

Vocabulary for Engineering



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Preface

Vocabularies for Chemical Engineering book

English words that are used to name objects or techniques of use. Words spoken both directly and these theoretical practices will be arranged in this book. By the structure of the content those words will be quoted with an explanation appended. Some items may be used at the same time and complement each other as some words. The author and editor tried to follow the usage and commonly known things in lessons and daily life to get 200 words and hope that the book will be suitable for people who want to be an engineer in the future and learn these words to prepare well for the future.

Sample

Chemical Engineering:

1. Chemical reaction
2. Catalyst
3. Reactor
4. Distillation
5. Thermodynamics
6. Mass transfer

7. Heat exchanger
8. Pressure vessel
9. Process control
10. Reaction kinetics
11. Fluid mechanics
12. Separation techniques
13. Polymerization
14. Chemical plant
15. Unit operations
16. Heat transfer
17. Reaction engineering
18. Petrochemicals
19. Environmental impact
20. Safety protocols

These words can be used as object names or to describe various techniques and concepts used in the respective fields. The book aims to provide explanations and examples for each word mentioned above, helping aspiring engineers understand and prepare for their future careers.

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- 62.** Safety Engineering
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Introductions

What is chemical engineering?

Chemical engineering is a branch of engineering that applies principles of chemistry, physics, biology, and mathematics to design, develop, and operate industrial processes that involve chemical transformations. It combines the knowledge of science with engineering principles to create and optimize processes that convert raw materials into useful products.

Chemical engineers work in a variety of industries, including pharmaceuticals, petrochemicals, food processing, energy production, and environmental protection. They are involved in the design and operation of chemical plants, where they develop and improve processes for manufacturing chemicals, fuels, plastics, and other products.

The role of a chemical engineer involves:

1. **Process Design:** Chemical engineers design efficient and safe processes for chemical reactions, separation of components, and product purification. They consider factors such as raw materials, reaction kinetics, energy requirements, and environmental impact.

2. **Process Optimization:** Chemical engineers analyze and optimize existing processes to improve efficiency, reduce costs, and enhance product quality. They may use mathematical models, simulation software, and experimental data to identify areas for improvement.

3. **Plant Operation:** Chemical engineers work on the operation and maintenance of chemical plants, ensuring that processes run smoothly, troubleshooting issues, and implementing safety protocols. They may also be responsible for managing the production schedule and coordinating with other departments.

4. **Environmental Protection:** Chemical engineers play a crucial role in developing processes that minimize environmental impact and comply with regulatory

standards. They work on waste treatment, pollution prevention, and sustainable practices.

5. Research and Development: Chemical engineers are involved in research and development activities to innovate and create new products, materials, and processes. They collaborate with chemists, biologists, and other engineers to explore new technologies and improve existing ones.

Chemical engineering requires a strong foundation in chemistry, mathematics, physics, and engineering principles. It involves problem-solving, critical thinking, and knowledge of safety regulations and ethical practices. With their interdisciplinary skills, chemical engineers contribute to the development of new materials, cleaner and more efficient processes, and advancements in various industries.

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200 vocabularies specific to chemical engineering

1. Chemical Engineering

Chemical engineering is a branch of engineering that uses principles of chemistry, physics, biology, and mathematics to design, develop, and optimize processes and products involving chemical transformations. It involves the understanding and manipulation of chemicals, materials, and energy to create useful products and solve various industrial challenges. Chemical engineering encompasses a wide range of applications such as the production of chemicals, fuels, pharmaceuticals, food, and beverages, as well as environmental and sustainable solutions.

2. Reaction Engineering

Reaction engineering in chemical engineering refers to the branch of engineering that focuses on studying and optimizing chemical reactions. It involves understanding the process of chemical reactions, including the reaction

kinetics, reactant and product properties, and the influence of various factors such as temperature, pressure, catalysts, and mixing. Reaction engineering aims to design, develop, and optimize chemical reactors and processes to achieve desired reaction outcomes, such as increasing reaction yield, selectivity, and efficiency, while minimizing undesirable side reactions and byproducts. It plays a crucial role in various industries, including petroleum refining, pharmaceuticals, polymers, and materials manufacturing.

3. Thermodynamics

Thermodynamics in chemical engineering is the study of energy and its transformation in chemical processes. It involves the application of the principles of thermodynamics to understand and analyze the behavior of chemical systems and their components.

Thermodynamics in chemical engineering encompasses several key concepts and principles, including:

1. Energy: Thermodynamics involves the analysis of energy exchanges and transformations within chemical systems. It defines various forms of energy, such as heat, work, and internal energy.

2. Laws of Thermodynamics: Chemical engineers employ the fundamental laws of thermodynamics, such as the First Law (conservation of energy), the Second Law (entropy and the direction of spontaneous processes), and the Third Law (the behavior of systems at absolute zero temperature).

3. Thermodynamic Equilibrium: This concept refers to the state of a system where there are no further changes in its thermodynamic properties. Chemical engineers use equilibrium thermodynamics to understand and predict the behavior of chemical reactions and phase changes.

4. Thermodynamic Properties: These properties, including temperature, pressure, volume, and concentration, are essential in describing the behavior of a system. Thermodynamics helps in determining and correlating

these properties, as well as their changes during processes.

5. Phase and Chemical Equilibria: Chemical engineers use thermodynamics to study the equilibrium between different phases (such as liquid-vapor phase equilibrium) and between reactants and products in chemical reactions (chemical equilibrium).

Thermodynamics provides a foundation for chemical engineers to analyze and optimize processes, design equipment, and understand the energy requirements and efficiency of chemical systems. It plays a crucial role in various fields, such as process design, energy production, and environmental engineering.

4. Mass Transfer

Mass transfer in chemical engineering refers to the movement of mass (atoms, molecules, or ions) from one location to another within a system or between different phases. It involves the processes of diffusion, convection, and mass transfer across interfaces.

Mass transfer is an important concept in chemical engineering as it plays a crucial role in a wide range of processes, including separation techniques, reaction engineering, and transport phenomena. Some key aspects related to mass transfer are:

1. **Diffusion:** Diffusion is the process by which particles move from an area of high concentration to an area of low concentration due to random molecular motion. It occurs in both gases and liquids and is responsible for mixing and homogenization.
2. **Convection:** Convection involves the bulk movement of a fluid carrying mass. It occurs through mechanisms such as fluid flow due to pressure gradients or forced flow induced by mechanical devices.
3. **Mass transfer across interfaces:** Mass transfer across interfaces occurs when there is a transfer of mass between different phases, such as between a gas and a liquid (e.g.,

absorption), a liquid and a solid (e.g., adsorption), or a gas and a solid (e.g., catalysis).

Mass transfer processes are commonly encountered in various chemical engineering operations, including distillation, absorption, extraction, adsorption, evaporation, crystallization, and membrane separations. Understanding and optimizing mass transfer is vital for efficient design, operation, and control of these processes.

5. Heat Transfer

Heat transfer in chemical engineering refers to the study and application of the movement of heat energy from one location to another in a chemical process or system. It is an essential aspect of various industrial processes and plays a crucial role in designing, analyzing, and optimizing chemical reactors, heat exchangers, boilers, and other equipment. Heat transfer can occur through three modes: conduction (where heat flows through a solid material), convection (where heat is transferred through a fluid), and radiation (where heat is transferred through electromagnetic waves). Chemical engineers utilize heat

transfer principles to optimize energy efficiency, control temperature profiles, ensure product quality, and improve overall process performance in diverse sectors such as petroleum refining, manufacturing, pharmaceuticals, and energy production.

6. Fluid Mechanics

Fluid mechanics in chemical engineering refers to the study and application of the behavior of fluids (liquids, gases, or mixtures of both) in relation to chemical processes and systems. It is a branch of physics that deals with the properties, motion, and forces of fluids, and their interactions with solid objects.

In chemical engineering, fluid mechanics plays a crucial role in the design, analysis, and optimization of various equipment and processes. It involves the study of fluid dynamics, which includes topics such as fluid flow, pressure, velocity, viscosity, and turbulence. Fluid mechanics principles are applied to understand and predict the behavior of fluids through pipes, pumps,

mixers, reactors, and other equipment used in chemical processes.

Chemical engineers utilize fluid mechanics principles to determine optimal flow rates, pressure drops, and mixing patterns in a wide range of applications, including oil and gas transportation, chemical reactions, heat transfer, filtration, and separation processes. By understanding fluid behavior, chemical engineers can optimize process conditions, improve efficiency, and ensure the safety and reliability of chemical processes and systems.

7. Chemical Process

A chemical process in chemical engineering refers to a series of operations or steps performed to convert raw materials (e.g., chemicals and feedstocks) into desired products through chemical reactions, physical transformations, or a combination of both. Chemical processes are fundamental to the field of chemical engineering and are designed to achieve specific objectives such as manufacturing products, refining chemicals, or converting raw materials into usable forms.

Chemical processes involve various unit operations, which are individual steps or operations that are combined to form a complete process. These unit operations can include mixing, separation, heat transfer, reaction, purification, and other processes. Each unit operation is carefully selected, designed, and integrated to achieve the desired chemical transformation or production goal.

Chemical engineers play a crucial role in developing, optimizing, and managing chemical processes. They consider factors such as reaction kinetics, mass and energy balances, safety considerations, economics, and environmental impact when designing and operating chemical processes. By understanding the underlying principles of chemical processes, chemical engineers can improve efficiency, productivity, and sustainability in various industries including pharmaceuticals, petrochemicals, food and beverages, materials synthesis, and energy production.

8. Process Design

Process design in chemical engineering refers to the creation and development of a detailed plan or blueprint for a chemical process or system. It is a crucial stage in the design and development of any chemical plant, facility, or production process.

Process design involves defining and specifying the various unit operations, equipment, materials, and operating conditions required to achieve the desired outcome. It includes determining the process flow, reaction kinetics, mass and energy balances, equipment sizing, control strategies, safety considerations, and environmental impact assessments.

During process design in chemical engineering, factors such as process efficiency, product quality, safety, and environmental sustainability are taken into account. The goal is to create a process that is reliable, efficient, cost-effective, and meets all regulatory and customer requirements.

Process design may also involve optimizing process parameters, analyzing alternative process routes, conducting simulations and modeling, and performing economic evaluations. It requires a deep understanding of chemical engineering principles, knowledge of process equipment and technologies, and expertise in process integration and optimization.

The output of process design is a comprehensive set of design specifications and drawings that serve as a guide for process engineers and construction teams during the installation, commissioning, and operation of the chemical process or system.

9. Process Simulation

Process simulation in chemical engineering refers to the use of computer-based models and software to simulate and analyze the behavior and performance of chemical processes. It involves creating a virtual representation of a process or system, and then using mathematical and computational methods to predict the process behavior under various operating conditions.

Process simulation allows chemical engineers to understand and optimize the performance of a chemical process before it is implemented in the real world. It involves the development and utilization of mathematical models that describe the physical and chemical phenomena occurring within the process. These models may incorporate equations that describe mass and energy balances, reaction kinetics, fluid flow, heat transfer, and other relevant factors.

By inputting process parameters, such as feedstock composition, temperature, pressure, and equipment specifications, into a process simulation software, chemical engineers can simulate the process behavior and analyze key metrics. This includes evaluating process efficiency, product quality, energy consumption, equipment sizing, and environmental impact.

Process simulation can help identify bottlenecks, optimize process conditions, design control strategies, and assess the feasibility of process modifications or improvements. It is an invaluable tool in process design, scale-up,

operation, and troubleshooting. The analysis and insights gained from process simulation can aid in making informed decisions, reducing costs, improving safety, and ensuring the overall success of chemical processes and systems.

10. Process Control

Process control in chemical engineering refers to the application of various techniques and strategies to monitor, regulate, and optimize the operation of a chemical process or system. It involves the use of instruments, sensors, and advanced control algorithms to maintain desired process variables within specific ranges, ensuring efficient and safe operation.

Process control aims to achieve stability, accuracy, and consistency in process variables such as temperature, pressure, flow rate, level, pH, and composition. By continuously monitoring these variables and making appropriate adjustments, process control systems can maintain the desired operating conditions, improve

product quality, reduce variability, and enhance process efficiency.

There are different levels of process control, including:

1. Basic control: This level involves the use of simple control strategies such as feedback control loops, where measurements of process variables are compared to setpoints, and adjustments are made to maintain stability.
2. Advanced control: This level involves more sophisticated control strategies such as model predictive control (MPC), which uses mathematical models of the process to predict and optimize future behavior. Advanced control techniques can handle non-linearities, constraints, and interactions within the process.
3. Supervisory control: This level involves higher-level control systems that coordinate and optimize the operation of multiple process units or equipment. It aims to maximize overall process performance and ensure optimal operation under varying conditions.

Process control systems in chemical engineering may consist of various components, including sensors, actuators, controllers, and human-machine interfaces (HMIs). These systems utilize feedback loops, cascade control, feedforward control, and other control strategies to maintain process variables within desired limits and respond to disturbances or changes in operating conditions.

Effective process control can enhance safety, minimize costs, reduce energy consumption, improve product quality, and increase the overall productivity of chemical processes and systems.

11. Unit Operations

Unit operations in chemical engineering refer to the individual steps or operations involved in a chemical process or system. Each unit operation performs a specific function or transformation on the materials or fluids within the process. These operations are combined and integrated to complete the overall chemical process.

Unit operations can be categorized into several types, including:

1. Separation operations: These operations involve the separation of components or phases based on differences in physical properties, such as distillation, absorption, extraction, filtration, and crystallization.
2. Reaction operations: These operations involve chemical transformations or reactions, such as reactions in reactors, catalytic reactions, and polymerization.
3. Heat transfer operations: These operations involve the transfer of heat energy between materials or fluids, such as heating, cooling, evaporation, condensation, and heat exchange in heat exchangers.
4. Mixing and blending operations: These operations involve the thorough mixing or blending of different materials or components, such as mixing in tanks or vessels, blending in pipelines, and solid blending.

5. Size reduction operations: These operations involve reducing the size or particle size distribution of solid materials, such as crushing, grinding, milling, and pulverization.

6. Material handling operations: These operations involve the movement, storage, and transportation of materials or products within the process, such as conveying, bulk handling, and packaging.

Unit operations are essential in chemical engineering as they enable the desired transformations, separations, and treatments required to produce desired products or achieve specific process objectives. Chemical engineers design, optimize, and manage unit operations to ensure efficient and effective process performance, product quality, and safety in industries such as pharmaceuticals, petrochemicals, food processing, energy production, and many others.

12. Separation Processes

Separation processes in chemical engineering refer to a set of unit operations that are specifically focused on the separation of different components from a mixture or stream. These processes are employed to separate desired products or substances from mixtures and to purify them.

Separation processes are crucial in various industries, including pharmaceuticals, petrochemicals, food processing, water treatment, and environmental engineering. They are used to separate liquids and solids, gases and liquids, and even different components within a liquid or gas mixture. Some common separation techniques used in chemical engineering include:

1. Distillation: This process involves the separation of components based on differences in their boiling points. It is widely used for separating liquid mixtures.
2. Extraction: Extraction involves the transfer of a solute from one phase to another, usually from a liquid into a solvent. It is commonly used for separating desired compounds from a mixture.

3. Filtration: Filtration is the process of separating solid particles from a liquid or gas by passing the mixture through a porous medium.

4. Crystallization: This process involves the formation of crystals from a solution, enabling the separation of a solid component from a liquid.

5. Membrane separation: Membrane processes use semi-permeable membranes to separate components based on size, charge, or other specific properties.

6. Adsorption: Adsorption is the process of capturing or retaining one or more components of a mixture onto a solid surface, such as activated carbon, to achieve separation.

7. Ion exchange: Ion exchange involves the exchange of ions between a solid resin and an aqueous solution, enabling the separation and purification of specific ions.

These are just a few examples of separation processes in chemical engineering. Each process is selected based on the specific properties of the mixture and the desired product or separation outcome. Chemical engineers carefully choose and optimize separation processes to achieve efficient separations, minimize energy consumption, and maintain product quality and purity.

13. Distillation

Distillation in chemical engineering refers to a separation process that involves the vaporization and subsequent condensation of components in a liquid mixture. It is one of the most widely used and fundamental separation techniques in the chemical and process industries.

Distillation relies on the differences in boiling points of the components in a liquid mixture to separate them. The process typically involves heating the mixture in a distillation column or still until the component with the lowest boiling point (known as the more volatile component) vaporizes. The vapor is then cooled and

condensed back into liquid form, resulting in the separation of the components.

The key components of a distillation system include a distillation column, a heat source (e.g., reboiler), and a condenser. The distillation column consists of a series of trays or packing material that provides surfaces for vapor-liquid contact and separation. During distillation, the liquid mixture enters the column, and heat is applied to vaporize the more volatile component. As the vapor rises through the column, it comes into contact with liquid on the trays or packing material. The liquid on the tray or packing material acts as a barrier, causing further separation of components. The less volatile component remains in the liquid phase and exits the bottom of the column as a bottom's product, while the more volatile component is condensed on the trays or packing and collected as a distillate at the top of the column.

Distillation is used for a wide range of applications, including the separation of mixtures in the petroleum industry (such as crude oil refining), production of

alcoholic beverages, purification of chemicals, recovery of solvents, and many more. The design and operation of distillation systems require considerations of thermodynamics, mass transfer, heat transfer, column configuration, and control strategies. Optimization of distillation processes aims to achieve high separation efficiency, reduced energy consumption, and improved product quality.

14. Absorption

Absorption in chemical engineering refers to a separation process in which a gas or vapor component is dissolved or absorbed into a liquid phase. It is commonly used to remove one or more components from a gas stream and capture them in a liquid solvent.

During absorption, the gas or vapor mixture is brought into contact with a liquid solvent, where the desired component(s) transfer to the liquid phase due to differences in solubility or affinity. The absorption process allows for the selective removal of specific components from a gas mixture.

The key components of an absorption system include an absorber column or tower, a gas stream inlet, a liquid solvent, and a packed bed or trays within the column. The gas stream, which contains the component(s) to be absorbed, enters the absorber column at the bottom. The liquid solvent is introduced at the top and flows downward counter currently to the gas stream. As the gas stream rises through the packed bed or trays, it comes into contact with the liquid solvent. The desired component(s) readily dissolve or react with the solvent and transfer to the liquid phase, while the remaining gas components exit the tower as an overhead stream.

Absorption processes are used in various industries and applications, including:

1. Gas purification: Absorption is used to remove impurities, such as carbon dioxide (CO₂) or hydrogen sulfide (H₂S), from natural gas or synthesis gas.

2. Gas treatment: Absorption is employed for the removal of toxic or harmful gases, such as ammonia or chlorine, from industrial emissions.

3. Separation and purification: Absorption can separate different gas components, such as separating oxygen from air or separating volatile organic compounds (VOCs) from industrial off-gas streams.

4. Solvent recovery: Absorption can be used to recover valuable solvents or chemicals from process waste streams.

The design and optimization of absorption processes involve considerations such as mass transfer, heat transfer, selectivity of the solvent, column design, solvent regeneration, and energy consumption. By selecting appropriate solvents and operating conditions, chemical engineers can efficiently separate and capture desired components from gas streams using absorption techniques.

15. Extraction

Extraction in chemical engineering refers to a separation process that involves the transfer of a solute from one phase (usually a liquid) into another immiscible phase (such as a solvent), creating a solution or mixture. This process is commonly used to separate and purify desired components from a mixture or extract valuable substances from raw materials.

Extraction relies on the differences in solubility or affinity of the components in the mixture between the two immiscible phases. The mixture is brought into contact with a solvent, and the solute transfers from one phase to the other based on its preferential solubility or affinity. The solvent, which contains the extracted component, is then separated from the mixture to obtain the desired product.

The key components of an extraction system include an extraction vessel or column, the liquid mixture to be extracted, the extracting solvent, and methods for mixing and separating the phases. The mixture and the solvent may be agitated or allowed to come into contact for a

certain duration to enhance the transfer of the solute. Separation is then achieved by allowing the two immiscible phases to settle or by using separation techniques such as decantation, centrifugation, or filtering.

Extraction processes have broad applications in chemical engineering, including the following:

1. Pharmaceutical industry: Extraction is used to isolate and purify active pharmaceutical ingredients (APIs) from natural sources or chemical synthesis reactions.
2. Food industry: Extraction is employed to obtain flavors, essences, or natural extracts from food products, such as coffee, tea, and spices.
3. Environmental engineering: Extraction can remove pollutants or contaminants from soil, water, or air samples for analysis or remediation purposes.

4. Mining and metallurgy: Extraction techniques are used to extract metal ions from ores or solutions during metal refining processes.

5. Petroleum industry: Extraction is utilized to extract valuable components, such as aromatic compounds, from crude oil or petroleum products.

The design and optimization of extraction processes involve considerations of solubility, selectivity, mass transfer, equipment design, solvent regeneration, and separation techniques. Chemical engineers carefully select solvents and operating conditions to achieve efficient extraction, maximize product yield, and minimize the use of solvents and energy.

16. Filtration

Filtration in chemical engineering refers to a separation process that involves the passage of a fluid (liquids or gases) through a porous medium to remove solid particles, impurities, or unwanted substances. It is a widely

used technique for separating solids from liquids or gases based on differences in particle size, shape, and density.

In filtration, a porous material known as a filter medium or medium is used to trap and retain the solid particles while allowing the fluid to pass through. The filter medium can be made of various materials, such as cloth, paper, sand, activated carbon, or membranes, depending on the specific application and desired level of filtration.

The key components involved in filtration processes include a filtration system, the fluid to be filtered, the filter medium, and methods for collecting and disposing of the separated solid particles. Filtration can be achieved using different types of filtration equipment, including filters, filter presses, centrifuges, and filter cartridges.

Filtration processes have a wide range of applications in chemical engineering, including the following:

1. Water treatment: Filtration is used in municipal water treatment plants, industrial water purification, and

wastewater treatment to remove suspended solids and impurities.

2. Pharmaceutical industry: Filtration is employed in drug manufacturing to separate particulate matter, purify liquids, and remove contaminants from drug formulations.

3. Food and beverage industry: Filtration is used for clarification, sterilization, and removal of particles or impurities from liquid foods, beverages, and food processing streams.

4. Air pollution control: Filtration systems help remove particulate matter and pollutants from industrial exhaust gases and improve air quality.

5. Process filtration: Filtration is used for the separation and purification of chemicals, catalyst recovery, and product polishing in various chemical processes.

The design and optimization of filtration processes involve considerations such as filter media selection, pore size,

flow rate, pressure drop, cake formation, cleaning or replacement of filters, and environmental impact. Chemical engineers carefully design filtration systems to achieve efficient separation, meet product quality requirements, and ensure the effective removal of contaminants or unwanted substances from fluids.

17. Adsorption

Adsorption in chemical engineering refers to a process in which molecules or particles from a fluid phase adhere to the surface of a solid material, known as an adsorbent. This phenomenon occurs due to attractive forces between the adsorbent and the adsorbate.

Adsorption is primarily driven by intermolecular forces, such as van der Waals forces, hydrogen bonding, ion-dipole interactions, or chemical bonding. The adsorbed molecules or particles accumulate on the surface of the adsorbent, forming a layer known as an adsorption film or monolayer.

The key components involved in adsorption processes include an adsorbent material, the fluid or gas containing the adsorbate, and methods for bringing them into contact and separating them. Adsorbent materials can include activated carbon, zeolites, silica gel, alumina, and various other porous materials that have a high surface area and affinity for the adsorbate.

Adsorption processes have diverse applications in chemical engineering, including the following:

1. Purification and separation: Adsorption is used for the removal of impurities, such as pollutants, organic compounds, or colorants from gases or liquids.
2. Gas storage and separation: Adsorption is employed to capture and store gases, such as hydrogen or carbon dioxide, and separate gas mixtures based on differences in adsorption affinity.

3. Catalysis: Adsorbents can act as catalysts by selectively adsorbing reactant molecules on their surface and facilitating chemical reactions.

4. Desiccation and dehydration: Adsorbents like silica gel or molecular sieves are used to remove moisture from gases or liquids.

5. Drug delivery: Adsorption processes are utilized in pharmaceuticals for adsorbing and controlled release of drugs to targeted tissues or organs.

The design and optimization of adsorption processes involve considerations such as adsorbent selection, surface chemistry, contact time, temperature, pressure, regeneration, and capacity. Chemical engineers carefully choose adsorbents and operating conditions to achieve efficient adsorption, maximize adsorbate uptake, and minimize energy consumption. Adsorption processes can be further enhanced through techniques such as pressure swing adsorption (PSA), temperature swing adsorption

(TSA), or other cyclic adsorption and regeneration methods.

18. Crystallization

Crystallization in chemical engineering refers to a separation and purification process that involves the formation of solid crystals from a solution or a melt. By manipulating the temperature, concentration, and other variables, chemical engineers can induce supersaturation and encourage the formation and growth of crystals.

During crystallization, solute molecules within the solution come together and arrange themselves in a highly ordered, repeating pattern to form a solid crystal lattice structure. The crystal formation typically occurs through precipitation from a supersaturated solution, cooling a melt, or evaporation of a solvent.

Crystallization processes find wide application in various industries, including:

1. Pharmaceutical industry: Crystallization is used to isolate and purify desired chemical compounds, such as active pharmaceutical ingredients (APIs) or drug intermediates.

2. Chemical industry: Crystallization is employed for separation and purification of chemicals, such as separating and recovering desired products from reaction mixtures.

3. Food industry: Crystallization is used for separation and purification of sugars, salts, and other food ingredients, as well as formation of food-grade crystals.

4. Mining and metallurgy: Crystallization is utilized in metal refining processes to concentrate and separate valuable metal ions from solutions.

The design and optimization of crystallization processes involve considerations such as selection of suitable solvents, control of cooling or evaporation rates, manipulation of supersaturation levels, choice of crystal

form (polymorphs), and methods for crystal growth and harvesting. Crystallization processes can be influenced by factors like solute solubility, nucleation, crystal growth kinetics, seed crystals, and crystal size distribution.

Chemical engineers carefully manipulate process parameters to control crystal size, shape, purity, and yield. Techniques such as batch crystallization, continuous crystallization, or controlled cooling and evaporation can be employed to achieve the desired crystalline product meeting specific quality criteria. Furthermore, downstream processes like filtration, drying, and milling are often employed to isolate and further process the obtained crystals, if needed.

19. Membrane Separation

Membrane separation in chemical engineering refers to a separation process that utilizes semi-permeable membranes to separate components or solutes based on their size, shape, charge, or other specific properties. The process involves the selective transport of certain components across the membrane while preventing the passage of others.