Proc S Afr Sug Technol Ass (2008) 81: 154 - 159

OPTIMISING BAGASSE DEWATERING IN A CANE DIFFUSER AT SEZELA SUGAR FACTORY

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Abstract

Sezela sugar factory changed to cane diffusion in the 1982-1983 season. Over a 25-year period the bagasse moisture was decreased from 52.01% to 46.85%. This paper describes some of the changes that took place over this period that contributed to the reduction of bagasse moistures. The value of bagasse as a fuel can be enhanced by decreasing its moisture content. Typical dewatering roll settings are shown for the 2006-2007 season. The relationship between bagasse moisture, bagasse calorific value and the coal equivalent is shown.

Keywords: cane diffuser, bagasse dewatering, calorific value of bagasse, mill settings, pressure feeders, bagasse moisture

Introduction

The Sezela sugar factory changed to total cane diffusion in the 1982-1983 season, when two identical diffusers were commissioned. The diffusers, each rated for 225 tons cane per hour, were of the horizontal, fixed-screen type. Each diffuser was installed with two dewatering units of the Walker design with pressure feeders. Each dewatering unit had six rolls. The two dewatering units per diffuser were installed such that they could be operated in parallel or series mode.

The cane preparation equipment, the diffusers and the dewatering setup is described by Hulley (1989).

The importance of a low bagasse moisture

The Sezela sugar factory exports bagasse and steam to an adjoining by-products factory. The sugar factory is a net coal user, and about 50 000 tons of coal are consumed each season to meet the total energy demand of the sugar and by-products plant.

The calorific value of bagasse increases with decreasing moisture content. The relationship is shown in the following formula (Anon, 2005).

$$LCV = [18260 - 207.01M - 182.06A - 31.14B] \text{ kJ/kg}$$

where LCV = net calorific value, also known as lower calorific value
M = moisture % bagasse
A = ash % bagasse
B = brix % bagasse

Inserting the actual 2006-2007 season moisture, ash and brix figures into the formula results in the following LCV of bagasse for Sezela:

$$\begin{aligned} LCV &= [18260 - (207.01 \times 46.85) - (182.06 \times 3.4) - (31.14 \times 1.5)] \text{ kJ/kg} \\ &= 18260 - 9698.4 - 619.0 - 46.7 \text{ kJ/kg} \\ &= 7895.9 \text{ kJ/kg} \end{aligned}$$

The relationship between various bagasse moistures and calorific values from the 2006/07 season are shown in Table 1. For this exercise the ash % bagasse and brix % bagasse were kept constant at 3.4 and 1.5%, respectively.

Table 1. The effect of bagasse moisture on bagasse calorific value.

Bagasse moisture (%)	LCV (kJ/kg)	LCV decrease from 46% moisture (%)
46	8 072	–
48	7 658	5.1
50	7 244	10.3
52	6 830	15.4
54	6 416	20.5

In Sezela's case, any drop in bagasse calorific value needs to be compensated by additional coal usage.

Increase in coal cost

In the past coal was abundant and was readily available at a relatively low cost in the South African sugar industry. However, this changed dramatically in recent years as coal producers found good export markets. Coal supply has also become highly erratic, as producers prefer high volume exports. The average landed cost of coal, excluding handling and ash disposal costs, is shown in Table 2.

Table 2. Average landed cost of coal at Sezela over 10 seasons.

Season	Landed cost (R)	Increase from 1999-2000 (%)
1999-2000	179	–
2000-2001	191	6.7
2001-2002	216	20.7
2002-2003	275	27.3
2003-2004	308	53.6
2004-2005	328	83.2
2005-2006	365	103.9
2006-2007	388	116.8
2007-2008	487	172.1
2008-2009	751	319.6

Coal is now a very expensive input at Sezela and there will be renewed focus on decreasing bagasses moistures further, amongst other energy saving measures. It is thus appropriate to review the steps taken over the years to decrease bagasse moisture.

Sezela mill processes an average of 2 200 000 tons cane per season at an average fibre % cane of 15.75. The difference between 46 and 52% bagasse moisture is equivalent to 8 883 tons coal (net calorific value of 26 800 kJ/kg). This equates to R6.67 million using the 2008/09 landed coal price, highlighting the importance of low bagasse moistures simply from a calorific value point of view. Low bagasse moistures have further value in steady and optimum operation of boilers. Energy wastage due to stop/start boiler operations and resultant boiler drum blowdowns can be very expensive.

Bagasse moisture trend at Sezela

The bagasse moisture for the period 1982-1983 to 2006-2007 is shown in Table 3.

Table 3. Sezela's bagasse moistures for the period 1982-1983 to 2006-2007.

Season	Moisture % bagasse	Season	Moisture % bagasse
1982-1983	52.01	1995-1996	48.75
1983-1984	52.55	1996-1997	48.67
1984-1985	50.04	1997-1998	47.68
1985-1986	52.52	1998-1999	48.30
1986-1987	51.52	1999-2000	48.88
1987-1988	50.96	2000-2001	48.11
1988-1989	50.01	2001-2002	47.98
1989-1990	49.30	2002-2003	47.18
1990-1991	49.68	2003-2004	47.65
1991-1992	48.74	2004-2005	47.06
1992-1993	49.67	2005-2006	46.96
1993-1994	49.64	2006-2007	46.85
1994-1995	49.12		

The bagasse moisture trend at Sezela is shown graphically in Figure 1.

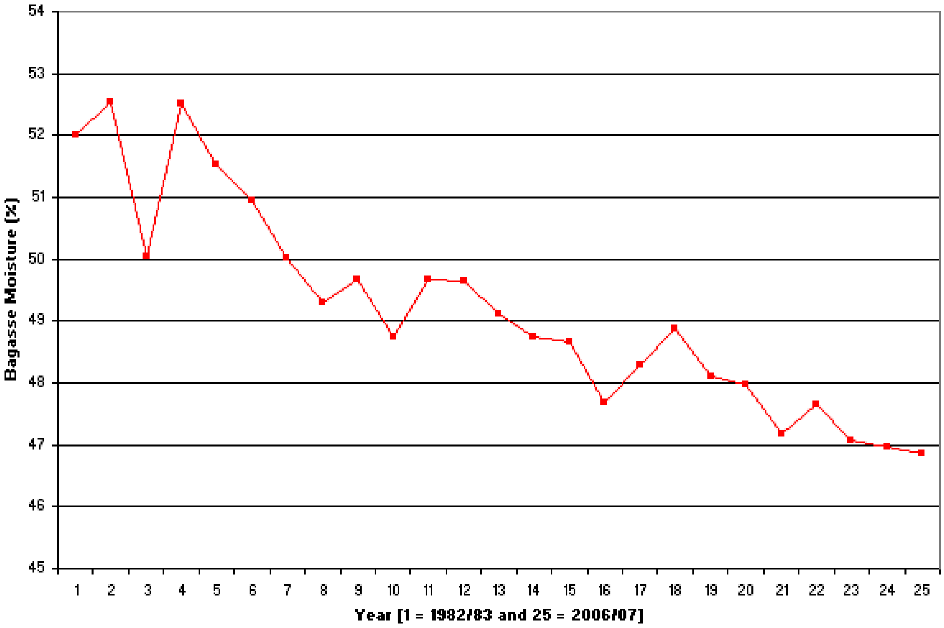

Figure 1. Sezela's bagasse moisture trend for the period 1982-1983 to 2006-2007.

The theory of bagasse dewatering

There are large numbers of excellent scientific papers on milling and dewatering. Most of the papers relate to milling; however, the paper by Jayes (1994) relates specifically to cane diffuser bagasse dewatering at Maidstone mill. The various parameters used in mill setting are discussed by Jayes and summarised as follows:

> "In summary, in order to reduce bagasse moisture the mill should be run as slowly as possible, with as much lift as possible, and the mill must be set such that the fibre fill is as high as possible but less than 1 100 kg/m³."

Wienese (1987) states that, "low mill speed, a thin bagasse blanket, high torque and rough roller surface" contribute to low bagasse moistures.

The debate between parallel and series dewatering comes up all the time. One must note that in diffuser bagasse dewatering the primary objective is moisture removal, whereas in milling the objectives are extraction and then moisture removal at the last mill. Where the required bagasse moisture can be obtained in a single step, the author recommends parallel dewatering where more than one dewatering unit is part of the setup. This allows the dewatering units to be run with split bagasse feed. In Sezela's case this would be 17 tons fibre/hour/unit rather than 34 tons fibre/hour/unit in a series configuration. The lower fibre rate allows optimisation of the factors that produce low bagasse moistures.

In practice, the 'mystery' of dewatering roll settings is simplified as follows:

- Ensure that the geometry of the various rolls is correct.
- Aim for the lowest possible roll speed.
- Select a moderate feed/discharge opening ratio of 1.8 to 2.2.
- Select a moderate fibre fill of about 1000 kg/m³ for the discharge roll setting.
- Use moderate hydraulic pressure of 15-20 MPa (gauge).

Significant changes to the sezela dewatering setup

There were two significant changes to the dewatering setup at Sezela mill during the period under review. These were the installation of direct current (DC) electrical drives as prime movers and the removal of the pressure feeders from the Walkers design units.

The two (2134 x 1067 mm) dewatering units per diffuser were originally installed with 560 kW turbine drives coupled to gearboxes with a total reduction of 2000:1. The turbines were generally operated at speeds varying between 2500-4800 rpm. This was equivalent to roll speeds of 1.25-2.40 rpm.

In the 1989-1990 season the steam turbines were replaced with DC drives. The drives were rated at 573 kW and maximum speed of 1459 rpm. The primary gearboxes were removed and the total gear reduction was lowered to 872:1. This resulted in a maximum roll speed of 1.67 rpm. The normal operating speeds ranged between 700-1000 rpm on the motor, or 0.80-1.15 rpm on the roll. The constant torque DC drives allowed for very low speeds. The installation of the DC drives resulted in bagasse moisture reduction from above 50% to below 50%. The change can be seen in Table 3.

Due to ongoing problems with the pressure feeder connecting chute, it was decided to remove the pressure feeders and convert the six-roll unit to a conventional three-roll unit with an underslung feed roll. A conventional inclined Donnelly chute replaced the pressure feeder chute. The main problem with the pressure feeder was the bursting of the pressure feeder chute. The reason for this mechanical failure is not clear, and the author is not implying that pressure feeder units are not suitable for diffuser bagasse dewatering. A possible reason for the failure could be that Sezela was using conventional mill settings for diffuser bagasse dewatering. Diffuser bagasse at around 80% moisture and 85°C is very different from bagasse in a conventional milling tandem. The chute failures were highly disruptive, and the benefit of the six-roll unit was diminished with repeated failures and dewatering unit bypasses. It was not an easy decision to remove the pressure feeders, as conventional thinking in a sugar mill dictated that 'more rolls were better'. In a very brave step the pressure feeders were removed. From the 1991-1992 season onwards the dewatering units were operated as conventional units. The 1991-1992 season produced an all-time low bagasse moisture of 48.74%, to the great relief of mill staff who put their faith in the modification.

Another modification was changing the roll grooves from 50 to 38 mm pitch. This was done over a period of time. The smaller pitch provides more surface area for gripping and tearing the bagasse.

Continuous improvement in bagasse moistures were recorded after the removal of the pressure feeders. This was due to factory staff gaining more confidence to experiment with the various factors that contribute to low bagasse moistures without fear of pressure chute failure.

The 2006-2007 season

Record low bagasse moistures were achieved at Sezela mill in the 2006/07 season. The season figures, together with typical roll dimensions, are given in Table 4. The rolls are not re-shelled every off–crop, therefore the diameters differ over the re-shell cycle. The figures given are averages for the dewatering units at the beginning of the season.

Table 4. Dewatering related data for the 2006/07 season at Sezela mill.

Parameter	Value
tons cane per hour	394
fibre % cane	15.90
tons fibre per hour	62.65
tons fibre per diffuser	31.32
tons fibre per dewatering unit	15.66
sucrose % cane	12.53
sucrose extraction (%)	98.49
pol % bagasse	0.62
moisture % bagasse	46.85
mean roll diameter (mm):	
underfeed	857
top	1 001
feed	1 015
discharge	1 010
roll length (mm)	2 133
underfeed roll length (mm)	2 057

The typical mill settings at the start of the season (calculated values for the purpose of assembling the rolls) and the adjusted values (adjusted for crush rate and bagasses moisture) are given in Table 5. The mill settings are measured every stop day. The figures given are average values taken at the mid-point of the rolls.

Table 5. Typical mill settings used at Sezela in the 2006-2007 season.

Parameter	At start of season	May	June	July	Aug	Sept	Oct
top to underfeed (mm)	230	210	214	216	215	216	217
top to feed (mm)	94	84	88	90	91	93	95
top to discharge (mm)	44	40	41	42	38	40	41
feed/discharge ratio	2.14	2.10	2.15	2.14	2.39	2.32	2.32
discharge float (mm)	10	10	10	10	10	10	10
top roll lift (mm)	2	2	2	2	2	2	2

Conclusion

The effect of moisture on the calorific value of bagasse must not be underestimated. With future co-generation possibilities the value of bagasse will increase. A cost effective method of increasing the value of bagasse as a fuel is to decrease its moisture content before combustion. Many factors influence low bagasse moistures. Optimum dewatering setup with correct roll settings is one of the ways to reduce the moisture. The importance of good cane preparation, automation, skilled staff and day-to-day housekeeping must also not be underestimated.

It is also important for technologists to challenge 'conventional thinking' in sugar factories. The philosophy of 'more equipment is better' can be detrimental to performance and costs. The annual maintenance costs saved by removing eight rolls (four pressure feeders with two rolls each) are huge.

The question now is, how low can cane diffuser bagasse moistures get to under South African cane quality conditions? Hourly bagasse moisture figures show that 44-45% is possible. Factories must consult their boiler supplier for recommendations for burning bagasse below 46% moisture. The boilers might need a few mechanical and operational changes. The lower the bagasse moisture the higher the bagasse dust, and this must be taken into consideration.

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