

While continuous processing has been used in bulk solids manufacturing for many decades, continuous blending is receiving renewed attention, largely because of the need for increased process reliability and robustness in the pharmaceutical industry. In this column, we'll discuss continuous blending's advantages and disadvantages relative to batch blending. Let's begin with some definitions:

Continuous blending is where ingredients are automatically and continuously loaded into an operating blender in the desired proportion, usually by means of gravimetric (loss-in-weight) feeders, as shown in Figure 1. The ingredients are mixed as they travel along the blender, which typically consists of a fixed shell with an internal agitator that both stirs the powder and moves it along the blender's axis. Mixing is achieved as a function of the powder's position as it moves through the blender. The mixture is continuously discharged at the same mass flow rate as the ingredients entering the blender.

Batch blending is where the powder to be mixed (called the batch, lot, or load) is manually loaded into a blender at discrete times during the blending operation. The ingredients are typically preweighed and, depending on the blend, can be loaded simultaneously or sequentially as a whole or in successive fractions. The blender then tumbles or stirs (or both) the ingredients, and mixing is achieved as a function of the length of time the blender is turned on. When the ingredients are fully mixed, the blender is turned off, and the blend is discharged all at once for subsequent packaging or processing.

Semibatch (or semicontinuous) blending is any process between continuous and batch blending or an operation that uses elements of both: for example, mixing ingredients as a batch in a portable bin and then continuously filling the mixture into bags, boxes, or sachets.



*Fernando J. Muzzio*

## Continuous versus batch powder blending

A very large process may require continuous blending, and a very small process may require batch blending. For example, continuous blending is unlikely to be economically advantageous for a process that will run for less than 100 hours, while a process that requires a material throughput greater than 1,000 kg/h would be very difficult to implement using batch blending. However, in many applications, either continuous or batch blending will work. To choose the best option for your application, you need to consider each type's advantages and disadvantages.

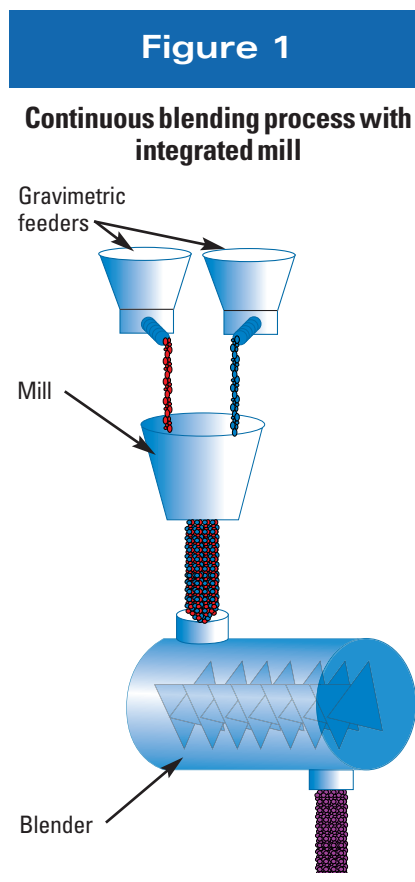
### Footprint and fixed capital costs

The equipment footprint of a continuous blending process is usually a fraction of that of a batch blending process because batch blending requires that the entire batch is mixed simultaneously. However, the capital cost of continuous blending equipment can be higher because the continuous process requires an automated control system. The continuous process's smaller footprint often offsets the higher cost, however, which can be quickly recovered by the continuous process's higher productivity, lower labor costs, and higher product quality.

### Operational simplicity

Batch blending is simpler in the sense that the tasks involved (measuring and loading ingredients, mixing, and discharging) can be performed sequentially, one at a time. An operator with minimal training can usually batch blend successfully by following a simple recipe. However, when blending is just one component of an overall manufacturing process, batch blending requires careful scheduling and efficient equipment use to avoid production delays.

Continuous blending requires that multiple activities (feeding, mixing, and discharging) occur simultaneously. Moreover, each activity must occur at the specified rate to ensure that the blend has the desired characteristics. As a result, implementing a continuous blending process is more complex and requires more planning than implementing a batch process. The



continuous blending process also usually requires a closed-loop automated control system to achieve optimal operation. However, once the process has been properly implemented, it requires minimal scheduling and very little labor.

### Operational flexibility

Continuous blending requires that you carefully select feeder conditions and fine-tune your control system to ensure accurate ingredient feeding for each blend you produce. Batch blending is much simpler to implement, allowing you to produce a variety of blends with one blender. If you need to use the same equipment to produce small amounts of many different blends, batch blending is often the only practical approach.

However, continuous blending provides much more flexibility in production quantity because of the equipment's often substantial throughput range. Also, you can increase or decrease the total yield by simply running the process for a longer or shorter time. In batch blending, the minimum and maximum batch sizes are usually within a relatively narrow range that's determined by the equipment size. If your production amount and throughput rate are very large or vary widely, and the number of products you're blending is small, continuous blending is frequently the best approach.

### Process development and scalability

A continuous blending process is much easier to develop and scale up than a batch blending process. In fact, it's possible to develop a continuous blending process at the same scale and using the same equipment that you will later use for actual manufacturing. This is simpler and more robust than scaling up a batch blending process. In batch blending, typically you must first develop the process using small equipment and then scale it up using much larger, production-scale units that rarely

work the same as the smaller equipment. In many applications, you can scale up a continuous blending process by simply running it for a longer time, as discussed in the previous section.

### Final product quality

Continuous blending has a significant advantage over batch blending when it comes to robust performance, which often correlates to final product quality. As I've discussed in previous columns, batch blending is potentially adversely affected by several factors, including how the blender is loaded, the fill level, the blend's tendency to segregate, and the presence of agglomerates in the blend. [*Editor's note:* For more information about previous "Mixing Mechanics" columns, see reference 1.] Continuous blending tends to be protected against the first three of these factors, since the blender is loaded automatically, the agitator speed controls the fill level, and a properly implemented continuous blender can handle segregating blends. Also, when a mill is required to break up agglomerates in the blend's ingredients, this is much more easily integrated into a continuous blending process than a batch process because a mill is an intrinsically continuous machine (Figure 1).

Continuous blending does require a larger upfront effort and expense, and it's often possible to obtain adequate performance from batch blending, but when properly implemented and operated, continuous blending is frequently more reliable and profitable than batch blending. Except in an application where low product volume or the need to produce a large variety of different products gives batch blending the advantage, continuous blending tends to yield superior results.

### Reference

1. Find topics, issue dates, and page numbers for previous "Mixing Mechanics" columns in *Powder and Bulk Engineering's* article index in the December 2014 issue or the Article Archive at *PBE's* website, [www.powderbulk.com](http://www.powderbulk.com). (All columns listed

in the archive are available for free download to registered users.)

*Fernando J. Muzzio is director of the National Science Foundation's Engineering Research Center for Structured Organic Particulate Systems (<http://ercforsops.org/>) and Distinguished Professor, chemical and biochemical engineering, Rutgers University, Piscataway, N.J. He can be reached at 848-445-3357 ([fjmuzzio@yahoo.com](mailto:fjmuzzio@yahoo.com)). He earned his BS in chemical engineering at the University of Mar del Plata, Buenos Aires, and his PhD in chemical engineering at the University of Massachusetts, Amherst. He has published more than 200 peer-reviewed papers on mixing and blending, presented at numerous conferences, and earned several patents.*

The author will answer your questions in future issues. Direct questions to him at [fjmuzzio@yahoo.com](mailto:fjmuzzio@yahoo.com) or via the Editor, *Powder and Bulk Engineering*, 1155 Northland Drive, St. Paul, MN 55120 ([jbrenny@cscpub.com](mailto:jbrenny@cscpub.com))