THE PERFORMANCE OF DIFFUSER BAGASSE DEWATERING MILLS

By A. WIENESE
Sugar Milling Research Institute

Abstract

A study of the performance of diffuser bagasse dewatering mills commenced in the 1985 crushing season and was continued in the 1986 season. This study involved a global investigation of milling parameters and a more detailed investigation of some additional variables at Illovo, Ubombo Ranches, Sezela, Felixton, Amatikulu and Maidstone. These additional variables included mill torque and power, mill lift and hydraulic loading of the mill. In the 1986 season the yearly bagasse moistures ranged from 46 to 55 %. No clear reason for this large difference was found. However it is believed that factors which contribute to low bagasse moistures are: low mill speed, a thin bagasse blanket, high torque and a rough roller surface. In addition to this the properties of the bagasse before entering the mill appear to affect mill performance.

Introduction

Towards the end of the 1986 crushing season the yearly bagasse moistures ranged from 46 to 55 % (see Figure 1).

Milling tandems apparently perform better with regard to final moisture than diffusers. This is particularly evident in those cases where a milling tandem and diffuser are operating in parallel. However the best results in the industry are obtained on a diffuser dewatering mill and in the top ten only 4 are milling tandems and 6 are diffusers. At the bottom of the range one finds mainly diffusers and it is thus in the case of diffuser dewatering mills that maximum benefit can be obtained.

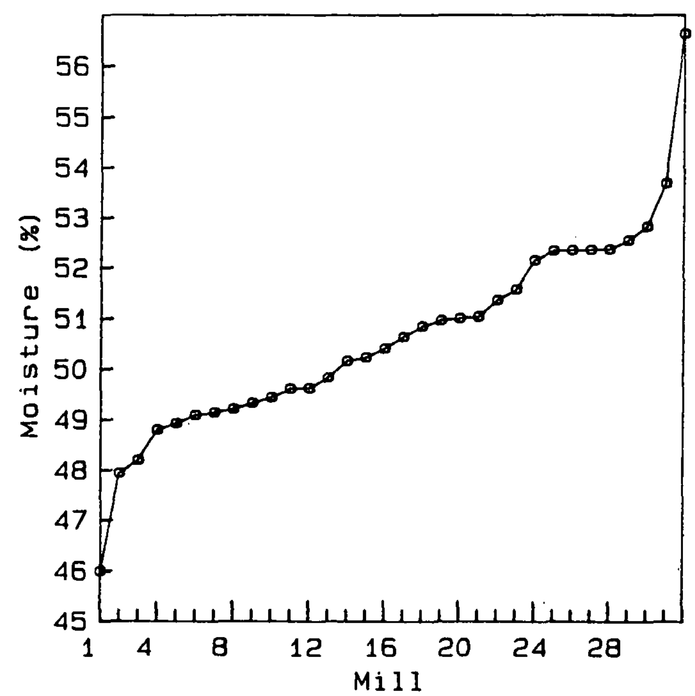

FIGURE 1. Bagasse moisture at each mill (1 = PG, 2 = NH, 3 = UR, 4 = DW, 5 = IL, 6 = MH, 7 = GH, 8 = HV, 9 = ML, 10 = HV, 11 = UK, 12 = MH, 13 = SM, 14 = UR, 15 = ME, 16 = GH, 17 = SZ, 18 = TR, 19 = NH, 20 = UF, 21 = TR, 22 = DL, 23 = UC, 24 = NB, 25 = FX, 26 = SZ, 27 = FX, 28 = AK, 29 = EN, 30 = GD, 31 = MS, 32 = MS).

The parameters that affect the performance of dewatering mills can be divided into two groups. The first group relates to the bagasse, and includes moisture of the bagasse before entering the mill, preparation index and cane variety. The second group relates to the mill, and includes fixed parameters such as the geometry of the mill, the number of rolls and the type of feeding device, and variable parameters such as mill settings, mill speed, hydraulic pressure, roll roughness, mill lift and mill torque.

It is believed that the variation in cane over the season is greater than the variation in cane between the different mills. With bagasse moistures, however, the differences during the season are much smaller than the differences between the mills. For this reason it was thought that an investigation into the performance of dewatering mills should concentrate on mill parameters rather than on cane and bagasse properties.

For these reasons, this paper is mainly concerned with variable mill parameters on diffuser dewatering mills. In particular, mill torque and mill lift were measured at various mills in the industry. Mill torque together with mill lift provides an indication of slippage or reabsorption. Low slippage combined with high torque gives a high effective absorbed power per ton of fibre which should result in good performance.

This report represents the results of the first phase of an on-going research project.

Test Procedure and Equipment

Tests were carried out on diffuser dewatering mills at Illovo, Ubombo Ranches, Sezela, Amatikulu, Felixton and Maidstone. At each of these mills measurements were taken of mill torque, pressure feeder torque if applicable, turbine speed, roll lift and turbine nozzle box pressure if available. At Maidstone the pressure chute pressure was also recorded.

The torque measurements were carried out using strain gauges and FM telemetry equipment (see Figure 2). A detailed description of this technique has been given by Reichard and Vidler[1].

Initially strain gauges were also used for the lift indicators. The strain gauges measured the bending of a small lever caused by mill lift. However these indicators were highly sensitive to heat and the ingress of dirt and moisture. Better results were obtained from lift indicators using a turning potentiometer. The turbine speed was either directly available at the control panel or measured straight from the turbine tacho-generator. At Maidstone a diaphragm plate fitted with strain gauges was built into the pressure chute in order to measure the chute pressure. This method has been described in detail by Wienese and Reid[2]. An IBM-PC was

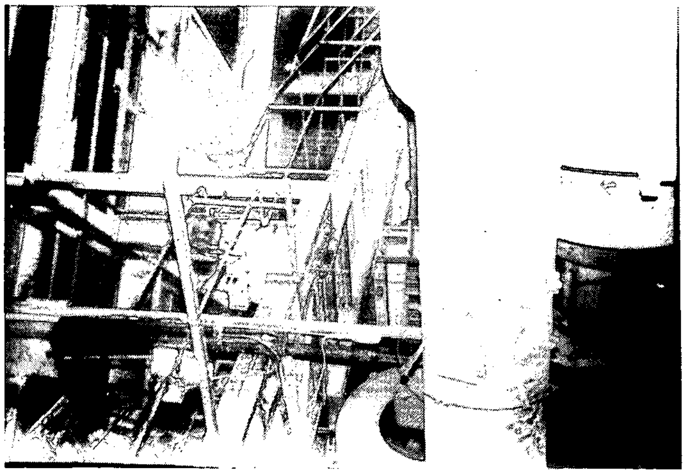

FIGURE 2 Torque measurements on dewatering mill

used for data collection with a data logger acting as an analogue to digital interface between the measuring points and the computer. The software written for the IBM provides an easy method of calibration. A real time graphical and digital display enables the data to be constantly monitored. The raw data are subsequently stored on diskette for later analysis. The data logging system as described here is discussed in more detail in another paper presented at this congress[3].

Test Results

The mills investigated are operating under different conditions. These conditions can not always be chosen freely but are to a large extent determined by cane throughput, percent fibre and the general mill arrangement. Table 1 shows mill throughput and settings in relation to bagasse moistures for the different mills. This Table gives an indication of the influence of hydraulic loading, mill speed and thickness of the bagasse blanket on bagasse moistures. A description of the different mills and the results of the tests are given as follows for each mill in the order of performance.

TABLE 1
Mill operation conditions

Description	IL	UR	SZ	FX	AK	MS
Cane throughput th^{-1}	170.00	180.00	110.00	166.00	140.00	190.00
Fibre % cane	15.52	13.50	15.00	17.50	15.80	17.50
Fibre throughput $^{-1}$	26.38	24.30	16.50	29.05	22.12	31.35
PF Speed m min^{-1}	-	-	7.10	11.73	3.02	11.45
Mill Speed m min^{-1}	6.88	12.54	5.43	10.37	5.31	9.15
PF WO mm	-	-	53.47	69.49	197.82	66.84
Feed WO mm	67.03	45.19	46.97	46.06	78.25	41.80
Delivery WO mm	32.02	18.08	26.21	21.88	36.99	22.59
Ratio PF/Feed	-	-	1.49	1.71	1.44	2.00
Ratio Feed/Delivery	2.09	2.50	1.79	2.11	2.12	1.85
Hydraulic load MN/m	2.78	2.51	1.79	2.94	2.40	1.71
Bagasse Moisture %	48.94	50.17	50.65	52.36	52.38	56.63

PF=Pressure Feeder; WO=Work Opening

Illovo

Illovo has a diffuser followed by two dewatering mills in series. The first is an 1 828 × 914 mm mill, and the second is a 2 134 × 991 mm mill. Both mills have floating top rolls and single underfeed rolls. The diffuser has a maximum capacity of 200 tons of cane per hour. Measurements were carried out on both mills. Due to operational conditions it was not possible to run the mills at a constant speed and tests could only be carried out with the turbine speed varying under mill chute control. Table 2 gives the results as recorded at Illovo.

TABLE 2
Illovo results

Mill 2 Speed rpm	Mill 2 Torque kNm	Mill 2 Power kW	Mill 2 Lift mm	Mill 1 Speed rpm	Mill 1 Torque kNm	Mill 1 Power kW
2.21	960	222	16	3.21	570	192

On many occasions the torque on mill No. 2 was almost twice the torque on mill No. 1. Figure 3 shows the torque and roll lift on mill No. 2.

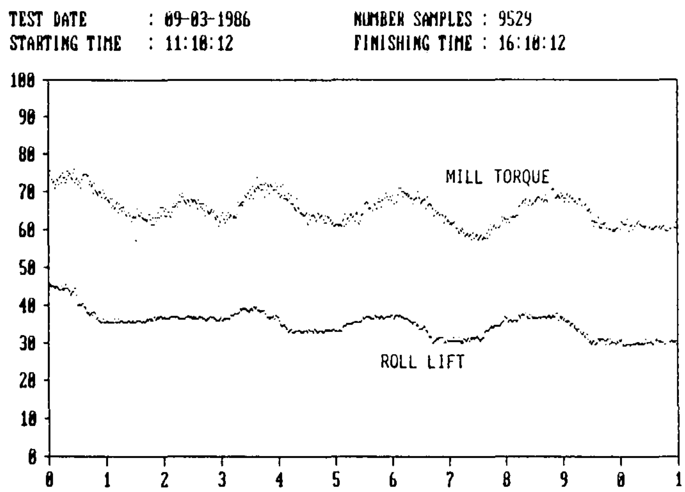

FIGURE 3 Mill torque and roll lift at Illovo

Torque and lift are in phase, an increase in torque being always simultaneous with an increase in roll lift. One of the reasons for this is without doubt the changing hydraulic loading. It was found that roll lift had quite a significant influence on the hydraulic pressure, both increasing and decreasing simultaneously. The absorbed power per ton of fibre throughput is about 9 kW. The low moistures achieved by Illovo are most likely the result of high hydraulic loading in combination with low mill speed.

Ubombo Ranches

Ubombo Ranches operates a milling tandem and a diffuser in parallel. The diffuser is followed by one dewatering mill on which tests were carried out. This is a 2 134 × 1 067 mm mill with hydraulics on the top roll and a single underfeed roll. During the test period the mill was running at a constant speed of 3.74 rpm. No electronic lift indicators were fitted and the lift was measured manually. The results are given in Table 3.

TABLE 3
Ubombo Ranches results

Mill Speed rpm	Mill Torque kNm	Mill Power kW	Mill Lift mm
3.74	940	368	3

Despite the high mill speed, Umbombo Ranches is achieving good bagasse moistures of just over 50%. It is believed that the main reason for this is the fact that they are operating with high hydraulic loading together with a thin bagasse blanket, two factors which favour good moistures. The absorbed power per ton of fibre throughput is 15 kW. This is particularly high when one considers that the mill is operating without a pressure feeder.

Sezela

Sezela has two parallel diffusers with a combined capacity of 400 tons of cane per hour. Each diffuser is followed by two 2 134 × 1 067 mm six roll pressure fed mills in parallel. The mills are fitted with discharge roll hydraulics and fixed top roll. Again no lift indicators suitable for permanent recording were available and the lift was measured manually. Tests were carried out on the first dewatering mill at different but fixed turbine speeds on what is called the "West Diffuser Line". The results of the tests have been reported[2] and repeated here in Table 4.

TABLE 4
Sezela results

Mill Speed rpm	Mill Torque kNm	Mill Power kW	Roll Lift mm	PF Speed rpm	PF Torque kNm	PF Power kW
1.40	990	145	4	1.82	328	63
1.97	869	179	5	2.55	292	78
2.50	915	240	3	3.24	288	98
2.69	991	279	9	3.47	323	117

Unlike most other mills the roll lift seems to increase with an increase in speed. Also different from other mills is the fact that the highest torque occurs at the highest speed. The absorbed power per ton of fibre is approximately 14 kW. Although Sezela operate the mill at a low hydraulic pressure they still achieve good moistures of just over 50%. This is mainly due to the low mill speed of about 2 rpm. On the "East Diffuser Line" the mills are running at similar conditions but at a higher speed of approximately 3 rpm and the average moisture of that line is 52.36%.

Felixton

Felixton has two parallel diffusers with a combined capacity of 600 tons of cane per hour. Each diffuser is followed by two dewatering mills in parallel. All mills are identical 2 134 × 1 168 mm mills with pressure feeder and are fitted with hydraulics on the top roll. The pressure feeders each have separate drives which allow for variable speed ratios between mill and pressure feeder. Tests were carried out at different mill and pressure feeder speeds. The results are given in Table 5.

TABLE 5
Felixton results

Mill Speed rmp	Mill Torque kNm	Mill Power kW	Roll Lift mm	PF Speed rmp	PF Torque kNm	PF Power kW
1.49	1 036	162	8	1.73	653	118
2.07	947	205	6	2.50	431	113
2.24	967	227	4	2.77	482	140
2.87	901	271	3	3.38	390	138

The figures show a clear decrease in torque with an increasing speed for both mill and pressure feeder. They also show a lower roll lift with an increased speed. Figure 4 gives a graphic display of this relationship between speed, torque and roll lift as it was recorded during one of the tests.

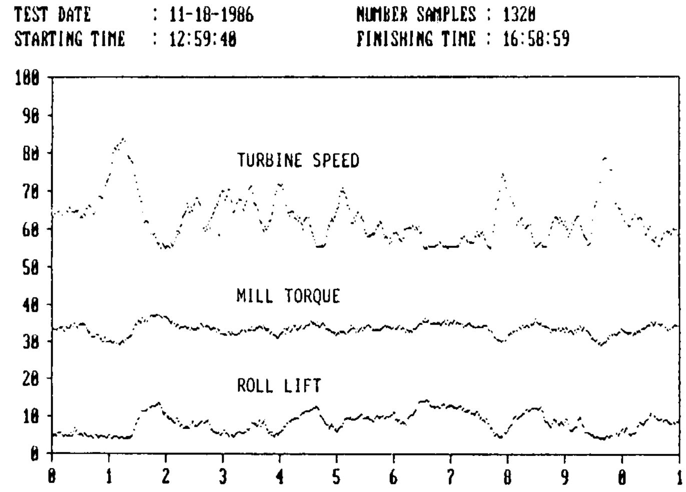

FIGURE 4 Turbine speed, mill torque and roll lift at Felixton

The absorbed power per ton of fibre throughput was about 15kW. Although a high hydraulic pressure is applied, the high mill speed and variable cane supply are affecting the bagasse moistures in a negative way.

Amatikulu

Amatikulu has a diffuser with a maximum capacity of 400 tons of cane per hour. After the diffuser the bagasse is split into three parallel lines, of which two are generally used. The line investigated consists of one 2 134 × 1 143 mm mill equipped with a spikey-tooth pressure feeder. Hydraulics are fitted on the top roll and the discharge roll is fixed. Tests were carried out at four different speeds. The results are given in Table 6.

TABLE 6
Amatikulu results

Mill Speed rpm	Mill Torque kNm	Mill Power kW	Roll Lift mm	PF Speed rpm	PF Torque kNm	PF Power kW
1.55	1 488	242	15	2.14	245	55
1.81	1 335	253	15	2.49	224	58
2.06	1 359	293	17	2.85	221	66
2.32	1 393	338	15	3.21	242	81

By far the biggest mill torque was recorded at Amatikulu, averaging close to 1 400 kNm with peaks of up to 1 800 kNm. The biggest torque, for the mill as well as for the pressure feeder, was found at the lowest speed. The power absorbed by the pressure feeder was about 19% of the total power which is much lower than the conventional pressure feeders with about 30%. The average absorbed power per ton of fibre is approximately 13 kWh/t. Roll lift did not show any significant change and moved around 15 mm. The high hydraulic loading together with the slow speed should give low moistures, however the average moisture for the season was as high as 52.38. A possible reason for this high moisture is the thick bagasse blanket which restricts the juice drainage.

Maidstone

Maidstone has a diffuser with a maximum capacity of 220 tons of cane per hour. The diffuser is followed by one 2 134 × 1 067 mm dewatering mill. The mill is equipped with a two roll Walker type pressure feeder and an auxiliary drum. Both top and discharge rolls are fitted with hydraulics. Tests were carried out at fixed mill speeds of 2.83, 3.39 and 3.98 rpm. The results of the measurements are given in Table 7.

Roll lift is given as a combined figure for top roll and discharge roll.

TABLE 7
Maidstone results

Mill Speed rmp	Mill Torque kNm	Mill Power kW	Roll Lift mm	PF Speed rpm	PF Torque kNm	PF Power kW
2.83	964	286	17	3.73	287	112
3.39	947	336	16	4.47	237	111
3.98	934	389	17	5.26	236	130

During the tests, bagasse moistures were taken by the Sugar Industry Central Board every 15 minutes, resulting in a total of five samples for each speed. The average moistures were 52.8 %, 56.8 % and 57.1 % for mill speeds of 2.83, 3.39 and 3.98 rpm respectively. Only at the lowest speed was a decrease in moisture found together with an increase in torque. The pressure chute pressure, which was recorded simultaneously, decreased with increasing mill speed. The lift on the discharge roll was negligible in comparison with the lift on the top roll. No significant change in mill lift was found at the different speeds. Maidstone is running the mill at a high surface speed at a low hydraulic loading which is believed to be one of the main reasons for the high moistures they are getting.

Conclusions

Each mill is operating under completely different conditions and it is not easy or even advisable to compare the different mills. It is also very difficult to find common factors, with respect to dewatering, that apply to each mill. However it is believed that the following factors contribute to low moistures:

(1) Mill speed. High speed will cause bad drainage and the excess of juice will act as a lubricant between the bagasse blanket and the mill roll which will result in slippage and hence high moistures.

(2) Bagasse blanket. A thin bagasse blanket provides better drainage therefore less slip and lower moistures.

(3) Hydraulic pressure. An increase in hydraulic pressure will cause an increase in torque which will favour low moistures. Beyond a certain point however, the pressure will restrict drainage.

(4) Mill torque. High torque with minimum slip means high power for squeezing which obviously results in lower moistures.

(5) Roller surface. A rough roller surface will minimize slippage and therefore improve moistures.

Unfortunately these factors cannot be chosen freely. The required throughput will impose a restriction on speed and thickness of the bagasse blanket. The mill configuration will cause limitations; in particular the mill drive will force the speed to be within certain limits. Finally these factors are interdependent and require a great deal of tuning to achieve an optimal setting. From the work done so far it would appear that the emphasis should be laid on a rough roller surface, slow speed and high torque rather than on a thin bagasse blanket and low hydraulic pressure.

As noted above, no clear reason has been found for the large differences in bagasse moistures being experienced within the industry. It is felt that factors related to the bagasse before entering the mill can have a significant influence and it is in this direction that it is hoped to proceed with the investigation into the performance of dewatering mills.

Acknowledgements

Thanks are due to the staff of the Illovo, Ubombo Ranches, Sezela, Felixton, Amatikulu and Maidstone mills for their contributions to this project.

REFERENCES

1. Reichard, S.R. and Vidler, T.L. (1981). A telemetry system for tailbar torque monitoring. *Proc Aust Soc Sug Cane Technol* 243-248.
2. Wienese, A. and Reid, M.J. (1985). The use of strain gauges in the measurement of pressing feeder torque and internal chute pressure. *Proc Safr Sug Technol Ass* 83-87.
3. Wienese, A.; Schaffler, K. and Bachan, L. (1987). Personal Computers as data loggers in the sugar industry. *Proc S Afr Sug Technol Ass* (in press).