FLOW METERS FOR DETERMINING MIXED JUICE MASS?

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Abstract

Accurate massing of mixed juice is critical to the South African industry for cane payment purposes, as well as for controlling performance in a factory. The batch weighing system usually employed in the South African sugar industry consists of load cells, holding tanks, weighing bins, processors, valves and actuators. Due to the nature of the mechanism used, the system can be subject to frequent downtime because of mechanical and electronic malfunctions. Any errors or interruptions within the weighing system could result in mixed juice weighing being suspended or the mill stopping until the problem is rectified. During these periods, the unweighed mixed juice has to be estimated as accurately as possible.

The Cane Testing Service (CTS) has developed a number of methods for estimating the mass of mixed juice in such an event (Brokensha, 1997). These methods usually involve the use of an assumed pol factor, the value of which may differ according to the amount of cane already crushed in the week. Due to the indirect nature of such a correction, and the need for decision making at laboratory manager level, the correction of the mixed juice mass can be lengthy and disputes as to its validity can arise.

With a view to the eventual standardising on a direct method that could be applied automatically in all situations, the determination of mixed juice tonnage by flow meter was investigated at the Umzimkulu mill.

The daily tonnages of mixed juice derived via the use of a flow meter already existing at the mill were compared against the routine massing of mixed juice and were recorded over the 2003 crushing season. After correcting the volumetric flow meter values for temperature, brix and specific gravity, the data showed a very good correlation to the tonnage obtained by the conventional massing of mixed juice.

This paper describes the two measuring systems and discusses the preliminary results.

Keywords: mixed juice, flow meters, Umzimkulu

Introduction

The Umzimkulu mill initially had two mixed juice weighers, but with the advent of mud recycling during the 1999 season, one weigher was dedicated to weighing mud only and the other was upgraded to cope with the total tonnage of mixed juice. In addition, the amount of imbibition had been progressively increased over the ensuing years in an effort to improve extraction and as a result the mixed juice flow rate increased accordingly.

By 2003, the mixed juice scale had reached its maximum capacity and was due for another upgrade. However, there were structural and space limitations and the only way of increasing mixed juice weighing capacity would be to construct another scale in a different location. This proved to be a costly exercise at the time and other options of accommodating the increased mixed juice flow rate were explored.

One of the options was to speed up the actions of the actuators that control the valves on the weighing bin. This would result in a reduction to the cycle time per batch and hence more juice would be allowed to pass through the weigher. However, it was observed that the downtime due to mechanical failures on the actuators had also increased over this period, and it was considered unwise to speed them up.

With each breakdown, the mixed juice weigher had to be either by-passed or the mill would have to stop. Whenever the weigher was by-passed, the quantity of unweighed mixed juice had to be estimated. Depending on when the weigher was by-passed, for example, start-up, mid week or shut-down, there were different methods for estimating the amount of mixed juice (see Appendix 1). These are standard procedures that are used by CTS for such cases. There were other complicating requirements also, such as ensuring that the mixed juice flowrate remained constant during the period that the weigher had been by-passed.

In order to standardise on a method of estimating mixed juice during all conditions, other devices were explored to assist in this regard. Umzimkulu already had a magnetic flow meter (Safmag, 200D2PTSSR0052) on the mixed juice line that was used for process control so this was logically the first piece of equipment to be considered. The position of the flow meter relative to the mixed juice weigher is illustrated in a simple schematic diagram (Figure 1).

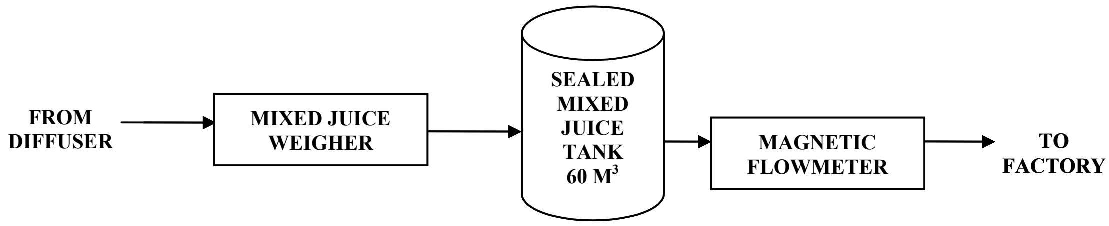

Figure 1. Schematic diagram of juice weighing at Umzimkulu mill.

Flowmeters

There are various types of flow meters that can be used to measure flowrates and the quantities of product that pass through them. Some examples include: vortex flowmeters, pressure and differential pressure transmitters, magnetic flowmeters, coriolis mass flowmeters and variable area flowmeters.

All of these flowmeters work on different principles and could be used effectively if the right flowmeter is matched to the right application. In the case of Umzimkulu mill, a magnetic flow meter had already been in operation, so all of the preliminary work for this paper was based on it and the results and conclusions are based on comparisons between the results from the mixed juice weigher and a magnetic flow meter.

Method

Readings were initially taken on a daily basis and compared to the daily mixed juice tonnage as determined by the existing method, that is the mixed juice weigher. These readings were also compared on an hourly basis but over shorter periods, such as a shift. The method was relatively simple as Umzimkulu Mill practised mud re-circulation and there was no filtrate to account for. Neither were there any other streams to account for such as sump returns. It must be noted that most of the readings were obtained with a mixed juice flow rate that ranged between 350 and 380 tph, because that was the normal operating condition for Umzimkulu mill. Also, the levels of suspended solids in the mixed juice remained fairly constant at approximately 0.21%. Cognisance of the varying levels in the mixed juice tank was taken into account and the readings were taken at approximately the same level whenever possible. It was also assumed that the hourly brix analyses by CTS were correct and valid for the juice that had progressed a short distance from the original sample point.

Results

The readings from the flow meter were corrected for temperature and brix (Anon, 1985), and then compared to the readings from the weigher. A correlation of $R^2 = 0.9414$ was obtained with a simple regression equation of $y = 0.9614x + 375.13$ as depicted in Figure 2. By applying this regression equation to the flow meter results, it was possible to obtain results similar to that of the weigher. Hypothesis testing about the difference between the two means showed that the results from the weigher and the results as calculated by the regression equation on the flow meter do not differ significantly at the 5% level of significance. A summary of the statistical results is given in Table 1.

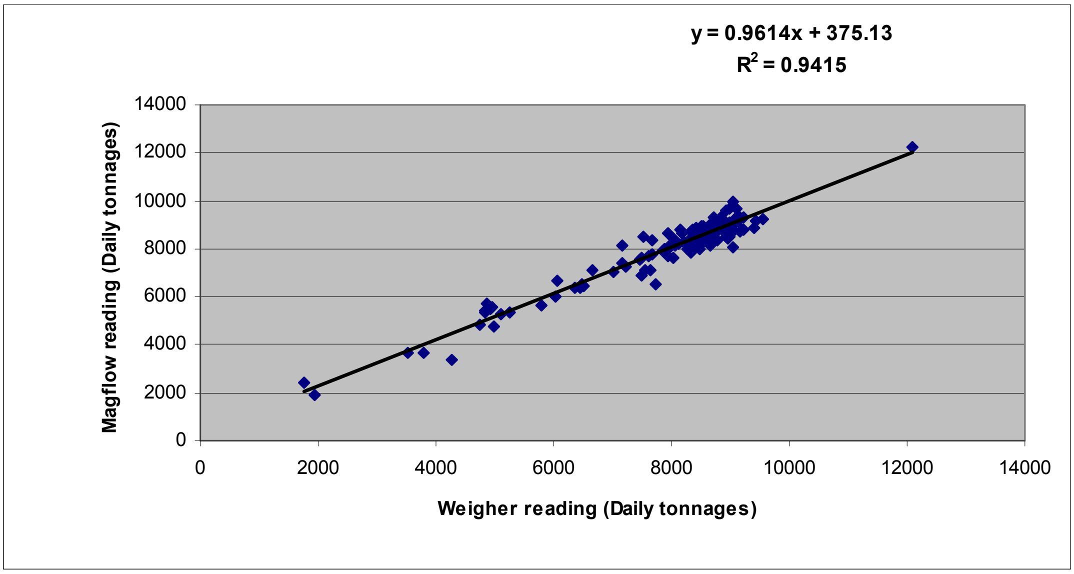

Figure 2. X-Y scatter of corrected flow meter readings versus weigher readings.

Table 1. Summary of statistical results of the differences between the readings from the weigher and the regressed readings of the flowmeter.

Parameter	Value
n	154
Sum (tons)	~406.792
Average	~2.6415
Standard deviation	367.4522
T	~0.08921

Conclusion

Following the results of the experiment at Umzimkulu Mill, the magnetic flow meter has been subsequently used on three separate occasions to successfully estimate the mass of mixed juice during periods when the weigher had failed. This has been a promising development for Umzimkulu mill, but it may be argued that the mixed juice weigher gives an absolute amount and the weights that are used to calibrate the weigher can be traced back to international standards. But, so can flow meters. The primary head of the flow meter that was used at Umzimkulu was calibrated against reference meters certified by a SANAS accredited calibration laboratory.

In addition, with the advent of Laboratory Information Management System (LIMS), the readings could be automatically compensated for brix and by applying the regression equation the tonnage of mixed juice obtained by this method should be very close to that as determined by the conventional method. There are checks and balances in place to signal any inaccuracies with the determination of mixed juice tonnages, such as the pol and brix factors.

Factors such as the cost of setting up a new scale or upgrading an existing one, the maintenance costs of actuators, liners, etc, the adverse conditions that one is required to work on during break downs of the weigher, the undetermined loss that is associated with mixed juice overflows and the maintenance contract fees required for the weighers are just some of the reasons that would make the choice of a flow meter as an alternative to determining mixed juice tonnages an area for further investigation.

Future work

The flow meter would be re-calibrated and the brix corrections together with the regression equation would be programmed into LIMS to allow for corrected weights. The option of purchasing the most suitable flow meter for the application would be explored and pending the outcome of these trials, the possibility of purchasing additional flow meters would be considered. These would be used to constantly check each other. This was a preliminary investigation and further work would be carried out to ascertain whether flow meters are sufficiently accurate for cane payment and factory performance purposes.

REFERENCES

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APPENDIX 1

Methods mill balance sucrose adjustments

Method I
Average three closest normal hours tons mixed juice and calculate tons mixed juice per minute.

This is then applied to the number of minutes of the bypass.

Where a mill has a flow meter and accurate records of correlation between flow meter and tons mixed juice as recorded by the scale exist, the flow meter output can be used in conjunction with the above.

Method II
Average three closest normal hours tons mixed juice (before and after) and calculate tons mixed juice per minute.

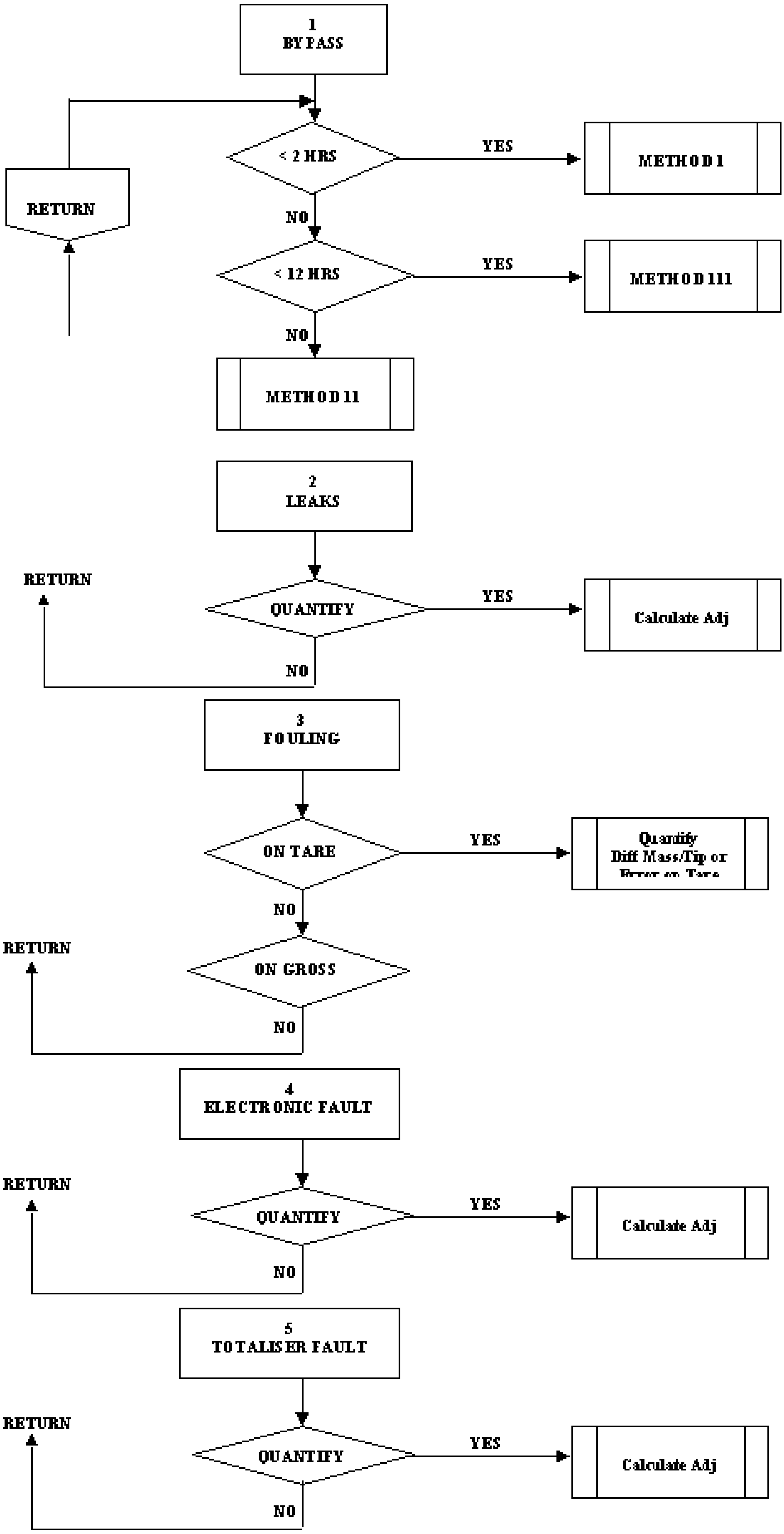
This is then applied to the number of minutes of the bypass.

Where a mill has a flow meter and accurate records of correlation between flow meter and tons mixed juice as recorded by the scale exist, the flow meter output can be used in conjunction with the above.

Method III
MAB formula (Brokensha, 1997) using previous week/todate pol factor whichever is more relevant.

$$\text{Tons Mixed Juice} = \frac{\text{Pol factor}[(\text{F\%Bag} * \text{TonsDAC pol}) - (\text{Pol\%Bag} * \text{TonsDAC Fibre})]}{(\text{Pol\%MJ}(1-0.01 * \text{SS\%}) * \text{F\%Bag}) - (\text{Pol\%Bag} * \text{SS\%MJ})}$$

MASS ERRORS


1
BY PASS
< 2 HRS
YES
METHOD 1
RETURN
NO
< 12 HRS
YES
METHOD 111
NO
METHOD 11
2
LEAKS
RETURN
QUANTIFY
YES
Calculate Adj
NO
3
FOULING
ON TARE
YES
Quantify
Diff Mass/Tip or
NO
RETURN
ON GROSS
NO
4
ELECTRONIC FAULT
RETURN
QUANTIFY
YES
Calculate Adj
NO
5
TOTALISER FAULT
RETURN
QUANTIFY
YES
Calculate Adj
NO