ISO 9001:2015 CERTIFIED
BROOKFIELD
AMETEK

POWDER ANALYSIS APPLICATION NOTE: Flour

USE
Used for baking and cooking.

TEST EQUIPMENT

Instrument:	Powder Flow Tester (PFT)
Trough:	230 cc, 6-inch diameter (Standard Volume)
Lid Type:	Vane Lid, 33cc, 6-inch diameter
	Wall Lid, 2B finish, 6-inch diameter
Type of Test:	Flow Function Test, Wall Friction Test
Temperature:	Room Temperature (70-72°F)
Humidity:	24%

TEST METHOD
A Brookfield Powder Flow Tester equipped with Powder Flow Pro software for automated instrument control and data acquisition. The flour was scooped into the trough, and the scraping tool was then used to evenly distribute the powder throughout the trough. After recording the sample weight and entering it into the software, a standard flow function test and then a wall friction test were run. Time required for each test was 25 minutes and 13 minutes respectively.

PARAMETERS MEASURED
Flowability: Very Cohesive to Cohesive
Wall Friction: 12° (0.5 kPa) to 9.5° (4.75 kPa)
Bulk Density: 530 kg/m^3 (fill density) to 880 kg/m^3

ANALYSIS

Hopper Shape:	Conical
Critical Arching Dimension:	Plain Hopper: 71.7 mm
	Conical Hopper: 143.3 mm
Rat-hole Diameter:	Dependent on bin diameter

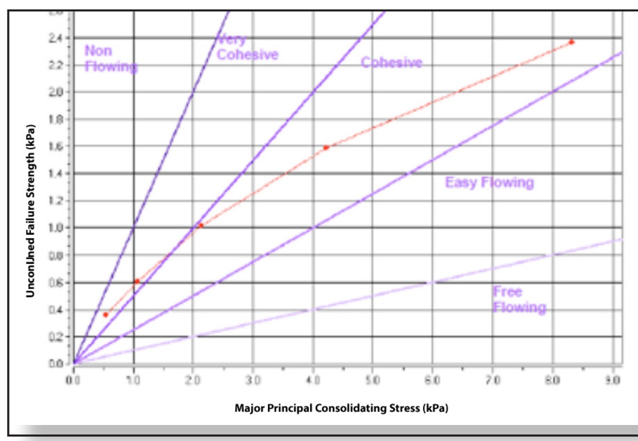

Figure 1: Flour Flow Function Graph
Failure Strength vs. Consolidating Stress

RESULTS
Figure 1 shows the flowability of the flour at different levels of consolidating stress. These results show that the flour is generally cohesive except at very low levels of consolidating stress where it begins to fall into the very cohesive range (below 2 kPa).

Note: The Flow Function data is indicated by the red line. When interpreting a Flow Function graph, the data is read from the right to the left. The right most data point is indicative of powder flow when the hopper is full; the left most data point is indicative of powder flow when the hopper is almost empty. The purple lines are Standard Flow Indices which distinguish the different types of flow behavior through levels of consolidation, ranging from "free flowing" (bottom segment) to "non-flowing" (top most segment).

Figure 2 represents the angle of wall friction at different levels of normal stress. 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 304 stainless steel lid was used, illustrating what the friction would be like if the flour was in a stainless steel hopper. Wall friction angles of >30° indicate the material will have difficulty sliding against this surface. At a low normal stress of about 0.5 kPa, the effective angle of wall friction is about 12° and goes down to about 9.5° at higher levels of normal stress (4.75 kPa).

Note: The Wall Friction test and the Flow Function test are independent tests. The Flow Function test measures flow of the powder through the orifice while the Wall Friction test measures the flow of powder against a specific material of construction.

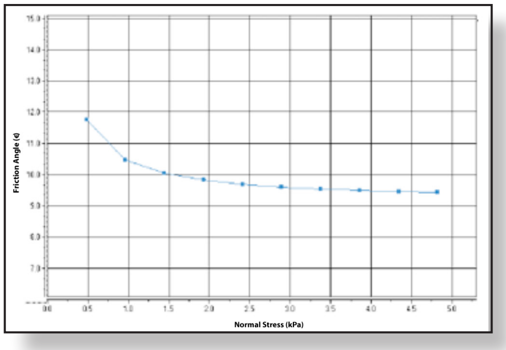

Figure 2: Flour Wall Friction Graph
Effective Angle of Wall Friction vs. Normal Stress

Figure 3 shows the bulk density of the material at different levels of consolidating stress. This graph tells us that the flour has a fill density of about 530 kg/m^3 and rises to about 880 kg/m^3 at around 4.5 kPa of consolidating stress. In general, a free flowing powder will show very small changes (less than 30%) in bulk density, while a cohesive or poor flowing powder will generally show a large increase (greater than 30%) in bulk density. In this case, the change in bulk density is 66% indicating a more cohesive, harder to flow material.

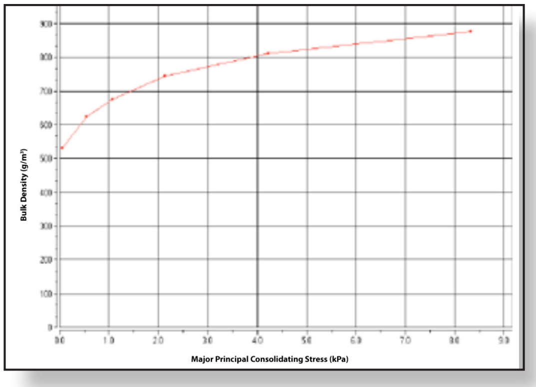

Figure 3: Flour Bulk Density Graph
Density vs. Consolidating Stress

CONCLUSION

The flour is a very cohesive powder at low consolidation stress levels and cohesive at high consolidation stress levels. This means that the flour may have flowability issues as the hopper empties. Potential problems include arching (when the powder forms a cohesive bridge over the outlet) and rat-holing. The critical rat-holing dimension is dependent on the diameter of the bin. Powder Flow Pro can automatically calculate the rat-hole diameter once the bin diameter is entered. The critical arching dimension was determined to be 4.192 inches (104.8 mm) and provides a conservative estimate to prevent arching from happening, provided the minimum outlet dimension of the hopper exceeds this value. The large arching dimension in this case indicates this material will be difficult to flow.