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علوم الكيمياء
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Chapter one:

Introduction: the chemical process industry

1.1 The chemical process Industry

The chemical process industry includes those manufacturing facilities whose products result from **(a)**chemical reactions between organic materials ,or inorganic materials, or both **(b)** extraction ,separation, or purification of a natural product, with or without the aid of chemical reactions, **(c)** the preparation of specifically formulated mixtures of materials, either the natural or synthetic. Examples of products from the chemical process industry are plastics, resins ,dyes, pharmaceuticals, paints,soaps, detergents, petrochemicals,perfumes, inorganics,and synthetic organic materials,many of these processes involve a number of unit operations of chemical engineering.

the three largest largest sectors within the world chemical industry are petro chemicals, pharmaceuticals, and performance chemicals .

The U.S. government uses the following eight standard industrial classification codes to categorize chemical companies.

1-Industrial inorganic chemicals

2-Plastics,materials, and synthetics

3-Drugs

4-Soap,cleaners,and toilet goods

5-Paints and allied products

6- Industrial organic Chemicals

7-Agricultural chemicals

8-Miscellaneous chemical products

Organic chemical industry: It is an important branch of of industry and its structure usually centers on petroleum and hydrocarbon derived chemicals, the nonpetroleum industry based on organic

industries such as paints, dyes, edibleoils, fats and waxes,soaps and detergents, sugars,fermentation,chemical explosives andagrochemical industries.

1.2The batch and continuous processes in chemical reaction

The primary types of chemical reactions are either *batch or continuous.*In **batch reactions,**the reactant chemicals are adddeed to the reactor(reaction vessel)at the same time and products are emptied completely when the reaction is finished. The reactors are made of stainless steel or glass-lined carbon steel and range from 200 to several thousand liters. Batch reactors are provided with a stirrer to mix the reactants, an insulating jacket, and the appropriate pipes and valves to control the reaction conditions.

Batch processes generally are used for small-scale productions .the processes are easier to operate ,maintain, and repair. The batch equipment can be adapted to multiple uses.the soap, and drugs industries produced by batch process.

In **continuous processes,** the reactants are added and products removed at a constant rate from the reactor, so that the volume of reacting material in the reactor(reaction vessel)remain constant. The reactors in this system either(1) a continuous stirred tank or (2)a pipe reactor generally used. A continuous stirred tank reactor is similar to the batch reactor described above. A pipe reactor typically is a piece of tube arranged in coil or helix shape that is jacketed in a heat-transfer fluid. Reactants enter one end of the pipe, and the materials mixed under the turbulent flow and react as they pass through the system. Pipe reactors are well suited for reactants that do not mix well, because the turbulence in the pipe causes all materials to mix thoroughly.

Because continuous processes require a substantial amount of automation and capital expenditure, This type of process is used primarily large –scale productions.

The organic chemical industry is a very high technology industry, which uses the latest advances in electronics and engineering.

Computers are very wiedely used in automation of chemical plants, quality control , and molecular modeling of structures of new compounds.

1.3The capital costs of the industrial process

The capital costs represents the cost of setting up the chemical manufacturing .

The Factors affecting capital costs:

1. **The number of the reaction steps:**

   Vessels for chemical conversions and formulating(chemical reaction) and equipment for separation processes represent the largest single expenditure in chemical plants. The industry also buys large large quantities of such generally used item as valves ,pumps, and instruments for recording and controlling processes and product quality. If the chemical process include more than one step of reaction it will be more expensive industry.

   The formula for calculation of charge price per hour for the Vessel .If the Vessel is assumed to be in use,for example,for 80% of the time. It is decided to pay for the equipment in certain time, say, 10 years.

   (Charge price of equipment/hr)=(installed price of equipment)/ (no.hr in 80% of 10 years)

   (Total batch cost for equipment)=(no. hr to make batch)(Charge price for equipment/hr)

   (Fraction of cost of production/kg for equipment)=(total batch cost for equipment)/batch size)

2. **Extensive separation:**

   The reaction products are often not in pure form, usable by customers or downstream manufactures. Therefore ,the desired product must be isolated and purified by using various separation and purification methods. Common separation methods include

filtration , distillation and extraction, center fuges, crystallization Multiple methods are also used to achieve the desired purity.

3-Use of corrosive materials

When we use acids and acid oxides this is will be more expensive in chemical processing .Thus corrosion is constant and continuing problem with the chemical engineer in industry.

In some cases corrosion cannot be prevented; it can only be minimized. In these instances the designing engineer must provide for periodic replacement. The advance of chemical engineering has provided many corrosion –resisting materials. Among such relatively new materials are the following:rubber-covered steel , resin –bonded carbon , to resist hydrochloric acid-stainless steel to resist the action of aqueous nitric acid even under pressure, and nickel or nickel –clad steel to resist caustic solutions , hot or cold.

4- The physical phasses of the material

When we use gasses or liquids material in chemical process ,they are more easy than solids.

5-Extremes of temperature and pressure

In any manufacturing there are many sources of heat such as boilers, kilns, evaporators, cryogenic facilities. Extreme temperatures can lead to engineering problem and lead to injuries of personaland also may cause damage to equipment .these factors can generated by the thermal changes in the environment that lead to accident . On the other hand, reduce temperetures can cause a loss of ductility of metals and can increase their brittleness. The brittle failure of steel may seriously affect structures such as bridges causing them to collapse, ships and heavy equipment to break up, and gas transimission lines crack.the above mentions facts demand a thorough inspection of the process, technical design and regular checking of the equipment as to their safe working temperatures.

It is some time necessary to work at lower pressure to avoid serious in juries and damage. It is also commonly and mistakenly belived that injury and damage will result only from high

pressure. When the expansive force of a liquid inside a container exceeds the container's strength it will fail by rupturing. Rupturing may occur by opening of a crack that provides a passage for fluid. When bursting is rapid or violent, the result will be destruction of the container.

A vacuum (the negative difference between atmospheric and below atmospheric pressure) can be as damaging as the high pressure systems. Sometimes a vacuum is more damaging to the structures that may not be built to withstand reversal stresses.

The negative pressure can also be generated by the condensation of vapors that could cause a collapse of closed containers .When vapors are cooled down to liquiefy, the volume occupied by the liquid is far less than their vapors. As a result, the partial pressure inside the container decreases significantly. Vessels are desighned to sustain the load imposed by the difference between the outside and inside pressures, or unless a vaccum breaker is provided.

1.4The production costsof the industrial process

The production costs represents the cost of operating the chemical manufacturing.

The affecting production costs

1- Raw materials

Industrial chemistry procures raw materials from natural environments to convert them into intermediates, which subsequently serve as base materials to every other kind of industry. There are four sourses of natural environment:

a.The earth's crust (lithosphere)

b. The marine and oceanic environment (hydrosphere)

c. The air (atmosphere)

d. The plants (biosphere)

Raw materials derived from the above natural resources are classified as either renewable or nonrenewable .**Renewable resources** are those that regenerate themselves,such as agricultural, foresty,fishery, and wildlife products.The renewable

raw materials are being used to solve environmental problems in that the products made from them generally are more readily bio degradable and less toxic.these renewable resources can become nonrenewable.

Non renewable resources are those that are formed over long periods of geologic time. They include metals, minerals, and organic materials.

The renewable resources such as agricultural materials were the main source of raw materials until the early part of the twentieth century for the manufacturing of soap,paint,ink,lubricants,greases,paper,cloth,drugs,and other chemical products. The nonrenewable feedstock based on fossil fuels was added as an alternative resources in the later part of the twentieth century. This result was firstly because of the development of new products such as synthetic fibers, plastics, synthetic oils, and petrochemicals and then because of great advances in catalysis and polymer science.

The renewable raw materials are being used to solve environmental problems in that the products made from them generally are more readily biodegradable and less toxic.

These raw materials usually have to be pretreated. They may undergo a number of steps involve physical treatment, chemical reactions,separation, and purification before their conversion into a desired product:

1.raw material→2.physical treatment→3.chemical reaction
$\uparrow$
→4.separation and purification→5.product

2-The energy costs

There are many types of energy can be used in chemical induetry such as electrical energy and we can use it as electrothermal,electromagnetic process,electro static energy , sedimentation,electrocracking.

The heat energy can be used for physical operations without chemical reaction such as heating,fusion,drying,evaporating and

distillation.there are three types of industrial processes Endo thermic ,Exo thermic and Transformation energy.

In any manufacturing facility there are many souces of heat such as boilers,kilns,incinerators,evaporators.

Photochemical energy has been used in halogenations reaction .we should make the energy less than we could in any process .η_p **power utilization** :represents the percentage ratio between the theortical energy (W_t) and the real enrgy (W_a) for the industrial process.

η_{th} **Thermal efficiency:**represents the percentage ratio between the energy we used in chemical reaction(Q_t) and the energy we have been used in all the industrial process(Q_a).

3-Labor cost

It is necessary to determine the number of people needed to carry out the batch. Most of the time this will be one person, because of the automatic lifting and other devices available.Then it will be necessary to decided how many hours he will have to devote to this task and how much time the equipment can be put on automatic control devices. The cost per man-hour is that at the particular plant location and will includethe total cost company to employing him.the cost of the labor is calculated in the form Labor Cost/kg Product.

(Total cost ofLabor/batch)=(no.men)(man-hr batch)(cost/man-hr)

(Fraction of cost of product/kg for labor)=(total cost oflabor/batch)**/**(batch size).

4- The research and development

The best way to reduce pollution is to study ways of preventing it at the research and development stage.At this stage,all possible reaction pathways for producing the desired product can be examined .These can be evaluated in light of yield, undesirable by- products, and their impacts on the health an environment.