

Application Example

Flavor Blends, Encapsulated Flavors and Maillard Reaction of Flavors

Background

The use of flavors and aromas in food processing plays an important role in food consumption and consumer acceptance. Flavor stability and handling are important to the overall food quality; therefore it is critical that steps are taken to ensure this stability is not compromised through manufacturing or storage processes, packaging, or reactions with other ingredients.

Coperion K-Tron feeders and pneumatic conveying systems are used extensively in the food industry for the accurate and gentle handling of flavor blends to minimize aroma degradation. Coperion's food components fulfill the highest demands in hygiene, easy cleaning and gentle product handling. In addition, Coperion high efficiency ZSK MEGAvolume PLUS twin screw extruders are used to encapsulate volatile flavors and aromas. The encapsulated product can then be used to create food products with improved shelf life, easy product handling, and more controlled release properties. Encapsu-

lated flavors are used in instant beverages, teas, confectionery and bakery products.

A second field of operation for ZSK MEGAvolume PLUS extruders utilizes the Maillard reaction for flavor formation. The Maillard reaction is a chemical reaction between amino acids and reducing sugars which gives browned foods their desirable flavor. Savory flavors such as roasted onion, gravy base, roasted or cooked meat flavor can be created continuously in a very low moisture environment.

Ingredient Transfer

The 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.

Transfer to the Blending Operation

Major ingredients in flavor blends such as sugar, salt, etc. may arrive at the plant in a vari-

ety of forms, including railcar or truck and bulk bag systems. As shown in the process flow diagram, these major ingredients are usually stored in specialized silos and then conveyed to the specific weigh batch stations as required for the blend. In the case of moisture sensitive ingredients, the ingredients are conveyed with dehumidified air. PLC systems featuring recipe control for multiple ingredients can easily be integrated into this transfer system, in order to allow maximum flexibility for the system.

Dilute Phase Transfer: Pressure vs. Vacuum

Depending upon the volumes required, other possible sources of ingredient delivery include boxes, sacks, bulk bags or super sacks. Pneumatic conveying systems can be used to transfer these ingredients in all steps of the process, utilizing either positive or negative pressure dilute phase conveying. Positive pressure conveying systems are typically used to transport bulk materials over long distances

and at high throughputs. Applications which involve pressure conveying often include loading and unloading of large volume vessels such as silos, cyclones, railcars, trucks, and bulk bags.

Conversely, vacuum (negative pressure) systems are often used for lower volumes and shorter distances. One of the advantages of vacuum systems is the inward suction created by the vacuum blower and reduction of any outward leakage of dust. 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.

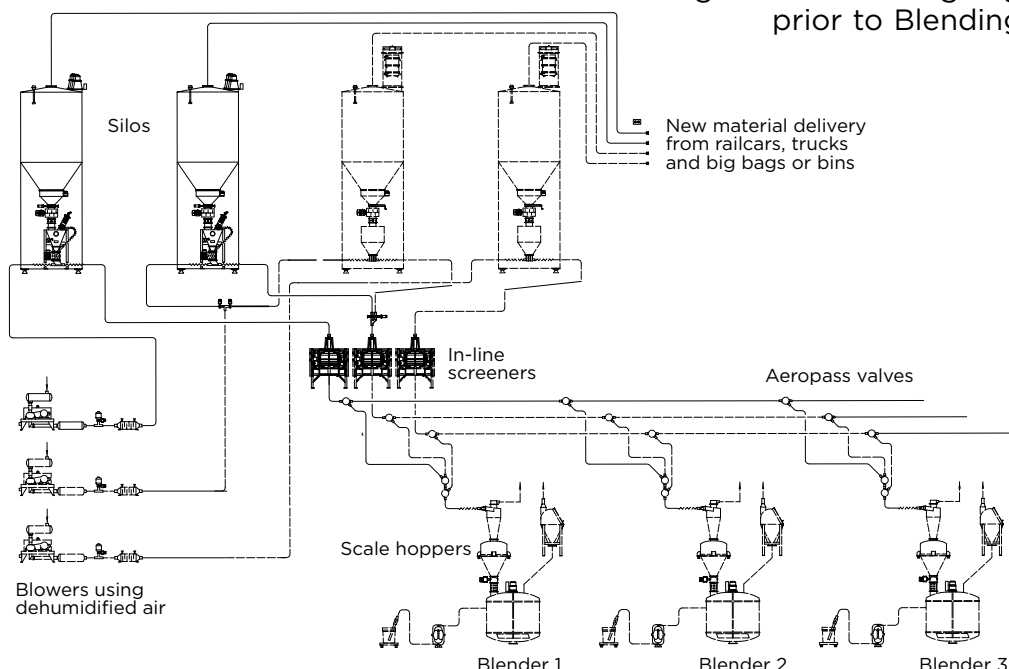
Screening and Sifting Operations

In-line screeners are often used during the raw ingredient transfer process for the removal of foreign materials prior to the introduction of the bulk material into the conveying line. Screeners can also be integrated directly into the conveying line for additional conditioning of the ingredient powder and at the end of the process for the proper scaling/sizing of the finished product prior to packaging.

Rotary Airlocks with Easy Clean Design

Coperion high efficiency and easy clean rotary airlocks are utilized in most types of conveying processes. These airlocks 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 certification and ATEX versions, as well as quick clean designs for both dry and wet cleaning to ensure quick turnaround times during product changeovers. In addition, the expanded inlet design

Material Handling and Batch Weighing prior to Blending



Flavor Blends, Encapsulated Flavors and Maillard Reaction of Flavors

ensures high capacities with minimal bridging. Operating pressures as high as 1.5 bar can be achieved, with low gas leakage rates for use in the pneumatic conveying systems outlined above.

As an added benefit for food safety, Coperion rotary valves can also be equipped with the innovative Rotorcheck design option, which can detect metal to metal contact between the rotating blades and valve housing, as a function of electrical resistance between the rotating vanes and housing.

Gain-in-Weight vs. Loss-in-Weight Batch

After transfer from the material source, the ingredients are usually delivered to the batching station. In the process example shown on page 1, this station is a hopper on load cells – or a scale hopper. This method is called Gain-in-Weight (GIW) batching. Alternatively, the station can include gravimetric feeding devices, such as screw or vibratory feeders, mounted on load cells or scales, which deliver the product to the process by means of Loss-in-Weight (LIW) feeding. As outlined below, in cases where small amounts of micro ingredients are required for a total overall batch, both methods can be combined: LIW feeders for the micros and minors, and GIW batchers for the major ingredients.

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 above each scale hopper can be used. After the fluidized material is discharged from a source such as a silo or bulk bag, it will typically drop through a rotary valve, through a sifter (if required), and is then metered into the conveying line by another rotary valve. Once in the convey line, it is then transported to the Aeropass valve located above a scale hopper.

Batch Weighing with Scale Hoppers

Scale hoppers are receiving hoppers suspended on load cells for ingredient batch weighing. The material resides in the scale hopper until the precise weight and/or combination of materials is achieved. With the scale weighing system, weigh accuracies of $\pm 0.5\%$ of the full scale capacity can be expected. Once the desired weight has been achieved, and the mixer calls for material, a discharge valve opens and the material in the scale hopper is emptied. When designing for a batching system, it is important to discuss all aspects of the



Coperion ZRD quick clean rotary valve with FXS extraction device

design requirements, including the expected changeover and cleaning times, as these options can greatly affect the overall system cost.

Addition of Micro Ingredient Flavors

LIW batching is used when the accuracy of individual ingredient weights in the completed batch is critical, such as with micro ingredient addition of high value additives or flavors or when the batch cycle times need to be very short. Gravimetric feeders operating in batch mode simultaneously feed multiple ingredients into a collection hopper. Adjustment of the delivery speed (on/off, fast/slow) lies with the LIW feeder controls and the smaller weighing systems deliver highly accurate batches for each ingredient.

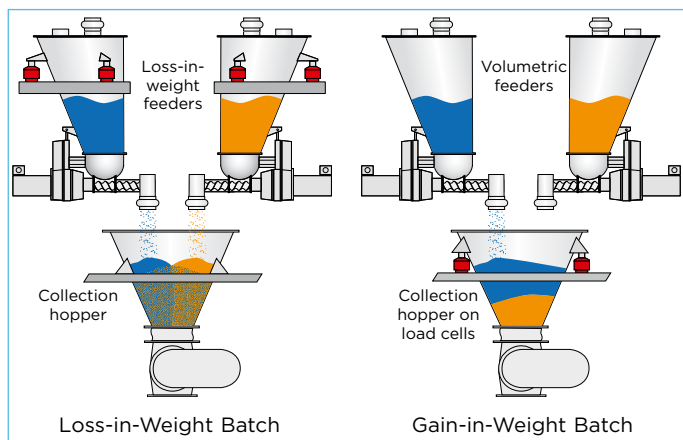
In the LIW batcher operation, the actual amount of product which leaves the feeder is determined by measuring the difference in weight (loss-in-weight feeding). As with GIW batching, the first 90% of the batch weight (as determined by the pre-programmed recipe) is fed at a fast rate by the feed screws. The last 10% is fed in a slower “dribble” mode to ensure an accurate batch weight, reaching accuracies of $\pm 0.1\%$ of the desired setpoint. The Coperion K-Tron Control Module (KCM) uses the LIW Batcher



P100 Conveying and Scale Hopper

control software to regulate the delivery speed and also offers the possibility to quickly change batch setpoints based on the packaging requirements for each product.

In the case of micro ingredient addition, LIW batching is used because the accuracy of individual ingredient weights in the completed batch is critical and the percentage of the aroma/flavor to the overall size of the final batch is very small. For example, a weighing system sized for the weight of a complete FIBC or bulk bag would not be able to detect the much smaller amount of added aroma/flavor. Therefore



the use of a smaller LIW feeder to accurately weigh and deliver this small amount is more appropriate.

Feeding of Powders and Liquids into the Extruder

Feeding and proportioning of the individual ingredients to the extrusion encapsulation process are crucial to the product quality and process efficiency. At any stage of the production process undetected feed rate and proportioning errors waste ingredients and add to overall ingredient costs, while at the same time compromising the overall quality of the encapsulated product.

Food processors are increasingly using highly accurate Coperion K-Tron gravimetric feeders to improve process efficiency and product quality.

Loss-in-Weight Feeding Principle

Coperion K-Tron screw feeders can be supplied in either volumetric or gravimetric designs. However, due to the high accuracy requirements of feeding in continuous extrusion or blending processes, the gravimetric feeding principle via loss-in-weight feeding is mandatory. For example, when feeding

materials with high variations in bulk density, volumetric feeders can have relatively high fluctuations in feed rate due to fluctuations in the filling of the screws. This fluctuation in feed rate results in inconsistencies in material delivery to the extruder below, thus resulting in variations in end product quality. In the case of cohesive materials, it is possible in volumetric mode to have relatively no material discharging while the screws are running, due to packing in the hopper. Since the feed rate in a volumetric feeder is purely a function of screw speed, the feeder – and the process below – has no way of detecting this error. Often even the use of level sensors in the feed hopper may not alert the process of this upset in a timely fashion, and off-spec product may result for a period of time.

Coperion K-Tron's gravimetric feeders utilize load cells with state-of-the-art SFT technology to constantly measure the weight of product delivered to the process below. In operation, the entire feeder, hopper, and material are continuously weighed, and the feeder's discharge rate (which is the rate at which the feeding system is losing weight) is precisely controlled to match the desired feed rate. With this technology, a constant mass flow is ensured, thus also ensuring for consis-

tent product output from the extruder.

LIW Feeder Refill

The mode of refill of product to a LIW feeder that is feeding a continuous process (e.g. blending or extrusion) can be almost as critical as the feeder technology itself. Since the objective of feeder refill is to refill as quickly as possible, pneumatic receivers which operate under a dilute phase vacuum transfer principle are often used as refill devices.

The pneumatic system utilizes vacuum to draw the material required to refill into a separately mounted and supported vacuum receiver. The receiver is filled to a set level and then holds this material charge until the feeder below requests a refill. The level of fill in the receiver is determined by level sensors. Upon refill request from the feeder below, the discharge valve opens and the receiver contents are discharged into the feeder hopper. While the receiver is discharging a gas pulse is sent through the filter mounted inside the vacuum receiver, in order to release any entrained particulate or material which may have settled on the filter.

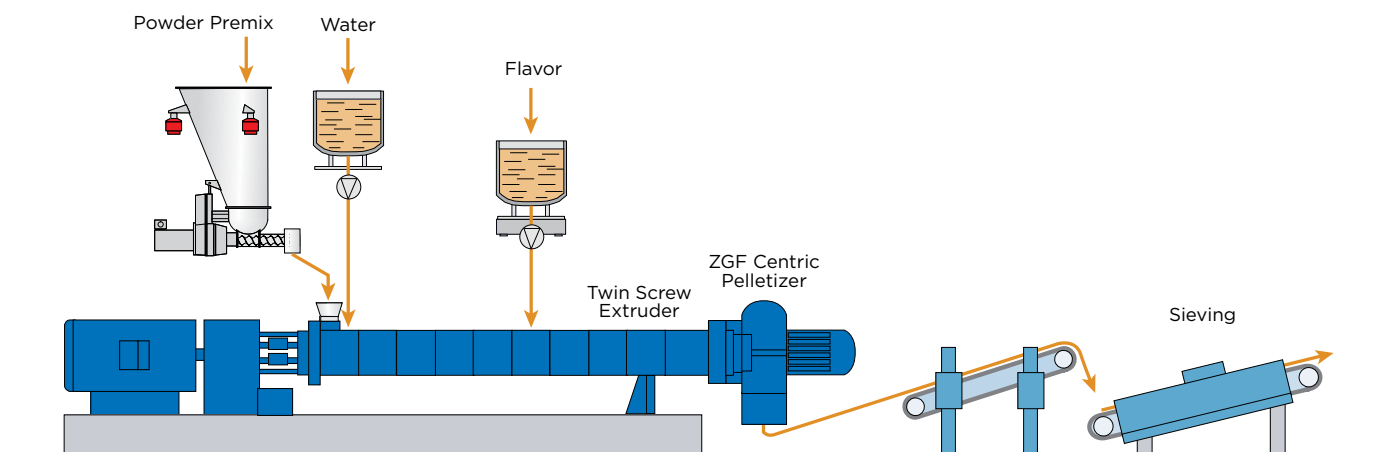
After dumping the material into the feeder hopper below, the discharge valve is closed and then the fill cycle immediately

begins, in order for the receiver to be ready for the next refill request. The material source can be bags, drums, IBC's, supersacks, bins or silos.

This series of sequenced "fill and discharge" steps is also known as vacuum sequencing. In all cases it is critical that the overall sequencing of the material pickup and delivery process be coordinated, so as not to interfere at all with the accurate delivery of the LIW feeder to the end process.

Addition of Liquids to the Extruder

As shown in the process flow diagram below, in addition to the solid ingredient being fed via dry bulk LIW feeding, additional liquid ingredients may also be introduced using a Coperion K-Tron liquid LIW feeder. The liquid LIW feeder uses the same principles outlined above, utilizing a tank mounted on a weigh bridge. Instead of sending a signal to the screw motor to maintain consistent mass flow, the signal is sent to the pump motor, in order to adjust the pump motor speed. This method of liquid feeding has shown to be especially effective in the replacement of traditional flow meters, when highly accurate addition of high value liquids is required, such as flavors and aromas.



Flavor Blends, Encapsulated Flavors and Maillard Reaction of Flavors



Twin Screw Extrusion for Microencapsulation

Coperion has extensive knowledge and experience in the development of extrusion systems for the microencapsulation of aromas and flavors. First, a matrix premix of maltodextrins and sugar-like substances is fed into the inlet of the extruder. This is specially demanding as the powder usually has a low bulk density and can include very small particles, down to 5µm. In the beginning of the extrusion process, a high viscous melt mass of maltodextrin and sugar substances is created, and then flavor oils are incorporated and homogeneously dispersed therein. It is possible to achieve a maximum flavor payload of more than 10%, depending on the specific recipe. At the end of the extruder the ZGF centric pelletizer for food applications – with its special die plate – forms and cuts very fine granules (diameters as low as 0.6 mm). The extruder handles the sensitive flavors very gently and at the same time ensures good homogeneous dispersion of the flavors and safely embeds them within the matrix.

Coperion can offer lines for microencapsulation of flavors for throughputs from 5 kg/hr to 300 kg/hr.

Advantages:

- Small footprint of extrusion line compared to spray drying
- Ability to process in highly viscous state with very little to no water addition, no subsequent drying needed
 - Resultant energy savings due to extrusion process
- Microencapsulation by extrusion is the only encapsulation

process that produces 100% enclosed droplets within the matrix

- Shelf life extension for sensitive flavors, especially for citrus flavors

Twin Screw Extruders for Maillard Reaction of Flavors

For reactive flavor extrusion, reducing sugars are fed into the extruder along with proteins, protein hydrolysates, amino acids and/or nucleotides. Applying mixing and high shear forces, the mass is first plasticized. The Maillard reaction takes place in a continuous manner in a very low moisture environment under very specific reaction conditions. Process and reaction control have to be very precise to ensure good flavor quality and the right degree of Maillard reaction.

Depending on the type of reaction flavor, the product exits the extruder either as a lump going to chill rolls, or via special dies.

Coperion's ZSK MEGA volume PLUS extruders are custom engineered for each specific application. The barrels as well as the screws are designed as a modular system which offers the possibility to set up a configuration which meets all process requirements. All materials of construction which are in direct contact with the product conform to food standards and are resistant to abrasion and corrosion.

Advantages:

- Continuous process with consistent quality
- Quick process in comparison to batch processes (1 minute versus 10 hours and more)

- Process in very low moisture conditions, no drying necessary (compared to batch >90% water)
- Energy-efficient and energy saving process
- Quick recipe changes possible, several recipes possible with one machine
- Small footprint of extrusion line compared to batch and spray dry equipment

Options in Cleaning and Construction

Depending on the ingredients to be conveyed, batched and processed, a variety of design executions can be provided for the equipment to reduce the overall cleaning or changeover steps. Stainless steel is generally used for the product contact surfaces, but sometimes carbon steel coated with FDA approved epoxies can also be used for large volume scale hoppers or silos in order to reduce overall equipment costs. Conveying receivers can be designed with retractable spray balls for wash-in-place cleaning to ensure quick changeover and minimal contamination between material runs. In the case of dry cleaning, design features such as feeders on tracks/rails or an easy access manway can easily be built into the overall feeding and conveying lines to make the process easy to take apart for inspection and to ensure that the system has been completely emptied.

Coperion Advantage

- Complete systems design integration of the manufacturing process for one source supply.

- Global systems engineering group with extensive application experience for the entire processing line ensures optimal design with an emphasis on product safety, quick product changeover, and increased efficiency.
- Use of Coperion's high efficiency ZSK MEGA volume PLUS extruders ensures maximum throughput.
- Innovative, custom engineered Coperion rotary and diverter valves ensure reliable, long-term and safe operation.
- The Coperion K-Tron line of feeders provides for the highest degree of accuracy in ingredient and product delivery in order to optimize ingredient cost savings.
- Highly accurate extruders, feeders and pneumatic conveying components designed to meet highest hygienic requirements.
- 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.
- 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 processing line.

Headquarters

Coperion GmbH | Theodorstrasse 10 | 70469 Stuttgart, Germany
info@coperion.com | www.coperion.com | fhn.coperion.com

