EVALUATION OF AN ETHANOL DETECTOR FOR STALE CANE IDENTIFICATION AT NOODSBERG

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Abstract

Previous work has shown that there is a relationship between the degree of deterioration of cane and the amount of ethanol present. The use of an ethanol detector for identifying stale cane was investigated at Noodsberg. This tool will enable the cane quality controller to identify areas where cane delays occur and implement appropriate action.

The detector uses the infrared absorbance of ethanol to measure the concentration of ethanol present in the air drawn through the instrument. Although this technique was shown to work exceptionally well in the laboratory, in a factory many practical problems can arise. The cane must be shredded, since little or no ethanol is released through the rind of the cane. Shredding releases moisture that, if not separated from the air sample, will accumulate on the optics and cause drift in the readings. The measurement is actually ethanol per unit volume; consequently, any pressure drop in the sampling system will cause a drop in the reading. Small pieces of fibre accumulating in the piping may allow fermentation of the sugar and lead to false ethanol readings. Temperature has a marked effect on the evaporation rate, and hence the ethanol present in the air sample. Compensation functions had to be included.

This paper examines the test data that was collected to verify the detector's ability to indicate ethanol in cane. The techniques used to prepare the air sample for the detector in continuous operating conditions are also discussed.

The application of the detector will allow the prediction of problems in the processing of deteriorated cane and also give an early alert to cane quality monitors so that speedy corrective action can be taken along the supply chain.

Keywords: ethanol, ethanol detector, deterioration, cane supply

Introduction

There is no doubt that deterioration of cane prior to processing causes loss of sucrose in the cane (de Robillard *et al*., 1990) and reduces the potential level of recovery (Fulcher and Inkerman, 1978; Geronimos and Greenfield, 1978; Ivin and Foster, 1977; James and Cameron, 1971). Deteriorated cane is a source of concern to sugar factories, and effective management tools are required. One of the products of cane deterioration is ethanol. Lionnet and Pillay (1988) produced a correlation between ethanol level and cane delays. The production of ethanol, however, depends on many factors such as time, temperature and humidity. It nonetheless remains a good indicator of the condition of the cane and may be used for detecting deteriorated consignments.

Once cane deterioration has been identified, the knowledge of its source will facilitate the implementation of remedial plans.

Simply watching and monitoring cane quality has been shown to improve the quality of cane delivered. Alternatively, assistance can be given to address the management of delays. After all, it is the whole cane supply and factory community that suffers as a result of deteriorated cane being crushed.

In this project, a commercial unit, based on near infrared absorption, was applied to the detection of ethanol in a sugar factory. The unit was designed to measure gas concentrations in a pipeline. This is different to a stream of shredded cane where there are acids, liquids and solids present. The challenge is to separate the gas from the hostile components before passing the gas through the tube that houses the detector.

Ethanol, An Indicator of Delay

In the work done by Lionnet(1986), Cox and Sahadeo (1992) and Lionnet and Moodley (1993, 1994) correlations were derived relating ethanol content to time delay. The correlation is much clearer for burnt than for unburnt cane. This is especially notable in the work by Smith (1993), where no significant correlation could be found for unburnt cane, whereas results for burnt cane were similar to those obtained by Cox and Sahadeo (1992). The lack of consistency between results is an indicator that time is not the only factor that determines ethanol production, and that temperature and humidity have a significant role to play. The deterioration mechanisms in unburnt cane are also such that less ethanol is usually produced per unit sucrose lost due to deterioration. Despite the lack of a universal deterioration model, the presence of an amount of ethanol, being one of the possible deterioration products, does indicate that the cane has deteriorated and could have a marked influence on the performance of a factory if it is processed.

The focus of this project was to identify deteriorated cane using an ethanol detector. A relationship between the level of ethanol detected and the ethanol on brix was required. From this, the degree of deterioration and a rough estimate of the cane delay could be determined.

Ethanol Detection

Several techniques exist for detecting compounds such as ethanol. The most commonly used in the sugar industry is gas chromatography. This is a laboratory procedure and, being well established and proven in the sugar industry, was chosen to determine the actual ethanol in the DAC samples extracted from samples to be analysed.

Near infrared absorption can also be used for detecting compounds. Each compound has its own characteristic spectrum. Statistical techniques can be used to isolate specific species present in the sample. When a single analyte is of interest, the detector can be tuned to the characteristic frequency of the specific compound. A measure of the concentration can then be derived directly.

Other techniques such as gas diffusion electrodes (De Castro, 1996) are also developing rapidly.

Description of Apparatus

Figure 1 shows the layout of the test equipment. A gas sample was drawn from around the freshly shredded cane. Various apparatus were used to separate any entrained moisture and solids from the gas stream. The gasses were drawn though the gas analyser using a vacuum pump.

The gas analyser converted its measurement into a 4-20mA signal, which could be logged on a computer using an analogue to digital converter.

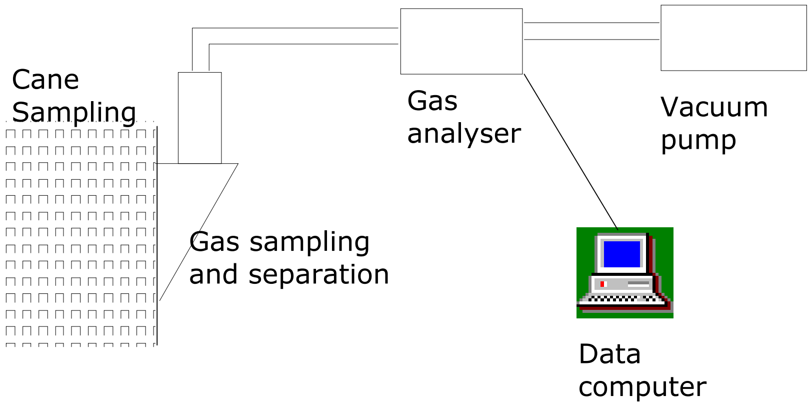

Figure 1. Configuration of ethanol sniffer.

A temperature probe was also introduced into the sampling volume so that temperature effects could be investigated after a difference between day time and night time ethanol levels were observed.

Considerations

The gas analyser used has a proven record for analysis of clean industrial gasses. The main problem is the moisture and solids that get entrained in the gas sample stream. Much of the effort must be directed at separating the gas from the dirt. This task poses additional challenges. Since ethanol is a fermentation product, any decay that occurs in the pipework and the detector will lead to false readings. It is therefore essential that a build-up of fibre and juice in the equipment must be minimised, and that the possible amount of ethanol that can be produced on this account must be small in comparison to the actual signal.

Problems were encountered where air from an outside source diluted the gasses associated with the cane. This led to low, inconsistent readings.

Placement of Sampling Point

Initial tests were conducted in the shredder housing at Noodsberg sugar mill, and subsequently at Umzimkulu mill. Although the results were very encouraging, the detector rapidly became contaminated and extensive tests could not be completed.

A second site that was investigated was at the top of the chute of the number one mill at Noodsberg. This had the advantage that lower contamination levels were expected. The problem encountered, however, was that the gasses from the cane were diluted by additional air entering at the top of the chute. This meant that the signal levels were extremely low and inconsistent, since variable amounts of dilution were encountered.
The most successful location found to date is just below the cane level in the chute. This forces the gasses drawn into the detector to have passed through the cane bed thereby increasing the amount of ethanol evaporated to pass through the detector. Similar areas in the shredder will be sought in the new season.

Calibration Procedure

The apparatus was installed on the number one mill chute at Noodsberg mill. The advantage of using this position was its proximity to the DAC sampling station. The gas was extracted from the chute through the analyser. The output was logged on a data-logging computer. At the same time, samples of the cane could be taken and DAC samples extracted. For this phase of the trials, the samples were chosen specifically for their high ethanol content as indicated by the detector. These were then frozen until they could be analysed using a gas chromatograph and the brix also determined. The ethanol on brix could then be compared to the detector reading. The correlation achieved can be seen in
Figure **2**.

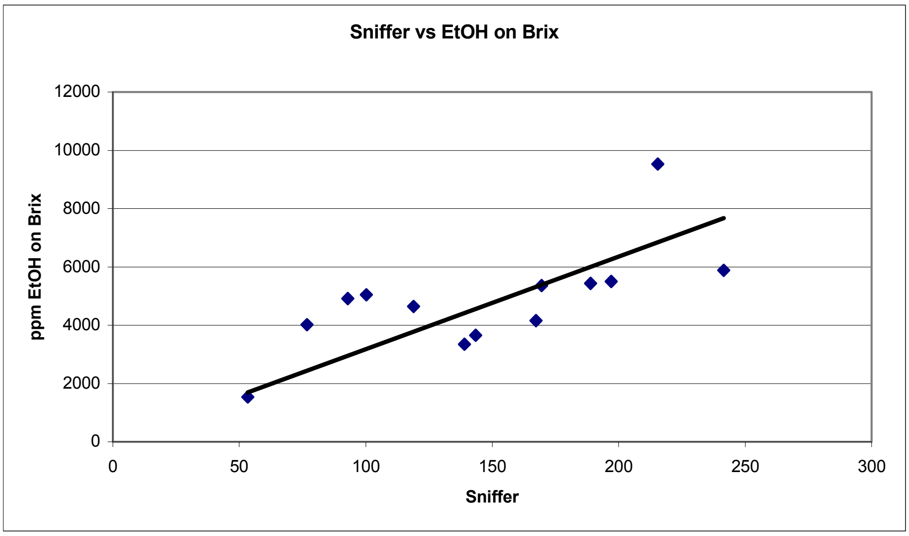

Figure 2. Ethanol on brix versus detector reading.

Traces of detector reading and temperature reading were plotted against time. From the typical trace in Figure 3, it can be seen that temperature has an effect on the ethanol vapour presented to the detector. This effect needs to be removed before a quantitative result can be derived, although batches of deteriorated cane can clearly be seen.

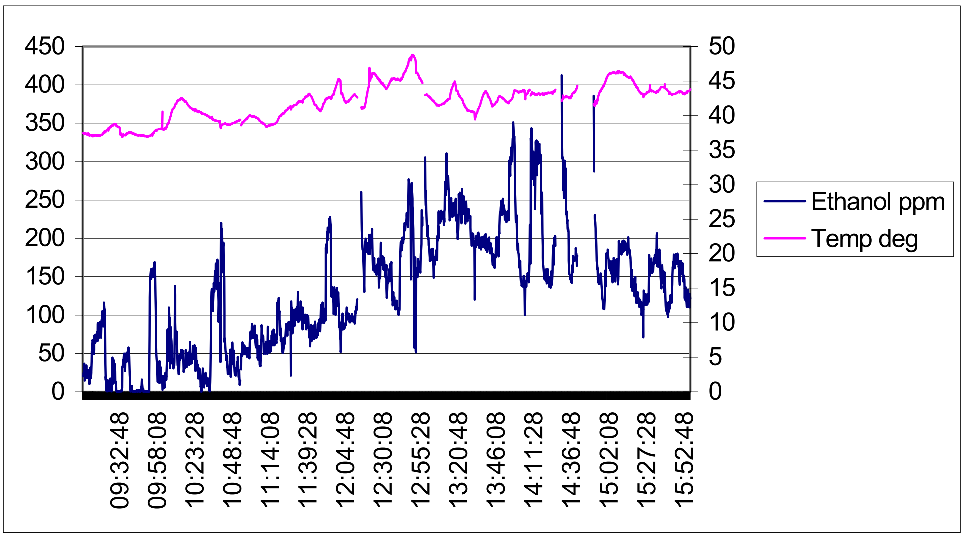

Figure 3. Temperature and detector reading against time.

The relationship between ambient temperature and ethanol evaporated is complex. The ideal would therefore be to produce a calibration function from which the actual ethanol could be calculated. In the new season, one of the tasks will be to derive the function. An offset proportional to temperature together with a constant was used to generate Figure 4.

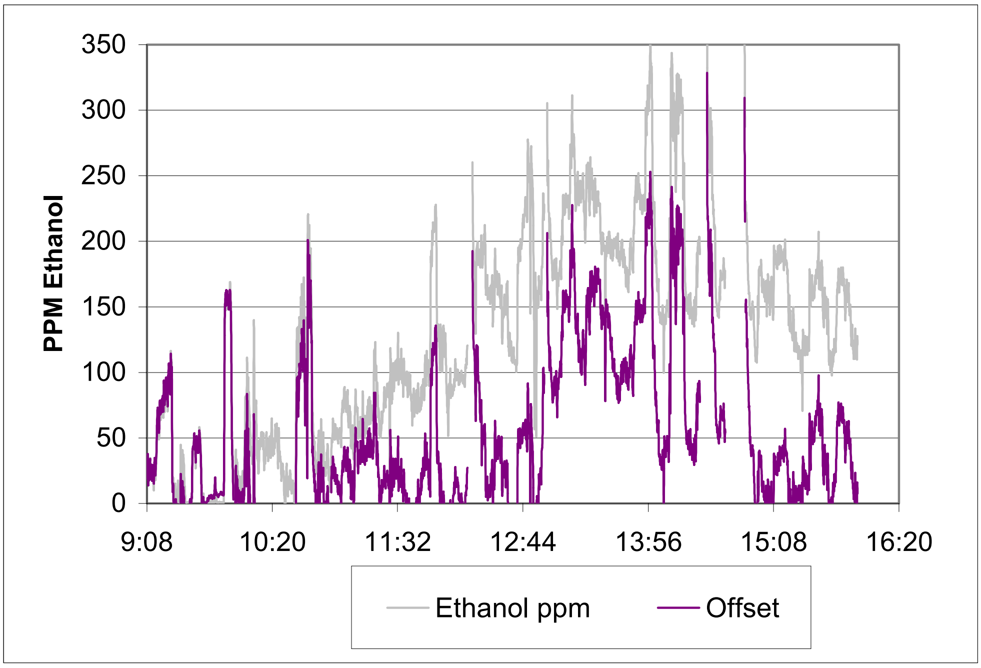

Figure 4. Sniffer trace after removal of temperature effects.

From these data, the batches of deteriorated cane can clearly be seen. It will be necessary to set limits for acceptable values on the output of the detector. These limits will, however, vary from factory to factory since the geometry of the gas collection facility will not be consistent. Further work will be required to refine the expressions relating ethanol detected to actual ethanol in the cane as a function of temperature. There is insufficient information to indicate whether the increase of ethanol detected at midday is indicative of an actual increase in ethanol on brix, or whether refinement of the compensation function is required.

Use of Data

The main objective of the installation of an ethanol detector is to identify problems in the cane supply chain. During the trials, when areas of concern were identified, discussions with the growers confirmed that the sniffer reading was a reflection of the delays encountered on those particular consignments, despite the time-ethanol relationship only being a rule of thumb.

The sniffer was a great help in emphasising the need for preventing stale cane from entering the factory. It is interesting to note that the freshness of the cane improved for the duration of the trial.

If cane quality can be improved, the performance of the whole factory should improve, and with it, the profitability of the entire field-to-crystal chain of activities. This will be to the benefit of all players.

Another concern that will be addressed with fresher cane is the prevention of the formation of some polysaccharides. This should improve filterability of the sugars, especially for overseas markets, and reduce viscosity in the boiling house, leading to improved exhaustion of molasses.

Conclusion

This research has shown that the on-line measurement of ethanol levels in the gasses drawn from shredded cane holds considerable promise as a more rapid and convenient routine procedure than the current laboratory method for detection of deteriorated cane.

Further work is necessary for determining a suitable procedure to correct for temperature effects on ethanol measurement.

The results reported in this paper were entirely for burnt cane, and the investigations will need to be extended to unburnt cane when procedures for removing moisture and solids from the gas samples have been finalised.

The measurement of ethanol provides a tool for monitoring the input to the factory. The introduction of stale cane into the process has marked detrimental effects on the recovery and quality of sugar produced. The best way to solve problems is to put some effort into solving the root cause, namely the acceptance of stale cane into the factory.

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