EXPERIENCE AND UTILISATION OF AN ON-LINE SUGAR COLORIMETER IN A RAW SUGAR MILL

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KEYWORDS: Raw Sugar Colour, On-line Colorimeter, Real-time Measurement, Back-end Refinery, Process Control.

Abstract

AN ON-LINE sugar colour instrument was installed on the wet sugar screw directly downstream of the raw sugar centrifugals at Harwood Mill. The device accurately and reliably measured raw sugar colour in the process environment and provided valuable, real time indications of its pol. Reduced recirculation of sucrose to the boiling house by minimising over-washing in the centrifugals was achieved while maintaining sugar quality. The sugar stream discharged from each centrifugal was continuously measured, permitting the identification and diagnosis of problems within and between machines and the subsequent optimisation of each centrifugal. Broadcast of the instrument output across the plant SCADA system provided information to process supervisors and other operators. The raw sugar boiler operator was able to monitor raw sugar colour for immediate feedback of massecuite quality, and that information was used to assist with decisions on boiling formulation adjustments. The mill supplies raw sugar directly to the back-end refinery. A more uniform and tighter colour feed to the back-end refinery reduced colour load and improved operational stability. Raw sugar colour and pol deviations from standard had previously caused problems in the refinery. The refinery operators were able to use the raw sugar colour data to proactively adjust clarification and decolourisation operating parameters to suit the incoming raws and keep their process within specification. The accurate real time colour measurements have contributed to labour cost savings and assisted the training of new supervisors and operators.

Introduction

In 2004, staff at the Harwood Mill and Refinery, reviewed the Mill/Refinery relationship and determined an economically ‘optimal’ raw sugar quality (purity 99.5%, colour 1200–1400 ICUMSA units, IU), based on a mill/refinery relationship similar to that discussed by Meadows (2005).

Following changes prompted by this review, there was a step improvement in raw sugar quality in 2004, as illustrated by the raw colour and purity data in Figure 1.

The focus of this paper is on subsequent developments and improvements in performance resulting from the use of a Neltec ColourQ colorimeter and extends the results reported previously by King (2007).

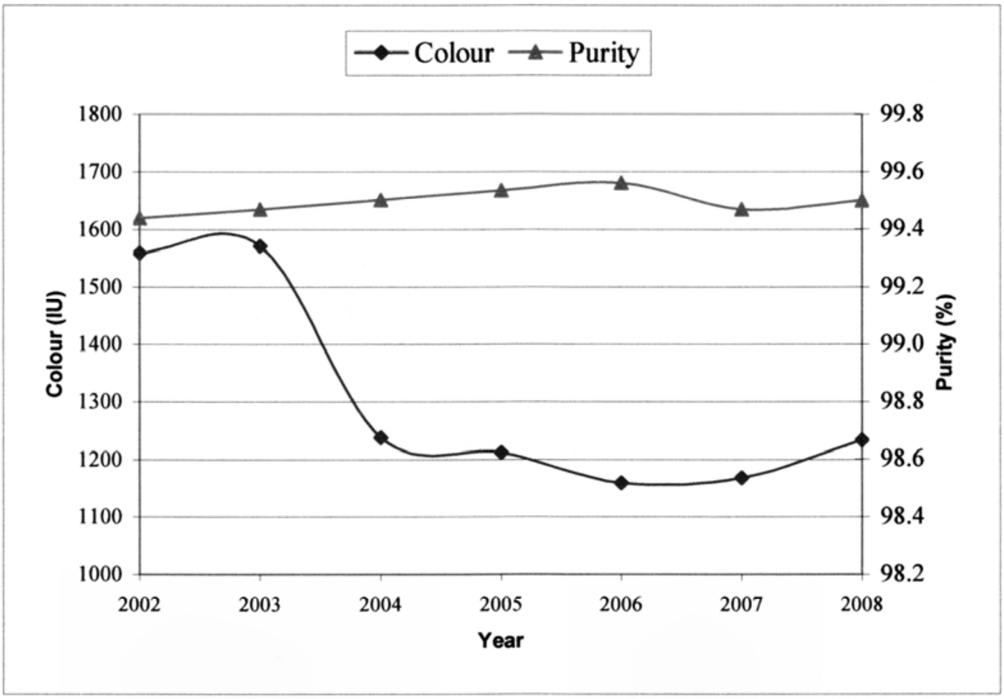

Fig. 1—Improvements in colour and purity of raw sugar at Harwood Mill between 2002 and 2008.

Harwood mill supplies up to 90% of the raw sugar feed to the back-end refinery, directly and without blending. The phosphatation clarification/ion exchange decolourisation refinery was built at Harwood in 1989 to closely match the high polarisation (pol) raw sugar produced by the mill and had very little spare decolourisation capacity. Since commissioning, the refinery has increased throughput rate incrementally with no augmentation of the decolourisation plant.

Consequently, the flow rate in the ion exchange plant is significantly higher than industry norms. Higher than specified raw sugar colour levels can lead to reductions in the refinery rate and higher decolourisation costs to maintain production of within-specification refined sugar.

Prior to October 2005, the shift supervisor (who supervises both the mill and refinery) regularly analysed raw sugar from the mill for colour several times during night shift to check against specifications.

Furthermore, the raw sugar colour would often swing from over to excessively under specification within single shifts and the raw sugar produced within and between centrifugals often varied greatly.

It was identified that the sugar boilers and centrifugal operators had no short-term feedback information on the sugar quality. Therefore, a more time- and cost-effective, automated, preferably real-time method for monitoring raw sugar colour was sought.

Figure 2 shows the colour variation among the five centrifugals across a 12-hour period just after the installation of the colorimeter.

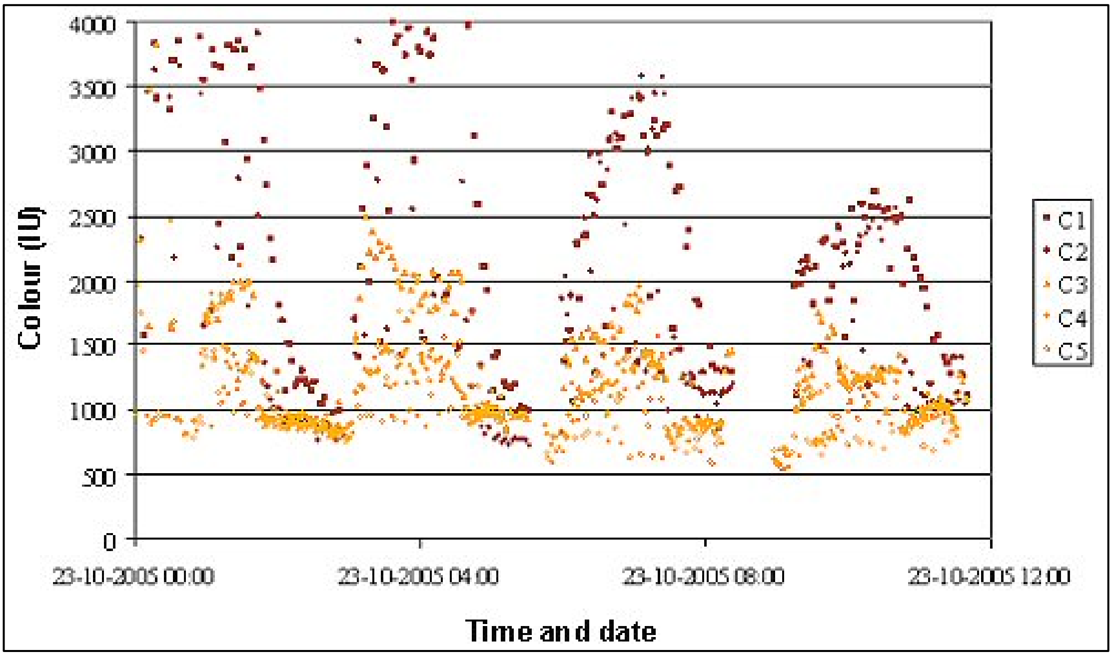

Fig. 2—Variation in colour from all centrifugals C1 to C5 over a 12-hour period just after installation of the colorimeter.

After a period of utilisation of the newly available real-time data by supervisors and operators, colour variation within and between centrifugals had fallen markedly. Comparing Figure 2 above with Figure 3 below (14 months after installation) shows a notable reduction in colour variation over a 12 hour period.

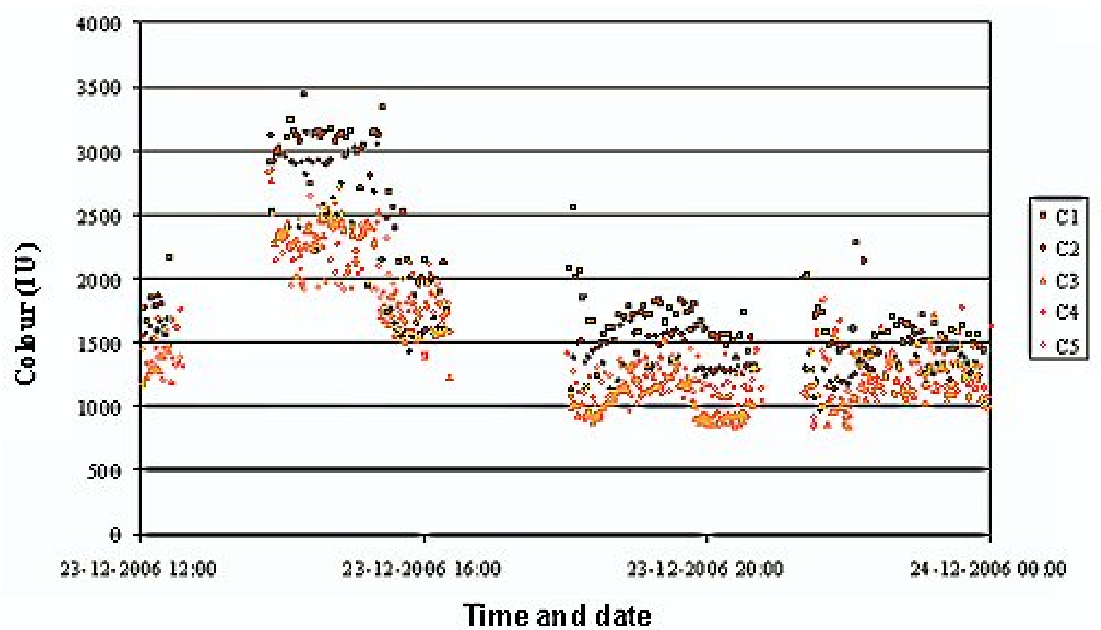

Fig. 3—Variation in colour from all centrifugals C1 to C5 over a 12-hour period 14 months after installation of the colorimeter.

The instrument selected was a ColourQ colorimeter supplied by Neltec, Denmark. it consists of two stainless steel tubes, one containing an illuminator and the other a detector. The lamp in the illuminator sends light to the surface of the sugar. Reflected light is collected by the detector and split into different wavelengths – including 420 nm. Following calibration, the instrument can calculate colour from the strengths of the signal at various wavelengths. The instrument manufacturer claims calibration stability over many years, and results that are highly consistent with laboratory ICUMSA colour determinations with very low errors (e.g. a SEP of 1.4 IU for white refined sugar in tests at the Tereos refinery, Origny-Ste-Benoîte, over more than a year; Bienaimé and Nielsen, 1999; Mabillot, 2000; Edye *et al*., 1997). Further important claims were that, since the readings it gives are in real-time and can be accessed via readily understood screen displays at relevant stations, it allows operators to make timely adjustments (Malgoyre *et al*., 1999) and to identify faults, notably in specific centrifugals (Nielsen, 2006). In addition, since colour/impurities relationships in sugar streams can be quite constant for several days (depending on local conditions and the process stream considered), there is scope to obtain indications of sugar pol, arguably the most important and valuable quality parameter of raw sugar.

In October 2005, a ColourQ colorimeter was installed, initially for a trial period of six months, to monitor wet raw sugar exiting the centrifugals at Harwood Mill. The claims that sugar pol can be inferred from the colorimeter's readings in real-time, as well as other assertions mentioned above, were tested after commissioning. The instrument was found to provide accurate real time raw sugar colour measurements within a matter of weeks. It has operated without incident since commissioned, and has provided a number of additional benefits, which are described below.

Materials and methods

A photograph of the ColourQ colorimeter, installed above the wet sugar screw directly downstream of the raw sugar centrifugals at Harwood Mill, is shown in Figure 4.

Fig. 4—The ColourQ colorimeter *in situ* above the wet sugar screw at Harwood Mill.

After it had been calibrated and shown to provide reliable indications of ICUMSA colour (Anon., 2005), it was used to monitor the sugar exiting the mill's centrifugals.

Increasingly, the sugar boiler and centrifugal operators became reliant on the instrument's real-time output to make timely adjustments to optimise production.

Operational parameters before, during and after the instrument's installation were then compared to assess its contribution to performance.

The key parameters considered were the colour and purity of raw sugar, percentages of raw sugar within colour and purity specifications and above colour thresholds, and sugar boiling efficiency (expressed as pan yield i.e. massecuite/sugar ratio).

n addition, staff at the relevant stations took notes on observations regarding its effects on their operational procedures and the performance of the plant.

Results and discussion

Figure 5 shows the increased percentage of raw sugar production within purity specification achieved from 2005 to 2008 and the increased percentage of raw sugar production within colour specification achieved from 2006 to 2008.

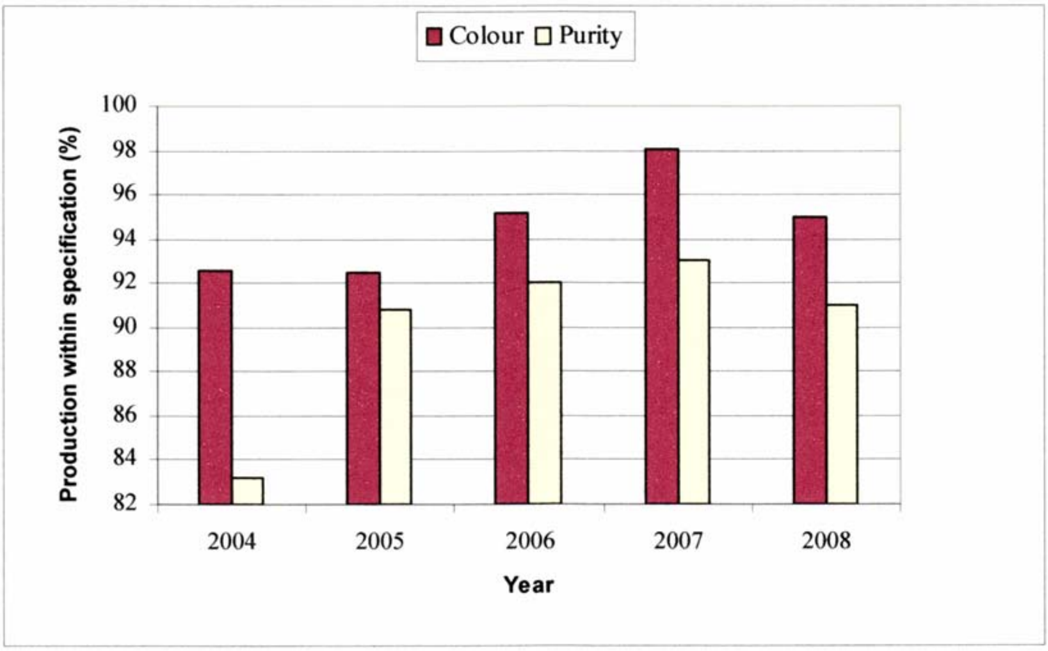

Fig. 5—Percentages of raw sugar production within specification from 2004 to 2008.

Figure 6 shows reductions in percentage of raw sugar above colour thresholds (1600, 1800 and 2000) achieved from 2006 to 2008. Production of raw sugar in these higher colour thresholds have an immediate negative impact on the refinery process.

Figure 7 shows improvement in high grade pan yield achieved in 2005, 2007, 2008 (exception 2006) while maintaining raw sugar colour. The 2006 crushing was a difficult processing season, with wet weather throughout the crush delaying completion by over four weeks; there were long periods in which deteriorated cane was processed, with significantly depressed purity, high soil loadings and corresponding processing difficulties.

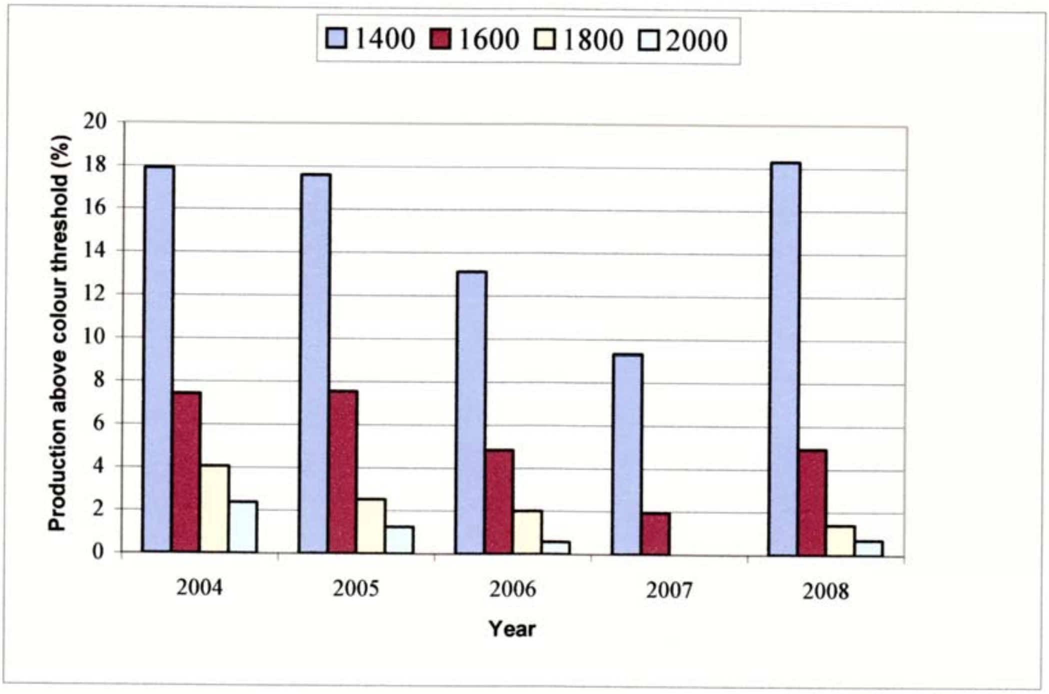

Fig. 6—Production (%) above colour thresholds set at 1400, 1600, 1800 and 2000 IU between 2004 and 2008.

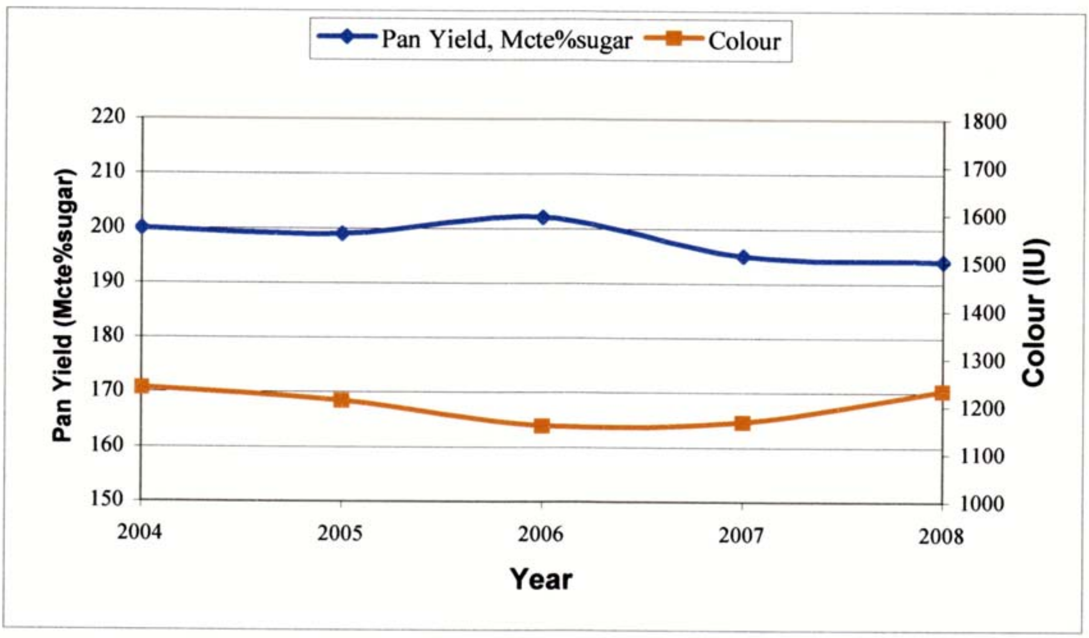

Fig. 7—Sugar boiling efficiency i.e. high grade pan yield in terms of massecuite/sugar ratio from 2004 to 2008.

For a number of reasons the ColourQ has played a key role in post-2005 improvements. The first is the value of the instantaneous sugar colour measurements and inferred pol from colour/impurities values. Typically, raw sugar is composited and analysed for pol only once in a 12 hour shift.

The analysis takes some time and there is a consequent delay in feedback to the process supervision. However, the colour/impurities ratio of the raw sugar is fairly constant over several days.

Thus, the instantaneous on-line sugar colour measurements provided by the ColourQ can be simply related to sugar pol providing instantaneous feedback to operators regarding the sugar boiling and centrifugal performance.

Immediate action can then be taken to correct deviations from target values. This facilitates the production of more consistent sugar, with more sugar within product specifications, and maximises the financial returns for premium grade raws.

In addition, the ColourQ information assists operators to minimise over-washing in the centrifugals which aids pan stage capacity maximisation by reducing sugar recirculation.

Harwood Mill provides up to 90% of the raw sugar directly to the backend refinery at Harwood. Therefore, the sugar colour and pol must be within specification at all times as there is very limited on-line blending of raw sugar, and short periods of high colour raws have an immediate negative impact on the refinery process. The quantity of out-of-specification raw sugar that had to bypass the refinery process (to be blended in later) was reduced by nearly 80% following the introduction of the colorimeter.

Data collected by the ColourQ is displayed as the average sugar colour for every centrifugal discharge as well as instantaneous trends of sugar colour during the discharge. Figures 8, 9 and 10 are examples of the real-time colour information made available to the operators and supervisors.

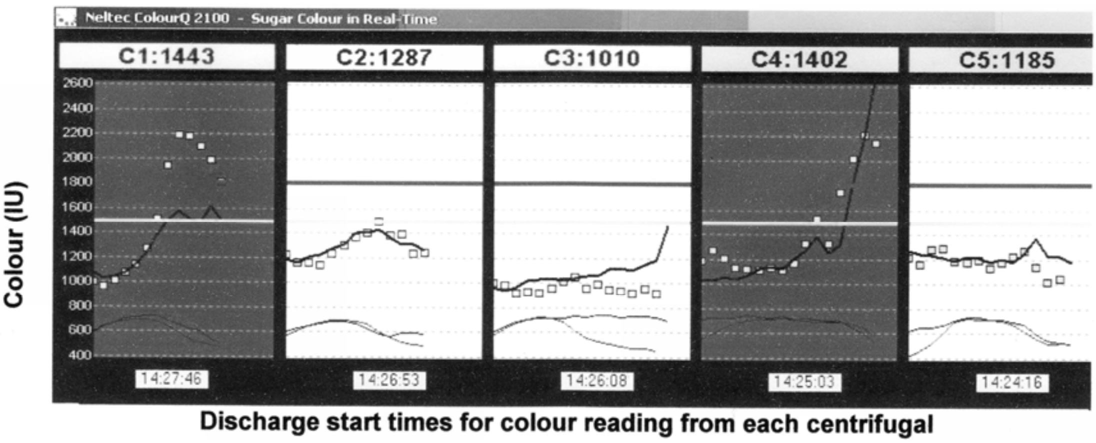

Fig. 8—ColourQ real-time screenshot example. Centrifugals C1 and C4 exceed high raw sugar colour limit.

The screenshot in Figure 8 indicates that raw sugar from centrifugals C1 and C4 exceeded the high raw sugar colour limit. Investigation of these centrifugals found a spray was blocked in centrifugal C1, and the backing screen in centrifugal C4 was blinded by insoluble material (fibre and ash).

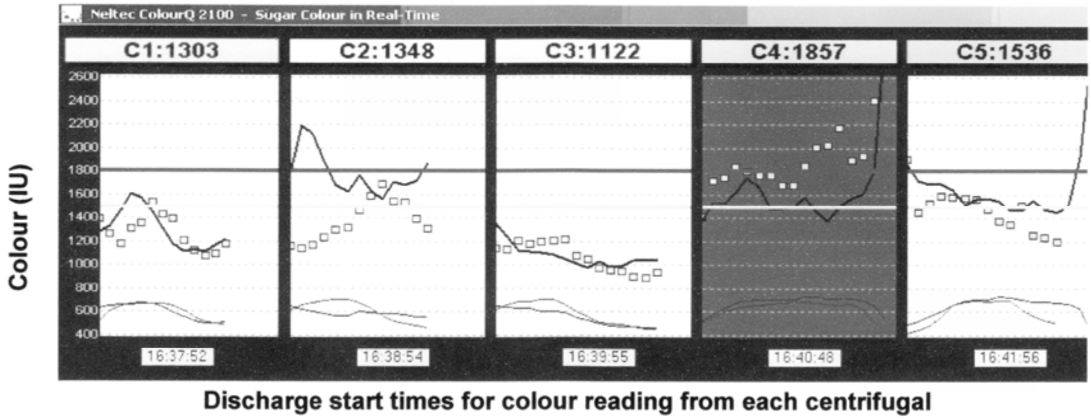

Fig. 9—ColourQ real-time screenshot example. After spray had been cleaned in centrifugal C1.

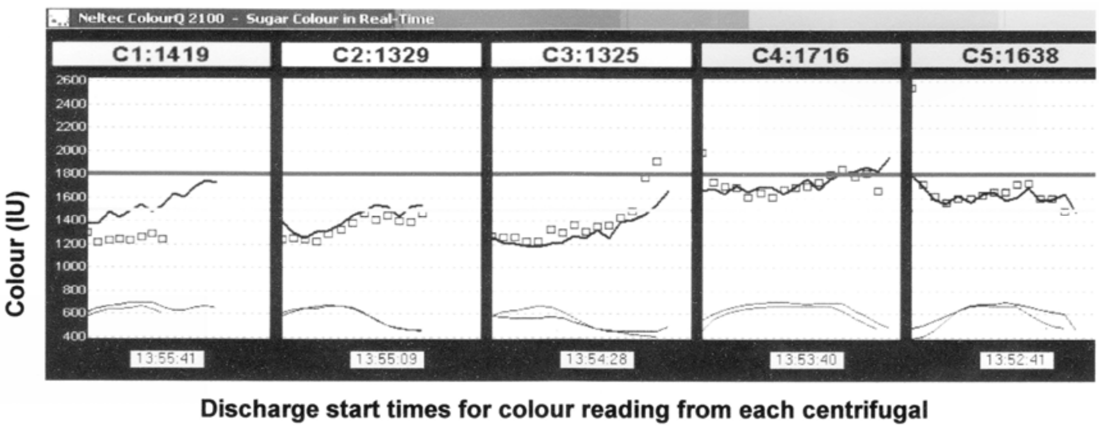

Fig. 10—ColourQ real-time screenshot example. After backing screen had been cleaned in centrifugal C4.

Figure 9 shows a screenshot obtained after the spray had been cleaned in centrifugal C1, and Figure 10 is a subsequent screenshot obtained after the backing screen had been cleaned in centrifugal C4. The centrifugals C1, C2, and C3 were processing A massecuite (87 purity), while C4 and C5 were processing B massecuite (83 purity). This information allows each centrifugal's performance to be analysed and tuned with respect to wash time, charge depth, spin time and speed, with immediate feedback regarding the effects of the adjustments. It was found that, in many of the centrifugals, the spray wash was not consistent over all sections of the baskets e.g. the colour of the sugar discharged from the bottom 20% of the basket of one machine was twice the colour discharged from the top due to poor alignment of the sprays.

On another machine several sprays were blocked. The readings from the colorimeter allowed these faults to be quickly detected, diagnosed and corrected. In addition, collapsed or scaled/fouled backing screens were systematically detected and rectified. The instrument has also facilitated modifications of the centrifugal spray systems to optimise their configuration and thus minimise the amount of wash water used while maintaining sugar quality.

Finally, the ColourQ has contributed to labour cost reductions. The instrument has allowed the level of supervision to be reduced and devolved, and refinery laboratory duties to be reduced.

Training of new operators and supervisors in the areas of raw sugar quality and centrifugal operations has been enhanced by the accurate real-time raw sugar colour measurements.

Conclusions

Changes made to operational procedures at Harwood Mill and Refinery following a review in 2004 led to a step improvement in raw sugar quality, but several problems still needed to be addressed.

Better information on raw sugar colour and impurity levels was required to address these problems, so a ColourQ colorimeter was installed, initially on a trial basis. Since then, the instrument has reliably provided instantaneous feedback information on sugar colour and (inferred) pol. Benefits identified since the installation include:

- Raw sugar pol specifications are met more frequently, and over-washing of sugar has been minimised (or at least reduced).
- Pan floor capacity utilisation is increased by reducing the recirculation of sucrose, i.e. high-grade massecuite to sugar ratios are reduced, while optimising the raw sugar quality.
- Colour feedback information is related instantaneously to the back-end refinery and other stations.
- The efficiency of the refinery is enhanced by closely controlling the sugar colour within a range that minimises refinery decolourisation costs.
- Assessment of the performance of individual centrifugals relative to other machines, and the determination of mechanical faults affecting sugar colour, are detected in real time.
- The instrument was commissioned in a short period and has operated without incident since 2005. After each slack season the system is switched back on and continues to perform as it did before the interruption.
- Labour savings have been made and training enhanced.

Acknowledgements

The authors wish to thank the management and staff of the New South Wales Sugar Milling Co-operative Limited for the opportunity to present this paper.

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