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Application Example

Grain and Ingredient Transfer for Brewery Applications

Introduction

Worldwide, breweries produce about two billion hectoliters of beer annually, according to Kirin Beer University. That same global beer market is expected to reach over 700 billion USD by 2023, according to First Research's latest July 2018 report. Growing popularity of premium beers, craft beers and new products with flavor innovations are all contributing to this increase in production. As a result, smaller and larger breweries alike are searching for ways to optimize production efficiency, while still maintaining and adhering to strict environmental, health and safety (EHS) guidelines for breweries. One approach is the automation of the raw ingredient delivery to both the grist mill and the brew kettles using pneumatic transfer and weighed dispensing. Both pneumatic transfer and batch weighing options as part of the conveying system design can significantly improve cleanability, while ensuring efficient and precise dispensing of the ingredients to the process below.

Application details

The complete brewing process typically begins with delivery of purchased malts – germinated grains that have been dried. The malt can be delivered to the brewery in a variety of methods including truck, bulk bags and even railcars. Malts are then typically stored and then transferred to a grist mill, forming "grist" product, as shown in Figure 1. This crushed grain is then transferred to a "mash tun", a specialized tank where a mash is created by adding water, heating and stirring. This process step converts the mixture into fermentable sugars. The mixture is then strained and rinsed to produce "wort", a liquid with high levels of these fermentable sugars. The spent grain from the tun can then be conveyed using the same vacuum pump directly to the spent grain bin or truck as shown in Figure 1, thus saving on further manual handling as well as equipment costs.

The wort then flows from the wort receiver into a brew kettle. At this time, hops as well as additional flavors and additives are added to the kettle. The resulting flavor of the wort depends on the hops, additives, temperature and length of the brewing. Flavor additives that can be added at this step include everything from orange peels to spices like coriander, ginger and cinnamon. The final steps include straining, cooling and storing.

The process outlined above which includes transfer of dry ingredients can be an extremely labor intensive when done manually. In addition, the open environments used for the transfer of these ingredients can also lead to risk of contamination of ingredients and eventually the end product. Inaccurate addition of high value additives such as spices, flavorings and other ingredients can add to overall ingredient costs as well as modify end product flavor.

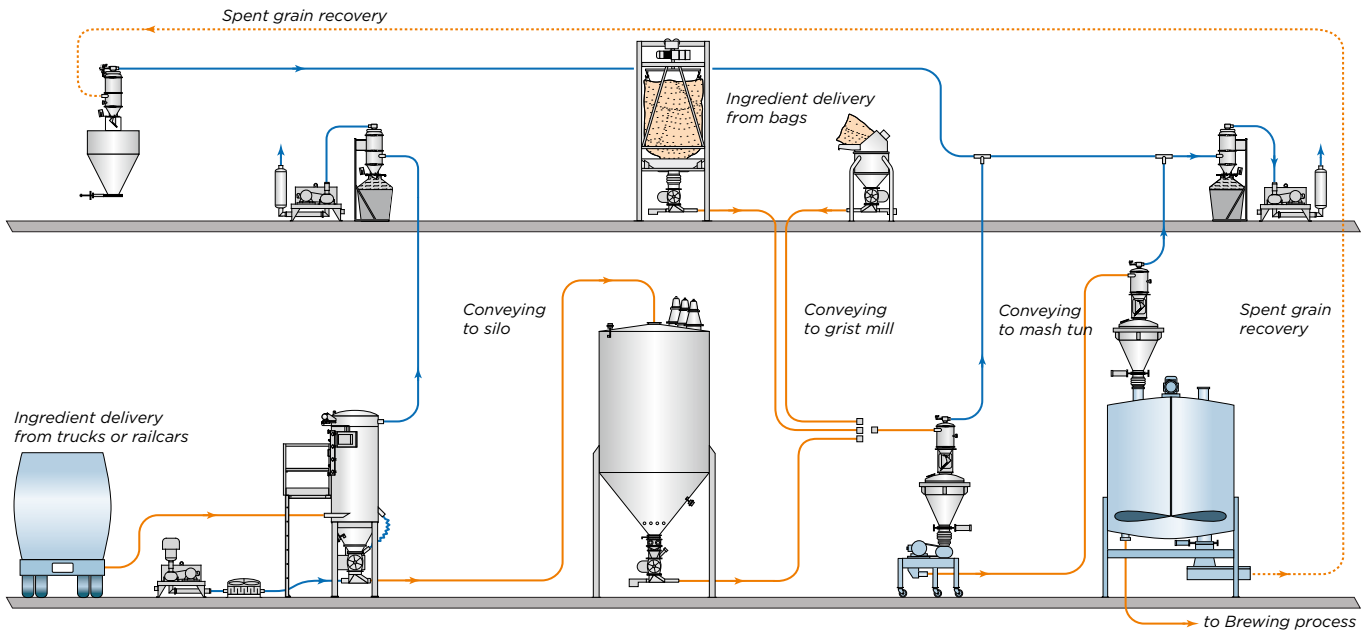

Figure 1: Brewery process flow, from raw ingredient delivery to mash tun

Grain and Ingredient Transfer for Brewery Applications

In order to optimize handling ergonomics, cost of ingredients, as well as ingredient safety and product quality, automated material handling processes including pneumatic transfer and automated weighing/dispensing, such as those supplied by Coperion and Coperion K-Tron are quickly becoming the process improvements of choice.

Malted barley transfer from truck to silo

The arrival and transfer of major ingredients such as malted barley, corn or rice to a brewery can include a number of different types of conveying systems. The mode of transfer of ingredients is dependent upon a wide variety of process parameters, including material characteristics, distance to be transferred, required rate of transfer, and the type of container in which the ingredient is originally received. Pneumatic conveying systems are used to transfer dry materials from one process to another via either positive (pressure) or negative (vacuum) modes. Typical systems include an air source, a material feed device, a convey line and some type of air/material separator, such as the Coperion K-Tron filter receiver shown in Photo 1. Pneumatic systems typically operate in a fully enclosed line, which greatly improves hygienic operation and also minimizes product loss.

Majors such as grains are often received by truck or railcar and then stored in silos prior to usage. Truck unloading can be done via positive or negative pressure. Pressure Differential (PD) trucks and railcars use positive pressure to unload material, whereas other types of delivery to the batching step of process can involve either positive pressure or negative pressure pneumatic conveying. Positive pressure conveying systems are typically used to transport product over long distances and at high throughputs. Applications which involve pressure conveying often include loading and unloading of large volume vessels such as silos, railcars, trucks, and bulk bags

PD transfer

In cases where PD truck unloading is possible, a flexible hose is connected from a pressure blower to the PD truck, upon arrival at the brewery, and another from the PD truck to the conveying line. The system operator selects the desired destination (for example, silo 1 for malted barley) on the truck unload control panel.

When the system is started, the blower pressurizes the PD truck and conveys material via positive pressure from the truck through the conveying line and directly into the silo. Many times, an inline magnet installed in the conveying line to remove any metal particles which may be present in the conveyed material. When the high level sensor in the silo is activated, the operator closes the material flow gate on the truck and allows the system to purge the conveying line before finally stopping the operation.

Pneumatic transfer – vacuum vs. pressure

Depending upon the volumes required, other possible sources of ingredient delivery include boxes, sacks, bulk bags or super sacks. In all of the ingredient transfer steps, pneumatic conveying systems can be used to transfer these ingredients. These systems can also utilize either positive or negative pressure dilute phase conveying.

Vacuum (negative pressure) systems, such as shown in Figure 1, are often used for lower volumes and shorter distances. One of the advantages of vacuum systems is the inward also suction created by the vacuum blower and reduction of any outward leakage of

Photo 1: Filter receiver

dust. This is one of the reasons why vacuum systems are often used in higher sanitary or dust containment applications. Another advantage of vacuum systems is the simple design for multiple pickup points. It should be noted, however, that the distances and throughputs possible with a vacuum system are limited due to the finite level of vacuum that can be generated. Often a combination of pressure and vacuum conveying designs are used for a system, as shown in Figure 1 with delivery to the mash tun, taking full advantage of the process and efficiencies of each technology.

Robust and safe rotary valves

In either of these types of conveying applications, Coperion K-Tron high efficiency rotary valves can be utilized (Photo 2). These rotary valves can be provided for blow through systems or for discharge valves at the bottom of silos or feed bins. These specialty valves include options for EHEDG and ATEX certification, and to ensure a robust and operationally safe brewery operation.

As an added benefit for brewery safety, the Coperion rotary valves can also be equipped with the innovative Rotorcheck design option (Photo 5), which detects any metal to metal contact in the valve, as a function of electrical resistance between the rotating vanes and housing. This system is ideal for detection of contaminant metal in the product as a result of wear and can be instrumental to ensure safe operation.

Photo 2: ZRD rotary valve

Photo 3: Scale hopper

Batching ingredients to brew kettles

In many brewery applications, additional ingredients such as flavors, additives and hops are added directly to the brew kettle, as shown in Figure 2. In order to accurately weigh and meter these ingredients they may be transferred to a batching station prior to the kettle. This station often includes a

metering device such as a rotary valve which delivers the product to a scale hopper on load cells. This method is called Gain-in-Weight (GIW) batching.

Batch weighing with scale hoppers

Scale hoppers are receiving hoppers suspended on load cells for ingredient batch weighing (see Photo 3 and Figure 2). The material enters the scale hopper until the precise weight and/or combination of materials is achieved. With the scale weighing system, weigh accuracies of +/- 0.5% of the full scale capacity can be expected. Once the desired weight has been achieved, the kettle then calls for material, the discharge valve is activated and the material in the scale hopper is discharged.

Photo 4: Bag dump station

Multi-destination majors batching

When major ingredient batching requires a single ingredient to be delivered to multiple stations or multiple ingredients delivered to a single destination, scale hoppers with specialty Aeropass™ valves mounted after the scale hopper can be used (see Figure 3). After the fluidized material is discharged from a source such as a silo or bulk bag, it will typically drop into a scale hopper, is weighed, and then conveyed. Once in the convey line, it is then transported to the Aeropass valve, located above the receiving vessel(s) or brew tanks.

Aeropass principle of operation

The Aeropass valve operates on a diverter type principle and is ideal for diverting material directly into a hopper from a conveying line. Due to the valve's low-clearance height, it is ideal when requiring inline diverters in tight spaces. As shown in the diagram, the valve includes an internal wafer type device which allows for the discharge of material into the hopper below when activated in the correct discharge position. After the weighed material is discharged into the first brew kettle, the Aeropass valve can be immediately switched to allow for the transfer of the material in the conveying line either to the next process, or back into the original source. This closed loop design results in a more efficient method of product transfer with higher product yields.

When designing a batching system, it is important to discuss all aspects of the design requirements, including the expected changeover and cleaning times, as these options can greatly affect the overall system cost, ingredient accuracy and total batching times.

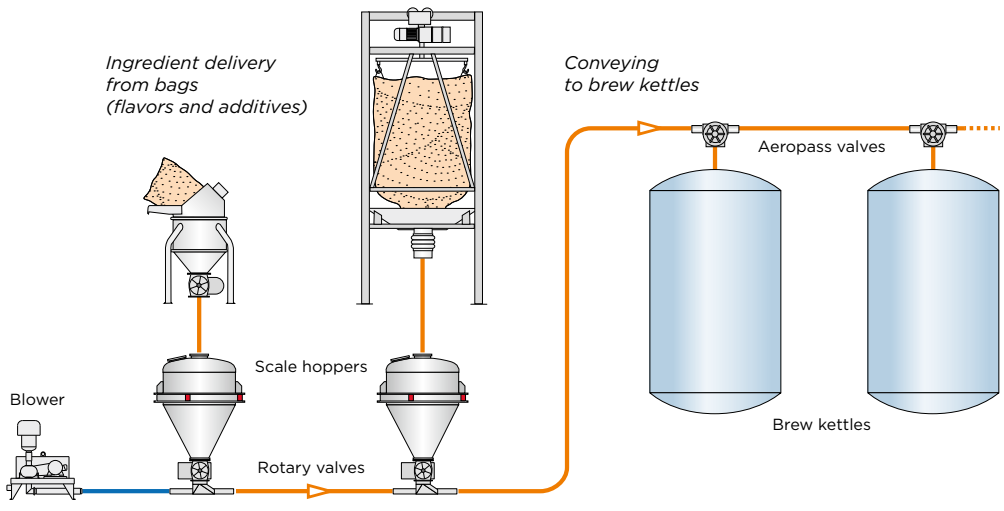

Figure 2: Batch weighing of ingredients and flavors to the brew kettles

Pneumatic or mechanical conveying

As an alternative to the pneumatic conveying options outlined above, mechanical conveying is sometimes also used. A mechanical conveying system uses a mechanical device (such as conveyor belt, flexible screw, bucket elevator) that is in direct contact with the conveyed material. Conversely the previously described pneumatic conveyors utilize gas (typically air) to transfer the suspended material through the convey line. A distinctive difference between the two modes is that pneumatic conveyors have almost no moving parts, resulting in less downtime for cleaning and maintenance than their mechanical counterparts.

Additional advantages of pneumatic conveying for brewery applications include the following:

- Less maintenance required
- Increased operator safety due to fewer moving parts
- Increased product safety due to enclosed convey line minimizing product contamination.
- Less product loss and dust leakage; this is especially true in vacuum systems where the material stays within the line due to the negative pressure

It should be noted however, that there are cases where both modes can be used in a system together. This may be the case, for example, when headroom

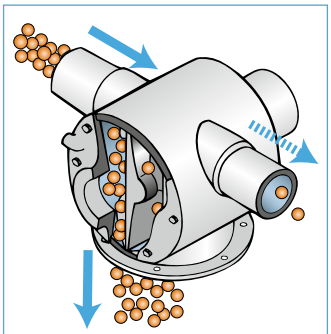

Figure 3: Aeropass valve

Grain and Ingredient Transfer for Brewery Applications

above the brew kettle or tank to transfer of ingredients is an issue. In this case, materials may be transferred for the bulk of the distance via pneumatic transfer, and then sent to a receiver or batch weigher above a mechanical screw. The screw then transfers the final ingredients direct to the kettle.

It is important when evaluating different modes of transfer that manufacturers work with system engineers such as those at Coperion K-Tron who are experienced in a variety of options, so that the most efficient operation be chosen for the brewery application.

Conclusion

Properly weighing and accurately delivering all the ingredients for the brewery process without manual intervention can result in a number of process advantages, including fewer mistakes, better accuracy, lower bulk costs, improved product quality and savings in manufacturing costs. In addition, using devices and systems which involve highly accurate weighing and metering of precious and expensive ingredients such as flavors and additives can result in lower overall ingredient costs. The highly experienced personnel of Coperion K-Tron can provide a wide variety of design and layout options in both ingredient transfer and delivery to help brewery manufacturers to not only lower process costs but also to improve efficiency and product quality.

Coperion advantage

- Complete systems design integration of the brewing process for one source supply.
- Global systems engineering group with extensive application experience for the entire dry material handling brewery processing line ensures optimal design with an emphasis on product safety, quick product changeover, and increased efficiency.
- Engineered solutions from both Coperion and Coperion K-Tron reflect extensive experience in hygienic and sanitary design standards, including CIP/COP, EHEDG, FSMA, GFSI, USDA, and 3A where applicable.
- All system receivers and components are designed with ease of maintenance and accessibility in mind.
- Coperion and Coperion K-Tron rotary and Aeropass valves are available in a variety of sizes and design options and meet CE and ATEX 3D classifications.
- Coperion K-Tron Weigh Scale Hoppers and Batch Weigh Receivers are designed to provide batch weigh accuracies of ± 0.5% of the full scale capacity.
- Integrated control systems featuring Coperion K-Tron SmartConnex and customized PLC control allow for a variety of programming options including ingredient control and recipe management.

Photo 5: ZRD rotary valve with RotorCheck

- Extensive material handling knowledge in a wide variety of ingredients by the engineers at Coperion and Coperion K-Tron ensures the most efficient means of product transfer.
- Superior global service network to ensure 24-7 support and coverage of your complete brewery processing line.

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