Dry Filling

By John R Henry

In previous papers I discussed liquid filling. This month I'll talk about dry, or solids, filling. There are many types of dry products ranging from fine powders like talc or flour, to irregular pieces like frozen chicken parts. Other types of dry products include pharmaceutical powders, regular shaped products like nuts and bolts, candies and pharmaceutical tablets.

A variety of filling technologies are available. Many times more than one technology will give satisfactory results on a particular product/package combination. In most instances, there is one technology which will give the best results when all factors are considered.

Dry filling technologies can be broken down into 3 basic categories:

- Volumetric filling dispenses a measured volume of product.
- Weight filling dispenses a measured weight of product.
- Piece filling dispenses a specific count of product.

Sometimes the package label claim will determine the technology to be used. Two popular candy mints are packed in similar containers. In the 90’s and prior, one of them claimed a certain weight of mints on the label. The other claimed a specific number of mints. To assure label claims were met, one had to be filled by count, the other by weight.

Volumetric filling

Volumetric filling dispenses a specific volume of product. In liquid filling volume and weight are directly and closely correlated. In dry filling they may be but, especially in the case of fine powders like flour, they may not be. As the powder is handled through the filling system it may compact or may fluff up. As the density changes, the weight per unit volume will also change. Powders are not the only product where this can be an issue. Breakfast cereals such as corn flakes can change density as well. This is why when opening a bag of cereal it may appear less than full. The bag may have been completely full when sealed but the vibration of handling and transit causes it to compact or “settle” by the time the consumer opens it.

Product handling becomes critical to maintain a consistent density. The actual density at any point in the process is less critical than that it be carefully controlled and consistent at the point of filling.

Augur fillers

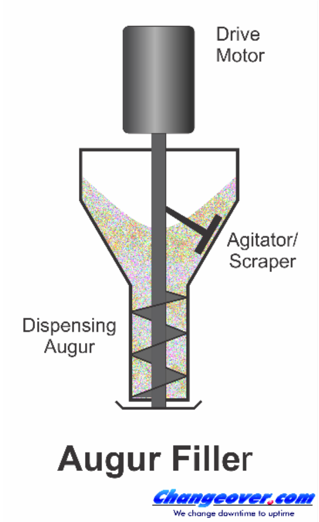
Augur fillers consist of a hopper and a dispensing augur, sometimes called a screw or worm. They work well with a variety of dry products ranging from fine to coarse. In some cases they have even been used to fill viscous liquids. They work best with relatively free flowing products of relatively uniform particle size.

The product is fed into the filler from a bulk supply. Keeping that level constant is key to consistent filling. Variations in hopper level will result in underfills and overfills of the product. Generally there needs to be an automatic level control and bulk feed mechanism.

The augur is driven by a servo motor or, in some older models, a motor with a clutch/brake drive. On a signal, the motor rotates the augur a precise number of turns and fractions of a turn. As the augur turns, if forces product out the discharge. The amount of product is determined by the amount of rotation. This is fairly, though not always exactly, linear. If 2.7 rotations of the augur fill 6oz of product, 5.4 rotations should dispense 12oz.

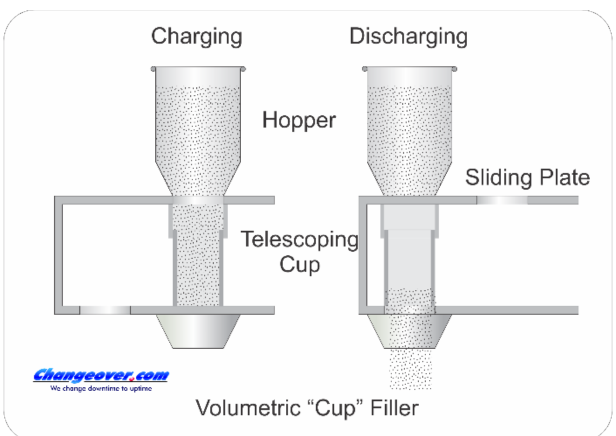
Speed of the augur is also important. Faster rotation can result in more product dispensed for the same amount of rotation. If the product is very fine, faster rotation can cause product compaction in the screw flights. In a severe case this can cause a filler jam.

When the augur rotation stops, the product will want to continue dribbling. It is important that flow cease with augur rotation. The illustration shows a “bird feeder” type of discharge. Other fillers will have a positive shutoff valve in the discharge to cut flow. If a valve is used, it is important that it not close while the augur is still running. If it does, the force of the screw on the product can overload the motor. It is always a good idea to have a torque or amp limiting circuit on the motor so that it stalls before it exerts enough force to cause harm.



Cup filler

Cup fillers use an open-ended volumetric cup to measure the product prior to dumping into the container. The internal volume of the cup determines the volume of product to be dispensed.



This schematic shows a simple single cup filler which shuttles back and forth. In the charging position, the top of the cup is exposed to the product hopper and the bottom of the cup is closed. Product flows by gravity completely filling the cup.

Once sufficient time has been allowed to completely fill the cup, the sliding plates shift. This closes the top of the cup scraping off any excess product. As the plate continues to shift it opens a hole under the cup allowing product to discharge into the container. After sufficient time for a complete dump, the plate shifts back, closing the bottom of the cup and opening the top, allowing the cycle to begin again.

Volume is a function of the diameter and height of the cup. Cups are often designed to telescope which allows precise adjustment of the cup and fill volume. The schematic is of a single channel filler. Cup fillers are often integrated on rotary machines allowing high speed (400cpm or faster) filling.

Weight filling

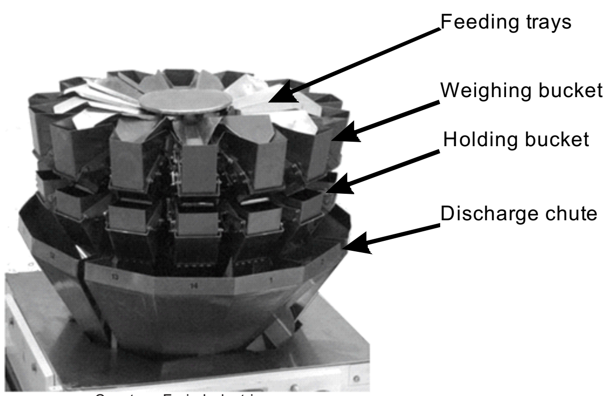
Weight filling is the most precise way of filling dry products since it will not be affected by variations in product density. Even so, there are some tricks to getting precise fills.

The simplest weight filler places the container on a scale and tares it. The product is dispensed, by a vibratory trough or other means, until the scale reaches the desired weight. One issue with this type filler is that if the feed rate is set high to give good filling speeds, it may be hard to stop precisely and overfills can result. If feed rate is slow to avoid this, the cycle speed is significantly reduced. One way to solve this is to do what is called “Bulk and Dribble”. The product is fed at a high rate until it approaches the setpoint, typically around 95-98%. The feed rate then slows to "dribble" the last few percent into the container.

This is simple and effective for low flow rates but dispensing directly into the container means no dispensing can take place while the filled container is indexing out and the next empty container indexed in. This can cut filling speed as much as 30-50%. A "bucket", between filler and container, can greatly improve fill rates. The bucket is mounted on a scale or load cell and tared. Product is dispensed into the bucket, as above, until the desired setpoint is reached. As soon as the empty container is in position under the bucket, the bucket drops its charge and the feeder begins recharging the bucket. Feeding is never paused while waiting for a container.

Combining scales

When higher speeds or precision are required, a combining scale may fill the bill. The combining scale uses feeders, buckets and scales similar to above. The difference is that they use multiple, often a dozen or more, feeders, scales and buckets used.



Courtesy Frain Industries
www.frain.com

Let us take a 10 bucket combining scale filling a 10oz product. Each bucket will be charged with 2oz of product, as closely as possible. Since there will be some variation, especially with irregular products like chicken parts, some buckets might have as much as 2.2oz and others as little as 1.8oz with some right on the money at 2.0oz.

The scale's computer will look at all 10 buckets and calculate which 5, will combine most closely to give the desired 10.0oz fill. When the container or bag is in position, those 5 buckets will drop their product. Combining over and underfilled buckets results in a highly precise final fill. Per Yamato, a large builder of combining scales, selecting 5 buckets out of 10 provides 252 possible weight combinations.

Some combining scales are arrayed with the individual scales side by side. This works well when there are a few scales but when there are more than 4 or 6 scales, they can be too far from the discharge chute, slowing cycle times. Many combining scales are arranged in a circular pattern for this reason. (See illustration)

Piece filling

Pharmaceutical tablets as well as hardware and some other products are normally sold by count, rather than by weight. Nobody wants to be putting their IKEA chair together and find that, while they have the correct weight of screws, they only have 9 of the 10 required. These products must be counted into their container.

There are a couple of ways to do this:

The most common is by physically counting the products as they fall or are conveyed past a photoeye or other sensor. This can be a single row and sensor where low speed, 100 or fewer parts per minute, are required.

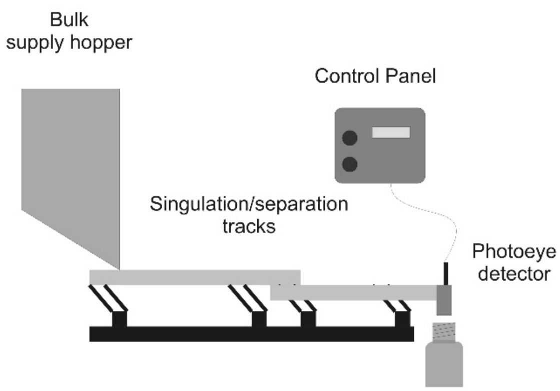


Figure 7-12 Piece counting filler

As the products are detected, they increment a counter. When the setpoint is reached, the feeder stops and a new container placed under the filler. Some systems discharge into a bucket, similar to weight fillers, where the product is stored until a container is in position. This allows the feeder to count almost continuously allowing greater cycle speeds on the machine.

High speed fillers as used on pharmaceutical lines use multiple feed lines and sensors to achieve speeds as high as 300 bottles per minute on a 100 count fill.

An issue with dusty products is that the dust can accumulate on the lens of the sensor. Air jets can and vacuum can sometimes prevent this but if it does build up, accuracy may suffer. Periodic cleaning of the sensor will avoid counting problems.

Another counting technique uses a defined cavity. Slat fillers use a series of slats with cavities sized to hold a single product. Brushes and guides help the product enter the cavity and brush away any excess. Each slat can hold 10 to 100 products depending on machine and product size.

The slats are mounted on an endless chain and dragged under a hopper full of product, where the products fall into the cavities. The slat is then dumped and the products funneled to the bottles. A variation of the slat filler uses wheels with cavities in the periphery. These fillers are mainly used for pharmaceuticals, vitamins, candies and similar products. they will only work with products of uniform shape and size. They have the advantage of being very fast. Some filler can achieve speeds of 350-400cpm on small products and fill counts. A disadvantage is that they tend to be more complex than comparable sensor based counting fillers.

Dry filling looks harder than liquid filling but it really isn’t. Pay attention to details and make sure the product is supplied to the machine in a consistent manner. Density, especially of finer products it a critical parameter and must be carefully controlled for good filling precision. The technology must be matched to the product, the container and the plant staff who will operate and maintain it. It is not rocket science but it must be done properly.