OUTPUT

The output of a given generator is, of course, fundamentally a function of the shaft or grate area and is roughly proportional to it. There are, however, other important considerations. A Winkler generator has one of the highest outputs/M^2 shaft area of any gasification process, and when making water gas from grude is normally of the order of 1,200 to 2,000 M^3/hr/M^2, although even higher outputs have been claimed. These high outputs are due primarily to the active nature of the fuel and the intimacy of contact of fuel with oxygen and steam, as a result of the finely divided nature of the fuel and the "boiling" motion of the bed.

For a generator of given shaft area, however, the output can be altered usefully only within a comparatively limited range. Below a certain output the bed ceases to "boil", although what blast there is will still find its way through the fuel bed. This immediately removes the means whereby heat is evenly distributed throughout the fire-bed. Consequently the lower layers, which the blast meets first, become overheated and slagging results. On the other hand, as the blast rate increases larger and larger particles can be carried away from the fuel bed and ultimately, of course, the whole bed is carried away, i.e. the fuel becomes fully entrained with the gas; long before this point is reached, however, the dust content of the gas becomes so high that the carbon losses become serious, whilst dedusting of the gas presents a formidable problem; moreover if velocities much exceed designed values, serious erosion will occur, especially in the waste heat boilers. The practical limits of output for generators, such as those at Böhlen and Zeitz, appear to be between 9,000 and 25,000 or possibly 30,000 M^3/hr water gas. Although limited this range, of course, is ample to permit two generators to cover all likely loads.

Thus the Winkler generator is capable of appreciable overload for a short time, provided one is willing to countenance the decreased efficiency and increased maintenance.

The figure of 50 mms given in Ref.2 should obviously be 50 cms.

Ref.10 comments on the effect of output on the performance of a generator at Leuna in 1935, making water gas from dry brown coal. The higher output was maintained for only one day, because of overloading of the waste heat boiler, but the comparison with normal running is given as follows :-

		Normal	High Output
Output, M^3/hr. water gas		30,000	42,000
Gas Analysis:	CO_2	21.8	15.7
	H_2S	1.5	1.5
	H_2	38.5	36.0
	CO	35.3	44.4
	CH_4	1.8	1.6
	N_2	1.1	0.8
C in fuel, Kg/1,000NM^3 H_2 + CO		452	455
98% O_2, NM^3/ -		366	316
Steam, kg/ -		407	250
% C utilization		*86.5%	80%
% steam decomposition		33%	27%
% C in fly dust		31%	35%
% C in ashes		35%	40%
Fly dust, kg/1,000 NM^3 H_2 + CO		148	211
Ashes, -/ -		41	44

*Allowance was made in the high output for CO_2 introduced with the fuel; if the same allowance is made for normal output, the C utilization is reduced to 82.8%.

The report remarks on the better gas composition (80.4% H_2 + CO, as against 73.8%) at the higher output, and especially the appreciable reduction in oxygen and steam consumption; the carbon consumption is about the same, although the C losses in dust and ash increase, as does the amount of dust blown over. The report goes on to say that theoretically one might expect better performance at lower outputs, since this gives longer times of contact in the space above the fuel bed, and the only tentative explanation given for the reversed findings is that, despite the fact that recorded temperatures were kept the same, the actual temperature in the fuel bed at the higher output was in fact different (and presumably higher) since the thermocouples measure the temperature only near the walls.

Whether the above is reliable evidence may be open to doubt. Other figures given in Refs.1 and 6, however, tend to bear out the lower-oxygen requirements at higher outputs.

SERVICE REQUIREMENTS : EFFICIENCIES AND BALANCES

Because of the varying conditions it is difficult to give typical figures for service requirements and efficiencies, but perhaps the following list of ranges encountered might be a useful summary of known achieved results :-

Grude	Per 1000 NM^3 H_2 + CO
	650 to 1000kg.
Carbon	420 to 630 kg
Oxygen (98%)	305 to 335 NM^3
Steam used	350 to 900 kgs.
Steam decomposition	30 to 35%
Carbon utilization	88 to 57%

Dry brown coal	Per 1000 NM^3 H_2 + CO
	800 to 860 kg
Carbon	445 to 460 kg.
Oxygen (98%)	315 to 360 NM^3
Steam used	300 to 400 kgs.
Steam decomposition	27 to 33%
Carbon utilization	86 to 80%

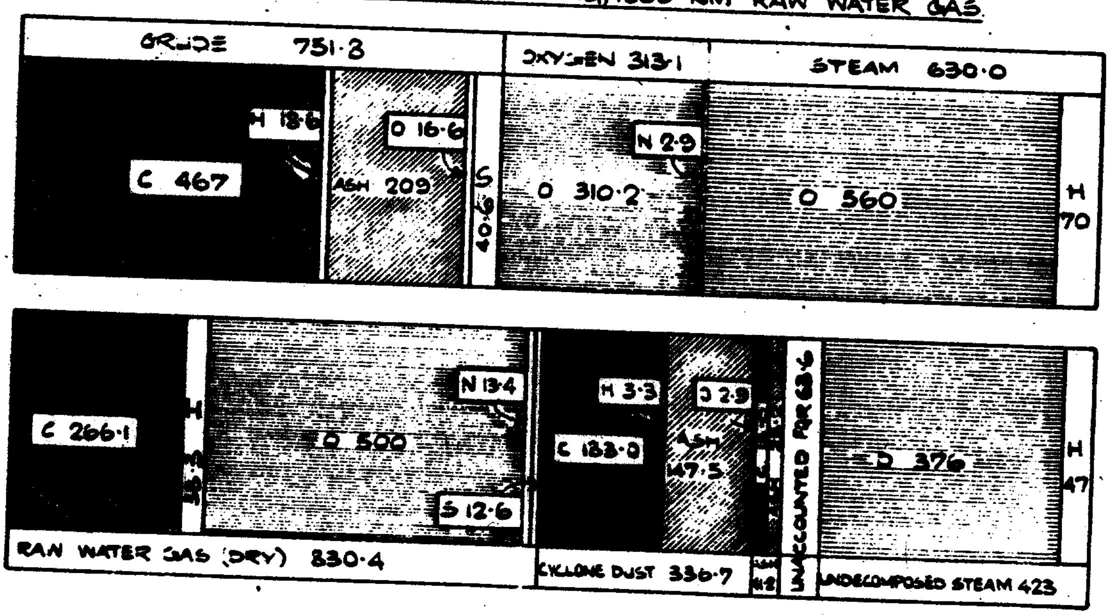
Data for various plants are collected together in Tables III (water gas from grude) and Table IV (water gas from dry brown coal) and these should be consulted for more detailed information, as far as it is available.

Material and heat balances will now be drawn up for one or two plants for which sufficient information is available.

MATERIAL BALANCE AT ZEITZ

Ref.14 gives a material balance for the whole of 1944, from which the following is taken.

INGOING MATERIAL IN KG/1000 NM^3 RAW WATER GAS



OUTGOING MATERIAL

MATERIAL BALANCE AT ZEITZ.

NOTES

1. The actual balance given in Ref.14 shows 5.0 H and 300.6 H_2O as "unaccounted for". This obviously indicates an incorrect measurement of H_2O in or out, so in the above balance the measured steam in has been assumed to be correct and a hydrogen balance has been struck and hence the amount of undecomposed steam calculated. Comparing Ref.14 with the above chart, we then have :-

		Ref.14	Above Chart	
		kg/1000 NM^3	kg/1000 NM^3	% of component
"unaccounted for" :	C	4.9	4.9	1.05
	H	5.0	Nil (assumption)	
	Ash	33.3	33.3	15.9
	N	-	-10.5	
	S	28.0	28.0	
	H_2O	300.6	-	
	O	not given	7.9	0.9
Steam added + H_2O from grude		648.7	648.7	
Steam decomposed		345	222.3	
% steam decomposition		53%	34.4%	

2. The low value of "unaccounted for" oxygen, when a perfect H balance is assumed, indicates a satisfactory overall balance. The negative value of "unaccounted for" nitrogen does not arise entirely through neglecting N in grude: for balance 1.4% N in grude would be required, and it is unlikely to be so high. The high amount of "unaccounted for" S arises through neglecting the S content of dust and ashes.

3. The "unaccounted for" C and ash are presumably lost as dust passing the cyclones. Assuming the "unaccounted for" ash of 33.3 is correct and that dust has the analysis of cyclone dust, then this indicates that the multicyclones have an efficiency of $\frac{147.5}{147.5 + 33.3}$ or 81.6%, which is in good agreement with other information.

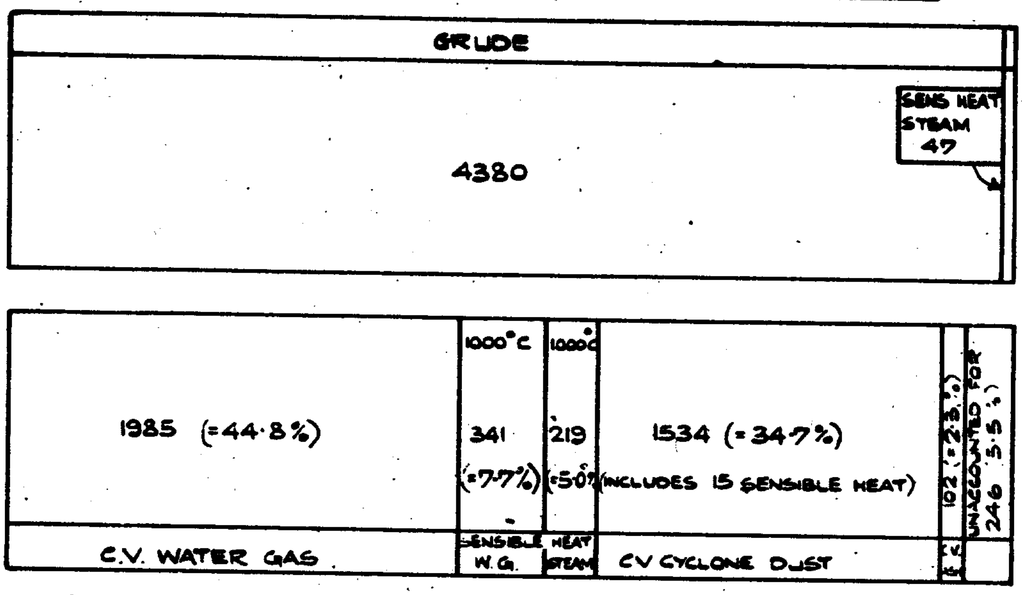
COMMENTS

The chart shows up clearly the poor carbon efficiency at Zeitz and the magnitude of the dust nuisance. The carbon efficiency, i.e. the percentage actually gasified, is 57% (Ref.14 from the same figures gives 49.25% and this error is repeated in Ref.3); the bulk of the ungasified carbon is blown over with the bulk of the ash as dust in the gas.

HEAT BALANCE AT ZEITZ

From the above data and Ref.14 the following heat balance of the generator itself (i.e. excluding waste heat boilers, etc.) has been drawn up for Zeitz :-

INGOING HEAT IN T. CALS/1000 NM^3 RAW WATER GAS.



OUTGOING HEAT

HEAT BALANCE AT ZEITZ.

The above quantities are expressed in T.cals/1000 NM^3 raw water gas, using net calorific values and expressing sensible heats above 0°C.

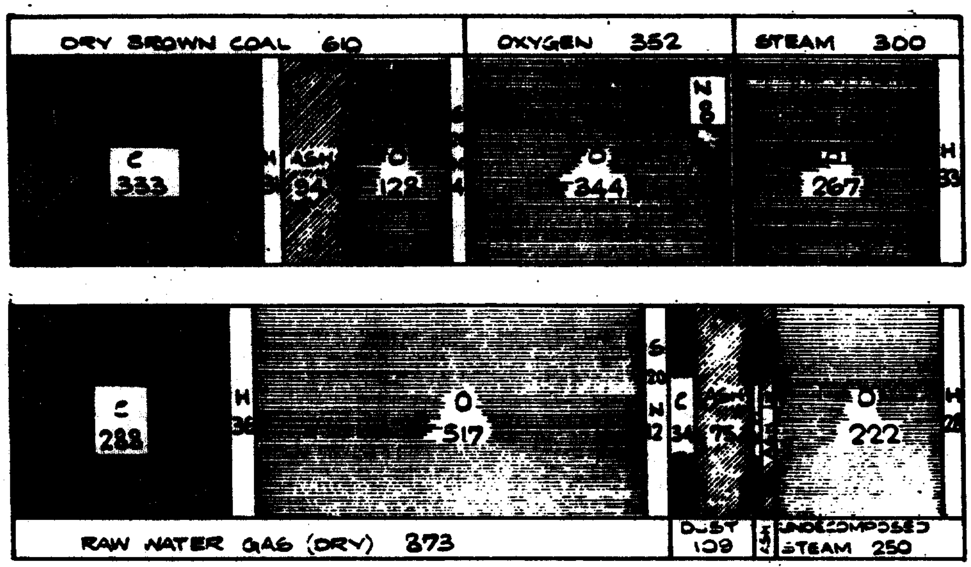
This chart shows much the same story as the material balance. The thermal efficiency of the generator itself (i.e. net c.v. of water gas divided by net c.v. of grude + sensible heat of steam) is 44.8%; the major inefficiency of 34.7% is as cyclone dust, whilst sensible heat of the water gas and steam at 1,000°C removes 12.7%. The "unaccounted for" loss of 5.5% has to cover c.v. of dust passing the multicyclones and losses by radiation, etc.

If all carbon in cyclone dust can be usefully recovered as a boiler fuel, then the net carbon efficiency is 93.5% and the net thermal efficiency is 70%, still however omitting waste heat recovery.

MATERIAL BALANCE AT LEUNA

The above balances for Zeitz, although representative of working at that plant, give a poor impression of the Winkler process; appreciably better efficiencies are obtained at Böhlen and even better at Leuna. Since we have available from Ref.10 the actual performance at Leuna over 12 months in 1935, material and heat balances are given below for Leuna, making water gas from dry brown coal. The output was relatively low, at 27,000 M^3/hr for a generator of 25 M^3 cross-sectional area.

INGOING MATERIAL IN KG/1000 NM³ RAW WATER GAS.



OUTGOING MATERIAL.

MATERIAL BALANCE AT LEUNA

NOTE:

1. The above balance is exactly as given in Ref.10. The perfect balance of each component indicates that certain items have been estimated by difference; however, the overall picture is probably very near truth.

2. Of the ingoing H in fuel, 25 kgs are as H and 6 kgs as H_2O (49 kgs).

COMMENTS

The picture presented here is very different from that given for Zeitz. The carbon efficiency, i.e. the percentage actually gasified, is 86.4% (of 57% at Zeitz). The carbon blown over as dust is only 34 kg/1000 NM³, as against 183 kg at Zeitz.

HEAT BALANCE AT LEUNA

Using slightly different data Ref 10 gives the following heat balance :-

INGOING HEAT IN T.CALS/1,000 NM^3 RAW WATER GAS

Dry Brown Coal
3100 +75.6 −280.7 XK

C.V. Water Gas	Sens. Heat W.G.+Steam	Dust+Ash	Losses etc.
2050 (66%)	420 (14%)	470 (15%)	160 (5%)

The thermal efficiency is 66% (compared with 44.8% at Zeitz), and dust and ash accounts for a loss of only 15% (compared with 37% at Zeitz.

If all carbon in cyclone dust can be usefully recovered as a boiler fuel, then the net carbon efficiency is 96% and the net thermal efficiency 74.5% (compared with 93.5% and 70% respectively at Zeitz). Thus so long as Zeitz can utilize the cyclone dust there is very little loss of carbon or thermal efficiency due to the high dust carry-over at Zeitz; however, such high dust carryover does necessitate more expensive equipment to deal with it.