HIGHER EFFICIENCY OF THE CENTRIFUGAL STATION DUE TO OPTIMIZED SPRAY WATER CONTROL, BASED ON THE RESULTS OF INLINE COLOUR MEASUREMENT.

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Sugar colour is one of the important criteria to evaluate the quality and the price of the sugar on the market.
Raw sugar as well as refined sugar is traded with quality criteria, which have to be fulfilled by the sugar industry.
The standards for colour measurement in the sugar industry are given by the ICUMSA.

Many sugar factories are producing sugar of lower colour (higher quality) than necessary. This requires extra costs and extra energy and will increase the sugar losses in molasses as well as the total energy costs in the sugar production.

Neltec Denmark A/S has installed various inline colour measurements in cane sugar factories as well as in beet sugar factories worldwide, to optimize the sugar colour in real time without any time delays and also to reduce production costs and increase the capacity of the sugar factories.

The paper shows an example of potential cost savings in the sugar house by using optimized control of spray water times based on the results of the inline colour measurement of crystal sugar behind the centrifugals.

Introduction

The quality of all sugar traded globally is determined by methods stipulated by the International Commission for Uniform Methods in Sugar Analysis (ICUMSA), which differ for sugar of different qualities. The quality of refined white sugar is defined by colour type ("the visual appearance of the sugar to the eyesight") and colour in solution ("the determined colour of a filtered 50% sugar solution at a wavelength of 420 nm") [1]. The reason that two colour criteria for sugar are applied is that no correlation has been found between the colour of sugar crystals to the naked eye (colour type) and the color of the dissolved sugar (colour in solution), although they are caused by the same substances [2].

The colour of sugar is not only an important quality variable, but also commercially critical since market prices are heavily based on it (in addition to supply and demand). Therefore, it must be monitored during production runs in factories and refineries. Traditionally this is done by regularly analysing samples in a laboratory, but there are delays between the sampling and acquisition of results. During these delays the colour of any sugar produced may be too high (costly due to the need to re-process the sugar to meet specifications) or lower than necessary (costly because it could have been more cheaply produced). Furthermore, technicians must be continuously employed for the laboratory analyses.

Thus, there is a clear need to measure the colour of sugar at key process steps (particularly when leaving centrifugals and dryers) as quickly as possible to check that it is *just* within specification, and if not take immediate appropriate action.Several instruments are available to measure sugar colour on line. However, most provide data from photospectrometers based on the CIELAB system (describing all the colours visible to the human eye). Only the Neltec ColourQ colorimeter determines sugar colour by solely measuring its absorption of light at 420 nm. Hence, it provides the best and most reliable indications of colour in solution. It has numerous applications for monitoring and adjusting the colour of sugar in factories and refineries, as illustrated here by its use in control systems at the Saraburi Sugar factory in Thailand.

Project to reduce amounts of centrifugal spray water at the Saraburi Sugar Factory

In 2013 owners of the sugar factory in Saraburi, Thailand, decided to install a Neltec ColourQ colorimeter to control the colour of the white sugar delivered by the centrifugals in their back end refinery. This was a key element of a project to install automatic systems to adjust the centrifugals' spray times according to the colour of the sugar they delivered.
The instrument was installed in March 2013, commissioned shortly afterwards, and in early April the operators started to adjust the centrifugals' spray times according to the ColourQ readings. In July 2013 the factory switched from manual to automatic control of spray times, solely using its readings.

Start of the project in April 2013

The back end refinery at Saraburi can produce 800 t of white sugar per day. The maximum sugar colour accepted by customers at the time of the project was 35 IU, hence the factory set a maximum colour limit of 34 IU for sugar entering the silo. However, the factory laboratory staff was responsible for ensuring that no sugar out of specification was sent to the silo. So before installation of the ColourQ they instructed that the maximum colour of sugar samples brought to the laboratory should be 30 IU.
Furthermore, to ensure that there was an adequate safety margin, the amount of spray water used in the centrifugals was adjusted manually by the operators to ensure that the colour of sugar leaving their station did not exceed 25 IU. Thus, there was a 10 IU difference between the customers' specifications and the centrifugal operators' upper target (Figure 1).

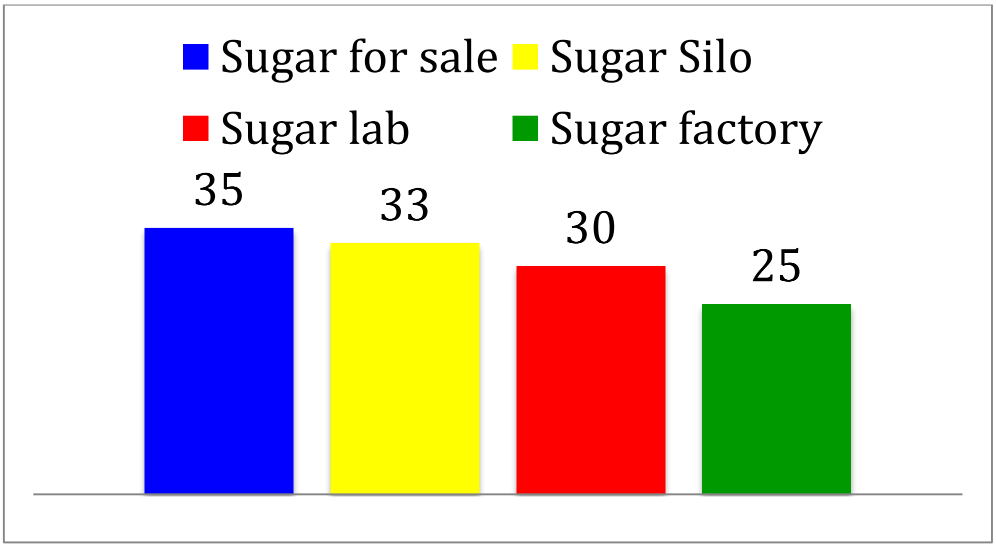

Figure 1: Sugar colour targets (IU) at the Saraburi factory.

The spray water automation project started in April 2013. The first task was to show the operators and other factory staff effects of the spray water consumption on the centrifugals' sugar output.
Figure 2 shows colour profiles of outputs of three centrifugals provided by the Neltec colourQ on the 5th of April. Centrifugals B1 and B2 were Broadbent 32M centrifugals with a sugar output of approx. 500 kg per batch, while B3 was a Broadbent 58M centrifugal with an output of approx. 900 kg per batch.'
The smaller and larger centrifugals delivered 21 IU and 20 IU colour, with spray time settings of 4 seconds and 7 seconds, respectively. Thus, all three delivered sugar with far lower colour than required by the customer (35 IU) and the maximum allowed by the laboratory (30 IU).
Since the spray nozzles delivered 3 l of water per second at the standard water pressure the two smaller centrifugals were using 12 l water per 500 kg batch of sugar (2.4 %) and the bigger centrifugal 22.5 l water per 900 kg batch (2.5 %).

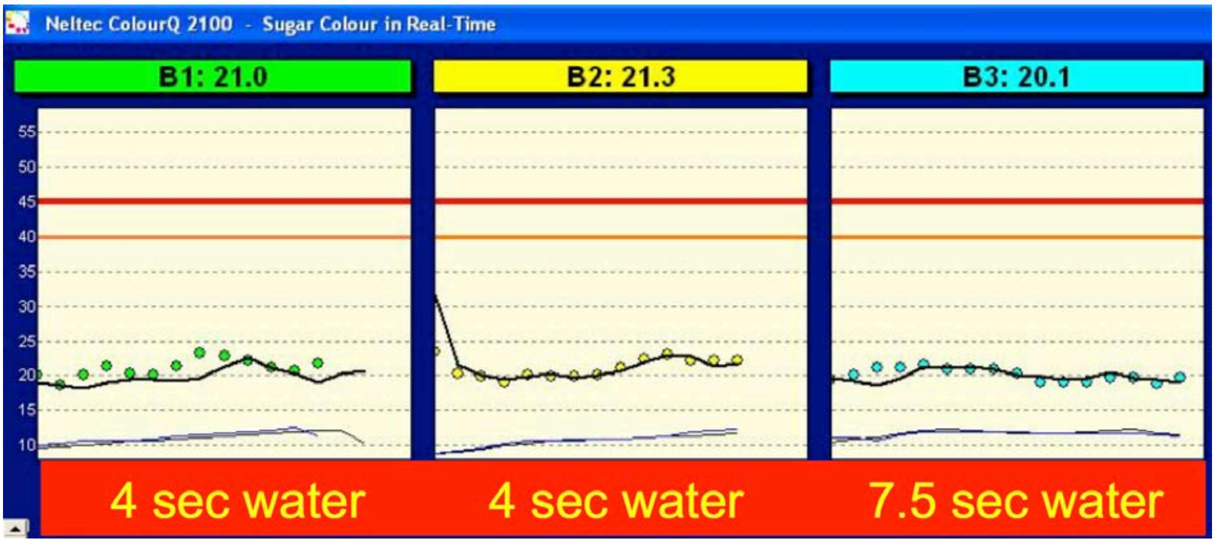

Figure 2: Sugar colour delivered by the three centrifugals with standard manual spray water settings.

Start of spray water reduction

To see how much the spray water consumption could be reduced without exceeding the laboratory limits for sugar colour it was decided to reduce the spray water used in one of the smaller centrifugals.
In a first step the spray time in Centrifugal B1 was reduced by half a second from 4 to 3.5 sec (and hence water consumption from 12 to 10.5 l).

As shown in Figure 3, readings of the ColourQ instrument after this reduction increased from 21 IU to 23 IU, while the colour of the sugar delivered by Centrifugal B2 remained at 21 IU.

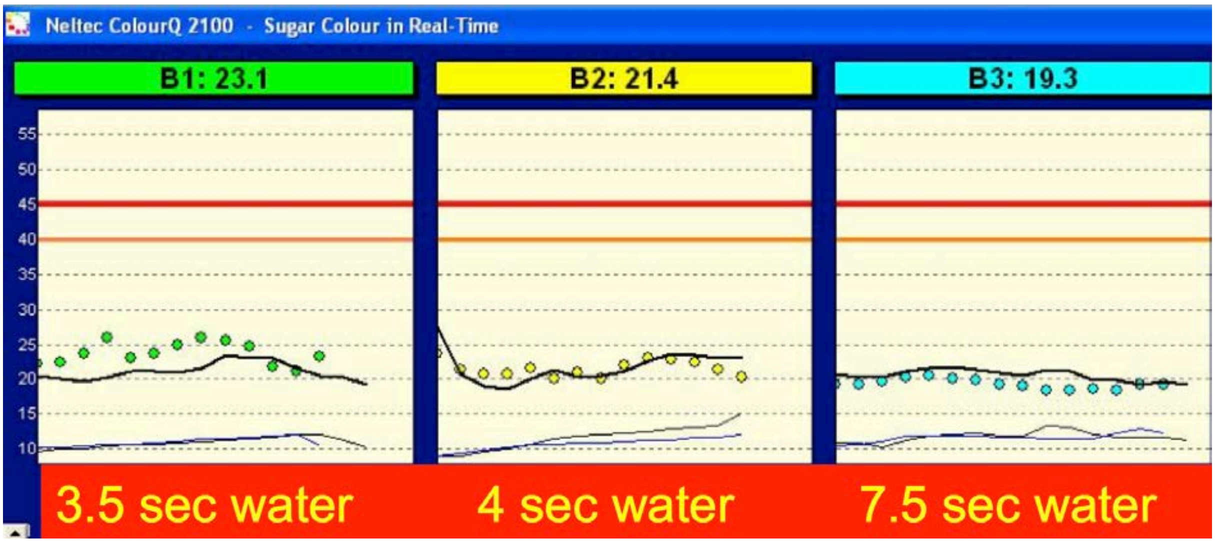

Figure 3: Colour of sugar delivered by the centrifugals after reducing the spray time in Centrifugal B1 by 0.5 sec (and thus the volume of water used by 1.5 l).’

In a second test the spray water time in Centrifugal B1 was further reduced to 3 seconds, and the colour reading of its output increased to 30 IU, 5 IU higher than the output of Centrifugal B2 (Figure 4). As expected, this difference was substantially higher than the 2 IU difference in the colour of sugar delivered by Centrifugals B1 and B2 in the first trial, when the spray water time in Centrifugal B1 was reduced by 0.5 sec. However, the sugar delivered by Centrifugal B1 remained within the required quality limits.

It should be noted that the centrifugals were processing a different massecuite than in the first trial, and the colour of the sugar delivered with manual settings was 3-4 IU higher.

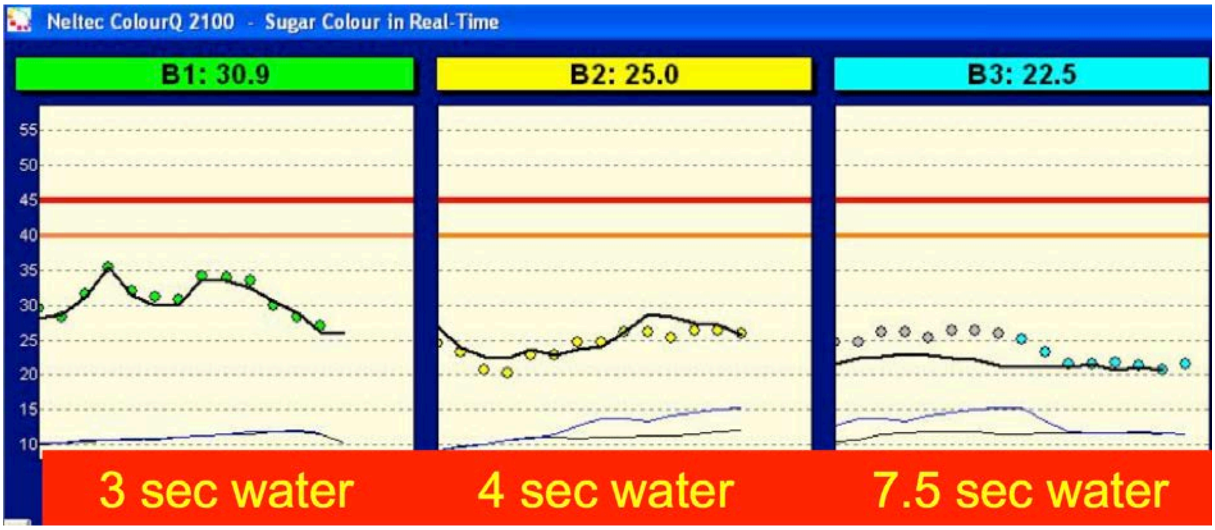

Figure 4 : Colour of sugar delivered by the centrifugals after reducing the spray time in Centrifugal B1 by 1 sec (and thus the volume of water used by 3 l).'

Table 1 shows the sugar losses that could be avoided by reducing centrifugal B1's (and B2's) spray water times as in the trials.

A 0.5 second reduction results in 1.5 l less spray water per cycle. The temperature of the spray water was 77 °C, at which a litre of water dissolves 3.54 kg of sugar. Thus, the reduction in spray water volume should increase the sugar output by 5.3 kg per cycle (more than1 % of the total discharge). Accordingly, a 1 second reduction in spray time should lead to a 3 l reduction in spray water volume, increasing output by 10.6 kg per cycle (more than 2 % of the total output).

			Broadbent	
			Type	32M
	Water (77°C) reduction (%)	Spray water (sec)	Cycles per hour	19
Original settings	0	4	Water per cycle (l)	12
Test 1	12	3.5	Water per cycle (l)	10.5
			Extra sugar per cycle (kg)	5.31
			Extra sugar per hour (kg)	100.89
Test 2	25	3	Water per cycle (l)	9
			Extra sugar per cycle (kg)	10.62
			Extra sugar per hour (kg)	201.78

Table 1: Effects of reducing spray time on centrifugal B1's performance

Analysis of the purity drop between massecuite and run-off syrup

To confirm these calculations the purity of the run-off syrup from the whole centrifugal station was measured under different spray water settings.
In the back end refinery at Saraburi all of the run-off syrup from the centrifugals is sent to the vacuum pans to produce the next lower sugar grade. High and low grade syrup are not separated, so any sugar not dissolved by saving spray water should decrease the purity of the syrup.

Before the test the centrifugals were operating with standard settings (4 seconds spray time for the smaller centrifugals, producing 23-24 IU sugar, and 7.5 seconds for the bigger centrifugal, producing 22.6 IU sugar) (Figure 5).

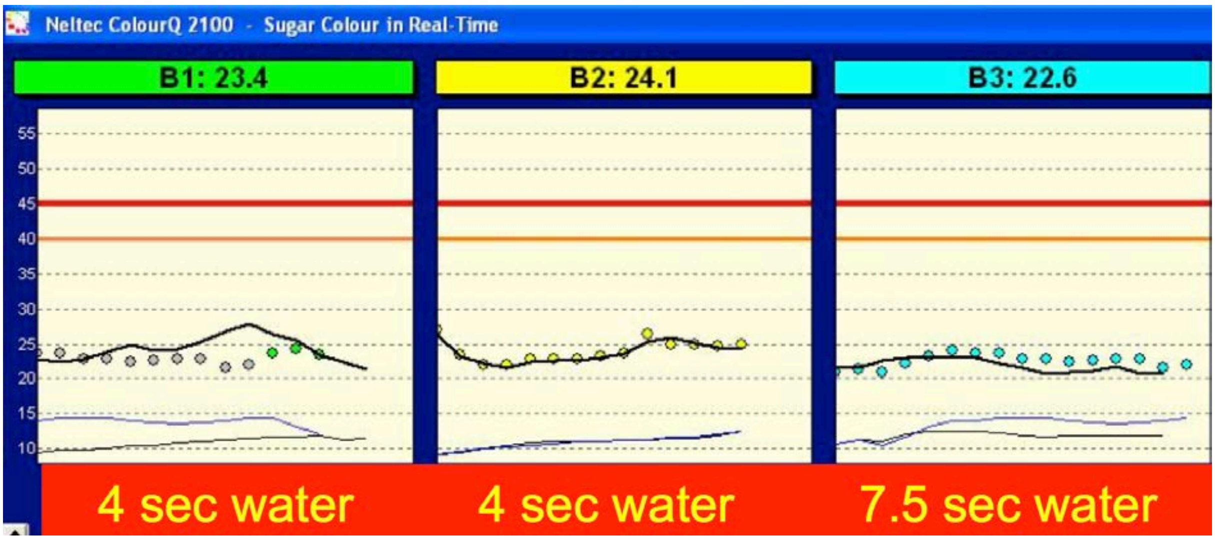

Figure 5: Colour of sugar delivered with standard spray water settings

Samples of the massecuite in the mixer above the centrifugals and the common run-off syrup tank were collected, and taken to the laboratory to determine their dry substance content (bx), sugar content (pol), and purity.

Table 2 shows the results of the analyses. The purity of the massecuite and run-off syrup were 97.32 % and 94.73 %, respectively: a total purity drop of 2.67 % from the massecuite to the syrup.

In a second test the spray time for the smaller scentrifugals was reduced to 3 seconds (delivering 9 l water) and for the bigger centrifugal to 5.5 seconds (delivering 16.5 l water). These changes reduced the spray water volume by 25 %
The centrifugals were processing the same massecuite as in the first test, so it was only necessary to take another sample from the common run-off liquor tank after the centrifugals. The purity of the run-off was 94.3 %, showing that it contained less sugar than the syrup in the previous test with longer spray times. The total purity drop from the massecuite to the run-off syrup in the second test was 3.08 %, 0.5 % higher than the drop for the syrup sample taken during the cycle with standard spray water settings.

		Spray time (s)	Spray time (s)
	Centrifugal 1	4	3
	Centrifugal 2	4	3
	Centrifugal 3	7.5	5.5
	Massecuite	Run off syrup 1	Run off syrup 1
Bx	88.45	74.9	71.65
Pol	86.08	70.95	67.58
Purity	97.32	94.73	94.32
Purity drop		2.59	3.0
Purity drop (%)		2.67	3.08

Table 2: Laboratory determinations of the dry substance content (bx), sugar content (pol), and purity of the massecuite and run-off syrup with the indicated spray times.

Start of automatic spray water control in July 2013

The results presented above convinced the factory staff that they could produce more sugar and make substantial financial savings if they installed an automatic spray water control system to avoid producing sugar with colour far below the specified limits.

In addition to the colour profile of each centrifugal's output, the Neltec ColourQ provides average colour readings for each strike, which are plotted against time as points in the same colours as the colour profiles for the corresponding centrifugals (Figure 6).

Figure 6: Display of average colour of sugar discharged by each centrifugal in each strike (lower chart).

The average readings (which can be passed as 4-20 mA signals to a process control system) were used by the factory to automate control of the centrifugals' spray timers. After further optimisation, the automatic spray water control system was activated on July 24th, with minimum and maximum points for the colour set at 28 and 30 IU, respectively.

Figure 7 shows the average colour of sugar outputs every day in July 2013. The blue indicators show the average colour during the days when the spray water control was still in manual mode, while the red indicators show the average colour during the days when the spray water control was automatically controlled. The colour was constantly between the limits of 28 and 30 IU on every day except one (when average colour was still within customer specifications, at 31 IU).

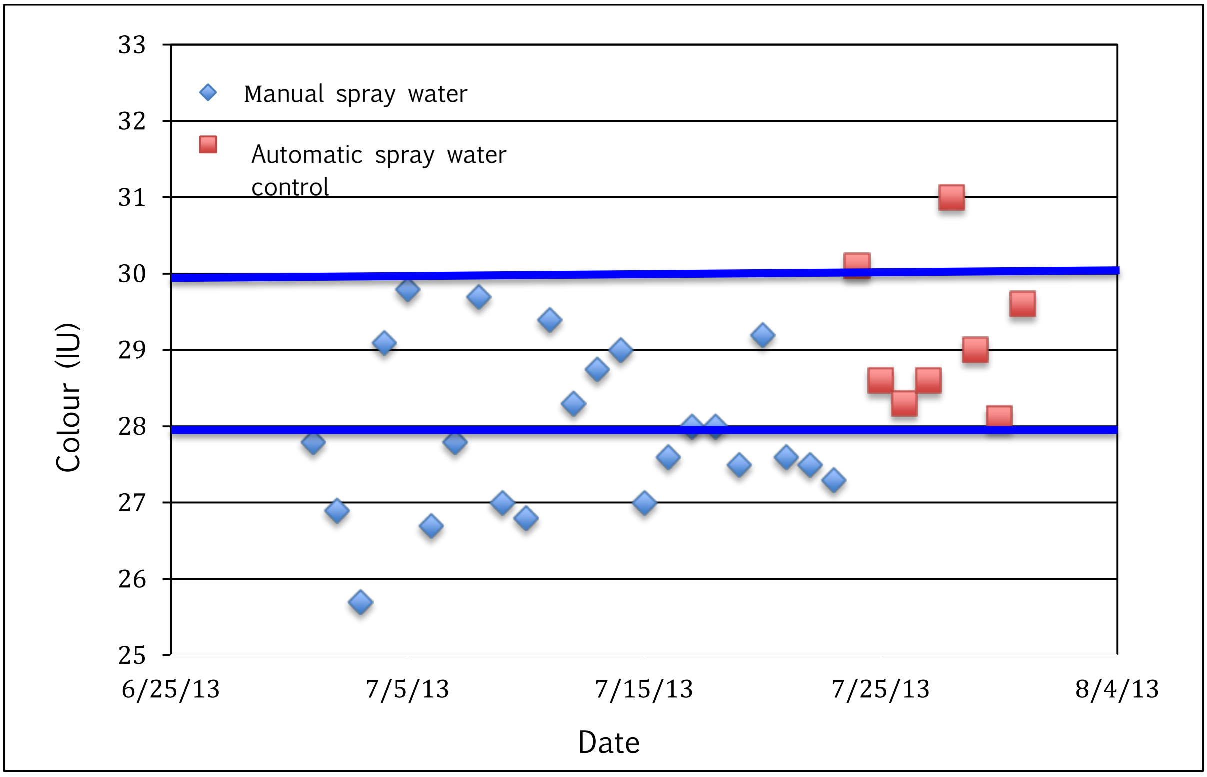

Figure 7: Average colour of sugar output from the centrifugal station, every day in July 2013.

Summary:

After installation of the Neltec ColourQ in the Saraburi sugar factory it soon became obvious that the sugar colour delivered by the centrifugals for refined white sugar had been far below customer-specified limits because too much spray water had been used.
Trials with less spray water showed the operators that the centrifugals could run with up to 25 % less spraywater and still produce sugar within the factory's colour specifications.
The reduction of spray water by 25 % increased the centrifugal capacity by more than 2% and avoided the dissolution of up to 16 t of sugar per day, which did not have to be reprocessed. In addition, the purity drop between massecuite and run-off liquor could be increased by more than 3%, due to the higher recover of sugar from the molasses.
The Harwood sugar factory in Australia achieved similar results by optimising spray water times in manual mode between 2011 and 2013 [3].
Danijel Pusic reported similar success with automatic spray water control at the Viro sugar factory in Croatia [4].
Further examples of the payback for the investment into an Neltec inline colour measurement were given by Malgoyre, Suhr and Chorão [5, 6, 7].

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