REDUCTION OF BAGASSE FIRED BOILER STACK PARTICULATE EMISSION LEVELS

TL BOSHOFF AND WH YEO

Tongaat-Hulett Sugar Ltd, Private Bag 3, Glenashley, 4022, South Africa

Abstract

Sugar mill bagasse fired boilers which are not fitted with devices to reduce the concentration of flue gas particulates produce high levels of stack particulate emissions. To meet statutory emission standards it is therefore necessary to install flue gas dust collection equipment. Emission tests on a bagasse fired boiler equipped with a wet sieve-plate flue gas scrubber are described and the results presented, proving the effectiveness of this type of dust collection equipment.

Introduction

Bagasse fired boiler flue gas particulate emissions before dust collectors are usually between about 8 000 and 12 000 mg/Nm3 (Chang and Lee, 1991). This level of emission is unacceptable from an environmental point of view, and some form of dust collection is therefore essential.

Different countries have differing statutory maximum levels for bagasse fired boiler stack emissions. For example, in South Africa the limit is 200 mg/Nm^3 (Anon, 1985), whereas in Australia the limit is 250 mg/Nm^3 (personal communication).

The statutory limits and financial restraints dictate the choice of dust collector type, with secondary considerations being the preferred method and cost of handling and disposing of the collected particulates.

A problem associated with dust collectors for bagasse fired boilers is the predominance of smaller particles in the gas to be cleaned (Allan, 1981). This increases the difficulty of removing the necessary proportion of particles.

Alternative collector types

The types of dust collectors which could be used on sugar mill boilers are:

- Dry cyclones
- Wet scrubbers of various types, for example:
  - venturi
  - irrigated sieve plate
  - wet cyclones
  - water surface impact
- Bag filters
- Electrostatic precipitators.

Costs of the different types of scrubber vary considerably, as shown in Table 1.

Table 1. Approximate relative costs of collector types (personal communication).

Type of collector	Approximate relative cost
Dry cyclones (medium efficiency)	0,5
Dry cyclones (high efficiency)	1,5
Wet scrubbers	1,5
Bag filters	5,0
Electrostatic precipitators	10,0

The costs given in Table 1 do not include the equipment required for handling and disposal of the collected dust, which could affect the relative costs depending on specific installation requirements.

Table 2. Typical emission performance of collector types.

Type of collector	Typical particulate emission level (mg/Nm^3)
Dry cyclones (medium efficiency)	600 (estimated)
Dry cyclones (high efficiency)	450 (Allan, 1981)
Wet scrubbers	100 (Allan, 1981)
Bag filters	<50 (estimated)
Electrostatic precipitators	<50 (estimated)

Characteristics of alternative collector types

Different types of collectors also offer different levels of performance efficiency, as shown in Table 2.

Dry cyclones are subject to high wear rates because of the relatively high proportion of abrasive grit in the particulates being collected. The combustible nature of much of the particulates collected can lead to fires in the collection hoppers. This raises the possibility of refiring the collected material, but this is seldom practised in South Africa because the abrasive grit collected with the combustibles leads to excessive boiler tube erosion.

The performance of even the higher efficiency dry cyclone type does not meet the required emission level in South Africa, because of the high inlet burden and predominance of relatively small particles from a typical bagasse fired boiler.

Wet scrubbers achieve satisfactory levels of particulate removal at reasonable capital cost, and maintenance costs are low.

Bag filters achieve good particulate removal efficiencies but at substantially higher costs than wet scrubbers. Fires in the collecting hoppers can cause expensive damage.

Electrostatic precipitators are more expensive than the other types and it has been suggested that the particulates carried over from bagasse combustion are not readily ionised and therefore do not lend themselves to removal by electrostatic fields (personal communication). The relatively high moisture content of the boiler gas resulting from bagasse combustion is also expected to cause problems in electrostatic precipitators.

The wet scrubber is the preferred type in South Africa, with the irrigated sieve plate being the design in general use. Trials were carried out on such an installation to prove that it meets the South African statutory requirements.

Description of boiler installation

The No.1 boiler at Darnall Sugar Mill, located on the KwaZulu-Natal north coast, was chosen for the test.

Manufacturer of boiler	:	Babcock and Wilcox
Fuel	:	Bagasse
Maximum continuous rating (MCR) (evaporation)	:	85 tons/hour
Superheater outlet steam pressure	:	3,1 MPa (g)
Superheater outlet steam temperature	:	380°C.

The boiler includes bagasse spreaders and a continuous ash discharge grate. The gas from the furnace passes over a pendant superheater followed by a three-pass main generating bank, an airheater and an economiser. The wet scrubber is installed after the economiser, and downstream of the scrubber is the induced draught fan which exhausts to a concrete stack.

Description of scrubber installation

The scrubber is one of a number designed by Tongaat-Hulett Sugar and which are operating satisfactorily. A sketch of the scrubber is shown in Figure 1.

The flue gas from the boiler enters from the side at the bottom of the scrubber and rises through a perforated plate. The scrubbed gas rises further through an entrainment separator and leaves the scrubber at the top through a horizontal duct, which then passes downwards, turning horizontally into the Induced Draught fan, which exhausts to the stack. The concrete stack has a constant 2,9 m inside diameter and is 28 m high.

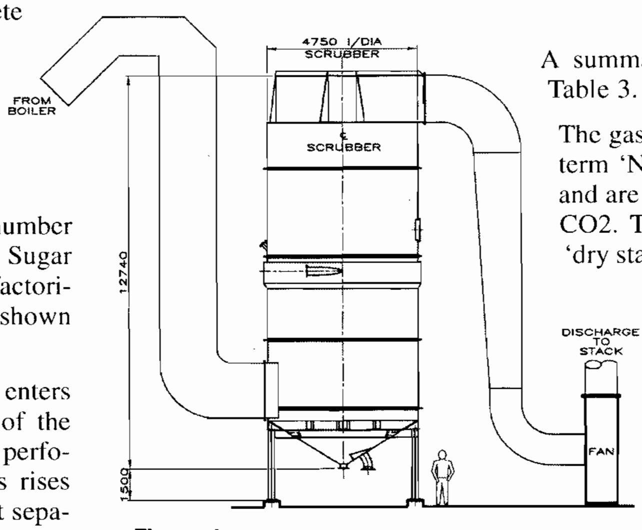

Figure 1.

Water flows radially onto the perforated plate from a channel located around the outside of the scrubber. The water containing the entrapped particles finds its way through the perforated plate, against the gas flow, and is collected in a conical section at the bottom of the scrubber. Thereafter the water is pumped, with most going directly to the settling system from where clarified water is recycled to the scrubber. Some of the water is recycled directly from the scrubber water outlet pumps back to the scrubber to help maintain the necessary water flowrate.

Description of test procedure

The tests were carried out in accordance with the requirements of the US Code of Federal Regulations (40CFR Pt60) and the US EPA standard test methods for isokinetic sampling. Two 100 mm diameter holes positioned at approximately 75 degrees relative to each other were drilled in the stack at a height of 20 m above ground level. Scaffolding was erected to provide access for the testing personnel.

Gas sampling and velocity measurements were taken at various points along the axes of the two access holes. From these measurements and samples the following information was obtained for each sampling position: gas velocity, dry gas molecular weight, water content of the gas and the particulate content by isokinetic sampling. Isokinetic sampling implies that the sample is withdrawn at the same velocity as the gas passing the sampling point, thereby being extracted without disturbing the surrounding flow.

Test runs were carried out with the boiler steaming below MCR at 65 tons/hour evaporation, with the boiler steaming at MCR (85 tons/hour) and above MCR (95 tons/hour).

Test results

A summary of the test results is given in Table 3.

The gas conditions implied by the 'N' in the term 'Nm^3' refer to 'normal wet conditions' and are 20°C, 101,3 kPa (absolute) and 12% CO2. The 'ds' values as in 'dsm^3' refer to 'dry standard conditions' and are 0°C, 101,3 kPa (absolute) and 12% CO_2.

The abnormally high value for the dry standard volume flow at below MCR, is ascribed to this being the average value of a number of tests which exhibited considerable scatter because of fluctuations in boiler operating conditions.

Table 3. Summary of results.

Boiler steaming rate	65	85	95
Actual volumetric flow (m^3/h)	206 959	203 784	220 666
Dry standard vol. flow (dsm^3/h)	126 152	122 845	123 450
Average gas velocity (m/s)	8,70	8,57	9,28
Water content (% v/v)	23	24	29
Average stack temperature (°C)	69	68	74
Average stack pressure (mm Hg)	751,92	757,04	758,34
Particulate concentration (mg/dsm^3)	39	41	89
Particulate concentration (mg/Nm^3)	28	29	59
Mass flow of particles (kg/h)	4,9	5,1	10,5
% isokinetic (90 to 110% allowable)	98,9	94,2	98,1

Despite various attempts it was not possible to obtain meaningful information on the inlet dust burden to the scrubber. This was because the inlet duct did not have a suitable straight run before and after the sampling point and the readings were subject to unacceptable variations.

Discussion of results

The particulate emission levels of the irrigated sieve plate scrubber were all below the statutory limit. The particulate emission levels and the moisture content increased as the boiler steaming rate increased, indicating that the efficiency of the particulate removal process and of the mist eliminator decreased at higher loadings.

Further tests are desirable to determine the inlet dust burden and the inlet and outlet particle size distribution.

Acknowledgements

The assistance of the Darnall mill staff, of ECOSERV Environmental Consulting Services, of Babcock Africa Contracting (Pty) Ltd and of John Thompson Africa (Pty) Ltd is gratefully acknowledged.

REFERENCES

Allan, GN (1981). Progress review of air pollution control in the South African sugar industry from 1972 to 1981. *Proc S Afr Sug Technol Ass* 55: 37-42.

Anon (1985). Guidelines for stack emission in the South African sugar industry. Sugar Milling Research Institute General Communication, 14 August 1985.

Chang, CJ and Lee, JT (1991). A practical report on an effective exhaust scrubbing system for bagasse boiler. *Taiwan Sugar* Sept-Oct 1991: 9-16.