

# UCH 1201 Principles of Chemical Engineering

## Introduction to Chemical Engineering

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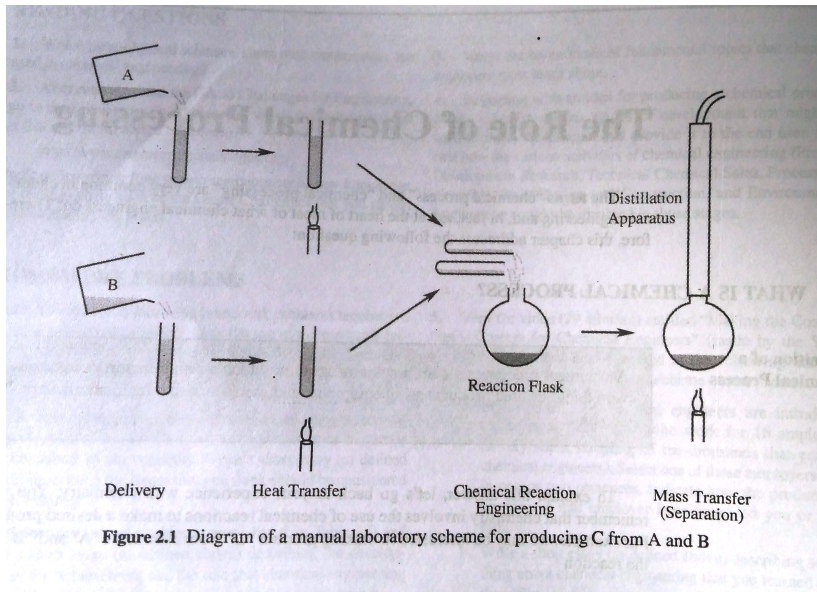
# Contents

Introduction to Chemical Engineering - Chemical process industries:  
History and their role in society. Role of Chemical Engineer.  
Description of different Unit Processes and Unit Operations.

# Objectives

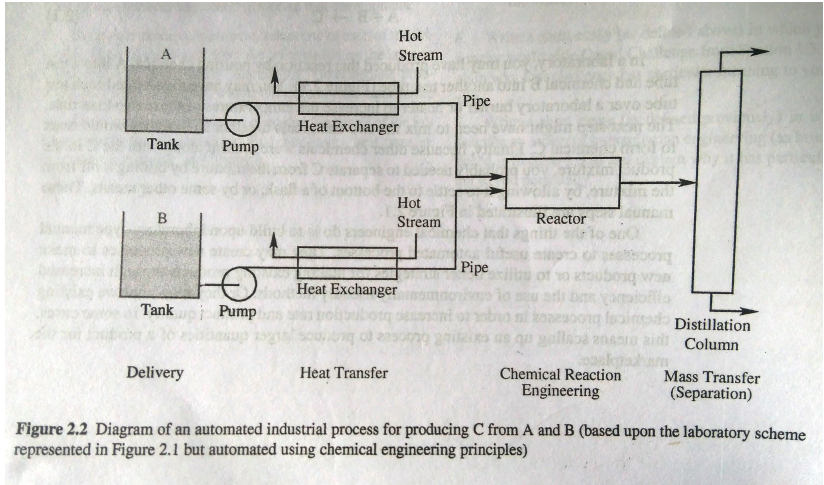
- ▶ To give an overview of chemical engineering by comparison with production of chemical at laboratory.
- ▶ To give a broad picture of various roles played by chemical engineer.
- ▶ To introduce the concept of unit operation and unit processes.

# Chemist Synthesizing a Chemical





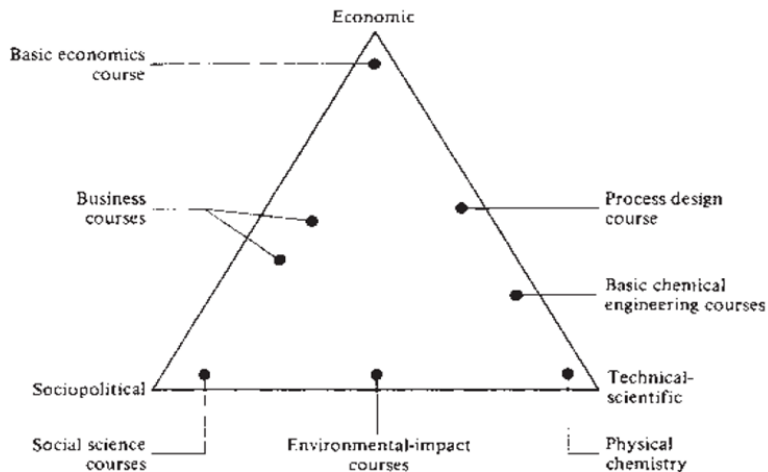
# Engineering the Production of Chemical



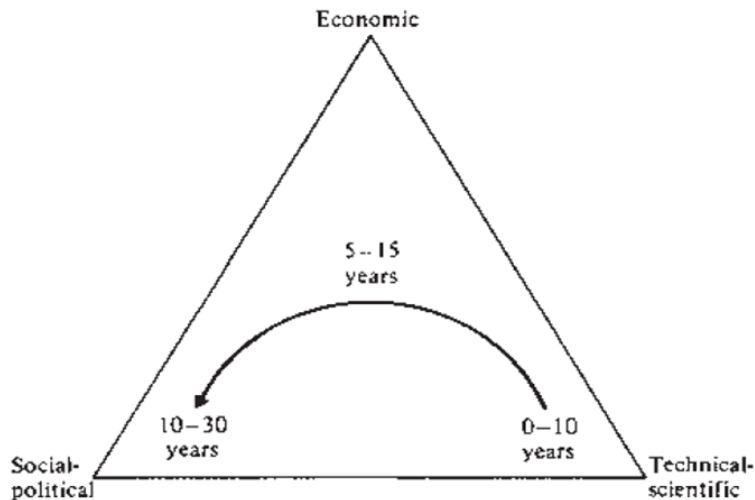
# Opportunities for Chemical Engineer



# Chemical Engineering Courses



# Typical Career Path of an Engineer



# Chemical Engineer

- ▶ **All engineers** employ **mathematics, physics, and the engineering art** to overcome technical problems in a **safe and economical** fashion.  
Yet, it is the **chemical engineer alone** that draws upon the vast and powerful science of **chemistry** (and biology) to solve a wide range of problems.
- ▶ The breadth of scientific and technical knowledge inherent in the profession has caused some to describe the chemical engineer as the **“universal engineer.”**

# History

For all intents and purposes the chemical engineering profession began in 1888. While, the term "chemical engineer" had been floating around technical circles throughout the 1880's, there was no formal education for such a person. The "chemical engineer" of these years was either a mechanical engineer who had gained some knowledge of chemical process equipment, a chemical plant foreman with a lifetime of experience but little education, or an applied chemist with knowledge of large scale industrial chemical reactions.

# Topics

- ▶ Introduction to Chemical Engineering:
  - ▶ Difference between 'Science' and 'Engineering'
  - ▶ Definition of 'Chemical Engineering'
  - ▶ Difference between Chemical Engineering and Other Engineering courses
  - ▶ Difference between 'Chemist' and 'Chemical Engineer'
- ▶ Chemical process industries: History and their role in Society
  - ▶ History of chemical industries
  - ▶ Types of chemical industries - inorganic / organic / petroleum / petrochemical
  - ▶ Role of chemical industries for the society - food preservation, fertilizer, energy, plastics, rubber, fibers, cosmetics, etc.

- ▶ Role of Chemical Engineer
  - ▶ Different kind of job areas for chemical engineer: production, technical services, design, R& D, sales and marketing, teaching, non-core jobs.
  - ▶ Employment sectors for chemical engineers: Chemical, food and drink, energy, environment, water, materials, biotechnology, pharmaceuticals, information technology, banking, education.



# Role of a Chemical Engineer

The duties and responsibilities of a chemical engineer generally include:

- ▶ Designing and inventing new chemical processes/products
- ▶ Construction, installation, and supervision of manufacturing plants and equipment
- ▶ Planning and operating industrial plant facilities
- ▶ Development of advanced and improved manufacturing processes
- ▶ Creating modernized and high-quality chemical materials for industrial production
- ▶ Processing of food and agricultural products, cosmetics, and mineral based industries
- ▶ Providing safety measures for chemical industry work conditions
- ▶ Creating environment-friendly health and safety standards
- ▶ Research and development activities in the Bio-Tech firms

# Chemical Engineering Jobs

- ▶ Production
- ▶ Technical Services
- ▶ Design and Detailed Engineering
- ▶ Erection and Commissioning
- ▶ Research and Development
- ▶ Consultancy
- ▶ Teaching

# Different Job Roles for a Chemical Engineer in a Chemical Industry

- ▶ **Production Engineer:** A chemical engineer play vital role in day today operation and non stop running of plants. To monitor the plant parameters and run the plant at the desired conditions in spite of any disturbances in form of changes in feed compositions, fluctuating power, steam pressure etc.
- ▶ **Process Engineer:** Based on the observation of regular operation, suggests modification to the process so as to improve productivity.
- ▶ **Technical Services:** to provide support to production department by keep monitoring plant data and do simulation and guide production department about possible scenarios in advance.

# Unit Operations and Unit Processes

Any chemical process consists of sequence of activities involving physical changes (e.g.: change in state from gas to liquid) and chemical changes due to reactions (e.g.: change from one chemical to another, for example due to sulfonation reaction).

Physical changes are called as 'unit operations' and chemical changes are called as unit processes.

# Example for Unit Operations

- ▶ **Fluid flow** (transportation of gases and liquids)
- ▶ Size reduction (reducing the size of materials for ease of handling)
- ▶ Filtration (separate solid from liquid by forced flow)
- ▶ Sedimentation (separate solid from liquid by gravity)
- ▶ Classification (divide mixture of particles into different “classes” on the basis of settling velocities)
- ▶ **Heat exchange** (change temperature of a stream)
- ▶ **Evaporation** (remove water from liquid)
- ▶ **Humidification** (add water to air) and, Dehumidification (remove water content of air)

## Example for Unit Operations (contd..)

- ▶ **Gas absorption** (remove one component of a gas mixture)
- ▶ **Distillation** (separation of a mixture into its components on based on their difference in vapor pressure)
- ▶ **Extraction** (separation of a mixture into its components on based on their difference in solubility in different liquids)
- ▶ **Drying** (removal of moisture from solids, by contacting with hot dry air)

Brief discussion of selected topics (**shown in bold fonts**) of above are covered in Units-II, III, and IV. More elaborate discussions will be in your other courses in the following semesters in the subjects: Fluid Mechanics, Mechanical Operations, Heat Transfer, and Mass Transfer.

## Example for Unit Processes

Unit process involves principle chemical conversions leading to synthesis of various useful product and provide basic information regarding the reaction temperature and pressure, extent of chemical conversions and yield of product, nature of reaction whether endothermic or exothermic, and type of catalyst used.

- ▶ Oxidation
- ▶ Combustion
- ▶ Hydrogenation
- ▶ **Sulfonation** - a chemical reaction which introduces the sulfonic acid functional group ( $-\text{SO}_3\text{H}$ ) into a molecule.
- ▶ Halogenation
- ▶ Hydrolysis
- ▶ Polymerization

Unit processes applied to various chemical industries will be discussed in detail in your course on **Chemical Process Industries**

- **IV Sem**

## Unit Processes (contd..)

- **Combustion:** Combustion is a chemical process in which a substance reacts rapidly with oxygen and gives off heat. The original substance is called the fuel, and the source of oxygen is called the oxidizer. The fuel can be a solid, liquid, or gas, although for airplane propulsion the fuel is usually a liquid. The oxidizer, likewise, could be a solid, liquid, or gas, but is usually a gas (air).  
When a hydrogen-carbon-based fuel (like gasoline) burns, the exhaust includes water (hydrogen + oxygen) and carbon dioxide (carbon + oxygen).



# Unit Processes (contd..)

- ▶ **Nitration:** Nitration involves the introduction of one or more nitro groups into reacting molecules using various nitrating agents like fuming, concentrated, aqueous nitric acid mixture of nitric acid and sulphuric acid in batch or continuous process.
  - ▶ Nitration products find wide application in chemical industry as solvent, dyestuff, pharmaceuticals, explosive, chemical intermediates.
  - ▶ Typical products: TNT, Nitrobenzene, m-dinitrobenzene, nitroacetanilide, alpha nitronaphthalene, nitroparaffins.

## Unit Processes (contd..)

- ▶ **Halogenation:** Halogens involve introduction of one or more halogen groups into a organic compound for making various chlorine, bromine, iodine, fluorine organic derivatives. All though chlorine derivatives find larger application, however some of the bromine and fluorine derivatives are also important.
  - ▶ Various chlorinating agents are: chlorine, HCl, phosgene sulfuric chloride, hypochlorite,
  - ▶ Bromination: bromine, hydrobromic acid, bromide, bromated, alkaline hypobromites.
  - ▶ Iodination: iodine, hydroiodic acid and alkali hypoiodites

## Unit Processes (contd..)

- ▶ **Polymerization:** Polymerization is one of the very important unit processes which find application in manufacture of polymer, synthetic fibre, synthetic rubber, polyurethane, paint and petroleum industry for high octane gasoline.

Polymerisation maybe carried out either with single monomer or with comonomer. Polymerisation reaction can be addition or condensation reaction.

Typical important product from polymerization are, Polyethylenene, PVC, poly styrene, nylon, polyester, acrylicfibre, poly butadiene, poly styrene, phenylic, urea, melamine and alkyd resins epoxy resin, silicon polymers, poly vinyl alcohol etc.

## Unit Processes (contd..)

- ▶ **Hydrogenation:** The process of hydrogenation involves the use of hydrogen molecules to saturate organic compounds, in the presence of a catalyst.  
Common catalysts used during hydrogenation are metals such as nickel and platinum.  
Hydrogenated fats and oils are common ingredients found in some of the foods we purchase. They are used to extend the shelf life of a food item or keep the intended food flavor stable.

# Quiz

1. Differentiate between 'chemist' and 'chemical engineer'.
2. How is chemical engineering different from other engineering courses?
3. Discuss the roles of chemical engineer to the society?
4. What are the various jobs available for a chemical engineer in chemical production and related industries?
5. Differentiate between 'unit operation' and 'unit process', with examples.
6. Give an account of history of chemical engineering.