Factory performance evaluation with the Advanced Monitoring System (AMS)

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Abstract

During the last decades, automation systems, process control systems, process and laboratory information systems as well as management information systems have been introduced to the sugar industry and have been developed to a high standard today. These tools offer the advantage of much improved data availability/accessibility and a tremendous decrease in labour costs as well as improving factory operations. However, in other industries (e.g., the petrochemical industry) even more advanced expert systems are already state of the art. The "missing link" between the current data & information architecture and the implementation of expert systems is a consistent on-line mass and energy balance of sugar factories.

1.   Introduction

The process control system (PCS) of a sugar factory handles pressures, temperatures, flows and other values that are constantly being measured and controlled at various process areas. Data such as dry substance content (Brix), sugar content (Pol) and purities are determined in the factory's laboratory. Employing data management systems, data from the laboratory and process control system is centrally stored and made available for further evaluations (*Vogl* et al. 2000). Until today, the operators had no means to automatically elaborate a complete and self contained mass and energy balance of the factory. The Advanced Monitoring System developed by IPRO Industrieprojekt GmbH and Sugars International LLC (*Morgenroth* and *Weiss*, 2003) closes this gap. The **A**dvanced **M**onitoring **S**ystem (AMS) automatically imports data from the laboratory and the process control system. Thus, with only roughly 100 process parameters, the whole production process can be balanced regularly and with high precision. The AMS visualises mass and energy flows of the main stations such as extraction, juice purification, evaporation and crystallisation. The

operator reaches a much improved transparency of the whole process with the possibility of direct and fast optimisation.

2. Functional description of the AMS

Figure 1 gives an overview about the data processing by the AMS. Data from the laboratory and the process control system are automatically collected in a Process Data Acquisition System (PDAS). The decisive data for the simulation is converted into a XML file (e**X**tensible **M**arkup **L**anguage) and subsequently transferred to the AMS simulation model especially created for each factory. The simulation software is Sugars^{TM} in combination with Microsoft® Visio®. Future applications are intended to export data from the AMS into an Expert system which is able to manage the data for further calculations.
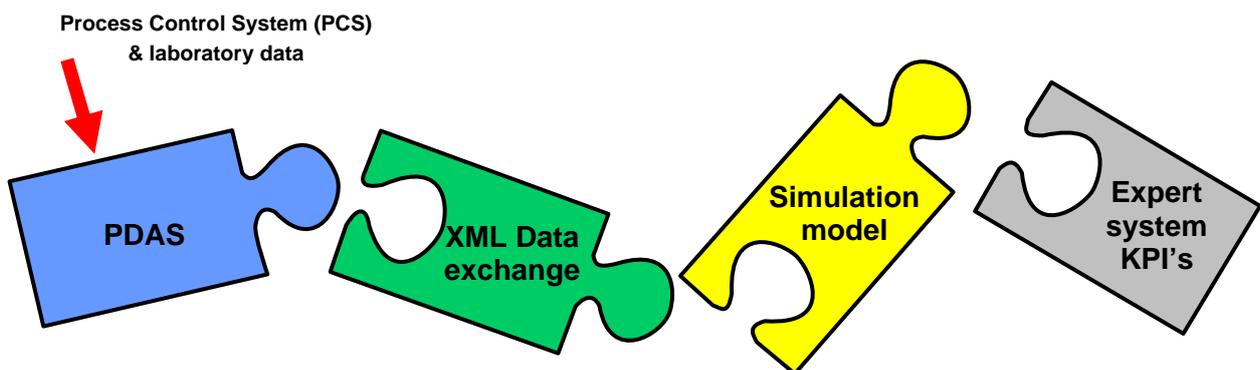
Process Control System (PCS)
& laboratory data

PDAS

XML Data exchange

Simulation model

Expert system KPI's

Figure 1:   Data import with the Advanced Monitoring System

Prior to being imported to the Sugars^{TM} model, measured data will be checked for plausibility. If the actual value ranges within laid down tolerance limits, the value will be read in. If it is outside the limits, either the lower or the upper tolerance value will be read, in order to balance at all. Additionally, an "Error report" will be initiated showing breaches of tolerances. Should errors occur during the data exchange between the XML-file and the AMS, this will be displayed as well. Additionally, in Sugars^{TM} the newly read data will be compared with previously processed data establishing a „Comparison Report" and proportional deviations will be calculated and shown. With this the operator has the possibility to observe operational changes.

Figure 2 shows an excerpt from a simulation model of an evaporation plant with 5 effects. The Sugars^{TM} model displays the actual balance of the particular factory. This model shows among others the demand of exhaust steam with 128,48 t/h and a pressure of 220 kPa.

Apart from that, the mass flows of vapour I to V to each consumer will be verified with actually measured data. Process data, i.e. dry substance contents, temperatures, etc. of juices in the evaporation station as well as condensate and vapour temperatures will be balanced and shown.
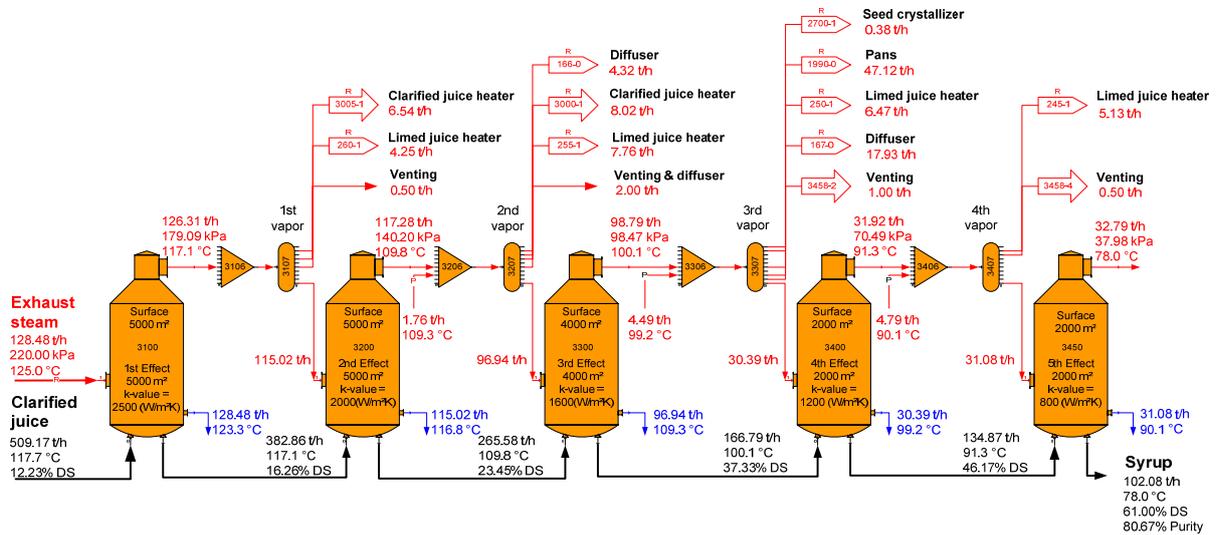

Figure 2:   Excerpt from a simulation model of an evaporation station, 5 effects

The figure 3 shows an excerpt from a sugar house model of a factory. With the AMS, sugar crystal losses occurring in a centrifugal can be easily detected. This information could lead to timely decisions on the need to replace faulty screens, for example or indicate other problems within the sugar boiling station.

A fundamental problem regarding approximation to a true on-line balance is the different measuring intervals for various process data. Whereas, for temperatures, pressures and for example the cane mass flow values are usually recorded, e.g. every twenty seconds, the analytical data (dry substance, purities, etc.) is only available in an hourly rhythm or even much larger intervals. The on-line measurement of analytical data is, even today, not developed far enough as to measure all values precisely on-line. Apart from that, the costs for on-line measuring instruments today are still very high. The intervals for every measurement can be chosen freely with the AMS and thus be adapted easily to the factory system. The consideration of product retention times can have positive effects on the accuracy, as the non-sugar load brought into the process has a retention time of up to three days until discharged with the molasses.
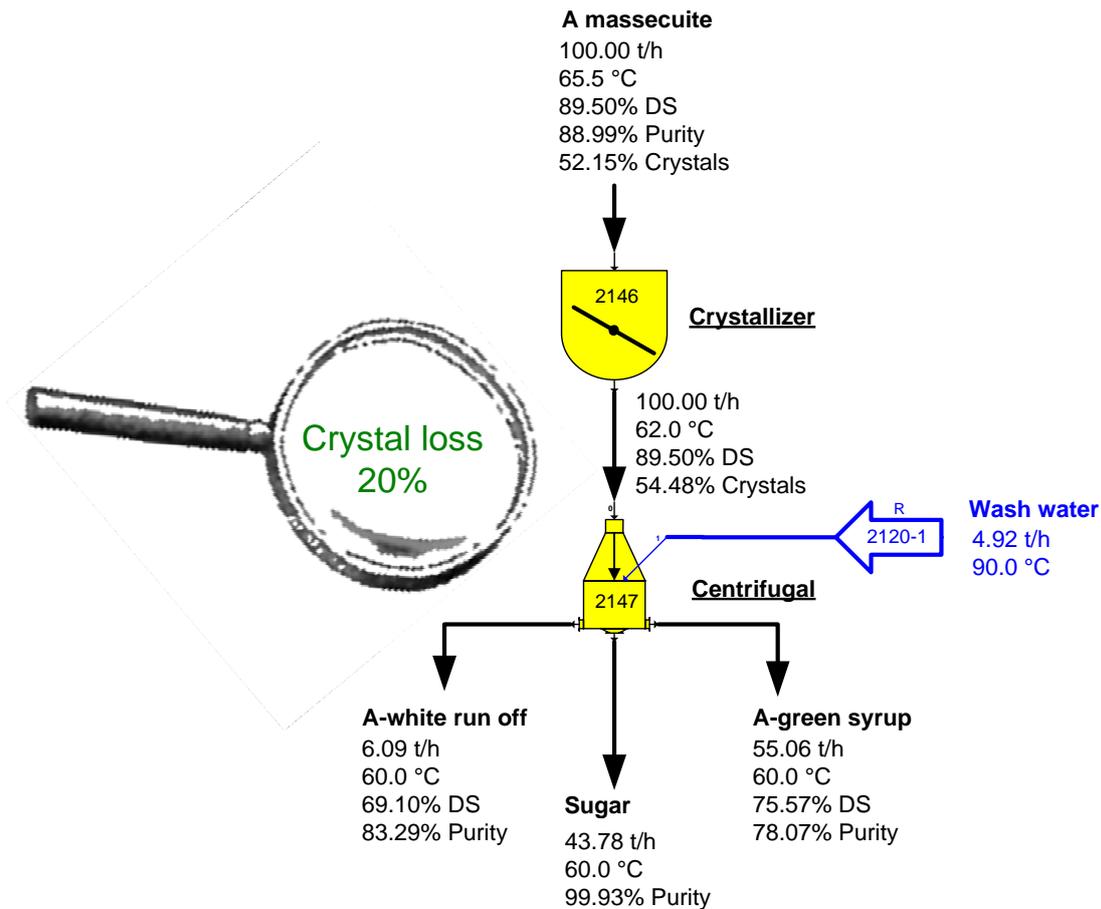
A massecuite
100.00 t/h
65.5 °C
89.50% DS
88.99% Purity
52.15% Crystals

2146   **Crystallizer**

Crystal loss 20%

100.00 t/h
62.0 °C
89.50% DS
54.48% Crystals

R
2120-1

Wash water
4.92 t/h
90.0 °C

2147   **Centrifugal**

A-white run off
6.09 t/h
60.0 °C
69.10% DS
83.29% Purity

Sugar
43.78 t/h
60.0 °C
99.93% Purity

A-green syrup
55.06 t/h
60.0 °C
75.57% DS
78.07% Purity

Figure 3:   Excerpt from a sugar house simulation model

Further advantages of the AMS/Sugars[TM] are: high flexibility, adjustment at any time or to new operating conditions and its simple installation and mode of operation. The specially designed Sugars[TM] model balancing and graphical displaying the factory operation can also be helpful to the management concerning decisions on capital investments. By means of variations of the Sugars[TM] model, many different proposals can be simulated providing an optimised result.

The XML-file with the actual process data can also be transmitted via Internet and thus allows the possibility of absentee diagnosis.

3. First experiences in Brazilian cane sugar factories with the AMS

With the installation of an Advanced Monitoring System in three Brazilian cane sugar factories, first experiences have been made and flawless function has been proven. The AMS offers the factory management a permanent mass and energy balance of the whole

production process (transparent factory). Balance periods of 12 h or 24 h have proven to be reliable. A balance variant with process data collected at 15 minute intervals and the analytical data collected at a 12 hours interval produces also good results, but makes the system more sensitive to disruptions. The existing process data management system had to be adjusted to the demands of the AMS. The access to laboratory data whenever wanted - meaning a free choice of the interval for balancing - was not possible at first and had to be adjusted.

4.   Outlook

Cutting down the data flood by introducing the AMS to only about 100 parameters needed for balancing the process allows, in the medium term, a significant reduction of measuring points in the PCS and in the laboratory, as virtually all operation relevant parameters can be calculated with the program. However, the demands on accuracy of the parameters used for balancing are high. Today, AMS data can be transferred directly into the data management system of the factory and calculated process values can be displayed in the factory PCS allowing the operating team an improved overview of the process. The "over-automation" sometimes observed in certain factories can be stopped and investment and maintenance costs can be lowered. Above all, we regard the AMS only as a necessary intermediate step for the implementation of expert systems.

Key performance indexes (KPI's) such as the k-values of heat exchangers and evaporators determined with the system could then be compared deliberately with benchmark data. Following this, for example automatic cleaning orders could be given and a multitude of other functions are conceivable. Another important KPI is the centrifugal sugar crystal loss due to dissolving of crystals that can be monitored directly with the system.

Figure 4:   Handling sequence of Key Performance Indexes (KPI's) of chosen equipment or process steps by means of the AMS

5.   Summary

With the Advanced Monitoring System (AMS) the whole production process of a cane sugar factory can be balanced and presented in a "transparent" simulation model. The AMS puts the operator in the position of fast recognition of disturbances in the process or of equipment and thus enables him to intervene at the right time and place. The AMS can also be the basis for a later installed expert system so that an automatic optimisation of processes can go forward.
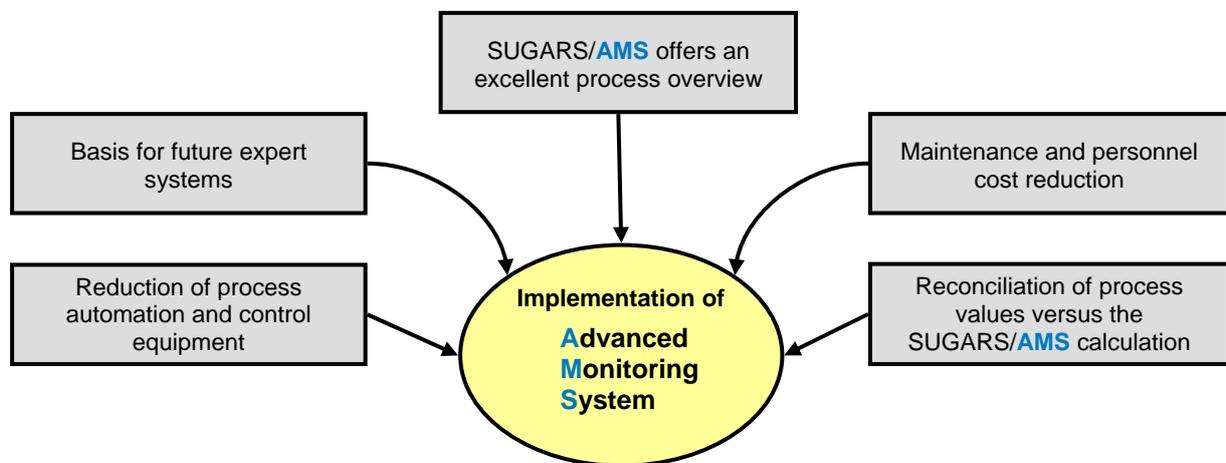

Figure 5:   Decisive factors in favour of AMS implementation

6.   References

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Vogl, W., Koenig, H., Woehrle, K., Zahrer, R., 2000: Automatic integration of process and laboratory data into a Management Information System at the Südzucker factory in Offenau, International Sugar Journal 102, 522-529