- Case history: Rotary batch blender
- Automated batching

WEIGHING AND BATCHING
Automated batching for improved product quality and processing efficiency — Part I

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This two-part article explains how an automated batching system can overcome the inaccuracy, limited output, and other problems associated with manual batching operations. Part I explains how automated gain-in-weight and loss-in-weight batching systems work, how they are applied, and what to consider when selecting a system for your application. Part II (October) concludes the article with information on selecting conveyors for an automated batching system, integrating the system with your plant equipment and controls, and promoting flow of difficult materials in the system; two automated batching system case histories are also included.

Manual batching is a time-consuming operation in which an operator adds premeasured ingredients or individually weighs ingredients before adding them to a blender or other process vessel. This operation can slow the entire process, generate considerable dust, and result in lost product through spillage and incompletely emptied bags. However, the biggest problem with manual batching is that it can be an inaccurate and inconsistent method of weighing batch ingredients, thereby affecting product quality and consistency. For many plants, whether large or small, switching to an automated batching (also called weigh batching) system is a cost-effective way to solve these problems.

Consider the room for human error in this typical manual batching operation: To add 500 pounds (227 kilograms) of an ingredient, an operator dumps ten 50-pound (23-kilogram) bags into a blender. However, each bag may not contain exactly 50 pounds (23 kilograms) of material, and the operator may not empty each bag completely. These inaccuracies compound as all ten bags are dumped. Moreover, if the operator is counting the bags as a way of measuring the ingredient added to the batch, one mistake in the bag count can lead to major error in the ingredient's proportion in the batch. In contrast, an automated batching system controls the weighing and addition of each ingredient into the blender, eliminating the possibility for human error.

While an automated batching system usually requires a more significant capital investment than a manual system, automation can quickly pay for itself by improving the accuracy of your ingredient measurements, and, in turn, improving product consistency. The system also can increase your production rates, minimize dust and product loss, and reduce raw ingredient costs by allowing you to purchase materials in larger containers or bulk volumes.

How automated batching systems work

Two types of automated batching systems are available: gain in weight and loss in weight. While these systems share many characteristics, they operate in fundamentally different ways.

Gain-in-weight system. A gain-in-weight system, as shown in Figure 1, measures the amount of weight gained by a central batch vessel as each ingredient is added. The system typically includes a source for each ingredient (such as a hopper or bulk bag), a mechanical or pneumatic conveyor for each ingredient, the batch vessel (called a
An operator pushes a manual start button (or a plant PLC sends a signal) to start the batching process. The controller then starts the mechanical conveyor (or the rotary airlock valve at the pneumatic conveyor’s inlet) for the first ingredient to load it into the weigh hopper at the maximum feed rate. The load cells transmit weight-gain data to the controller. The controller steps down the feed rate to dribble before the ingredient reaches the target weight to achieve greater accuracy. The controller stops the mechanical conveyor or rotary airlock valve at a preset amount before the target weight is reached to compensate for material inflight — that is, discharged from the conveyor or valve but not yet loaded into the weigh hopper. (This stop point is called a precast.) This process is repeated for each ingredient in the batch. When all the ingredients have been added to the weigh hopper, the controller automatically discharges the batch from the hopper into the process vessel.

Loss-in-weight system. A loss-in-weight system, as shown in Figure 2, measures the amount of weight lost at the ingredient source as each ingredient is conveyed to a central batch vessel. The system includes a source for each ingredient (often a bulk bag unloader or a preloaded hopper) that is mounted on load cells, a mechanical or pneumatic conveyor for each ingredient, the batch vessel (such as a hopper, blender, or other process vessel), and a controller.

An operator pushes a manual start button (or a plant PLC sends a signal) to start the batching process. The controller then starts the mechanical conveyor (or the rotary airlock valve at the pneumatic conveyor’s inlet) at each ingredient source to load the ingredient into the batch vessel at the maximum feed rate. As each conveyor discharges an ingredient, the source’s load cells transmit weight-loss data to the controller. When the weight loss from a source approaches the target weight for that ingredient, the controller steps down the feed rate to dribble for greater accuracy. This system can be configured to allow all ingredients in the batch to be weighed and transported simultaneously to the batch vessel.

In both the gain-in-weight and loss-in-weight systems, preweighed minor ingredients can be manually added to the batch vessel. Be aware that preweighing this material before adding it can eliminate weight variations in preweighed packages of ingredients.
How the systems are applied

Each type of automated batching system is suited to different applications. A **gain-in-weight system** is generally more suitable for weighing a relatively large number of smaller-volume ingredients transported by relatively short mechanical or pneumatic conveyors from the ingredient source to the batch vessel. This is because:

- The entire system requires only one set of load cells.

- A gain-in-weight system can generally achieve higher system accuracy because the load cells used by the system's relatively light central batch vessel can weigh smaller amounts of ingredients than the load cells in a typical loss-in-weight system, which must support the weight of each ingredient and the equipment containing it.

- A gain-in-weight system with a weigh hopper above the process vessel saves time because it weighs and stages one batch while the previous batch is being processed, allowing the staged batch to be loaded into the process vessel as soon as the previous batch is discharged.

A **loss-in-weight system** is typically better suited to weighing a smaller number of larger-volume ingredients from nearby or distant sources. This is because:

- Mounting the bulk bag unloader or supply vessel for each ingredient on its own set of load cells increases the system's cost.

- The heavy-duty load cells capable of supporting large volumes of ingredient and equipment at the ingredient sources cannot weigh small amounts of ingredients in a batch with high accuracy.

- Because the loss-in-weight system weighs the amount of ingredient lost from the source, the system does not have to account for in-flight material, eliminating this potential source of batching inaccuracy.

What to consider when choosing a system for your batching application

Which automated batching system — gain in weight or loss in weight — is best for your application depends on a combination of factors. While the most basic are those discussed in the previous section, you also need to consider how and where your raw ingredients are received and stored, the batching rate you require, your plant's space limitations, and many other factors.

**Raw ingredient receiving and storage.** If your ingredients are delivered in railcars or bulk truck trailers and stored in

![Figure 2](image-url)

Typical automated loss-in-weight batching systems

- With mechanical conveyors
- With pneumatic conveyors
silos, a gain-in-weight system is more appropriate because mounting the silos on load cells for a loss-in-weight system would be impractical.

Which automated batching system — gain in weight or loss in weight — is best for your application depends on a combination of factors.

**Batching rate.** If you require the shortest possible batching cycles, a loss-in-weight system can fill your requirement. This is because the system’s load cells are located at the ingredient sources, allowing the system to weigh all ingredients in the batch simultaneously, rather than sequentially, as in a gain-in-weight system where only the batch vessel is on load cells.

**Space limitations.** If headroom in your batching area is limited, it may not be possible to fit a gain-in-weight hopper — and the conveyors feeding it — above your process vessel. In this case you can mount the process vessel directly on load cells, eliminating the need for a separate weigh hopper. Other options are to use low-profile feeding equipment, such as a low-profile flexible screw conveyor with its motor drive located at the conveyor’s inlet end rather than the discharge end, or to use a loss-in-weight system.

In this gain-in-weight batching system, a major ingredient discharged from bulk bags and a minor ingredient manually dumped from small bags are automatically transferred by flexible screw conveyors to a weigh hopper.
In-flight material. If you select a gain-in-weight system, the controller should be programmed to compensate for the in-flight material to avoid inaccurate batching.

The gain-in-weight system’s conveyor configuration has a significant effect on the amount of in-flight material. In a system with mechanical conveyors that discharge ingredients by gravity directly into a weigh hopper, the vertical distance between the conveyor discharges and the hopper will determine the amount of in-flight material and, accordingly, the weighing accuracy you can achieve. For example, if a conveyor discharge is positioned immediately above the weigh hopper, in-flight material will be minimal, allowing the controller to compensate with the greatest accuracy by stopping the conveyor by the appropriate amount of time before the target batch weight is gained.

In contrast, a gain-in-weight system that includes relatively long pneumatic conveyors between the ingredient sources and the weigh hopper has a significant amount of in-flight material. When the controller stops the rotary airlock valve at a conveyor’s inlet, the conveyor will be full of material that is already en route to the weigh hopper. Although trial-and-error tests can help you approximate how much sooner the valve should be stopped to compensate for in-flight material, large volumes of material resident in the conveyor or rotary valve can result in large variations in the weight of the in-flight material, resulting in greater batch inaccuracies.

In this case, a better choice may be to use a loss-in-weight system, which eliminates the in-flight material variable. In this system, the rotary airlock valve feeding the pneumatic conveyor stops as soon as the ingredient source has lost the preset target weight of that ingredient, and all the material in the conveyor is transported to the batch vessel.

Another option for overcoming gain-in-weight system inaccuracies with long pneumatic conveyors is to install a scale valve in the conveying line above the weigh hopper. The valve is a type of diverter valve that either allows material to pass through the valve body or directs the material downward to the weigh hopper below. When the ingredient’s target weight is reached, the valve redirects any remaining ingredient in the conveying line past the weigh hopper, eliminating or minimizing excessive in-flight material. Because the ingredient continuing downstream after the weigh hopper (called carryover) must be collected and the conveying air must be vented from the conveyor, the conveying line downstream from the weigh hopper typically is routed back toward the ingredient source into a filter receiver with a rotary airlock valve at its outlet; this valve reintroduces the carryover into the conveying line just downstream from the ingredient source.

Because reusing carryover this way requires a separate filter receiver for each ingredient, a scale valve is typically
suited to a gain-in-weight system handling only one or two ingredients with single or multiple destinations, especially when headroom is limited above the weigh hopper.

**Load cell protection.** One potential downside to a loss-in-weight system is that the load cells weighing the system’s ingredient sources are often at floor level, where they can be damaged by impacts from pallet jacks, forklifts, and other mobile equipment or require frequent recalibration because of such impacts, or both. One option for some applications is to install steel bumpers to protect the floor-level load cells, as shown in Figure 3. Another option is to choose a gain-in-weight system, which can eliminate the potential for impact damage to load cells because the load cells are typically mounted on a weigh hopper suspended above the floor.

**Checkweighing.** A gain-in-weight system with a weigh hopper to accumulate ingredients above the process vessel offers the option of checkweighing the batch before dis-

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**Figure 3**

Steel bumpers protecting loss-in-weight system's floor-level load cells
charging it into the process vessel. This allows the operator to adjust a batch that exceeds allowable weight tolerances before it is discharged to the downstream process. Conversely, check weighing is not possible with a gain-in-weight system in which the process vessel itself is mounted on load cells nor with a loss-in-weight system that discharges each ingredient directly into the batch vessel, precluding the possibility of correcting a batch weighing error.

Next month: Part II covers selecting conveyors for an automated batching system, integrating the system with your plant equipment and controls, and promoting flow of difficult materials in the system. Two automated batching system case histories are also included.

For further reading
Find more information on automated batching in articles listed under “Weighing and batching” in Powder and Bulk Engineering’s comprehensive article index at www.powdernote.com and in the December 2006 issue.

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