REFEREED PAPER

OPTIMISATION OF WHITE SUGAR COLOUR MANAGEMENT THROUGH THE UTILISATION OF ON-LINE COLOUR CAMERAS

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Abstract

The priority for any factory operation is to produce sugar that meets its customers' specifications while minimising the financial impact of such compliance. To ensure low colour sugar, the default position tends to be to over wash it. It leads to substantial water volume and energy consumption with a high amount of melted sugar which should instead be reduced. The over washing at the sugar end of the process can also mask significant variations occurring within the beet end operation. This paper describes the optimisation of a Thai centrifugal workshop that is particularly subject to significant variations in the quality of the massecuite. The Erawan sugar refinery installed two Colobserver® from Iteca Socadei in early 2016 to successfully address this issue, stabilise its production within a few months, and improve its productivity.

Keywords: on-line, colour, measurement, Colobserver®, out of specification, detection

Introduction

Now more than ever before, in a very competitive international landscape, it is essential to produce good quality sugar at lower cost. Among all the parameters, a factory must track to produce white sugar that meets high quality standards. Colour is a key factor.

The standard approach recommended by ICUMSA to measure sugar colour is a method based on the analysis of samples taken on the sugar conveyor at variable time intervals. The number of analysis performed is always limited by the speed of the sampling and the means implemented by the laboratory to carry out the work.

We found at ERAWAN that, at best, the laboratory could analyse one sample every one or two hours, therefore leaving several discharges of centrifugals unseen, with possible colour variations between two measurements. With so little information it is very hard for the operators to adjust the process properly and there is a high risk of sending out-of-specification products to the dryer.

The implementation of ITECA colourimeters, which takes more than two images per second over the full width of each conveyor, not only provides a constant tracking of the whole production with high precision, but the measurements are also delivered in ICUMSA units as the equipment is first correlated to the standard method.

The paper shows that the operators can now detect any fluctuation and react in real time by optimising the individual washing time of each centrifugal, and feel confident that the production complies with the specification.

Erawan Sugar Plant Description

After crystallisation, the massecuite exiting the six batch pans flows into two consecutive sets of four Fives Cail D412 batch centrifugals feeding two separate vibrating conveyors (Lines 1 and 2 - Figure 1). The 1 000 tons of refined sugar produced per day are conveyed to a dryer or may be occasionally diverted to a melter if the quality produced is out of specification.

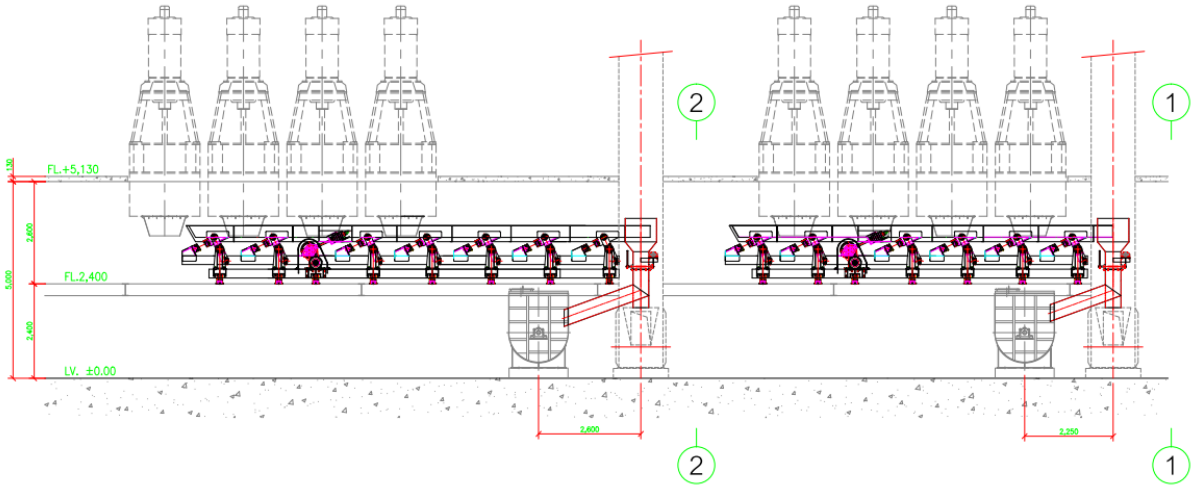

Figure 1: Configuration of the two sets of four Fives Cail centrifugals

The ITECA installation consists of two colourimeters (type Colobserver®) mounted at the centrifugal floor on top of each conveyor (Photos 1, 2 & 3 below in Figure 2). They measure moist white sugar colour, discharged from every batch of eight centrifugals. Powerful stroboscopic Xenon light sources illuminate the sugar surfaces without being affected by the ambient light. The use of a broadband light source, from the UV to the NIR, ensures measurement across a wide range of sugar colours with high precision. It also enables the automatic detection of brown lumps using image processing techniques. High resolution colour calibrated cameras measure the reflected light and sends the images to a computer in the control room where they are processed in real-time by dedicated and customised ITECA software.

To closely monitor the overall performance of the installation, internet remote monitoring and secured screen sharing have been set up. This provides ITECA with real time access to the installation from the facility in France or from anywhere in the world should it be required.

The data is filtered and a mathematical algorithm applied to calculate the colouration values in ICUMSA units after applying the correlation with the laboratory. The video of the sugar is continuously displayed in real time on the main screen in the control room with the colour trends of each centrifugal and the global trend of the production. Videos are registered according to a predefined registration strategy. It can be done for instance whenever the software detects a non-conformity and an alarm is triggered. As the colourimeters communicate with each centrifugal, operators know from which centrifugal the sugar they are watching is produced and use the images to identify and trace the origin of the problems faced.

On the main screen of the computer in the control room, the individual colour trends of the four centrifugals of each line are displayed as well as the global colour trend over 24 hours of production. The image of the video displayed in Figure 3 is the sugar coming from the centrifugal C3 of Line 2, against a colour target of less than 35 IU. A set of coloured banners is used as visual support: green when the measurement is close to the target, blue when it is

Figure 2. Photo 1, 2 & 3: Colobserver® ITECA at the centrifugal floor, above vibrating conveyors

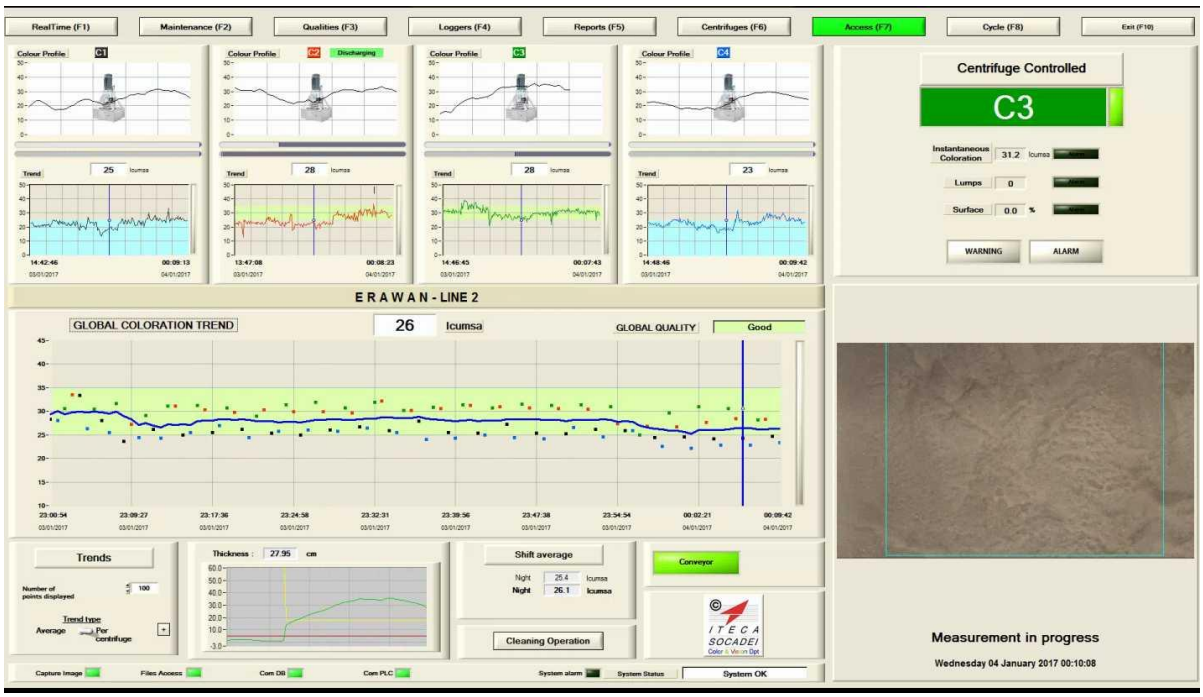

Figure 3: Control room display with individual and global colour trends and real time video

too low (over washing), or red when it is too high. This makes it easier to read the measurements from afar. In Figure 3 above, it can be noted that the global colour was slowly drifting down to 20 IU. This was due to centrifugals C1 and C4 that were over washing. The

operators took the necessary action by reducing the washing time on C1 and C4 to return to the colour set point to 35 IU. These adjustments have been done manually but the plan for the 2017 campaign is to do it automatically through Fives's Smart Control™. This program can alter the amount of wash water according to both the basket load and the colour measured by the Colobserver®.

Results and Discussions

Correlation with the laboratory standard measurements

In March 2016, the critical first step that was commissioned by Iteca's engineer was the correlation of the colourimeters analysis with the laboratory standard ICUMSA colour measurements.

Sugar samples discharged by each of the centrifugals were taken across the full range of colour produced at the plant, following a rigorous procedure to minimise measurement bias. Each sample was then analysed by both the laboratory and Iteca's colourimeters. Their results have been compared to establish the correlation equation which, once integrated into the software, allows the colourimeters to calculate and display the sugar colour in ICUMSA units without having to recalibrate the instruments over the full campaign.

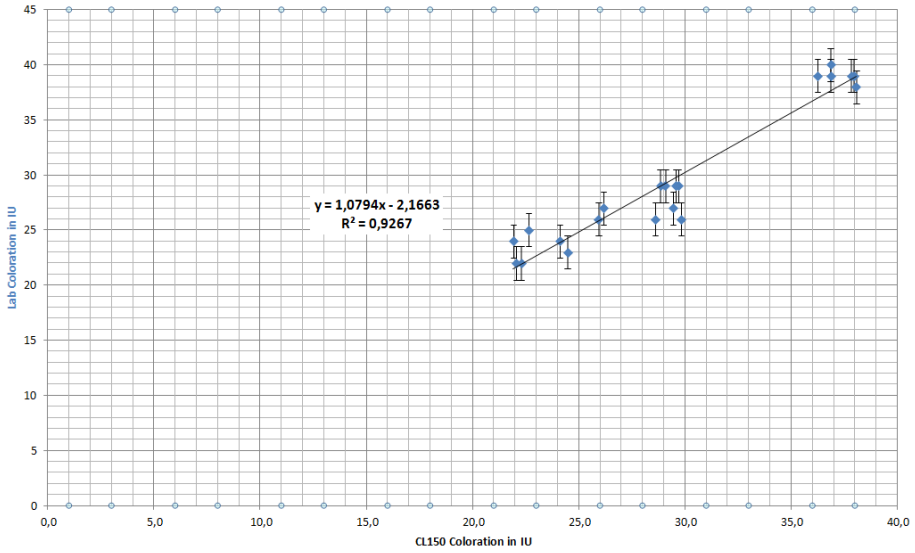

Figure 4: Correlation equation after a short sampling campaign. Laboratory Colouration vs Colobserver Colouration correlated for Line 1

It is important to note that in addition to providing continuous measurements, the colourimeters ensure very stable and repeatable precise measurements, which is far more challenging when using standard laboratory methods.

Importance of individual tracking

When using the traditional measurement methods, it is more likely that the colour taken into account is the average colour of several discharges of various centrifugals. The average value is a good indicator of the overall production but it rather artificially smoothes the value of the colour measured. The reality can be that only one centrifugal with default is causing the average colour to increase or even exceed the acceptable limits.

The Iteca colourimeter communicates in real time with each centrifugal and therefore can track the colour profile of each discharge individually.

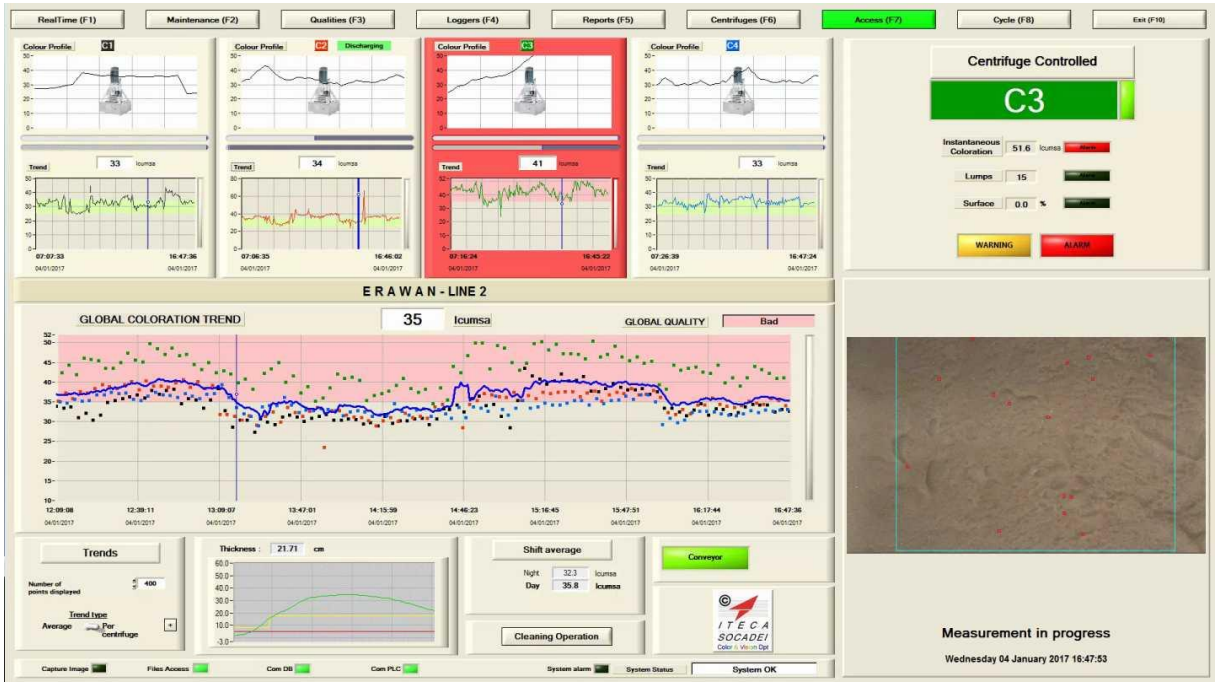

Figure 5: Main display showing centrifugal C3 exceeding the 'Alarm' threshold

In the case presented in Figure 5 above, centrifugals C1, C2 and C4 were producing sugar with colour within the colour target level whereas C3 was discharging sugar with too high average colour of 41 IU, causing the colour of the overall production to fall out of specification. Clearly in this case, the solution to regain an acceptable colour level was to address the issue on centrifugal C3.

Follow up of the massecuite qualities

The colour of the sugar discharged by the centrifugals strongly depends upon the quality of the massecuite feeding them.

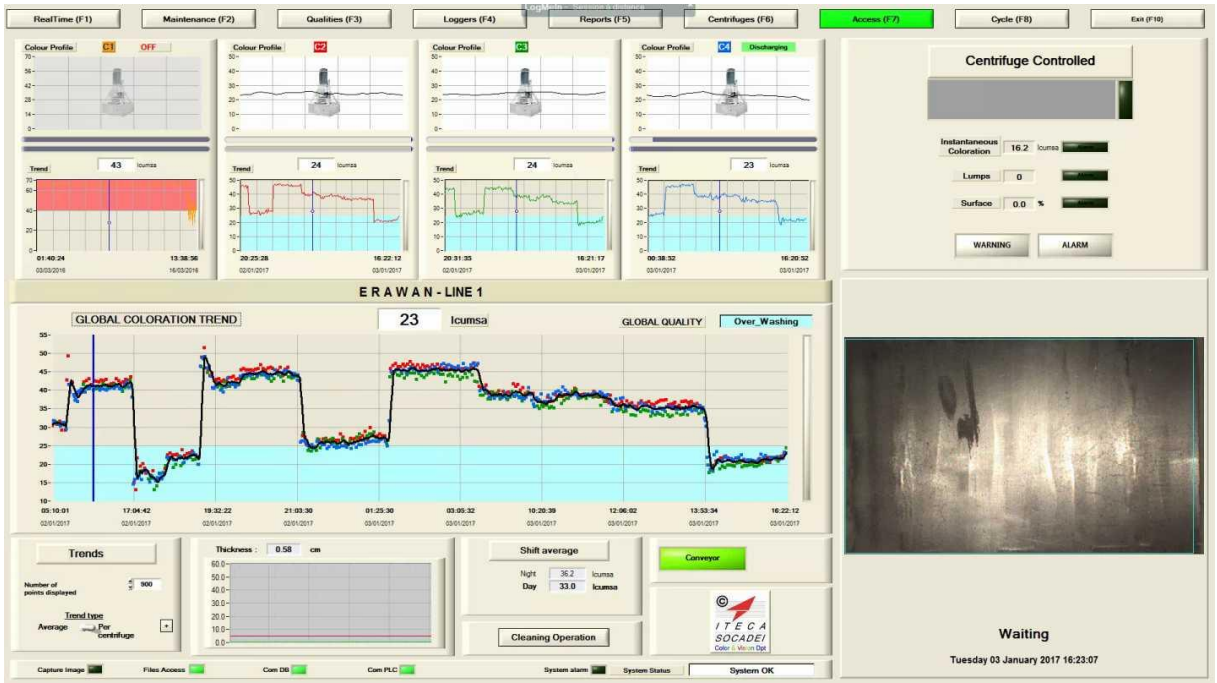

Figure 6: Impact of the massecuite qualities at the centrifugal output

This was highlighted with a short trial where the centrifugals washing time was kept constant, and the sugar colour at the centrifugal output was logged. The results showed abrupt drops of approximately 20 IU for every change of massecuite quality (Figure 6). It is therefore necessary to anticipate any sudden change in the massecuite quality when adjusting the washing time of each centrifugal independently; the better the massecuite quality, the lower the wash water volume needed for the overall colour to remain within the predefined limits. Again, this fine-tuning can be performed automatically by entering the on-going colour measurement results into the centrifugal PLC so it can modify the water volume sprayed on the next batch.

Monitoring of the process failures

We have seen that individual tracking of each centrifugal is critical to optimise sugar colour. Due to real time image processing, Iteca cameras provide an additional detection tool, which is not correlated to the colour measurement. Any non conformity appearing on the sugar surface is automatically detected, counted, its surface measured and alarms can be triggered if their number, dimension or colour exceed pre-set thresholds.

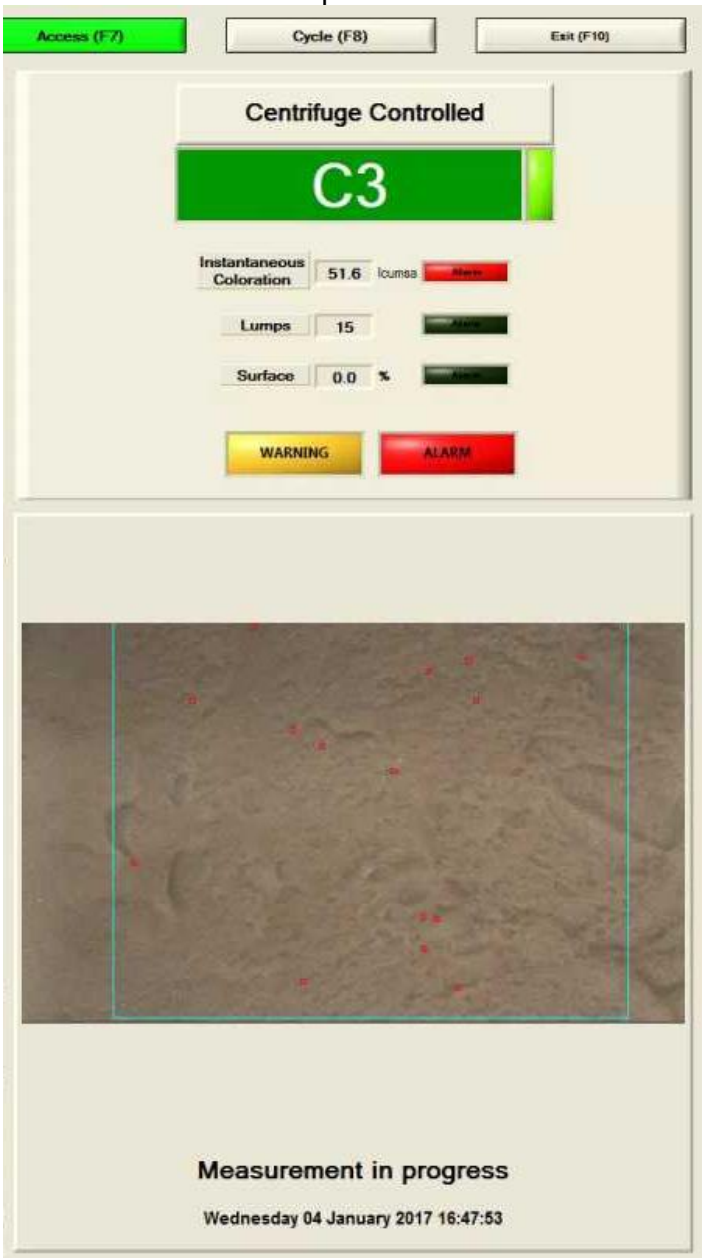

Figure 7: Very small brown lumps detection highlighted in red on the video

Figure 7 is a zoom-in on the case described above in Figure 5 and it shows that centrifugal C3 was producing too high colour levels because of the presence of brown lumps coming out of each batch. Although the lumps were very small, the camera was still able to detect them and trigger an alarm based on their number (15 lumps as shown in Figure 7 above). It enabled the operators to identify and fix nozzle blockage issues causing the formation of brown lumps.

An additional capability of ITECA control software is to communicate with the plant PLC any time a critical threshold is exceeded which enables the camera to initiate an action, for example, an out of specification product can be automatically rejected to avoid contaminating the dryer. During the first routing at Erawan Sugar, operators would manually divert out of specification sugar, mainly on 'lump events', into the melter but the plan is to set up the automatic version later this year.

Each event was recorded as well as the date and time of its occurrence as seen in Figure 8.

Figure 8: Example of Colobserver® alarm logbook

It is possible to click on any of the alarms and watch the corresponding video as 24 hours of taping are registered around the detection time. It can be done at any time, without interrupting on-going measurement, and is very useful for analysing root causes of the identified issues.

Financial interest of the wash water reduction and the automatic "auto wash"

The benchmark for crystal dissolution from wash water is one litre of water can melt up to 3 kg of good sugar. It is therefore essential to avoid over washing the centrifugals and only use the exact amount of water required to keep the colour as close to the colour set point as possible. If one considers an average water consumption of 2.5 litre/s/centrifugal, a one second reduction of washing time avoids remelting more than 16 tons of good sugar per day.

In addition to huge reprocessing costs, there is also a significant reduction of the water and energy consumption as well as an increase in production capacity.

During the first year of service of ITECA cameras at Erawan Sugar, the washing time was adjusted manually after analysing the individual colour trends of each centrifugal. This period was necessary for the operators to make it a routine to use the colour cameras as an efficient diagnostic tool and understand the impact of the washing time adjustment on the sugar colour discharged from the centrifugals. As can be seen in Figure 5, the time elapsing between when a colour drift is detected and the colour goes back to the colour set point can be relatively high as it depends on the operator's response to adjust ITECA Colobserver washing times.

For a much greater response and accuracy, the washing time optimisation must be done automatically. This will be commissioned during the 2017 campaign using the Fives's control system improvements that can alter the amount of wash water according to both the basket load and the colour measured by Iteca cameras. Regardless of the disparity between each centrifugal or the massecuite quality, the exact amount of wash water will be fine-tuned to maintain the colour at the predefined set point. Furthermore, as it is able to perform accurate cost analyses based on detailed records of machine usage, Fives Smart Control™ web application should be very useful to calculate the exact profit obtained by the washing time adjustment.

Conclusion

After a one year period, significant improvements were achieved to the stabilisation of the sugar colour at the centrifugal output using Iteca colour cameras. Both production shifts (night/day) trust and rely on ITECA Colobserver® measurements to take immediate corrective actions on the process whenever there is a colour drift or a non conformity is detected.

The automatic individual auto wash and the out of specification product automatic diversion that will be set up aims to improve the overall efficiency. It will also ensure an optimal level of quality whatever the process fluctuations encountered.

In order to expand the improvement strategy, another ongoing project at Erawan Sugar is the installation of ITECA pan microscopes that will be used to enhance the crystal yield and optimise the massecuite quality feeding the centrifugals.