coperion
confidence through partnership

coperion k-TRON

BEST COMPONENTS
BETTER SYSTEMS

THE RECIPE FOR PERFECT FOOD

Application Example

Extruded Snack Food Manufacture

Background

Thanks to a general rise in household disposable incomes worldwide, the snack food industry is expecting a steady growth in production. This growth trend, coupled with a rise in consumer interest for safe foods and healthy snacks, has required snack food manufacturers to pay increased attention to the monitoring of raw ingredients in the extruded snack process while also designing more efficient and safe methods of material handling and precise ingredient measurement. Coperion K-Tron pneumatic transfer systems and feeders are used throughout the extruded snack process to accurately and safely deliver the exact amount of major, minor and micro ingredients to the process. Coperion's food components fulfill the highest demands in hygiene, easy cleaning and gentle product handling. In addition, high efficiency Coperion extruders are used for both the production of extruded and coextruded snack products.

Major and Minor Ingredient Transfer

As shown in the graphic below, major ingredients such as grains and flour can arrive at the plant in a variety of forms, including railcar or truck and bulk bag systems. These major ingredients are usually stored in specialized silos and then conveyed to the specific weigh batch stations as required for the blend. 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.

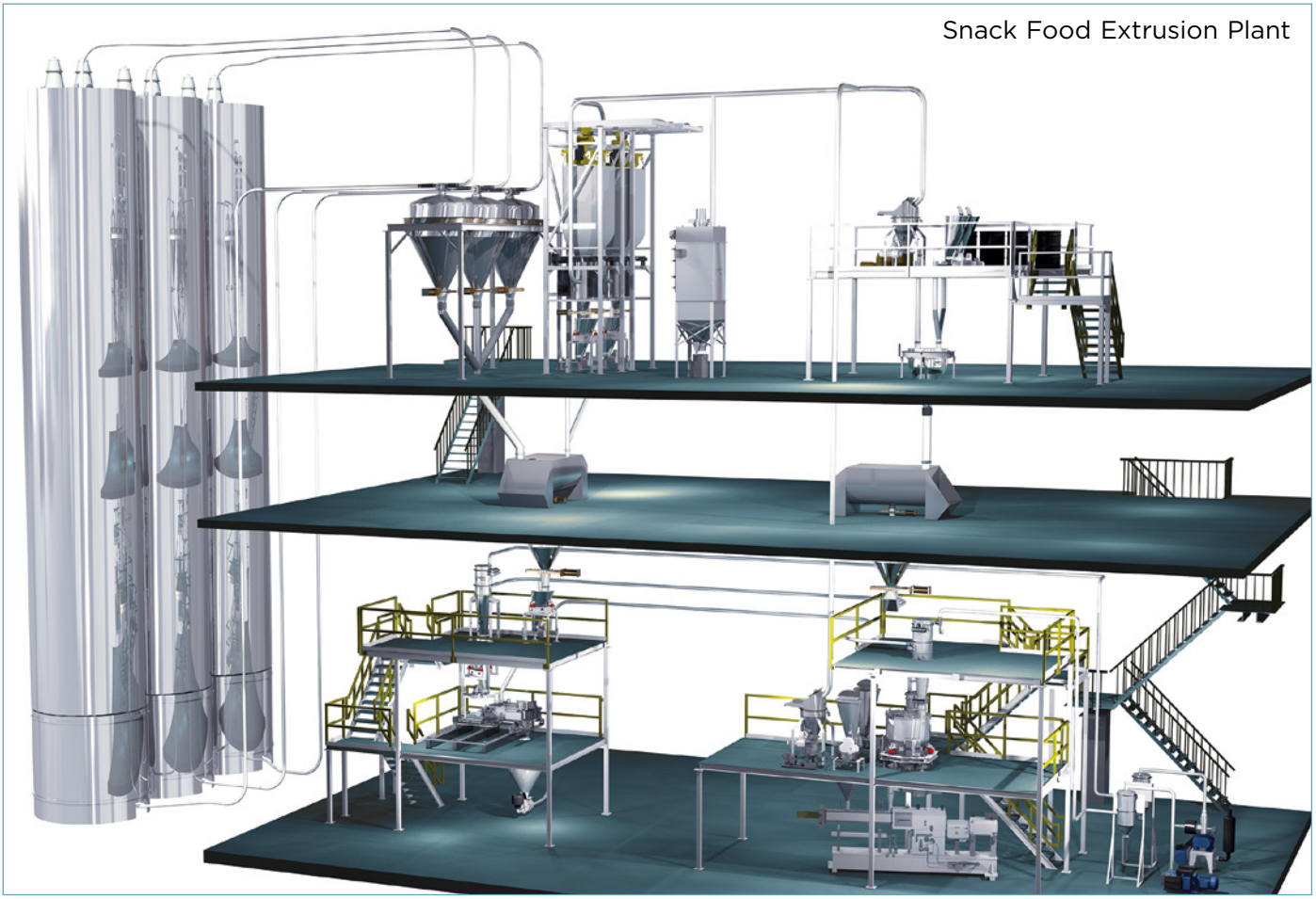
Selecting the Right Conveying Technology

The arrival and transfer of major ingredients to a snack food plant 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.

Pressure Differential (PD) trucks and railcars use positive pressure to unload material, whereas other types of delivery to the batching step of process can often be done by either positive pressure or vacuum pneumatic conveying, or a combination of vacuum and pressure conveying.

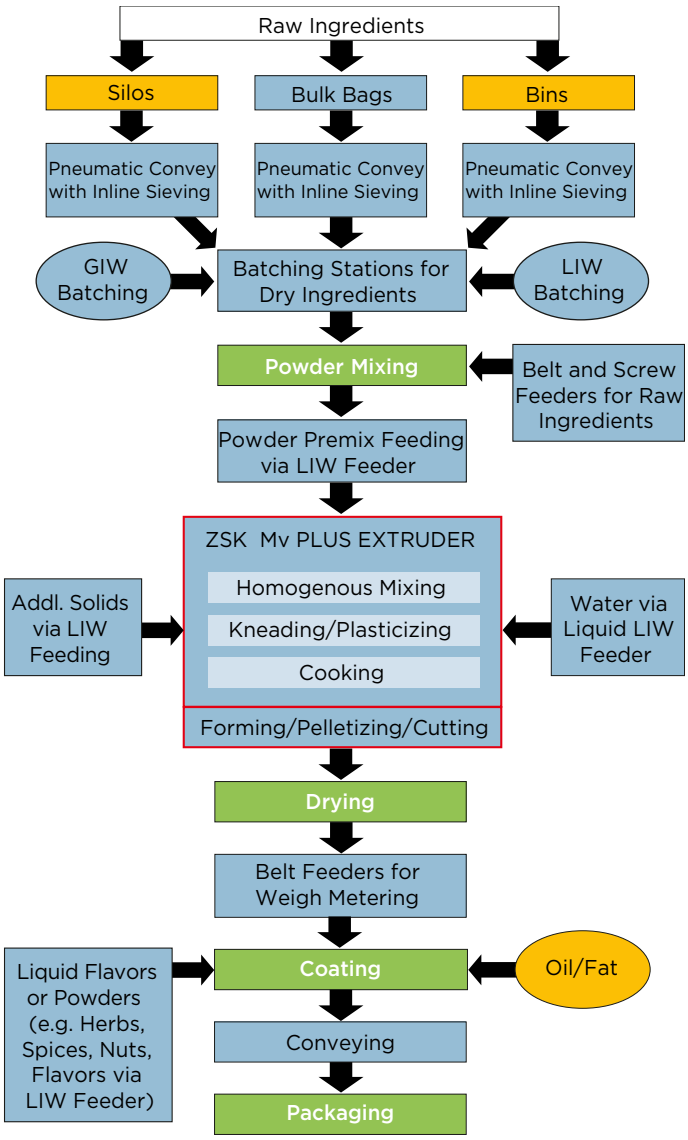
Dilute Pneumatic Transfer – Pressure vs. Vacuum

Depending upon the volumes required, other possible sources of ingredient delivery include boxes, sacks, bulk bags or super sacks. Pneumatic conveying

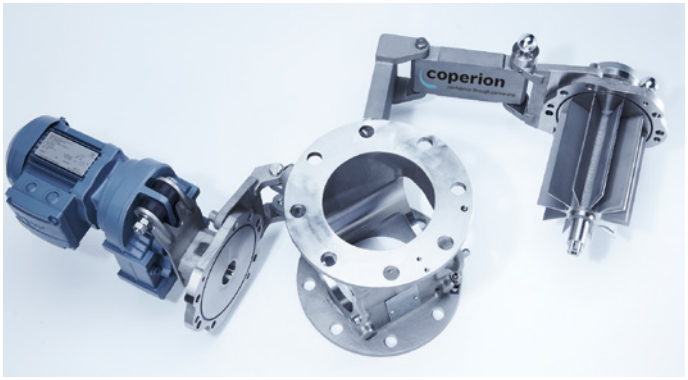


Snack Food Extrusion Plant

Extruded Snack Food Manufacture



Process Flow: equipment for all process steps in blue are manufactured by Coperion & Coperion K-Tron. Equipment for all process steps green/yellow can be supplied as part of a complete system.

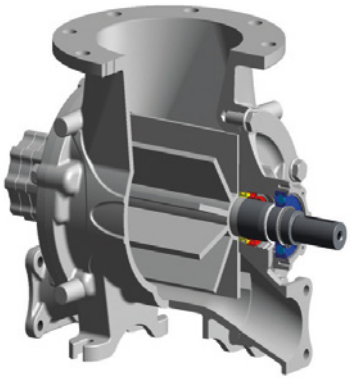


Coperion ZRD rotary valve with FXS extraction device

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. This is one of the reasons why vacuum systems are often used in 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.

(Note: For more details on pneumatic conveying systems for snack food ingredient transfer see Application Sheet A-800310)



Cutaway of rotary airlock

Screening and Sifting Operations

In-line or off-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. This sifting method is also often used at the end of the process for the proper scaling/sizing of the finished product prior to packaging. Sifters and screeners are an integral part of the overall material handling system for reliable product quality and safety, and are easily integrated into the overall system design by Coperion and Coperion K-Tron system engineers.

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 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.

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. This station can include volumetric metering devices, such as screw feeders or valves, which deliver the product to a hopper on load cells. 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.

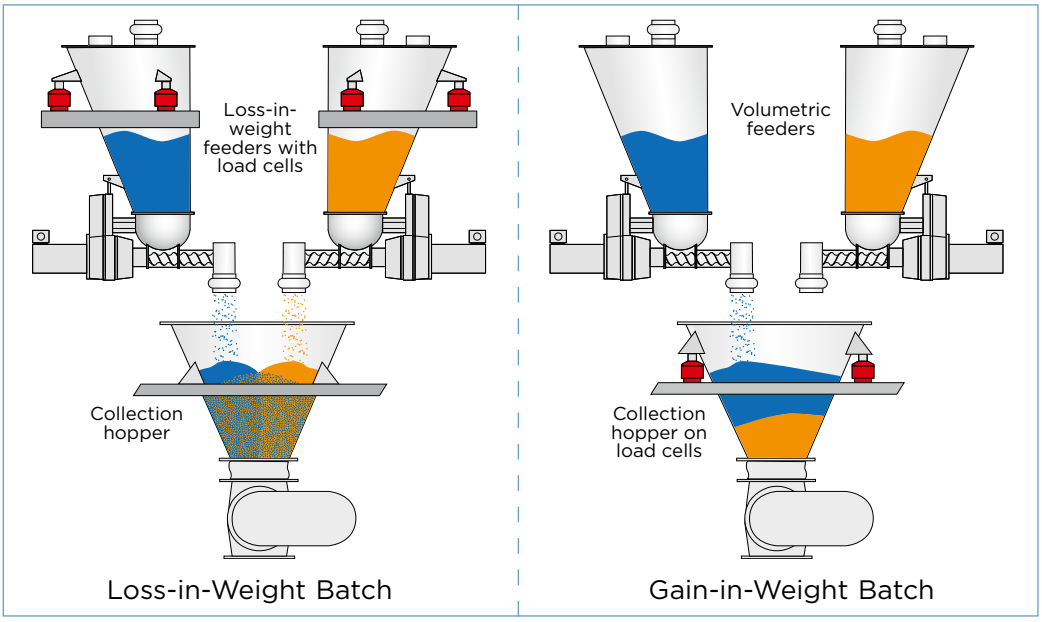
As outlined below, in some cases where small amounts of micro ingredients are required for a total overall batch, both methods can be combined: LIW feeders for the micros and minors, and GIW batchers for the major ingredients.

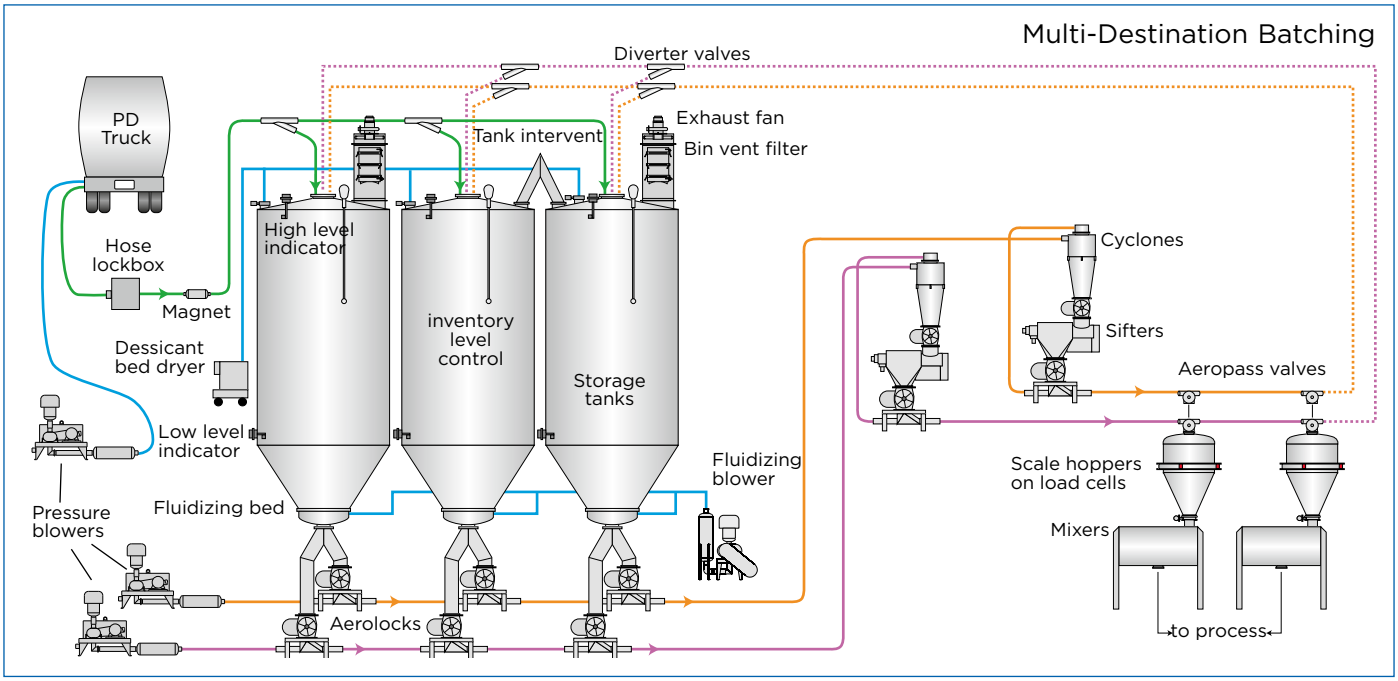
Gain-in-Weight Batching Principle

In GIW batching volumetric metering devices sequentially feed multiple ingredients into a collection hopper mounted on load cells. Each feeder delivers approximately 90% of the ingredient weight at high speed, slowing down towards the end of the cycle to deliver the last 10% at a reduced rate to ensure higher accuracy. The GIW controller monitors the weight of each ingredient and signals each volumetric feeder to start, increase or reduce speed, or stop accordingly. Once all the ingredients have been delivered, the batch is complete and the mixture is discharged into the process below. It should be noted that this type of batching method is sequential for each ingredient, and therefore generally results in a longer overall batching time than with LIW batching (outlined below) if the number of ingredients is high.

Loss-in-Weight Batching Principle

LIW batching is used when the accuracy of individual ingredient weights in the completed batch is critical or when the batch cycle times need to be very short. Gravimetric feeders operating in batch mode





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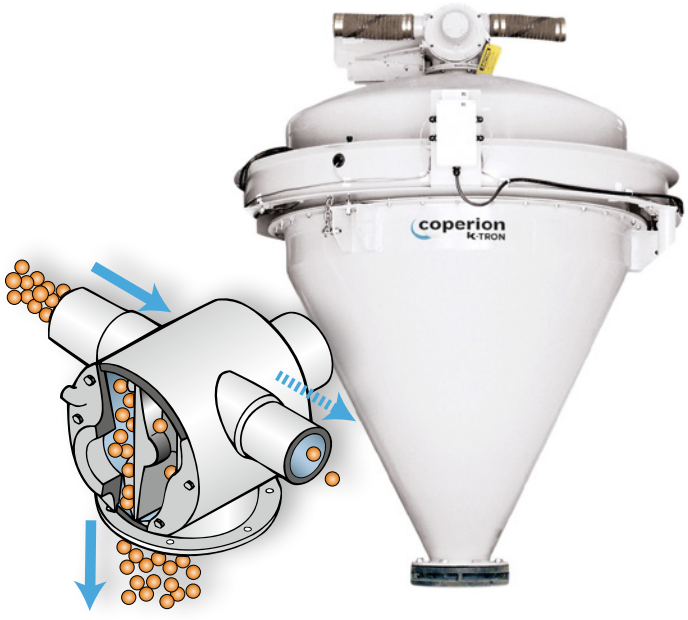
simultaneously feed multiple ingredients into a collection hopper. Adjustment of the delivery speed (on/off, fast/slow) lies with the LIW feeder controls and the smaller weighing systems deliver highly accurate batches for each ingredient. Once all the ingredients have been delivered, the batch is complete and the mixture is delivered to the process below. Since all ingredients are being delivered at the same time, the overall batch time as well as further processing times downstream are greatly reduced. This method of batching is often used for micros (such as vitamins and probiotics) due to the highly accurate requirement of their weight in the mix as well as their ingredient cost. In some cases the LIW feeder for the probiotic material can even be located within a protected enclosure or glove box, in order to ensure no contamination from the environment and a completely contained delivery of the ingredient to the process below.

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 material is discharged from a source such as a silo or bulk bag, it will typically be metered through a rotary valve, through a sifter (if required), and is then fed 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. *(See diagram on page 3)*

Aeropass™ Valve 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 figure below, 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. When the scale hopper below indicates the batch is complete based on the weight signal, the Aeropass valve can be immediately shut. This allows for the transfer of the excess material in the conveying line either to the next process or scale hopper, or back into the original source. This closed loop design results in a more efficient method of product transfer with higher product yields.



Scale hoppers are often used with Aeropass valves

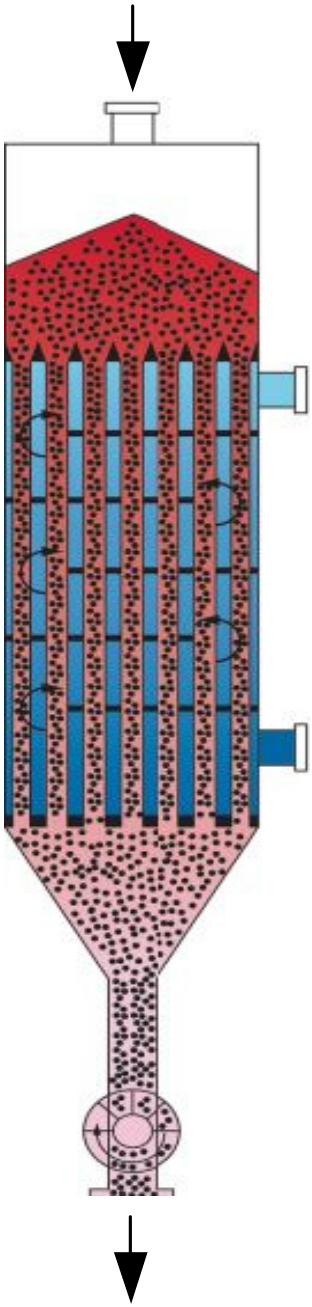
Batch Weighing with Scale Hoppers

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 ± 0.5% of the full scale capacity can be expected. Once the desired weight has been achieved, the mixer then 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 design requirements, including the expected changeover and cleaning times, as these options can greatly affect the overall system cost.

Pretreating Ingredients

In snack food applications when preheating of the bulk ingredients (e.g. cornmeal, flours, etc.) prior to extrusion can help shorten the overall extrusion process time, the Coperion Bulk-X-Change™ heat exchanger is ideal. This vertically oriented and tubular heat exchanger is designed for the cooling or heating of the product in line.



Bulk-X-Change heat exchanger

The principle of operation is based upon the vertical mass flow of product through the inner tubes, with the cooling or heating medium on the shell side of the exchanger. The patented product distribution plate above the tube bundle guarantees clean and even discharge without product residuals. Each

Feeder refill via vacuum receiver

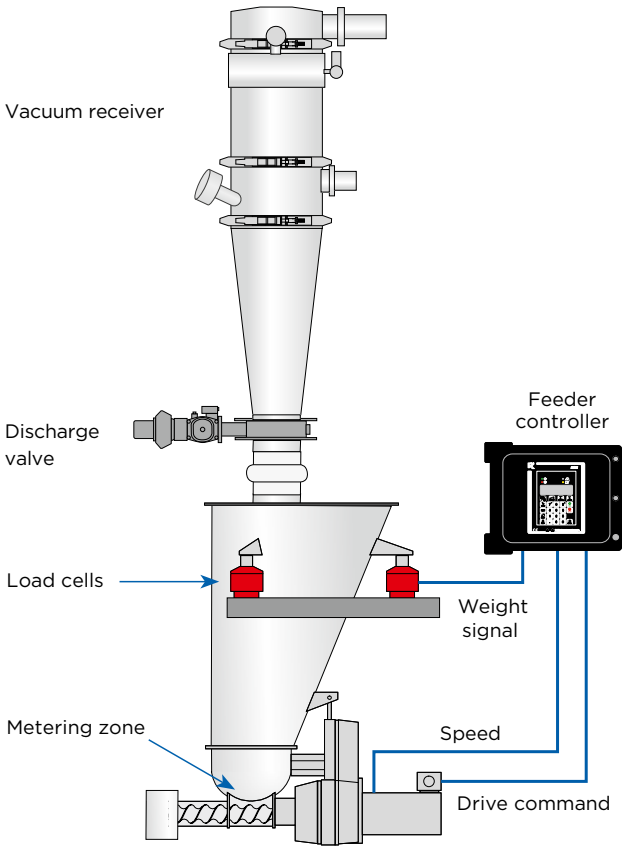
tube has a funnel shaped inlet and the tubes are arranged in such a way that there are no horizontal areas which can encourage product deposits, thus ensuring product flow regularly and evenly within the tubes.

Several options of inline orientation can be provided, including integration into a pneumatic conveying line. High efficiency Coperion rotary valves are used to ensure the consistent flow of product into the process stream, either by gravity to a LIW feeder system before the extrusion step or into a pneumatic conveying line.

Feeding of Pre-blends and Additional Ingredients into the Extruder

Feeding and proportioning of the preblends or the individual ingredients to the extrusion process are crucial to the product quality and process efficiency. At any stage of the production process undetected feed rates and proportioning errors waste ingredients and add to overall ingredient costs. In addition, the ability to accurately measure and track ingredients such as salt is of utmost importance when listing ingredients on product labelling. Today, more and more snack food processors are using highly accurate Coperion K-Tron gravimetric feeders to improve process efficiency and product quality.

In addition, the integration of LIW feeders to accurately deliver the bulk conditioned product after exiting the Bulk-X-Change heat exchanger ensures that the material temperature is maintained, thus optimizing the overall extrusion process.



Loss-in-Weight Feeder with Refill

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 mixing process below, have 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 patented SFT technology to constantly measure the weight of product delivered to the process below. Loss-in-weight feeding affords broad material handling capability and thus excels in feeding a wide range of materials from low to high rates. 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 consistent 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

Extruded Snack Food Manufacture

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 any form of storage such as 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.

Extrusion of Direct Expanded Snacks

Twin screw extrusion is well known to be a suitable High Temperature Short Time (HTST) process for direct expanded snack products. Coperion's ZSK MEGAvolume PLUS twin screw extruders are custom engineered. The barrels and screws are designed as a modular system which offers the possibility to set up a custom configuration tailored to the 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. The extruders come in different sizes and feature throughput ranges from a few kilograms up to several tons of final product. Their geometrical similarity allows for easy scaling between extruder sizes. This is especially beneficial when developing products on a smaller extruder.

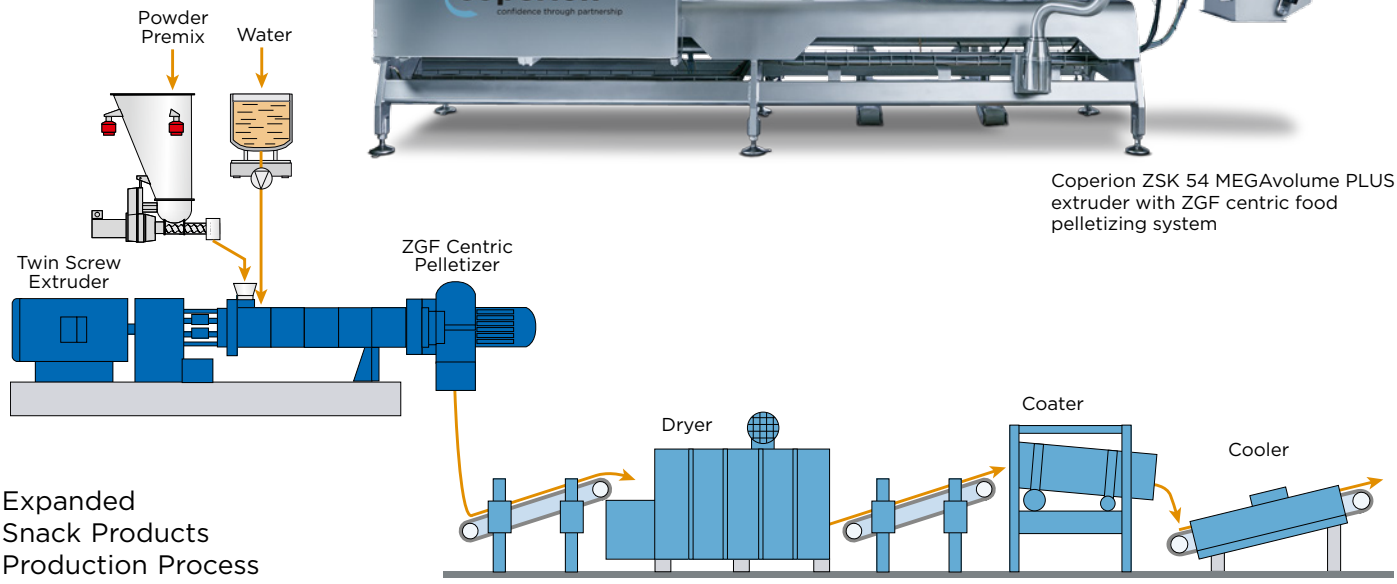
For processing direct expanded snacks the typical process steps are described below. First the premix of solid ingredients (mainly based on starch and protein and consisting mainly of flours and grits) is fed via Coperion K-Tron LIW feeders into a hopper fixed above an open barrel of the ZSK extruder.

Usually these raw materials have a bulk density between 0.5 to 0.8 kg/dm³. Coperion's twin screw extruder series ZSK MEGAvolume PLUS with D_o/D_i (outer to inner diameter) of 1.8 is the twin screw extruder with the highest free volume on the market. This extruder offers a large amount of free volume and provides for best powder intake. This enables our customers to run higher throughputs than on other machines with similar screw diameters.

After the premix is fed into the process section of the ZSK extruder one or more liquids are injected, especially water. The liquid is required for starch gelatinization and protein denaturation. When the plasticized product mass exits the nozzle, the pressure drops and some of the water evaporates, which is essential to product expansion.

The performance of the extruder strongly depends on the feed rate of both the solid and the liquid raw materials. The extruder is generally referred to as the "slave" of its feeders. It depends on consistently reliable feeding equipment to supply a

Coperion ZSK 54 MEGAvolume PLUS extruder with ZGF centric food pelletizing system



Expanded Snack Products Production Process

constant flow of material. Gravimetric loss-in-weight feeders are state-of-the-art and are in most cases the best choice for a continuous extrusion process.

After all ingredients have been fed into the extruder, they must be mixed homogeneously. Usually, this can be done by one or more mixing zones which consist of combinations of different types of kneading blocks. Depending on the raw materials, special mixing elements might also contribute to a satisfactory result. During mixing the product is also sheared, which leads to mechanical energy input and the increase of product temperature.

Coperion K-Tron LIW feeders delivering seasonings in coating process

Next the mixture is plasticized within a shear-intensive cooking zone. At this point the starch contained in the mixture gelatinizes and proteins get denaturized. This step can also be described as "shear-assisted melting" which is defined by process parameters as well as the recipe of the product. Within this zone, combinations of elements are used which cause high mechanical energy input. Pressure, shear forces and temperature increase lead to a plasticized starch matrix.

After a total residence time of a few seconds up to one minute the material is pushed through the orifices of the die plate. Due to the immediate decrease in pressure the water within the plasticized mass evaporates and forms bubbles. The product strands expand and the resulting steam dries the surfaces.

Now the strands can be cut by using the Coperion centric food pelletizing system ZGF. The size of the extrudate can be adjusted through the selection of the number of knives and the rotational speed. Usually the product is pneumatically conveyed to the next processing step (e.g. drying).

Coating of the Dried Snack Food

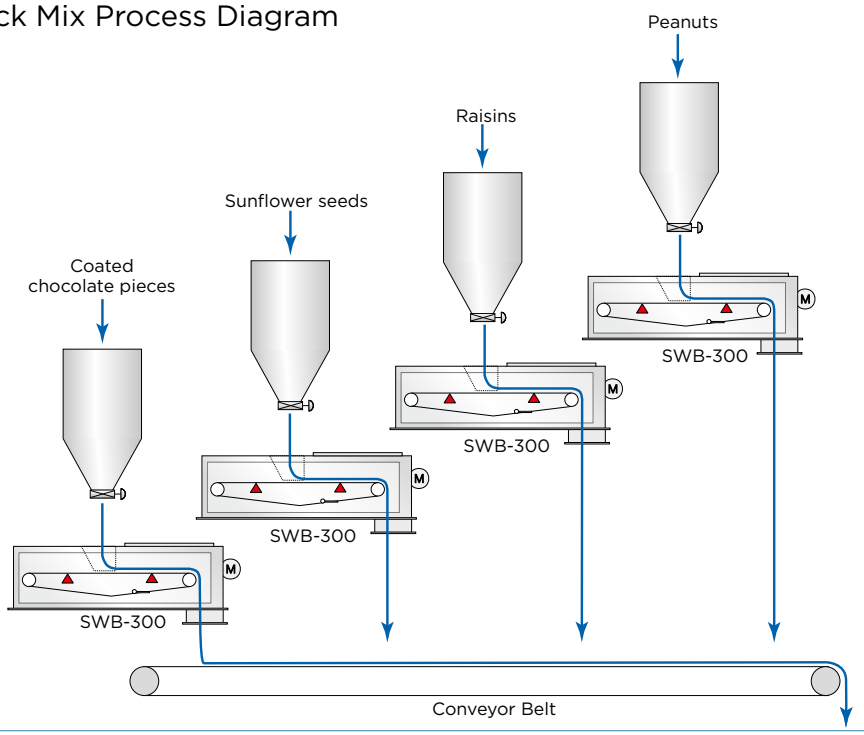
After the drying or baking step, additional seasonings or coatings may be added to the snack food product. These seasonings can be both in the form of powder blends (such as in dry mixed coatings) or liquids (such as in coatings which include liquid flavorings or oils). In both of these coating types, Coperion K-Tron liquid and powder feeders are used to accurately deliver the precise amount of coating to the snack product. In the case of salt seasoning, the use of high accuracy load cells is extremely crucial, in order to accurately report on the exact amount of salt delivered to the product. Seasonings can be either sprayed on the product in coating drums or simply delivered to the product on a conveying line below.

Proportioning of Snack Blends

In the production of multi-component snack blends such as nut or party mixes, Coperion K-Tron weigh belt and vibratory feeders are used to ensure the accurate proportion and desired ratio and rate. The use of these highly accurate devices ensure the product quality and have also proven to offer an added benefit in overall ingredient cost savings. Continuous or batch proportioning systems employ component feeding devices appropriate to the ingredient handling requirements. Coordinated proportioning is achieved through centralized recipe control or via programmed master/slave relationships between each of the ingredient feeders.

(NOTE: For more detailed information on secondary proportioning, see Application Sheet A-800304)

Snack Mix Process Diagram



Extruded Snack Food Manufacture

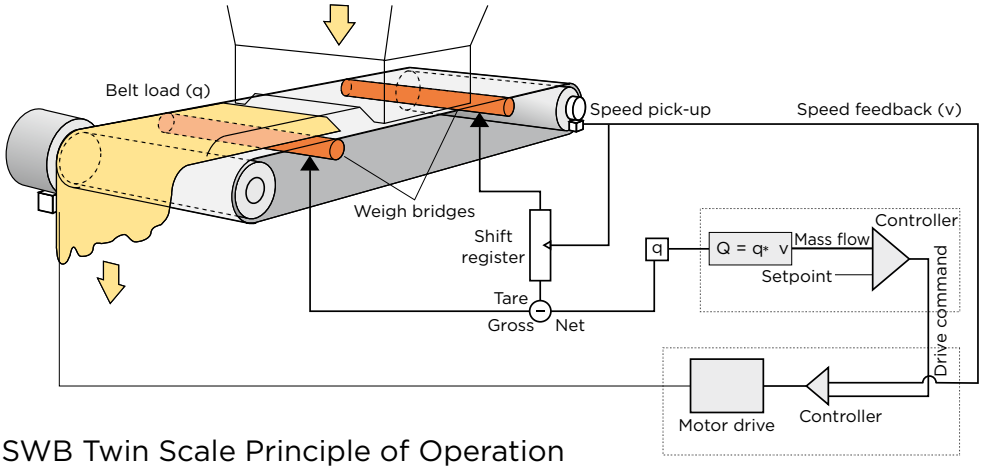
Options in Cleaning and Construction

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.

In cases where minimal product contamination is desired, such as delivery of isolated minors like vitamins or probiotics, a specialized glove box design bag dump station can be provided. This ensures protection of the product from the outside environment.

The Coperion Advantage

- Complete systems design integration of the snack food manufacturing process for one source supply.
- Global systems engineering group with extensive application experience for the entire snack food processing line ensures optimal design with an emphasis on product safety, quick product changeover, and increased efficiency.
- 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.
- Use of the Coperion line of high efficiency ZSK MEGAvolume PLUS extruders ensures maximum throughput.
- 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.
- Innovative, custom engineered Coperion rotary and diverter valves ensure reliable, long-term and safe operation.
- The efficiency of the ZSK extruder may eliminate the need for a preconditioner, therefore minimizing downtime due to cleaning and optimizing overall space requirements while lowering capital costs.
- 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.
- Highly accurate extruders, feeders and pneumatic conveying components designed to meet highest hygienic requirements.
- Superior global service network to ensure 24-7 support and coverage of your complete snack food processing line.



SWB Twin Scale Principle of Operation

Smart Weigh Belt Feeders in a snack blend process

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