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THE LURGI CARBONIZER WITH GASIFICATION OF RESIDUE

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The Lurgi Carboniser developed for carbonisation of all types of non-caking coals and lignite in order to produce tar oils and a smokeless free burning coke for domestic heating with 10-15% volatiles, or a coke for industrial purposes with 2-3% volatiles, has proved very efficient in many big industrial plants. As far as industrial utilisation is concerned the coke is mostly used for the production of gas for heating or for chemical synthesis purposes. The rest is burned in power stations.

Lately a considerable interest has grown up to combine carbonisation of the fuel with complete gasification of the residue. By such combination the heat economy can be considerably improved and the cost of investment and of labor can be considerably lowered. For such combination the coke-cooling zone of the Lurgi-Carboniser had to be replaced by a gasification zone. Extended experience with gas producers of the rectangular type has been very helpful for developing the type of a rectangular carboniser-gas producer.

Recently, interest in a combined carboniser-gas producer has been shown by many power stations which have to work with fuels of high ash content and a relatively low melting point of the ash. In this case the efficiency of a boiler plant may be considerably reduced if fired with a pulverised fuel. With gas-fired boilers this difficulty can be eliminated and much better working conditions, reduced cost of investment, and an improved economy of power production can be expected.

The latest development in this line, however, seems to end in power production by gas-turbines, which would raise the consumption of gas considerably.

Until now, gas producers for gasification of lumpy coal have been of the rotating grate type, with a maximum diameter of 12 feet and not exceeding 50 tons per day capacity per unit for uniformly sized fuel having ash of a relatively high melting point. Recovery of oils is not feasible with such a producer.

With the principle of a rectangular shaft such as that on the Lurgi carboniser, subdivided for an equal and controlled distribution and movement of the coal and the gases, the capacity per unit can be increased considerably. The normal carboniser with 2 shafts of 16 m^2 (277 sq. ft.) each has a cross section 3.2 times larger than that of a 3.5 m (12 ft.) cylindric producer. Furthermore, it was possible to utilise in the rectangular carboniser the system of gasifying downwards in the direction of the flow of the coal. In this way the throughput of the small gas producers has been increased considerably. This principle of construction allowed the building of a carboniser-gas-producer-unit for capacities of 150-200 tons of bituminous coal per day, equal to 200-300 tons of sub-bituminous coal or lignite with 10-25% moisture content.

As in a normal carbonizer plant the charge and the discharge of the units are fully automatic. The coal is dried and preheated before entering the carbonising zone, which allows recovery of oils and phenol with a minimum of gas and a minimum of waste water to be treated. The residue of carbonization is gasified in a separate zone. In this way the greatest part of the gas is produced nearly free of hydrocarbons and sulphur and needs only a

very moderate amount of cleaning for utilisation in a synthetic process. For power stations it can profitably be used without any cooling or cleaning.

By gasifying with concentrated or pure oxygen, any gas as required for the synthesis of hydrocarbons or ammonia can be produced. The gas from the carbonising zone which contains all the hydrocarbons can be used directly as a high grade heating gas or it can easily be cracked into a mixture of hydrogen and carbonmonoxide for synthetic purposes.

The scheme of construction and processing of the combined carboniser-gas producer is shown on Sketch 1. It operates as follows:

The fuel, suitably screened (to size limits 1 to 4), is dropped into Storage bin, 4, which in its lower part contains the usual device for drying with circulating gas. The preheated material then passes through the shaft, 2, into the carbonising zone, 3. Here it is carbonised by a circulating flow of distillation gas entering with a temperature of 600 to 900 centigrade at the nozzles, 8, and leaving with a temperature of about 200 centigrade through the pipe, 14. In the usual equipment, 15, suitable for gas cleaning and cooling, oils and benzine are extracted from the gas. After passing a fan, 16, the main part of the gas is heated in the heat-exchanger, 17, and returns to the carbonising zone passing through the combustion chamber, 18, in which its temperature is regulated as desired by means of a partial combustion with air. Oxygen may be used if a high grade gas is required.

The carbonised fuel enters through a narrow opening into the gasification zone, 5. Here air is introduced into the fuel bed from the channel formed underneath the support, 9, which is watercooled to prevent its

burning. A second flow of oxygen, saturated with steam, enters through the channel, 11, in order to complete gasification of the rest of the carbon under conditions which prevent heavy clinkering of the ash. The gas produced in zone, 5, leaves through the pipe, 20, with a temperature of 500 to 700° centigrade, and after passing the heat exchanger, 17, it goes to consumption in a furnace or may be used for synthesis after an adequate cleaning.

The fuel bed is supported at the bottom of the shafts by a table, 10. Upon this table an iron bar is mounted that is movable to both sides by a mechanical gear, 12. By altering the movement and speed of this bar, the throughput of coal and the extraction of ash is regulated. The ash is dropped from the table into the ash chamber, 6, from which it is discharged by a sluice, 13, or through a water seal.

The surplus gas from the carbonizing zone has a calorific value of 1800 to 2500 kcal/m^3 when air is used in combustion chamber, 18, and of 4000-4500 Kcal/m^3 after washing with water when oxygen is used. It may be utilized separately or it may be cracked by partial combustion with oxygen in the cracking chamber, 19, after preheating it in the heat-exchanger, 17. If only heating gas is required carbonization and gasification take place with air. The heating of the carbonizing zone can be simplified in this latter case by sucking part of the hot producer gas directly upwards into the carbonizing zone.

The method of gasifying solid fuels, as described above, permits a good recovery of by-products and a separate treatment and recovery of the distillation gas and it allows, at the same time, the gasification of most of the fixed carbon in the fuel with the use of very little or no steam. In this

way, a gas of a relatively high content of carbonmonoxide, as required for some synthetic processes, is produced. For heating purposes, a reduced consumption of steam may decrease the production cost considerably.

In many cases coals and lignites with a high content of oil, but also a high content of ash and moisture, can be mined so cheaply that they can be considered as a very cheap fuel for industrial heating, chemical synthesis and power stations as well as for the production of oils. Combined carbonization and gasification opens a way for utilizing such fuels on a big scale.

With an industrial plant, operated with a high volatile sub-bituminous coal and with only one type of carbonizer-gas producer, practically all types of industrial gases can be produced that are required for heating, synthesis, and city gas. Even a wide variation of the quantity and the quality of the products, according to the actual market, is possible within short intervals.

The most important figures of the operation and the efficiency of the carbonizer-gas producer for a medium sub-bituminous coal are the following:

A. Coal: Size: 1/4 to 1" or 1 to 3" or briquette

Moisture	10%
Tar (Fischer Ass.)	10%
Ash	12%
High cal. value	5800 kcal/kg 10440 BTU/lb

B. Thermal efficiency of the process

$$y = \frac{\text{high cal. val. (Tar + dist. gas + prod. gas)}}{\text{high cal. val. of coal}} = 80\%$$

$$= 4640 \text{ kcal/kg}$$
$$= 8350 \text{ BTU/lb}$$

C. Recovery of tar incl. Light Oils

92% of Fischer assay

0.092 Kg/kg = 0.092. 9600 = 883 kcal/kg coal
3500 BTU/kg coal

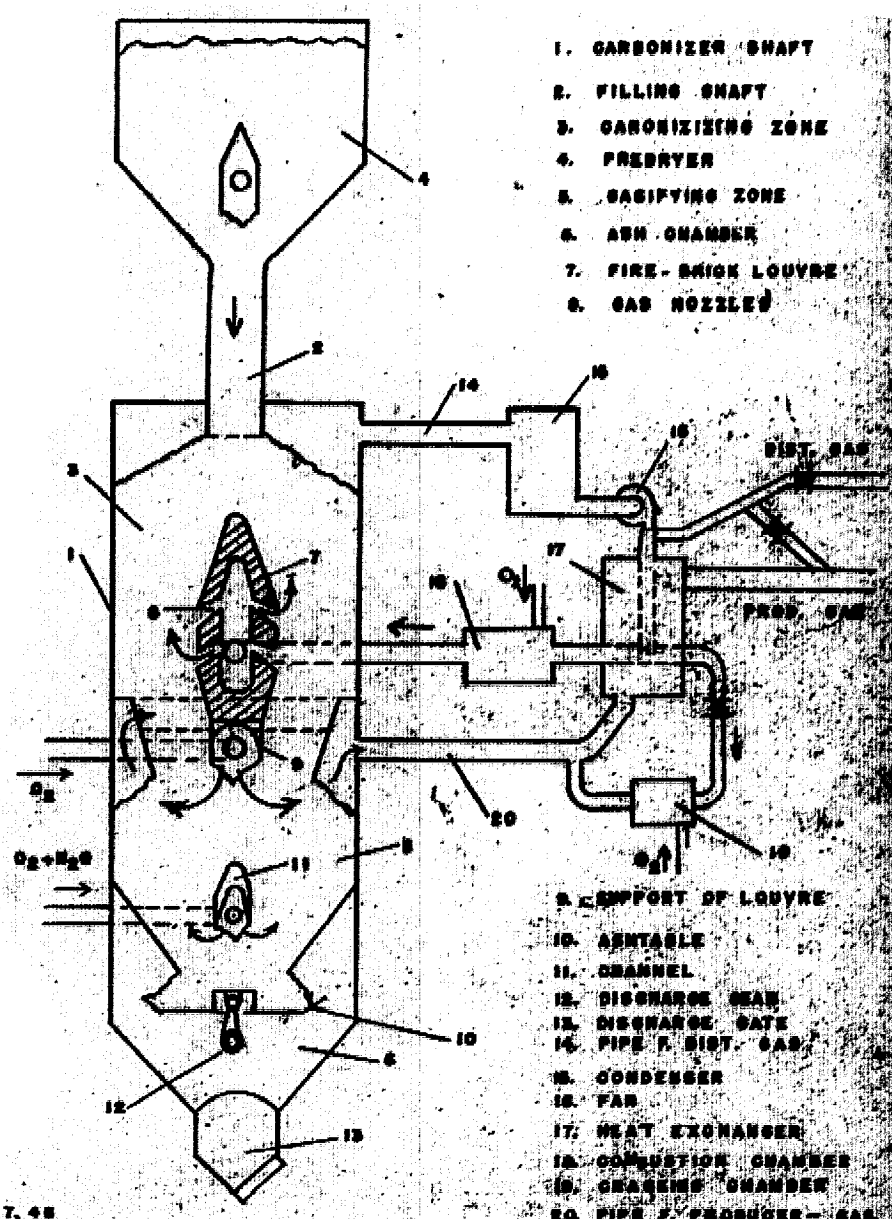
D. Quality of gas with variant operating conditions

	Operated with:	AIR	95% OXYGEN	
			Raw	Washed
	Nm^3/kg	0.27	0.19	0.172
	CO_2 %	12.0	18.0	2.0
Distillation gas	C_nH_m %	0.6	1.0	1.1
	O_2%	0.1	0.1	0.1
	CO%	18.3	27.9	33.4
	H_2%	24.0	36.5	43.6
	CH_4%	10.0	15.5	18.6
	N_2%	35.0	1.0	1.2
	high val. kcal/nm^3	2325 (243)*	3586 (377)*	4270 (448)*
	Nm^3/kg	2.62	1.2	1.07
	CO %	9.0	15.0	2.0
Producer-gas	O_2 %	0.1	0.1	0.1
	CO %	21.8	38.2	43.9
	H_2 %	17.0	45.0	52.1
	CH_4%	0.1	0.2	0.2
	N_2%	52.0	1.5	1.7
	high val. kcal/nm^3	1188 (125)*	2544 (267)*	2839 (297)*

* (- -) BTU/cu.ft. 60°F 30" moist

A gas for the synthesis of ammonia can be produced with a 40% Oxygen-concentration.

Annexed table shows the operating conditions in connection with various industrial utilisations of the gases. Many types of manufacturing can be combined according to the conditions of the market. Five types of gas, each being variable in its contents of Nitrogen, Hydrogen, Carbonmonoxide and in its heating value according to the momentary demand of consumers, are available from the two zones of the Carboniser Gas producer. Variations in composition can be made within a few hours. Even a temporary production of coke is possible by shutting down the gasifying zone.



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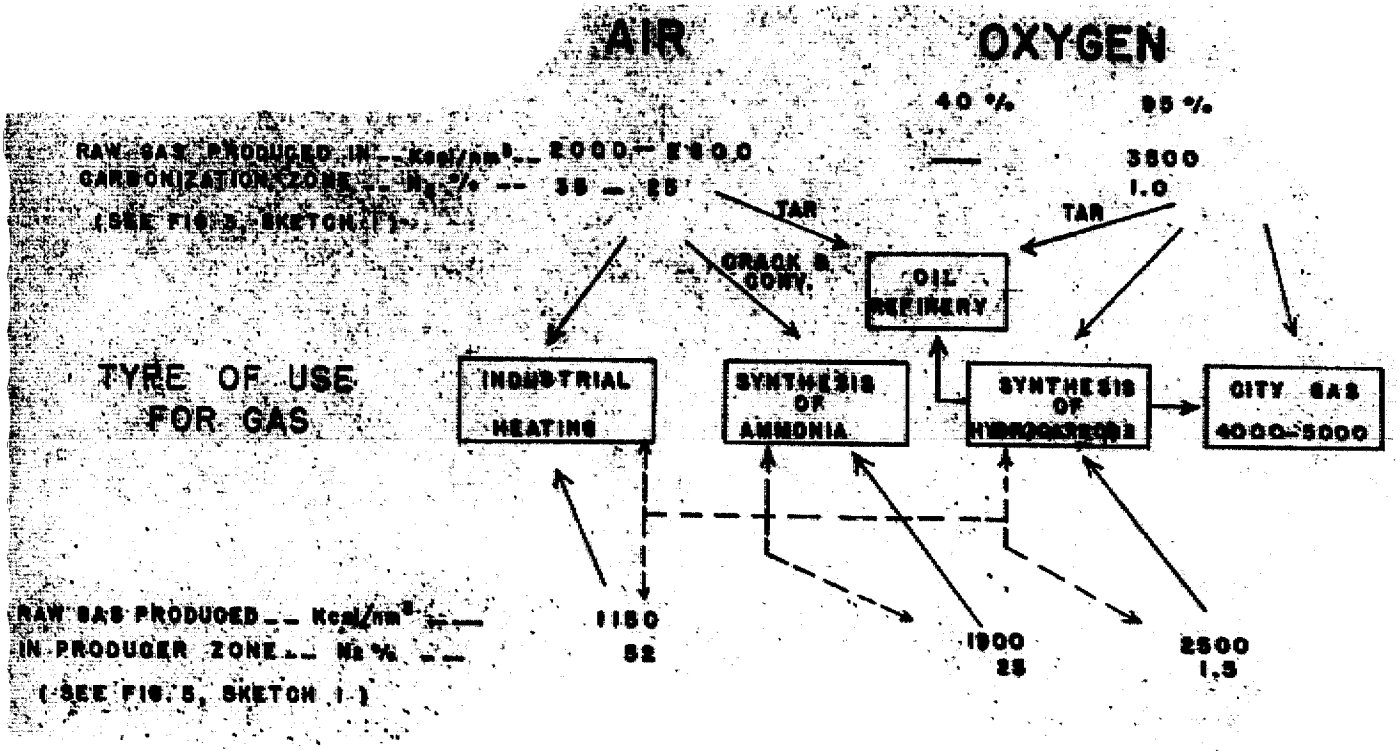
LURGI CARBONIZER—GAS PRODUCER



UTILIZATION OF CARBONIZER — GAS PRODUCER GAS FOR VARIOUS INDUSTRIES