MILL PERFORMANCE MONITORING AT GLEDHOW SUGAR MILL

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Abstract

A system is described for monitoring the performance of a milling tandem involving the calculation of compaction ratios, W.O.R. and reabsorbtion factors which are related to bagasse moistures and mill extractions. Experience obtained with the system at Gledhow is related whilst practical steps are provided for its implementation in optimising mill performance.

Introduction

In order to effectively operate a milling tandem, the performance of each mill must be monitored and optimised at regular intervals. It may seem unnecessary to monitor the performance of a milling tandem and a diffuser which are both consistently achieving extractions in the region of 98 %. However, extraction is merely one variable involved with milling, albeit the most prestigious. Other important variables are power absorbed and bagasse (fuel) moisture.

Method

Before entering into discussion, it may be necessary to define several concepts referred to in this paper:

Compaction Ratio

$$\text{Compaction ratio} = \frac{\text{mass of fibre per minute}}{\text{escribed volume per minute}} (\text{Kg/m}^3)$$

(See appendix for formula).

Work Opening Ratios (W.O.R.)

$$\text{W.O.R.} = \frac{\text{feed work opening}}{\text{discharge work opening}}$$

Reabsorbtion Factor

$$\text{Reabsorbtion factor} = \frac{\text{bagasse volume}}{\text{discharge escribed volume}}$$

(See appendix for formula).

To begin with, discharge compaction ratios, W.O.R. and mill speeds had to be chosen for each individual mill to form a foundation upon which further investigation could be based. Table 1(a) and (b) show the abovementioned parameters for the milling tandem and diffuser dewatering mill respectively.

Table 1(a)

Initial performance parameter - milling tandem

Mill no	Discharge compaction ratio (kg/m³)	W.O.R.	Mill speed (ft/min)
1	720	2,2	28
2	780	2,5	29
3	840	2,5	30
4	900	2,5	31
5	950	2,5	31
6	1000	2,5	31

Table 1(b)

Initial performance parameters - dewatering mill

Mill no	Discharge compaction ratio (kg/m³)	W.O.R.	Mill speed (ft/min)
7	900	2,8	20

A spreadsheet using Lotus 1-2-3 was constructed into which the weekly averages of the following variables were inserted:-

- bagasse analysis ie fibre %, brix %, moisture %
- mill settings
- mill lift
- mill speeds.

The following dependent variables were then calculated within the spreadsheet:-

- bagasse volume
- W.O.R.
- compaction ratios
- reabsorbtion factors
- escribed volumes.

Interpretation of data

Compaction ratio

The effect of the discharge compaction ratio upon bagasse moistures and individual mill extractions is clearly demonstrated in Table 2, where the performance of mill numbers 1 and 2 are compared during weeks 12 and 32. Where compaction ratios were within the range specified, bagasse moistures were lower and individual mill extractions higher.

Table 2

Actual performance results for mill number 1 and 2 during weeks 12 and 32.

Mill No	Week No	Discharge compaction ratio (kg/m³)	Bagasse moisture %	Individual extraction %
1	12	714	53,7	77,7
	32	737	52,3	80,2
2	12	756	55,6	7,5
	32	941	58,3	2,8

Further monitoring of all mills' performance during the last quarter of the 1986/87 season resulted in the discharge compaction ratios listed in tables 1(a) and (b) being verified upon the basis of favourable bagasse moistures, individual mill extractions and reabsorbtion factors.

Reabsorbtion Factors

Table 3 clearly indicates the effect which favourable and unfavourable reabsorbtion factors have upon a mill's performance. By comparing the performance of all mills at various stages of the season, a very clear distinction could be drawn between mills with high reabsorbtion factors and high bagasse moistures and mills having low reabsorbtion factors and low bagasse moistures.

Table 3

Actual performance results for mill numbers 1, 2 and 7

Mill No	Week No	Reabsorbtion factor	Discharge compaction ratio (kg/m³)	Bagasse moisture %
1	12 32	1,76 1,63	714 737	53,7 52,3
2	12 32	1,75 2,37	756 941	55,6 58,3
7	12 26	2 1,44	1157 855	50,32 49,2

Reabsorbtion may be countered by:

- correct mill settings
- improved drainage between trashplate, top, feed and discharge rolls
- correct trashplate profiles with sufficient sweep.

Table 4 depicts a typical weekly mill performance check sheet for Gledhow's milling tandem and dewatering mill. A compact record of mill performance such as this is particularly useful in the following regards:

- individual mills whose performance begins to diminish may immediately be identified
- the effect of any changes in mill settings can effectively be monitored
- the effect of the seasonal changes in sugar cane quality upon the performance of a mill (eg fibre % cane and pol % cane) may be monitored
- a compact mill performance report serves as a very useful tool to management.

Tabulation of Data (Weekly Mill Performance Report)

Table 4

Weekly Mill Performance Data Sheet

C G Smith Sugar (Ltd): Gledhow Sugar Mill
Mill Performance

Week No. 32/86

Mill No	← Roll Dia (mm) → UF	F	T	D	Bagasse Analysis Fibre%	Brix %	H20%	Bag Vol. (m³/min)	Mill Settings (mm) UF	F	D	Lift (mm)	Work Openings (mm) UF	F	D	N.B. Pres (MPa)
1	830.00	1133.00	1133.00	1133.00	39.17	8.56	52.27	1.14	200.00	93.00	36.00	2.36	200.00	94.89	37.89	1.15
2	820.00	1115.00	1106.00	1090.00	35.00	6.66	58.37	1.30	145.00	93.00	30.00	2.24	145.00	94.79	31.79	1.10
3	820.00	1106.00	1133.00	1090.00	35.08	5.11	59.81	1.30	155.00	75.00	24.00	2.39	155.00	76.91	25.91	1.25
4	820.00	1106.00	1128.00	1128.00	38.87	3.62	57.68	1.15	190.00	72.00	26.00	4.85	190.00	75.88	29.88	1.00
5	830.00	1115.00	1115.00	1114.00	37.89	2.62	59.49	1.19	195.00	72.00	26.00	6.07	195.00	76.86	30.86	0.80
6	825.00	1133.00	1133.00	1133.00	48.45	1.61	49.95	0.89	200.00	65.00	26.00	3.73	200.00	67.98	28.98	1.15
7	830.00	1090.00	1080.00	1065.00	48.95	1.50	49.54	0.47	170.00	57.00	21.00	2.77	170.00	59.22	23.22	1.05

Mill No	Mill Ratio UF/F	F/D	Compaction Ratio (kg/m³) UF	F	D	Comp. Ratio UF:	F:	D	Average Top Roll Speed (ft/min)	(m/min)	(rev/min)	Rea. Fac	ESC Vol (m³/min) Feed	Disch.	U/F	Extraction % IND	ACC
1	2.11	2.50	84.18	294.41	737.34	1.00	3.50	8.76	29.89	9.11	2.56	1.63	1.76	0.70	6.15	80.15	80.15
2	1.53	2.98	237.09	312.08	941.64	1.00	1.32	3.97	28.14	8.58	2.47	2.37	1.66	0.55	2.18	2.79	82.94
3	2.02	2.97	187.34	326.92	977.69	1.00	1.75	5.22	33.63	10.25	2.88	2.45	1.58	0.53	2.76	5.79	88.73
4	2.50	2.54	165.94	359.66	904.04	1.00	2.17	5.45	30.92	9.42	2.66	2.02	1.44	0.57	3.12	6.06	94.79
5	2.54	2.49	187.06	410.93	1024.04	1.00	2.20	5.47	26.46	8.07	2.30	2.35	1.26	0.51	2.77	1.50	96.29
6	2.94	2.35	208.10	524.90	1231.18	1.00	2.52	5.92	23.40	7.13	2.00	2.11	0.99	0.42	2.49	1.63	97.92
7	2.87	2.55	143.10	359.06	927.07	1.00	2.51	6.48	21.17	6.45	1.90	1.57	0.78	0.30	1.96		

Crushing Rate	: Mill	191.16 TCH
Tons Cane	: Diff.	101.12 TCH
Fibre % Cane	: Mill	16.25 %
	Diff.	16.60 %
Fibre Rate	: Mill	31.06 TFH
	Diff.	16.79 TFH
Pol % Cane	: Mill	11.84 %
	Diff.	11.82 %
PMB % Fibre	: Mill	356.00 %
	Diff.	376.00 %
Extraction	: Mill	97.97 %
	Diff.	376.00 %
Pol/Fibre Ratio	: Mill	0.73
	Diff.	0.71

Discussion

Compaction Ratios and W.O.R.

Compaction ratios and W.O.R. used on the Gledhow milling tandem were found to be somewhat higher than those specified by Hugot[1] and Walkers.[2]

The compaction ratios and W.O.R. were, however, found to be compatible in alleviating the feed problem at the mills whilst favourable extraction could still be achieved, largely at the discharge opening, without promoting reabsorbtion.

A careful check on compaction ratios is essential as compaction ratios below those specified will result in the underutilisation of a particular mill leading to high bagasse moistures and low individual mill extractions. However, compaction ratios in excess of those specified will result in the following:

- excessively high power consumption
- increased bending and torsional stresses in mill roll shafts, shells and gear shafts
- increased wear on gear teeth
- reabsorbtion.

Reabsorbtion Factors

The effects of reabsorbtion include:

- increased bagasse moistures due to extrusion of bagasse and juice through the discharge opening. High bagasse moistures particularly after the final mill in a milling tandem and after the diffuser dewatering mill, lead to increased steam generating costs. This is important at a mill such as Gledhow, where bagasse is exported thus necessitating the use of a certain amount of coal in the steam generating plant.
- power wastage at the mills – power is wasted in expressing juice already expressed at a previous mill.
- maceration is less evenly distributed.

For the abovementioned reasons the extent of reabsorbtion occurring at a mill should be monitored and controlled to within acceptable limits. These limits were found to be between 1,6 and 1,8 on the mills of the milling tandem and between 1,4 and 1,6 on the diffuser dewatering mill.

Identification of Problem Areas – A Direct Result of Performance Monitoring.

- When trashplates began to wear on the feed side of the mill, the feed roll was adjusted into the trashplate thus changing the mill settings, W.O.R., mill speeds and compaction ratios from these calculated. For the 1987–88 season, the dumbturners of mill Nos 4 and 6 are being modified so that the trashplate may be adjusted into the feed roll when trashplate wear renders this necessary.
- It was found that the underfeed roll compactions were unable to be realised due to the small diameter underfeed rolls being used. This season the underfeed rolls have been increased in diameter so that the desired compaction ratios may be achieved.

The abovementioned problems were identified as a direct result of mill performance monitoring and could readily be solved so as to improve mill performance.

Conclusion

With the exception of mill speed, which was found to decrease along the tandem, all performance parameters were verified by the comparison of theoretical values such as compaction ratios, W.O.R. and reabsorbtion factors with the practical results of milling, namely exctraction and bagasse moistures.

Although discharge compaction ratios, W.O.R. and reabsorbtion factors were found to be higher than those generally accepted the mills performed well with respect to bagasse moistures and extraction.

The reabsorbtion factor was found to be an extremely useful measure in monitoring a mill's performance due to its interdependence with most other variables involved with milling.

Although much progress was made with mill performance monitoring during the 1986/87 season, most work was developmental in nature. During the 1987/88 season, the data logging programme as developed by Wienese[3] of the S.M.R.I. will be utilised to ease the data compilation process whilst more time will be devoted to optimising the performance of all mills.

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REFERENCES

1. Hugot, E (1972). *Handbook of cane sugar engineering.* 2nd Ed. (Elsevier Publishing Co, Amsterdam) p 199.
2. 'Walkers' milling handbook (1979). *Operation and maintenance instructions for Walhers sugar cane crushing mills.* p 30.
3. Wienese A (1987). The performance of diffuser bagasse dewatering mills. *Proc S Afr Sug Technol Ass 61* (in press).

APPENDIX 1

The formulae for calculating the compaction ratio and reabsorbtion factor are as follows:

$$\text{Compaction ratio} = \frac{\text{TCH} \times 1000 \times \text{Figre \% Cane}}{60 \times \text{TT} \times \text{D} \times \text{L} \times \text{WO} \times \text{n (kg/m}^3)}$$

where:

TCH	=	crushing rate
D	=	roll diameter (m)
L	=	roll length (m)
WO	=	work opening (m)
N	=	speed of mill (rev/min).

The fibre throughput may be referred to underfeed, feed or discharge rolls to render the underfeed, feed or discharge compaction ratios.

$$\text{Reabsorbtion factor} = \frac{\text{Bagasse volume}}{\text{Discharge escribed volume}}$$

where bagasse

$$\text{volume} = \frac{\text{TCH} \times \text{Fibre \% cane} \times 1000}{60 \times \text{A}} \left[\frac{(\text{B} + \text{C})}{\text{D}} + \frac{\text{A}}{\text{E}}\right] (\text{m}^3/\text{min})$$

where:

A	=	Fibre % bagasse
B	=	moisture % bagasse
C	=	brix % bagasse
D	=	juice density (kg/m³)
E	=	fibre density