Fiat 425

C. 1-A

U. S. GROUP CONTROL COUNCIL

GERMANY.

OFFICE OF THE DIRECTOR OF INTELLIGENCE

# Gasification of Brown-Coal Briquettes in Pintsch-Hillebrand Water-Gas Generators at Wesseling, Germany.


Reported by:-

IRVIN H. JONES (U.S.)


REPORT ON INVESTIGATION BY THE
TECHNICAL INDUSTRIAL INTELLIGENCE COMMITTEE


Prepared by Direction of

FIELD INFORMATION AGENCY, TECHNICAL ([illegible])

USFET (Main)

APO 757

NEW YORK, N. Y.


Date of Trip:- October 9 - 10, 1945.

# TABLE OF CONTENTS.



Personnel of Team:-

IRVIN H. JONES (U.S.)

# GASIFICATION OF BROWN-COAL BRIQUETTES IN PINTSCH-HILLEBRAND WATER-GAS GENERATORS AT WESSELING, GERMANY

## GENERAL

The first large installation of Pintsch-Hillebrand Water-Gas Generators was made at the plant of the Union Rheinische Braunkohlen Kraftstoff A.G., at Wesseling, Germany. This plant was visited between March 10 - 12, 1945, inclusive, by a Team of the Combined Intelligence Objectives Sub-committee and the present reporter was a member of that Team. Reference is here made to CIOS Report XXVIII - 40 describing operations at the Wesseling plant.

For the purpose of obtaining more detailed information relative to the general construction of the Pintsch-Hillebrand generators and especially the type of refractories employed at divers points in their construction, the reporter again visited the Wesseling installation on October 9 - 10, at which time Dr. Ernst Peukert and more particularly Dipl. Ing. Erwin Rose were interrogated, the latter having years' long experience in the operation and development of this novel type of water-gas generator; he had been formerly employed by Julius Pintsch of Berlin, and was in charge of construction of the Wesseling installation and remained there as Superintendent of their gasification operations.

## PROPERTIES OF SOLID FUELS ADAPTED FOR USE IN PINTSCH-HILLEBRAND GENERATORS.

During the course of the interrogation, Rose emphasized that these water-gas generators were developed especially for employing brown-coal briquettes formed from such brown coals as have an ash which will not exhibit incipient fusion below about 1290° - 1300°C. This was stressed as a most important criterion for determining whether to choose the Pintsch-Hillebrand type of water-gas generators for operation on a specific brown-coal. Also the lump size or shape of the employed briquettes must be relatively uniform to avoid channeling of the employed Wälzgas. In addition, the briquettes must exhibit a good resistance to rupture; their "Druckfeatigkeit" must be not less than about 140 kg and preferably 180 kg/cm$^2$. In form, they should preferably be cylindrical in ~~shape, their diameters being about 1.5 times their height which~~ is about 1.75 inches. Successfully employed has been that briquette-product having the shape known in Germany as "Industrie Form". All these requirements must be rigidly observed otherwise this type of water-gas generator is uneconomical of use doubtless in consequence of the features around which it is constructed.

## TECHNICAL FEATURES OF THE GENERATOR, ETC.

Inside the generator, there are no moving parts and the gasification process depends for its necessary heat entirely on the sensible heat that is carried by a Wälzgas. In the event of such channeling therefore as can develope when the fuel is of heterogenous sizes, by creating zones of unequal resistance to gas-flow through different fuel-bed portions, there are no mechanical means for agitation to alleviate the condition and charged fuel could pass through the gasification zone of the water-gas set without being gasified. Obviously, a coking or caking coal could not be employed. In consequence of the fact that the sole source of gasification heat resides in the sensible-heat carried by a Walzgas too low a fusion point of the coal-ash would limit the effective heat carried by a given volume of the Wälzgas. It was stated that if the ash of a given coal cannot withstand a temperature of about 1300°C without becoming tacky, such coal is uneconomical of use in this type of generator and another design of apparatus and type of process should be chosen for its use. This will be more clearly appreciated when it is realized that in the method of gasification employed in these generators, the highly-preheated Walzgas is first introduced into the generator fuel-bed through a peripheral ring-grate which also accomodates passage of the coal-ash as it flows downwardly into the ash-discharging means; if the coal-ash therefore exhibits a tendency to fuse or to adhere to the ceramics forming the grate-openings and to restrict them, not only is the down-flow of coal impeded but also the inflow of Walzgas into the gasification section of the generator.

Dipl.Ing.Rose said that the fusion-point of the coal-ash is normally determined by the well-known Baum Test but that an empirical control-test was used at Wesseling and found satisfactory for plant work. This test comprised igniting a quantity of the ash in an open crucible in a muffle-oven wherein the temperature is periodically increased by small amounts and held constant for a time. If the ash remains relatively powdery at about 1300°C, the briquettes from which it is derived, if they are adequately resistant to breakage, are considered satisfactory for use. Although this test does not provide the reducing atmosphere encountered in actual practice, the results obtained by its use are close enough to be determinative for operational purposes.

The composition of the ash of the Rhineland brown-coals employed at Wesseling is given as follows in a volume entitled "Braunkohlen Anhaltszahlen", 4-Ausgabe (1934) published by the Rhenische Braunkohle Syndikat, Köln:-

Ash of the Rhineland Brown Coals.

a) Composition in Percent.

| $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | Sulfate |
|---|---|---|---|---|---|
| 6 | 15 | 5 | 50 | 4 | 20 |

b) Fusion Point of the Ash - 1300°C.

Resistance to Rupture of the Brown-Coal Briquettes - 140-180 Kg/cm$^2$.

The briquettes are formed by drying the raw coal to a moisture content between 13-14% by wt., and then compressing the dried coal without added binder at a pressure of about 1500 atm. They are then sufficiently strong for use in the Pintsch-Hillebrand generators.

CONSTRUCTIONAL FEATURES OF THE GENERATOR

As is shown in drawings of the herein-above-mentioned CIOS report, the Pintsch-Hillebrand water-gas generators comprise:-

a. - A low-temperature distillation zone for the charged briquettes;

b. - A gasification zone (generator) for the residual briquettes of the above distillation;

c. - A combustion zone for burning producer-gas and pre-heating regenerators;

d. - A regenerator structure divided into two alternately-operative halves;

all said structural features being disposed the one above the other in the stated sequence. The zones (a) and (b) have separate off-takes for the make-gas and tar.

The distillation zone (a) is about 9.25 feet in diameter exclusive of brickwork; its lower walls are formed of Sicromal shaped as a tube that extends downwardly into the gasification zone (the actual water-gas generator) for a distance about one-third the latter's height. This tube, or insert, serves both to support charged briquettes in the distillation zone at a considerable height above the gasification zone during their distillation and so to direct their flow from the former into the latter as to restrict them to a relatively thin bed providing a relatively high and large gas-space thereabove in said gasification zone.

The gasification zone (b), that is, the water-gas generator itself, is nearly 20 feet in diameter exclusive of brick-work. From the ring-grate, that is formed as a peripheral annulus, to the start of its crown, the gasification zone is about 12.6 feet high. The greater part of the bottom-surface of the gasification - zone is shaped as a stationary truncated cone that is formed of masonry; its top is about 8.4 feet above the level of the ring-grate and has a diameter of substantially 5 feet. The diameter of the base of said cone is 14.7 feet. The sides of the cone thus direct the briquettes being gasified, in their downward flow-path, outwardly toward the ring-grate through which the Wälzgas is introduced into the gasification zone and also through which the ashy residues is withdrawn into a stationary water-sealed annular ash-receiver that is equipped with a rotatable shovel which continuously lifts it over the receiver's outer edge to disposal means.

The ring-grate that is as aforesaid, located at the lower outer periphery of the gasification zone has openings formed by spaced refractory members; the Wälzgas is delivered into said zone through said openings from a circular conduct directly therebeneath which communicates by a plurality of horizontal ducts with the combustion zone (c) which in turn is in direct communication with the regenerators (d); these horizontal ducts so communicate with the combustion-zone that they can all be supplied simultaneously with regeneratively-preheated Wälzgas.

The so-called combustion-zone (c) is formed as a vertically-disposed cylinder and it communicably connects the regenerators beneath with the gas generator. Its over-all diameter, which is considerably less than that of the gasification - or the regenerator-zone, is about $9\frac{1}{4}$ feet and it is 18.4 feet in height to the base of its crown-arch which also forms a part of the support for the above said truncated refractory cone located in the gas-generator section. A division wall disposed along a diameter of this combustion shaft extends upwardly about three-quarters of its height, thereby dividing it into two substantially semi-circular shafts that are interconnected at their tops in hair-pin fashion and they are each thus in communication with all the ducts supplying the entire ring-grate, so that the same can be supplied optionally with Wälzgas preheated in either of those regenerator-sets that individually communicate with one or the other of the semi-circular combustion shafts. This division wall is in effect structurally a vertical extension of a similar wall that also divides the regenerator-space therebeneath also into two-semi-circular halves. This combustion-zone is employed for the combustion of producer-gas whereby the regenerator brick-work and checker-bricks are alternately preheated. Its combustion-products always flow downwardly through the combustion-zone and through the associated regenerators during the latter's preheating period and are not allowed to enter the gasification zone, otherwise they would introduce nitrogen into the produced water-gas. This is prevented by always carrying a slightly higher pressure in the up-flow (Wälzgas) regenerators than in the down-flow ones. Producer-gas and adjacent air-nozzles are supplied in the walls of each semi-circular combustion-shaft, and valve means supply these gases simultaneously from a source therefore to each said shaft in alternation.

The regenerator structure is circular. It has an over-all diameter of about $23\frac{1}{4}$ feet and a height of $24^{3}/_{4}$ feet including the sole-flues. It is operatively divided, as above indicated, into two halves or semi-circular regenerators each of which is further divided into three equal sections by radially-disposed walls, and all three of these sections of a regenerator-half communicate with the lower part of one of said semi-circular combustion-shafts by individual ports. The two so-formed semi-circular regenerators are operatively disposed by means of appropriate supply-pipes and outlet-pipes, and valves alternately to function as down-flow regenerators when they are preheated by combustion-products flowing from the combustion zone and as up-flow regenerators for preheating Wälzgas when the same is flowing into the gasification zone. Usually the gaseous flow is reversed every 15 minutes. As previously indicated, there are no valve means for separating the two semi-circular combustion-shafts from each other during their alternate operations of carrying combustion-products to the regenerators and Wälzgas to the gasification zone, ~~both~~ operations being continuously in progress simultaneously. By means of an appropriate pressure maintained in the upper part of the hair-pin portion of the combustion-shaft a small amount of Wälzgas is continuously bled into the down-flow combustion-products thereby preventing their entering the gasification zone.

The ring shaped piping that serves both for introducing Wälzgas into the regenerator sole-flues and for carrying away combustion-products therefrom is divided into two half-rings by means of two mechanically-operated Wälzgas valves and of two combustion-products valves whereby, according to their positions, one ring-half can be placed in communication with that pipe containing Wälzgas under pressure while the other ring-half is connected with the combustion-products stack.

The masonry of the gasification zone of the Pintsch-Hillebrand generator is contained in a metallic shell that is suspended at its upper part at points immediately below its cover by bracket members. The stationary ash-receiver is supported on a separate platform therebelow and its inner-wall is in gas-tight contact with the metallic shell also provided for the combustion-zone. The total expansion of the shell for both the regenerators and the combustion-zone is compensated for by an expansion member positioned adjacent the lower part of the latter and just above the annular cover-plate for the regenerators. An expansion member in the piping between the gasification chamber and its waste-heat boiler is also provided and ~~the piping is resiliently supported.~~ Expansion joints permit the masonry walls of the combustion-zone and the regenerators to expand vertically independently of the masonry of the gasification zone and of the crown-arch of the former, said crown-arch being structurally integral with the masonry of the bottom of the gasification space.

## REFRACTORIES EMPLOYED AT DIVERS POINTS IN THE PINTSCH-HILLEBRAND WATER-GAS GENERATORS AND THEIR PROPERTIES.

| Location | Name of Refractory | Composition | Seger Cone | Resistance to Load. At °C | Resistance to Load. Amount |
|---|---|---|---|---|---|
| 1. Regenerator Sole Flues | Chamotte B4 | Less than 30% $Al_2O_3$ | 28/29 | 1200-1250 | 2 kg/cm² |
| 2. Lower Half Regenerator Walls | Chamotte A5 | About 30% $Al_2O_3$ | 30/31 | 1300-1520 | 2 kg/cm² |
| 3. Upper Half of Regenerator Walls & Lining of Combustion Zone | Silica | About 94.5% $SiO_2$ | 32/33 | 1630 | 2 kg/cm² |
| 4. Crown-Arch of Combustion Zone & Inner part of ducts therefrom to Ring-Grate | P.T.22 | About 90% $SiO_2$ | 33 | 1450-1500 | 2 Kg/cm² |
| 5. Exterior Brick Tiers of Combustion Zone | Porous Silica Bricks. | - | 32 | 1550 | 1 kg/cm² |

REFRACTORIES EMPLOYED AT DIVERS POINTS IN THE PINTSCH-HILDEBRAND WATER-GAS GENERATORS AND THEIR PROPERTIES. (Contd)

| Location | Name of Refractory | Composition | Seger Cone | Resistance to Load: At °C | Resistance to Load: Amount |
|---|---|---|---|---|---|
| 6. Intermediate Brick Tiers of Ring-Grate | Alumanit | 80% $Al_2O_3$ | 40 | 1550 | 2 kg/cm$^2$ |
| 7. Top & Bottom Brick Tiers of Ring-Grate & Fuel Gas & Air Nozzle-Bricks of Combustion Zone | Sillimanite | About 60% $Al_2O_3$ | 38 | 1650-1700 | 2 kg/cm$^2$ |
| 8. Interior of Central Cone of Gasification Zone. | Porous Chamotte | Under 30% $Al_2O_3$ | 30 | 1250-1470 | 2 kg/cm$^2$ |
| 9. Outer Brick Tiers of Central Cone and Lower Portion of Walls of gasification Chamber | Chamotte a5 | A bout 30% $Al_2O_3$ | 30/31 | 1360-1520 | 2 kg/cm$^2$ |
| 10. Upper Brick Tiers & crown of Gasification Chamber | Chamotte B4 | Under 30% $Al_2O_3$ | 28/29 | 1250 | 2 kg/cm$^2$ |

## OPERATING RESULTS

A. Quantities per Generator

1. - Briquette Through-put:- 71,180 kg/24 hrs = 2966 kg/hr.

2. - Produced Water-Gas:- 5,500 $Nm^3hr$ (0°C; 760 mm Hg) = 1.85 $Nm^3$ /kg.Briquettes

3. - Wälzgas :- 3850 $Nm^3h$ = 1.30 $Nm^3$/kg. Briquettes.

4. - Underfiring:-

   a. - Producer Gas - 3,100 $Nm^3/h$ = 1.04 $Nm^3kg$. Briquettes

   b. - Air :- 6,800 $Nm^3/h$ = 2.29 $Nm^3/kg$ "

5. - Saturation Steam:-
   Contained in Wälzgas from evaporation of
   Water in the Saturator:-
   1,475 Kg/h = 0.5 kg/kg Briquettes

6. - Steam Additions:-
   To Wälzgas

   a. - From Waste-Heat Boiler at 2 atm - 75%
   b. - " Power Plant 25%

   Total :- 3,100 Kg/h = 1.04 kg/kg Briquettes

7. - Total added Steam to Wälzgas
   at inlet to Regenerators = 4,575 kg/hr or
   1,54 kg/kg Briquettes

## ANALYSES OF GASES

| | $CO_2$ | CmHn | CO | $H_2$ | $CH_4$ | $N_2$ | Net Heating Value |
|---|---|---|---|---|---|---|---|
| 1. - Watergas | 13.7 | 0.0 | 28.2 | 55.9 | 1.4 | 0.8 | 2408 |
| 2. - Wälzgas | 16.4 | 0.6 | 26.8 | 50.4 | 5.0 | 0.8 | 2634 |
| 3. - Schwelgas | 17.3 | 0.8 | 26.4 | 48.5 | 6.2 | 0.8 | 2710 |
| ~~4. - Producer~~ Gas | ~~5.9~~ | ~~0.3~~ | ~~38.9~~ | ~~7.1~~ | ~~1.6~~ | ~~46.2~~ | ~~1544~~ |

## OPERATING TEMPERATURES

| | | | |
|---|---|---|---|
| 1. - Wälzgas:- | Inlet Generator | | 1270°C |
| 2. - Klargas:- | Outlet " | | 705°C |
| 3. - " | " | Waste-Heat Boiler | 240°C |
| 4. - " | " | Saturator | 72°C |
| 5. - " | " | Dust Separator | 68°C |
| 6. - Schwelgas | " | Schwel Zone | 92°C |
| 7. - " | " | Tar Separator | 84°C |
| 8. - Wälzgas | " | Blower | 72°C |
| 9. - " | Inlet to Regenerator after addition of 2 atü steam, about | | 100°C |

The propertion of Schwelgas and Klargas in Wälzgas is

a. - Klargas 25% and
b. - Schwelgas 75% ;

Therefore, since the Total Wälzgas employed per kg. Briquettes is 1.30 $Nm^3$, there enters the generator per kg treated briquettes,

a. - 0.325 $Nm^3$ Klargas and
b. - 0.975 " Schwelgas.

Since in the low-temperature distillation zone of the generator at a temperature of 650°C, the total gas yield is 0.174 $Nm^3$/kg briquettes, there consequently enters the low-temperature distillation zone from the gasification zone 0.975 - 0.174 = 0.801 $Nm^3$ Klargas/kg Briquettes treated. This functions in effect as a Spülgas. The total quantity of Klargas leaving the generator's gasification zone is therefore

| | |
|---|---|
| 1.85 $Nm^3$ | Watergas |
| 0.325 " | Klar and Wälzgas |
| 0.801 " | Spülgas |
| 2.976 $Nm^3$/ | Kg. Briquettes Treated. |

In order to effect adequate distillation of the briquettes, a temperature of about 90°C must be maintained at the outlet of the low-temperature distillation zone. The amount of Spülgas directed therethrough depends on the water content of the briquettes, which is normally 15% and the volume of Schwelgas varies accordingly. Since for a desired through-put the quantity of Wälzgas must remain constant, the proportion of Klargas and Schwelgas in the Wälzgas varies

for Klargas between 40% to 15%, and
" Schwelgas " 60% to 85%.

In the producer-gas plant employed to furnish the fuel-gas for preheating the regenerators of the water-gas generators, the through-put of briquettes per producer is 30 tons/24 hours when adding steam to the air-blast and is 38 tons/24 hours when adding $CO_2$ to the blast. The producer-gas yield is 2.3 $Nm^3$/kg briquettes.

Engineering Drawings:-

In series G, reel 13, of Microfilms taken by the Liquid Fuels and Lubricants Group there will be found copies of the following drawings:-

Item 57, Partial Elevational View and Partial Vertical Section through the Pintsch-Hillebrand Water-Gas Generators at Wesseling, Germany, showing Construction and Support of the Generator Shell and the Arrangement of the Brick-Work; and

Item 58, Partial Plan View of Top of Regenerators and Gas-Piping and Partial Horizontal Sections through the Regenerator Brick-Work of the above Pintsch-Hillebrand Water-Gas Generators.

These Microfilms have been deposited with the Secretary of Interior, Interior Building, Washington 25, D. C. and also with the Ministry of Fuel andPower, London, England.