FLY ASH AND BOILER ASH HANDLING AND DISPOSAL AT SEZELA

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Abstract

The Sezela sugar mill and chemical by-product plant complex is situated on the banks of a river, about 50 metres from the Indian Ocean and in the middle of the country's most popular holiday coastline. During the past 10 years two different fly ash and grate ash handling and disposal systems were commissioned. Some design and performance parameters of the two systems are discussed and some recommendations are given. It has been found that unless the disposal system works properly the pollution problem is transferred from the atmosphere to the land, and pollution of natural water sources can occur to such an extent that all aquatic life is destroyed.

Introduction

The Sezela sugar mill of C. G. Smith Sugar Limited is situated on the east coast of South Africa about 70 kilometres south of Durban. The mill has an installed processing capacity of 12 000 tons cane per day and an average processing season of 38 weeks. The steam generation plant has an installed capacity of 400 tons steam per hour. The sugar mill supplies approximately 100 tons steam per hour to the adjoining chemical by-products plant. There is a net export of energy to the chemical plant and for this reason the sugar mill fires a large quantity of coal to meet the energy demand of the combined plants. During the 1988 processing season the mill burnt nearly 32 000 tons of coal.

The South African pollution control regulations specify a maximum of 400 mg/m^3 emission level in flue gases and in practice this could only be achieved by wet scrubbing, which is the method used at Sezela. During the past 10 years two different approaches to disposal of ash and recycling of scrubbing water have been used at the mill. They are:

(a) Separation of ash by clarification and filtration, and disposal by mixing it with the rawhouse defecation filter cake and returning the mixture to the fields

(b) Pumping the ash-laden water to settling dams from which it gravitates back to the scrubber inlet.

In this paper the two processes are compared.

Clarification and Filtration

Description of the System

This plant was similar in design to that described by McDougall *et al.*[3] It consisted of a set of DSM type curved wedge bar screens through which the ash-laden water was passed to remove the coarse particles. The water was then clarified in a modified juice clarifier and the overflow was returned to the scrubber inlet. The underflow from the clarifier was filtered on a top feed rotary vacuum filter with the filtrate being returned to the clarifier. The cake from the filter was conveyed to the raw house filter cake system for transportation to the fields as fertilizer. Specifications of the plant, which was rated for 350 tons cane per hour and which operated from 1979 to 1982, are listed below.

Bar Screens:	No. of	4
	Hydraulic loading (max)	2 400 ℓ/min/screen
	Screen opening	1,0 mm
	Area per screen	2,65 m^2
Subsider:	Diameter	9 100 mm
	Installed power	5,5 kW
	Rotation	0,05 rpm
Vacuum Filter:	Surface area	12 m^2
	Screen	0,12 mm 316 s.s. mesh
	Solids loading (max)	8,5 tons/hr

Performance of the Plant

The system produced extremely good return water with a solids content of about 0,02% and a dry cake with a moisture content of about 50%. However, the plant was expensive in terms of capital, maintenance and operating costs, as reported by Kedian.[2] The installation cost of the plant was about R300 000. The plant required a full time operator on a shift basis and consumed about R4 000 pa worth of flocculant.

The estimated maintenance cost was R25 500 per annum. The major maintenance cost items were replacement of curved bar screens, vacuum filter screens, pump parts and valves. The subsider drive failed on numerous occasions due to solids compacting in the cone of the subsider.

The system worked satisfactorily until 1982, when the installation of two 250 tch diffusers resulted in an increase in cane throughput and in the quantity of sand trapped in the bagasse. In addition the chemical by-products plant increased its operations, resulting in the boilers having to burn more coal, and the ash handling plant became undersized. The overloading of the plant resulted in excessive spillage that was diverted into either the estuary or the effluent treatment plant, causing the treatment plant to malfunction.

The result of the ash plant spillage was that the estuary was continuously polluted and the pollution problem was transferred from the air to the water. Overloading of the ash handling plant caused the cake moisture to increase which increased the transport cost of the cane mud filter cake.

The mill was now faced with an ash handling system that had the following drawbacks:

(i) undersized for the new sand loading and higher cane throughput

(ii) high maintenance cost due to sand erosion

(iii) excessive spillage that resulted in water pollution

(iv) high moisture % cake that resulted in increased transport cost.

Settling Dams

In 1984 a new ash handling and disposal system was commissioned at Sezela. After careful consideration, it was considered that the system most suitable for the mill involved pumping the ash-laden water to two settling dams in series, and gravitating the clean water back to the factory. The main components of the system (pump station, pipelines and settling dams) are discussed below. The capital cost of the whole installation was about R1,5 million in 1983/84.

The Pumps

Two slurry pumps were connected in series, the discharge of the first unit pumping directly into the suction of the second pump. Another set of two pumps was installed as spare units. The details of the pumps are listed in Table 1.

Table 1
Details of the ash handling slurry pumps

Type	centrifugal
Capacity (m^3/h)	900
Delivery pressure (kPa.g):	
operating (in series)	775
closed valve (in series)	900
Impeller material	Ni-hard
Casing material	Ni-hard
Pump rpm	600
Motor size (kW)	270

The Pipelines

These were fabricated of 450 mm nominal bore polypropylene pipes. A number of 80 mm double orifice air valves were installed at all the high points and 150 mm drain valves at all the low points of the lines. Some design details are shown in Table 2. The capacity of the return pipeline was calculated using the Manning formula (Chadwick & Morfett[1]) with a roughness coefficient of 0,010, which was regarded as a conservative value at the design stage. For the design of the pumps and pipe wall thickness, the friction loss in the pipe was calculated using the Colebrook-White formula (Chadwick & Morfett[1]) with a surface roughness coefficient of 0,05.

Table 2
Design parameters of the ash handling pipelines

Parameter	Design Specification	
	Pumping Main	Return Main
Pipe diameter (mm)	450	450
Capacity (m^3/h)	900	800
Temperature (°C)	70	24
pH	4–6	4–6
Static head (m)	58	25
Linear length (m)	1 800	2 000
Suspended solids (%)	0,50	—
Average particle size (mm)	0,15	—

After commissioning, the average flow in the pumping main was found to be 870 m^3/h and the measured roughness coefficient was 0,19. The gravity return pipe could not handle the flow of water from the settling dams and the second (clean water) dam overflowed most of the time. Scouring the pipeline and raising the level of the water in the dam improved the flow only marginally. The average flow in the return pipeline was measured at 740 m^3/h and the measured Manning roughness coefficient was 0,14. It is believed that the additional friction loss in the polypropylene pipeline was due to oversized beads caused by the fusion welding procedure of the pipe sections and also the pipe being rougher than anticipated. All the mitre bends in the pipeline had to be replaced with flanged natural bend sections due to excessive erosion at these points.

Sedimentation and clean water collection dams

The two dams were connected in series, the first and second being known as the sedimentation and clean water dams respectively. The sedimentation dam was built in a deep valley about two kilometres away from the factory and about 30 metres above the factory floor. The retaining wall was constructed of impermeable material which has a bottom consisting of gravel and a system of agricultural pipes to act as filters to drain the water that percolates through the sediment. Running along the lowest part of the dam bed was a 900 mm concrete pipe with a number of concrete risers (penstocks) attached to it. The height of the riser was adjusted by gluing concrete rings onto it. The ash-laden water was distributed parallel to the retaining wall by a set of distribution pipes. The intention was that the dense particles (sand) would settle near the retaining wall, adding stability to the wall, and the less dense material away from it. The surface water, with most of the solids already deposited, was allowed to flow into the risers and the remaining water percolated through the sediment and drained through the filter system into the second (clean water) dam. The 900 mm concrete pipe was also led into this dam. The clean water dam was an ordinary dam with a retaining wall of impermeable material and a simple isolating and draw off facility.

The sedimentation dam filled up earlier than expected. The quantity of ash deposited was estimated at approximately 67 000 m^3 in a 38 week season. The density of the sediments in the dam was estimated at 540 kg/m^3. The rate of deposition of sediments varied from about 1 300 m^3/week in the dry season to about 2 000 m^3/week in the wet season. The unit rate of sediment deposit is estimated at about 16,5 kg/ton cane. There was a significant quantity of "carry over" into the clean water dam, estimated at about 700 tons per annum. The sediment dam showed no signs of water logging and it drained fully in the off-season, which indicated that the filter system was functioning correctly. The use of flocculant at a rate of 3 ppm decreased the solids content of the water overflowing the risers from 120 ppm to 8,5 ppm, but the cost of the flocculant and the danger of blinding of the filter medium resulted in flocculants not being adopted as part of the operational procedure. The sedimentation dam retaining wall was raised in 3 stages and the wall height at the end of the useful life of the dam was about 24 metres. It is estimated that a total volume of about 250 000 m^3 of sediment was deposited during the dam's 4 year operational life. The sediment was analysed and found to contain about 20% combustible material. The chances of spontaneous combustion therefore are low and the filled dams could be reclaimed for agricultural or recreational purposes.

The cost of a new sedimentation dam with a 12 year operating capacity was estimated at R600 000 in 1988 and about R80 000 is required annually to raise the level of the retaining wall.

Water Quality

The return water quality was satisfactory and only on one occasion did the scrubber nozzles choke due to solids in the water when the clean water dam level ran below the operating level. Some of the quality parameters are listed in Table 3.

Recommendations for future installations

Problems which were experienced during the initial stages of this project have prompted the following recommendations.

Table 3
Water quality for part of the 1988 season

Parameter	Pumping Main	Return Main
Flow (m^3/h)	800	–
pH	3,5–8,0	7,0–8,0
Suspended Solids (ppm)	6 000	15
COD (ppm)	300	25
Sulphur (ppm)	80	70
Temperature (°C)	60	ambient
Phosphate (ppm)	12	9

(i) It would be useful to have the pump speeds arranged in such a way that the flow in the pumping main can be increased to re-entrain solids that occasionally settle in the pipeline. Adequate flow measuring and control devices are required on the pumping main to ensure that the solids velocity in the line does not drop below the level where settling occurs.

(ii) Where more than one boiler is operated it is essential that the boilers do not dump their grates at the same time. The sudden increase in solids loading could cause the pipeline to choke. Good agitation at the pump suction is required to prevent solids settling at the pump suction and thus decreasing the flow in the pumping main.

(iii) The welding of polypropylene pipes must be such that the bead size is carefully controlled and all excessive beads are cleaned. The head loss due to pipe roughness needs to include a good safety factor. In practice it has been found that the loss is higher than quoted in manufacturers' catalogues.

(iv) The air and scour valves must be easily accessible and well maintained on a regular basis.

(v) Where the clean water is returned by gravity it is essential that pipes are adequately sized and that inverted siphons are avoided. The return pipe suction at the clean water dam must be protected with a suitable screen that can be serviced easily. The pumping of return water to the scrubber is preferred to gravity flow and the cost of the pumping installation can be offset by the reduction in pipe size for the same duty.

(vi) Developed mitre bends must be avoided and flanged natural bend sections must be used instead.

Conclusions

The topography of Sezela is such that a number of deep valleys exist close to each other near the mill, and a number of sedimentation dams could be built at low cost and with virtually no change to the pumping and return pipelines and to the clean water dam. Although the capital cost of the new system is higher than the old system, the operating costs are lower. Motor transport costs are very high and the transportation cost alone of the ash from the mill to the fields was estimated at R364 000 per annum if the old system was still in use in 1988. If one assumes that a sedimentation dam costs R600 000 and has an operational life of 12 years, with R80 000 required annually for raising the wall, then the annual cost of the sedimentation dam is R130 000. The new system has proved to be more economical than the old one.

If careful thought is not given to the disposal of boiler fly ash and grate ash, the pollution aspect can be transferred from the air to the land and surrounding water sources. With the increased awareness in environmental pollution and preservation of natural resources, poor ash handling and disposal could earn the company a bad name. The new ash handling system at Sezela has worked satisfactorily and has removed all spillage of dirty water into the effluent treatment plant and the estuary. The treatment plant now discharges treated water with an average COD value of 30.

The estuary has now recovered and at the latest fish count in 1988 there were many different species of fish. Although the clean water dam overflows regularly, the average COD of the water in 1988 was 25 ppm and there was no indication that the overflow was detrimental to the vegetation or aquatic life. The dam has no offensive smell and both the dirty water and clean water dams now have a thriving bird population.

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REFERENCES

1. McDougall, EE *et al* (1976). Racecourse Boiler Ash Handling System. *Proc QSSCT 43rd Conference* 157–163.
2. Kedian, MR (1981). The Sezela Smuts Dewatering System. *Sugar Milling Research Institute, Durban.* Technical Report No. 1268.
3. Chadwick, A and Morfett, J (1986). Hydraulics in Civil Engineering. (*Publ Allen and Unwin Ltd, London*) P101–127.