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Solid Fuels 46

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Thyssen'sche Gas und Wasserwerke G. M. B. H.
Duisberg-Hamborn
Krupp Treipstoffwerk
Wanne-Eickel

Newman, L. L.

RESTRICTED

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

THYSSEN'SCHE GAS UND WASSERWERKE G.m.b.H
DUSIBURG-HAMBORN
DUISBURG-HAMBORN

and

KRUPP TREIBSTOFFWERK, WANNE-EICKEL
THYSSEN-GALOCSY GAS PRODUCER

Reported by

L.L. NEWMAN, TIIC

On Behalf of U. S. Technical Industrial
Intelligence Committee

[1945]

CIOS Target Numbers 30/118 & 30/159

Fuels and Lubricants

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE,
G-2 Division, SHAEF (Rear) APO 413

16 p. diagr.

RESTRICTED

TABLE OF CONTENTS

THYSSEN'SCHE GAS UND WASSERWERKE G.m.b.H.
DUISBURG-HAMBORN
and
KRUPP TREIBSTOFFWERK, WANNE-EICKEL
THYSSEN-GALOCSY GAS PRODUCER

Summary:

The Thyssen'sche Gas and Wasserwerke at Duisburg-Hamborn and the Krupp Treibstoffswerk at Wanne-Eickel are considered a single target for the purpose of reporting the information secured on the Thyssen-Galocsy Slagging Gas Producer Process.

The following were members of the team:

Mr. L. L. Newman (American)
Dr. H. J. Rose (American)
Dr. E. T. Wilkins (British)

The Germans interviewed were:

Dr. A. Rettenmaier)Thyssen'sche Gas und
Mach. Ing. Albert Breisig)Wasserwerke, Duisburg-Hamborn

Dipl. Ing. Erich Combles
Gen. Mgr. Wanne-Eickel Plant

Visits were made to Duisburg-Hamborn on June 28, 1945 by Dr. Rose and Mr. Newman, and on July 2, 1945 by Dr. Wilkins and Mr. Newman. A visit to Wanne-Eickel was made on July 2, 1945 by Drs. Rose and Wilkins and Mr. Newman.

This report presents the statement made by Dr. Rettenmaier and Ing. Breisig and includes a sectional drawing of the generator. Appended are (1) a statement (supplied in English) of the Thyssen-Galocsy Process, and (2) a Preliminary Report on the Thyssen-Galocsy Plant at Wanne-Eickel (Translated from the German by Lieut. Young, NAVTECMISEU).

All of the available figures are presented without change. No attempt was made to check the claimed

efficiencies and percentages of steam decomposition, nor have any calculations been made on the rate of gasification. The previously published data on the Thyssen-Galocsy Process are not available for comparison with the results presented to this investigating group. It appears, however, that the gas composition is about as previously reported, but that the oxygen consumption - which is one of the major factors in the cost of production - is approximately 50% higher than mentioned in any of the reviews.

THYSSEN'SCHE GAS UND WASSERWERKE G.m.b.H.
DUISBURG-HAMBORN
THYSSEN-GALOCSY SLAGGING GAS PRODUCER

Introduction.

Almost every review of German complete gasification processes, particularly those in which oxygen is used for the continuous production of water gas, includes a description of the Thyssen-Galocsy Slagging Gas Producer. These descriptions have generally been based on pilot plant operations which have been conducted for several years on a unit which was gasifying two tons of coal per day at the Thyssen'sche Gas und ~~Wasserwerke at Duisburg-Hamborn, and one gasifying 10~~ tons per day at the ammonia synthesis plant at Pecs, Hungary.

The results reported, though sketchy, seemed to indicate that non-coking or weakly coking coals having ash of low fusion temperature were suitable and that the gas generated had a higher quality than in other continuous gasification processes using oxygen at normal pressures. The admission of oxygen at two levels and the use of recirculating gas to spread the reaction zone was claimed as an important advantage because it lessened the intensity of combustion and lengthened the life of the refractories.

On the basis of the foregoing information a visit was made to the plant and the personnel directly concerned with its operation were interviewed.

Statement by Dr. A. Rettenmaier.

On June 28, 1945, Dr. H. J. Rose and Mr. L. L. Newman visited Dr. A. Rettenmaier at the offices of the Thyssen'sche Gas und Wasserwerke, 159 Duisburgerstrasse, Hamborn.

Dr. Rettenmaier stated that he was in charge of the development work and confirmed that a two ton per day unit based on the Galocsy patents was built at the works for preliminary research on the slagging operation using oxygen for gasification. The unit demonstrated the possibilities of the process but was not sufficiently large to furnish conclusive data on the results obtainable in the gasification of various fuels.

A unit capable of gasifying 40 tons per day was, therefore, erected at the Krupp Treibstoffswerk at Wanne-Eickel. It took two years to build the unit because of wartime restrictions on the use of labor and materials and interference by enemy bombing. No use was made of the 2 ton unit at Duisburg-Hamborn during this construction period. It was hoped in the 40 ton unit to demonstrate that it was feasible to gasify any grade of fuel in any size or combination of sizes from 5 to 80 mm., coking or non-coking, and regardless of the ash flowing temperature. It was desired to establish the operating conditions under which any fuel could be best gasified so that adjustments could be quickly made for each grade of fuel.

The fuels available in the Krupp company's own mines range from poorly coking coal with a volatile matter content of 35-40% in the upper seam which is at a depth of 400 meters, through coking coal in one of the lower seams at a depth of 700 meters. Below this depth there is a series of leaner coals all the way to anthracite. The younger coals in the upper zones were considered the most economical to use in the slagging operations.

The tests at Wanne-Eickel were frequently interrupted. One test, however, lasted four weeks and it was established that coke 40 to 60 mm in size could be gasified without any operating difficulty. Although laboratory determinations showed an ash flow temperature of 1300°C, it was found that trouble-free operation could only be maintained at 1600°C with coke containing 8-10% ash and without the addition of limestone or iron fluxing material.

Other tests were tried with the use of refuse from the Demag-Duisburg generators containing 40 to50% ash, and also non-coking coal. Various combinations of fluxing material (20 to 40%) were tried, but the tests were interrupted before any conclusive data could be secured by one of three possibilities, namely: (a) the bombing of their own plant; (b) bombing of the Krupp plant which supplied the steam, electricity and water; and (c) bombing of the Stickstoffwerk Hibernia which supplied the oxygen. Only two days of operation were conducted with coal and no stability of operation was attained.

The best sizes of coke were stated to be 30 to 60 mm. No difficulty was experienced in gasifying 40 tons per day with a yield of 100,000 cu meters. The gasification rate was limited by the available amount of oxygen. The calorific value of the gas was about 2700 calories (290 Btu per cu.ft.) and some means of methanation would be required to make the gas suitable for city distribution requiring about 4200 calories (450 Btu per cu. ft.).

Dr. Rettenmaier was very anxious to resume operations, and hoped to test 3 to 5 mmnsize coke breeze. He desired also to have at least one month for testing young coals and six additional months for making tests with other Krupp coals.

In commenting on oxygen costs Dr. Rettenmaier stated that the power cost was about 4.3 pf. per KWh at the works and was prohibitive for oxygen production. The cost of purchased oxygen was 2.3 pf. per m^3. He felt that he could obtain cheap oxygen (1 to 2 pf. per m^3) by using the coal screenings to generate steam at high pressure for driving the turboblowers and compressors in the Linde-Fräukl plant and by using the exhaust steam in the gasification process.

Dr. Rettenmaier further stated that Wanne-Eickel was chosen for the installation of the 40 ton unit because the Thyssen'sche Gas and Wasserwerke is a gas company buying coke oven gas which it purifies and distributes through a pressure grid system. Intermittent water gas machines are used for standby purposes only, and gas producers are kept in readiness to transmit gas for heating the ovens in the event of any failure of the supply of blast furnace gas normally used for this purpose. The water gas machines are Demag and the gas producers Koppers.

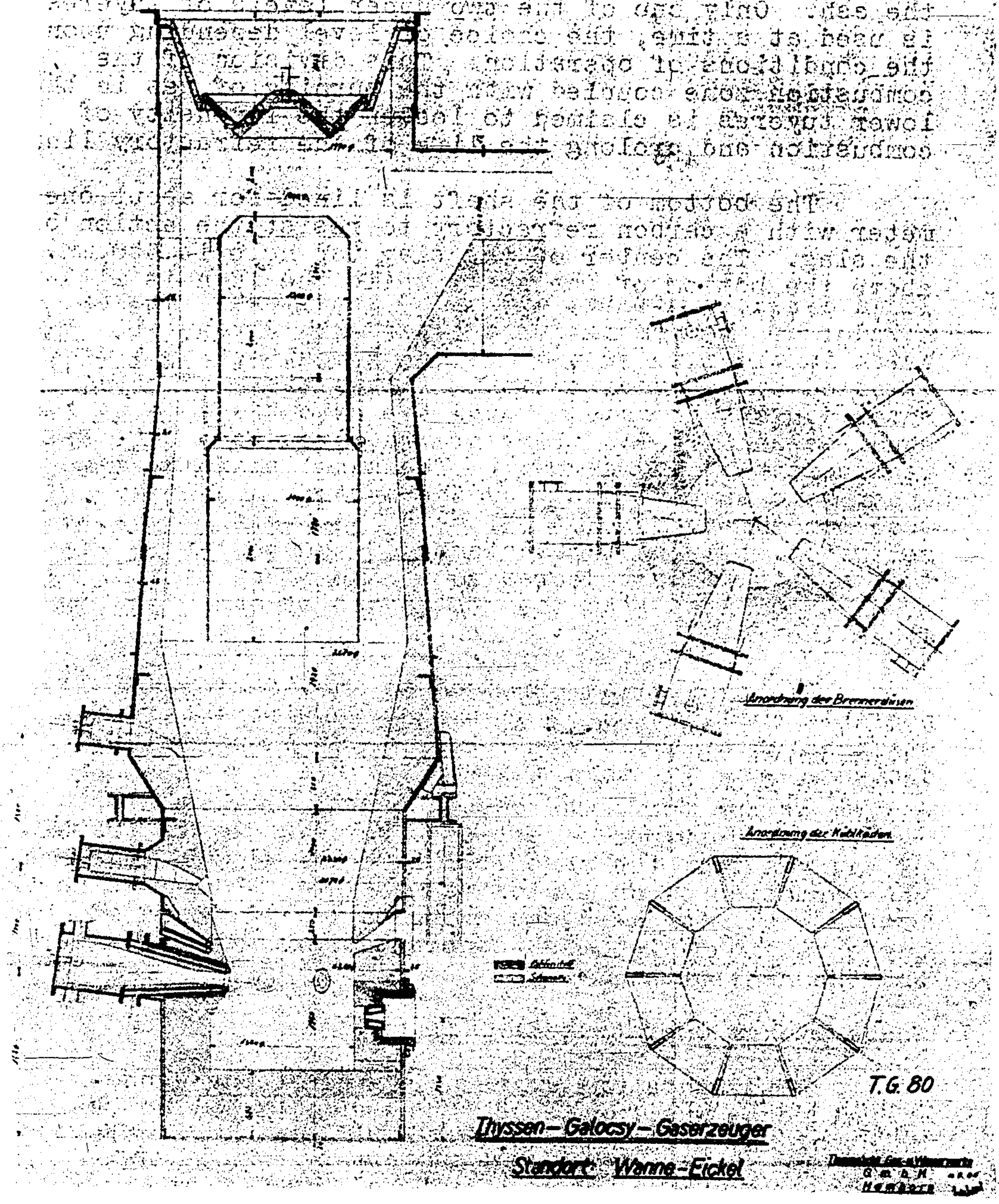
No documents were available. The reason given by Dr. Rettenmaier was that one commission consisting of three American officers had previously visited and evacuated whatever documents remained after the general destruction resulting from Allied bombings. Nevertheless, he promised to provide copies of drawings, which were in process of preparation, and statements regarding the process and operating results.

These documents were secured on July 2, 1945 by Dr. Wilkins and Mr. Newman prior to the visit to the Wanne-Eickel installation on the same day.

Wanne-Eickel Installation.

The Wanne-Eickel installation was visited on Monday, July 2, 1945, by Drs. Wilkins (British) and Rose and Mr. L. L. Newman (American) under the guidance of Dipl.-Ing. Erich Comblés, General Manager of the plant and Dr. Rettenmaier and Herr Breisig, the engineer who supervised the operations. It was found that the instrument house was completely destroyed and there was considerable damage to the piping and the structures surrounding the generator. The generator itself was in fair shape and a good idea of the kind and position of the burners and piping could be secured by inspection.

The generator was found to be blast-furnace shaped, about 35 feet high and about ten feet in diameter. The attached photostat of Drawing No. T.G.80 of the Thyssen-Galocsy Gas Generator at Wanne-Eickel shows the design of the unit at the present stage of development. Note that it has provisions for three levels of tuyeres, with five tuyeres at each level. The tuyeres at the lowest level are actually water cooled burners in which gas from the producer or any other source is burned in a mixture of oxygen and steam and admitted into the fuel bed at a temperature high enough for the steam and carbon dioxide to react with the carbon. (There was no evidence of preheating the gas, steam or oxygen). The tuyeres at the upper levels are not water cooled and are used for the admission of additional oxygen for the purpose of supplying additional heat to balance the amount required for the



Anordnung der Brennerdüsen
Anordnung der Kühlkästen
T.G. 80
Thyssen-Galocsy-Gaserzeuger
Standort: Wanne-Eickel

reduction of the steam and carbon dioxide and to melt the ash. Only one of the two upper levels of tuyeres is used at a time, the choice of level depending upon the conditions of operation. This division of the combustion zone coupled with the burning of gas in the lower tuyeres is claimed to lessen the intensity of combustion and prolong the life of the refractory lining.

The bottom of the shaft is lined for about one meter with a carbon refractory to resist the action of the slag. The center of the slag tap hole is 650 mm. above the bottom of the shaft while the iron is withdrawn directly off the bottom of the shaft. The remainder of the generator is lined with firebrick. The brick in the zone just above the lowest set of tuyeres is cooled by water circulating in two tiers of steel water jackets arranged around the circumference in ten equal segments. Two tiers are required to permit the replacement of any segment. The steel shaft in the upper zone is kept empty by the system of charging the fuel for the purpose of balancing the wall effect of the generator. The unit resistance of the center of the fuel bed is thereby decreased to the point where it is equal to or less than the resistance of the fuel bed along the wall.

The piping was arranged to provide for any possible combination of operating requirements. The steam inlet to the oxygen line was at a considerable distance from the generator to provide for thorough mixing of the two. The oxygen passed through a water seal designed to act as a barrier to the travel of any gas from the generator into the oxygen line and the formation of an explosive mixture. There was no vent, but an explosion head was provided to take care of any explosion which might occur between the water seal and the generator.

Wanne-Eickel Operating Results.

Although a preliminary report of the Wanne-Eickel tests was furnished (See Appendix II) no results of any prolonged operation of the plant were supplied. Below is shown a summary of conditions over three typical days in Test No. 3 which was claimed to have established the feasibility of gasifying coke in slagging operation:

Day	1	2	3
(a) Charge			
Oxygen (pure) Nm^3	32350	24800	25800
Percentage purity	81	90	90
Steam, tons	25.8	17.8	18.9
Auxiliary gas (i.e. gas produced but used in the process) Nm^3	16330	16070	17250
Coke (40-60 mm dia) tons	46.6	39.2	41.3
Analysis: Water 5.0%, Ash 8.5%, V.M. and S 1.5%, Heating Value 6865 Kcal/kg			
(b) Yield	1	2	3
Oxygas (Total gas less auxiliary gas) Nm^3	105400	84665	89270
Analysis CO_2	4.6	2.8	2.1
O_2	0.1	0.1	0.1
CO	65.3	70.4	71.0
H_2	24.6	23.1	23.3
CH_4	0.2	0.2	0.2
N_2	5.2	3.4	3.3
Lower Calorific Value cal/m^3	2600	2735	2760
Steam decomposition %	82.1	90.1	90.1
Percentage gasification (Total Gas C.V.) / (Total Coke C.V)	85.6	85.2	86.7
(c) Requirements for each 1 Nm^3 Oxygas			
Pure oxygen Nm^3	0.30	0.29	0.29
Steam, kg.	0.25	0.21	0.21
Coke, kg.	0.44	0.46	0.46

It was stated that the capacity of the unit was not reached because of the limitation on the amount of oxygen which could be supplied by Stickstoffwerk Hibernia. Herr Breisig was emphatic in his statement that better results might have been obtained if more oxygen were available to operate the unit at a higher rate. He backed his statement by adding that the results were improved when one of the burners was turned off and the available supply of oxygen was divided among the remaining four burners. Although he admitted that the operation was not quite as smooth, he claimed that the efficiency was increased as a result of the decrease of the heat losses in the cooling water circulated through the tuyeres.

Dr. Rettenmaier felt that the use of a slagging gas producer built along the lines of a blast furnace is the best means of providing the large volumes of synthesis gas required for even moderate quantities of synthetic liquid fuels produced by the Fischer-Tropsch process, and that the admission of a controlled amount of steam above the combustion zone would yield the desired ratios of carbon monoxide and hydrogen.

List of Documents.

1. Description of Thyssen-Galocsy Process (in English) See Appendix I.
2. Preliminary Report on the Thyssen-Galocsy Plant, at Wanne-Eickel (in German) See Appendix II.
3. Drawing No. T. G. 60 - Plan of Wanne-Eickel Test Plant, April 24, 1941.
4. Drawing No. T.G. 67 - Elevations of Wanne-Eickel Test Plant, May 29, 1941.
5. Drawing No. T. G. 64 - Cross Section of the Producer - Undated.
6. Drawing No. T.G. 80 - Cross Section of the Producer - July 4, 1945.

These documents are on file in Bag. No. 1481A.

APPENDIX I

Thyssensche Gas-und Wasserwerke Duisburg-Hamborn,
May 1945 G.m.b.H.

T h y s s e n - G a l o c s y - (T.-G.-) P r o c e ss

applying oxygen for tdal gasification of solid fuel or reduction of ore in a blast-furnace.

The application of oxygen instead of air-blast for the gasification of solid fuel has become econmically interesting, since the Line-Fraenkl-process made possible to produce it cheap, if a great quantity is wanted. Lignite has already been gasified on largest scale with oxygen in Winkler-gasproducers. Technical difficulties, especially unsufficient durability of refractory materials at the attained high temperatures, prevented till now similar large plants for non-baking bituminous coal.

The T.-G.-process overcomes these difficulties with a trick of the proceeding, namely by the division of the extraordinary vehement combustion with oxygen into two steps, either of which can be easily controlled. In the first step a mixture of oxygen and steam is blown into an entrance-chamber of the producer and therein simultaneously such a quantity of any combustible matter is ignited, that the resulting gas mixture is heated up to the temperature, at which steam and carbnic acid are able to react quickly with hot carbon; in the second step this hot mixture is admitted to the solid fuel in the shaft of the producer with such contents of superfluous oxygen, that the heat attained by the combustion of carbon to carbon-monoxide exactly covers the demand of heat for the decomposition of steam and carbonic acid, the smelting of slack and if desired the reduction of ore. Any excess of temperature, which could destroy the refractory shaft lining is however avoided.

The industrial producer is similar to a blast-furnace. The lower part has several burners, each of which having an entrance-chamber for the above mentioned primary combustion. Preferable auxiliary-gas is ignited therein. If for this purpose no cheap gas or other combustible is available, a part of the produced gas is blown in. By such means no surplus of fuel is consumed, because the products of combustion are reduced in the second step to carbon-monoxide and hydrogen, consuming thereby exactly the heat gained by the combustion in the first step.

After having studied the process during several years in a semi-industrial producer, consuming daily 2 tons of bituminous coal, a producer of industrial scale with complete testing installation has been erected during the last war, using surplus oxygen of a synthetic ammonia plant and producing gas for synthesis of benzine. An existing shaft-furnace 12 m high of 28 cbm contents with an internal diameter of 1,35 m at the burners, was adapted to test the system. With the maximum available quantity of 29,800 ncbm with 85.5% oxygen consequently 26,300 ncbm pure oxygen a day, the producer consumed 47 t of metallurgical coke thus producing 105.400 ncbm gas of 2.600 kcal interior calorific value, that is 274×10^6 kcal/day. A three day's test at the equal consumption, using only 4 of the 5 installed burners demonstrated, that the maximum output was not yet reached with the available quantity of oxygen. The producer was in operation during several months and has given full satisfaction in spite of many war events, by which sudden interruption often arrived mostly by destroying conduit pipes or wires, by cutting off steam, oxygen, auxiliary gas, electric current or cooling-water, even sometimes these all together. These repeated interruptions have hindered until now the gasification of a supplied stock of 500 t bituminous coal of the same quality, which had given best results in the small testing plant. The producer itself has never been essentially damaged and can start, if the synthetic ammonia plant is able to supply oxygen again.

Technical advantages

Continuous working, simple construction, no change of valves during the run, no mechanical device or work except charing fuel and tapping of slack (and iron if desired). Application of approved proceedings and methods of practical operated gas-producers and blast furnaces.

Highly increased output in comparison with existing plants, highest thermal efficiency on account of low nitrogen contents, total gasification without any loss of combustible in the slack. Recovery of by-products of the low-temperature-distillation type.

Immediate adaptability of the output to the consumption places start from coal to full run in 12 hours.

Economical advantages

Utilization of nearly all available and cheaper combustibles for total gasification, using as an example coal with high contents of ash or not suitable for coke-production, in case of need mixed with ashes in order to prevent caking in the shaft, instead of classified coke or producer-coal.

Cheaper gas for industrial heating and synthetic process.

Production of large quantities of low-temperature tar as by-product of an economical industry.

Suitable sphere.

Production of large quantities of gas, from 100.000 to 1.000.000 cbm/day in a single unit, with low contents of carbonic acid and nitrogen, consequently of high combustion temperature with a calorifique value of 2.700 to 3.100 kcal/ncbm according to the gasified combustible. Especially suitable for the following purpose of

gas production:

Heating-gas for industrial plants,

gas for synthesis of hydrocarbons, securing nearly the theoretical amount of liquid products. Since the waste gas of the synthesis is poor on nitrogen, it can be returned almost totally as auxiliary-gas to the burners. Methane and other not desired hydrocarbons become thereby regenerated to gas for the synthesis.

Gas for hydration-process, the change of carbon-monoxide with steam to hydrogen and carbonic acid being performed in the upper part of the shaft.

Gas for the supply of towns and industries, either indirectly by heating coke-ovens, setting free an equivalent quantity of distillation gas to be additionally supplied, or directly by enriching the calorific value by methane, formed by synthetic method from a part of the produced gas.

In blast-furnaces used for the redustion of iron ore. The process has the following advantages:

Diminution of the costs of plant and operation: Air heaters not needed, since preheating takes place in the entrance-chambers of the burners; smaller furnaces and blowers an account of low nitrogen contents.

Immediate adaptability to change the heat required by change of ore qualtities or moisture or atmospheric conditions.

Increased output of existing blast-furnaces.
Saving of coke for the reduction of ore in consequence of the combustion of blast-furnace-gas and of the diminution of heat losses. Most economical use of furnace-gas, since its quality and quantity can be regulated and its use is multiplied on account of the low nitrogen contents.

Thyssensche Gas- und Wasserwerke
G.m.b.H.

APPENDIX II

Duisburg-Hamborn, May 1945

PRELIMINARY REPORT ON THE THYSSEN-GALOCSY PLANT AT WANNE-EICKEL

Translation - by Lt. Yung, Original German Report filed with Documents

The plant was operated in four periods, namely:-

I. Run from 25/10/43 to 22/11/43, end, Hibernia suspended

II. Run from 3/2/44 to 10/2/44, end, off stream, coling chambers burned through

III. Run from 13/4/44 and 29/4/44 to 23/5/44, end Hibernia suspended

IV. Run from 17/6/44 to 4 /7/44, end, bombs on lines and 22/6/44 to 25/7/44

The first and second runs served to teach the operators, who were mostly Dutch workmen who had never worked on blast furnaces or gasification plants before.

The operation confirmed our suspicions that temperatures in this work had to be maintained appreciably higher than in blast furnace operation, but that the burner arrangement first chosen did not meet requirements. The highly heated gasification mixture came out of five burner tips in a ring header, 1.100 metres above the floor, which was placed in a break in the lining and coke bed. With this arrangement, iron coming out of the fuel ash did not fuse with the slag, although in the second run the temperatures went as high as the equipment would stand.

For the third run, these difficiencies were corrected by an arrangement of "tuyeres", similar to the copper ones used in blast furnaces, but made of welded iron because of the heavy duty. Iron and slag ran freely, and every experimental temperature first desired between 1400 and 2000°C could be held constant in front of the tuyeres. The plant was also subject to the unusual wartime accidents, for example, the oxygen failed five times for 2 to 15 hours, twice the main and cooling water failed and during the last run fuel and cooling water fell before the tuyeres in the middle of operation at 1800°C with the plant's being damaged. Gasification, temperature, slag and iron could be fully controlled.

The use of coke was termininated as the new burner system had proved itself in the third run. With the introduction of Baldur coal new difficulties were encountered, chiefly because of enemy action, and the run had to be stopped because Hibernia couldn't supply oxygen. Advantage was taken of the ovens' cooling down to clean them and to examine the condition of the lining, for the fourth run, carbon lining was used instead of the clay used in the third run.

The fourth run was stopped after warming up because Hibernia couldn't supply oxygen, and the two warm-ups, 16 days later, by direct hits which suddenly cut off the gasification material. Both interruptions were too short to allow switching from the coke needed for warming up to hard coal.

Damage which the plant suffered from enemy action could in all cases be fixed on the spot without any particular shop-work and certainly in a shorter time than the fuel plant and Hibernia could again supply operating material. While this was the case, however, a new attack was made, so that from the end of July 1944 to the middle of January 1945 further moving the plant to foreign soil was impossible. Gasification of the local hard coal was not carried out. On 17/1/45 and 23/2/45 all the buildings were smashed by bombs and, with part of their contents, completely destroyed. Work was stopped, but the wrecked machines were cleaned out and the useable parts of the plant, which were difficult to build, were, as far as possible, removed and protected against splinters.

After this, the plant was not further damaged, it was left in its essential parts and can be put in operating condition in 2 to 3 months, without any extensive new construction.

In the following is a summary of conditions over three typical days in the third run.

DAY	1	2	3
(a) Charge			
Oxygen, (pure) Ncbm	32350	24890	25800
Percentage purity	81	90	90
Steam, tons	25.8	17.8	18.9
Auxiliary gas (own gas), Ncbm	16330	16070	17250

Coke (40-60 mm. dia.), tons		46.6	39.2	41.3
Analysis	Water 5% Ash 8.5% S and gas, 1.5% Heating value, 6865 kcal/kg.			
(b) **Yield**				
Oxygas (surplus)	Ncbm	105400	84665	89270
	CO_2	4.6	2.8	2.1
	O_2	0.1	0.1	0.1
	CO	65.3	70.4	71.0
	H_2	24.6	23.1	23.3
	CH_4	0.2	0.2	0.2
	N_2	5.2	3.4	3.3
	Hu	2600	2735	2760
Steam decomposition,%		82.1	90.1	90.1
Percentage gasification		85.6	85.2	86.7
(c) **Requirements for each 1 Ncbm Oxygas**				
Pure oxygen, Ncbm		0.30	0.29	0.29
Steam, kg.		0.25	0.21	0.21
Coke, kg.		0.44	0.46	0.46