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Real-Time Measurement of Solution Colour

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Sugar Colour has Frequent Variations

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In sugar production the colour of the sugar changes all the time.

When measuring dry sugar in the factory or refinery you would expect variations to occur slowly in the colour, because the dryer mixes sugar from the different centrifugals. However, we have observed shifts of up to 7 ICUMSA units (ICU) in less than two minutes in sugar leaving the dryer.

For moist sugar leaving the centrifugals the variation is much higher. Sugar crystals from different parts of a centrifugal basket are cleaned differently by the water sprays. Unless you spray too much water - and dissolve too much good sugar - you'll see a significant colour variation over each charge. Because of these variations a traditional, manual sample is rarely representative of the average sugar colour.

The traditional colour measurement in the laboratory has another disadvantage: it takes time. You have to wait for at least half an hour to get the results. During this time too high coloured sugar may have been sent to the silo - or good sugar may have been remelted. [1]

Since 1988 Neltec has been delivering ColourQ real-time colour measurement systems to sugar factories and refineries to safeguard quality and to reduce the costs of production. [2,3,4]

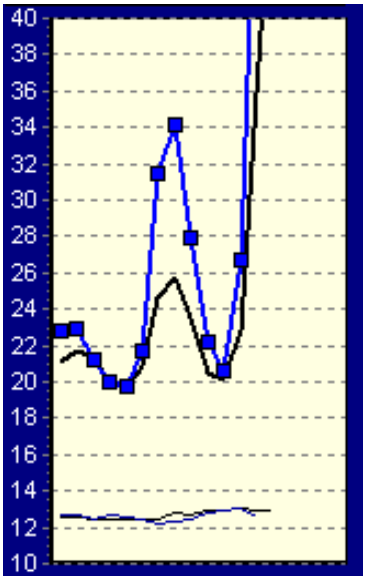


FIGURE 1
Example (not typical) of the colour variation from the beginning to the end of a charge.

Principle of Measurement

The ColourQ measures solution colour and works by analysing light reflected from crystalline sugar on a conveyor. The conveyor may be of the hopper/shaker, belt, or screw type. [5]

Ambient light changes constantly in intensity and colour temperature. If this is allowed to influence the measurements, the results will merely show changes in the illumination instead of variations in the sugar colour.

The ColourQ provides its own illumination with stroboscopic light. The detection unit is able to eliminate the ambient light from the measurements. In a PC, data on the measured wavelengths and intensities are used to calculate corresponding sugar colour in solution values. This calculation is done via a “calibration” - by reference to a mathematical model of the syrup, the sugar crystals, and their interaction with light. Neltec generates the calibration model from a set of samples taken during production and measured in the laboratory.

Neltec calibrations have proven to be stable for years.

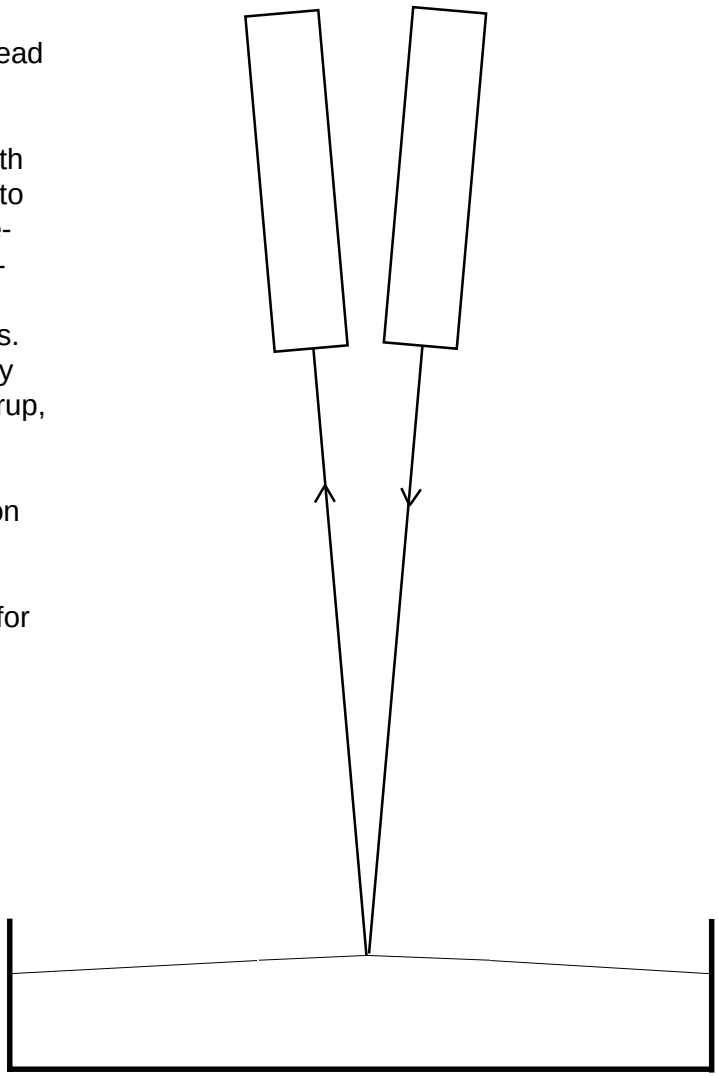


FIGURE 2.
Illuminator and detector over conveyor.

Presentation of Results

The ColourQ system takes 15 to 40 measurements per second and presents a new colour value every few seconds. The results are presented as a curve on the computer screen and can be sent to the central process control system.

For moist sugar after the centrifugals the ColourQ keeps track of which centrifugal has delivered the measured sugar. With this information the ColourQ can draw a curve - a ColourProfile - of every charge leaving each centrifugal. [6,7]. In most installations the ColourProfile has 10 to 20 colour values from the beginning to the end of the charge. From the ColourProfile the operators immediately see if the sugar is being washed too much or too little, if the spraying system is working efficiently, if the flow through the small holes in the basket has been blocked by sugar, or if any other non-optimal parameter is making one centrifugal run less efficiently than the others.

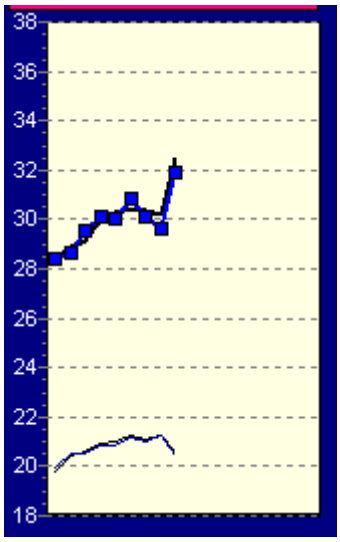
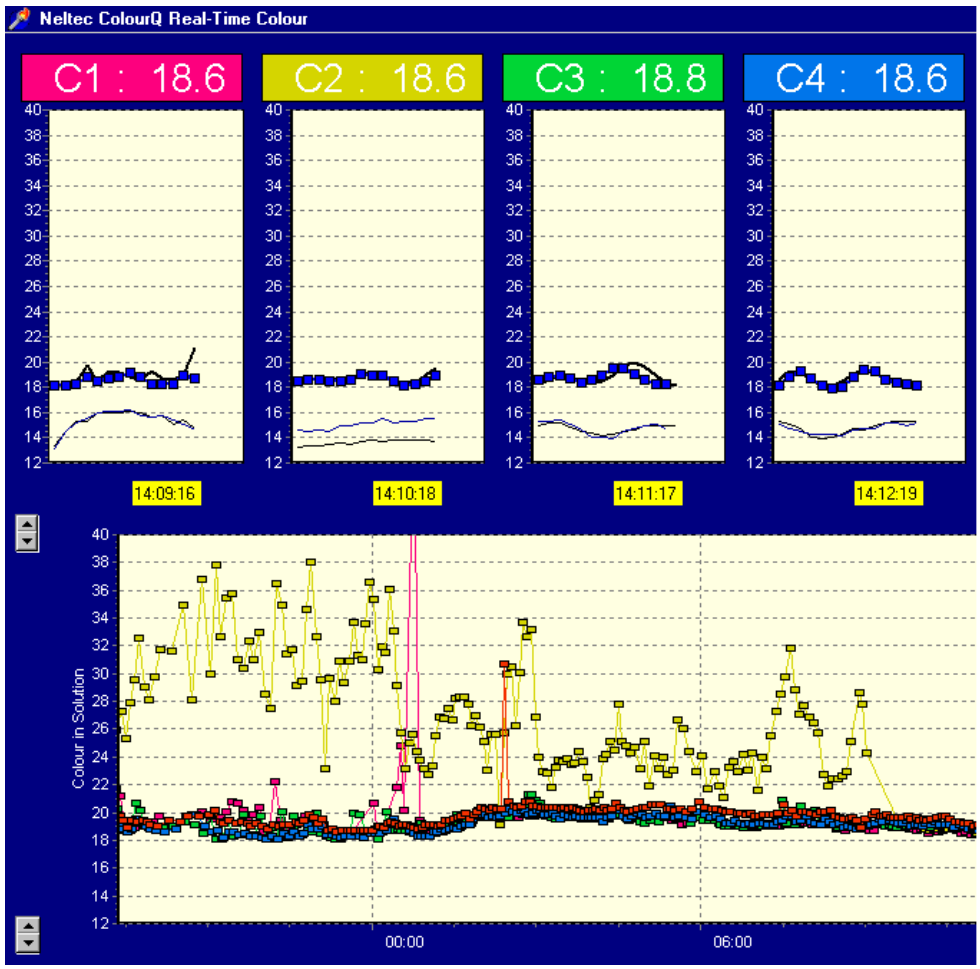


FIGURE 3.

ColourProfile with a typical variation over a charge.

FIGURE 4.

ColourQ computer screen



Optimisation of Spraying

In a batch centrifugal it is impossible to ensure that all the sugar in a charge is sprayed uniformly.

The innermost sugar in the basket (Figure 5, position A) is washed with pure water. As the water flows outwards through the sugar it dissolves more and more syrup and sugar. At position B the water has formed a high concentration sugar solution, which has less ability to dissolve further syrup and sugar.

When all syrup has been removed from the surface of the crystals at position A, there will still be some syrup on the surface of the crystals at position B. This can only be removed by spraying more water.

The additional water will dissolve good sugar from the already pure crystals at position A and further out on its passage out through the sugar.

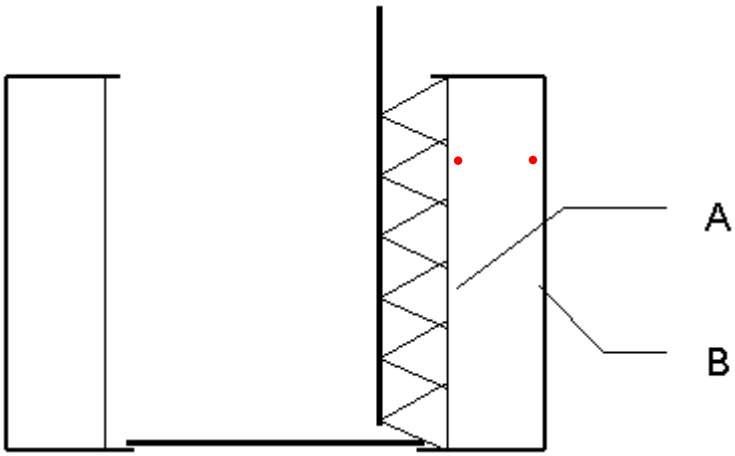


FIGURE 5

Centrifugal basket with sugar and spraying system

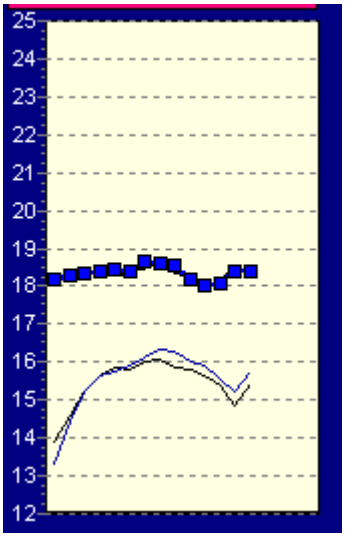


FIGURE 6

ColourProfile without colour variation over the charge

The charge in figure 6 has been overwashed to remove any trace of syrup from the crystals. Here the spraying could be reduced by several seconds without any significant colour increase.

With centrifugal control based on laboratory measurements your adjustments are infrequent and too late for precise refinement. Further, there is always a risk that the sample will not be representative for the production run.

With real-time colour measurement it is possible to make frequent adjustments of the spraying water and the filling level of the basket. [8]

Accuracy

The accuracy of the ColourQ is measured by comparing its output with colour measurements from the laboratory. The Standard Deviation between the two measurements (Standard Error of Prediction, SEP) is then calculated. [5,9]

The error calculated by this method includes the error from the ColourQ as well as the sampling error and the error in the laboratory. Consequently, the SEP calculated for the ColourQ can never be smaller than the error of the laboratory measurements.

For white sugar in the range 0 to 50 ICUMSA units (ICU) most of our customers with hopper/shaker or belt conveyors find a SEP between 1.0 and 1.5 ICU. For screw conveyors the typical SEP is between 1.5 and 2.5 ICU due to the larger sampling errors. [1,8]

The repeatability of the measurements by the ColourQ in the 0 to 50 ICU range is better than 0.2 ICU.

The ColourQ is sold with guaranteed performance. For 0 to 50 ICU the SEP is guaranteed to be lower than 2 ICU for dry sugar on a belt conveyor, lower than 3 ICU on a hopper conveyor, and lower than 4 ICU in a screw.

Benefits from the ColourQ

1. You know immediately, when a problem arises in the process, so you can correct it immediately.
2. The instrument measures all sugar with out interruption, so the measurements are representative of the production.
3. The ColourProfile helps you detect and correct malfunctions in the centrifugals.
4. With the ColourProfile you can trim the centrifugals to optimize their performance. Well-trimmed centrifugals produce lower colour with the same amount of spraying - or the same colour with less spraying.
5. When the massecuite is good, you can reduce the spraying to avoid melting good sugar.
6. With reduced spraying you get more sugar from each filling.
7. You avoid bad sugar entering the dryer or the silo.

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