Lecture 12. Production and processing of acetylene. Production of acetylene by wet method. Using of acetylene.

Acetylene is a colorless, combustible gas with a distinctive odor.

When acetylene is liquefied, compressed, heated, or mixed with air, it becomes highly explosive!!!

The acetylene production technologies

1. Using calcium carbide:

Wet method:

a) Carbide adding to water generation

b) Water adding to carbide generation

Dry method

2. Using hydrocarbons like natural gas and naphtha:

Electric arc processes, Partial combustion processes, Thermal cracking, Regenerative furnace processes, Co-product in ethylene synthesis

2. Using coal:

Rotating arc reactor technology

Magnetically rotating arc reactor technology

Production of acetylene using hydrocarbons

Other processes use natural gas, which is mostly methane, or a petroleum-based hydrocarbon such as crude oil, naphtha, or bunker C oil as raw materials.

Coal can also be used. These processes use high temperature to convert the raw materials into a wide variety of gases, including hydrogen, carbon monoxide, carbon dioxide, acetylene, and others.

$$2\,CH_4 \rightarrow C_2H_2 + 3\,H_2$$

The other gases are the products of combustion with oxygen. In order to separate the acetylene, it is dissolved in a solvent such as water, anhydrous ammonia, chilled methanol, or acetone, or several other solvents depending on the process.

Production of acetylene using calcium carbide

The simplest process reacts calcium carbide with water to produce acetylene gas and a calcium carbonate slurry, called hydrated lime.

$$CaC_2 + 2\,H_2O \rightarrow C_2H_2 + Ca(OH)_2.$$

There are two basic conversion processes used to make acetylene.

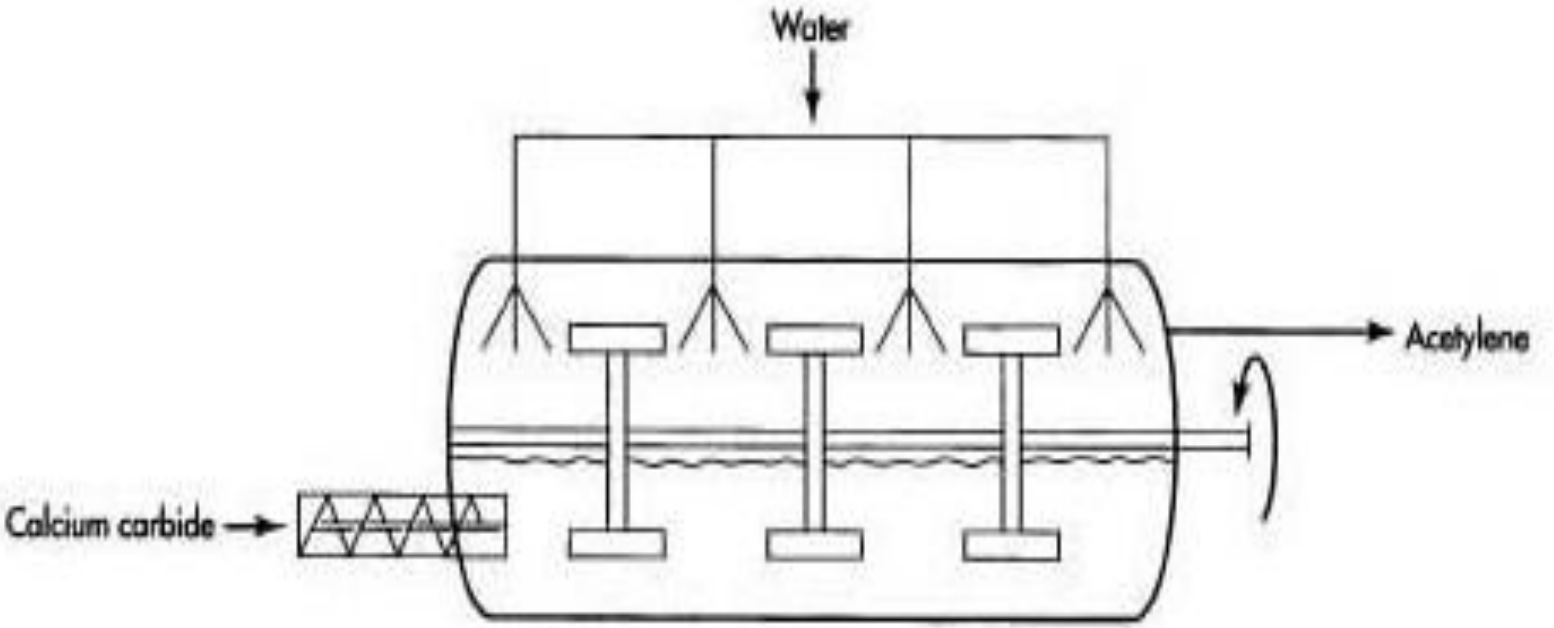
- at normal temperatures.
- at extremely high temperatures.

Acetylene may be generated by the chemical reaction between calcium carbide and water. This reaction produces a considerable amount of heat, which must be removed to prevent the acetylene gas from exploding.

There are several variations of this process in which either calcium carbide is added to water or water is added to calcium carbide. Both of these variations are called wet processes because an excess amount of water is used to absorb the heat of the reaction.

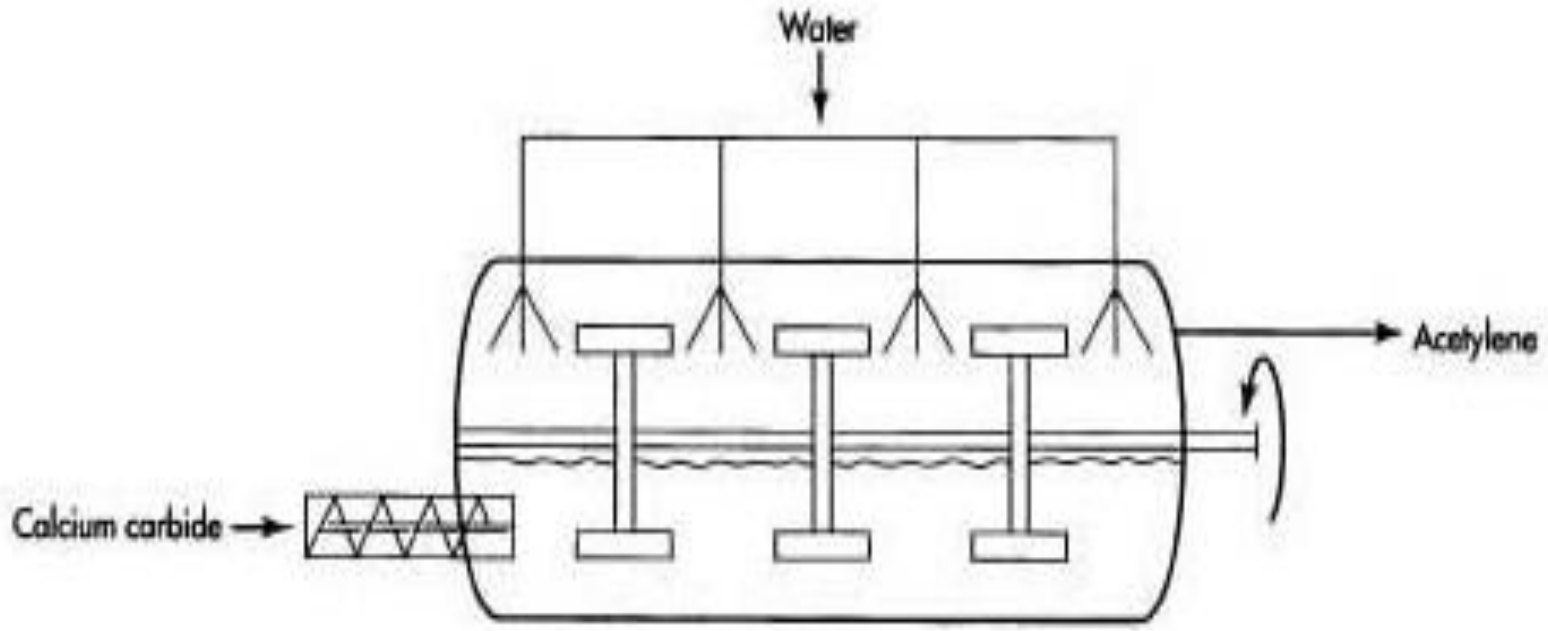
A third variation, called a dry process, uses only a limited amount of water, which then evaporates as it absorbs the heat. The first variation is most commonly used in the United States and is described below.

Most high-capacity acetylene generators use a rotating screw conveyor to feed calcium carbide granules into the reaction chamber, which has been filled to a certain level with water. The granules measure about 2 mm x 6 mm, which provides the right amount of exposed surfaces to allow a complete reaction. The feed rate is determined by the desired rate of gas flow and is controlled by a pressure switch in the chamber. If too much gas is being produced at one time, the pressure switch opens and cuts back the feed rate.



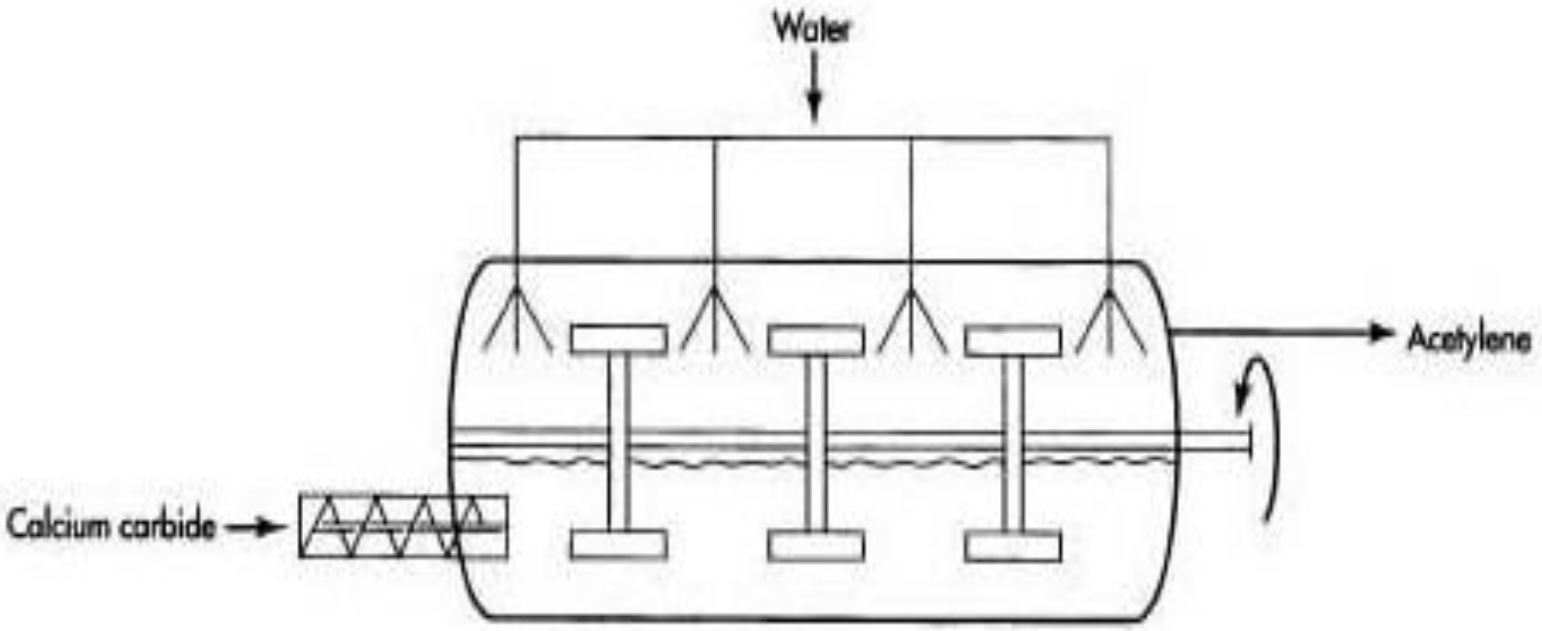
To ensure a complete reaction, the solution of calcium carbide granules and water is constantly agitated by a set of rotating paddles inside the reaction chamber. This also prevents any granules from floating on the surface where they could over-heat and ignite the acetylene

The acetylene gas bubbles to the surface and is drawn off under low pressure. As it leaves the reaction chamber, the gas is cooled by a spray of water. This water spray also adds water to the reaction chamber to keep the reaction going as new calcium carbide is added. After the gas is cooled, it passes through a flash arrester, which prevents any accidental ignition from equipment downstream of the chamber.



Flow Sheet of Acetylene production

As the calcium carbide reacts with the water, it forms a slurry of calcium carbonate, which sinks to the bottom of the chamber. Periodically the reaction must be stopped to remove the built-up slurry. The slurry is drained from the chamber and pumped into a holding pond, where the calcium carbonate settles out and the water is drawn off. The thickened calcium carbonate is then dried and sold for use as an industrial waste water treatment agent, acid neutralizer, or soil conditioner for road construction.



Flow Sheet of Acetylene production

Acetaldehyde Production from Acetylene

Acetylene used as raw material for producing acetaldehyde in petrochemical industries.

In theory, there are two methods for acetaldehyde production using acetylene.

- **Using solid catalyst in vapour phase system for acetylene hydration.**
- **By using a mercury-ion (liquid) catalyst in liquid phase for hydration of acetylene.**

In fact, acetaldehyde is also manufactured from vinyl ethers, ethyl alcohol by oxidation and from ethylene by oxidation.

Industrial process of producing acetaldehyde by hydration of acetylene using mercury-iron catalyst in liquid phase is much simpler in construction and handling the operation.

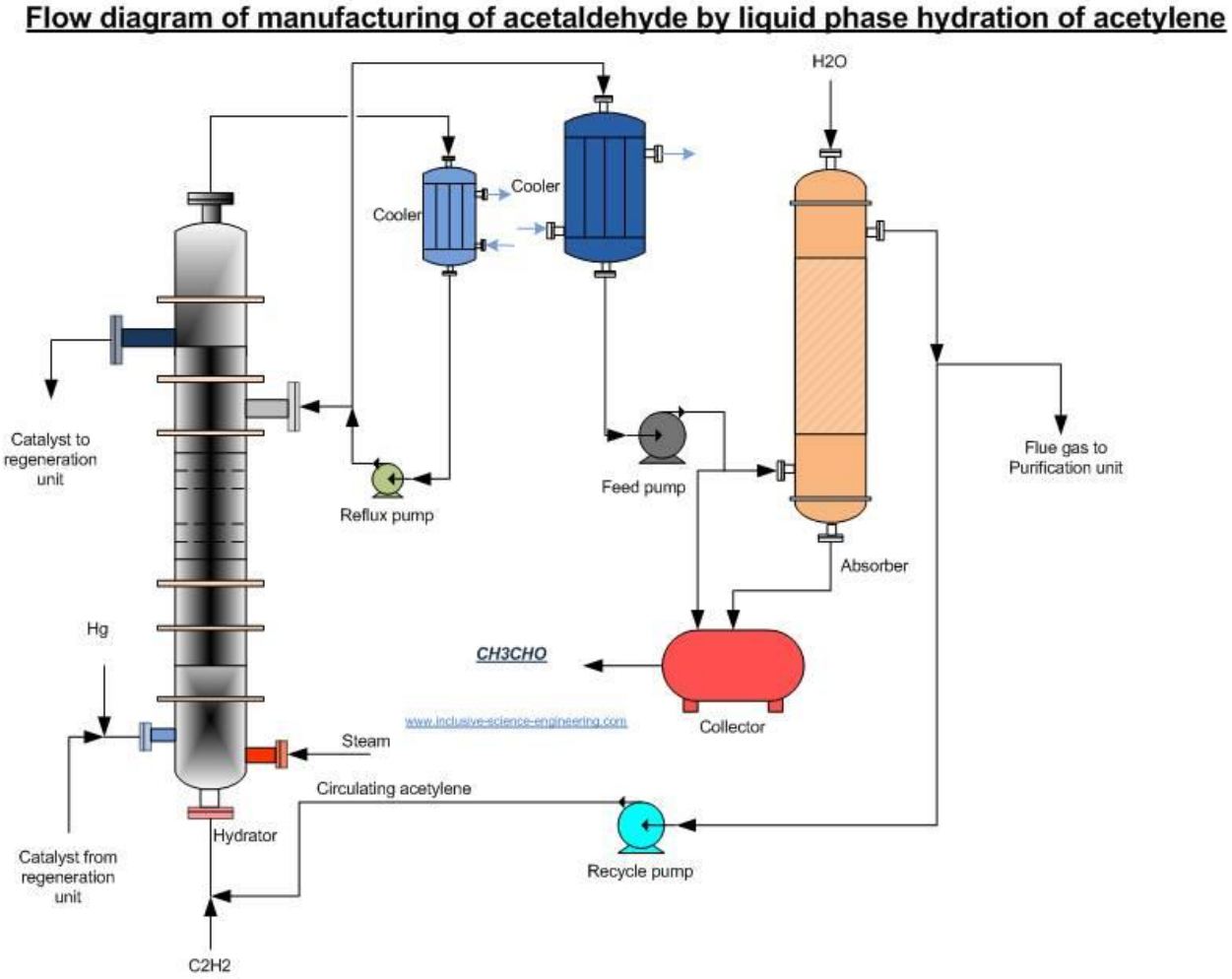
$$\mathbf{C_2H_2 + H_2O \rightarrow CH_3CHO + 151\ KCal}$$

Condition of the hydrator:

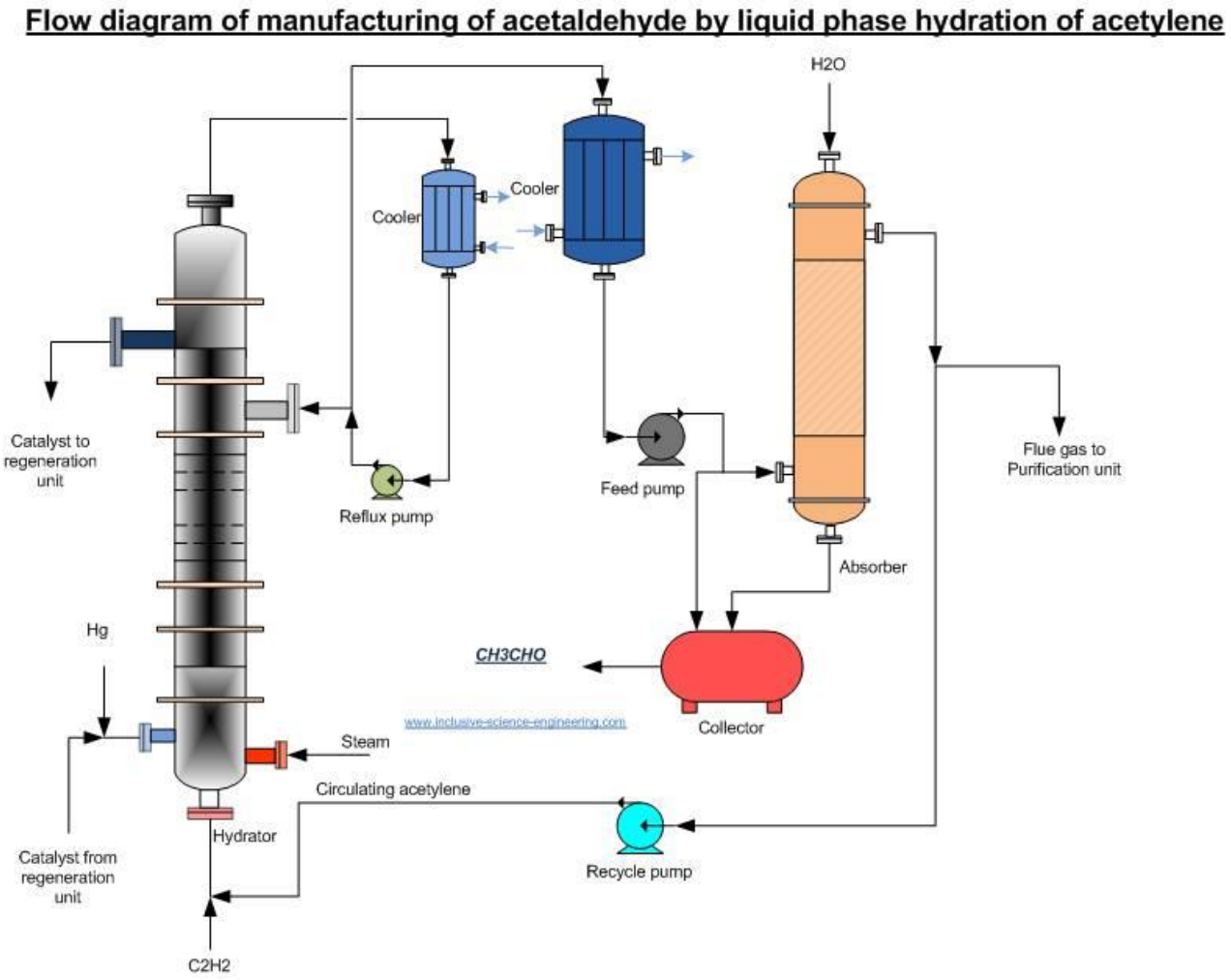
P=1.5-2.5 atm

T=80-100 ^{o}C.

Acetylene is fed continuously through the liquid catalyst. The temperature is maintained by steam, it is injected at the bottom of the column. The hydrator is made of stainless steel or with ferrosilicon. The top stream of the hydrator is sent to a cooler. All the water vapour is condensed and recycled.



The second cooler takes the outlet from the first one. Acetaldehyde is condensed along with trace of water. Unreacted acetylene and non-condensable vapour is feed to a water scrubber. The water scrubber is operated at temperature of 10 ºC. Traces of acetaldehyde and water-soluble compounds are scrubbed down. Remaining gases are used as fuel or recycled to the dehydrator.



The liquid catalyst is a solution made of mercury (II) sulphate dispersed in sulphuric acid. As acetaldehyde is good reducing agent it reduces Hg(II) to Hg(I) and finally reducing Hg(I) to Hg.

$$2Hg_2SO_4 + H_2O + CH_3CHO \rightarrow Hg_2SO_4 + H_2SO_4 + CH_3COOH$$
$$Hg_2SO_4 + H_2O + CH_3CHO \rightarrow 2Hg + H_2SO_4 + CH_3COOH$$

Fluidized bed type equipment is used as hydrator. Even zinc oxide, magnesium oxide and iron oxide are used in place of mercury.

In general, calculations 680 kg of acetylene, 0.1 kg of mercury are consumed to produce one ton of acetaldehyde. The conversion of this process is about 50-60% per pass. Catalyst is regenerated through the process.

Flow diagram of manufacturing of acetaldehyde by liquid phase hydration of acetylene