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TECHNICAL REPORT No. 217-45

THE PRODUCTION OF SYNTHETIC FUELS BY THE HYDROGENATION OF SOLID AND LIQUID CARBONACEOUS MATERIALS

SUMMARY

This report describes the various principal methods of producing synthetic fuels by high pressure hydrogenation as practiced in Germany. The various techniques of operation, designs of equipment, and characteristics of the products are described, and whenever possible, the relative merits and best uses of the different items are discussed. No attempt has been made to make an economic survey of the industry, since the subject is greatly confused by German finance and slave labor. However, this report does analyze the important features so that there is a technical basis for evaluation of the various phases in the light of existing local conditions. The data in this report were all obtained either by interrogation of personnel, examination of documents collected from the various plants, or by visual observation.

August 1945

U. S. NAVAL TECHNICAL MISSION IN EUROPE.

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THE PRODUCTION OF SYNTHETIC FUELS BY THE HYDROGENATION OF SOLID AND LIQUID CARBONACEOUS MATERIALS

1. Introduction.

The production of synthetic fuels by the hydrogenation of coal and tar under conditions of high temperature and pressure is a comparatively new industry even though the initial experiments were completed by Dr. Bergius before the start of World War I. For a long time, the process of converting solid fuels of low hydrogen content to liquid ones with a high hydrogen content appeared to be of mere scientific interest because of the high investment and operating costs of the necessary plant. In 1933 when Germany started in rapidly to prepare for war, it became imperative to improve the processes, and so an enormous amount of effort was expended in experimental development of better methods for coal hydrogenation. The results of this work were successful in developing techniques for treating coal and tar so that over three million tons of fuel were produced in 1942 by these methods. The cost of gasoline produced by hydrogenation was high (about 15 cents per gallon)(1) but, for a country that had practically no petroleum this was not exorbitant. In order to better understand the changes in practice, it is of interest to briefly trace the development of hydrogenation in Germany.

In 1911, Dr. Friederich Berguis started his first experiments in treating coal with hydrogen under pressure. By 1913 the work had reached the point where he took out his first patents on the subject. The research continued for a number of years, on a small scale, until 1924 when I.G. Farbenindustrie started work at Ludwigshafen on the hydrogenation of tar. Dr. Berguis continued his work until about 1930. He will probably be remembered as the "Father of Coal Hydrogenation", but it was the I.G. Farbinindustrie that developed the industrial applications.

After a brief period of research work at Ludwigshafen I.G. started the construction of a plant at Leuna in 1926

1. Introduction (cont'd.)

to produce 100,000 tons per year of gasoline from lignite, and in April, 1927 the first gasoline was produced. The through-puts of coal were low and the efficiencies poor, but these were gradually improved by new design of equipment and better understanding of the process(2). In 1933 a new high activity pelleted tungsten sulfide catalyst was developed that increased the gasoline yield. The following year another catalyst tungsten sulfide on activated clay was developed, which in combination with the first one, was used throughout the war in most of the plants, and produced high quality gasoline.

Between 1935 and 1941 about ten large hydrogenation plants were created in mid-Germany, the Ruhr, and eastern Germany to hydrogenate coals and tars. Research work had shown the beneficial effect of high pressure on the decomposition of coal, and so most of the new coal plants were built to operate at 700 atmospheres pressure. The research work in this period was largely devoted to methods of increasing production by changes in operating technique and/or equipment, as well as to methods for increasing the octane number of the gasoline. With the start of the war the accent was on production, and every effort was made to obtain the maximum quantity of fuel from a given plant. Most plants hydrogenated quantities of tars in addition to coal, since the specific output of gasoline was greater from tar.

Although the hydrogenation plants were owned by several large companies, the integration of the industry was such that most of them followed the I.G. process, and exchanged information with the I.G. research center at Ludwigshafen for the material benefit of all. The result was that only minor variations in operation were found at the different plants, these having been largely caused either by differences in raw material or older design of equipment.

The following report is intended to present the chief items of interest in the German hydrogenation industry, and to describe features which have not been reported in the literature. It is not intended to be a complete record of

1. Introduction (cont'd.).

German hydrogenation technology, but only to cover the important principles of the art so that the reader can evaluate the process.

2. Sources of Information.

The data in this report were collected by personal inspection, interrogation of personnel, and examination of the documents(3,4,5) of most of the hydrogenation plants in Germany. The plants in the Ruhr area and in middle Germany were covered on two inspection trips, while some data were obtained from operating reports(6,7) on plants in eastern Germany that were in Russian occupation territory. The following is a list of the plants visited, the principal type of material processed, and the important personnel interrogated.(8)