DEDUSTING OF THE GAS

This is a most important aspect of the Winkler generator. An appreciable proportion (18 to 50%) of the solid material fed into the generator is carried away as a finely-divided dust with the exit gases, and adequate plant must be installed to separate out the dust. If possible the dust so recovered should be able to find some useful outlet, e.g. as a boiler fuel, the credit so obtained helping to offset the inefficiency of utilizing fuel in the generator and the cost of the equipment required for dedusting; according to Ref.11 Zeitz received a credit of RM.5.-/T for recovered dust.

The older Leuna generators had single cyclone dust-catchers installed between the generator and waste heat boiler and the recovered fines were fed straight back into the fuel bed; these single cyclones, however, were relatively inefficient and caused excessive quantities of dust to appear at the water seals.

In all later installations there is no attempt to remove dust from the gas before it has passed through the waste heat boilers: then when it has been cooled to 200° or 300°C it is treated by multicyclones. At Zeitz the gas passes in two parallel streams, each stream passing through two sets of multicyclones in series; the two sets of multicyclones in one stream are larger than those in the other, the object being to give a choice to suit the particular output; in practice hand operation of the necessary valves is found to be cumbersome and a nuisance, although this problem appears to be readily soluble by using hydraulically-operated valves. At Magdeburg electrostatic precipitators were originally used instead of multicyclones, but one day, due to faulty operation free-oxygen appeared in water gas and an explosion occurred; they now also use multicyclones. At Leuna electrostatic precipitators were also tried in the early days, but the dust content was so great that it was difficult to maintain the potential difference under such circumstances.

After the multicyclones the gases bubble through a simple water seal, which is really a safety device to prevent gas passing back from the main into a generator, which is not producing, but it also removes a certain amount of dust from the gas and cools and saturates it with water vapour at about 80° to 85°C; water has to be passed through this seal continuously, to cover the evaporation of water and to flush away the dust removed. The gas from all generators passes into a common main and thence through direct contact water scrubbers, which both cool and de-dust the gas and remove some H_2S; it is believed these are empty towers, fed with an excess of sprayed water. Finally the gas passes through Theison disintegrators, for final dedusting, and is then termed raw water gas, ready for H_2S removal and subsequent working up.

Water from the seals, coolers and disintegrators contains dust and H_2S and must be treated before being discharged to river or recirculated. At Zeitz the water is passed through two towers in series, with a common spare, all packed with wooden grids; CO_2 is blown through the first tower, to remove the bulk of the H_2S, which is subsequently treated in a Claus kiln for conversion to elemental sulphur, since it cannot be blown to atmosphere; air is blown through the second tower to remove the remaining H_2S, which is blown to atmosphere. Finally the water is sent to large settling ponds, where the bulk of the dust settles out, and the relatively clean water can then be discharged to the river; at Zeitz the final water contains about 20 mg/l of suspended matter, said to be not greater than that of the river water itself.

Occasionally the settled dust is recovered from the settling pits, dried and used as boiler fuel, but in general it is uneconomic to do so. However, the much larger amount of dry dust recovered from the multicyclones is normally used as boiler fuel, although it too may be wetted down and pumped as a slurry to dumps. At Zeitz dust from the multicyclones is collected in special fixed containers; when full these are isolated by remote-operated valves, the dust is roused by admission of CO_2 through a stand-pipe and the dust pumped away pneumatically to the boiler plant, using CO_2 as carrier gas.

The amount of dust carried over with the gas varies greatly from plant to plant, and increases notably with the output. Naturally unless clinker forms all the ash in the incoming fuel must be blown overhead; the ash particles must be considerably smaller than the average size of fuel particles, which fixes the linear velocity of the blast. In practice 80 to 90% of the ash passes overhead. In addition finely divided unburnt fuel must appear above the fuel bed, since some fines ($<$ 0.2mms) are fed in with the fuel and some fines are continually being produced as the result of combustion and attrition of larger particles in the fuel bed; only a portion of such fines is gasified in the space above the fuel bed. With higher outputs larger particles can be carried away and so the amount of fines in the gas increases with output. Also since the quantity of carbon gasified/M^3 gas is relatively constant, then for a given fuel of fixed ash content the carbon content of dust carried away must increase with the dust content of the gas.

Under normal running conditions the dust contents, in gms/N M^3 gas leaving the generator, is variously reported (see Table III), as between 100 and 360, being lowest at Leuna and highest at Zeitz, with carbon contents of from 30 to 55%. This represents between 10 and 40% of the carbon charged to the generator. At Zeitz the 1944 average analysis of dust recovered from the multicyclones was :

C	54.3%
H	0.9%
ash	43.8%
moisture	1.0%
net C.V.	5,000 T.cals/T

The multicyclones at Zeitz and Böhlen (Refs.3 and 11) are about 80% efficient, so that at Zeitz gas leaves the multicyclones with about 60 g/N M^3 dust. At Zeitz the dust content after the direct contact coolers is reduced to about 2 g/N M^3 and finally after the disintegrators to 3 to 4 mg/N M^3. This must be considered as a very creditable overall dedusting performance, even though there are four stages of dedusting. According to Ref.12 the dust content of gas after the disintegrators at Böhlen was 2 to 5 mg/N M^3 for a generator output of 16,000 M^3/hr, but the dedusting train was overloaded at 19,000 to 21,000 M^3/hr and the dust content at this point rose to 40 mg/N M^3.

The higher dust content of gas at Zeitz may be a function of the fuel used, but as stated before it may be significant that at Zeitz appreciably less oxygen is introduced above the fuel bed.

We have been unable to find any data concerning the size of the dust at any stage, except that Ref.1 states the dust to have a maximum size of 0.3 to 0.4 mm; this also fits the statement made in Ref.11, that any material < 0.5 mms is liable to be blown out of the fuel bed.

STARTING UP

For starting up a small auxiliary Winkler generator is used; one such is shared between two generators and hence two have to be provided for three generators. One can be seen at the extreme left of Fig.1. This has an I.D. of 1.0 to 1.5 m but is always open to atmosphere through a wide open stack (0.5 to 1.0 m I.D.). A fire is started with wood and briquettes, air being blown through, whilst grude is run in slowly from a hopper. When hot enough the glowing grude is run by gravity into the large generator, standing full of N_2 or CO_2, with the safety valve open to atmosphere. A good rate of air is then blown through the grude and the level is built up by feeding in fresh grude in the normal way. The bed must be kept "boiling", otherwise the heat of combustion is not properly dissipated and clinkering results. The blast is then changed over to a mixture of steam and oxygen and when the gas made is of sufficiently good quality the safety valve is closed and gas making proceeds.

The reason why the generator cannot be lit up directly lies in the difficulty of ensuring a uniform fire-bed right across the grate. If part of the fuel-bed became hot, whilst the rest remained cold, then producer gas and unchanged air might accumulate above the fire-bed and lead to an explosion. Dr Schairer at Zeitz thought the generators there were not too large to start up directly on grude, but it would be dangerous to start them up with briquettes or dry brown coal, since the presence of carbonisation gases would make explosions more likely. No dangerous explosion can occur in the auxiliary generator because it is always adequately vented to atmosphere.

The valves on the outlets from the small generator are in contact with hot grude for only a short time whilst it is flowing into the large generator; at other times they are protected by a layer of cold grude.

A Winkler generator can be on line from cold within an hour or two, although longer is taken if possible to avoid damage to brickwork.

INSTRUMENTS AND SAFETY DEVICES

Temperature control is very important, since it is desired to work at as high a temperature as possible, but not so high as to cause slagging or clinkering difficulties. The temperature in the space above the fuel bed and the temperature within the fuel bed are both recorded continuously and fitted with alarms.

Mention has already been made of differential pressure manometers in duplicate, to measure the fuel bed depth, and also of the pilot flame, burning a sample of the exit gases before a photo-electric cell, fitted with an alarm. In addition, of course, there are the usual flowmeters, temperature indicators and pressure gauges.

There are bursting discs at strategic points, notably on the wind-box, whilst a large stack can readily be opened to atmosphere through the medium of a hand-controlled electrically or hydraulically operated valve.

There is a non-return water safety valve on the oxygen line to prevent gas passing back along the oxygen main, should the oxygen pressure fail; steam added to the secondary oxygen also performs a similar function. The water seal on the gas leaving the multi-cyclones, as already mentioned, prevents gas flowing back from the common gas main into a generator, which is not producing.

Mention has also been made of the emergency supply of steam to the wind-box, to guard against failures of the normal steam supply.

All these instruments and controls, together with controls for operating the fuel and ash conveyors and adjustment of the oxygen and steam rates, etc., are brought to a single control cabin, which at Zeitz and Böhlen controls all three generators; it is located about 5 m above ground level, i.e. approximately on the level of the fuel bed.

<u>PRESSURE SURVEY</u>

The following is a pressure survey at Böhlen (see Refs.2, 11) and Zeitz (Ref.13).

		Böhlen	Zeitz
	Generator output, M^3/hr water gas	20,000	15,000
		cms water gauge	cms water gauge
Pressures	Steam to Generator	1,950	1,450
	Oxygen to generator	-	-
	Wind-box	220	120
	Above grate	200	-
	Above fuel-bed	150	80
	After W.H.B., multicyclone	100	-
	After water seal	80	-
	After coolers	50	25
	After disintegrators	-	20

Pressure Drops:-	cms water	cms water
Across grate	20	40
Across fuel bed	50*	
Across W.H.B., multicyclone	50	55
Across water seal	20	
Across coolers	30	

Bearing in mind the difference in output, these two sets of figures are in reasonable agreement.