



White Paper

# Optimizing Product Flow on the Packaging Line

Packaging distribution systems that take solid food products from the processing line to form-fill-seal (FFS) packaging machines typically include conveyors with gates, scale feed shakers, and multihead weighers that feed either vertical- or horizontal-form-fill-seal machines. By understanding the interaction of these components and considering the system as a whole, processors can maximize the output of the FFS machine while maintaining the highest product quality and easing operations.

In this white paper, we will explore the physical relationship of the FFS machine to the upstream equipment. We will cover analog versus digital call signals, flood feeding versus steady state feeding, mass flow versus volumetric flow, proportional gates versus standard gates, integrated control systems, and more. The objective is to help food processors optimize their packaging operation by selecting machines that work harmoniously as a system and integrating the controls so the machines communicate seamlessly.

Snack food processors arguably have the most challenging situation when integrated seasoning application systems are added to the line and small packages are produced at the fastest line speeds possible. However, the benefits of fully integrating the distribution system apply to all types of food processors. Whether the company is packaging snacks or baked goods, cereals, confections, shredded cheese, fresh-cut produce, frozen fruits and vegetables, nuts, poultry, seafood, or pet foods into flexible bags, the same considerations exist in line optimization.

### Form-Fill-Seal Machines

A vertical-form-fill-seal (VFFS) or horizontal-form-fill-seal (HFFS) packaging machine is the anchor of the packaging distribution system. A processor's preference in bag style and need for line speed mandate the decision to choose one type of FFS machine over the other, and upstream and downstream machines must complement it. Optimizing the output of the FFS machine is the goal of the packaging line because the quantity of saleable bags produced has a direct effect on the processor's bottom line.

The FFS machine must pull film and achieve good seals

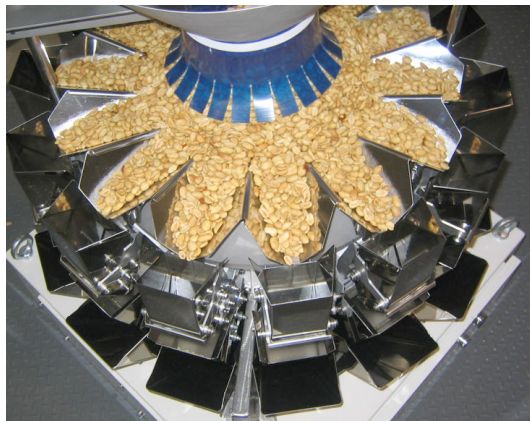


## Optimizing Product Flow on the Packaging Line

with jaws that maintain the correct temperature, dwell time, and pressure while the ideal amount of product is filling each bag at a rate that optimizes the line. Thus, the success of the operation is dependent, in part, on the ability of upstream equipment to deliver the ideal amount of product to the FFS machine at the perfect speed with the necessary separation between product charges that allows the jaws to seal properly without product interfering and compromising the quality of the seal.

To achieve this, the FFS machine and the scale upstream are integrated – the FFS machine is the system “master” because its demand for product controls the upstream equipment.

For most solid food products, a multihead weigher, often called a radial combination scale, is used in conjunction with a FFS machine because of its speed, accuracy, and reliability.



### Multihead Weighers

The goal of the multihead weigher is to deliver product charges to the FFS machine at the ideal weight and at a speed that allows the FFS machine to maximize its output while achieving the perfect separation between product charges for the FFS machine’s jaws to seal properly. The scale is a “slave” to the FFS machine.

The speed of the FFS machine, the weight and volume of the product to be packaged, along with other physical characteristics of the product are factors used to determine the ideal multihead weigher for the application. The number of buckets, the size of the buckets, and the configuration of the chutes may vary dramatically from one application to another.

Ideally, the speed of the scale should be set slightly faster than the speed of the FFS machine so the FFS machine is never starved for product. The FFS machine will provide a signal to the multihead weigher when it is ready to accept the next product charge. Typically, a 100 millisecond separation between the trailing edge of one product charge to the leading edge of the next charge is sufficient regardless of the dwell time needed to achieve a good seal.

The multihead weigher is also known as a combination radial weigher. The weigher will use multiple buckets in a combination to achieve the total target weight desired. For example, if the desired target weight is 100 grams, the scale will choose multiple buckets that combined will equal 100grams. Typically, the scale chooses between 3 to 5 buckets in combination. The computer on the scale is constantly looking at individual bucket weights in search of the perfect combination.

Overfeeding the multihead weigher by delivering too much product results in fewer available bucket combinations within the scale. This affects the weigher’s ability to hit

## Optimizing Product Flow on the Packaging Line

the perfect total weight of the charge, which hurts weighing accuracy. Underfeeding the scale requires more buckets in a combination to achieve the total weight, which hurts the speed of the system since the buckets will need time to refill before being available again. Both speed and accuracy of the packaging line will affect the production yield and ultimately, the bottom line.

In general, better speed and weighing accuracy is achieved with a multihead weigher that features more buckets because there are more potential combinations available to achieve the perfect total charge weight. However, higher capital costs associated with a larger scale force most food processors to consider the trade-offs, select a scale that achieves the optimal balance, and then focus on maximizing the effectiveness of the equipment.

For these reasons, feeding the scale at the proper rate has a direct effect on the efficiency of the scale and thus, the output of FFS machine. Infeed rings, infeed funnels, and linear feed pan designs help present a constant waterfall of product to each bucket. Yet it's the relationship between the weigher and the upstream scale feed shaker that ultimately controls the flow of product to the scale. The better the integration between the weigher and the scale feed shaker, the better the FFS machine's output.

### Scale Feed Shakers

Scale feed shakers are specialized vibratory conveyors that feature either mechanical drives or electromagnetic drives. While horizontal motion can be used to feed scales, vibratory shakers offer the advantage of spreading and smoothing the product uniformly across the pan, which improves feed. The goal of this shaker is to evenly feed the scale so it is never overfed or underfed.

The most basic relationship between the scale and the scale feed shaker uses the scale's infeed funnel as an accumulation device and a load cell or a level eye at the top cone of the scale that sends a digital on/off signal to the upstream scale feed shaker to stop and start, as needed. This method of integration, referred to as "plop and drop" or "flood feeding," is less than optimal. This highly ineffective strategy has a tendency to overfeed the scale at the start and then starve the scale before turning back on, which hurts accuracy and speed and thus, has a significantly negative impact on the output of the FFS machine. Unfortunately, this method of scale feeding is widely used.

Fortunately, there are several options available for processors to optimize scale feeding and scale operations, which increase FFS machine efficiency and ultimately profitability, by providing a steady stream of product from the scale feed shaker at the proper flow rate.

One way to achieve this is to utilize a load cell or optical sensor at the top cone of the scale to send an analog signal to the scale feed shaker based on the weight or the height of product on the weigher's top cone. The analog signal



will speed up or slow down the flow rate of product from the scale feed shaker. This is designed to maintain a constant weight or height of product on the scale. Slight changes in speed may be required to adjust for bulk density changes in the product. Maintaining a constant weight or height of available product on the weigher's top cone assures good product distribution to each bucket, which optimizes weights and speed.

An additional improvement, called volumetric flow control, integrates the analog scale signal with a photo eye on the scale feed shaker, which monitors the volume of product and controls the distribution shaker upstream to feed a specific amount of product to the scale feed shaker. Since bags are filled by weight, not volume, volumetric flow can be improved upon, especially when the density of the product varies.

The most accurate way to achieve a steady stream is called mass flow control. It integrates the analog scale signal with a load cell on the scale feed shaker, which monitors the weight of product and regulates the distribution shaker upstream to feed the perfect amount of product to the scale feed shaker.

Product flow from the upstream distribution shaker to the scale feed shaker are regulated by either a standard gate or a proportional gate. Standard gates simply open and close. Proportional gates allow the aperture to vary and thus, better control the amount of product flowing to the next stage. Using a proportional gate upstream of the scale feed shaker is an ideal way to control product flow. Snack food processors with a seasoning application drum between the shaker and the scale often settle on mass flow and proportional gates since these systems maintain the most constant feed rates, which will achieve the most uniform seasoning.

### Distribution Shakers

Distribution shakers transport product from the processing line to the scale feed shakers. Typically, each processing line leads to one distribution system that features multiple shakers and gates that discharge product to multiple scale feed shakers, each of which feed a scale and FFS machine. Depending on the type of distribution shaker used, the configuration of the system, and the controls, line efficiency and product quality are both affected at this stage.



The distribution shaker can be a traditional vibratory shaker or a horizontal motion shaker. Horizontal motion shakers are ideal for many fragile, seasoned, coated, and frozen foods because they offer gentle, quiet, and sanitary conveying. Both conveyor types can be fitted with standard slide gates, flip gates, pivot gates, or proportional-control gates to discharge product to downstream equipment.

## Optimizing Product Flow on the Packaging Line

If the downstream scale feed shakers have sensors – either a photo eye that monitors the depth of product or a load cell that measures the weight of product – each gate on the distribution shaker can be controlled to feed the ideal amount of product to each scale feed shaker. Distribution systems can rely on data from volumetric or mass flow controlled feed shakers or unique optical sensors to control gates.

On the most basic lines with the fewest sensors and the least integration, if the FFS machine goes down, the FFS machine signal causes a cascading effect on the slave systems, shutting them down. However, this basic line is incapable of making more minor adjustments to compensate for constant changes in line flow. Systems operated in this manner can often be identified by overfeed conditions at the first scales in the line, which choke the scales and reduce the accuracy of fills and cause bags to break, followed by underfeed conditions at the subsequent scales, which stave the scales and reduce the output of these FFS machines.

On more sophisticated lines with more integration, each FFS machine controls its scale, which controls its scale feed shaker, which controls the gate on the distribution system so each machine is optimized individually as well as in combination. Each FFS machine can operate at different rates, producing different size bags, and the distribution shaker opens and closes each gate to discharge the exact amount of product to each scale feed shaker to optimize each scale and maximize the output of saleable bags being produced by every FFS machine.

### Adding a Buffer

To maximize line efficiency and product quality, the distribution system must accommodate a constant flow of product coming off the processing line even when a FFS machine is down. This can be accomplished by either recirculating product or accumulating product.

If it is important to package the freshest product, as is the case with many snack foods, frozen poultry and seafood products, and fresh-cut produce, recirculation is not advisable because product could recirculate multiple times and then substandard product will be packaged and shipped. For these products, accumulation is preferred.

Product can be accumulated in different ways at various points along the line. If the distribution shaker is a horizontal motion conveyor that allows the flow direction to be controlled, the conveyor itself can be used for storage as well as distribution. The speed at which the distribution conveyors operate can also buffer the flow of product. Alternatively, a storeveyor or binveyor can be added to the line to provide bulk storage. In some applications, select areas along the processing line can accumulate product without negatively affecting product quality. For example, a freezer could accumulate product without hurting product quality – a fryer could not.

### Control Systems

Each machine has its own control system. Among other things, the FFS machine controls how fast it pulls film and the time, temperature, and pressure of the sealing jaws; the

## Optimizing Product Flow on the Packaging Line

scale controls the weight per charge; the scale feed shaker controls the product feed rate; and the distribution shaker controls its gates and product flow rates. The key to maximizing the performance of the line is linking these independent machines so they communicate with the others to improve the efficiency of the system.

On a fully integrated packaging line with integrated controls, one change on one machine or one point of input on one user interface automatically triggers all the necessary adjustments on other machines on the line. If a FFS machine goes down, upstream equipment automatically adjusts to accommodate it and continues to maximize the efficiency of the line, given the situation. If one FFS machine is changing over from a 14-gram bag to a 14-ounce bag, one point of input at one human machine interface (HMI) changes all the components on the line.

Typically, this high level of integration is achieved through a PLC at the distribution system level. If desired, data can be fed into a SCADA network so the system can be accessed from any computer on the network. Additionally, the network can be programmed to alert personnel via smart phones, tablet computers, emails, and/or text messages, regarding machine and system performance and conditions.

### Conclusion

The benefits of optimizing a packaging line are numerous. Maximizing each FFS machine's output of saleable product and eliminating product giveaway by producing on-weight packages goes straight to the bottom line. Maintaining high product quality promotes customer loyalty, and easing operations reduces training requirements and helps the line operate at peak performance.

Selecting right-size equipment that handles a specific product and produces the desired package is only the beginning of integrating a highly effective production line. To optimize the packaging operation, food processors – or their line integrators – must understand the interaction of the components and consider the line holistically rather than as separate machines that are connected. Fully integrating the controls costs more initially, but the added cost is quickly recovered by increases in overall equipment effectiveness (OEE) and the increased output of the FFS machine producing saleable bags.



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#### Published by:

Key Technology, Inc.

† 509.529.2161

150 Avery Street

✉ product.info@key.net

Walla Walla, WA 99362

www.key.net