

CHAPTER 1

INTRODUCTION – AN OVERVIEW OF THE CHEMICAL PROCESS INDUSTRY AND PRIMARY RAW MATERIALS

THE CHEMICAL PROCESS INDUSTRY

- The chemical process industry includes those manufacturing facilities whose products result from:
 - (a) chemical reactions between organic and/or inorganic materials;
 - (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 natural or synthetic.
- Examples of products from the chemical process industry are plastics, resins, dyes, pharmaceuticals, paints, soaps, detergents, petrochemicals, perfumes, inorganics, and various other synthetic organic materials.

THE CHEMICAL PROCESS INDUSTRY

- Many of these processes involve a number of unit operations of chemical engineering depending on the size definition of a plant, as well as such basic chemical reactions (processes) as polymerization, oxidation, reduction, hydrogenation, etc.
- The global chemical industry is valued at one and a half trillion US dollars today with more than 70,000 commercial products.
- The total world trade in chemicals is valued at US \$ 400 billion, 10% of the value of global trade.

THE CHEMICAL PROCESS INDUSTRY

- The three largest sectors within the world chemical industry are petrochemicals, pharmaceuticals and performance chemicals.
- Petrochemicals dominate the global chemical industry with a share of 30%, followed by pharmaceutical (16.5%) and performance chemicals (16%).

THE CHEMICAL PROCESS INDUSTRY

- The United States, Japan and Germany are the three largest manufacturers followed by France, United Kingdom, Italy and other Asian countries.
- There has been a significant shift of global demand for chemicals from industrialized to developing nations, and the movement of basic chemicals manufacturing from industrialized regions to Asia for markets and the Middle East for lower costs.

DEVELOPMENT OF THE CHEMICAL INDUSTRY

- The organic chemical industry has grown at a remarkable rate since 1940 due to the development and growth of the petroleum refining and petrochemical sectors.
- The rapid growth in petrochemicals in the 1960s and 1970s was largely due to the enormous increase in demand for synthetic polymers.
- The chemical industry today is highly research and development (R & D) intensive while producing a high rate of innovation, making significant contributions to the economy.

DEVELOPMENT OF THE CHEMICAL INDUSTRY

- The chemical industry may be regarded as having become a mature manufacturing industry, following its rapid growth in the 1960s and 1970s dampening the returns from the high-risk R & D investments.
- Many of the basic processes for producing key intermediate chemicals have lost their patent protection over the years, enabling other countries of the world, who wish to venture into this area, to buy their own manufacturing plants.

DEVELOPMENT OF THE CHEMICAL INDUSTRY

- Petroleum producing countries, such as Korea, Mexico, Saudi Arabia and other Middle Eastern countries, have entered and rapidly expanded their production of the aromatic petrochemical intermediates together with the final polymer products such as polyethylene, polypropylene, polyesters and epoxy resins.
- There is also a growing shift in the global chemical industry as a consequence of both the rapidly growing population and the industrial development of countries of Southeast Asia.
- It is envisaged that China, with its enormous population, will become both a major market and a major producer in chemicals production during the 21st century.

CHARACTERISTICS OF THE CHEMICAL INDUSTRY

- The chemical industry produces many materials that are essential for our most fundamental needs for food, shelter and health.
- It also produces products of great importance to the high technology world of computing, telecommunications, and biotechnology.

CHARACTERISTICS OF THE CHEMICAL INDUSTRY

- Industrial inorganic chemicals;
- Plastics, materials and synthetics;
- Drugs;
- Soap, cleaners and toilet goods;
- Paints and allied products;
- Industrial organic chemicals;
- Agricultural chemicals; and
- Miscellaneous chemical products.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- Industrial chemistry procures raw materials from the "natural environments" in order to convert them into "intermediates" which subsequently serve as base materials to every other kind of industry.
- There are four sources of the "natural environment":
 - a) The earth's crust (lithosphere),
 - b) The marine and oceanic environment (hydrosphere),
 - c) The air (atmosphere), and
 - d) The plants (biosphere).

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- 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, forestry, fishery, and wildlife products.
- If the rate they are consumed becomes so great that it derives, these resources to exhaustion, however, these renewable resources can become nonrenewable.
- Nonrenewable resources are those that are formed over long periods of geologic time. They include metals, minerals and organic materials.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

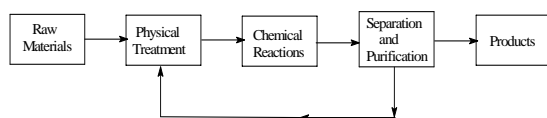
- The renewable resources such as agricultural materials were the main source of raw materials until the early part of twentieth century for the manufacturing of soap, paint, ink, lubricants, greases, paper, cloth, drugs and other chemical products.
- The nonrenewable feedstock based on fossil fuels was added as an alternative resource in the later part of twentieth century.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- This result was firstly due to the development of new products such as synthetic fibers, plastics, synthetic oils and petrochemicals and then due to great advances in catalysis and polymer science.
- The use of petroleum gas and oil has increased during the past thirty years as a result of a complete changeover from coal to petroleum technology.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- Every industrial chemical process is designed to produce economically a desired product from a variety of raw materials.
- The economical extraction and use of exploitable raw materials are the essential prerequisite for a chemical industry.
- These raw materials usually have to be pretreated. They may undergo a number of physical treatment, chemical reactions, separation and purification steps before their conversion into a desired product.



RAW MATERIALS, MANUFACTURING AND ENGINEERING

- The primary types of chemical reactions are either *batch* or *continuous*.
- In *batch reactions*, the reactant chemicals are added 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 in size from 200 to several thousand liters.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- 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 production. These processes are easier to operate, maintain, and repair. The batch equipment can be adapted to multiple uses.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- In *continuous processes*, the reactants are added and products are removed at a constant rate from the reactor, so that the volume of reacting material in the reactor (reaction vessel) remains constant.
- Two types of reactors, either 1) a continuous stirred tank or 2) a pipe reactor, are generally used.
- Since continuous processes require a substantial amount of automation and capital expenditure, this type of process is used primarily for large-scale productions.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- The reaction products are often not in a pure form usable by customers or downstream manufacturers.
- Therefore, the desired product must be isolated and purified by using various separation and purification methods.
- Common separation methods include filtration, distillation, and extraction. Multiple methods are also used in order to achieve the desired purity.

RAW MATERIALS, MANUFACTURING AND ENGINEERING

- The organic chemical industry is a very high technology industry, which utilizes the latest advances in electronics and engineering.
- Computers are very widely used in automation of chemical plants, quality control, and molecular modeling of structures of new compounds.

ENVIRONMENTAL ASPECTS

- The organic chemical industry uses and generates both large numbers and quantities of a wide variety of solvents, metal particulates, acid vapors, and unreacted monomers.
- These chemicals are released to all media including air, water and land.
- Due to public awareness of the dangers of chemicals in the environment, the chemical industry is one of the most highly regulated of all industries.

ENVIRONMENTAL ASPECTS

- The regulations are intended to protect and improve worker's and public health, safety and environment.
- The current large expenditures for pollution control in the developed world reflect mainly the intervention of the governments with strict laws. In the USA, these laws are enforced by the Environmental Protection Agency (EPA).
- The biggest global organic chemical companies have been promoting pollution prevention through various means.

ENVIRONMENTAL ASPECTS

- Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts.
- This is done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and substituting benign chemicals for toxic ones.
- Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

ENVIRONMENTAL ASPECTS

- 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 health and environmental impacts.
- In general, changes made at the research and development stage will have the greatest impact.
