

2.3 Sedimentation

Sedimentation is a physical separation process in which solid particles settle from a suspension or a mixture due to the force of gravity. This process takes advantage of the difference in density between the solid particles and the surrounding fluid. Sedimentation is widely used in various industries, including water treatment, wastewater treatment, and mineral processing, to separate particulate matter from liquids.

Gravitational Sedimentation of Particles in a Fluid:

The gravitational sedimentation process involves the settling of particles in a fluid under the influence of gravity. The rate at which particles settle is determined by factors such as particle size, density, and the viscosity of the fluid. Larger and denser particles settle more quickly than smaller and less dense ones.

The basic steps involved in gravitational sedimentation are as follows:

Particle Suspension:

Solid particles are initially suspended in a liquid or gas. The mixture is allowed to stand undisturbed, initiating the sedimentation process.

Gravity's Effect:

Due to the force of gravity, particles experience a downward force. The settling velocity of a particle depends on its size and density, as well as the properties of the fluid.

Formation of Sediment or "Sludge":

As particles settle, they accumulate at the bottom of the container, forming a layer of sediment or sludge. The clarified liquid above the sediment is referred to as the supernatant.

Stoke's Law:

Stoke's Law describes the relationship between the settling velocity of spherical particles in a fluid and various factors influencing sedimentation. The law is expressed by the equation:

$$v = \frac{92 \cdot \eta \cdot g \cdot r^2 \cdot (\rho_p - \rho_f)}{18}$$

where,

- v is the settling velocity,
- g is the acceleration due to gravity,
- r is the radius of the particle,
- ρ_p is the density of the particle,
- ρ_f is the density of the fluid, and
- η is the viscosity of the fluid.

Sedimentation in Water Treatment:

Explore the role of sedimentation in water treatment plants for the removal of suspended solids. Understand the design and operation of sedimentation basins in the context of drinking water purification.

Lamella Clarifiers:

Investigate the use of lamella clarifiers, which enhance the sedimentation process by incorporating inclined plates to increase the effective settling area. Learn about their applications in wastewater treatment and industrial processes.

Zeta Potential in Sedimentation:

Understand the concept of zeta potential, which influences the stability of colloidal suspensions. Explore how zeta potential impacts the sedimentation behavior of particles and the use of electrokinetic phenomena in particle separation.

Density Currents and Turbidity Currents:

Explore natural sedimentation processes in water bodies, including the formation of density currents and turbidity currents. Understand how these currents contribute to the deposition and transportation of sediments in rivers, lakes, and oceans.

Flocculation in Sedimentation:

Delve into the role of flocculation in sedimentation processes. Learn how the addition of flocculating agents promotes the aggregation of fine particles, enhancing their settling characteristics in water and wastewater treatment.

Sedimentation in Mining and Mineral Processing:

Investigate sedimentation techniques employed in the mining industry for the separation of valuable minerals from ore. Understand the design and operation of thickeners and clarifiers in mineral processing plants.

Sediment Transport Modeling:

Explore mathematical models used to predict sediment transport in rivers and channels. Understand how factors such as flow velocity, sediment size, and bed morphology influence sedimentation patterns.

Sedimentation in Geology:

Examine the geological aspects of sedimentation, including the formation of sedimentary rocks. Understand how sediments accumulate over time, undergo lithification, and contribute to the Earth's geological history.

Sedimentation in Reservoirs:

Study sedimentation processes in reservoirs and the impact on water storage capacity. Explore methods for managing sedimentation in reservoirs to maintain their functionality and longevity.

Sedimentation and Erosion Control:

Explore strategies for controlling sedimentation and erosion in construction sites, agricultural areas, and natural landscapes. Understand the environmental implications and best practices for sedimentation control.

Sedimentation Tanks in Industrial Processes:

- Investigate the use of sedimentation tanks in various industrial processes such as chemical manufacturing, pulp and paper production, and food processing. Understand their role in separating solids from liquid streams.

These topics offer a comprehensive exploration of sedimentation processes in various contexts, providing insights into the principles, applications, and challenges associated with gravitational sedimentation.

Flocculation in Sedimentation:**Definition of Flocculation:**

Flocculation is a process in which fine particles in a suspension aggregate to form larger, heavier particles known as flocs. These flocs settle more rapidly during sedimentation, aiding in the separation of solid particles from the liquid phase.

Mechanism of Flocculation:

Flocculation is often induced by the addition of flocculating agents, such as polymers or coagulants, which neutralize the repulsive forces between particles and promote their aggregation.

As the particles come together to form flocs, the effective size and settling characteristics of the particles change, facilitating their removal during sedimentation.

Applications in Water Treatment:

In water treatment plants, flocculation is a crucial step before sedimentation. Coagulants are added to raw water to destabilize colloidal particles and initiate the formation of flocs.

The flocculated water is then allowed to flow into sedimentation basins, where the flocs settle, leading to the removal of suspended solids and impurities.

Types of Flocculants:

Flocculating agents can be organic or inorganic. Organic flocculants include polymers like polyacrylamide, while inorganic options include salts like aluminum sulfate and ferric chloride.

Sedimentation in Mining and Mineral Processing:**Role of Sedimentation in Mining:**

Sedimentation processes, particularly in thickeners and clarifiers, play a vital role in mineral processing plants.

After crushing and grinding, ore slurry containing valuable minerals is subjected to sedimentation to separate the solid particles from the liquid phase.

Thickeners in Mineral Processing:

Thickeners are commonly used for the thickening or concentration of slurries. In a thickener, settled solids are removed from the bottom, and clarified liquid overflows from the top.

Thickeners aid in recovering water from tailings, reducing the environmental impact and improving the overall efficiency of the mineral processing circuit.

Clarifiers in Mineral Processing:

Clarifiers operate similarly to thickeners but are designed for applications where the overflow clarity is critical.

In mineral processing, clarifiers help produce a clarified overflow stream with minimal suspended solids, ensuring that valuable minerals are not lost with the liquid discharge.

Challenges and Optimization:

Challenges in sedimentation processes in mining include dealing with varying ore characteristics, particle sizes, and water quality.

Optimization involves adjusting variables such as flocculant dosage, feed density, and underflow withdrawal rates to achieve the desired separation efficiency.