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Powder Flow Analysis of Brownie Mix

Understanding the powder flow characteristics of brownie mix is crucial for ensuring its optimal handling, storage, and processing.

Test Equipment:

- **Instrument**: Brookfield Powder Flow Tester (PFT)
- **Trough**: 230 cc, 6-inch diameter (Standard Volume)
- **Lid Types**:
  - Vane Lid, 33cc, 6-inch diameter
  - Wall Lid, 2B finish, 6-inch diameter
- **Type of Test**: Flow Function Test, Wall Friction Test
- **Conditions**: Room Temperature (70-72°F), Humidity: 48%

Method:

A PFT equipped with Powder Flow Pro software was used to evaluate the brownie mix. The procedure involved:

Flow Function Test Duration: 25 minutes

Wall Friction Test Duration: 13 minutes

1. Scooping the brownie mix into the trough.
2. Using the scraping tool to evenly distribute the powder throughout the trough.
3. Recording the sample weight and entering it into the software.
4. Running a standard flow function test followed by a wall friction test.

Parameters Measured:

- **Flowability**: Very Cohesive
- **Wall Friction Angle**: 45° to 25°
- **Bulk Density**: 475 kg/m³ (fill density) to 660 kg/m³

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Analysis:

- **Hopper Shape**: Conical
- **Critical Arching Dimension**: 108.6 mm (4.28 in.)

Results:

Flow Function:

The flowability of the brownie mix at different levels of consolidating stress is illustrated in Figure 1. The results indicate that the brownie mix is generally very cohesive across various consolidating stress levels. The flow function graph shows the data points read from right to left, with the rightmost data point representing powder flow when the hopper is full and the leftmost data point representing powder flow when the hopper is almost empty.

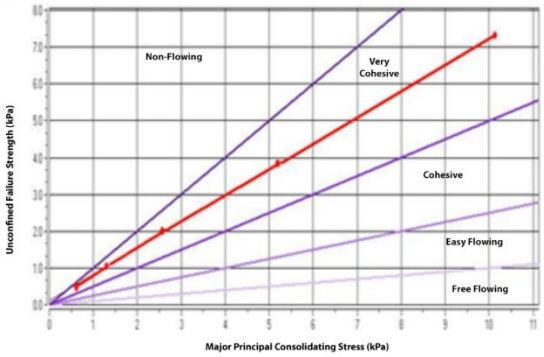

Figure 1: Brownie Mix Flow Function Graph

Wall Friction:

Figure 2 represents the angle of wall friction at different levels of normal stress. The angle of wall friction represents the friction between the sliding powder and the wall of the hopper or chute at the onset of flow. In this test, a stainless-steel lid was used. At a low normal stress of about 0.5 kPa, the angle of wall friction is approximately 45°, which decreases to about 25° at higher normal stress levels (4.75 kPa). Wall friction angles above 20° are considered high.

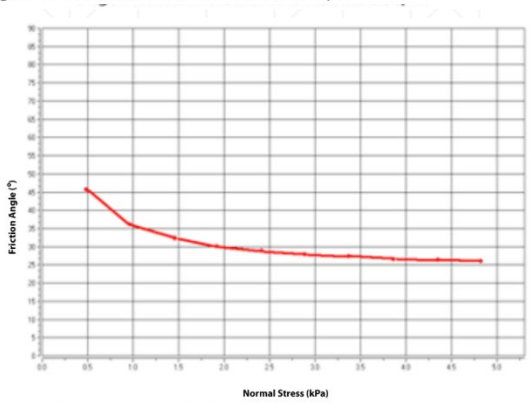

Figure 2: Brownie Mix Wall Friction Graph

Bulk Density:

Figure 3 shows the bulk density of the brownie mix at different levels of consolidating stress. The brownie mix has a fill density of about 475 kg/m³, which increases to approximately 660 kg/m³ at around 4.75 kPa of consolidating stress. A free-flowing powder typically shows small changes in bulk density, while a cohesive powder exhibits significant increases. The substantial rise in bulk density indicates that the brownie mix is very cohesive.

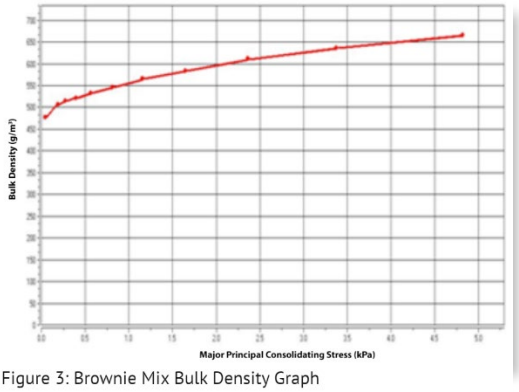

Figure 3: Brownie Mix Bulk Density Graph

Conclusion:

The brownie mix is a very cohesive powder at all levels of consolidation stress, which suggests potential flowability issues if proper precautions are not taken. Possible problems include:

- **Arching**: When the powder forms a cohesive bridge over the outlet.
- **Rat-Holing**: When the powder flows out only from the center, leaving the rest of the material static against the walls.

The critical arching dimension of 108.6 mm (4.28 inches) provides a conservative estimate to prevent arching, provided the minimum outlet dimension of the hopper exceeds this value. The critical rat-holing dimension depends on the diameter of the bin. If the bin diameter is known, the software can automatically calculate the rat-hole dimension.