P8 PETROCHEMICALS

FISCHER-TROPSCH TECHNOLOGY

CHEMICAL INDUSTRIES RESOURCE PACK

Introduction

Franz Fischer and Hans Tropsch were chemists working at the Kaiser Wilhelm Institute for Coal Research in Mulheim, Ruhr. The institute was formed in 1913, but the research on which Fischer and Tropsch worked only started to produce results in the 1920s. Their aim was to develop a system that produced hydrocarbon molecules from coal-derived gas. They reacted hydrogen and carbon monoxide together at reasonable temperatures and pressures and produced a range of molecules that could be used as fuels and other feedstock chemicals. Their process was patented in 1925. Sasol uses Fisher-Tropsch technology to synthesise the wide range of chemicals they produce. The Sasol Advanced Synthol process uses a high-temperature synthesis to produce C_1-C_{20} hydrocarbons. The Slurry Phase Distillate (SPD™) process uses a lower temperature synthesis to produce linear hydrocarbon waxes and paraffins.

Sasol Advanced Synthol (SAS™) process

The SAS™ process uses a catalytic reaction at a temperature of about 340°C to synthesise low molecular hydrocarbons from synthesis gas.

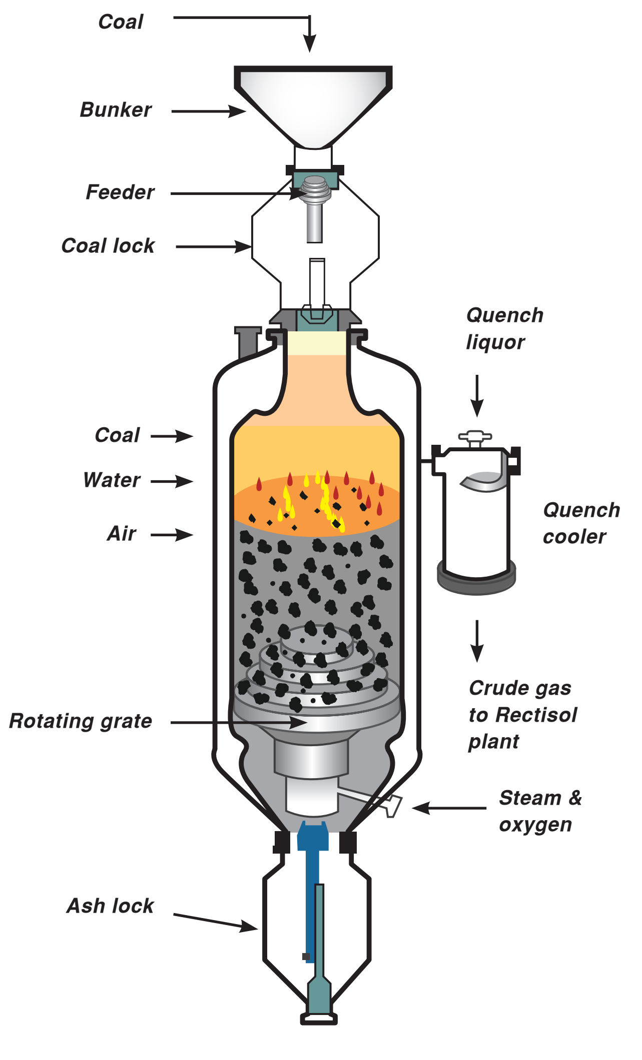
Gasification

Synthesis gas is obtained from coal that is gasified. After the mixed coal is screened the coarse coal goes to the 80 Lurgi gasifiers. At the top of the gasifier is the coal lock. It takes about 8 tonnes of coal. When the coal lock is filled, the lid is closed tight and gas is fed into it. The bottom of the lock is then opened and the coal falls into the body of the gasifier. High-pressure steam and oxygen also enter the gasifier to combust the coal at temperatures of 800 - 1400°C. The reaction is exothermic and excess heat is removed by circulating water through the wall of the reactor. The unbalanced net reaction inside the gasifier is:

C (coal) + H_2O + O_2 → CO + H_2 + CO_2 + small quantities of CH_4, other hydrocarbons and impurities.

The product from gasification is called the raw synthesis gas. This gas is cooled to 35°C at a pressure of 2700 kPa and fed to the Rectisol plant. The raw synthesis gas produced by the gasifiers contains not only the hydrogen and carbon monoxide needed for the next stage, but also contaminants like hydrogen sulfide, ammonia, carbon dioxide and phenol. These contaminants are removed during the Rectisol process. This is important, because these contaminants would poison the reactor's iron oxide catalyst. Methanol at -70°C is used to absorb the impurities and pure gas leaves this process.

Gasifier



Source: Mind over Matter, www.sasol.com

Two impurity fractions leave the Rectisol reactor - the naphtha stream and the off-gas which contains 97% CO_2, 1,5% H_2S and other impurities. The unsaturated chemicals in the naphtha stream are extracted for further processing.

The off-gas is treated in the Sulfolin process. Originally the hydrogen sulfide from the Rectisol process was released into the air, but this caused problems. The rotten-egg smell can travel for hundreds of kilometres in the air and can be smelt in a ratio as small as a few parts per billion. Sasol developed the Sulfolin process in which H_2S is oxidised to sulfur.

The sulfur is used to manufacture sulfuric acid. Sasol was the first company in the world to use both the Rectisol and Sulfolin processes on a commercial scale. The purified synthesis gas is then finally ready for the reactor.

Conversion

The purified synthesis gas is sent to the Sasol Advanced Synthol (SAS™) reactors. The hydrogen and carbon monoxide gases react under pressure in the presence of a fluidised, iron-based catalyst at a temperature of about 340°C to yield C_1 to C_{20} hydrocarbons.

The SAS™ process also produces oxygenated hydrocarbons and reaction water. Hydrocarbons from the SAS™ reactors are cooled slowly in a product recovery plant until most components become liquefied.

The differences in boiling points are used to separate the different hydrocarbon fractions and the methane-rich gas. Some of the methane-rich gas is sold as pipeline fuel gas and the remainder is sent to a reformer to be converted back to synthesis feed gas. The gas is then routed back to the SAS™ reactors.

The C_2-rich stream is separated into ethylene (C_2H_4) and ethane (C_2H_6). The ethane is cracked in a high-temperature furnace to produce ethylene for further purification. Propylene (C_3H_6) is also separated from the light hydrocarbon gases. Some of this propylene is converted into polypropylene at Secunda and some into butanol at Sasolburg.

The C_4 to C_{20} hydrocarbons - the heavy cut - contain large quantities of C_5 to C_{11} olefins. The three alpha olefins recovered from this mixture, 1-pentene (C_5H_{10}), 1-hexene (C_6H_{12}) and 1-octene (C_8H_{16}), are sold to the international market. The rest of the oil stream is routed to a refinery where liquefied petroleum gas (LPG), propane, butane, fuel oil, illuminating paraffin, petrol and diesel are produced.

The oxygenates in the aqueous stream from the SAS™ process are also separated and purified to produce alcohols, acetic acid and ketones, including acetone and methyl ethyl ketone.

This article was obtained from Sasol Group Services. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: UCT Chemical Engineering Schools Project. 2010. Chemical Industries Resource Pack. Cape Town.

Raw gas from gasifier	Pure gas leaving the Rectisol process
39% H_2	55% H_2
23% CO	31% CO
10% CH_4	12% CH_4
28% CO_2	<1% CO_2
Traces of C_nH_{2n}, H_2S_7, N_2 and NH_3	

Rectisol gas purification columns

DID YOU KNOW?

'Olefin' is another word for alkene.

Source: Mind over Matter, www.sasol.com