EXPERIENCES IN EVAPORATOR CONTROL AT AMATIKULU

By R. G. MONTOCCHIO and R. P. SCOTT

Tongaat-Hulett Sugar Ltd - Amatikulu mill

Abstract

Changes made for the 1984/85 season to the Amatikulu quadruple effect evaporator are discussed including the introduction of nuclear density brix measurement of the final effect syrups. Alterations were also made to the systems for juice flow distribution and the level control philosophy was changed from feed forward to cascade back control. The motivation behind these changes is highlighted - principally that the feed forward juice flow control, in conjunction with the unusual evaporator configuration, was inadequate for process operations. Commissioning difficulties were slight and optimisation improvements continued throughout the year. The evaporator performs to design, presents no hold-up target throughput, and syrup brix control is to within one unit.

Introduction

Prior to the 1984/85 crushing season, the configuration of the Amatikulu quadruple effect evaporator station was somewhat unusual and was characterised by the following features:

- combinations of series and parallel juice flows between vessels
- parallel flow through the two Kestners, separation of juice in a common separator followed by parallel flow through two evaporator banks, each of five vessels
- series flow through the vessels forming the individual evaporator bank
- feed forward juice level control
- outlet syrup brix (monitored by conductivity) controlling Vapour 2 (V2) steam to the third effects.

The combination of feed forward level control and V2 throttling, inversely proportional to syrup brix set-point deviation, was inherently unstable. Deviations from brix set-point caused major changes to the evaporation rate, which resulted in changes in juice flow down the evaporator and the consistently unstable level control.

Just prior to the curtailment of the 1983/84 season, two 3-term PID controllers and two nuclear density meters were installed on the syrup tails to replace the conductivity single-term control circuit. The motive behind this alteration was to increase sophistication of control but little improvement in outlet syrup brix stability was possible (Figure 1).

It was thought that this philosophy of control coupled with the configuration of the evaporator station had the net effect of two quadruple effect evaporators acting independently, in which the evaporator itself was never a bottleneck but rather syrup tank size. Sluggish response and instability of control led to an inability to control outlet syrup brix within acceptable limits.

Evaporator station modifications

In the off-crop of 1984 it was decided to rectify the obstacles to control presented by this configuration. Figure 2 illustrates the arrangement prior to alterations whilst Figure 3 shows the present line-up.

The primary objective was to rationalise and reduce complexity through re-organisation of the evaporator station. By configuring the vessels into one quadruple effect evaporator in which juice/syrup piping was split in parallel to effects, it was

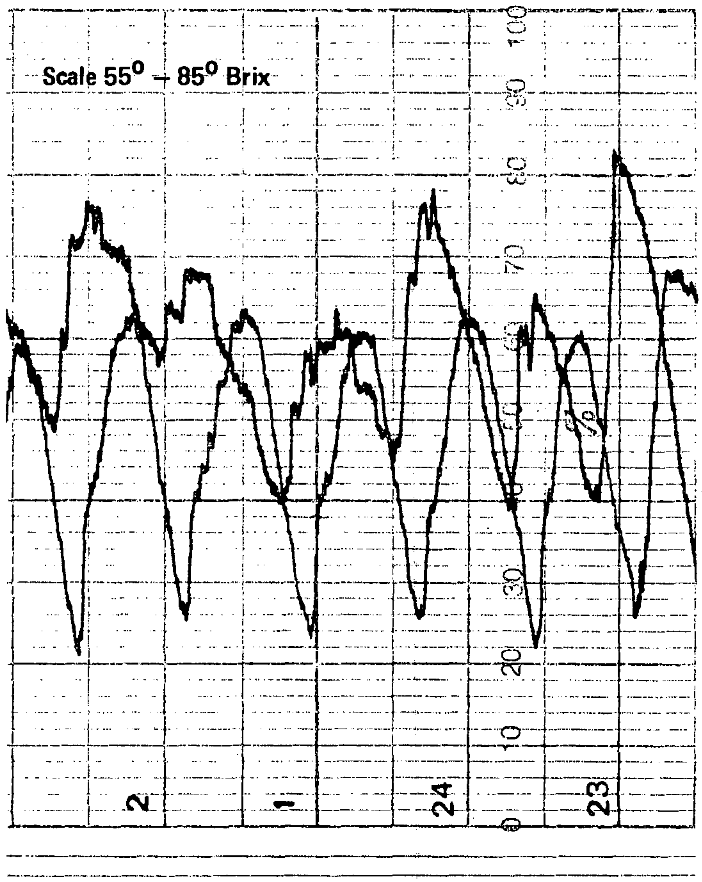

FIGURE 1 Brix control chart pre-1984

envisaged that more steady steam demand and syrup brix conditions would be induced. A further fundamental change to ensure controlled outlet syrup brix was achieved by altering control philosophy to cascade feed back juice level control.

Other modifications included:

- outlet syrup from the vessels comprising the fourth effect to flow through a single nuclear density meter
- linking control of V2 steam proportional to the clear juice tank level
- installing semi-sealed downtanks in all vessels to avoid short-circuiting of vapour and juice.

The grouping of the vessels as per the previous vapour arrangement was to remain unaltered. This allowed a reduction in the number of control devices, namely evaporator juice level controllers and nuclear density measuring and control equipment. In addition, the speed of response of control would be improved.

Commissioning and optimisation

With the commencement of the 1984/85 season, the newly configured evaporator station was immediately brought on line. Some of the initial problems encountered were a syrup bottleneck at the nuclear density meter and pressurising of the heaters. Modifications to piping and the Kestner juice flow control valves soon overcame these difficulties.

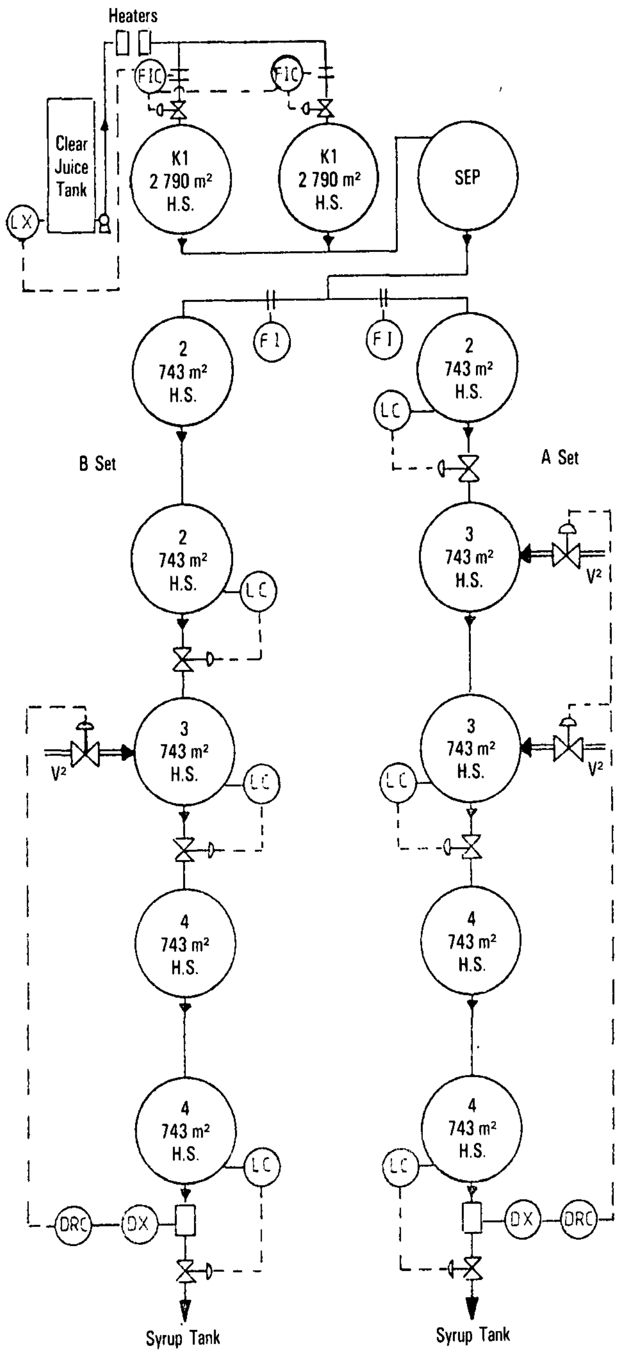

FIGURE 2 Amatikulu evaporator station pre-1984

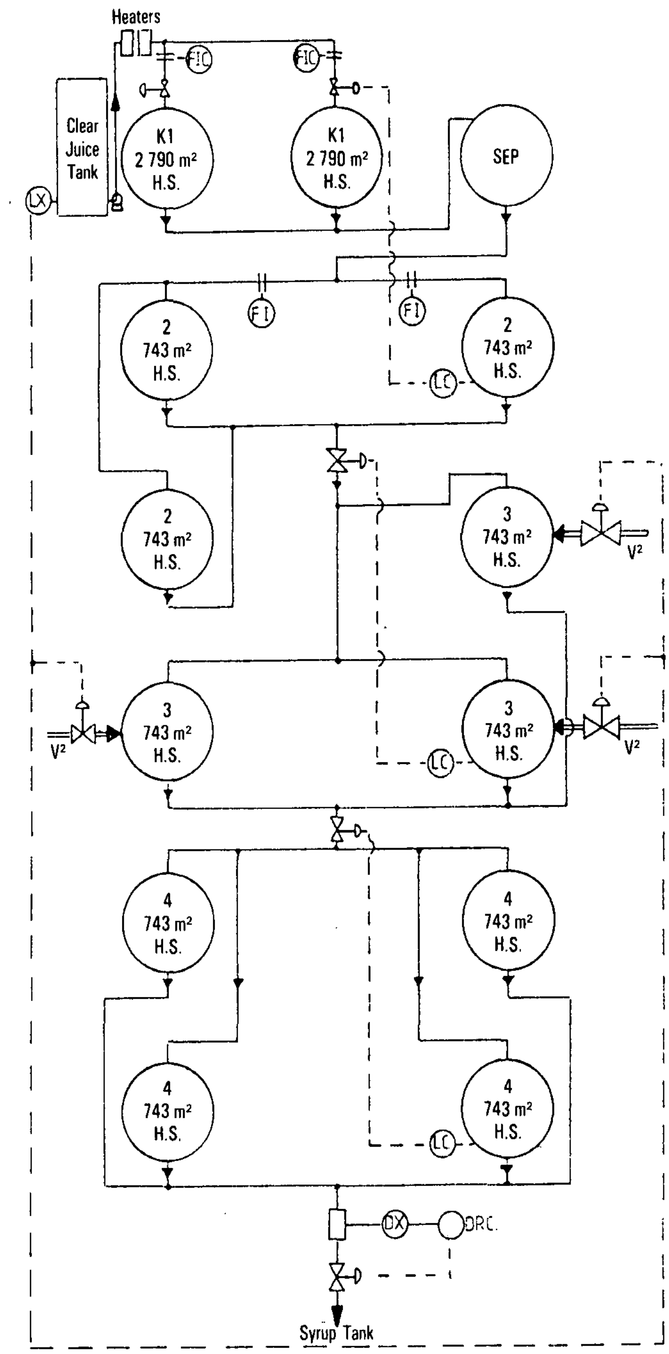

FIGURE 3 Amatikulu evaporator station 1984/85 season.

During the first six months of operation the evaporator station did not perform entirely satisfactorily and, although handling the throughput of 400 tons cane per hour in most instances, the following characteristics were prevalent:

- a time control lag in the juice flow between the Kestners and second effect vessels
- high juice levels in the second effects with low juice levels in the third and fourth effects.

By pre-setting the one Kestner juice flow control valve to a fixed position (30% open) and allowing the second effect level controller to control the second (other) Kestner juice inlet valve, the time lag and juice surge effect across the Kestners and separator system was damped. At the same time, the problem of the pressurising of the heaters was pre-empted.

The Kestner juice split is often uneven, but no adverse effects to tube encrustation have been observed.

A number of measures were necessary to overcome the juice starvation of the third and fourth effects, including increasing the juice feed ring orifice open area by 25% and 100% respectively.

Further refinements to control were achieved only after a lot of trial and error. The necessity for competent and trained personnel, proficient in the complexity of evaporator control, to tune the system cannot be stressed too strongly. Each system has its own quirks and prolonged observation, action and reaction techniques need to be applied.

Brix Control Results

An illustration of a typical evaporator brix control chart, once optimisation measures had borne fruit, appears in Figure 4. Measurement is by means of a Krohne 10 milli-Curie type DH 80 Radiometric in-line density meter contained in a 150 mm pipe section, the interior of which is PVDF-lined. The instrument is calibrated over the specific gravity range of 1,25 to 1,45 at 20°C, which corresponds to a range of 55° to 85° brix at about 60°C.

From the results in Table 1 it is clear that very uniform brix control has been achieved.

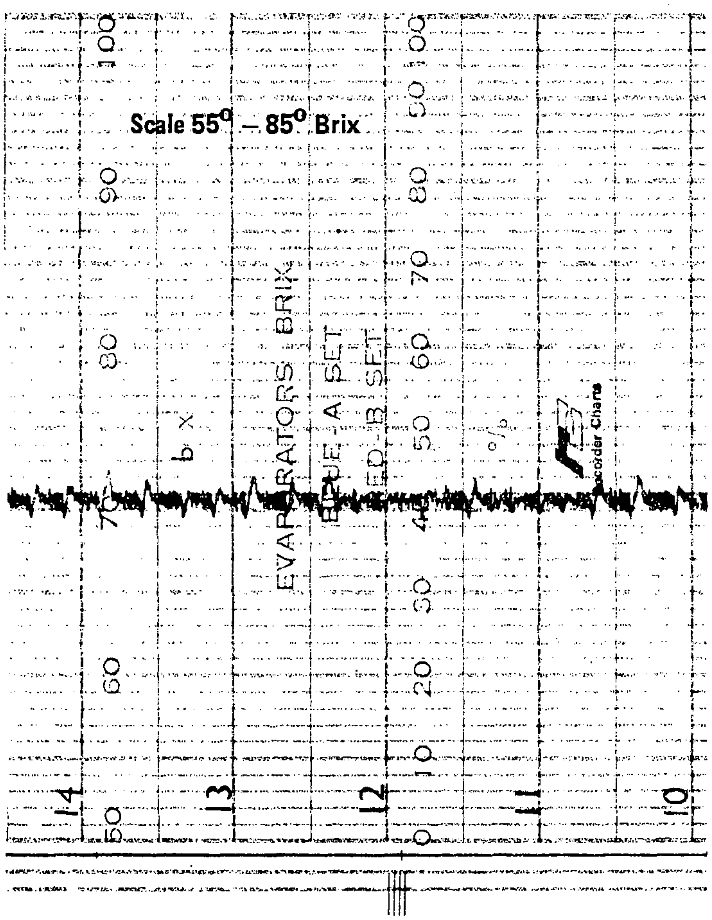

FIGURE 4 Brix control chart 1984/85 season.

TABLE 1

Density versus brix comparison

Time (min)	Chart reading (%)	Converted brix from chart (°Bx)	Actual brix (°Bx)
0	39	66,7	66,00
5	37	66,1	65,50
10	39	66,7	66,00
15	37	66,1	65,50
20	37	66,1	65,50
25	37	66,1	65,00
30	39	66,7	65,50
35	38	66,4	65,00
40	38	66,4	65,00
45	38	66,4	65,00
50	37	66,1	64,50
55	39	66,7	66,00
60	39	66,7	66,00

A pre-requisite for this form of control is very steady mixed juice flow control. It is intended to improve this system further by the installation of a more sophisticated PID controller on the second effects to replace the out-dated and rather inflexible float and torsion lever controller presently installed.

Conclusions

Despite the fact that the problems surrounding the time lag and juice surges which occur across the Kestners and their separator have not been totally resolved, a system has been introduced that reduces this problem to acceptable levels. This has allowed very steady level control of the juice in the third and fourth effects from which it has been possible to obtain very consistent brix control with a variation of about one unit. The evaporators have shown themselves well capable of handling the design throughput of the Amatikulu mill such that the emphasis on factory processing capacity has switched from the size of the syrup tank to the capacity of the evaporators. Prolonged throughputs in excess of design can be accommodated by reducing the outlet syrup set-point to match process conditions.

It has been found that the automated steam control link between V2 and clear juice tank level does not appear necessary, as this is set to maximum most of the time.

The nuclear density meter has found a useful application in maintaining evaporator efficiency. The sensitivity of this device immediately indicates, in the form of a changed pattern in its recording, any untoward occurrence (generally leaks) in the system, notwithstanding that there may have been no apparent change in evaporator conditions.

Acknowledgements

Thanks are due to the Technical Management Department, Tongaat-Hulett Sugar Ltd and to the management of Amatikulu mill for their advice and support.