MANUFACTURE OF POWER GAS

At Leuna a number of compressors of the ammonia synthesis plant have always been driven by gas engines, fired by producer gas. Since 1926 the producer gas or power gas has been made mostly on one of the large Winkler generators.

Since a high CH_4 content of power gas is not objectionable, and may even be desirable, dry brown coal has been the normal fuel used. Hydrogen is an undesirable constituent of power gas, since in excess it causes too violent explosions in the engines, so that the blast used has been air alone, sometimes with the addition of CO_2, but never with the addition of steam. The water and hydrogen content of the fuel of course are the source of a certain amount of hydrogen in power gas.

The method of working is very similar to that of making water gas; in fact one generator at Leuna acts as a common spare to one water gas and one power generator. The air blast is split into blast through the grate and secondary air above the fuel bed. The output of power gas from a large generator of 25 M^3 cross-sectional area is about 75,000 M^3/hr, which is somewhat greater than the output of water gas, 60,000 M^3/hr, from the same generator, since power gas does not carry with it any undecomposed steam.

Very complete data are available for Leuna for the whole of 1935 from Ref.10, and these are set out in Table V along with other published data. Figures in the first two columns, from Refs. 9 and 10 using dry brown coal, are in very good agreement, but published figures from Ref.9 using grude record too low a fuel consumption. The carbon utilization efficiency is about 82%.

The dust content of gases at Leuna is shown below, when working on dry brown coal :-

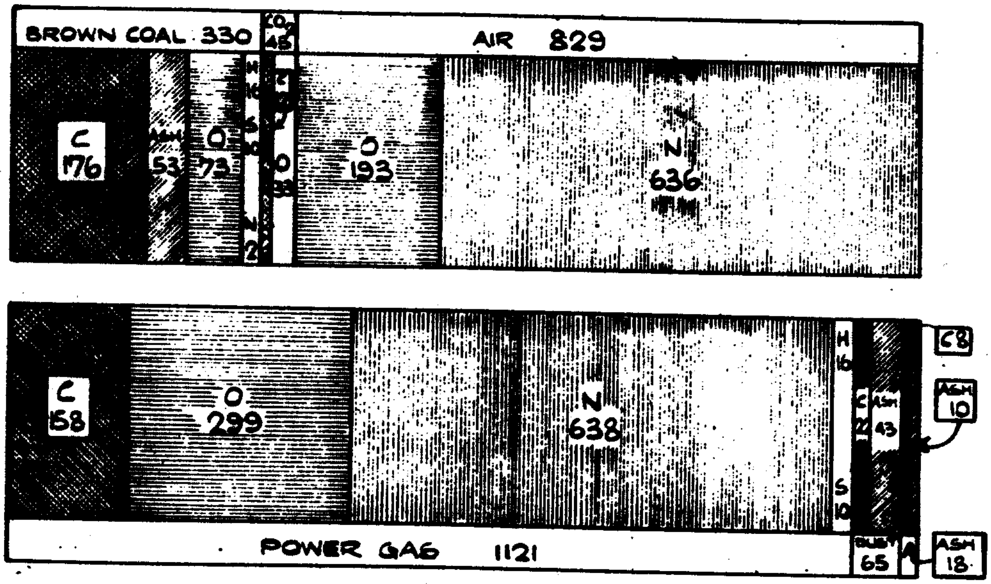
	Output M^3/hr.	Density Air = 1	Dust g/M^3
Water Gas			
(a) dry water gas	27,000	0.74	109
(b) water gas + undecomposed steam	36,000	0.72	81
Power Gas	50,000	0.91	65

At first sight it is difficult to see why power gas should contain less dust than water gas, since higher output and higher density would be expected to give more dust. However, evidently the main factor is the amount of fuel gasified, which controls the amount of fines brought in with fresh fuel and probably also the amount of fines resulting from attrition and gasification. Thus the percentages of dust in gas in terms of fuel used are 19.7% and 17.8% for producer gas and water gas respectively.

MATERIAL BALANCE AT LEUNA (Power Gas)

The following chart is based on Ref.10, giving the average for twelve months in 1935 :-

INGOING MATERIAL IN KG/1000 NM³ POWER GAS



OUTGOING MATERIAL

MATERIAL BALANCE AT LEUNA

NOTE:

Of the ingoing H in fuel, 13 kgs are as H and 3 kgs are as H_2O (26 kgs). Of the outgoing H in power gas, 12 kgs are as H and 4 kgs are as H_2O (35 kgs).

HEAT BALANCE AT LEUNA (Power Gas)

The following chart is also based on Ref.10, giving the average for 12 months in 1935 :-

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

Dry Brown Coal
1660

1000 (60%)	330 (20%)	260 (16%)	70 (4%)
C.V. Power Gas	Sensible Heat	Dust & Ashes	Loss

The thermal efficiency is thus about 60%.

MANUFACTURE OF AMMONIA SYNTHESIS GAS

The only direct data available is published in Ref.9. Oxygen enriched air with steam is used as the blast, and the efficiencies, etc. are those to be expected from combining data for water gas and producer gas, to give a mixed gas of the right composition.

USE OF FUELS OTHER THAN BROWN COAL

Obviously the Winkler generator becomes of much wider application if it can utilize fuels other than dry brown coal or grude. Here information is not nearly so reliable, since as far as we are aware no large generator has ever run very long on such fuels. Ref.1 states that I.G. designed large-scale plants in Japan to run on a grain size mineral coal of a particularly active character, but we know nothing of their operation.

Most of the experimental work has been carried out on a small generator (0.8 M^2 shaft area) at Oppau, and some on a small generator (2 M^2 shaft area) at Leuna. There are also references in the literature.

As stated before O_2-gasification is a relatively expensive way of gasifying a fuel and may become economic only with fuels which cannot be gasified conveniently in other ways. Examples, which have been considered, are bituminous coal dusts, especially those whose ash content is high or whose ash has a low softening point, and hard coke breeze. Nevertheless, since these fuels can in general be used as boiler fuels, perhaps at some discount, they will in general have an appreciably higher cost than brown coal, near the brown coal deposits.

All the fuels mentioned are appreciably less reactive than brown coal or grude, and to obtain reasonable outputs from a given generator it is necessary to work at higher temperatures; this means higher exit gas temperatures, higher oxygen consumptions, higher CO_2 contents of water gas and possibly troubles with clinker formation. Moreover, because of the lower reactivity it is more difficult to gasify any dust in the space above the fuel bed, and the secondary blast tends to react with the gas rather than with the dust.

It is probable that fuels like young gas coals and low-temperature coke breeze could be gasified successfully in Winkler generators, with efficiencies and outputs only somewhat less than with brown coal or grude, but such fuels are rarely cheap.

Ref.6 (p.12) states that hard coke breeze cannot be gasified in Winkler generators at Leuna. Ref.10 briefly describes tests in the experimental generator at Leuna in 1935. Certain brown coals were unsuitable because of low ash softening point and high proportion of soluble salts in the ash (see also below).

Earlier tests at Oppau are described in Ref.5. Short tests on an American bituminous coal (Old Ben Coal Corporation, Mine 8, Chicago) gave promising results. This coal is described as fairly reactive, not strongly caking. Crushed coal, "about the size of peas to hazelnuts, containing some dust" was fed by screw conveyor into the boiling bed of coke; the coal was quickly distributed in the bed and no caking occurred. No gas analyses are given.

MISCELLANEOUS POINTS OF INTEREST

Ref.10 describes difficulties arising from the high sand content of Elise coal, sand being the chief cause of variable ash content. Sand caused chokes in the stack-lines and valves; it also led to the formation of volatile silicon sulphide (cf. Chem.Fabrik 1935, p.512), which after decomposition gave rise to finely divided silica, which was able to pass through the disintegrators.

It is desirable to keep low the content of water-soluble salts in the ash; such salts tend to be volatile and give rise to slagging difficulties. Thus Ref.10 states that Elise coal had a total ash content of 20%, of which 10% was water-soluble; on the other hand a grude which gave considerable trouble with slagging had an ash content of 22%, of which 20% was water-soluble.

The use of blast preheaters has often been suggested, but as far as we are aware they have not been successfully applied to

Winkler generator so far, although attempts have been made at Leuna. On theoretical grounds one would expect that preheating the steam and oxygen mixture would reduce the oxygen requirements. According to Ref.6 preheating the blast to 400°C would save about 25% of the oxygen required with no preheating. The most economic way of preheating, from the point of view of running costs, would be to interchange the heat in the hot exit gases with the incoming blast, but the capital cost of such preheaters is likely to be high.

COMPARISON WITH OTHER PROCESSES FOR MAKING SYNTHESIS GAS

As stated before, the Winkler process has the great advantage of being able to use low-grade fuels, difficult to gasify in other ways, and this at once may give it a great local advantage. When, however, it is considered for coals which can be gasified in other ways or where it has to use fuels having enhanced value for other purposes, e.g. as a boiler fuel, then it becomes much less attractive.

The two great drawbacks to the Winkler process are its relatively poor thermal efficiency, which is no higher than that of a conventional coke water-gas generator, and the cost of oxygen. If fuel is at all expensive the poor carbon efficiency is a disadvantage, only partly mitigated if the dust can be collected and used as a boiler fuel. Even when made in modern Linde-Fränkl units oxygen is never cheap, and it is interesting that the I.G. consider (see Ref.6, p.10) that it is more expensive to use continuous oxygen-gasification of any fuel than to use a make and blow process with air, provided the same fuel can be got into a suitable form in both processes.

All processes using oxygen-gasification have an additional disadvantage in that any oxygen added must eventually appear as CO_2 in the synthesis gas; hence greater compression costs and water scrubbing costs are incurred to remove it, with corresponding increased capital costs.

Although the amount of gas produced per unit shaft area is relatively great (say 900 to 1,500 M^3/hr H_2 + CO/M^2, as compared with say 600 M^3/hr H_2 + CO/M^2 for make and blow coke water gas generators), and although the absence of distribution difficulties in a boiling bed enables very large units to be used (e.g. up to 50,000 M^3/hr H_2 + CO at Leuna, compared with say up to 8,000 M^3/hr H_2 + CO in the largest coke water gas generators), nevertheless all the auxiliary equipment required means that the output of Winkler generators per unit area of site is no greater than that of coke water gas generators. Thus at Böhlen and Zeitz the capacity of three generators was obtained for a site area of about 50 M^2 site /1,000 M^3/hr H_2 + CO installed capacity, including fuel handling, waste heat boilers, coolers, etc. but excluding the oxygen plant; the oxygen plant and its associated share of the boiler and power plant probably occupied an equal area. A coke water-gas plant, with all auxiliaries, would probably make the same amount of gas for a site area of about 40 to 60 M^2 site/1,000 M^3/hr

$H_2 + CO$ installed capacity. Moreover the large reaction space above the fuel bed, in terms of capital cost, largely offsets the advantage of a high output per unit area of grate.

CAPITAL COSTS

Available figures are of doubtful significance, but it is probably true to say that the capital cost of a Winkler plant, including oxygen plant, waste heat boilers, etc. is somewhat greater than that of a corresponding coke water gas plant, including coke ovens. The oxygen plant probably costs more than the Winkler plant it supplies.

PROCESS LABOUR AND MAINTENANCE COSTS

About four operators are required for each generator, but this depends to some extent on the size of generator. One man would be in the control cabin, which might however serve more than one generator, two men would be on waste heat boilers, dedusting and cooling equipment and dust handling, and one man on ash handling and miscellaneous labouring jobs. Labour additional to these four men would be required for fuel handling, especially if the preparation is done at the plant, and for machinery, such as oxygen blowers, boiler feedwater pumps, disintegrators, etc.

At Leuna in 1935 (Ref.10) 90 men and 11 chargehands were employed on the Winkler plant, running one power gas generator and one water gas generator. There would probably be one chargehand/shift for each generator and one for fuel handling, but if there were only four men/shift on each generator, this would leave about 60 men to cover fuel handling (but excluding drying) machinery, etc., as well as day labour; this figure seems excessive but it is not clear from the reference whether any maintenance labour is included. A rough figure for water gas might be taken as 0.4 man hours/1,000 M^3 $H_2 + CO$.

Also at Leuna over 1935 (Ref.10) maintenance costs for water gas averaged 1.75 RM/1,000 M^3 $H_2 + CO$, for an average output of 20,000 M^3/hr $H_2 + CO$. Maintenance costs for power gas averaged 0.46 RM/1,000 M^3 power gas, for an average output of 50,000 M^3/hr.