brix in MJ} \times \frac{88,1}{100} = 14,09
\]

2) **Pol in filtercake % cane**

\[
\text{Pol in filtercake} \times \frac{2,68}{100} = 0,03
\]

3) **Non-sugar in filtercake % cane**

\[
\text{Non-sugar in filtercake} = 2,50
\]

**Purity loss in filtercake**

\[
0,03 \times 100 = 42,86
\]
4) Brix in molasses % cane
\[
\frac{92.74 \times 3.9}{100} = 3.61
\]
Pol in molasses % cane
\[
\frac{29.29 \times 3.9}{100} = 1.14
\]
Non-sugar in molasses % cane
\[
\frac{3.61 - 1.14}{100} = 2.47
\]
"Purity loss" in molasses
\[
\frac{3.61}{100} = 31.58
\]
5) Non-sugar in unknown loss
\[
2.54 - (0.04 + 2.47) = 0.03
\]
Sugar in unknown loss
\[
11.55 - (0.03 + 1.14 + 10.28) = 0.10
\]
Brix in unknown loss
\[
0.03 + 0.10 = 0.13
\]
"Purity loss" unknown
\[
\frac{0.10 \times 100}{0.13} = 76.92
\]
6) Total brix losses
\[
0.07 + 3.61 + 0.13 = 3.81
\]
Total pol losses
\[
0.03 + 1.14 + 0.10 = 1.27
\]
"Total purity loss"
\[
\frac{1.27 \times 100}{3.81} = 33.30
\]
7) Virtual purity of molasses by Deerr's formula
\[
= \frac{100J - JR}{10000 - JR} \times 100
\]
\[
= \frac{8199 - 81.99 \times 89.01}{10000 - 81.99 \times 89.01} \times 100
\]
\[
= 33.30
\]

PURITY OF A LOSS VERSUS PURITY OF A MATERIAL

Purity of a loss
\[
= \frac{\text{Sucrose loss}}{\text{Solids loss}} \times 100
\]

Purity of a material
\[
= \frac{\text{Sucrose content}}{\text{Solids content}} \times 100
\]

In a material, the purity cannot be more than 100 because, evidently, the sugar contained in it cannot be more than the total solids in it. But there is a difference in the case of purity of a loss, because sometimes loss of sucrose can be more than the loss of solids, as in the case of sucrose inversion in which sugar loss does not involve any solids loss. On the other hand, 95 parts of sucrose when inverted becomes 100 parts of invert sugar. Thus there is slight gain in solids in sucrose inversion. When sucrose loss takes place without any solids loss, the purity of the loss is infinite:

"Purity loss" in sucrose inversion
\[
= \frac{\text{Sucrose loss by inversion}}{\text{ZERO}} = \text{Infinity}
\]
The unknown loss usually is due to the combined effect of sucrose inversion and spillage loss of materials of various purities. So “purity loss” unknown, can be less or more than 100 depending upon the extent of inversion loss and the materials lost by spillage.

“PURITY LOSS” — A MEASURE OF CLARIFICATION EFFICIENCY

In carbonation factories where very large quantities of non-sugar are precipitated and removed from the juice during the clarification and filtration operations, the “purity loss” in clarification will be very low, resulting in the “total purity loss” (virtual purity of molasses) coming down below the actual final molasses purity. This is a clear indication of the superiority of the carbonation process in obtaining higher sugar recovery by elimination of more non-sugar at the clarification stage. This is also the reason why the carbonation factories attain boiling house recoveries exceeding the “maximum retention” calculated by SJM formula.

When the “total purity loss” is more or less equal to the actual final molasses purity, the sugar and non-sugar are lost in the pan boiling and other operations of the process house, in more or less equal proportions. It is difficult to obtain this level of efficiency in either a defecation or a sulphitation process of clarification due to their inadequate precipitation and elimination of non-sugar. But in the more efficient carbonation process, the purification effect by non-sugar elimination is so high that the “total purity loss” (virtual purity of molasses) will be lower than the final molasses purity, indicating thereby the degree of efficiency of a better clarification process.

CONCLUSIONS

1) The “total purity loss” is a simple, but reliable measure of operating efficiency in cane sugar factories, because it indicates the sugar loss per unit non-sugar in the total operations of the process house.

2) The “purity loss” calculations from factory data facilitate the measurement of the efficiency of different sections of the process house. Purities of different losses, such as, clarification loss, molasses loss and unknown loss indicate the efficiencies of their respective operations, whereas the “total purity loss” indicates the efficiency of the total operations.

EL CONCEPTO DE “PERDIDA DE PUREZA” UNA MEDICIÓN SIMPLE DE EFICIENCIA DE LA ELABORACIÓN

T. T. Oommen

RESUMEN

En este artículo se discute un concepto nuevo, el de “pérdida de pureza”. Este es “la pureza virtual de la miel final” concebida por Noel Deerr para calcular la eficiencia de la elaboración reducida para la comparación de distintas eficiencias de la elaboración. El proceso de fabricación de azúcar de caña consiste en incrementar la pureza de los sólidos contenidos en el jugo hasta alcanzar el grado de pureza deseado en el Azúcar Comercial.
Esto significa la eliminación de la máxima cantidad de no-sacarosa con la menor pérdida posible de sacarosa en los sub-productos y en pérdidas indeterminadas en la operación total. La pérdida de sacarosa por unidad de no-sacarosa eliminada en cada etapa es una medida de la eficiencia de la operación. Eso queda indicado por la pérdida de pureza en esa operación. Por ejemplo, la pérdida de pureza en la clarificación es una medida de la eficiencia de la clarificación. La "pérdida de pureza" en el proceso de cristalización está indicada por la pureza de la miel final, mientras que el grado de inversión, pérdidas por derrames, etc. . . . están indicadas por la pureza de las pérdidas indeterminadas. El método de cálculo de la "pérdida de pureza" en cada etapa partiendo de los datos de operación, ha sido demostrado. La "pérdida de pureza total" (pureza virtual de la miel final) puede ser calculada fácilmente partiendo de la pureza observada en el jugo mixto y la eficiencia de la elaboración con la fórmula SJM de Noel Deerr.