Better process control and large savings

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**Abstract**

Laboratory determinations of sugar solution colour are not suitable for process control for two reasons. Firstly, their time lags are too long. Samples for the determinations are taken hourly and, hence, results are only available hours after they were taken – and thus hours after any events causing colour levels to rise. Secondly, their errors are too large. Samples with relatively small sampling errors can be taken after the dryer, which has an equalising effect on sugar quality, but only at the cost of further time delays. Sampling right after the centrifugals increases sampling errors to such degrees that the results are not reliable, unless the sugar is subjected to severe over-washing. In contrast, real-time monitoring of the process using a Neltec ColourQ colorimeter enables small problems to be detected almost immediately, because they result in sudden - albeit small - jumps in the colour curves.

To allow for the uncertainties of laboratory results, much better sugar than required, and paid for by the customers, is often produced. This insurance against bad sugar in the silo is very expensive in terms of chemicals used, and the resulting decrease in effective sugarhouse capacity. This paper describes examples of errors in real factories that would have been difficult to detect using any instrument other than a real-time Neltec ColourQ colorimeter. Illustrative examples of automatic and real-time process control by the instrument are described, as well as results obtained by a factory applying the ColourQ in the continuous pursuit of process optimization.

**Introduction**

Colour, the most important quality parameter in a sugar factory, is measured by the laboratory at hourly intervals. Thus, when the laboratory reports high colour, the shift manager or operators have no way of knowing when the problem started, if the problem is still persisting, or which part of the process caused the problem. They get no indication of where to look for problems, but have to rely on experience. This can be compared to driving a car with a blurred rear-mirror and not finding out that you have a flat tyre until you see the smoking remains on the road behind you.

The unwelcome consequence is that out-of-specification sugar may already have been packaged or sent to the silo before anyone realises there is a problem. To reduce the risk of this, all sugar factories work with substantial safety margins. In a refinery you may often see sugar with colour that is 30 % lower than the upper limit. Even then, variations in the volatile process may sometimes take the colour over the upper limit. This paper provides information about an instrument that offers real-time measurements of the sugar’s colour as soon as it leaves the centrifugals. With this instrument it is possible to obtain immediate warnings of any problems in the sugarhouse, so that corrective actions can be taken before bad sugar reaches the dryer. Further, the instrument can tell where the problem originated. You can go directly to a centrifugal causing a problem and start to correct it, or you can tell if the problem originates before the centrifugals. With batch crystallizers you can even see which crystallizer is causing the trouble.

**Method**

Fig. 1 shows an instrument positioned over the conveyor right after the centrifugals. In this position the instrument can measure the sugar from all the centrifugals in the battery. All discharges from each centrifugal are monitored from the start to the end, and the measurements for every charge are displayed as a colour profile, showing the colour variations within it.
Fig. 2 shows how the results are displayed on the instrument's screen. Each centrifugal has its own window, where the colour profile is displayed. The coloured squares in the centrifugal windows represent results that are added every one or two seconds to the curve of a discharging centrifugal. The solid black curve in the centrifugal window shows the results from the previous charge from the same centrifugal. In the lower part of the window two thin curves show the level of the sugar on the conveyor. The blue curve indicates the current charge, while the black curve represents the previous charge.
When the instrument has finished monitoring a charge, it calculates the charge’s average colour, and displays it both as a number at the top of the window and as a coloured square in the lower window (in which each square represents a specific charge from a specific centrifugal). In the actual display over two days most of the charges are superimposed, due to the high stability of the production.

Below the window the instrument displays the average colour for the current shift and all shifts during the previous 24 hours.

**Results**

The following illustrative screens all indicate undesirable process variations in centrifugals and crystallisers. It should be noted that all of these examples illustrate real situations in various, real factories.

Fig. 3 shows that centrifugal #2 was delivering higher colour sugar than the others, and the colour was deteriorating. The reason for this was defective spraying in some parts of the basket.

Fig. 4 shows there had been a sudden change in the performance of centrifugal #1. The previous charge showed no high colour, but the colour of the last part of the charge was rapidly increasing. This was due to insufficient flushing of the centrifugal screen.
Fig 5 shows a case in which a new charge from a crystallizer had different properties from the previous charges. At 17:50 the colour from all centrifugals suddenly increased. Two of the centrifugals were able to cure the new massecuite, to a barely-acceptable quality, but the third was delivering much higher colour. The ColourQ readings highlight both the poor crystallization and the unacceptable performance of centrifugal #2.

Fig. 6 illustrates a case in which different crystallizers were delivering massecuite of substantially differing quality.

Fig. 7 shows how the purging properties of the massecuite changes when a new batch from a crystallizer meets the previous batch in the mixer.
Fig. 8 shows information obtained when two different massecuites were cured in the same centrifugal battery. The curves are very uniform (indicating overwashing). Furthermore, curves for centrifugals #1 and #2 show drops in the colour of the last sugar leaving the centrifugal. This is unexpected, since sugar in the lower corner of the basket is often more difficult to wash thoroughly than the rest of the charge. After inspecting the centrifugals the explanation was evident. See the photos below.

Fig. 9 shows that the spray water continued to flow long after the spraying should have stopped. This extra water over-cleaned and dissolved sugar at the bottom of the basket, making the sugar delivered to the dryer humid, because the water was added late in the cycle.

![Figure 8](image1.png)

![Figure 9](image2.png)

**Figure 9a**
Spraying

**Figure 9b**
Leaking water

**Figure 9c**
More leaking water
Fig. 10 illustrates a case in which the quality of the massecuite was relatively stable for many hours, and then colour suddenly rose. Immediately, all centrifugals raised an alarm.

None of the cited problems could have been detected by a laboratory method in due time - or at all.

Fig. 11 shows how lack of adjustment of the centrifugals can considerably reduce sugar quality. Here, all centrifugal windows show that the massecuite had sufficient quality to give 23 IU sugar, because the colour profile in every window goes down to 23 IU. However, sugar colour in other parts of the charges exceeded the upper limit of the windows, and the average colour from all centrifugals was 41 IU at the time the display was stored. Hence, efforts earlier in the process to produce massecuite with colour as low as 23 IU were nullified in the centrifugals.
Fig. 12 was produced by British Sugar, Cantley. The figure has two curves. One shows the laboratory colour of the shift composite sample. The other shows the shift average as measured by the ColourQ instrument. At the start of the campaign, both curves show large variations (in step with each other). The factory staff realised that upwards deviations were quickly compensated by increased wash water, while it could take some time before downwards deviations were corrected by reductions in wash water. Consequently, an automatic control system for the wash water was installed. This was implemented in the last third of November, and the large variations subsequently disappeared.

A flow meter was installed to measure the amount of water used in the white centrifugals. The measured flow includes the wash water, the water used to clean the screens and centrifugals, and water used for remelt sugar. From the flow measurements the factory calculates how much water is used to manufacture 100 (metric) tonnes of sugar. The results are displayed in fig. 13.
1999/00 was the last year the factory operated without the ColourQ instrument. Since then, water consumption has been reduced from 10.2 cbm to 5.5 cbm per 100 tonnes of crystals; a saving of 4.7 cbm water per 100 tonnes of crystals. The factory staff estimate that about half the reduction in water usage is directly attributable to use of the ColourQ instrument.

4.7 cbm of water per 100 tonnes crystals dissolves 14.1 tons of sugar, equivalent to 14.1% of total production. Given annual production of 175,000 tonnes of sugar this means that more than 24,000 tonnes of sugar is now sent directly to the silo instead of taking an extra turn through the sugarhouse, and since reprocessing results in 5% losses to molasses, this saves ca. 1200 tonnes of sugar.

John Crosby from Cantley has this to say about the instrument: "The instrument has reduced the requirement to rework sugar saving a considerable amount of cost to the business"

Conclusions
The instrument enables many production errors to be detected that are not detectable by laboratory methods.

The instrument is a tool for correcting process errors and for tuning the process to run much closer to quality limits.

By actively using the instrument it is possible to obtain large savings and to reduce losses. The instrument pays for itself in a short time.

The shift managers and operators appreciate the instrument, because it allows much better and tighter control of the process.

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