

The Chemical Industry



The UK Chemical industry is a major contributor to both the quality of our life and our national economy.

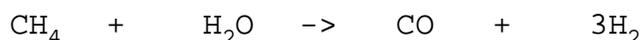
The UK chemical industry is, by and large, capital rather than labour intensive. Most production processes are now automated and computer controlled, reducing the need for plant workers. Modern plants require only a few operators with the backup of fitters, engineers, and instrument technicians when breakdowns occur.

Stages in the manufacture of a new product from scratch:

1. **Research to establish the chemical processes and conditions required.**

For example, it is important to know how much heat is given out or taken in by the reactions occurring in the process e.g.

The following reaction is used in the Haber Process to obtain the Hydrogen required by the process:



It is difficult to carry out in the lab and therefore its enthalpy change is difficult to measure.

Hess's Law to the rescue!!

Hess's Law states that the energy change in a chemical reaction is independent of the route taken.

It is easy to measure the enthalpies of combustion of CH_4 , CO and H_2 :



We will try to manipulate the above three equations so that they will add up to give the TARGET equation in the box below:

$\Delta H/\text{kJ mol}^{-1}$

CH_4	+	H_2O	\rightarrow	CO	+	3 H_2	?
$1/3 \text{ H}_2\text{O}$			\rightarrow	3 H_2	+	$3/2 \text{ O}_2$	+ 858
CH_4	+	2 O_2	\rightarrow	CO_2	+	$2 \text{ H}_2\text{O}$	- 891
CO_2			\rightarrow	CO	+	$1/2 \text{ O}_2$	+ 283
CH_4	+	H_2O	\rightarrow	CO	+	3 H_2	<u><u>+ 250</u></u>

Yields must also be high: the use of a high temperature and low pressure would ensure a high yield of Hydrogen in the above reaction.

2. The building of a small pilot plant to test the theory.

There are certain factors which theory cannot easily predict, factors which can only be studied in the pilot.

e.g. the life of the catalyst can be reduced by poisoning.

This would affect the cost of the process.

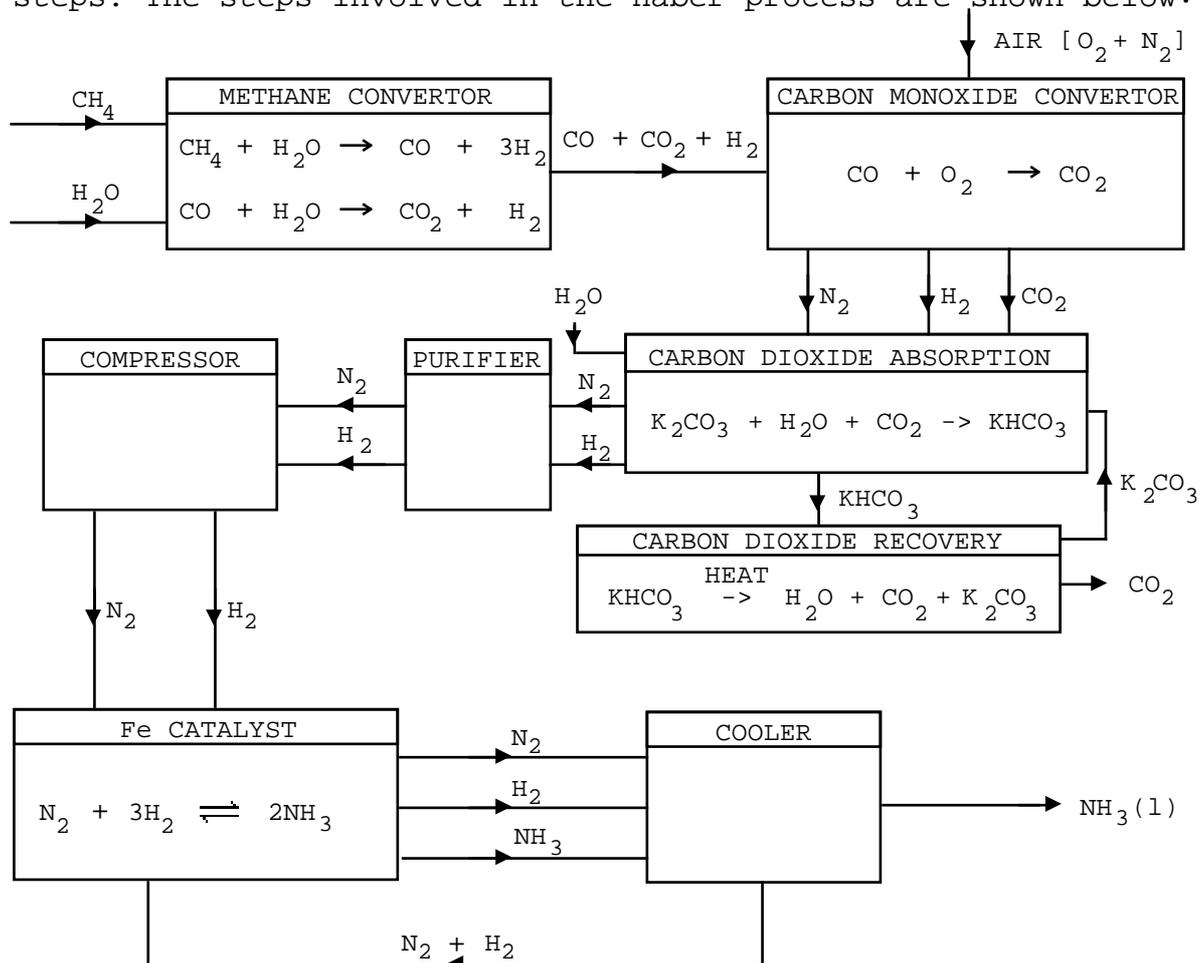
3. Building the full scale plant.

Many factors influence the site chosen for a new manufacturing plant. Ideally it should be near the source of the raw materials (naturally occurring substances e.g. crude oil, natural gas, coal, metallic ores and minerals e.g. Limestone) and have good transport by road, rail or sea.

Every care will be taken to provide a safe, working environment for the work-force and to minimise environmental pollution. Waste products are always kept to the minimum; toxic waste is treated before disposal.

Capital costs (costs incurred in the building of the plant and purchasing apparatus etc) are the main expenditure in this initial phase.

A chemical manufacturing process usually involves a series of steps. The steps involved in the Haber process are shown below:



The Haber process is a **continuous** process: raw materials (air, natural gas (CH_4) and Water) flow in; products flow out. There is no break in the process so there is greater production, less labour is required and the process is more easily automated.

When small amounts of specialised products (e.g. drugs, dyes and pesticides) are required, **batch** processing is used. Feedstocks are reacted and products are obtained. The process is restarted when the next batch is required. Batch processing is also used when the products would be too dangerous to manufacture in bulk e.g. explosives. Compared to the continuous process, capital costs are less and it is easier to make changes in the process.

4. Production

Fixed costs are those which are incurred whether a plant is operating at maximum capacity or not. They include the cost of repaying loans, rates, salaries and telephone bills. These fixed costs must be kept to a minimum.

Cheap, readily available raw materials should be used. In the Haber Process Hydrogen is obtained from natural gas or naphtha and Nitrogen is obtained by removing Oxygen from the air.

Recycling reactants can help to keep costs down e.g. N_2 and H_2 are recycled in the Haber Process.

The efficient use of energy can help to keep these costs down e.g. insulation, extracting heat from cooling water etc.

By-products are often marketable. This helps to keep costs down. Soda water, a solution of Carbon dioxide in Water, is a by-product of the Haber process !

Variable costs are on-going costs which are unpredictable e.g. repairs to damage. When demand for a product is low, less raw materials are purchased and transport costs are lower.

5. Reviewing and improving purity and yield etc.

All plant processes are continuously reviewed and modifications are made where necessary e.g. alternative reaction conditions, catalysts, effluent disposal etc.