Collecting and using accurate real-time process information to troubleshoot and prevent problems in the sugar factory

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Abstract

Troubleshooting is the logical, systematic search for the cause of a problem so that a solution can be found. Troubleshooting involves the identification of malfunctions within a system, finding a solution to stop the malfunction re-occurring and confirming that the process is functioning efficiently or the product quality has been restored.

To quickly identify and solve problems within the sugar factory, the operators need a tool that can measure the quality of the sugar, helping them to react quickly to resolve any issues that have arisen.

The Neltec ColourQ real-time colour measurement instrument for sugar has been designed to monitor sugar quality and help the operators easily understand any malfunction in the process, where the sugar quality does not meet with the specifications.

The accuracy of the measurement allows the factory to run the process efficiently and economically, achieving the desired quality without the need for large safety margins.

In this paper, the importance of troubleshooting and prevention of problems to avoid the production of unacceptable sugar quality is described. It also outlines steps for the optimization of the centrifugation process from a single machine to a complete control of the spray water process.
1. Introduction

Troubleshooting is one of the most important processes involved in maintaining efficient sugar manufacturing. If troubleshooting is performed correctly, the factory will be able to anticipate and react to problems before they actually occur. By using the right equipment for process control, the operators can quickly react to process changes and therefore avoid problems in the process steps that follow.

Troubleshooting is defined as a logical, systematic search for the cause of a problem so that a solution can be found.

The normal troubleshooting procedure can be divided into the following steps:

1. Identification of the problems within a system, from general issues to more specific ones
2. Finding a solution to prevent the problems identified
3. Implementation of that solution
4. Confirmation that the solution restores the product to the correct quality or the process to its working state
5. Optimization of the process after it has been fixed

The following explains how the different troubleshooting steps help to avoid the production of sugar whose quality does not meet the required standard in a sugar factory.

2. Identification of process problems by the laboratory

If a factory runs without on-line quality control equipment, it is usually the laboratory that first detects a quality issue. When producing sugar, the factory staff collect samples on a regular basis. These can be samples taken directly from the sugar conveyor or can be composite samples collected by a sample device over several hours.

In both cases, there will be a delay until the factory receives the result of the analysis from the laboratory. If the quality of the sugar is sub-standard, it is most likely that several tons of this sub-standard sugar will have already been sent to the silo.

It is only now that the operators and supervisors can look for reasons why the problem has occurred.

The problem may have been caused by the quality of the massecuite discharged from a pan or it could have been caused by a problem with a single centrifugal. No matter what caused the problem, it will take additional time to find the source of it. During this time the sugar has to be sent to the melter until the laboratory analyses another sample that has the desired quality.
3. Identification of process problems on-line after the drier

If the factory is using an on-line colour measurement after the drier, the quality of sugar going into the silo is monitored continuously. If the quality of the product does not meet the specification required, the operators can act immediately and send the sugar to the melter. Some factories have automated this step and the sugar is diverted to the melter automatically.

A typical graph of the colour of the sugar going into the silo is shown in figure 1. A change in colour can be seen immediately. However, the measurement does not indicate what the source of the problem may be. The qualified operators may be able to glean some hints from the graph but no specific source of the problem will be readily identifiable. If the colour of the dry sugar increases rapidly over a certain period it is most likely that the massecuite quality has decreased thus increasing the colour of the final sugar.

![Figure 1: Colour measurement of white sugar after the drier](image)

4. Identification of problems after the centrifugals

If the factory has installed an on-line colour measurement directly behind the centrifugals, troubleshooting is much easier. The operator can now see the colour of each batch dropped by the different centrifugals. If the colour increases at the same time after all the centrifugals, it is obvious that the quality of the massecuite is the cause of the problem (Fig. 2).

If only a single centrifugal delivers sugar with a higher colour, the operator immediately knows which centrifugal requires their attention (Fig. 3).

An installation like this allows the factory staff to start solving the problem immediately without losing time trying to find the source.
Figure 2: Colour increase in white sugar due to poor massecuite quality

Figure 3: A problem with the quality of the sugar delivered by centrifugal 1.
5. Identification of problems by analysing the colour profile of a centrifugal

The Neltec ColourQ has the ability to track the colour profile of each centrifugal during its discharge. Figure 4 shows the colour profile of three different centrifugals. It is obvious that centrifugal 2 has a problem. The detailed colour profile shows that a high colour peak occurs in the middle of its discharge. Since the centrifugal is discharged from the top to the bottom of the basket, the operator can see that the sugar in the middle of the basket has a higher colour. This is an indication that there are mechanical problems with the spray nozzles in the middle of the spray bar.

![Figure 4: Spray bar problems in centrifugal 2](image)

Figure 5 shows a different problem. Centrifugals 1 and 2 show an unusual decrease of sugar colour at the end of their discharge. Usually, the bottom of the basket is the area where it is most difficult to spray sufficient water. Therefore, one often sees a colour increase at the end of the discharge. After examining the 2 centrifugals it was found that the two nozzles at the bottom end of the spray bar delivered water after the spraying process was complete (Fig. 6)

![Figure 5: An unusual colour decrease at the end of the discharge](image)

![Figure 6: The reason for the colour decrease at the end of the discharge](image)
6. Solving problems and stabilizing the process

Often, factories do not have much information about the performance of their centrifugals until they install an on-line colour measurement. After a new installation, the first colour profiles can be quite surprising since the centrifugals are not mechanically optimized and so the colour profile varies during the discharge of a batch (Figure 7). Here, it is necessary to optimize each centrifugal separately, adjusting the spray nozzles and checking both the spraying time and the adjustment of the baskets. Once every centrifugal has been optimized, their colour profiles will be similar to those shown in Figure 8. The centrifugals are now mechanically optimized and the next step is the optimization of the volume of spray water.

Figure 7: Colour profiles after a new installation

Figure 8: Colour profiles after mechanical optimization of the centrifugals
7. Optimizing the volume of spray water added

In order to optimize the volume of spray water added, the factory must have set up its centrifugals in such a way that each centrifugal is running with an even colour profile.

To find out how much water is needed to achieve the optimum colour without using excess water, it is necessary to set the length of time the sprays operate to different values for different centrifugals.

Figure 9 shows a battery of six centrifugals each running with a fairly even colour profile. All the centrifugals were operated with a spray water time of 10 seconds.

Figure 9: Colour profiles for the same spray water time

In Figure 10, the spray water timers for centrifugals 1, 3, 4 and 6 have been set to 10 seconds. The spray water timer for centrifugal 2 has been set to 15 seconds and the spray water timer for centrifugal 5 has been set to 9 seconds.

Comparing centrifugals 1 and 3 with centrifugals 4 and 6, it is obvious that different centrifugals can deliver sugar of different quality even if the volume of spray water is the same.

By applying spray water for 15 seconds, the colour of the sugar was 24.8 IU, only about 1 unit lower than the centrifugals that sprayed for 10 seconds.

There are two conclusions from this:

1) The minimum colour for sugar processed from the current massecuite is 24.8 IU

2) 10 seconds of spraying time is sufficient to approach the minimum colour for sugar processed from the current massecuite.

The higher colour of 41.7 IU delivered by centrifugal 5 shown in figure 10 indicates that even a reduction in spray water time of only 1 second can have an enormous influence on the sugar colour.
After observing the influence of the volume of spray water on the colour profiles and the sugar colours, the spray water times for the centrifugals were adjusted. The spray water timers for centrifugals 1, 2 and 3 were set to 9 seconds, the spray water timers for centrifugals 4 and 5 were set to 11 seconds and the spray water timer for centrifugal 6 remained at 10 seconds (Figure 11). After these adjustments, each centrifugal delivered sugar with a colour between 31 IU and 37 IU.
8. Implementation of automatic spray water control

Further optimization of the volume of spray water used is possible if the factory installs an automatic spray water control.

Before installing this equipment, the factory needs to optimize the centrifugals as described in section 7. Once all centrifugals are running with a stable and even colour profile, the factory can measure the influence of the spray water time on the sugar quality. Figure 12 shows the influence of spray water time on sugar colour in the Aarberg factory in Switzerland. It is obvious that the effect of spray water on the sugar colour decreases with longer spray water times.

![Figure 12: Influence of spraying time on sugar colour](image)

At the time of writing, the average colour of the process in the Aarberg factory has been 17.6 IU, which corresponds to 26 seconds of spray water. To achieve a colour of 19 IU, the spray water time can be reduced to 18 seconds; to attain a sugar colour of 20 IU, the spray water time can be reduced to 15 seconds. The factory decided to produce a sugar colour of 19 IU using automatic adjustment of the spray water timers.

The average spraying time was reduced by 7 seconds per cycle corresponding to a saving of 12.6 l of water under local conditions. These 12.6 litres of water will melt 37.8 kg of sugar which corresponds to 4.4 % of the total crystal mass of 900 kg per cycle.

To achieve the accuracy shown here using on-line colour control, it is most important to have a stable calibration even when the process conditions and massecuite quality change. At Aarberg, the instrument was calibrated in 1997. It has now been running for fifteen years without any need to improve the calibration over this period.

Figure 13 shows the accuracy of the automatic colour control.
A similar spray water control has been installed in another European sugar refinery. Here, the colour target has been set to 45 IU.

Figure 14 shows the result of the laboratory analysis of the final sugar product over six weeks and confirms that the instrument is measuring as accurately as the laboratory tests. The laboratory results have almost always been in a range of ± 1 IU of the desired sugar colour.
Figure 15 shows the benefits of the troubleshooting and optimization procedure, described previously, for a British sugar factory.

Before the installation of the Neltec ColourQ, the factory was using 10.2 m$^3$ of spray water to produce 100 t of white sugar crystals. After the installation of the instrument in the autumn of 2000, they reduced the amount of spray water used to 7.8 m$^3$ per 100 t of crystal in the 2003/2004 production run. Afterwards, they implemented the automatic spray water control and, by further optimization of the process, they achieved a further reduction in the volume of spray water required to 5.5 m$^3$ per 100 t of white sugar crystals.

![Figure 15: Volume of wash water required for the centrifugals in a British factory](image)

9. Conclusion

Troubleshooting and optimizing the process by using the Neltec ColourQ instrument can save the factory significant money and will increase its production capacity.