

THE METHANOL PROCESS, A BASIC INTRODUCTION

What is Methanol ?

Many millions of tons of Methanol are produced by the Chemical Industry every year.

Methanol is the lowest member of a group of organic chemicals that belong to the Alcohol 'family'.

This material must never be confused with Ethanol, (note the different spelling) which is another, (next highest) member of that family group.

This is because Ethanol is a natural product of fermentation, and when produced that way becomes the active ingredient of alcoholic drinks.

However Methanol is extremely poisonous to humans, even when ingested in very small quantities.

Methanol is a basic 'building block' for the production of other chemical products such as Plastics, Paints and Man-Made Fibers.

It has also found a large use in the production of Gasoline Fuel additives.

How Is Methanol commercially produced?

Although some is still produced from old and inefficient coal gasification plants, Methanol is mainly produced in areas of the world where a large supply of Natural Gas is available at an economical supply cost.

By creating the necessary chemical reactions within the process, natural gas is converted into a valuable liquid product that is easily transported to markets in Europe, Asia and America by ship.

The two main essential ingredients, (feedstock) to produce Methanol here at 'Ampco' are basically Natural Gas and Water.

However it is simply not enough to mix gas and water, (as steam) together. A lot of other conditions are also necessary.

These extra conditions include a lot of heat and pressure, in addition to another necessary material.

This other material is called a Catalyst. This is something that promotes, (encourages) the ingredients in this particular process to 'crack' and 'reform' into something entirely different from the original feedstock.

This is the first major step in the production of Methanol, and the process is given the general name of 'Steam Reforming'

In order to understand the Steam Reforming process, a little knowledge of chemistry is helpful.

First, most people will know what H₂O is. It is of course water, but it is still H₂O even if it is in solid form, (ice), or as a vapor (steam).

Now if we can ‘crack’ H_2O into its basic elements of H_2 and O we get two types of gas: Hydrogen and Oxygen.

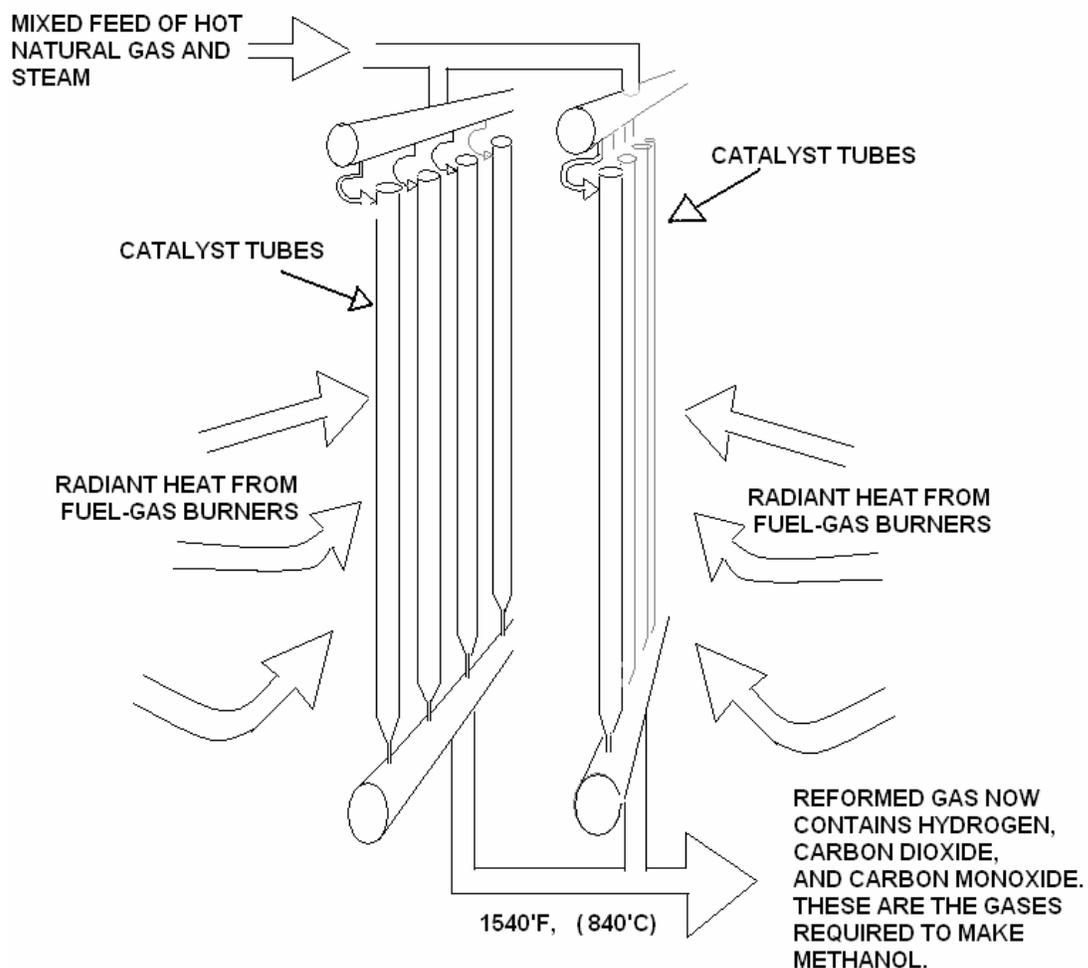
This is what is done in a Steam Reformer, some of that H_2O , (as steam) ‘cracks’ to go back to the elements that originally formed it.

However, not only is H_2O ‘cracked’, something similar happens to the Natural gas. Natural gas is composed of Hydrocarbons and the major part of this gas that feeds Ampco is the simplest type of Hydrocarbon, Methane, (CH_4)

The formula CH_4 shows that there is one piece, (atom), of Carbon (C), and four pieces, (atoms), of Hydrogen, (H) in this molecule. When this Methane molecule also cracks into its basic parts, we now have a situation where these elements can be reformed into something else.

And if controlled correctly, the result is exactly the correct mixture of gases to make Methanol.

HOW THE STEAM REFORMING REACTION TAKES PLACE



The gases required to make Methanol later in the process leaves the Steam Reformer and the mixture is simply called Reformed Gas.

The reformed gas contains a lot of unreformed steam at this stage, however this will be cooled, condensed into water and removed. The necessary ingredients are:

75% Hydrogen, (H ₂)	all very approximate
10% Carbon Dioxide, (CO ₂)	-- ----- '----- ---
10% Carbon Monoxide,(CO)	-- ----- '----- ---

A few percent of unreformed Methane, (CH₄) remains. This will be removed, (purged) from the downstream synthesis area and burned as another source of reformer fuel.

As mentioned, a great deal of heat is necessary to make this reforming reaction proceed.

A Steam Reformer is a huge gas fuelled 'hot-box' furnace that consumes about 30 million cubic feet of new fuel gas every day, it also burns other waste gases from the process.

The reason that such a large fuel consumption is necessary, is because the Steam Reforming reaction is 'endothermic' this means it is heat demanding.

The feed gases that pass through hundreds of catalyst filled tubes in the reforming furnace need to be heated, and maintained at about 1540°F, (840 °C).

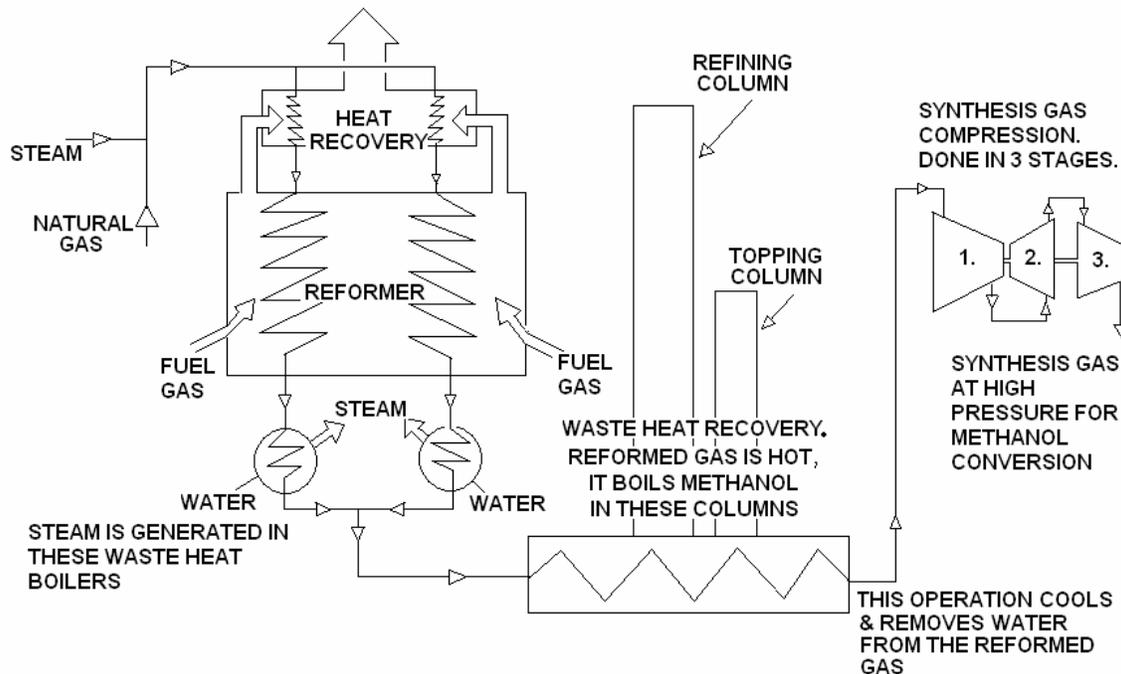
It is at these conditions, and in contact with the necessary catalyst, that the reaction takes place.

This is an extreme temperature for most metals and if you are to look inside a reformer furnace you would see that these metal tubes are 'white hot'.

Because of this, special high temperature resisting metallic alloys are used to construct these catalyst tubes.

After the Steam Reforming process, most of this heat is not wasted, it is recovered by use of heat exchangers that transfer this energy to other parts of the process that require it.

A SIMPLIFIED OVERVIEW OF THE 'FRONT END' PRODUCTION OF REFORMED GAS



As was also mentioned earlier, the methanol production process requires a lot of pressure energy.

The reformed gas that has passed through a cooling process of the plant must now have its pressure boosted in order for the Methanol Synthesis reaction to occur. Compression is achieved in 3 stages, Low, Medium and High. All these compression stages are driven by one large and powerful gas fired Gas Turbine, that itself consumes about 10 million cubic feet of gas every day.

Synthesis takes place at a pressure of about 1400 pounds per square inch, about 95 times atmospheric pressure.

Methanol Synthesis also requires the use of a Catalyst and the reaction takes place at a feed temperature that allows the best conditions for optimum production. Unlike the Steam Reforming Reaction, Methanol Synthesis creates heat and this type of heat of reaction is called 'Exothermic'.

Consequently outlet gases from this reaction vessel, (called a Methanol Converter) are significantly hotter than they entered. For example, 440°F inlet, 540°F outlet, (226°C / 280°C), these temperatures vary during the life of the catalyst. As is normal in process plant design, the exothermic reaction is made use of by heat exchange to preheat the incoming reaction gas.

Again some knowledge of basic chemical reactions is helpful to get an understanding of the process of Synthesizing Methanol.

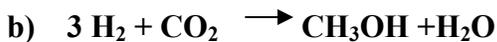
As the product methanol has the formula CH₃OH, one molecule of methanol has:

1 part, (atom), of Carbon, (C)

1 part, (atom), of Oxygen, (O)

4 parts, (atoms), of Hydrogen, (H)

Two separate reactions can produce methanol from the above gases that were first made in the Steam Reformer:

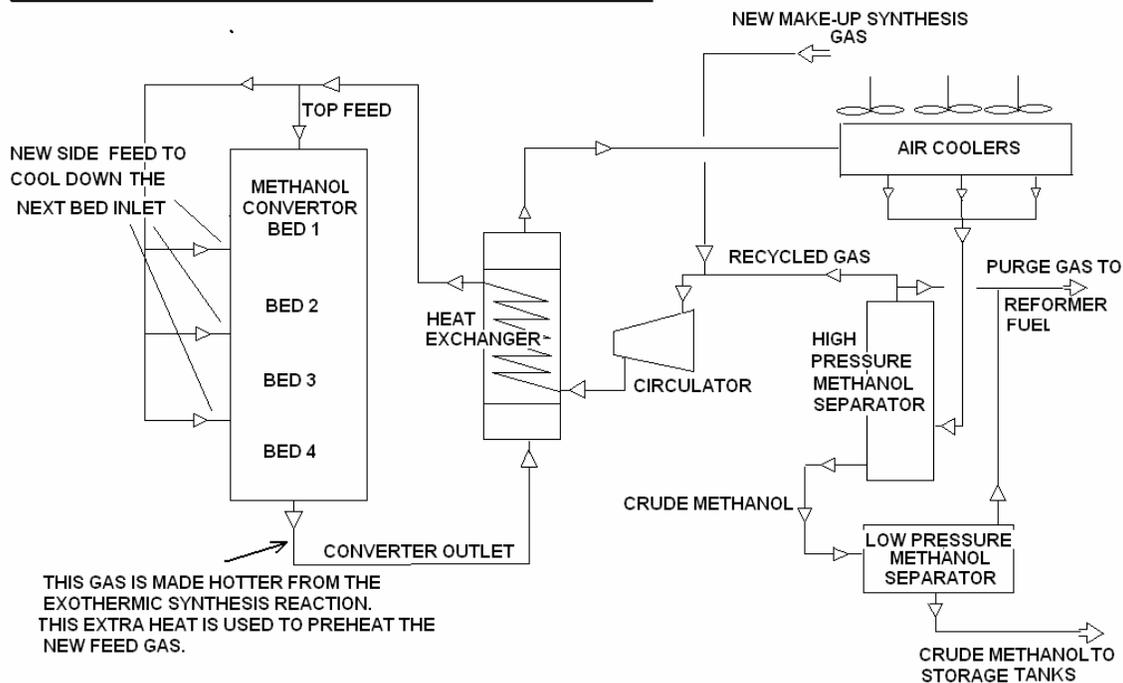


The methanol produced at this stage is in vapor form and is too hot to become a liquid, it is cooled by air fans and water cooled condensers so that it changes to liquid Crude Methanol.

In liquid form it can then be separated from other gases that are circulating around and through the Methanol Converter. This is done in special separation vessels. Constant circulation of the unreacted synthesis gases is maintained by a separate steam turbine driven compressor, simply called the 'Circulator'

Circulation, of unreacted synthesis gases is essential to ensure these reactants get as many opportunities as necessary to convert to methanol as quickly as possible.

THE SYNTHESIS OF METHANOL: THE SYNTHESIS 'LOOP'



It is in this next step of purification that the liquid is again constantly boiled until the water, (which boils at a higher temperature) is separated from product methanol.

A very tall distillation column is required for separating water from methanol. This is because these two materials 'like each other a lot' and are reluctant to separate.

It therefore requires a lot of heat energy, (heavy boiling) to achieve the required product purity.

Good quality methanol vapor separates and rises to the top of this column. From here it is changed back to liquid, (condensed). Part of this condensed liquid methanol, (called distillate) is taken to the product methanol storage tanks.

As is necessary with all distillation systems, a lot of the this good quality distillate must be returned back to the top of the column in a process called 'refluxing'

The water that has now been separated from the methanol product, accumulates in the bottom of this refining column.

This is constantly transferred out to a waste water treatment facility, and then for disposal.

REVIEW

This description of the methanol production process has purposely been kept simplified.

A large methanol production facility such as the Ampco, Punta Europa plant, has much more equipment and detail than can be explained here in a few pages.

A facility such as this must also have a lot of extra Utilities and Services that are necessary to allow the plant to operate.

These include:

Electrical Power Generation: This is provided by 4 X Gas Turbine driven generators that produce approximately 8 megawatts of electrical power that is necessary to run the Ampco facility.

A large methanol plant is a very big power consumer.

Water, (various types): Water is essential to Methanol production. Over 3000 metric tons of very clean 'new' water is required every day for duties varying from providing domestic drinking water (called potable water), to water that will be boiled to make steam.

The methanol process produces and consumes a lot of steam.

A lot of the drinking, (potable) water comes as treated natural water from underground wells, but the majority that is needed for other uses is produced from seawater by a process called 'Desalination' (removal of salt)

In addition, a very large amount, approximately 300,000 metric tons per day, of seawater is pumped and, (by heat exchange), is used for cooling the methanol production plant.

Note: Plant cooling is also done by electrically driven fan assisted air coolers.

Compressed Air and Nitrogen : These items are also necessary for the controlling power of a chemical plant by the use of compressed Instrument Air. Nitrogen gas is produced by separation of Oxygen from atmospheric air. It is distributed and used for fire prevention when processing and storing flammable gases and liquids.

Waste Treatment: Facilities are provided to process and clean Industrial and Human Waste, (sewage) products. It is the responsibility of any industrial company to ensure that waste material is returned to the environment safely and without causing pollution.

Product Storage and Shipping: This is another essential part of the Methanol Production Plant. At Ampco about 100,000 metric tons of Product Storage is available.

Sufficient capacity is always required to hold methanol until a ship is available to load and transfer the product away to a foreign market.

