Processing Milk Powder

The Flowability Challenge

Variability in raw ingredients and the need to produce various blends of finished product for different applications constitute the major challenge for processing plants. Flowability of the powders is the recurring problem that can lead to inconsistent blends on the one hand and total plant stoppages on the other.

Typical devices and methods used by plant personnel to assess powder flowability include the Flodex Cup and the Angle of Repose test. Although simple and easy to use, they fall short of what's needed. Both procedures are evaluating loosely consolidated powder which is not a true reflection of the powder's condition when sitting in a storage vessel on the plant floor awaiting discharge. Once powder is placed into the bin, consolidation starts to occur automatically due to the powder's self weight. This natural compaction process in turn has a direct impact on the powder's ability to discharge through the hopper opening. Therefore, the flowability is not being assessed correctly.

Shear cell testers have come into prominence in recent time for use in evaluating flowability. (See Figure 1) They are more practical than other devices because they physically compact the test sample, then shear the powder against itself to measure the amount of friction that will cause resistance to movement. This type of test gives several pieces of information that can be useful, such as flow function and density.

Figure 2 shows a typical report that characterizes various blends of milk powder. Note in the flow function graph that some of the powders are "easy flowing" while others are "cohesive". The graph plots the strength of the powder (the force needed to cause the powder particles to slide against each other) against the consolidation stress (gravity's effect on the powder which causes compaction). At low consolidation stress the powders can become "highly cohesive" which might explain why they will not completely discharge from a hopper.

The second piece of information that is useful is the density. Note that this is plotted on the graph as a function of consolidation stress. One way of looking at this is to think of how high the vessel is filled with powder. The fill level determines the amount of consolidation stress that the powder at the bottom of the vessel will experience.

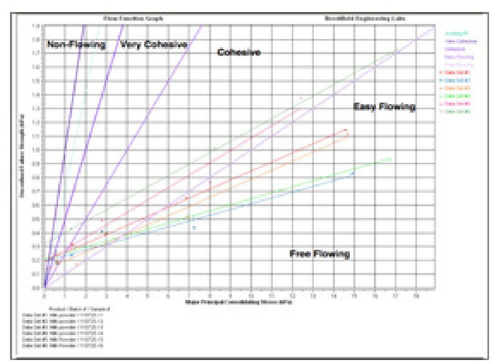
Arching dimension is a characteristic of the powder which relates to its ability to build a stable bridge across the bottom of the hopper. If this bridge is larger than the hopper opening, it can prevent powder from escaping. One of the calculated values that comes from these tests is the arching dimension. This number can be of use in characterizing milk powders and in designing future processing equipment.

Figure 1: Brookfield Powder Flow Tester with Shear Cell

Figure 2: Test Report for Milk Powder

MILK POWDER
Data Collected By: **Brookfield Powder Flow Tester**

Flow Function Graph (230cc Trough)



This flow function graph illustrates the flowability of the samples over different consolidating stresses. The x-axis parameter is the consolidating stress used to compress the sample; the y-axis parameter is the strength of the powder. All milk powders are free or easy flowing at consolidation stress values > 1kPa. Below 1kPa, they become cohesive which is reflected in the values noted for arching dimension and ratholе diameter in the attached test data report.

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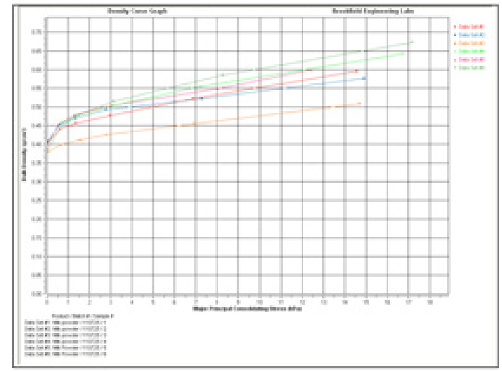
The arching dimension values in the attached report indicate that the hopper opening must be greater than 170mm for Milk Powder 6 in order to ensure reliable discharge of all powders. This dimension also applies to any conveyance device directly downstream of the hopper, such as the spacing between flutes on a screw feeder.

Data from the shear cell can also be used to calculate the critical rathole dimension, but this requires user input on bin shape, cross section dimension(s), and hopper type (wedge, conical). With the assumption of a 2m bin diameter, the rathole diameter was calculated for Milk Powder 6 at 575mm. The other milk powders all had lower values for rathole diameter.

The milk powder industry has become one of the major users of shear cells. Undoubtedly the test information has proven more useful in solving the problems of predicting flowability and designing the processing equipment, such as hopper opening and half angle, to handle the variations in raw materials and final blend requirements.

Bulk Density Graph (230cc Trough)



This bulk density graph illustrates the density of the samples over different consolidating stresses. All 6 milk powders show a moderate to high degree of compressibility. Loose fill density values start between 0.38 and 0.41 g/cm³. Milk powder 3 shows the least change, approximately 45%, while Milk Powder 6 shows the greatest change, approximately 70%. Powders with the greatest amount of change in density are more likely to exhibit flow behavior problems.

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