EXPERIENCE OF DIFFUSER PERFORMANCE AT VERY LOW IMBIBITION WATER RATES

VOIGT I

Bosch Projects(Pty) Ltd 203 North Ridge Rd, Morningside, Durban, South Africa
voigti@bproj.co.za

Abstract

The typical operation of sugarcane diffusers in South Africa involves the use of relatively high rates of imbibition water. Water addition is generally above 300% on fibre. At Usina Noroeste Paulista in Brazil, where the first Bosch Projects Chainless Diffuser was commissioned in 2008, imbibition water rates during the first season of operation were as low as 80% on fibre. This paper describes the experiences and operational results at these conditions.

Keywords: diffuser, imbibition rates

Introduction

The Bosch Projects Chainless Diffuser was developed by Bosch Projects in 2005 and was first implemented at UCL in 2006 (Schroder *et al.*, 2007). Since 1997 it was promoted internationally and found favour in Brazil, where nine units were sold through Dedini Industrias de Base, Bosch Projects' Brazilian partner. The first of the diffusers, a 12 metre wide unit designed to process cane at 500 tch, was installed at Usina Noroeste Paulista (UNP) in the state of Sao Paulo and was commissioned in September 2008. Its first season ended in January 2008 and the diffuser operated for its first full season in 2009. The 2009 season was characterised by operational conditions that were not ideal for diffuser operations. This paper describes some of the operation observations made during the 2009 season.

Usina Noroeste Paulista

The usina (sugar factory) is owned by the Noble Group, a multinational company headquartered in Hong Kong. It is located in the state of Sao Paulo, between the towns of Sebastianopolis do Sul and Votuporanga. The factory was originally built with a five mill tandem and a sixth mill was later added. An expansion project in 2007/08 aimed at increasing the factory capacity (by more than double) and the Bosch Projects Chainless Diffuser plus two dewatering units from Dedini were selected for the extraction plant. The expansion project included the simultaneous installation of two new boilers, a power station expansion, sugar processing expansion, and a new Dedini ethanol plant.

The expansion project was commissioned in September 2008, many months later than planned. At the date of commissioning, the two new boilers were incomplete, and the first of these would eventually be ready only at the beginning of the 2009 season. During the first three months (September to December), operations were characterised by a shortage of steam and frequent shut-downs of the new power station turbo-alternator (due to poor steam conditions). Conditions were so poor that no sensible results were obtained.

Operational problems during 2009

During the initial part of the 2009 season, severe operation problems were still apparent at the boilers. The first new boiler to be commissioned was susceptible to bagasse quality to the extent that operations were severely compromised. Once the first new boiler was commissioned, one of the original factory boilers had to be removed from duty to be re-tubed, and steam conditions in the factory remained sub-optimal. It was only when the second new boiler was commissioned well into the 2009 season that operations settled down to a familiar regime.

Bosch Projects, although not privy to full operational results for the 2009 season, nevertheless collected laboratory data for 55 days of operations between 20 July and 17 November 2009.

During the initial parts of the 2009 season when process steam was scarce, the tendency was to cut imbibition water rates to the mill tandem and the new diffuser to the bare minimum. The lowest rate of imbibition % fibre recorded was 80.47% on the diffuser and 113.25% on the mill. Other compromises were also instituted: the level of cane preparation was reduced to reduce the power absorbed at the shredder; the diffuser temperature was observed to be generally 5°C below the minimum specified temperature of 80°C; and imbibition water was bypassed to the second diffuser stage in an attempt to reduce bagasse moisture (the hydraulic control system used to automatically level the top rolls on the dewatering mills was faulty, leading to high moistures). However, as the mill management gained confidence in their new extraction line, it was gradually supplied preferentially with cane, and eventually the diffuser only was used at times of poor cane supply.

The operation of the Chainless Diffuser at very low rates of imbibition has presented a very good opportunity to evaluate this unusual operating condition.

Imbibition water rates

Figure 1 represents the imbibition % fibre values for the 55 days for which records are available. It shows a number of readings below a value of 100 and only one value above 350. The median value is 151.15. The gradual improvement of imbibition with time is evident from Figure 1.

By contrast, Figure 2 is the equivalent data for the milling tandem. The data have a median value of 230.42 and, in contrast to the diffuser, show only a small increase over the duration of the 2009 season, perhaps suggesting an early lack of confidence in the diffuser by the factory operators.

Improvement of operations at UNP with time during the 2009 season

An analysis of the data for the 2009 season at UNP shows that other factors also improved as the season progressed. The cane processing rate steadily increased (Figure 3); pol extraction and reduced extraction (12.5% fibre) improved as the season progressed, but moisture % bagasse readings increased toward the end of the season and cane preparation deteriorated.

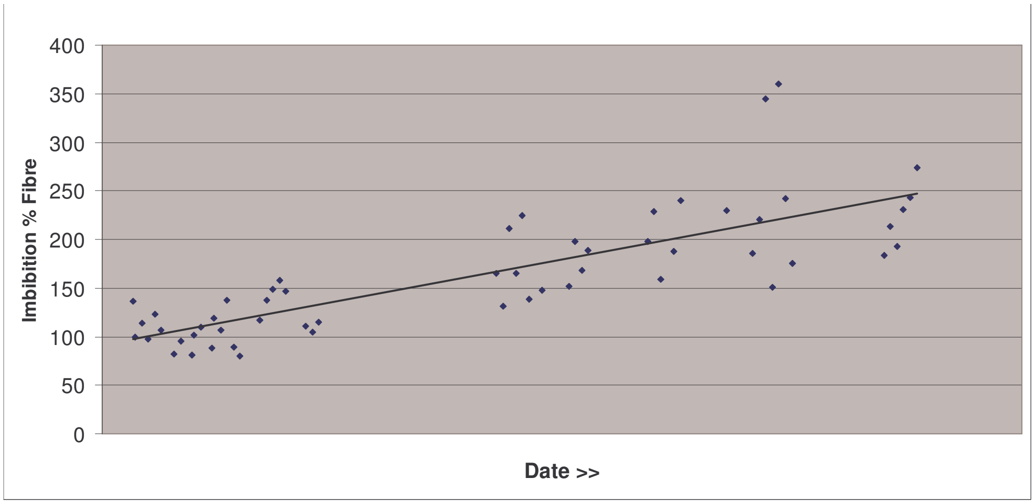

Figure 1. Diffuser imbibition % fibre vs. date.

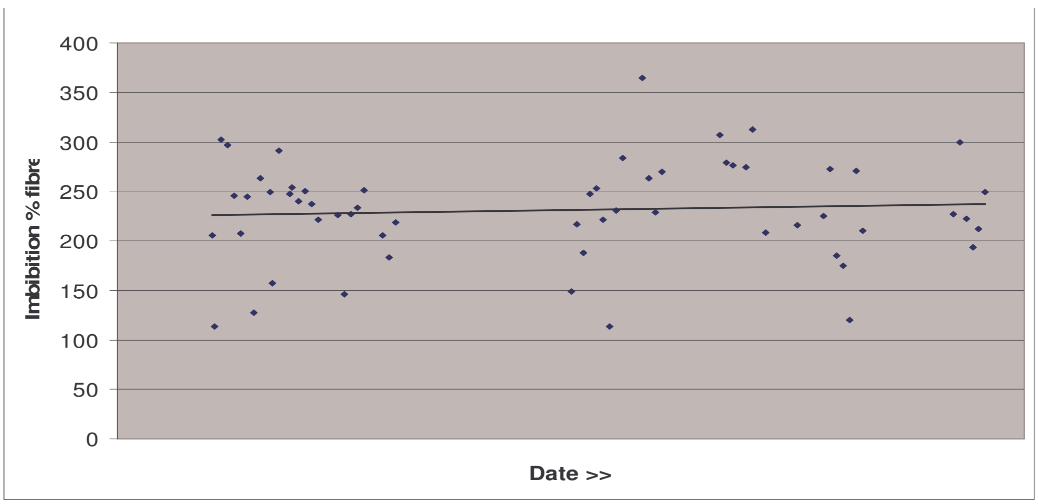

Figure 2. Mill imbibition % fibre vs. date.

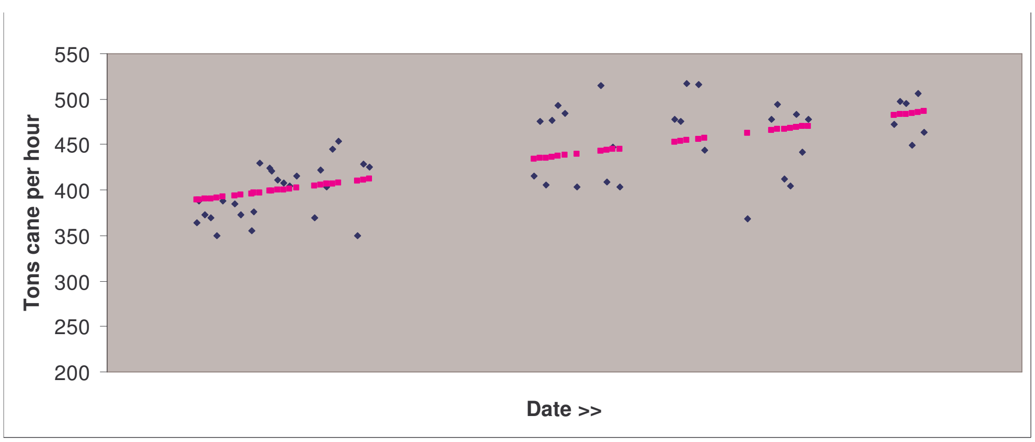

Figure 3. Diffuser tons cane per hour vs. time.

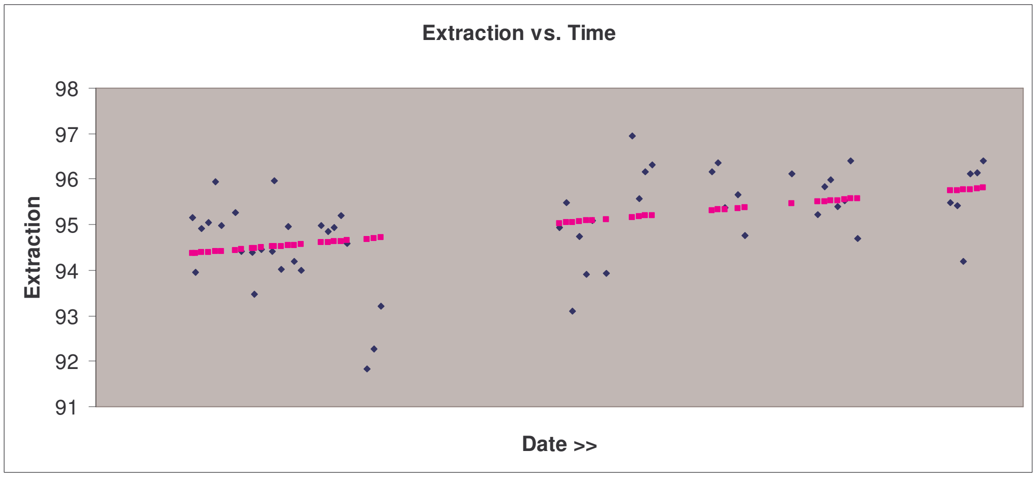

Fig 4. Diffuser pol extraction vs. time.

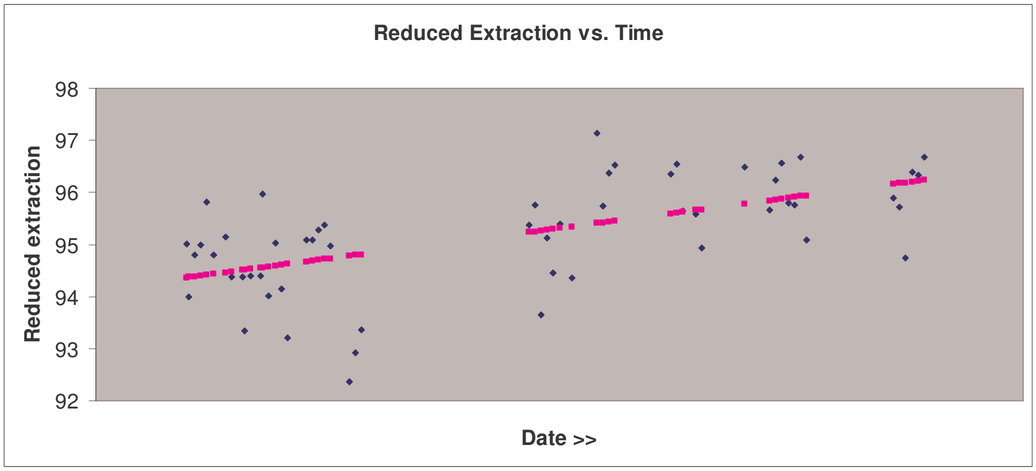

Fig 5. Diffuser reduced extraction vs. time.

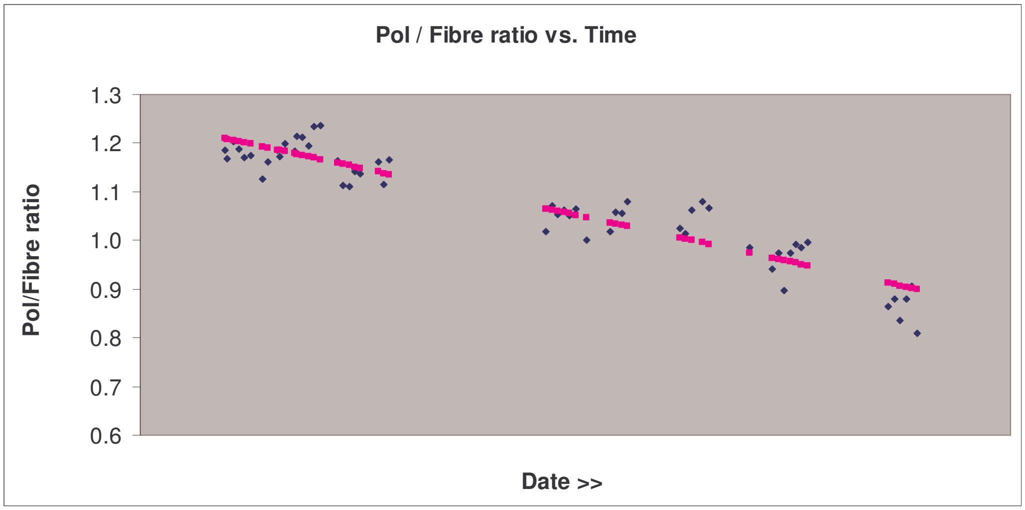

Fig 6. Cane pol/fibre ratio vs. time.

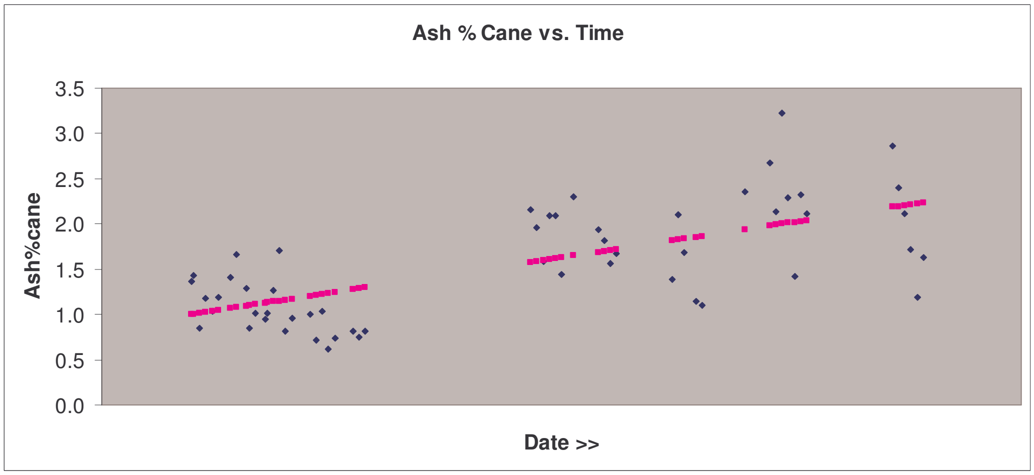

Fig 7. Ash % cane vs. time.

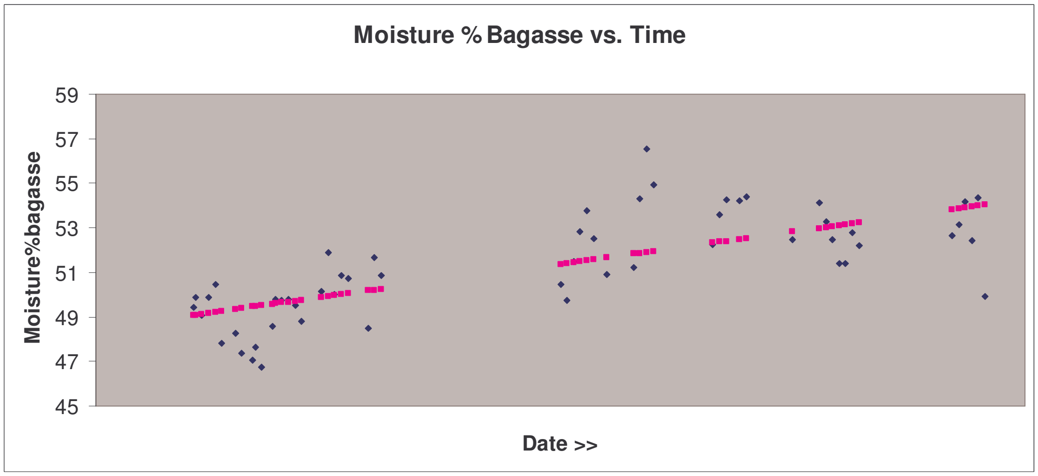

Fig 8. Diffuser moisture % bagasse vs. time.

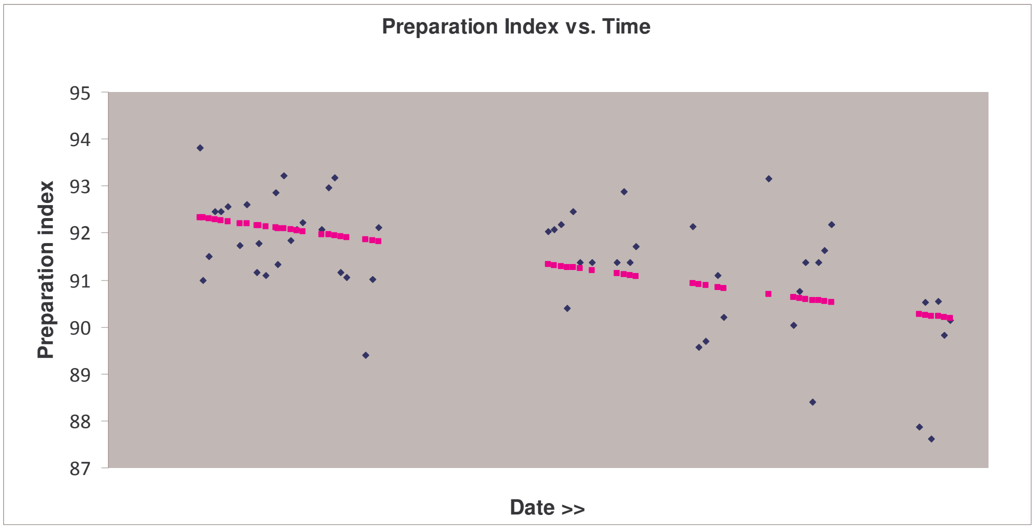

Fig 9. Diffuser preparation index vs. time.

Effect of low imbibition water rates on operations

It has become normal practice in the Southern African sugar industry to employ imbibition water rates of 300% on fibre or more. The industry average for 2008 was 349% and the average for 2005-2008 was 367% (Davis, 2009). It may thus be understandable that the expected performance and behaviour of the UNP diffuser under these conditions were difficult to predict.

The first item of diffuser plant that showed the effects was the kicker at the discharge end of the diffuser. The kicker is used to discharge megasse from the diffuser in a rateable fashion, so that the megasse conveyor does not become overloaded and the material supply to the dewatering mills is consistent. The 'normal' behaviour of megasse when agitated by the kicker should be to crumble and fall gently from the diffuser, and this behaviour has been observed in most BMA/Tongaat Hulett-type diffusers in our industry. (The De Smet diffuser uses a different arrangement for the discharge of megasse.)

The action of the kicker on the megasse at UNP was unlike that expected. Probably due to the low rates of imbibition water (and compounded by the action of the de-watering drum), the moisture of the megasse leaving the diffuser was measured at the end of 2008 to be approximately 70%. The observed effect of this was that the megasse did not crumble as expected under the action of the kicker (as is the case at the UCL Chainless Diffuser), but was more 'ductile' and compressed than expected and bridged over the diffuser draw bars, in some cases travelling to the very end of the discharge housing of the diffuser. (These draw bars are specific to the Chainless Diffuser and are not a feature of other types of diffuser.)

As a remedial action to continue operations, water ballast was removed from the dewatering drum and the direction of the kicker was reversed. The latter served to successfully break up the megasse so that it could be discharged from the diffuser as expected, although this did require some modifications to the megasse deflectors that are used to distribute megasse evenly over the width of the conveyor below.

Another diffuser mechanical problem was eventually also ascribed to the effect of the low rates of imbibition water, after close observation on site. It had become apparent that the diffuser lifting screw shear pins were susceptible to failure on this diffuser, far beyond expectations. A design review was carried out and proved that the design of the shear pins had been too conservative (i.e. the pins were shearing when the lifting screw was at only 50% of the allowable bending stress) and the shear pins were re-designed to fail at 80% of the allowable stress. However, shear pin failures still occurred and it took a lot of convincing of the factory engineers to prevent them from installing 'fail-safe' shear pins. At another Chainless Diffuser at Monte Verde (commissioned in June 2009 and also operating with extremely low rates of imbibitions water), the factory engineers were more determined, which led to the bending of a set of lifting screws.

After close observation, the over-loading of lifting screw shear pins was attributed to a dry cane bed in the diffuser (i.e. again, low rates of imbibition water application). It was positively established that, when imbibition rates were such that a level of juice could be maintained in the cane bed, shear pin failures stopped. Toward the end of the 2009 season, when imbibition water rates averaged 200% on fibre or more, the failure of shear pins ceased. (At the third Chainless Diffuser commissioned in Jatai, where 'normal' rates of imbibition were used from the date of commissioning onward, shear pin failures were a non-issue, even when the diffuser bed reached the level of the stage spray pipes!)

Effect of low imbibition water rates on diffuser extraction performance

It is recognised (Rein, 2007) that the following parameters have an effect on diffuser extraction performance:

- Cane preparation
- Imbibition quantity
- Retention time
- Diffuser temperature
- Bagasse moisture.

Linear regressions were performed on the laboratory data provided to correlate pol extraction vs. imbibition % fibre; and pol % bagasse vs. imbibition % fibre. These correlations are depicted in Figures 10 and 11, and provided the following statistical predictions:

$$\text{Extraction} = 93.7034 + 0.007953 \times (\text{imbibition \% fibre})$$
$$[R^2=0.22816; \text{P-value}=0.0002266]$$

$$\text{Pol \% bagasse} = 4.176315 - 0.00942 \times (\text{imbibition \% fibre})$$
$$[R^2=0.538682; \text{P-value}=1.83 \times 10^{-10}]$$

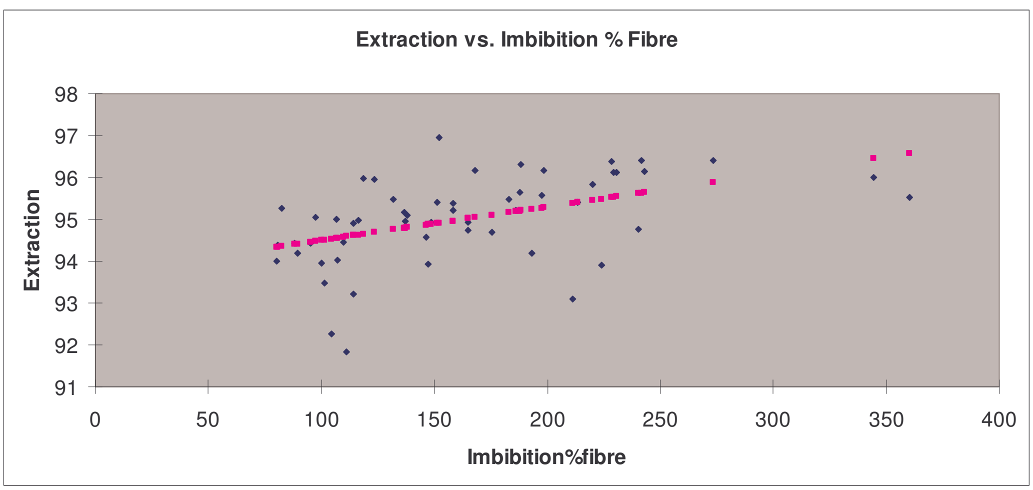

Figure 10. Extraction vs. imbibition % fibre.

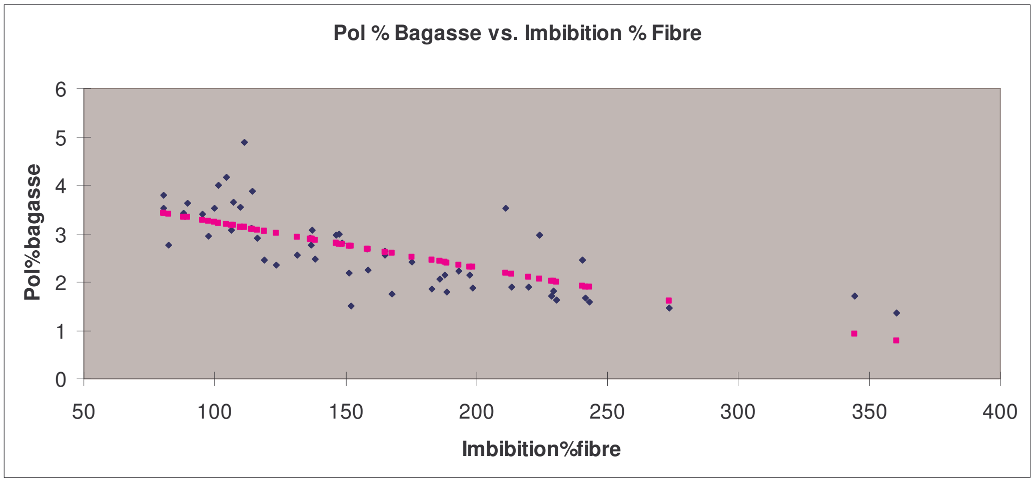

Figure 11. Pol % bagasse vs. imbibition % fibre.

Statistical analysis of diffuser extraction performance

A sensible analysis of the performance of a cane diffuser under conditions of low imbibition water rates is desired. However, given the multiple sub-optimal conditions at UNP during 2009 (low diffuser temperatures; high bagasse moisture), the initial analyses need to be adjusted to account for these. In order to do so, correlation analysis was performed on a number of parameters to determine their statistical effect on extraction and pol % bagasse at UNP. The factors considered and their statistical influence is given in Table 1.

Table 1. Statistical significance of various parameters on diffuser extraction.

Parameter	Statistical significance of effect on extraction	Statistical significance of effect on pol % bagasse
Pol % cane	Yes (- relationship)	Yes (+ relationship)
Pol/fibre ratio	Yes (- relationship)	Yes (+ relationship)
Ash % cane	Yes (+ relationship)	Yes (- relationship)
Time efficiency	No	No
Imbibition % fibre	Yes (+ relationship)	Yes (- relationship)
Tons cane per hour	Yes (+ relationship)	Yes (- relationship)
Moisture % bagasse	Yes (+ relationship)	Yes (- relationship)
Preparation index	No	No

There appear to be a number of results of the statistical analysis that do not agree with conventional diffuser wisdom. The correlation between extraction and pol/fibre ratio should be positive; ash % cane should have a negative correlation; and TCH and moisture % bagasse should have negative correlations with pol extraction.

The correlations that are surprising are:

- Extraction increased while the pol/fibre ratio decreased
- Extraction increased while ash % cane increased

- Extraction increased as cane throughput increased
- Extraction increased as moisture % bagasse increased
- Extraction reduced as preparation index increased.

It is presumed that these relationships may be statistically significant, but not causal. For example, the pol/fibre ratio reduced during the course of the season, as expected. Simultaneously, the extraction increased with time due to causes (e.g. imbibition water rates) unrelated to the pol/fibre ratio. Statistical methods have ascribed a causal relationship between the two factors of extraction and pol/fibre ratio where such a relationship does not exist.

It appears that other factors thus have a stronger influence on extraction than those listed above. Imbibition % fibre appears to be one such factor. Alternatively, significant errors exist in the laboratory data that has been analysed.

By comparison, Table 2 presents comparable statistical data for the milling tandem.

Table 2. Statistical significance of various parameters on mill extraction.

Parameter	Statistical significance of effect on extraction
Pol % cane	Yes (+ relationship)
Pol/fibre ratio	Yes (+ relationship)
Ash % cane	Yes (- relationship)
Time efficiency	No
Imbibition % fibre	No
Tons cane per hour	No
Moisture % bagasse	Yes (- relationship)
Preparation index	No

Conclusions

The first Chainless Diffuser in Brazil during the 2009 season was expected to provide valuable information of the performance of diffusers at low imbibition water rates. This was the case in considering the mechanical performance of lifting screws and the diffuser kicker. Some new information has also been presented regarding the extraction performance at low imbibition water rates. However, unexpected correlations were discovered between extraction and other variables, suggesting either other influences on extraction performance or poor quality of laboratory data. Further study is required.

REFERENCES

Rein PW (2007). *Cane Sugar Engineering*. Bartens, Berlin, Germany.

Davis SB, Smith GT and Achary M (2009). Eighty-fourth annual review of the milling season. *Proc S Afr Sug Technol Ass* 82: 1-29.

Schroder K, Voigt I and Moor B St C (2007). *Proc Int Soc Sug Cane Technol* 26: 1294 - 1302.