MILLING TRAIN MACERATION CONTROL UTILISING NIR TECHNOLOGY

By

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Abstract

IN RECENT TIMES, Australian sugar factories have tried to maximise throughput. This trend has continued with factory rationalisation and a need to maximise utilisation of existing capital. The amount of maceration applied to the crushing mills has a great effect on reducing pol loss in final mill bagasse. It is generally recognised that other things being equal, the more maceration the better the extraction. However the down side is that evaporators have to be able to boil off the extra water. The capacity of the evaporators to boil off that water in turn limits crushing capacity. Other issues associated with higher maceration rates are the evaporators scale quicker and the amount of steam required to maintain crushing capacity increases. Traditional maceration rates have been determined by using a fixed percentage of water at a daily average fibre rate which is at least a 24 hours out of date. Near Infra Red (NIR) measurement was introduced to Mackay sugar mills in 2006 and can be used to determine the quantities of fibre, pol and ash contained in the incoming cane. NIR gives a real time measurement of cane parameters and has allowed fibre rates through the mills to be measured accurately. Those measurements have been combined with cane crushing rates to provide a control value for maceration addition. This accurate control of maceration rate gives the following advantages over the traditional method of controlling maceration flow: mills have a consistent maceration % fibre which means there is always sufficient water to get the required pol recovery regardless of the cane characteristics; mills are not using extra maceration – just the right amount to give the right balance between bagasse loss, evaporator capacity and steam availability; more stable ESJ (Evaporator Supply Juice) brix which produces more stable evaporator performance; consistent final bagasse moisture and quality.

Introduction

Mackay Sugar uses the term ‘maceration’ to mean the brix free wash water applied to the fibre blanket ahead of the final mill. Many other organisations use the

term ‘imbibition’. The term maceration is used throughout this paper. The extraction performance of milling trains has been a highly discussed issue by milling engineers and technologists over the last 100 years.

Milling losses arguably are the biggest single recoverable sugar loss as a one unit drop can mean a bottom line loss to the business of up to $0.65 per t of cane or $49 000 per crushing week (based on sugar price of $450 per t and molasses price of $120 per t and a weekly crush of 75 000 t of cane).

Milling engineers have prided themselves on achieving minimum losses while still operating at acceptable crushing rates within the capabilities of the mills.

There are three main areas where engineers have focused their attention on reducing milling losses:

1. Cane preparation–performance of the shredder in breaking up the cane and allowing maximum pol extraction.
2. Mill performance –often dictated by the available power, design, roller configuration and setup together with the general condition of the mill.
3. Maceration water which is added to the individual mills (as ordinary compound imbibition) to maximise extraction of pol from the shredded cane as it passes through successive mills. The efficiency of pol extraction outside the physical constraints of the equipment is often determined by the quantity and temperature of this added water and the resultant system of counter current juice flows.

This paper highlights the importance of maceration in the extraction of pol from cane and presents the results of a trial of controlling maceration % fibre in an effort to maximise extraction through this parameter.

Factors affecting the effect of maceration on pol extraction

The parameters which can influence the effect of maceration on pol extraction and mill throughput are reviewed below before focussing on the trials at Marian mill during the 2009 crush.

Temperature

It is usually believed that the hotter the maceration water, the more the cells are opened and more pol extracted. Temperatures in excess of 90 ºC are sometimes targeted.

The higher temperatures are thought to cause the cane cells to become more permeable allowing the pol to be flushed from the cells more easily. This action is termed the thermal crushing factor (Allan and Saranin 1954).

A possible downside of this high temperature is that the mechanical crushing factor (Allan and Saranin 1954) or mechanical opening of the cells via mill compaction is rendered less efficient.

This higher temperature softens the bagasse making it more difficult for the mills to crush the fibre and mechanically break the juice cells open.

Temperature of maceration is a complex issue and there are many schools of thought regarding which is more efficient hot (>60 ºC) or cold (<60 ºC). The decision as to what temperature water shall be used will more likely be based on sugar quality or boiler performance issues rather than extraction efficiency.

During the 2009 season, Mackay Sugar Limited (MSL) trialled cold maceration (less than 60 ºC) and gained very good extraction figures, which were better than had been achieved using hot maceration. The apparent downside was final bagasse moisture was up to 5% higher than normal (averaging around 52%). This higher moisture content did cause some issues with boiler operation and efficiency.

Maceration addition

Maceration addition refers to the way the maceration water is presented to the open cane cells (bagasse) and drained away from the mills. The process is typically constrained by the design of the mill, the condition of the rollers and the design of how the juice drains away from the rollers. The maceration is added to the intermediate carriers prior to each mill and there are many variations in the distribution systems used throughout the Australia Sugar industry. Most aim to achieve a steady flow rate in time (no surging) and an even distribution across the width of the fibre blanket

Maceration quantity

It is generally accepted that the higher the specific maceration quantity, expressed as maceration per cent fibre (M%F), the better pol extraction achieved. The limiting factor is usually the factory's capacity to handle large amounts of mixed juice.

Mackay Sugar (MSL) has not expanded in the juice handling area in recent years (heater, clarification and evaporators stations). The evaporator station is often the rate limiting station due to the low installed capacity coupled with the need to chemically clean the Effets off line when they become scaled and less efficient. Typically sugar mills will operate in the range of 150% to 250% M%F. These are large quantities of water which need to boiled (evaporated) off to raise the brix from around 15 (effet supply juice) to 68 (syrup). For example, a factory processing cane at 500 t/h at 15% fibre will require 150 t/h of maceration water at 200% M%F.

High M%F levels produce better extraction, but there are diminishing returns with successive increases. Lower M%F levels reduce extraction efficiency and can also cause reliability issues with the crushing mills. High fibre levels or high levels of extraneous matter can overload crushing mills causing failure of chutes, rollers and gearing. The best solution would be to control accurately the M%F, so that just the right amount of maceration water is added to the milling train to maximise extraction and maintain plant throughput.

Given the wide acceptance of Near Infra Red (NIR) technology and the need for most factories to maximise plant availability and throughout, the remainder of this paper concentrates on a trial undertaken at Marian mill during the 2009 season in which NIR technology was used to measure fibre content continuously and, together

with other operational parameters, was used in a relatively simple program to control maceration addition rates automatically as the quantity of fibre being processed changed.

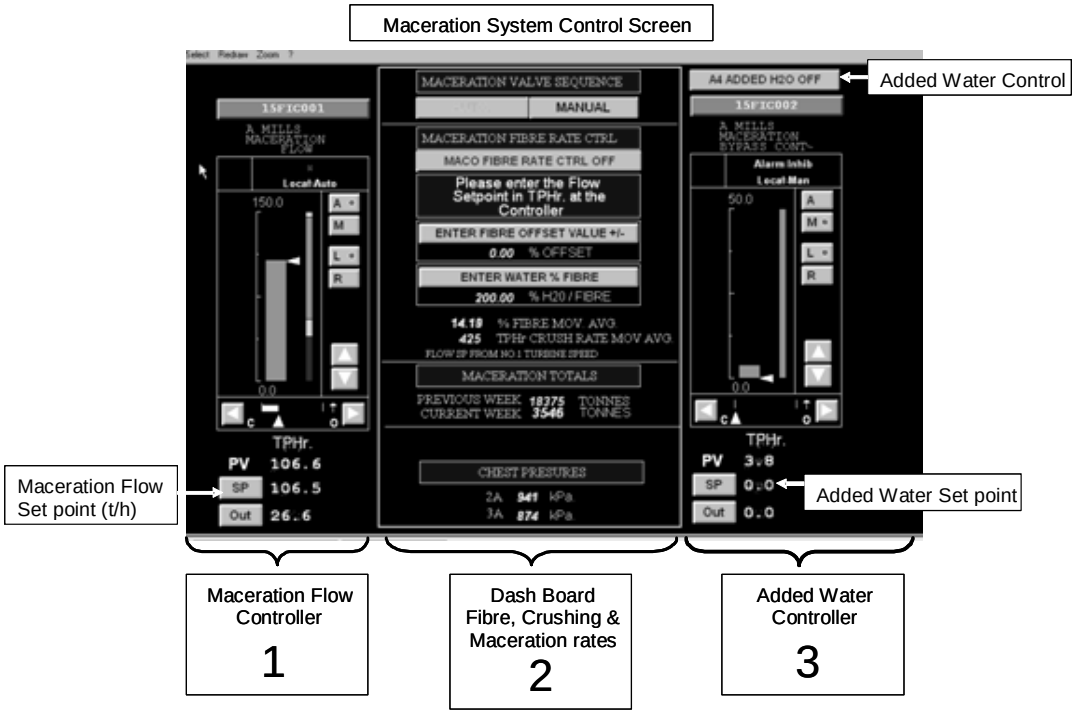
Trial during the 2009 crushing season

The trial at Marian mill during the 2009 season aimed to control maceration flow as a function of cane fibre levels when using existing equipment. Figures 1 and 2 show the control screen layout.

The trial involved taking inputs from:

- the cane tracker system (weighbridge) to give crushing rate–expressed as tonnes of cane per hour
- an NIR signal to give cane fibre content
- the factory's distributed control system (DCS) – #1 mill speed, #1 mill turbine chest pressure.

The fibre signal combined with the crushing rate was input into a simple program which adjusted the amount of maceration applied based on the maceration percent fibre set point.



The system is enabled by toggling the **Maceration Fibre Rate Control** selector on the main dash board.

When this is disabled the controller will return to 'Local' (**L**) set point control entered via the **Maceration Flow Controller** panel.

Added Water Control can be switched on / off by selecting the **Added H_2O** button and then selecting Local (**L)** and then entering the required Set Point (**SP)** value

Fig. 1—Maceration 'Dash Board'–Auto / Manual and Water % Fibre.

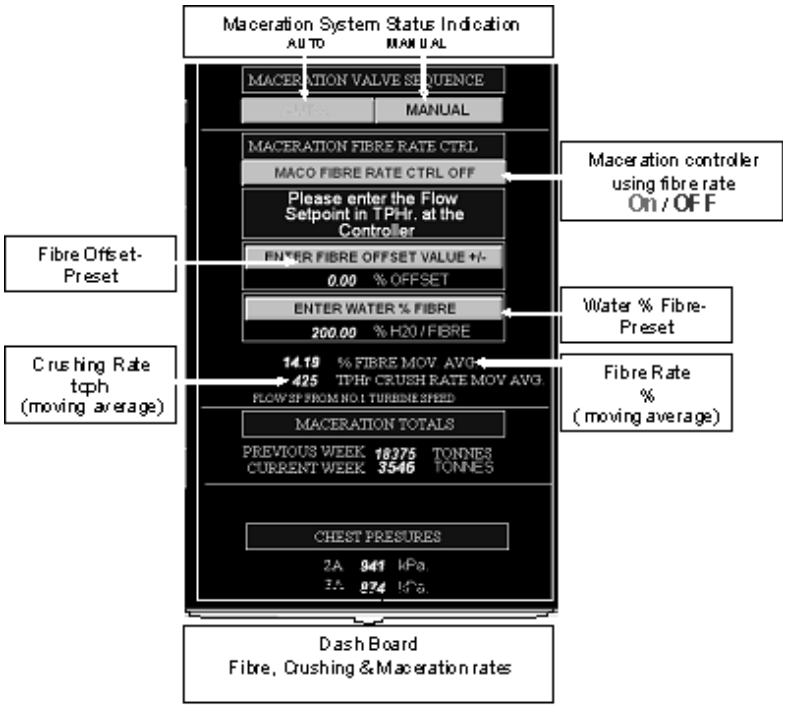


Fig. 2—Dashboard screen.

A lot of time was spent developing the operational strategy and ensuring sufficient safeguards were included which would minimise the risk of damage to the milling train of dry feed should the system fail and insufficient maceration be added. To have some safeguard built into the system, the program contained the following features:

- Fibre signal figure had to be in the range 13% to 17%.
- If the NIR signal or crushing rate were tested as bad or out of range then the preset maceration figure based on average fibre rate and #1 mill speed were used until these inputs were restored.

The operation of this control system was better than expected and operator acceptance was excellent.

A preliminary trial was conducted over a period of almost 9 weeks and failed to produce much in the way of statistically significant results due to the short nature of the trial and a lack of suitable instrumentation but the following observations were noted:

- ESJ brix was very consistent–typically ranged from 17 to 18 for the period of the trial.
- Maceration rates could be accurately changed depending on plant requirement (i.e. reduce evaporator load while still maintaining crushing rate) without the risk of damaging the mills due to cane of unusually high fibre or dirt content.

- The actual rates of maceration were consistently applied and any changes could be easily made without any plant disruption.
- NIR fibre signal proved to be reasonably stable and accurate requiring very little change to an off-set value.

Once the automatic maceration control operation is enabled (by toggling the *Maceration fibre rate control* selector), the controller mode then changes into *Remote* operation and the set point is adjusted according to fibre rate and desired M%F rate.

In automatic, the following control will be activated:

- If the milling train has been running for 18 minutes the maceration flow controller set point will be calculated from crushing rate, NIR % fibre and M%F setting. The operating mode will be displayed as *Flow set point from % fibre & crushing rate*.
- If the milling train has stopped or has low chest pressure for two minutes then the flow set point will be derived from No.1 mill turbine speed and the mode will be set to *Flow set point from No.1 turbine speed*.

The NIR fibre verses actual fibre results were checked each week and any calibration drift was corrected to ensure the fibre values from the NIR remained accurate.

2009 trial results

The trial produced very consistent ESJ brix which meant the evaporator station was handling a very consistent product. Evaporation stations will operate at higher average rates under these conditions. This consistent ESJ brix helped to achieve a steady flow rate through the rest of the factory.

Figure 3 shows that, from about week 10, the ESJ brix was consistently high. The last six weeks of crushing were when the maceration control system had settled down and very consistent results were achieved.

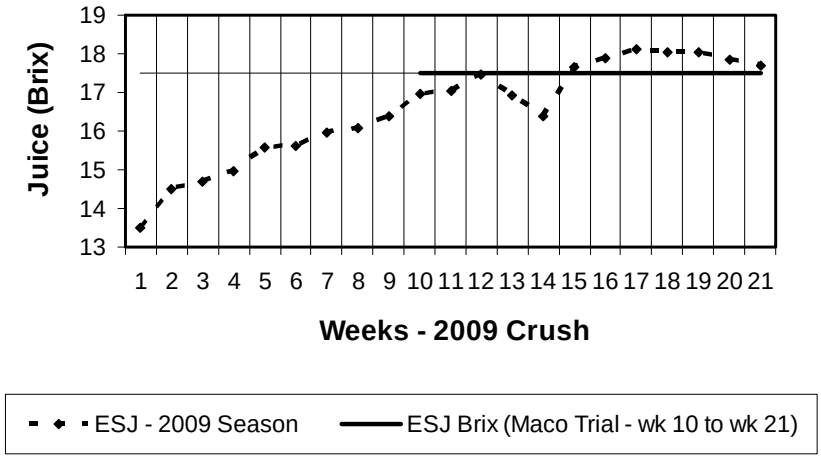


Fig. 3—ESJ brix 2009 crush v/s crush week.

ESJ Brix at Marian mill has been has been consistent over the years but the 2009 season was different. Lower than normal maceration levels were implemented early in the 2009 season but it wasn't until week 10 when the NIR based maceration control system was switched on that a stepped increase in ESJ brix was observed (Figure 4).

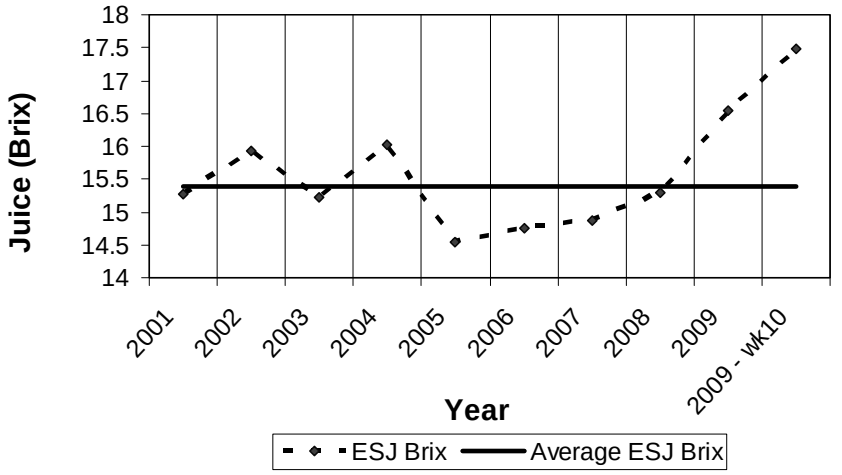


Fig. 4—ESJ brix v/s year.

Figure 5 shows that the reduction in added water percent fibre (M%F) had very little effect on final bagasse loss. There is expected to be a point where the reduction of maceration will dramatically affect bagasse loss but any reduction in maceration without a resultant increase in bagasse loss improves factory efficiency and throughput.

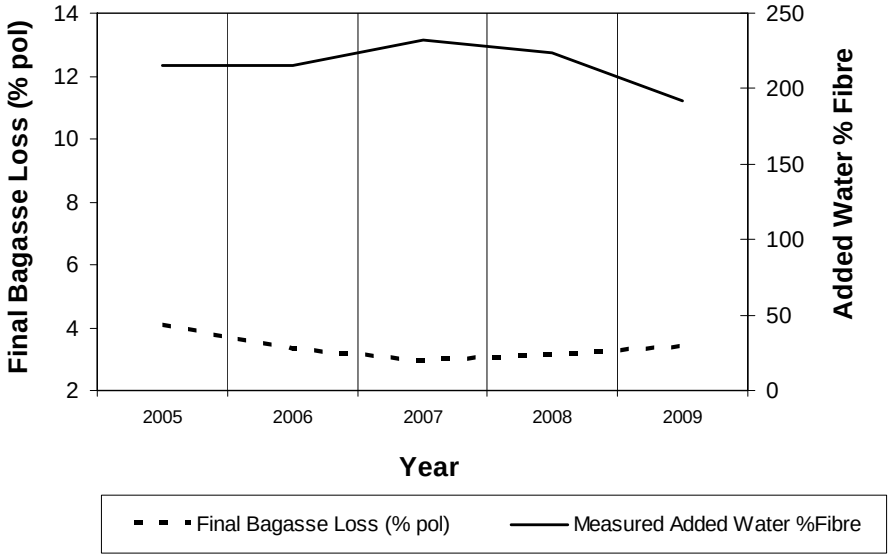


Fig. 5—Final bagasse loss and maceration % fibre v/s year.

Conclusions

Sugar mills have either under or over macerated when they have traditionally used a daily (or weekly) average fibre rate and used the speed of #1 mill or cane crushed per hour to determine the amount of maceration required. With the number of cane varieties and variability in fibre content in the cane supply, this average figure does not permit accurate control of M%F.

Under macerating potentially reduces milling extraction. Very low maceration puts the crushing plant at risk of serious failure due to dry feed.

Over macerating on the other hand means extra water will need to be boiled in the evaporator station and this can mean:

- Crushing rate may need to be reduced when juice tank levels are high.
- Evaporators will require extra cleaning as boiling extra water causes an increase in scaling and thus more plant stoppages (plant availability).
- Boiler loads increase and which results in more bagasse being burnt. In the past this increase has not been an issue, but with a demand from co-generation, bagasse has become a valuable fuel and steam efficiency (steam on cane %) has become a key efficiency measure.

Both under and over macerating results in ESJ of variable brix which in turn causes unsteady juice flow to the evaporator station. Evaporators rely on consistent flow (and levels) to operate at optimum boiling rates.

These results are only preliminary and while the results look promising a more trials and detailed analysis of the effect of controlled maceration needs to be undertaken.

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