

Drying

Drying

Objectives of Drying

1. **Preservation** – Removes moisture to prevent spoilage and microbial growth.
2. **Weight Reduction** – Eases handling, storage, and transportation.
3. **Volume Reduction** – Saves space for packaging and storage.
4. **Consistency** – Achieves desired texture, especially in food.
5. **Preparation for Processing** – Prepares materials for milling, mixing, or reactions.
6. **Quality Improvement** – Enhances product stability and shelf life.

Applications of Drying

1. **Food Industry** – Dehydration of fruits, vegetables, meat, dairy.
2. **Pharmaceuticals** – Stabilizes drugs and powders.
3. **Agriculture** – Preserves grains, seeds, hay.
4. **Textiles** – Dries fabrics post-washing or dyeing.
5. **Chemicals** – Maintains purity in chemical products.
6. **Construction** – Dries wood, bricks, and materials.
7. **Paper Industry** – Dries pulp for paper products.
8. **Ceramics** – Dries clay before firing.

Mechanism of Drying

- **Heat Transfer** – Heats material via conduction, convection, or radiation to provide energy for evaporation.
- **Mass Transfer** – Moisture diffuses from the interior to the surface and evaporates into the air.

Steps in the Drying Process

1. **Initial Heating** – Surface moisture begins to evaporate.
2. **Constant Rate Period** – Steady drying as surface moisture evaporates.
3. **Falling Rate Period** – Internal moisture moves to the surface; drying slows.
4. **Equilibrium Moisture Content** – Drying ends as moisture balances with surroundings.

Factors Affecting Drying

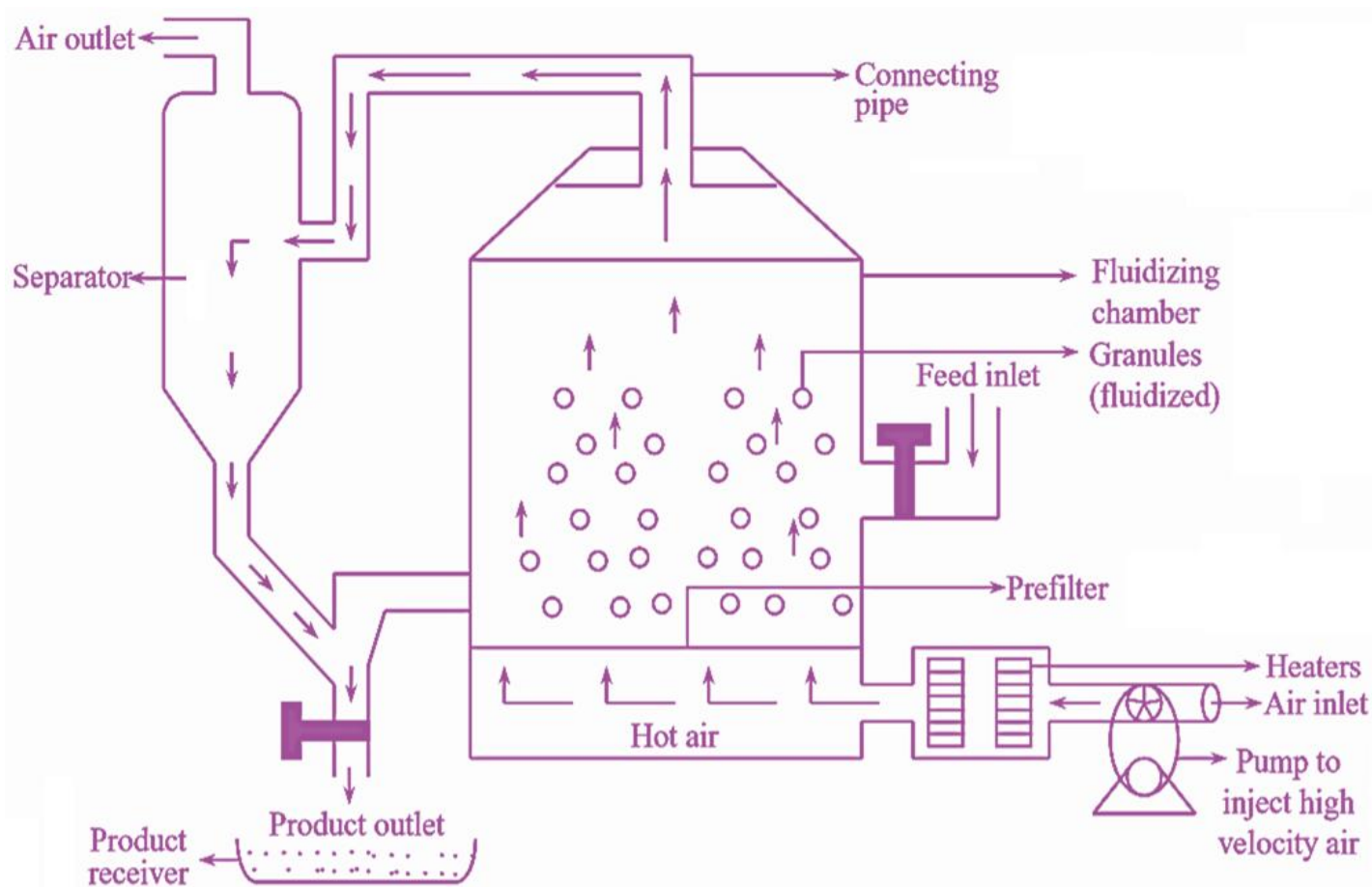
1. **Temperature** – Higher heat speeds drying but may affect sensitive materials.
2. **Humidity** – Lower humidity accelerates moisture removal.
3. **Airflow** – Promotes evaporation by removing surface moisture.
4. **Material Properties** – Moisture content, thickness, and permeability matter.
5. **Surface Area** – More exposure leads to faster drying.
6. **Drying Method** – Technique (air, vacuum, freeze drying) impacts efficiency and outcome.

Fluidized Bed Dryer

Principles

- The fluidized bed dryer operates on the principle of fluidization, where hot air is passed through a perforated bed of wet solids, causing the solids to behave like a fluid.
- This enhances the contact between the hot air and the material, leading to efficient drying.

Construction



1. **Drying Chamber:** A vertical chamber with a perforated or mesh bottom.

2. **Blower/Fan:** Forces hot air up through the bottom.
3. **Heating System:** Heats the air before it enters the chamber.
4. **Filters:** Prevent particles from escaping with the exhaust air.
5. **Exhaust System:** Removes moist air from the chamber.

Working

1. **Loading:** Material is placed on the perforated bottom.
2. **Fluidization:** Hot air is forced up through the bottom, causing the material to become suspended and fluidized.
3. **Drying:** Heat from the air causes moisture to evaporate from the material.
4. **Exhaust:** Moist air is exhausted from the chamber, often passing through filters to capture any entrained particles.
5. **Unloading:** Dried material is collected and removed from the chamber.

Uses

- Drying pharmaceuticals, chemicals, food products, and granules.

Merits

- **Fast Drying:** High heat and mass transfer rates.
- **Uniform Drying:** Consistent drying throughout the material.
- **Efficiency:** Effective for heat-sensitive materials due to lower temperatures.

Demerits

- **Particle Size Limitation:** Not suitable for very fine or very large particles.
- **Energy Consumption:** Can be energy-intensive.
- **Initial Cost:** Higher initial investment compared to other dryers.

Freeze Drying/ Freeze Dryer (Lyophilizers)

Principles

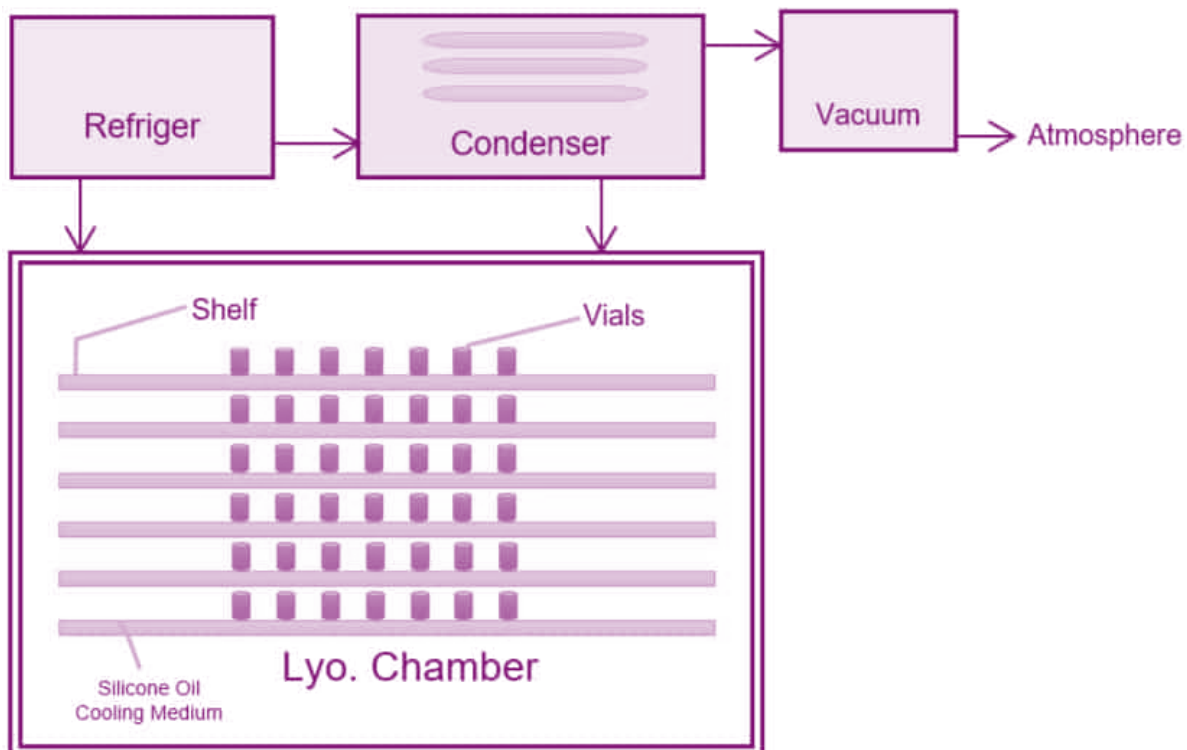
- Freeze drying, or lyophilization, involves freezing the material and then reducing the surrounding pressure to allow the frozen water to sublime directly from solid to gas phase.
- This method preserves the structure and composition of the material.

Construction

1. **Freezing Chamber:** Where material is frozen initially.
2. **Vacuum Chamber:** Encloses the frozen material and reduces pressure.
3. **Shelves/Trays:** Hold the material to be dried.
4. **Vacuum Pump:** Creates a vacuum in the chamber.
5. **Condenser:** Captures and freezes the sublimated vapor.
6. **Heating System:** Provides controlled heat to the material during drying.

Working

1. **Freezing:** Material is frozen solid.
2. **Primary Drying (Sublimation):** The chamber is evacuated, and controlled heat is applied, causing ice to sublime into vapor.
3. **Secondary Drying (Desorption):** Remaining bound moisture is removed by slightly increasing the temperature under vacuum.
4. **Condensation:** Sublimated vapor is captured and condensed on a cold surface.
5. **Unloading:** The dried material is removed from the chamber.



Uses

- Drying pharmaceuticals, biological products, food products, and delicate materials.

Merits

- **High Quality:** Preserves the structure, activity, and quality of the material.

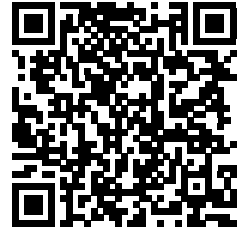


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