

COAL LIQUEFACTION ACTIVITIES IN WEST GERMANY

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The objective of the current coal liquefaction activities in West Germany is the industrial scale production of liquid products from coal with improved economic conditions relative to the earlier technologies developed in Germany until 1945. The development has reached the stage of pilot plants, which were designed by extrapolation of laboratory plants. The capacity of these pilot plants is chosen so as to minimize the extrapolation risks for the design and construction of large scale industrial plants.

1. The Pilot Plants in West Germany

1.1 The 200 t/d Pilot Plant Bottrop

The pilot plant Bottrop will prove the German Technology, which is based on the Bergius-Pier-Process. The plant is designed to process 200 tons of coal (maf) a day producing 30 tons light oil (C_5 -200 °C), and 70 tons middle oil (200 - 325 °C). The total investment for Phase I including commissioning is 200 m DM. The project is sponsored by the government of North-Rhine-Westphalia. Partners of the project are RUHRKOHLE AG/VEBA OEL AG. The plant is located at Bottrop directly adjacent to a coking plant. Due to this direct connection the pilot plant consists of the following main units: Coal preparation, hydrogenation, atmospheric distillation, vacuum distillation, flash evaporation, light oil stabilization and residue treatment.

The supply with coal, heating gas, process water and steam will be done by the coking plant. The hydrogen demand will be supplied by a pipeline.

The basic engineering of the pilot plant Bottrop was carried out by RUHRKOHLE OEL UND GAS GmbH and VEBA OEL AG.

The detail engineering, which has been finished at the end of 1980, was done by the two german engineering companies Firma Carl Still and Didier Engineering.

The plant site in Bottrop was opened in May 1979. After some prework the erection of steel constructions began in February 1980. At the end of 1980 construction was finished and 2,500 tons of steel constructions, 1,500 tons of apparatus and machines and 850 tons of high pressure and low pressure pipes had been installed.

During erection of the plant some problems occurred with the supply of high pressure fittings and pipes. Special materials had to be used due to the corrosion and erosion effects of the coal slurry containing a high amount of solids. Some contracting companies were not able to realize their delivery date. This problem results in a delay of the project of almost three months.

The "coal in"-date of the pilot plant Bottrop is planned for the beginning of July, 1981. It cannot be excluded that some problems will occur during start-up and operation of the plant.

Because it is not possible to foresee and avoid all problems, the total time for the tests per year is expected to be 3,000 hours in 1981, 5,000 hours in 1982 and 6,000 hours in 1983. The total time of 6,000 hours in 1983 means the total on-stream time per year planned for the pilot plant. This shows that enough time for repairs and changes was calculated in order to realize secured test runs.

It is planned to run the pilot plant in special test-periods. During these test-runs the reaction conditions (oil to coal ratio, pressure, hydrogen partial pressure, recycle gas ratio) as well as the quality of coal feedstock will be varied. Furthermore some special programs will be carried out, e.g. broad range analysis of products, determination of corrosion and erosion and pilot plant balancing.

In addition to those tests it is planned to carry out extensive basic work on thermodynamics and kinetics by using the results of the above-mentioned tests.

One aspect of the project pilot plant Bottrop is a research program called "Upgrading of oil from coal". The tests are carried out in bench scale units. A scale up from these units to a technical size is possible. During the planning and construction period of the pilot plant Bottrop the coal oil is delivered from a bench scale unit, run by Bergbau-Forschung GmbH. Therefore, the upgrading tests were started already. Costs for this program are included in the above mentioned project.

1.2 The 6 t/d Pilot Plant Volklingen-Furstenhausen

The Saarbergwerke AG have designed and constructed a smaller pilot plant for a coal throughput of 6 t (maf)/d in Volklingen-Furstenhausen. The start-up phase has started early in 1981. The plant will go into operation in mid 1981. The basic data for the design of this pilot plant have been developed from a small hydrogenation plant of the Saarbergwerke AG, which has been operated since 1975.

The plant is located at Volklingen-Furstenhausen directly adjacent to a cokery, a refinery, a power station and a laboratory of the Saarbergwerke AG. The existing infrastructure is advantageous referring to the supply with hydrogen from the cokery Furstenhausen and coal from the adjacent mine Ensdorf also referring to the disposal of the residues.

The site of the pilot plant with a coal throughput of 6 t/d has been chosen in order to be flexible during operation and on the other hand big enough for scale up.

The pilot plant Volklingen-Furstenhausen will also prove the German Technology with 2 modifications against the I.G.-process: new system of regeneration slurry preheating, use of distillates for slurry mixing.

The results of the test runs shall confirm and complete the design data for a commercial plant. In parallel to the test program measurements of the emissions of the pilot plant will be carried out.

1.3 The Project of a 350 t/d Pilot Plant

Lignite can be very easily liquified, because of its physical and chemical properties. Before liquefaction the lignite must be dried. This drying requires special know-how.

The development work for liquefaction of lignite is based on the Bergius-Pier-Process and experiences with a commercial plant for liquefaction of lignite, which produced about 250,000 t/a of motor fuels in 1943. The process is being further developed by Rheinische Braunkohlenwerke AG and UK Wesseling. A laboratory plant at UK Wesseling is in operation since 1978. The liquefaction of lignite is carried out in 2 steps, a liquid-phase hydrogenation into raw coal oil and gas-phase hydrogenation with refining, hydrocracking and reforming steps. The main point lies on the improvement of the liquid-phase hydrogenation. The improvements are similar to those of the hard coal liquefaction:

- Decrease of the pressure from 700 to 300 bar
- Increase of the space-time-yield
- Use of distillate oil for slurry mixing instead of a centrifuge overflow
- Use of residue for gasification.

The goal of the process is the production of chemical raw materials and motor fuels. The coal oil from liquid phase hydrogenation contains almost 70% middle oil and 30% light oil.

By catalytic hydrogenation of the middle oil the phenolic content is converted into hydrocarbons, with a light oil boiling range. Therefore, the ratio is shifted to almost 50% middle oil and 50% light oil.

Rheinische Braunkohlenwerke AG started in 1981 with a basic engineering for a pilot plant with a capacity of 350 t (raw)/d lignite. This plant is expected to go into operation in 1985.

2. Design of Commercial Plants in West Germany

A proposal of the industry for the design, construction and operation of commercial plants was made to the government in 1980.

Table 1 shows 4 projects of commercial plants. It is possible that Ruhrkohle AG and Veba Oel AG, which are already partners in the project of the pilot plant Bottrop, will become partners for a commercial plant. Beside the 2 projects of Ruhrkohle AG and Veba Oel AG 2 smaller projects of Saarbergwerke AG and Rheinische Braunkohlenwerke AG are foreseen. The processes are further developments of the old German Technologies proven until 1945 in commercial plants.

The improvements of the modified I.G.-Process are essentially:

- Decreasing of the pressure from 700 to 300 bar
- ~~Recycling of distilled oil for slurry mixing~~
- Gasification of residue.

2.1 Project of Ruhrkohle AG

At the end of 1980 Ruhrkohle AG has finished an initial project for the construction of a commercial plant with 4 lines (complete set-up) for liquefaction of 6.6 m t coal (maf)/a. The technical design, costs, locations and permits, feed and products and economics have been investigated.

By operation of 4 lines and a coal throughput of 20,000 t (maf)/d the following products (without byproducts S and NH₃) can be obtained:

Light oil :	3,000 t/d
Middle oil:	6,000 t/d
LPG	: 1,800 t/d
SNG	: max. 5.9 m m ³ /d

Feed coals could be from mines of Ruhrkohle AG or imported coals.

The result of a market research for the products was that the hydro-treated light oil can be used as feed for reforming in the fuel sector or as chemical raw material for the production of BTX aromatics. The hydro-treated middle oil can be used as substitute for light fuel oil.

The other products can also be sold without difficulties on the market.

Possible locations for a commercial plant have been investigated.

During planning environmental protection measures have been considered for decreasing of emissions as far as possible.

2.2 Other Commercial Scale Projects

Veba Oel AG is investigating a concept by which coal, oil residues or a mixture of coal and oil residues can be converted into liquid products on the scale of $2 \cdot 10^6$ t/year. The site of this plant should be either in the Ruhr area or at the coast.

Saarbergwerke AG are considering the production of 800,000 t/a gasoline. The capacity of such a plant would be 6,000 t/d or $2 \cdot 10^6$ t/a coal throughput.

Rheinische Braunkohlenwerke AG are developing a concept for the production of 400,000 t/a transportation fuels and chemical raw materials by liquefaction of $3.5 \cdot 10^6$ t(raw)/a lignite.

Company	Ruhrkohle AG	Veba Oel AG	Saarbergwerke AG	Rheinische Braunkohlenwerke AG
Capacity in t/a	$6,6 \cdot 10^6$ (maf)	$6 \cdot 10^6$	$2 \cdot 10^6$	$3,5 \cdot 10^6$ (raw)
Feed	hard coal	hard coal or heavy oil	hard coal	lignite
Liquid products in t/a	$3 \cdot 10^6$	$2 \cdot 10^6$	800,000	400,000
Process	modified I.G.	modified I.G.	modified I.G.	modified I.G.
Location	Ruhrgebiet	--	Saargebiet	Rheinisches Braunkohlenrevier

Table 1: Projects of commercial plants for coal liquefaction

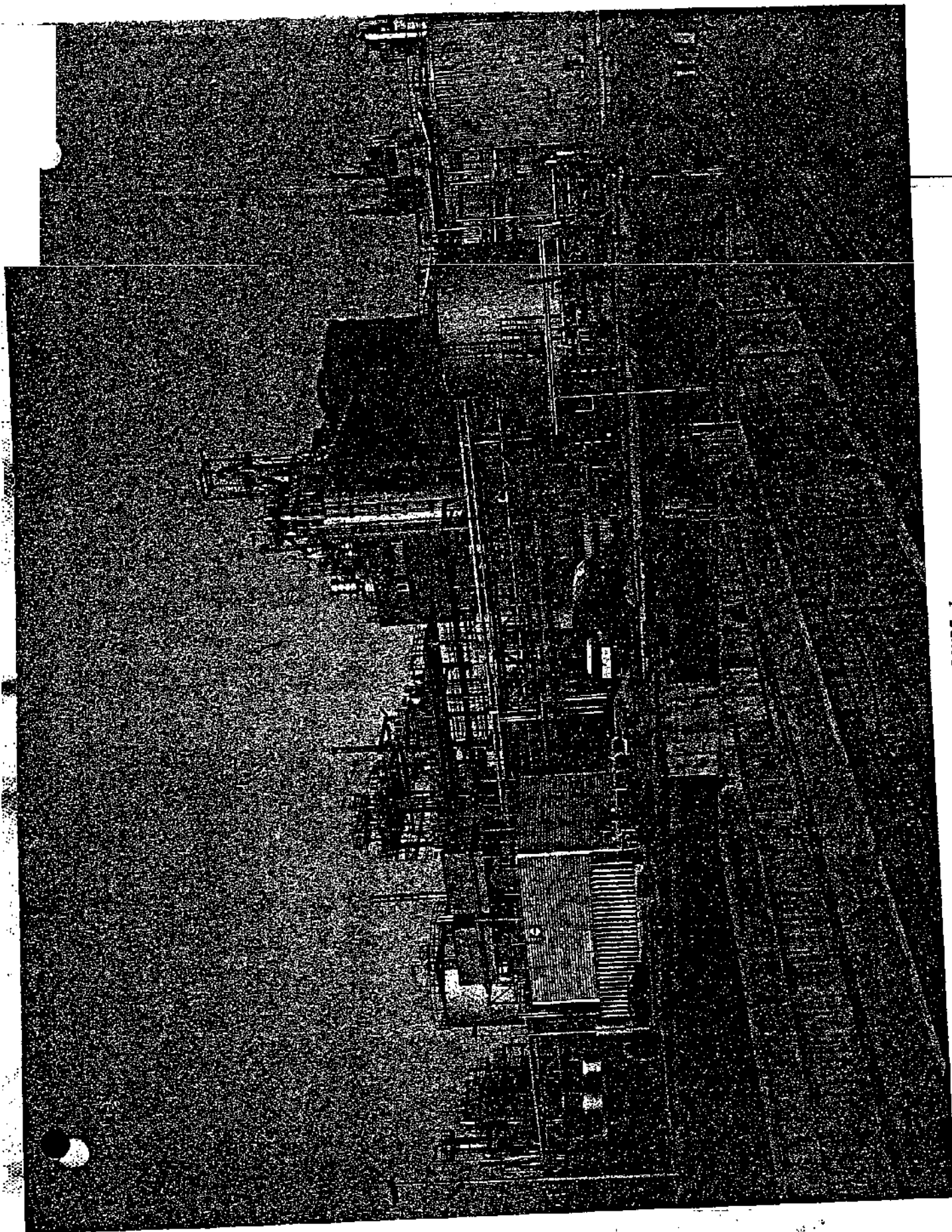


FIGURE 1