CENTRIFUGAL CONTROL WITH AUTOMATIC COLOUR MEASUREMENT

NIELSEN B C

Neltec Denmark A/S, DK-6541 Bevtoft, Denmark
bcn@neltec.dk

Abstract

In sugar mills, factories and refineries, the sugar colour varies depending on the quality of the massecuite. Compensation to get a more uniform quality is done by adjusting the amount of water spraying in the centrifugals. Delays in laboratory results and operator adjustments necessitate the sugar colour be kept at a safe margin below the maximum allowed colour. The time delays can be eliminated by applying automatic real-time colour measurement and using it for automatic control of the spray water. Consequently, the safety margin can be reduced. This leads to significant reductions in the amount of sugar melted in the centrifugals and sugar lost during recycling.

In 2005 two automatic Neltec ColourQ colorimeters were used to implement automatic control of the wash water in the centrifugals.

This paper explains how the instruments were installed, how results are obtained which show how colour varies throughout each charge, how the results are displayed to the operators and how the results are used to control the spraying in the centrifugals. The results and benefits from the automatic colour measurement before and after implementation of the automatic control are discussed.

Keywords: sugar colour, real-time, washing, control, quality, remelt

Introduction

Process optimisation is an important factor in keeping production costs and energy consumption as low as possible. Large variations in the process are expensive to correct and may lead to a quality outside specifications.

The traditional methods for measuring sugar solution colour are the laboratory methods specified by (Anon, 2005). These methods are indispensable for determining the quality of the sugar and for calibrating other, indirect methods. However, for process control the delay between sampling and obtaining a result is too long because of the time required for the laboratory determination. The sugar is already in storage before the colour is known.

Some companies have tried monitoring the sugar colour with systems based on video cameras. The resolution, accuracy and stability of these instruments are not at the same level as the instrument described here (unpublished data1).

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For more than 15 years Neltec has supplied robust and accurate in-line colorimeters (ColourQ) to the sugar industry. Frequent exchange of experiences and requests from existing or potential clients have led to continuous expansion of the application range, improvements to the instrument, and further development of the user interface.

**Measuring sugar solution colour in real-time**

Figure 1 shows the instrument installed over a belt conveyor. The two stainless steel tubes contain the illuminator and the detector. The lamp in the illuminator sends light to the surface of the sugar. Reflected light is picked up by the detector and split into different wavelengths – including 420 nm. From the strengths of the signal at various wavelengths the instrument uses its calibration to calculate the solution colour.

It is important to note that the instrument does not use the ICUMSA method in its direct measurement. It uses an indirect method, where it is calibrated by means of samples taken to the laboratory for ICUMSA solution colour determination. This method of calibration is called ‘chemometrics’, and is well known from NIR instruments. Compared to NIR instruments, this instrument has the advantage of a very stable calibration over many years.

![Figure 1. Neltec in-line colorimeter – ColourQ.](image)

Figure 2 shows the instrument installed on a screw conveyor. The instrument is able to measure in screw conveyors, grasshopper conveyors, belt conveyors and scraper conveyors. For dry sugar the belt conveyor is recommended. On other conveyors dry sugar dust may hinder the free sight to the surface of the sugar, thus disturbing the measurement.
Figure 2. ColourQ installed on a screw conveyor.

Accuracy

The results from a test in the sugar factory of Tereos, Bucy-Le-Long is shown below (Figure 3). Here the instrument measures wet sugar on a grasshopper conveyor after the centrifugals.

Figure 3. Test of Neltec ColourQ 800 calibration.

A test by Tereos, Origny-Ste-Benoîte, over more than one year showed a SEP of 1.4 IU and gave the following conclusion: “The SEP (Standard Error of Prediction) for the instrument includes, by definition, the SEP of the laboratory measurements. Thus, the additional inaccuracy introduced by the instrument is so small it is negligible. After completion of the
tests, the instrument was connected to the conveyor controls. It now automatically switches the sugar between two silos.” (Bienaimé and Nielsen, 1999).

Other tests have been made by sugar institutes (Buchholz and Bruhns, 1995; Edye et al, 1997; unpublished data2), refineries (Mabillot, 2000; Malgoyre et al, 1999), and sugar factories (Suhr et al, 2003).

**Colour profile of a charge**

In centrifugals error may occur. In many cases the error starts slowly in one part of the basket and gets worse and worse over time. To detect whether the colour increases to a critical level anywhere in the basket, it is important to be able to follow the colour variation second by second as the centrifugal discharges.

Figure 4 shows a very common example with higher colour in the corners of the basket, due to reduced flow of water at the top and bottom of the basket. First the plough meets some well washed sugar on the inside of the wall of sugar. As it moves outwards it hits the sugar in the upper corner with higher colour. On its way down it meets well washed sugar again until it reaches the lower corner of the basket.

![Figure 4. Typical colour distribution in a centrifugal.](image)

The curve to the right in Figure 4 shows a typical profile of the various sugar colours taken out by the plough on its way into the sugar and down along the outer rim of the basket. If a peak suddenly increases by many colour units, indicating a serious problem under development, it would be very easy to see in the curve. Without a colour profile, only a slight increase in the average colour would be detected. Further, it would be difficult to determine whether the increase was due to increased colour of the massecuite or was caused by an error in the centrifugal.

Figure 5 shows how an instrument can pick up measurements from a charge from the beginning to the end as the charge moves under the instrument on the conveyor. Signals from the centrifugals and timers in the instrument help identify the centrifugal from which the measured sugar originated. This means one instrument can collect colour profiles from all centrifugals in a battery (provided the charges have little overlap).

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The plate at the end of the conveyor indicates a switch in the sugar flow. The instrument can control the switch to automatically send sugar with high colour to remelt. Just as important, the instrument will switch back as soon as the sugar comes within specifications again.

**Presentation of results**

Figure 6 shows the display on the system's computer, when the instrument measures wet sugar coming out of the centrifugals. T1 to T6 indicate the centrifugals 1 to 6. The six windows in the upper part of the screen are one for each centrifugal. In each window you can follow the colour variation from the beginning to the end of a charge. The coloured squares are the measurements - one new square per second as the centrifugal discharges. The black curve shows the results from the previous charge from the same centrifugal. This makes it easy to follow colour changes even in a small fraction of the centrifugal. Above the window the system displays the average colour of the charge. Once a charge has been measured, the average colour is displayed as a coloured rectangle in the lower window, where every charge over two hours is shown. It is thus easy to check where some centrifugals have delivered sugar with higher colour than others. The black curve shows the average colour of the sugar from all centrifugals. At the bottom of the screen the system displays the average colour of the current shift (34.3 IU) and the three previous shifts, 31.9 IU, 31.6 IU and 34.0 IU, respectively.

The results displayed in Figure 6 show an example of how the centrifugals may be performing just after installation of the instrument and before much optimisation has been done. Centrifugal four delivers sugar with colour 24 IU in a small fraction of the charge. This means the current massecuite could deliver sugar of colour 24 IU, if washed properly. However, some parts of the charge have a much higher colour, leading to an average colour of 50.5 IU for the whole charge. By adjustment of the spraying system, checking the nozzles, checking the screen, and proper flushing of the screen, the current global colour of 41 IU may easily be reduced by 10-15 IU - without any increase in energy or other costs. The colour profiles of the centrifugals are important tools for the optimisation. Not only does the system tell which centrifugal has a problem, but also in which part of the centrifugal the problem is occurring.
Figure 6. ColourQ computer display.

Figure 7 shows an example of centrifugal performance after optimisation. The colour profiles are completely flat. The shift colours are 26.9 IU, 27.0 IU, 26.4 IU, and 27.7 IU for the last four shifts. The average colour from all centrifugals varies between 24 IU and 32 IU. This is due to variations in the incoming massecuite. This factory has pans of three different constructions, delivering massecuite of slightly different CV, and resulting in slightly different purging of the mother liquor.

Figure 7. Centrifugal performance after optimisation.
Influence from variation in wash water on colour

At the sugar factory in Aarberg, Switzerland, the influence from changes in wash water on the sugar colour has been tested. The results are shown in Figure 8 as sugar colour versus spraying time.

![Figure 8. Colour versus spraying time.](image)

The curve shows that at spraying times in the upper-20s and above, the colour improvement from additional spraying is marginal. Even at spraying as low as 20 seconds, a reduction of the spraying by one second increases the colour by just 0.2 IU. This shows that tight control of the spraying time can lead to important reductions in the amount of wash water without any significant change in quality.

Automatic control of washing

In a sugar beet campaign in 2005/06, two sugar factories implemented automatic control of the washing with the ColourQ instrument, Zuckerfabrik Aarberg in Switzerland and British Sugar in Cantley. Both have experienced a significant improvement in the stability of the quality produced.

Figure 9 shows a comparison between the colour of spot lab samples and the shift average colour measured by the ColourQ in Cantley. The automatic control was implemented on 25 November 2005. After this date the target colour could be increased without risk of producing sugar with too high a colour.

In January and February 2006 the curves show larger variations in colour due to lower beet quality. The curves sometimes show too high colour. This sugar is automatically sent to remelt - not to the silo.
Figure 9 shows the colour of each and every charge produced in Aarberg during the month of November 2005.
Reduction in wash water

Prior to the 2005 campaign, Aarberg sprayed for approximately 25 seconds on the charges in 1750 kg centrifugals filled practically to the rim (25 seconds of water corresponds in this case to 45 litres). After implementation of the automatic control the wash water is now kept within the range 14 to 21 seconds. For extended periods the system runs at 14 seconds.

Since the ColourQ was installed in the 2000/01 campaign, Cantley has monitored the total water consumption in the centrifugals (Figure 11). The graph covers the period from the installation of the ColourQ in 2000/01. The reduction of 2.4 cbm wash water per 100 t of crystal would have dissolved 7.2 t of crystal, corresponding to 7.2% of production.

Figure 11. White Cents wash water.

Savings from automatic washing

Based on the experiences from the two factories, the following assumptions can be made about the savings from automatic spray water control:

- Sugar per charge          900 kg
- Sugar dissolved per litre of water    3 kg
- Reduction in spraying time         7 seconds
- Sprayed water per second        1.8 litres

The seven seconds of spraying would have dissolved 37.8 kg of sugar from each charge. The sugar not dissolved due to the reduction in spraying time corresponds to 4.2% of production.

The 4.2% of the sugar taken away from the processing equipment frees capacity to process 4.4% more sugar in the same sugar house. If the sugar house is a bottleneck, then 4.4% more sugar can be processed or the length of the campaign can be reduced by 4.2%.
Savings from reduction of remelt

The real-time colour measurement enables real-time control of remelt. At the moment that the sugar colour gets too high, all sugar can automatically be sent to remelt, and as soon as the colour is back at an acceptable value the remelt can be stopped. Cantley estimates that the use of the instrument has reduced unnecessary remelt by 2000 tons per year, leading to savings of £20 000 per year. This reduction was seen already in the first year the instrument was installed.

Other savings

The real-time measurements from the instrument reduce the need for lab measurement of samples. A daily sample to check the function of the in-line instrument is sufficient for many users of the ColourQ. The reduced recirculation of sucrose in the sugar house reduces the loss to molasses. The saved water does not require energy for evaporation.

Summary

Automatic control of wash water in the centrifugals is possible and leads to significant savings through elimination of unnecessary spraying in the centrifugals, better utilisation of the installed capacity in the sugar house, a reduction in the amount of sugar sent to remelt, lower energy consumption, and reduced loss of sucrose to molasses.

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(The reference articles and footnotes may be downloaded as PDFs from www.neltec.dk)