THE DRY SMUT COLLECTOR AT SEZELA

By D.W. CAMDEN-SMITH

Reynolds Brothers Limited, Sezela

Abstract

The multicyclone dry dust collector and disposal installation on three bagasse fired boilers at Sezela is described. Operating difficulties and steps taken to overcome them are discussed. The results of efficiency tests carried out in November, 1971 are given.

Description of installation

The layout of the boilerhouse at Sezela is shown in figure 1.

Boilers number 1 to 6 are old three-drum I.C.L. watertube boilers with a maximum continous steaming rate of 4,5 kg/s each. They have dumping grates and spreader stokers for bagasse firing and boilers number 3 and 5 also have coal firing equipment. Each has its own forced draught fan, secondary air fan and air heater, but they have no grit intercepting and refiring equipment. They are arranged in two banks so that the three boilers in each bank share a common brick flue, induced draught fan, and brick stack. The Howden Centicell dust collector is installed in the flue of boilers number 1, 3, and 5, before the induced draught fan. Boilers number 2, 4 and 6 have no dust collector at all. Boilers number 7 and 8 are modern two-drum Yarrow watertube boilers with a maximum

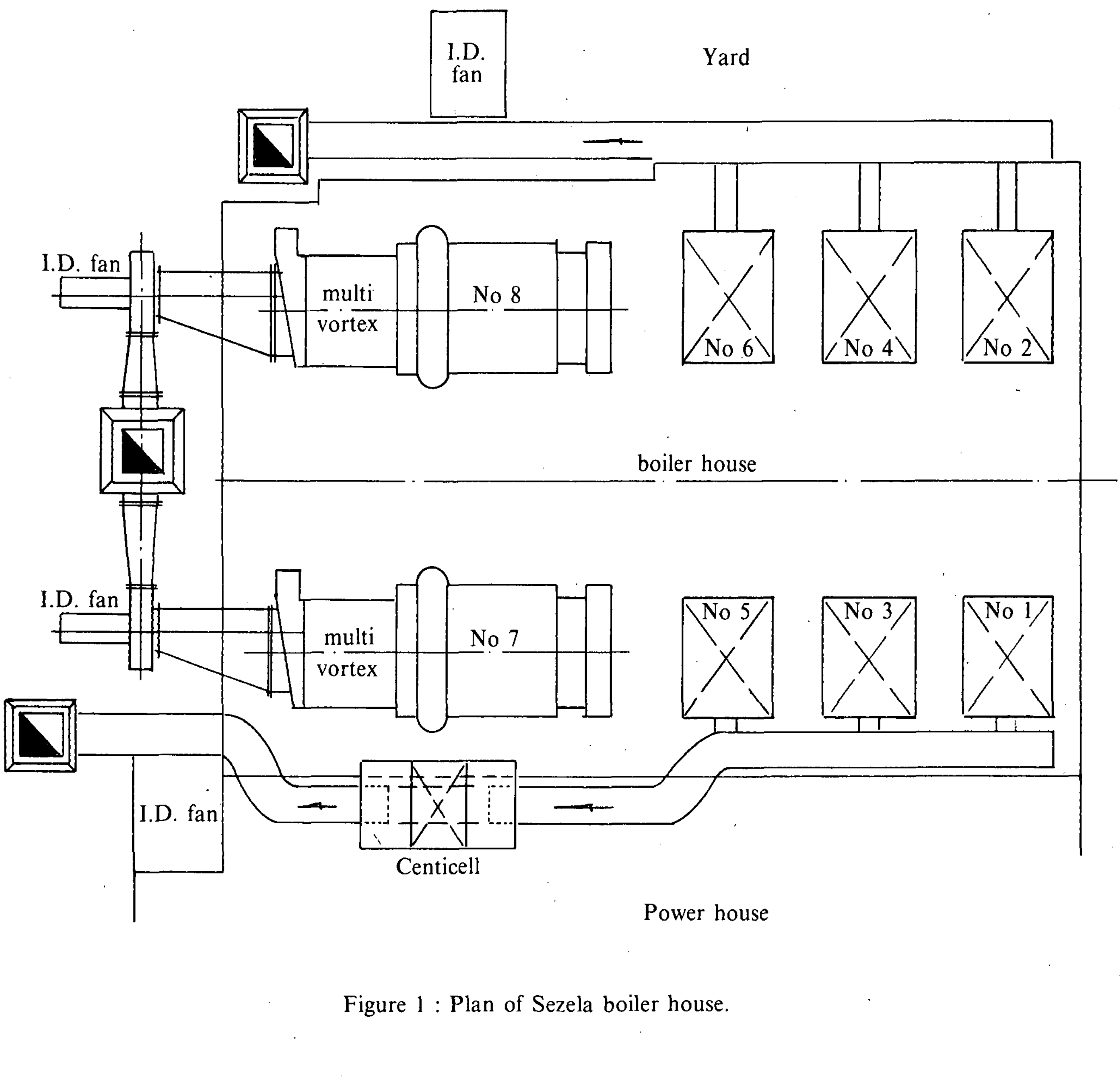

Figure 1 : Plan of Sezela boiler house.

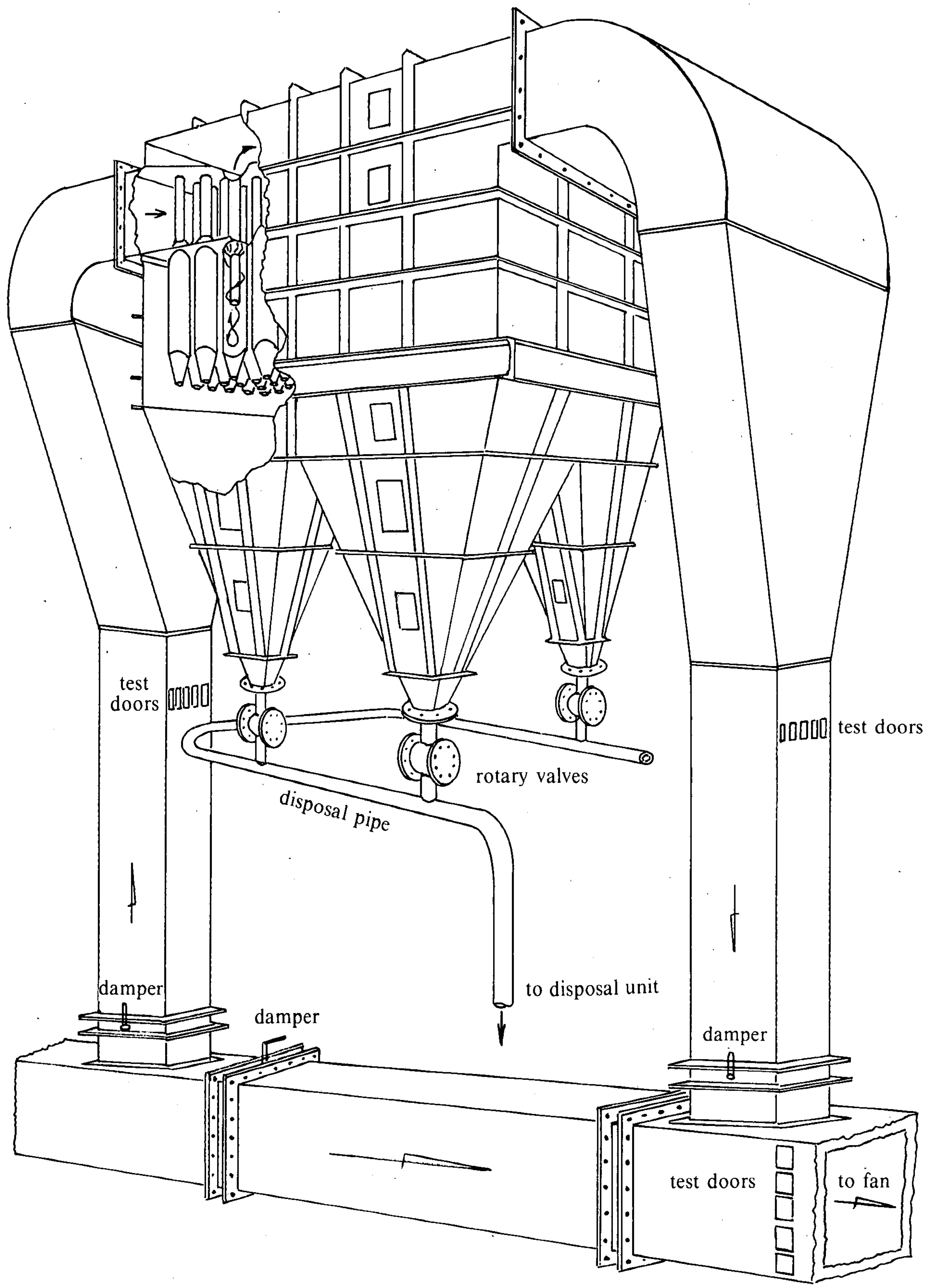

Figure 2 : General arrangement of Centicell collector.

continous steaming rate of 15,5 kg/s each. They have Babcock Detroit travelling grates and spreader stokers for bagasse or coal firing.

Each has its own forced draught fan. secondary air fans, grit interceptors and refiring equipment, air heater, economiser, multivortex dry dust collector, and induced draught fan, and they share a common brick stack. The multivortex collectors have secondary cyclone systems which discharge the dry solids through rotary valves. Normally both Yarrow boilers and five of the I.C.L. boilers steam at about 80% of their maximum rating. During periods of high fibre, when surplus bagasse is a problem, a sixth I.C.L. boiler is also fired.

The flues on either of the banks of I.C.L boilers were long enough for the installation of any type of dust collectors but there was very little space sideways on the flue of boilers number 1, 3 and 5. However this flue is built above ground and there is access to both sides of it for testing purposes, whereas the flue on boilers number 2, 4 and 6 is underground. Furthermore boilers number 1, 3 and 5 have more modern air heaters and a more constant supply of bagasse, so it was decided to install a new smut collector on this bank first. A set of 5 small doors for taking the equipment for measuring gas velocities and dust burden was installed in the flue between boiler No.5 and the induced draught fan so that there was at least 17m straight section of flue both upstream and downstream. The flue is of rectangular section, 2030 mm wide and 2475 mm high and these test doors are in its side, vertically one above the other.

The Centicell dry dust collector is shown in figure 2. It consists of a nest of 150 small cyclones, each 250mm diameter with a 150mm diameter centre tube, arranged 15 cyclones wide by 10 cyclones long and carried on a steel structure (not shown) above the flue. It has a diverging inlet duct and a converging outlet duct connecting it to the main flue. Each duct is provided with a damper and a set of test-doors.

There is also a bypass damper in the main flue. The dust collector can consequently be put in or taken out of service at any time without interfering with the boiler operation. The particulate matter collected by the cyclones drops into four hoppers from which it is continously removed by 4 rotary valves. These discharge into a 200 mm diameter disposal pipe connected to the suction side of the disposal unit. Each cyclone is designed to handle 0,28m^3/s of flue gas so the capacity of the unit is nominally 42 m^3/s. This is more than is required for the boiler installation but affords the opportunity of testing the unit at capacity ratings lower than 0,28 m^3/s per cyclone, with correspondingly lower gas velocities and pressure drop. Surplus cyclones can easily be blanked off if necessary.

The disposal unit is shown in figure 3 and it consists of a rectangular steel tank 1 220 mm wide by 5 500 mm long partly filled with water and with a covered air-tight top. The disposal pipe from the dust collector is connected to it at one end and an exhauster fan is connected to the other. In between there is a specially shaped baffle which causes the dust-laden air to pass momentarily below the surface of the water with great turbulence. The smuts remain in the water and clean cold air is discharged, via a demister, by the fan to atmosphere. The smuts sink in the water and are removed continuously by means of a very slow moving scraper conveyor, from which they discharge in the consistency of a stiff mortar of 67,4% moisture on to a belt conveyor and into a tractor-trailer unit which conveys them via a weighbridge to a convenient dumping groud.

The first disposal unit at Sezela was built to handle the discharge from the multivortex collectors on boilers number 7 and 8 only. It could not cope with the product of the Ceticell collector as well, so the unit described above was built which is big enough to handle the smuts from all eight boilers.

The pressure drop across the disposal unit is about 250 mm water gauge, somewhat more than

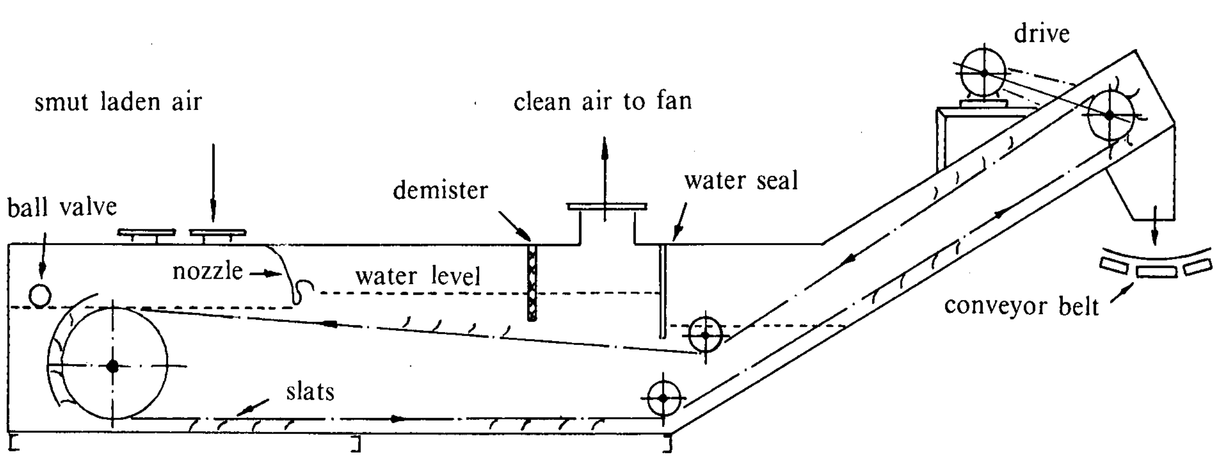

Figure 3 : Dust disposal unit = side elevation.

the difference in water level across the baffle. Smuts are difficult to wet so the inlet pipe must be positioned so that the gas impinging on the water surface causes the greatest amount of turbulence. The addition of a wetting agent at this point has also proved helpful. The scoops on the slat conveyor are made from galvanised wire screening so that they do not retain any air when they submerge at the tail sprocket, dragging any floating smuts down into the water. The scraper conveyor must run very slowly (0,3 metres per minute) otherwise it tends to stir up the smuts and the bath thickens up because the smuts are not withdrawn. Water is lost partly in the cold gas exhausting from the fan and partly in the smuts going to the dump. Makeup is supplied by a 19 mm ball-float valve in the downstream half of the tank, and is about 7,5 litres per minute. The fan is designed for 2,8 m^3/s at pressure of 500 mm water and has a 18 kW motor.

Figure 4 is a record of the total wieight of ash and dust removed daily from all boilers prior to 5th November the Centicell unit was not working continuously due to the inadequacy of the disposal unit, and an averagd of 23 tons per day was removed. After 5th November the Centicell unit was worked continuously until the end of the season, and the average weight removed was 36 tons per day, an increase of 13 tons per day at 67,4% moisture.

Operating experience

If the Centicell unit is not operated correctly, then either the hoppers under the cyclones will choke or there will be a loss of efficiency. When the hoppers fill up the dust eventually covers the outlet to the cyclones after which it gets carried over through the cyclones and up the stack. On no occasion have any of the cyclones themselves choked and caused a restriction to the gas flow. The only way to empty a choked hopper is to dig it out through the access door. Choked hoppers usually catch fire and clinker up so that it is generally impossible to discharge them through the normal disposal pipe. One of the reasons for choking was that the hopper sides were not steep enough. These were originally 55^0, and have now been altered to 60^0. Had there been headroom, a slope of 65^0 to 70^0 would have been better still. It is also important that the square-to-round section at the bottom of the hopper is perfectly streamlined, with no ledges on which bridging can start. The other reason for choking is inadequate dust disposal. Initially there were no rotary valves, and the pipe to the disposal unit had parallel branches connected directly to the bottom of the hoppers from where it was supposed to draw the smut out continuously against the flue draught. This was unsatisfactory because it was impossible to divide the gasflow equally between all four hoppers at all times, and a temporary loss of flow on one hopper would cause it immediately to choke. After installing the rotary valves and altering the disposal pipe so that it collected form the hoppers in series, as shown in figure 2, there were far less chokes. By making the vacuum in the disposal pipe greater than the vacuum in the hoppers, air is prevented from leaking into the hoppers, for example through a worn rotary valve, and continuous discharge from the hoppers is ensured. This is

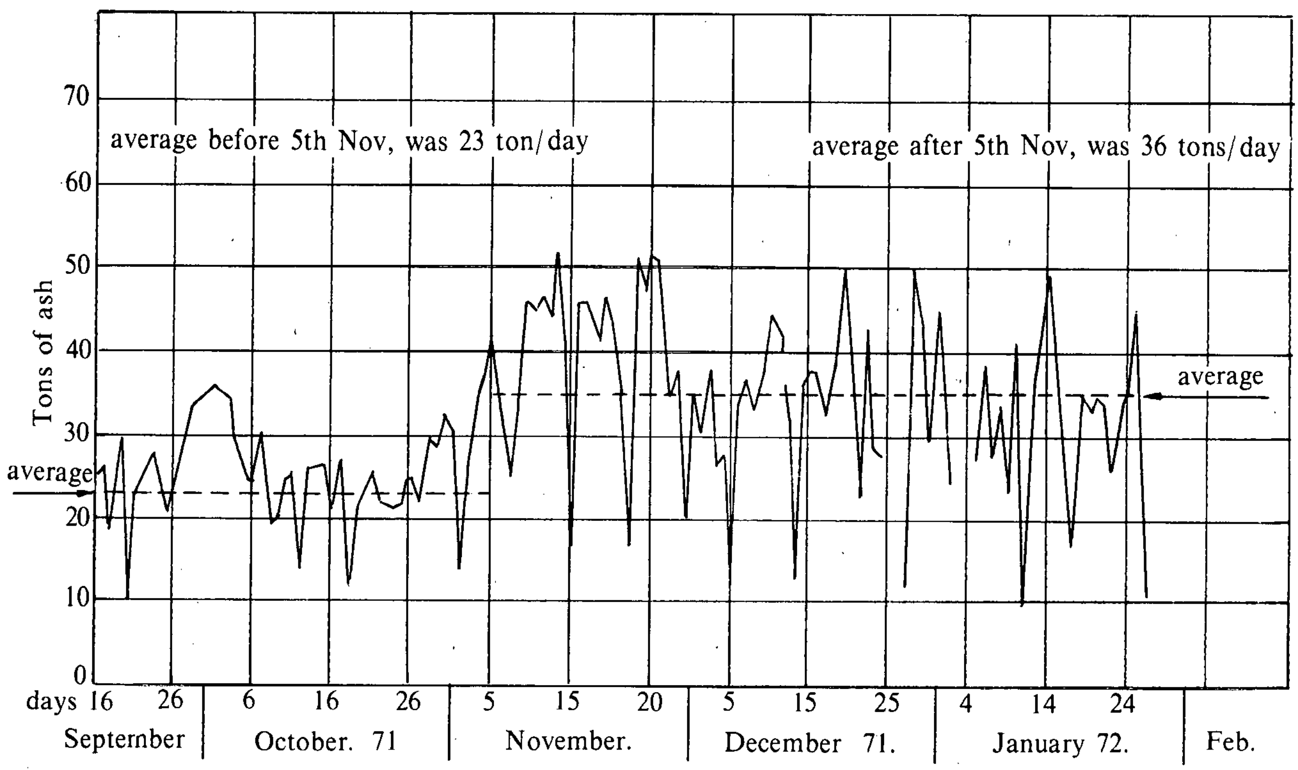

Figure 4 : Daily weights of total ash and wet dust removed from all boilers.

done by throttling the air inlet to the disposal pipe, taking care that sufficient airflow is maintained to carry the dust away.

A trial was made using flue gas instead of air in the disposal pipe by connecting the air-inlet end directly into the centicell outlet duct. This was discontinued because there was condensation in the disposal pipe and there was the possibility of reverse flow drawing the collected dust back into the flue. Also the water consumption of the disposal increased.

The disposal unit must work continuously and cannot be stopped, even for short periods because loss of flow in the disposal pipe would cause all hoppers to choke. Stoppage of the scraper in the disposal unit results in a fast accumulation of settled smut so that it soon becomes impossible to restart the scraper. It is considered important that the Centicell unit, including the hoppers, be adequately lagged to prevent any stickiness on the inner surfaces due to condensation. Special precautions must be taken when starting up the Centicell from cold, because a surprising amount of condensed water will run out through the rotary valves until such time as the platework tempreature exceeds dewpoint. Usually most of the gas is diverted through the bypass damper, and only a small amount passed through the Centicell unit during the warming up period.

The efficiency of the Centicell depends on the size of the cyclones, the gas velocities, and the particle sizes.

The cyclone size is determined by cost, many smaller ones being more efficient, and more costly, than fewer larger ones. Before installing the main unit at Sezela, tests were made on a pilot unit comprising three standard cyclones to establish how efficient these would be on bagasse fired boilers.

The gas velocities depend on the number of cyclones installed. Better results were obtained at Sezela by increasing the velocity in the cyclones by 20% by blanking off the last two rows of 15 cyclones, and thus reducing their number from 150 to 120. Because the cyclones are dimensionally similar it cannot simply be assumed that the gas flow will divide proportionally among them. The inlet and outlet conditions differ for each cyclone, so that it is more likely that some will pass more gas at the expense of others. Backflow through the dust discharge cone is even possible, though not observed, but to help prevent this the hoppers should be fully isolated from each other by carrying the hopper divisions plates right up to the underside of the lower tube-plate. Also there must be no leaks where the cyclones fit into the tube-plates, and the unit was carefully tested for these before commissioning. Blanking off these cells caused the pressure drop accross the Centicell unit to increase from 50 to 67 mm water gauge. This called for more suction from the induced draught fan which was already running at maximum speed. Fortunately additional horsepower was available so the extra pressure could be obtained by adding 75 mm to the tips of the fan blades.

The particle size of the dust, and its density also affect the cyclone efficiency because larger or heavier particles are more easily removed than smaller or lighter ones.

Test procedures

The dust burden in a flue is measured by withdrawing a measured volume of gas from it, and then separating and weighing the quantity of dust contained in this gas, the result being expressed in milligrams of dust per cubic metre of gas at normal temperature and pressure, i.e. 273°K and 760 mm Hg. The difficulty is in separting a representative sample of gas. The sampling procedure must neither increase nor decrease the amount of dust that the sampled gas was originally carrying in the flue. To this end samples are withdrawn isokinetically, i.e. at the same velocity as the gas in the flue. This is done (figure 5) by pointing a sharp-edged sample tube upstream in the flue and withdrawing the sample through it at such a rate that the gas velocity in the sample tube is the same as the gas velocity existing in that part of the flue. The gas from the sample tube then passes through a small high-efficiency cyclone backed up by a glass fibre filter pad so that all the dust it carries can be separated and weighed. This equipment is positioned inside the flue so that no condensation of moisture can take place in it. The gas sampling rate is measured across an orifice and adjusted by a valve. The procedure and equipment are specified in B.S. 3405 : 1961.

Attempts were first made in 1970 to measure the dust burden in the flue of boilers 1, 3 and 5, using the standard apparatus. But it did not work. The smuts were so large and of such a shape that they quickly blocked up the tiny passages in the high-efficiency cyclone.

A larger cyclone, complete with hopper and filter chamber was then made from light copper sheet, and tests were carried out with this, which indicated a burden of 3 286 mg/m³ in the flue of boilers 1, 3 and 5, before the smut collector was installed and a burden of 520 mg/m³ after the multivortex separators on boiler number 7. The same apparatus was used to establish the efficiency of the Centicell pilot unit. The design of the standard was then modified by making the high efficiency cyclone a little bigger and the air passages much larger to handle bagasse smuts and this equipment was used for all later tests, including the most recent one now described.

A test was carried out on 26th November, 1971, in order to determine the efficiency of the Centicell unit and the dust emission to atmosphere, with 30 of the 150 cyclones blanked off, with the rotary valves under suction from the disposal system, and without any heat insulation Gas velocities were measured with a pitot tube at 4 positions in each of the 5 test doors in the inlet duct, and from these 20 readings the average gas flow in the duct was calculated. The gas

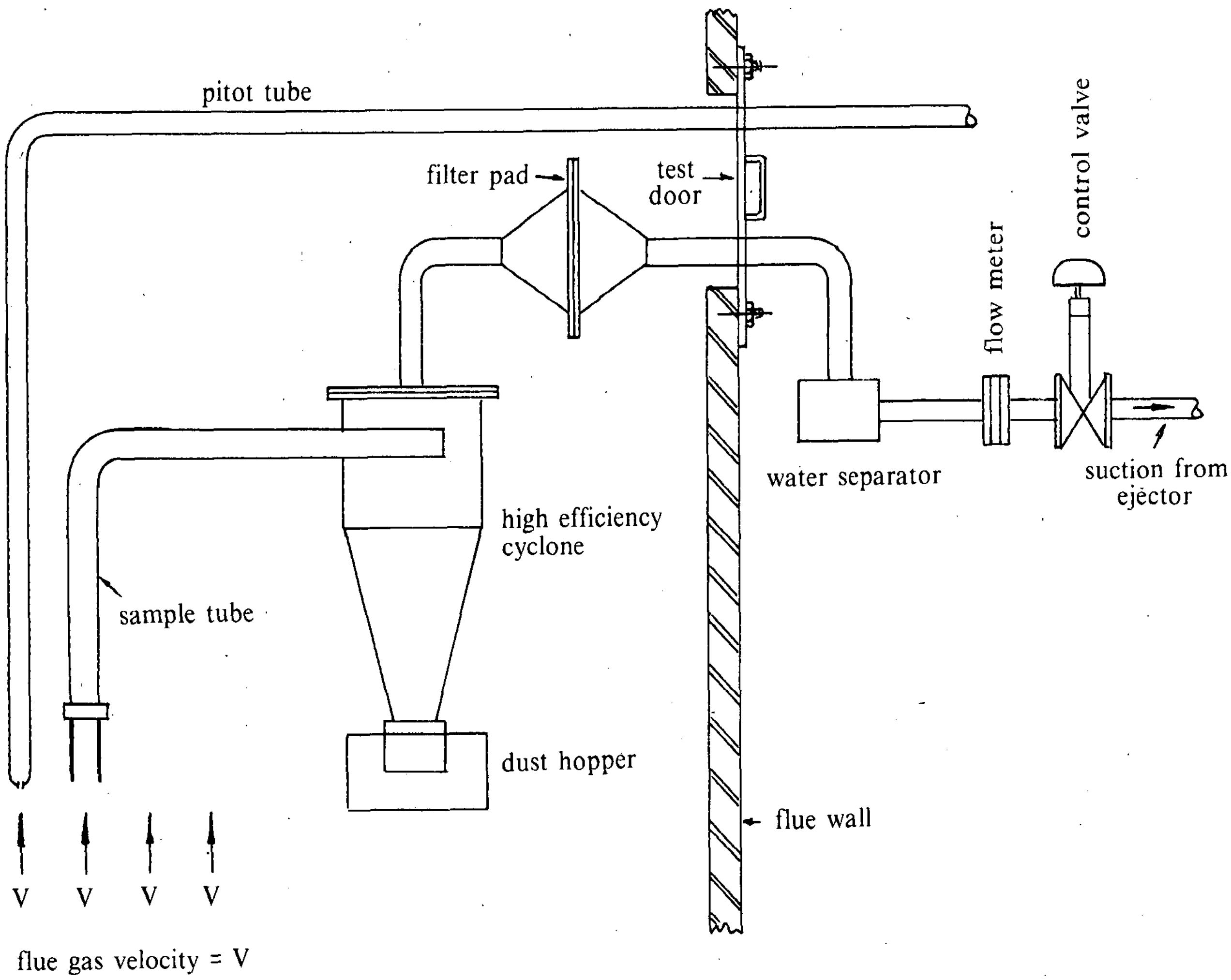

Figure 5 : Schematic arrangement of isokinetic sampling apparatus

temperature was also measured by means of a thermocouple. Then an isokinetic sample of the gas was taken for 5 minutes in each of the same 20 test points, giving a composite sample representative of the average dust burden across the section of the flue for 100 minutes. Similar measurements were made in the outlet duct, at the same time, using duplicate apparatus. The static pressures in the ducts and the barometric pressure were also measured. During the test period of about 3 hours special precautions were taken to keep operating conditions constant, so that the samples could be said to be representative of those conditions. Such precautions would not have been so necessary had it been practival to probe all 40 points simultaneously. The steaming rates of boilers 1, 3 and 5 were kept reasonably constant at 3,9 and 3,4 and 3,3 kg/s respectively, totalling 10,6 kg/s. Regular cyclic deviations of ± 0,5 kg/s were recorded on individual boilers, but these were ascribed to the characteristics of the on-off type of feedwater controllers used and not to firing conditions. There were no interruptions in the bagasse supply and fires were not cleaned during the test period.

Test results are displayed in Table I, and the dust grading of typical Sezela flue dust is shown in Figure 6.

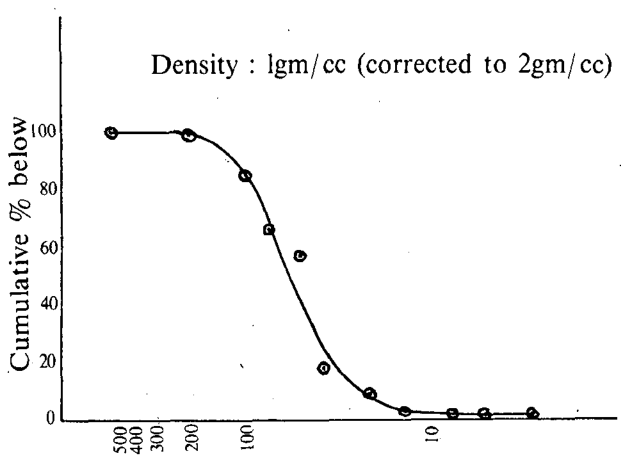

Figure 6 : Typical Sezela dust grading.

TABLE I

Results of Efficiency Test on Centicell Dry Dust Collector on Boilers Number 1, 3 and 5 at Sezela on 26th November, 1971.

Total boiler steam load .... 10,6 kg/s
Number of cyclone cells 120
CO_2% 10

			Units	Inlet Duct	Outlet Duct
1	Duct Area.	A	m^2	2,070	2,070
2	Number of Test Doors.			5	5
3	Number of Sampling Points.			20	20
4	Sampling Time per Point.		s	300	300
5	Total Sampling time.	t	s	6000	6000
6	Sampling Nozzle diameter		mm	9,525	9,525
7	Sampling Nozzle area.	a	mm^2	71,25	71,25
8	Gas Temperature	T	°K	476	466
9	Barometric Pressure		mmHg	762	762
10	Duct Static Suction		mmwg	51	119
11	Gas absolute pressure	P	mmHg	758	753
12	Dust trapped in sampling cyclone		g	11,0339	0,3612
13	Dust trapped on filter pad		g	2,5300	0,6327
14	Total dust trapped	W	g	13,5639	0,9939
15	Gas velocity in flue	V	m/s	15,845	14,698
16	Gas volume in flue	Q = VA	m^3/s	32,799	30,425
17	Gas volume at N.T.P. (Wet) $Q^1 = Q \cdot \frac{273}{T} \cdot \frac{P}{760}$	Q^1	m^3/s	18,762	17,660
18	Sampled Volume at N.T.P. (Wet) $q^1 = Vat \cdot \frac{Q^1}{Q} \cdot 10^{-6}$	q^1	m^3	3,875	3,647
19	Dust Concentration. $C = \frac{W}{q^1}$		mg/m^3	3500	272
20	Dust Burden in flues. $D = \frac{CQ^1}{1000}$		g/s kg/hr ton/day	65,67 236,4 5,674	4,81 17,28 0,415
21	Dry Dust removed	B	g/s kg/h ton/day	60,86 219,1 5,295	
22	CO_2 Content of flue gas		%	10	
23	Dust concentration corrected for 12% CO_2 (Dry)		mg/m^3	350	
24	Centicell Efficiency	$\frac{B}{D\ Inlet}$	%	92,67	

Conclusion

The multicyclone dry dust collector is a simple piece of equipment and will work reliably provided attention is paid in the designing stage to:-
a) The correct sizing of the unit.
b) Provision of adequate fan power
c) A continuous and reliable dust disposal system.
d) Elimination of possible sources of air leaks.

It requires no regular periodic cleaning and annual maintenance is necessary only on the rotary valves and the moving parts of the disposal unit. No wear has been detected so far on the cyclone cells but it must be admitted that bagasse at Sezela contains very little abrasive matter. There is no corrosion internally except in the disposal unit tank.

The unit is simple to operate and requires no adjustment for normal variations in boiler load. Its efficiency would drop on very low loads, for instance if one of the three boilers were taken off the range, because the gas velocity in the cyclones would decrease. Occasional inspection on shift is advisable to check that there can be no air leaks into the system due to faulty rotary valves, lack of draught in the disposal pipe or clogging of the disposal unit. A little attention is needed when starting up and closing down the unit. Labour is required only to transport the residue to the dumping ground.

The efficiency of the unit is over 92% when run on bagasse fired boilers with spreader stokers, resulting in stack emissions of the order of 300 mg/m^3. There is almost complete removal of all large or dense particles, such as large smuts or grit. The carry-over is comprised of very small light particles.

Acknowledgements

The generous co-operation of the management and staff of Messrs. James Howden and Safanco Limited and of Messrs. Reynolds Brothers Limited is very much appreciated.