AVOID OVERMIXING: HOW TO ENSURE MIX QUALITY AND OPTIMAL CYCLE TIME

Although there are a variety of different factors that affect bulk solids mixing and blending, some issues are common and one is overmixing. This article explains the risks of overmixing and offers simple tips to help achieve the most optimal mix cycle for your application.

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In the world of bulk solids mixing technologies, the one constant every application must avoid is overmixing. Whether pharmaceuticals or powdered chicken-broth base, prolonged mixing can degrade essential components in a mix, decrease end-product quality, and — in the worst cases — create triboelectric effects throughout the material, leaving it electrically charged.

Energy-efficiency and consistency also are important considerations. Achieving high material throughput with less energy input helps a processing operation stay competitive in today's world of lean manufacturing. But this means more than just quicker batch times. Refined mixing cycle times optimize the processing quality standard. More important, batch mixing repeatability shouldn't depend on an operator but instead on the robust consistency of the technology in place.

Overmixing risks

There are many risks associated with overmixing. A few of the most common include:

Demixing. Defined as "the unintended segregation of materials within a substance," demixing has a higher probability the longer the mixing cycle. The probability of demixing is even higher in mixtures of components with varying bulk densities because of gravity's influence. Heavier materials will undoubtedly sink to the lowest region of a vessel or mixture, which negates the possibility of homogeneity (an ideal mixture) over time. While there may be quality tolerances where this wouldn't be a problem, in industries such as pharmaceuticals where active ingredients must be time-released into specific parts of the digestive system for instance (think intestine rather than stomach), mix consistency is critical.

Consumer demand also matters. The same nut-to-fruit ratio in each trail mix package or consistent color in prepackaged macaroni and cheese mix are just a couple examples of consumer expectations for product consistency. Consumer standards must be met, at a minimum, and preferably exceeded, to maintain marketplace success. This requires mixing cycle optimization.

Agglomeration. Depending on the environment, bulk raw materials might be stored in silos, hoppers, drums, or bulk bags. Nonetheless, moisture has a way of making an unexpected and uninvited appearance even in the most controlled environments. Regardless of storage method, humidity is a factor that every manufacturer must mitigate as much as possible. When moisture is present, prolonged mixing times will act as a catalyst to spark reactions between mix components or draw the moisture to particle surfaces. This causes adhesion in the material, as well as with storage vessel walls and mixing agitators, which can lead to agglom-

FIGURE 1

A simple visual streak test shows that nail enamel and pigment weren't evenly dispersed in the mixing process.

eration and greatly impact a powder's compressibility and flowrate. In industries such as cosmetics and pharmaceuticals, this poses a quality assurance and control nightmare as agglomeration greatly impacts the dispersion performance of these materials.

Friction. Of the risks associated with prolonged mix times, friction may have the greatest impact by causing premature breakdown of components within a blend. This can not only lower end-product quality but can also result in the accumulation of fines, which are ultimately wasted product. This affects an operation's profitability.

Shearing active ingredients, which creates additional friction, can spark the same untimely reactions and have detrimental results. One of these results is the aforementioned triboelectric effect, which is the electrification of dissimilar materials caused by particle collisions. During prolonged mixing, particle interactions are increased, and the surface-to-surface particle contact can produce an electric charge. While most mixers are constructed of metal alloys and are good conductors of electricity, many powders are good insulators. The situation creates the perfect conditions for triboelectrification, more commonly known as static electricity.

Analysis can help ensure mix quality

Whatever the material or problems involved, navigating through the task of establishing ideal mixing parameters and cycle times can be tricky. Fortunately, there are some quick and easy methods and analyses you can employ — both prior to and after mixing — to help ensure that a batch doesn't exceed its mixing threshold.

Establishing the bulk density of each component in a mix, as well as a blended bulk density, is a good baseline to set before establishing what your mixing parameters are. Knowing your mixture's blended bulk density also is a critical component for accurately sizing mixing equipment.

There are several types of bulk density (aerated, poured, tapped, and others), so take care when using these values as they depend on how the material is handled. Values should be measured a minimum of three times to validate the result. Once values are determined, they can be used in conjunction with a compressibility index (measure of a powder's ability to settle) and Hausner ratio (ratio of tapped density to fluffy density) to predict powder flow characteristics. These characteristics affect the mixing process but are especially important for materials that will be pressed, molded, or vacuum sealed because they determine how the end-product will perform during packaging and after reaching the consumer.

In mixes comprised of various colored pigments, a simple visual streak test, shown in Figure 1, can be used to judge homogeneity. This test, which involves smearing a sample of the mixed material on a white surface, is ideal for conditions that call for multiple powders with or without liquid additions. The absence of color agglomerates, patchiness, and streaks denote thorough particle dispersion throughout the mix. Figures 2, 3, and 4 show additional examples of visual checks to determine the homogenity of a mix.

FIGURE 2

Samples show a completely homogenized blend of salt and pigment mixed in a fluidizing paddle blender.

FIGURE 3

Samples (left to right) show a batch's mixing progression. As the spots of oil agglomeration disappear, the powdered cosmetic foundation is homogenized. Total mix time was 4 minutes.

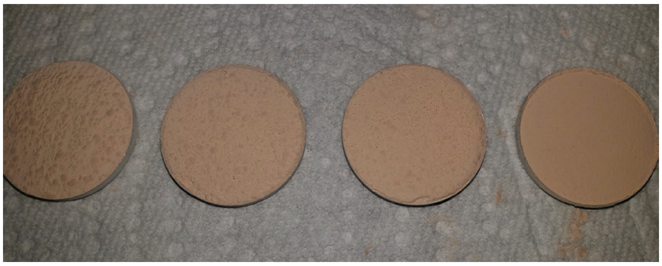

FIGURE 4

Visual test showing a poor-quality mix with red lines versus an evenly dispersed mix.

FIGURE 5

Supplier test labs can take you from benchtop to pilot-scale to production-scale testing to help optimize mixing cycle parameters.

Nonvisual tests

Nonvisual tests also can help determine an optimal mixing cycle. Vibratory sieve analysis is an effective way to measure material degradation over time and help establish acceptable mix tolerances. Often, this test is used to measure raw material degradation prior to mixing to establish baselines. The material is measured again after mixing to compare fines accumulation. In each case, material is sent through a number of sieves with different-sized mesh openings to evaluate particle size distribution.

To drill down even further, X-ray diffraction and scanning electron microscopy (SEM) can be used to determine particle dispersion throughout a batch. These methods use X-ray and electron beams that focus on material samples and measure material composition and particle characteristics. Both methods are performed using samples taken from different areas in the mix. These methods, unlike some of the others, are employed only after blending.

Testing helps

When mixing, the key is to homogenize materials — whether coffee beans or vermiculite — with minimal degradation but with enough energy to evenly distribute pigment, liquid, or other material throughout a given mixture in the minimal amount of time needed to achieve a reaction, color, or phase change without saturating, demixing, agglomerating, or shearing particulates within said batch. Many manufacturers have test centers, such as the example shown in Figure 5, where both the supplier and past customer test results can provide information to help you determine baseline mixing best practices. Taking the process from benchtop to pilot-scale to production-unit testing allows validation and fine-tuning of calculations along the way as you scale up to meet production goals. This can help optimize both batch quantity and, more importantly, batch quality. **PBE**

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For further reading

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