

I.O. 7370

Quantity: 150 tons per month.

Sample: No. 19.

Catalyst 5633

Use: Conversion of paraffinic hydrocarbons to aromatics and iso-paraffins (HF and DHD Processes).

Composition:

Al ₂ O ₃	95%
MoO ₃	5%
Na ₂ O	up to 0.7%

Preparation: Technical alumina is plasticised in a kneader with a little nitric acid and water, then extruded and rolled into balls. These are dried and later ignited at 450°C. The balls are then soaked in an ammonium molybdate solution, controlled so as to give 5% MoO₃ in the catalyst on subsequent drying.

Catalyst 5780 (also prepared at Ludwigshafen as No. 695A).

Use: Dehydration of alcohols. Intermediate product in the production of other catalysts.

Composition:

Al₂O₃ Gamma-form.
Na₂O (usual 0.03-0.04%) - less than 0.1%
Water - 4%

Preparation: 400 kg. of technical alumina (65% (Al₂O₃) is dissolved in 410 litres of 50% caustic soda at 110-120°C and diluted with 600 litres of water to 1.35 sp. gr. The solution is cooled and precipitated with nitric acid at a pH of 6.5, then filtered, washed, resuspended, brought back to a pH of 6.5 with NH₃, washed and dried at 100°C. (This intermediate product is known as 5780 Z 100). This product is ground, peptized with 1% nitric acid in a kneader, spread on a sheet, cut into cubes and dried stepwise at temperatures from 60 to 180°C (slow drying, 2-3 days. It is finally ignited at 450°C in air until nitrate-free.

Laboratory tests of catalyst activity are based on (1) absorption of propane, (2) dehydration of isobutyl alcohol at 350°C.

Quantity: 100 tons per month.

Catalyst 6067

Use: Amine synthesis (very small amounts used). Catalyst 6069 is preferred.

Composition:

Al ₂ O ₃	50%
Kaolin	50%

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Preparation:

Catalyst 6069

Use: Preparation

Composition:

Preparation:

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Quantity:

Catalyst 6448

Use: Dehydr

Composition

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Quantity:

Samples:

Catalyst 6523

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Catalyst 6853

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Preparation: See No. 6069.

Catalyst 6069

Use: Preparation of methylamine from methanol and ammonia.

Composition:

Al ₂ O ₃	90%
Kaolin (flotation to remove excess SiO ₂ by a Siemens electro-osmosis machine)	10%

Preparation: 150 kg. catalyst 5780 Z 100 (ground) are mixed with about 140 litres of water and 225 cc. of 52% HNO₃ and 11 kg. of kaolin then added. The mixture is kneaded for 2 hours, spread on trays, cut into cubes, air dried for 24 hours, dried 12-15 hours at 120°C and finally ignited for 4-6 hours at 450°C.

Quantity: 10 tons per month.

Catalyst 6448

Use: Dehydrogenation of n-butane to butenes.

Composition:

Al ₂ O ₃ (use ordinary alumina for iso-butane dehydrogenation)	90%
K ₂ O	2%
Cr ₂ O ₃	8%

Preparation: 22.5 kg. catalyst 5780 (finely ground), 2 kg. catalyst 5780 Z 100 (as peptizer-binder), 1.53 kg. KOH, 1.63 kg. CrO₃, 2.7 litres HNO₃ (62%) and about 7-9 litres water are mixed for about 40 minutes in a kneader, then formed into balls or cubes, dried at 150°C for about 16 hours, and finally ignited at 450°C for 4 hours.

Quantity: 100 tons per month.

Samples: Nos. 68 and 69.

Catalyst 6523

Use: Hydrogenation of phenol to cyclohexanol.

Preparation: Catalyst No. 3390 is reduced for 8 hours at 300°C with hydrogen (in situ; high space velocity, 400-600 cu.m./hr/500 litres catalyst) and purged with nitrogen.

Catalyst 6853 (Arobin Catalyst)

Use: Conversion of high boiling aromatic middle oil into lower boiling aromatic hydrocarbons. Conversion of higher alkyl benzenes to lower homologues.

Composition: Catalyst 7187 plus 1% MoO_3 .

Preparation: Catalyst 7187 is soaked in dilute ammonium molybdate solution so made that the product after drying contains 1% of MoO_3 .

Sample: No. 11.

Catalyst 7187

Use: Catalytic cracking (atmospheric pressure conversion of middle oils into isoparaffinic gasoline).

Composition:

SiO_2	85.1%
Al_2O_3	14.9%

Preparation: Kieselguhr (with 70% SiO_2) and activated alumina (70% Al_2O_3 , catalyst 5780 Z 100) are mixed to a stiff paste in a kneader with a little water and the addition of a small amount of nitric acid (sufficient stoichiometrically to convert 1% of the Al_2O_3 to $\text{Al}(\text{NO}_3)_3$). This mass is allowed to stand 24 hours at 60-70° C. to "ripen." It is then further kneaded, extruded and formed into 6 mm. balls, dried at 100° C. and ignited at 400° until nitrate-free. There is no humidity control during the drying.

Quantity: Planned to make 100 tons per month.

Samples: Nos. 36 and 37.

Catalyst 10927:

Use: Liquid-phase hydrogenation of tars.

Composition: 5% Fe on Winkler generator coke.

Preparation: Winkler generator fines are soaked with iron sulphate solution and then with an equivalent amount of caustic soda solution, the concentrations being adjusted so that the final dried product contains 5% of Fe.

Ammonia-Catalyst (No number)

Use: Ammonia synthesis from hydrogen and nitrogen. Synol catalyst (manufacture of alcohols from CO and H_2).

Composition:

Fe_2O_3	75%
FeO	20%
Al_2O_3	1.9%
K_2O	1.1%

Preparation: Five tons of pig iron is melted by a direct blast of oxygen. A cake containing a mixture of 200 kg. of crude alumina, 50 kg. of aluminum nitrate and 25 kg. of concentrated nitric acid is introduced into the molten iron with continued blowing with O_2 . The melt is allowed to cool and is broken up and screened to the desired size. Oxygen consumption: 7,000 cubic metres.

Sample: No. 23 - Synol Catalyst.

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XXIII. METALLURGYI. G. Experiences with Hydrogen-Resistant Steels

The following information was obtained at Leuna from Dr. Wyszomirski and Dir. Strombeck. For the early 250 ats. hydrogenation stalls a 6% chromium steel (N6) was normally used. This had satisfactory hydrogen-resistance properties but its creep strength limited its use to pressures not exceeding 200 ats. at 560°C. For 350 ats. stalls 1% molybdenum and 1% tungsten was added to N6 to give a steel which was designated N7. These additions improved the creep properties but resulted in difficulties in fabrication and in heat treatment. Molybdenum and tungsten contents were accordingly reduced to 1/2% (N8) and the resulting steel was found to be perfectly satisfactory as regards heat treatment which simply consisted of quenching from 700°C. No annealing was necessary and no heat treatment was required after welding. The steel was suitable for vessels operating at 350 ats. pressure and at temperatures up to 550°C. It could also be used for the cooler parts of 700 ats. stalls.

An improved material was nevertheless required for 700 ats. operation, particularly in the preheater elements. V2A could not be obtained because of the short supply of nickel and a new steel (N10) was developed which had the following analysis:-

Carbon	0.18 - 0.22%
Chromium	3.0 - 3.6%
Molybdenum	0.5 - 1.2%
Tungsten	> 0.3%
Vanadium	> 0.75%

Dr. Wyszomirski explained the theory behind the development of this steel. Pure iron-chromium alloys have a very poor creep resistance but this can be overcome if the steel contains finely divided carbides. In order to obtain a suitable chromium/carbon steel the chromium content must be limited. Too much of this component tends to absorb the carbides and also to increase the grain size of disseminated carbides thereby reducing creep resistance.

The composition of N10 is very critical. A minimum of 0.18% carbon is required to give the creep quality but a content of 0.22% must not be exceeded if welding difficulties are to be avoided. At least 3% of chromium is needed to give the necessary hydrogen resistance; more than 3.6 of this component has an adverse effect on creep properties. At least 0.5% molybdenum is required to give a workable steel but the 1.2% has the same effect as excess chromium in reducing creep resistance. Vanadium is necessary from creep considerations but this component appears to be responsible for much of the difficulty which has been experienced in getting an even distribution of fine carbide grains in the steel.

In addition to careful control of the composition of N10 the I. G. pay great care to its heat treatment. It is first heated to 1,050°C and, when it has assumed an even temperature, it is cooled through the range

I.G. 7370

800-600°C at a minimum rate of 25°C/minute. This is to avoid the complete transformation of austenite via martensite to pearlite. If this treatment does not result in even properties of the steel it is reheated to 1,150°C and the process is repeated.

A special heat treatment bench was developed dealing with preheater elements. A complete element was laid horizontally on a brick bench which was so designed that each leg of the preheater was immediately above a 25 mm. wide slot which extended the full length of the element. Compressed air could be injected through the slots by means of a series of jets. The element was heated electrically by passage of a direct current and even heating was ensured by providing a removable insulated cover fitted with auxiliary electric heating elements.

When the preheater element had attained a temperature of 1,050°C the top cover was removed and replaced by an arrangement by which air could be impinged on the preheater tube from above. During this change of covers the preheater element usually cooled to 850-900°C. Rapid control cooling down to 600°C was then carried out by means of the air jets.

Trials had been made with water for rapid cooling but this method was found to be less reliable than the air cooling method particularly in the case of fin tubes which scaled badly under water treatment.

Finally the steel was given a secondary heat treatment consisting of reheating to 680°C followed by slow cooling in air.

The I. G. claim that the above method of heat treatment results in at least a 33% higher creep strength at 560°C than is obtainable by oil quenching.

Enamelling of Preheater Bends

It has been mentioned in an earlier section of this report that trouble had been experienced at Leuna with the erosion of preheater bends when working at high paste rates. In an attempt to overcome this erosion, experiments have been made with enamelled preheater bends. Difficulty was experienced in getting an even distribution of enamel powder over the inner surface of the tube and in cooling the bends sufficiently rapidly to avoid an uneven enamel layer resulting from the flow of molten enamel. Enamel is in any case useless for pressures above 325 ats. because differences in expansion in enamel and steel led to cracking of the enamel layer.

Chromium-Plated Injector Rams

Normal deliveries of hard plated chromium rams were found to be very satisfactory for pressures up to 50 ats., reasonably good for working up to 250 ats. but useless for 700 ats. pressure. The makers tried to improve the chromium surface by high frequency electric treatment but little success was achieved.

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Material for Butane Dehydrogenation Reactor Tubes

FF30, a 30% chromium steel with about 40% nickel and about 0.10% of carbon, was found to be satisfactory mechanically but it catalysed carbon formation in the reaction, particularly at low space velocity.

Material for Catalytic Cracking Regenerators

For the regenerator of the catalytic cracking unit which was to be erected in the Kuchuk plant at Niedersachswerfen the I. G. proposed to use a steel of the following composition:

Chromium	0.8 - 1.0%
Silicon	0.5%
Carbon	0.12%

This steel was stated to have excellent resistance to oxidation.

XXIV. BLECHHAMMERIntroduction

Practically the entire Blechhammer staff left the plant at the end of January, one or two days before the Russians entered the area. Following a pre-arranged plan, they congregated at Naumberg about 20 miles from Leuna where an office was set up to arrange for their distribution to other German hydrogenation plants. By the end of February, Naumberg was so full of evacuees that the authorities insisted on the removal of the Blechhammer people and a large proportion of them went to Vorhum, near Peine (Brunswick). The movement of these people was surrounded with a good deal of secrecy due to their fear of being handed over to the Russians for the restart of the Blechhammer factory. The managing director of Blechhammer, Dr. Josenhans, was interviewed in Naumberg and Dr. Kronig, the chief chemist, was interrogated at Vorhum.

700 atms. pressure hydrogenation of selected Upper Silesian coal provided the main source of liquid products at Blechhammer. Hydrogen production was based on gasification of medium temperature coke made by carbonisation of bituminous coal briquettes. The tar produced as a by-product to coke manufacture was obtained in two fractions by controlled condensation. The lighter fraction was sold as Navy fuel oil after topping off light petrol and the heavy tar was used as a pasting oil component in the coal hydrogenation process.

The original plan was to hydrogenate coal in the ordinary way, i.e. recycling to the liquid phase stage all products heavier than middle oil. Before the erection of the plant was completed, however, it was decided to increase the production of Navy fuel oil by operating the liquid phase hydrogenation stalls in such a way that the production of distillate heavy oil exceeded pasting oil requirements. Blechhammer data on this method of operation are of particular interest because they provide a basis for assessment of a three-stage coal hydrogenation process, i.e. 700 atms. liquid phase hydrogenation of coal to give heavy oil, middle oil and petrol, liquid phase hydrogenation of distillate heavy oil to give middle oil and petrol, and vapour phase hydrogenation of middle oils to petrol products.

Another change which was made to the original Blechhammer plan was that as the shortage of aviation fuel became more acute, it was decided to make aviation fuel instead of motor petrol. D. H. D., butane dehydrogenation and alkylation units were therefore erected.

Ten medium temperature carbonisation units were installed, each with a design capacity of 275 tons/day of coal. These units behaved very satisfactorily and a throughput of up to 325 tons/day was achieved. The coal was briquetted using sodium sulphite lye from paper manufacture as a binding agent and the finished briquettes contained 2% of moisture and 12% of ash. The coal had a carbon content on the ash-and-moisture-free basis of 83.5%. The tar yield on carbonisation was 9% by weight on the coal, the heavier tar fraction amounted to 35% of the total tar.

The coal hydrogenation to reduce tar was dis

The hydrogenation of four liquid converters size 1,000 mm. diameter was 850 mm. 37-13.

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The carbonisation units were started up in October 1943. Before the hydrogenation plant was ready, the tar middle oil, topped to 120°C in order to reduce the flash point below 85°C, was sold as fuel oil and the heavy tar was disposed of to other companies for use as road tar, etc.

The hydrogenation plant actually installed at Blechhammer included four liquid phase stalls for 700 ats. operation. Each stall had four converters similar to those used at Gelsenberg. The internal diameter was 1,000 mm. and height 18 M. The internal diameter of the reaction basket was 850 mm. and the reaction volume provided by four converters was roughly 37 M³.

Two vapour phase pre-saturation stalls were installed. Each had three converters and was designed for 300-350 ats. operation. The plant was equipped with two vapour phase splitting stalls fitted with two converters each and designed to operate at 300-350 ats.

The coal used for hydrogenation was specially selected Upper Silesian coal with an ash content of 5% and a carbon content on the ash-and-moisture-free basis of 80-82%.

It was originally planned to add two further sections to the hydrogenation plant, each comprising two 700 ats. liquid phase units, one pre-saturation and one vapour phase splitting stall. With these additions, the total output of Blechhammer was to have been 450,000 tons/year of motor spirit and 500,000 tons/year of fuel oil.

It was considered likely that the demand for fuel oil would decrease and accordingly, consideration had been given to the erection of one or more additional 700 ats. stalls designed for the catalytic hydrogenation of distillate coal heavy oil to middle oil. The idea was to re-distil distillate coal heavy oil leaving a 10% heavy residue which would be returned as pasting oil to coal hydrogenation. The distillate was to be hydrogenated over 8376 catalyst at 700 ats. and at a temperature of about 450°C.

The hydrogenation plant started up in April 1944 but by July, bomb damage to other hydrogenation plants had resulted in such a large surplus availability of brown coal tar that it was decided to import this material for hydrogenation at Blechhammer. During the three months in which the coal hydrogenation plant operated, it was stated that operation was extremely satisfactory.

It was found that for the hydrogenation of brown coal tar it was necessary to increase the number of converters in each of the vapour phase stalls to four. It was found impossible to operate liquid phase hydrogenation of brown coal tar at 700 ats. because the rate of hydrogenation of asphalts was so high that catalysts could not be kept in suspension in the reaction vessels. Pressure was accordingly reduced to 400 ats.

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Details of Coal Hydrogenation to give Excess Heavy Oil

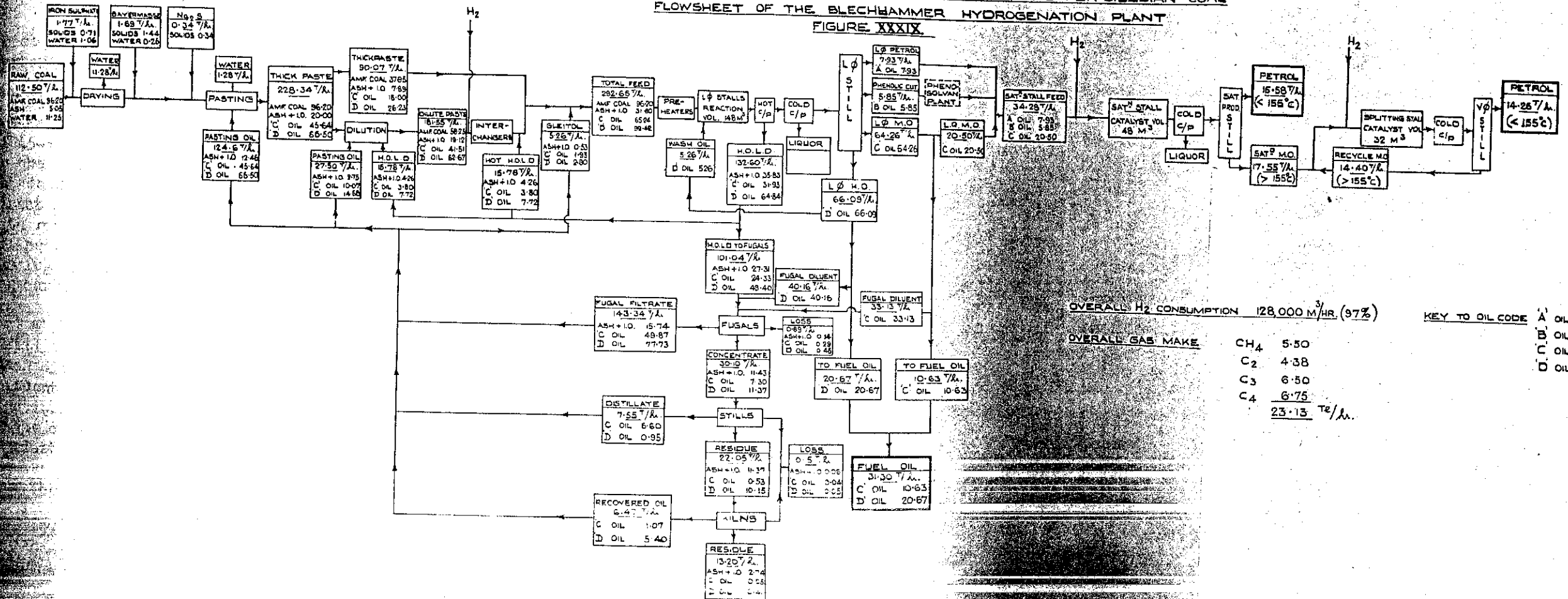
The flowsheet shown in Fig. XXXIX was supplied by Dr. Kronig. For simplicity, it refers to operation with coal as the only raw material. Actually, the amount of heavy tar which it was proposed to introduce into the coal paste at Blechhammer was comparatively small and would not greatly influence the flowsheet figures. All figures are tons/hour and refer to the operation of the total plant installed at Blechhammer, i.e. 4 liquid phase and 4 vapour phase stalls.

The coal was crushed and the first catalyst, iron sulphate, was added before drying. Dr. Kronig considered that better results would be obtained if the iron sulphate was added as a solution in order to obtain more even distribution. The mixture was then dried and it was stated that during the process, neutralisation of alkaline constituents of the coal ash was effected. The dry coal, with 2% of moisture was next mixed with approximately 1.5% of its weight of Bayermasse, a residue from aluminum preparation. This Bayermasse was previously dried to a moisture content of 15%. A third catalyst, 0.3% on the original coal of sodium sulphide, was next added, immediately prior to the pasting stage.

In order to produce heavy oil as one of the new-formed products of coal hydrogenation, it is necessary to reduce to a minimum the amount of recycle heavy oil in the coal paste. This necessitates the use of paste with a maximum coal content and the use of middle oil as a pasting oil component. Special difficulties are thereby introduced. For example, heat exchange between ingoing paste and exit products is not satisfactory with very thick pastes. Again, pastes made up of light oils and containing a low concentration of asphalts tend to settle when hot. These difficulties were overcome at Blechhammer in the following way: All the coal was first made up into a thick paste containing approximately 51% of total solids. About 40% of this thick paste was injected directly to the preheater, by-passing the paste interchanger. The remaining 60% was diluted down to approximately 43% total solids, i. e. maximum solid content for satisfactory paste interchange, and injected to the hydrogenation stall via the paste interchanger. In order to guard against settling of solids in the preheater as much as possible of the diluent oil was supplied as high asphalt content heavy oil let down from the hot catchpot. Settling in the preheater was further guarded against by circulating a quantity of heavy oil let down from the catchpot to the preheater, without cooling or letting down to atmospheric pressure. This recycle was carried out with the same type of remote control hot recycle pump as used in the tar hydrogenation stalls at Leuna.

A small amount of pasting oil (5% on the coal treated) was continuously injected direct to the preheater. The object of this was, firstly, to prevent plugging of the preheater in the event of a breakdown of the paste injectors and secondly, to provide a lubricant film between the paste and the inner wall of the preheater tubes.

PRODUCTION OF AVIATION PETROL & FUEL OIL FROM UPPER SILESIA COAL
 FLOWSHEET OF THE BLECHHAMMER HYDROGENATION PLANT
 FIGURE XXXIX.



The total liquid injection to the stall was equivalent to a rate of 1.9 tons per M^3 of reaction volume per hour. This corresponds to the treatment of 0.65 tons of ash-and-moisture-free coal per M^3 of reaction volume per hour. The figure supplied at Ludwigshafen for complete 700 ats. hydrogenation of bituminous coal to middle oil plus petrol was 0.45 tons per M^3 of reaction volume per hour.

The paste temperature at the exit of the interchanger was not allowed to exceed 310°C . The exit temperature of the preheater was usually controlled to 415°C and was never allowed to exceed 425°C . The reaction temperature in the converters was kept as uniform as possible at about 485°C .

The circulating gas rate was equivalent to $3.5 M^3$ per kg. of ash-and-moisture-free coal. The hydrogen partial pressure of the inlet of the converter system was 585 ats.

The whole of the products from the hydrogenation reactors passed to a hot catchpot which separated heavy liquid and solid products to the extent of 45-50% of the ingoing paste. Some 12% of this product was recycled hot to the preheaters as already described. The remaining 88% was cooled and let down to atmospheric pressure, after which a further 12% was returned direct to pasting as diluent for "thin" paste. The residual 76% was mixed with roughly 70% of its weight of diluent heavy oil obtained by topping off petrol and middle oil from the cold catchpot product and the mixture was fugalled. The fugalled filtrate was used as pasting oil and the residue was carbonised for recovery of oil.

The feed to the carbonisation ovens was given a preliminary flash distillation treatment to remove part of the oil. Recovered oil from the flash distillation and carbonisation ovens was used as a pasting oil constituent. The coke from the carbonisation ovens contained all the ash constituents of the original coal plus the catalyst plus the coke equivalent to the coal which had resisted liquefaction by the hydrogenation treatment. The latter amounted to roughly 4% on the a.m.f. coal fed.

The efficiency of recovery of oil in the two-stage sludge carbonisation plant was of the order of 75% and the oil lost at this stage amounted to 4.5 - 5% on the a.m.f. coal treated.

The vapors from the hot catchpot were cooled and the condensed liquid separated from recycle hydrogen in the cold catchpot. The liquid product was let down, separated from aqueous liquor and distilled to give $0-160^\circ\text{C}$, $160-210^\circ\text{C}$, $210-325^\circ\text{C}$ and $>325^\circ\text{C}$ fractions. Roughly half the $210-325^\circ\text{C}$ and two-thirds of the $>325^\circ\text{C}$ cuts were recycled as pasting oil components. The yields of new-formed oils, expressed as weight % on the a.m.f. coal treated, were approximately -

$0^\circ - 160^\circ\text{C}$	8.2%
$160^\circ - 210^\circ\text{C}$	6.1%
$210^\circ - 325^\circ\text{C}$	32.4%
$> 325^\circ\text{C}$	21.5%
Total	68.2%

210-325°C middle oil and 325°C distillate heavy oil were blended in the ratio of 1:2 to give fuel oil, the yield of which amounted to 32.5% by weight on the a.m.f. coal treated.

The remaining middle oil blended with the lighter boiling fractions was subjected to vapour phase hydrogenation in two stages. Pre-saturation was carried out over 8376 and 5058 catalyst, followed by splitting hydrogenation over 6434.

The pre-saturation was carried out in two stalls, each with three converters of 8 M³ catalyst volume. The first two converters were packed with 8376 and the third with 5058. The pressure was 300 ats., mean reduction temperature 410°C and the maximum throughput 0.8 kg. per litre of catalyst per hour. The yield of saturated product was 97% by weight on the feed. This product was distilled to give a petrol fraction which was blended in a final petrol product and middle oil was fed to splitting hydrogenation. The cutting temperature depended on whether aviation or motor fuel was required. In the former case a 0-155°C fraction amounting to roughly 45% of the saturated product, was blended direct into the final petrol.

The residual middle oil was hydrogenated in two stalls, each with two converters of 8 M³ catalyst volume, packed with 6434 catalyst. Pressure was 300 ats., average mean reaction temperature 390°C and maximum throughput - 1 kg per litre per hour. The conversion per pass was 50-55% when making aviation fuel and 65-70% when making motor petrol. Yields were 81-82% by weight of the feed of 0-155°C aviation fuel, or alternatively, 91-92% of 0-185°C motor gasoline. The former had a volatility of 55% at 100°C and a clear octane number of 74 which could be increased to 88 by addition of 0.09% by weight of TEL. The volatility of motor petrol was 35% at 100°C and the clear octane number was 70. The final blend of splitting stage motor petrol with the light distillate from the saturated product had a clear octane number of only 64. It was intended that, when making aviation fuel, the light distillate from the saturation product should be treated by the D.H.D. Process. A D.H.D. plant with a capacity of 26 tons/hour of feed had been installed. An alkylate plant for the production of 6.3 tons/hour of final product had also been built.

Phenol Extraction

Phenols in the liquors from both coal carbonisation and coal hydrogenation were extracted with phenosolvan (isobutyl acetate). This was a development made jointly by Lurgi and the I. G. The two liquors were treated separately and there were three plants; two operating and one spare.

It was intended to increase the output of phenolic products by washing the 160-210°C petrol fraction with recycle hydrogenation plant liquor from the phenosolvan extraction plant. This washing was to be carried out counter current at a temperature of 75°C.

The spent liquor from the phenosolvan plant contained rather less than 200 mgs. of tar acid per litre. There were serious restrictions on effluent disposal at Blechhammer and the spent liquor had to be treated in the following way:

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It was first diluted with recycle cooling water to reduce tar acid content to 20 mgs/litre and to raise the temperature to 25°C. It was then treated with diplococcus-type bacteria which reduced the tar acid content to 2 mgs/litre. Effluent from this treatment was finally pumped over waste ashes from the power station, when phenols were oxidised down to less than 0.5 mgs/litre.

Treatment of Hydrocarbon Gases

A Linde plant had been erected at Blechhammer in order to provide methane, ethane, propane and butanes from the mixed hydrocarbons produced in the hydrogenation process. These separated gases, apart from those required at Blechhammer for alkylate production, were to be sent to Heidebrech for use as chemical raw materials. A pipeline, 8 km. long, had been installed for this purpose.

Costs

Very little data on costs were available. The delivered cost of coal was 10-11 marks/ton, skilled workers were paid 80 pfgs - 1 mark/hour and unskilled workers 55-70 pfgs/hour. The middle German brown coal tar which was supplied subsequent to July 1944 cost 80 marks/ton.

According to Dr. Kronig, the estimated costs of production of heavy oil and aviation petrol at Blechhammer were 250 marks/ton and 450 marks/ton respectively. 65% of these costs were capital charges which included interest on capital at the rate of 4-1/2% and amortisation of the plant over a period of 11 years.

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