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Composite silos & tanks

Mass flow and core flow in silos

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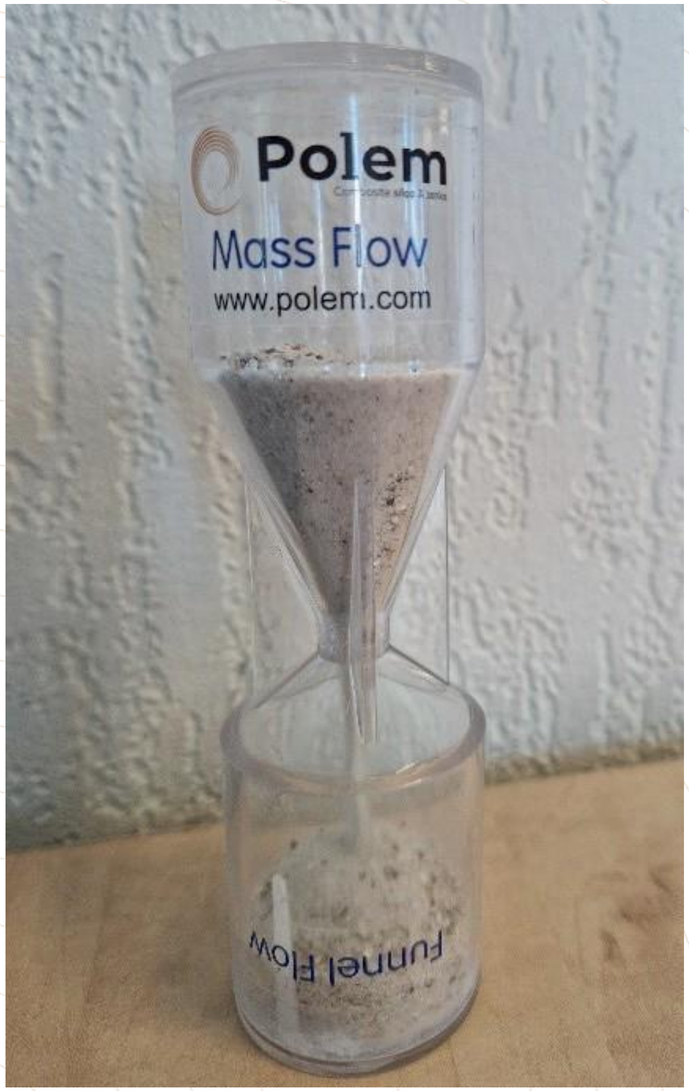
Mass Flow and Core Flow in Silos

In the world of bulk storage, silo technologies are essential for the efficient storage and distribution of dry materials such as grain, cement, and chemicals. While it is generally not difficult to get a product into a silo, it poses a challenge to extract the product in the desired and most favorable way.

The hopper shape plays a crucial role in this process. The flow patterns of materials in silos are also of great importance for the performance, efficiency, and maintenance costs of these storage systems.

Two fundamental flow patterns in silos are mass flow and funnel flow (core flow).This white paper provides a detailed overview of these flow patterns, their characteristics, advantages and disadvantages, and the impact on silo design and management..

A silo model in which mass flow occurs (turned upside down, the model shows core flow).



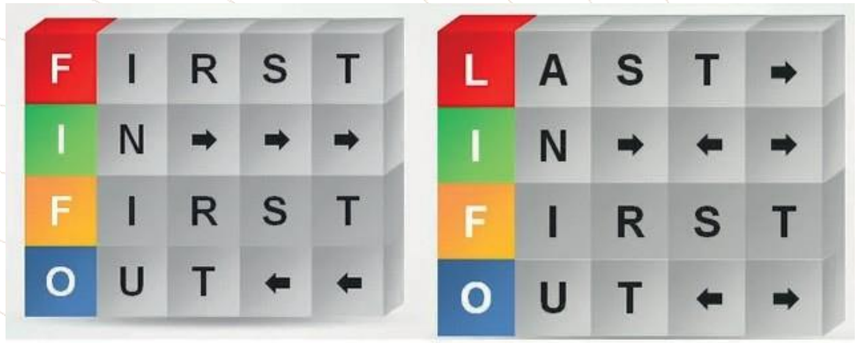
Mass flow

Mass flow occurs when the entire material in the silo starts moving as soon as material is removed from the outlet. This means that all layers of the material descend simultaneously, and the material flows along the walls of the silo. Mass flow is present when during product withdrawal, the entire bulk mass in the silo moves downward. Although small velocity differences can occur, there are no stationary zones. The flow rate is relatively low, and the flow is well controllable. Mass flow ensures the 'First in First out' (FIFO) principle and is particularly desirable for storing perishable products such as foodstuffs. A disadvantage of mass flow can be that with abrasive bulk goods, their friction against the silo wall causes wear.

A silo model in which mass flow occurs (turned upside down, the model shows core flow).

Characteristics of mass flow

- **Uniform depletion:** All materials move evenly downward, resulting in a first-in, first-out (FIFO) pattern.
- **Minimal segregation:** Due to the uniform movement of the material, there is less chance of segregation of particles of different sizes.
- **Faster discharge:** Material moves more quickly through the outlet, leading to more efficient unloading processes.
- **Higher wall pressure:** Because the material moves along the walls of the silo, more pressure is exerted on the silo itself, which affects the design and costs.



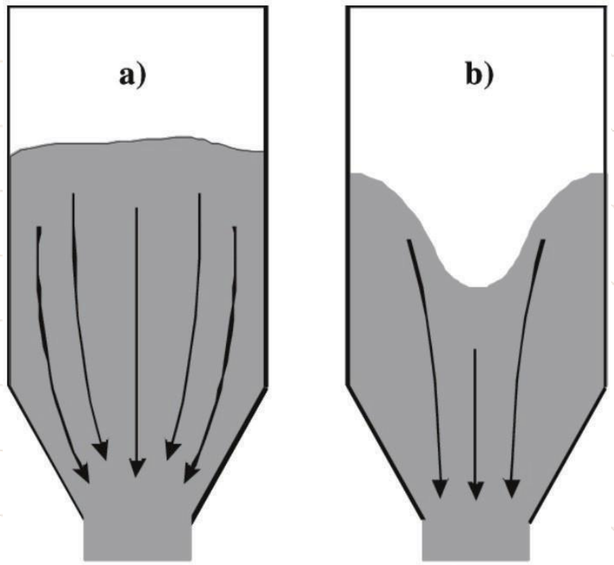
Advantages of mass flow

- **Consistent material quality:** The FIFO pattern ensures that older stock is used first, which promotes consistency of the material inventory.
- **Increased efficiency:** The uniform and rapid movement of material ensures more efficient unloading processes.
- **Reduces channeling:** Reduces the likelihood of bridging and channeling within the silo.

Disadvantages of mass flow

- **Higher construction costs:** The silos must be built more robustly to withstand the increased pressure on the walls.
- **Maintenance challenges:** The constant movement of material can lead to higher wear of the silo walls and other internal components.

The uniform and rapid movement of material ensures more efficient unloading processes.



Silos with mass flow (a) and core flow (b).

Core flow

Core flow, or funnel flow, occurs when material only moves in the central part of the silo, while the material at the edges remains stationary. This creates a funnel-shaped flow pattern where the material in the middle of the silo moves downward and the material at the sides remains stationary until the central column is empty. Core flow is present when during the outflow of product, the bulk material located near the wall of the silo initially remains at rest. During product outflow, a (funnel-shaped) channel spontaneously forms in the core of the silo, above the discharge opening. This channel is refilled from above from the stationary areas. The flow is sometimes less regular due to the jerky collapse of the dead zones. FIFO does not apply. If the silo is not regularly emptied completely – but continuously refilled – the bulk material in the dead zones can eventually spoil, clump, or cake on the wall. An advantage of core flow is that with abrasive bulk goods, the silo wall wears less quickly.

Characteristics of core flow

- **Funnel-shaped movement:** Material only moves in a column in the middle of the silo, while the rest of the material remains stationary.
- **Segregation:** Larger and heavier particles can move to the edges of the silo, which can lead to segregation of the materials.
  Slower discharge: The flow rate of the material is generally lower than with mass flow

Advantages of core flow

- **Lower construction costs:** The silo can be built less robustly because the pressure on the walls is lower.
- **Simpler maintenance:** Less wear on the walls of the silo, which can reduce maintenance costs.
- **Suitable for non-cohesive materials:** Better suited for materials that don't stick together or form bridges.

Disadvantages of core flow

- **Inconsistent material quality:** The last-in, first-out (LIFO) pattern can lead to inconsistencies in material quality.
- **Segregation problems:** Different particle sizes and densities can lead to segregation, which affects the quality and consistency of the discharged material.
- **Channeling:** Can lead to bridging and channeling, which may block the outlet and impede flow.

Applications and considerations

The choice between mass flow and core flow depends on various factors, including the type of material, the desired discharge flow, the storage duration, and the cost considerations.

- **Materials:** For cohesive materials that are sensitive to segregation, mass flow is usually the better option. For non-cohesive materials, core flow may be sufficient.
- **Storage duration:** If materials are stored for longer periods, mass flow can help maintain consistency and prevent quality loss.
- **Costs:** Core flow offers lower construction costs, but may lead to higher operational costs due to potential problems with segregation and outlet blockages.

For cohesive materials that are sensitive to segregation, mass flow is usually the better option.

Flow patterns of different materials in silos

When storing materials in silos, flow patterns strongly depend on the physical properties of the material. The main flow patterns are mass flow and core flow, each with specific characteristics depending on the type of material:

Bulk material, bulk goods, solid material, cohesive materials, powder, dry matter, sticky materials, granulate, granular material.

Granular materials

- **Examples:** Grain, rice, sugar, sand.
- **Mass flow:** In well-designed silos, due to uniform grain size and low cohesion, resulting in a FIFO pattern.
- **Core flow:** In less well-designed silos or with variable moisture levels, which can lead to segregation and channeling.

Cohesive materials

- **Examples:** Clay, wet sand, certain chemical powders.
- **Core flow:** Common due to high cohesion, leading to bridging and channeling.
- **Mass flow:** Achievable with special measures such as aeration systems or vibrating floors.

Sticky materials

- **Examples:** Wet fertilizers, wet salt, sticky food products.
- **Core flow:** Strong tendency towards bridging and channeling due to high cohesion.
- **Mass flow:** Difficult to achieve without advanced technologies such as heated walls, aeration systems, or mechanical agitators

Powder materials

- **Examples:** Cement, lime, flour.
- **Mass flow:** Possible with smooth walls and steep angles, minimizes accumulation and ensures a consistent discharge flow.
- **Core flow:** Due to higher cohesion, which can lead to bridging and inconsistencies in material quality.

Coarse materials

- **Examples:** Coal, pellets, ore, gravel.
- **Core flow:** Due to larger and heavier particles, leading to segregation.
- **Mass flow:** Less common, but possible with specialized silo designs.

Conclusion: Understanding and managing flow patterns in silos is crucial for the design and management of efficient bulk storage systems. By having insight into both mass flow and core flow, companies can make the right choices to meet their specific requirements. Effective application of these flow patterns can lead to increased efficiency, lower operational costs, and improved quality of stored materials.The use of techniques such as proper cone angles, agitators, knockers, and vibrating floors plays an important role in influencing the flow and mixing of different materials. The selection and combination of these techniques, depending on the specific properties of the stored material, are essential for ensuring an efficient and consistent material flow. This is of great importance for industries such as the chemical, pharmaceutical, and food industries, where proper flow patterns contribute to lower costs and better quality and safety of the stored materials.In short, by understanding and effectively applying the flow patterns of different materials, engineers and operators can choose the right silo designs and technologies for optimal storage and processing.

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