Sugar Milling Research Institute

Technical Report

No. 1910

The Calculation of Recoveries

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4 July 2003

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Objectives

- To investigate various options for the calculation of extraction, boiling house recovery and overall recovery in the case of mud recycling and in the presence of a backend refinery.

Summary

- Mud recycling does affect the calculation of extraction but the appropriate systems have been put in place. The present method used to calculate boiling house recovery in the presence of a backend refinery lacks sophistication. Refinery undetermined loss is attributed to the raw house and therefore the boiling house recovery is consistently low.

Recommendations

- An alternative system is proposed to deal with the calculation of boiling house recovery in the presence of a backend refinery. However, this alternative system may not be practical because of the need for the additional measurement of some factory streams.

Keywords

Extraction, Recovery

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ABSTRACT

For a conventional raw sugar factory, extraction, boiling house recovery and overall recovery are well defined and easy to calculate. However, the introduction of mud recycling and the presence of backend refineries complicate these calculations due to return streams. These complications can be dealt with adequately by redefining the recoveries whilst maintaining their interrelationship (OR = EXT * BHR / 100). At the same time it seems appropriate to define a refinery recovery and an overall factory recovery which includes the refinery. The calculation of these recoveries provides better factory control but requires the measurement of additional intermediate process streams.

INTRODUCTION

In a sugar factory, recoveries are normally calculated for the purpose of factory control and payment considerations. These calculations focus on the production and loss of sucrose and are quite straightforward for a conventional raw sugar factory. In such a factory, cane feeds into the extraction plant producing mixed juice and bagasse as outputs. The mixed juice is further processed in the boiling house which has as outputs filter cake, molasses, undetermined losses and raw sugar. This arrangement is shown in Figure 1.

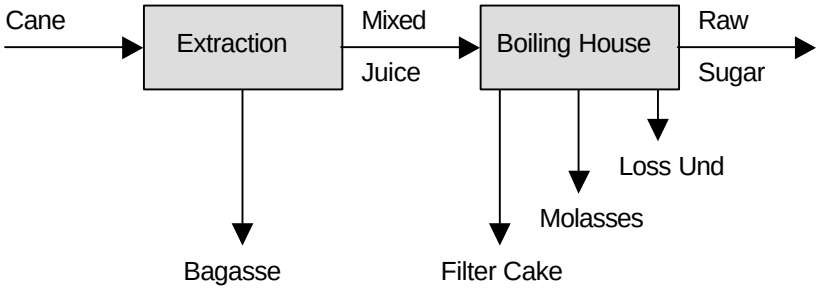

Figure 1. A conventional raw sugar factory.

The standard recoveries for such a raw sugar factory are extraction (EXT), boiling house recovery (BHR) and overall recovery (OR) . They are defined as follows:

$$EXT = Suc\ Juice / Suc\ Cane * 100 \quad [1]$$

$$BHR = Suc\ Raw / Suc\ Juice * 100 \quad [2]$$

$$OR = Suc\ Raw / Suc\ Cane * 100 \quad [3]$$

Note that the sucrose in cane is by mass balance and not by DAC. The following relationship exists between these recoveries:

$$OR = EXT * BHR / 100 \quad [4]$$

Two deviations from the conventional raw sugar factory complicate this simple calculation of recoveries. The first deviation is the mud return to the diffuser. The second deviation arises from backend refineries. Some ways of calculating extraction, boiling house recovery and overall recovery under these conditions are investigated. Example calculations are given in Appendix A.

MUD RECYCLING AND EXTRACTION

A recent development in the South African sugar industry is the returning of all or part of the clarifier mud to the extraction plant (Figure 2). This mode of operation is mainly practised by diffuser factories (ML, KM, FX, AK, MS, UK). Mud recycling has a direct effect on the calculation of extraction.

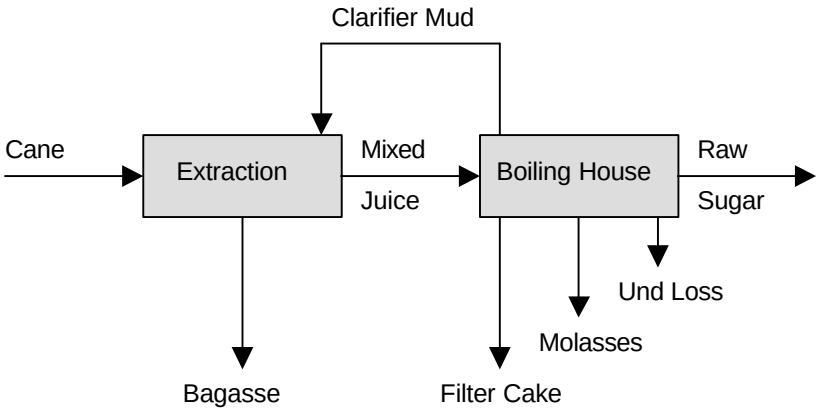

Figure 2. A raw sugar factory with mud recycling.

The definition of extraction given as equation [1] is not satisfactory for a raw sugar factory with mud recycling. However, this equation can be modified to suit both a conventional raw sugar factory and a factory with mud recycling without changing the outcome of the former. This modified equation looks as follows.

$$EXT = (Suc\ Cane - Suc\ Bagasse) / Suc\ Cane * 100 \quad [5]$$

The sucrose in cane minus the sucrose in bagasse is equal to the sucrose in juice minus the

sucrose in mud also called the sucrose in juice adjusted. Extraction can than be expressed in terms of the sucrose in juice, mud and cane as follows:

$$EXT = (Suc\ Juice - Suc\ Mud) / Suc\ Cane * 100 \quad [6]$$

This change in the definition of extraction has implications for the calculation of the boiling house recovery which is now better expressed as follows:

$$BHR = Suc\ Raw / (Suc\ Juice - Suc\ Mud) * 100 \quad [7]$$

Changing the equation for extraction and the boiling house recovery has no effect on equation [3] for the overall recovery and the integrity of equation [4] has been maintained.

BACKEND REFINERY AND BOILING HOUSE RECOVERY

Various factories (ML, PG, UF, GH, NB) operate with a backend refinery for the total or partial refining of the raw sugar with the possible import of raw sugar (Figure 3). The refinery return to the raw sugar factory, also called Jet 4 or final run off, complicates the calculation of the boiling house recovery.

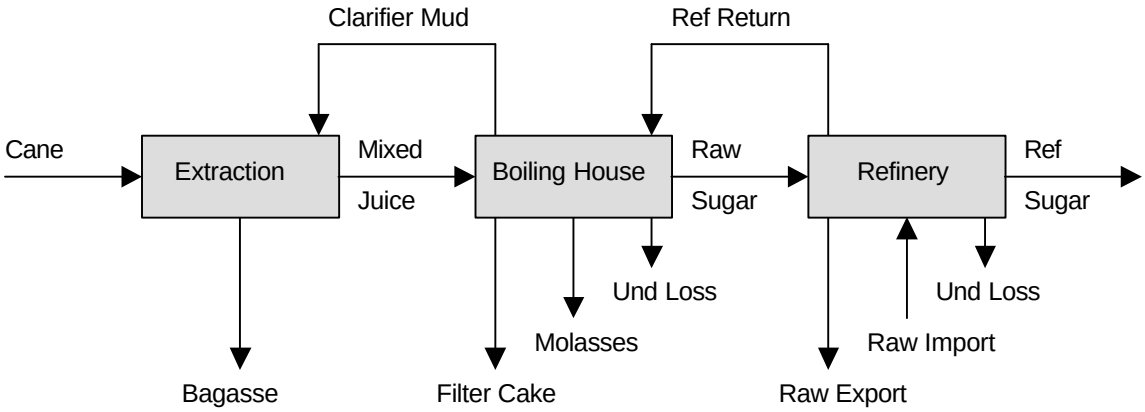

Figure 3. A raw sugar factory with mud recycling and a backend refinery.

Industry in general

The industry in general combines the raw house and the refinery in one recovery house. The import of raw sugar is discounted by correcting the refined sugar output. The corrected refined sugar output is the actual refined sugar output minus 98% of the raw sugar import. The output of that combined recovery house is then the sucrose in the corrected refined sugar plus the sucrose

in raw export. This leads to the following expression for the boiling house recovery:

$$BHR = (Suc\ CRef + Suc\ Exp) / (Suc\ Juice - Suc\ Mud) * 100 \quad [8]$$

The equation for the overall recovery changes accordingly:

$$OR = (Suc\ CRef + Suc\ Exp) / Suc\ Cane * 100 \quad [9]$$

Again the integrity of equation [4] has been maintained.

Malelane

The Malelane operation requires that their raw house and refinery are treated as separate entities. To this end they use a different system for the calculation of the boiling house recovery (Koster). The refinery return is translated into a deemed sugar and deemed molasses by calculating an SJM recovery using the actual molasses purity and assuming no undetermined loss in the conversion. The actual sucrose in raw sugar is subsequently corrected by subtracting the deemed sucrose. The boiling house recovery is then calculated from this corrected sucrose in raw sugar in the usual way:

$$BHR = (Suc\ Raw - Suc\ DRaw) / (Suc\ Juice - Suc\ Mud) * 100 \quad [10]$$

The equation of the overall recovery changes accordingly:

$$OR = (Suc\ Raw - Suc\ DRaw) / Suc\ Cane * 100 \quad [11]$$

Again the integrity of equation [4] has been maintained.

Alternative

Refinery return is for the boiling house recovery what returning mud is for extraction. To be consistent with the calculation of extraction the boiling house recovery must be expressed as follows:

$$BHR = (Suc\ Raw - Suc\ Return) / (Suc\ Juice - Suc\ Mud) * 100 \quad [12]$$

The equation for the overall recovery changes accordingly:

$$OR = (Suc\ Raw - Suc\ Return) / Suc\ Cane * 100 \quad [13]$$

Again the integrity of equation [4] has been maintained. Consistent with the calculation of extraction and boiling house recovery, the refinery recovery can now be expressed as the sucrose in the refined sugar output divided by the sucrose in the net raw sugar input minus the sucrose in refinery return:

$$RR = Suc\ Ref / (Suc\ Raw - Suc\ Return - Suc\ Exp + Suc\ Imp) * 100 \quad [14]$$

With no raw sugar import and export the factory overall recovery including the refinery can now be usefully expressed as follows:

$$FOR = Suc\ Ref / Suc\ Cane * 100 \quad [15]$$

Between extraction, boiling house recovery and refinery recovery there exists then the following relationship:

$$FOR = EXT * BHR * RR / 10000 \quad [16]$$

DISCUSSION

Mud recycling and the operation of backend refineries complicate the calculation of recoveries. Mud recycling affects mainly extraction and there seems to be general consensus about alternative calculation procedures. Backend refineries affect the calculations of boiling house recovery and overall recovery and are dealt with in different ways. The industry in general treats the refinery as part of the raw house and calculates a boiling house recovery and overall recovery which includes the refinery. This method is simple and requires no additional measurements but loses in its usefulness. Malelane negates the effect of refinery return by subtracting from the actual sucrose in sugar a deemed sucrose in sugar calculated from a theoretical recovery. This method is more representative but is rather complicated and requires the analysis of the refinery return. The alternative method uses the refinery return in the same way as the mud return is treated to calculate extraction. This method is simple and consistent but requires also additional analysis.

The method presently used by the industry lacks sophistication. Refinery undetermined loss is attributed to the raw house and therefore the boiling house recovery and overall recovery are consistently low.

REFERENCES

Koster, K (1994). Proposed approach for the separate backend refineries from raw houses for the calculation of factory balances. Inter Memorandum, Illovo Sugar.

APPENDIX A

Table 1. Analysis of factory streams

	Purity %	Sucrose tons	Brix tons
Cane	82.25	100.00	121.58
Mixed Juice	83.82	97.35	116.14
Bagasse	50.00	2.72	5.52
Clarifier Mud	83.82	0.07	0.08
Filter Cake	84.52	0.09	0.11
Molasses	33.00	8.96	27.16
Und Loss Raw	95.79	0.91	0.95
Raw Sugar	98.80	96.43	97.60
Raw Export	98.80	0.00	0.00
Raw Import	98.80	0.00	0.00
Ref Return	93.40	9.12	9.76
Und Loss Ref	98.80	0.58	0.59
Ref Sugar	99.41	86.74	87.25

Table 2. Calculated recoveries

	Industry	Malelane	Alternative
Extraction	97.28	97.28	97.28
Boiling House Recovery	89.16	90.03	89.76
Overall Recovery	86.74	87.58	87.32
Refinery Recovery	-	-	99.34
Factory Overall Recovery	-	-	86.74

SJM = 98.80 / 93.40 * (93.40 - 33.00) / (98.80 - 33.00) = 97.10

Deemed sucrose in raw sugar = 9.12 * 97.10 / 100
= 8.86

Deemed sucrose in molasses = 9.12 - 8.86
= 0.26