

Condensation of Products

Wax fog used to occur in the pipe-lines leading from the reactors and has penetrated even into the active carbon plant where it damaged the active carbon. It never occurs now since the cooling of the gases leaving the reactors has been made to take place more slowly, and it is never formed in the condensers if these are not run too cold. Ruhrchemie say that corrosion of the pipe-lines leading from the reactors is caused not only by condensed water, as would be expected, but also by oils which condense before any liquid water appears. Hence they used good insulation, or even steam heating, to prevent condensation of anything except wax in the pipe-lines leading from the reactors. No attempt was made at this point to prevent corrosion by injecting alkali, for fear of it getting back into the reactors.

Atmospheric Pressure

Condensation itself was done by direct cooling, and the Ruhrchemie plant consisted of a tower 3.45 m. diameter and 25.2 m. high, after the first synthesis stage, and another 2.85 m. diameter and 25.2 m. high after Stage II. Both are lined with acid-resisting stone. The pipe-lines for products and water are of aluminium so as to avoid corrosion. Each tower is packed with Raschig rings in four layers and the water sprays were arranged in three sections. After separating from the oil in tanks at the bottom of the tower, the water was recirculated at about 130 cu.m./h. through a cooling tower and then re-entered the condensation towers. Its pH was kept at 6.5.

Medium Pressure

Although direct condensation with a water spray is in general preferable, medium pressure products do not separate well from water, on account of the presence of higher molecular weight acids, so that in the medium pressure plants the oil is condensed indirectly in such a way that no separation from water is required.

Ruhrchemie found, however, that if the acids are first removed, direct condensation would be possible, and they proposed trying this on the large scale.

On the other hand, it must be remembered that since less C_3 and C_4 hydrocarbons are produced by medium pressure synthesis, condensation is essentially easier than for atmospheric pressure.

Between each stage of synthesis Ruhrchemie used a condensation plant consisting of a neutralizer and a tubular condenser. The neutralizer consisted of a tower with Raschig ring filling into which a dilute solution of alkali was sprayed, the amount of alkali being arranged so that the pH of the issuing water was 5.0 - 6.0. The condensers have a cooling surface of 400 sq.m. for Stage I and 300 sq.m. for Stage II. After the condenser the gas passes through a large pressure vessel to allow spray to separate before the pressure is finally let down to atmospheric. With this arrangement corrosion in the condensers was not serious, these being made of ordinary steel. Very serious corrosion did occur however on the water side of the condensers and no satisfactory solution of this problem has been found. Copper plating was tried and found to be ineffective. The best solution would naturally be to use acid-resisting steel for all the pipelines and the whole of the condensation plant. But when this was impossible owing to war-time shortage, the best that could be done was to use it at the worst points in the plant. Thus in the proposed plant for the Societa Italiana Carburanti Sintetici at Arezzo, a baffle of resistant 'Deutro' steel was to be arranged where the gas entered the condensation plant.

The Active Carbon Plant

The Ruhrchemie plant consisted of eleven absorbers holding 9 t. carbon each, and four holding 18 t. each. The small ones are cylinders with hemispherical ends, 3.8 m. diameter and with the layer of carbon 1.80 m. thick. The larger ones are 5.5 m. diameter and have a layer of carbon 2.20 m. thick. Gas is passed through an absorber till the active carbon contains 3-4% of its weight of spirit and 1-2% gasol, i.e. C₃ and C₄ hydrocarbons. The gas stream is then switched to a fresh absorber, and the used one steamed. The vapours produced are passed through a tubular condenser to separate spirit and water, and the gasol is collected in a gasholder. After steaming, the absorber is first dried by recirculating gas through the system, heater - absorber - cooler - pump, and then cooled by continuing the recirculation without the heater. Gas coming from another absorber is used in the cooling recirculation so as to recover a little more gasol from it. The best temperature for absorption is below 40°C. Up to 15% absorption on the charcoal, the spirit is removed from the gas quantitatively, and the removal of gasol can be judged from the analyses in Table 24, which are average figures for the Ruhrchemie plant for 1943-4.

Table 24

Performance of Active Carbon Plant, Ruhrchemie

	Gas from Atmospheric Pressure Synthesis		Gas from Medium Pressure Synthesis	
	Before Scrubbing	After Scrubbing	Before Scrubbing	After Scrubbing
CO ₂	36.5	36.6	44.2	42.3
C _n H _m	1.3	0.5	2.0	0.5
CO	14.1	15.2	9.7	12.0
H ₂	10.8	11.9	16.0	17.2
C _n H _{2n+2}	16.9	13.6	13.2	11.4
N ₂	21.3	22.2	14.9	16.6
"n"	1.69	1.11	1.79	1.10

Ruhrchemie consider that it would be advisable to scrub the gases with active carbon between the synthesis stages, but they themselves could not do this as they did not have an active carbon plant available for the purpose. The use of active carbon absorption between the stages does not improve the total yield or the boiling range of the products, but it does increase the proportion of olefines. This is in complete agreement with the results obtained by Rheinpreussen, who installed an active carbon plant between the stages for this purpose, and in particular, to increase the yield of propylene which they wanted for their alcohol synthesis. They found as a result of putting this active carbon plant into operation that the temperature of Stage II must be lowered 4 or 5° because of the more concentrated gas that is passed to that stage. This concentration of the gas is itself an improvement. Essener Steinkohle use an active carbon plant between the stages which removes most of the gasol hydrocarbons but the scrubbing is not as complete as that of the final residual gas. Since these gasol hydrocarbons are as valuable as liquid products there is no incentive to suppress their formation but as much of them should be collected as possible. Hence it is economical to use more steam and cooling water than is normally the case so as to recover more C₃ and C₄ compounds.