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BEST COMPONENTS
BETTER SYSTEMS

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*Application Example*

# Feeding, Conveying and Extrusion in Confectionery and Chocolate Manufacture

## Background

The candy manufacturing industry is expected to experience significant growth in the near future due to product innovations in established markets such as the US and Western Europe, and rising disposable incomes in developing markets such as India and China. The growth typically includes three major segments: companies that make chocolate directly from cocoa beans, companies that use purchased chocolate to make candy products, and companies that make sugar-based candy. The non-chocolate candy sector includes a wide variety of products including jellybeans, chewing/bubble gum, licorice and hard candies. Processes for each of these manufacturing sectors can involve batch and continuous operations. In all of these sectors, whether batch or continuous, the completely integrated material handling and feeding systems supplied by Coperion K-Tron ensure the optimum in accurate, cost efficient and safe process design.

Coperion K-Tron's highly accurate feeders and pneumatic conveying systems are used for transfer, weighing and feeding to batch cookers and/or mixers. In addition, Coperion provides food components that fulfill highest demands in hygiene, ease of cleaning and gentle product handling. This equipment, in combination with Coperion's high efficiency twin screw extruders, is used for the production of a variety of products including caramel and chocolate, licorice and various filled candies. Innovations in both material handling and extrusion for confectionery manufacture are an integral part of the overall Coperion systems solution.

## Transfer of Major Ingredients

Each of the confectionery types outlined above usually requires the transfer of bulk ingredients such as corn syrup solids and sugar from the source to the process. These major ingredients (including starch) can arrive at the plant in a variety of forms, such as railcar, truck or bulk bag systems. The major ingredients are usually stored in specialized silos and then conveyed to the specific weigh batch stations as required for the blend.

Specialty design options on the silos and conveying lines can be incorporated to avoid such hazards as moisture and product temperature when entering the plant. These options can include desiccant dryer systems, and/or use of heaters on silo fluidizers and system blowers.

## Conveying Ingredients: What Method is Best?

Regardless of the type of extrusion required, the transfer of raw materials from a variety of sources can be critical to overall production times and efficiencies. The arrival and transfer of major ingredients to a confectionery production line 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.

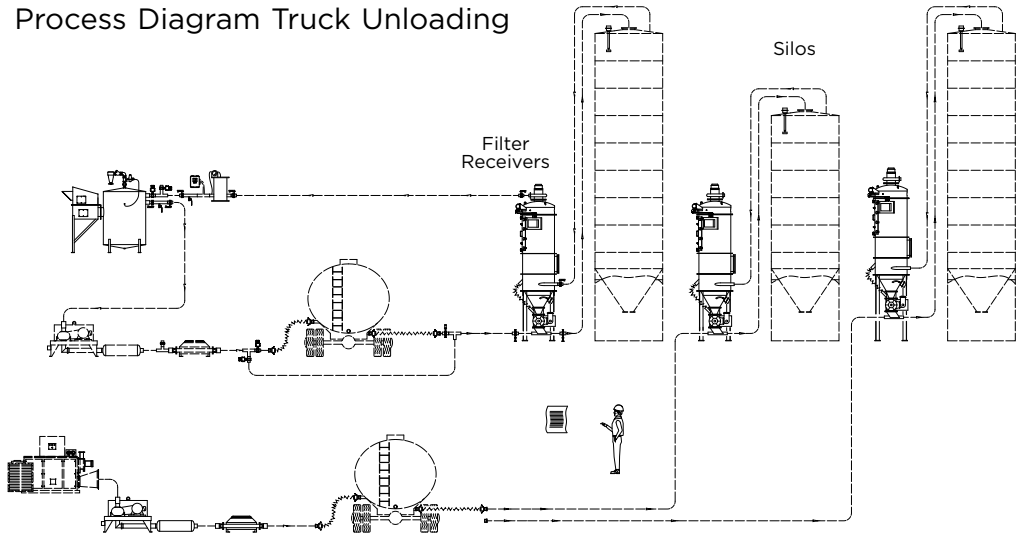
Pressure Differential (PD) trucks and railcars use positive pressure to unload material, whereas other types of delivery can often be done by either positive pressure or vacuum pneumatic conveying, or a combination of vacuum and pressure conveying.

## Dilute Phase 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 utilize either positive or negative pressure dilute phase 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, 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.

In addition to conveying raw ingredients prior to mixing or extrusion steps, Coperion K-Tron

Process Diagram Truck Unloading



# Feeding, Conveying and Extrusion in Confectionery and Chocolate Manufacture

pneumatic conveying systems are also provided for the transfer of intermediate ingredients in the chocolate bar manufacturing process, such as fragile cookie pieces and candy pieces. In these systems, specialty design receivers and conveying lines are utilized to ensure that minimal attrition of the intermediate ingredient occurs.

## Rotary Airlocks with Easy Clean Design

In either of these types of ingredient conveying applications, Coperion high efficiency and easy clean rotary airlocks are utilized. 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. When used in conveying lines for abrasive materials like sugar, the valves can be provided with specific materials of construction designed for minimized wear.

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.

## Batching Ingredients to Cookers

In many confectionery processes where batch cookers are used, Coperion K-Tron LIW feeders are used to accurately dose the powder directly into the cooker. These gravimetric feeding devices can be either screw or vibratory feeders, mounted on a weighbridges, which deliver the product to the process by means of Loss-in-Weight (LIW) batching.

In other processes the ingredients may be delivered to a batching station prior to the mixing step. 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. 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.

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, ingredient accuracy and total batching times.

*(Note: For more detailed information on all batching techniques prior to mixing see Application Sheet A-800311)*

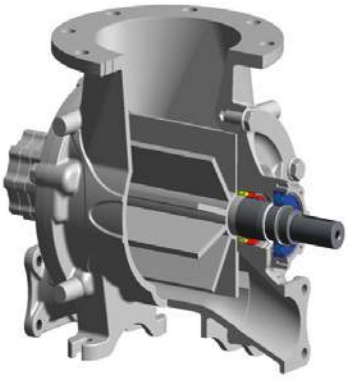
## Confectionery Processing Utilizing Twin Screw Extruders

### Chewing Gum

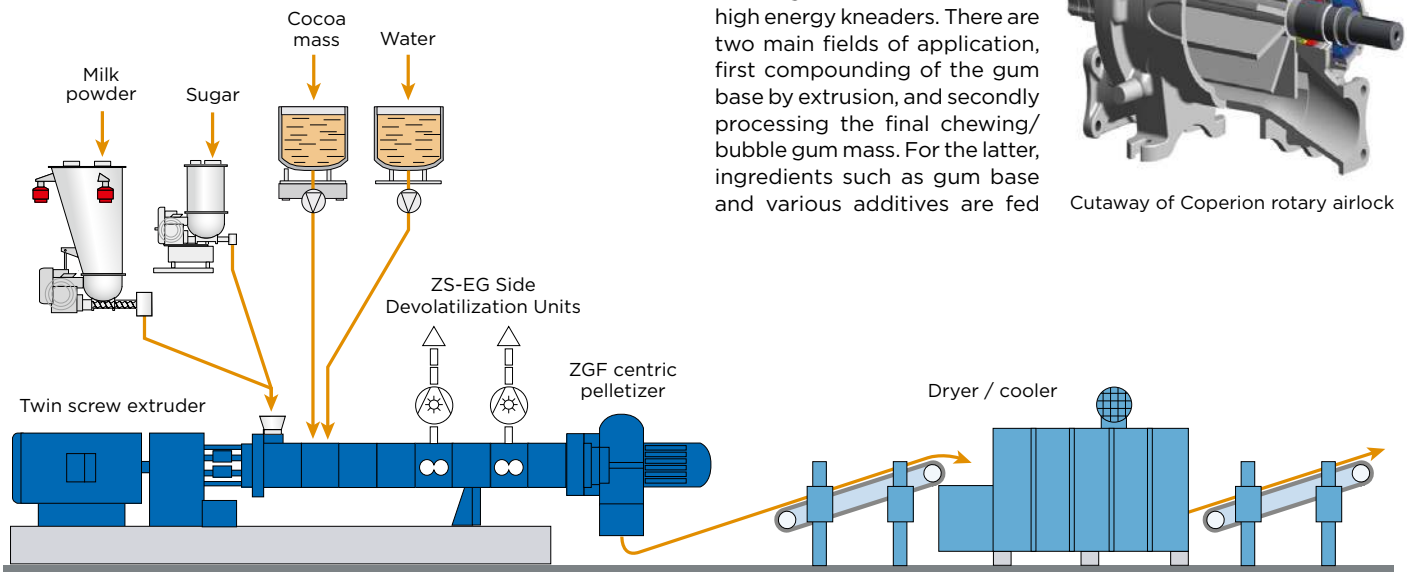
Coperion's ZSK twin screw extruders are used in the continuous production of chewing gum to replace the more traditional batch methods which use large, labor intensive and high energy kneaders. There are two main fields of application, first compounding of the gum base by extrusion, and secondly processing the final chewing/bubble gum mass. For the latter, ingredients such as gum base and various additives are fed into the infeed section of the extruder using high accuracy Coperion K-Tron LIW feeders. The extruder plasticizes the mass by means of high shear forces. Subsequently, sugar, sugar-like substances, sweeteners, flavors and other additives are added by means of a feed assembly which consists of a Coperion K-Tron LIW feeder above a Coperion ZS-B twin screw side feeder. The ZS-B feeds these ingredients directly into the plasticized mass in the process section. The extruder screws homogeneously disperse all ingredients into the gum matrix, ensuring best flavor retention and optimal release of flavor when the product is consumed.

### Extrusion of Chocolate Crumb

Coperion's ZSK twin screw extruders are in use for several different applications in chocolate manufacturing. For crumb chocolate flavor development sugar and milk powder are fed



Cutaway of Coperion rotary airlock




Chocolate Crumb Extrusion

into the extruder via highly accurate Coperion K-Tron LIW feeders. Liquid components like water and cocoa mass are metered in by Coperion K-Tron LIW feeding pumps as well. Inside the extruder, the screws generate the mass to high shear forces with resultant high temperatures. As a result the Maillard reaction for creation of chocolate crumb flavor takes place. Undesired volatiles and off-flavors native to cocoa are removed by atmospheric or vacuum degassing utilizing the Coperion ZS-EG twin screw side devolatilization unit. At the end of the extruder, the crumb is pelletized by the Coperion ZGF centric food pelletizer.

A further field of application is melting of chocolate powder coming from refiner rolls and mixing it with other ingredients like lecithin and cocoa butter. In this process step, the rheological properties of the chocolate melt can be adjusted by shear applied inside the extruder.

### Extrusion of Caramel Masses

Another field of application in the confectionary industry is the extrusion of caramel masses. Sugar and maltodextrins are fed via highly accurate Coperion K-Tron LIW feeders into the extruder. Inside the process section of the extruder the ingredients are melted by means of shear forces and mixed with milk powders containing protein. In a High Temperature Short Time (HTST) process, the Maillard reaction takes place creating caramel flavor. Fat, nuts, flavors or other ingredients may subsequently be fed into the extruder by means of a feed assembly, which consists of a Coperion K-Tron LIW feeder above a Coperion ZS-B twin screw side feeder, and gently mixed into the caramel mass. The product is often then discharged to a cooler belt to immediately stop the Maillard reaction.

## Feeding Ingredients to the Extruder

Ingredient dosing to the extruder via LIW feeders can be handled either by addition of a premix or by using separate feeders for each individual ingredient. The use of the individual ingredient feeders eliminates risk of segregation of blended product, eliminates added cost, reduces the duration of the mixing step, and results in higher productivity in the case of fewer dry ingredients and additives.

Regardless of the method chosen, 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 rate and proportioning errors waste ingredients and add to overall ingredient costs. Today, more and more confectionery manufacturers are using highly accurate Coperion K-Tron gravimetric feeders to improve process efficiency and product quality. The added integration of the feeding system directly into the Coperion extruder by our experienced system engineers ensures that the feeding, refill and extrusion steps all operate consistently, resulting in a higher quality product.

## 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 bridge building or 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, 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 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, IBCs,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.

## Accurate Addition of Liquids to the Process

As shown in the process flow diagram at left, 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.

These liquid LIW feeders are often used not only for the metered high accuracy addition of liquids to the extrusion process, but also for the liquid addition of high value sweeteners or flavors, such as menthols, to the confectionery forming process.

The liquid LIW feeder uses the same principles outlined above, utilizing a tank mounted on a weigh bridge. Instead of

# Feeding, Conveying and Extrusion in Confectionery and Chocolate Manufacture

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.

## Extrusion

Coperion's ZSK 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.

The ZSK MEGAvolume PLUS series is suitable for volume restricted processes, where raw materials with low bulk densities are used and very good mixing or degassing is the limiting factor. It should be noted that 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, offering best powder intake, degassing and screw speeds up to 1,800 rpm for optimum mixing characteristics. This enables our customers to run higher throughputs than on other machines with similar screw diameters.

Coperion's ZSK $Mc^{18}$ series offers the highest specific torque (up to 18.0 $Nm/cm^3$) in the market. High shear applications in the confectionary industry like for gum base compounding or sugar melting are easily mastered by this series of Coperion's twin screw extruders.

All materials of construction which are in direct contact with the product conform to food standards and are resistant to abrasion and corrosion.

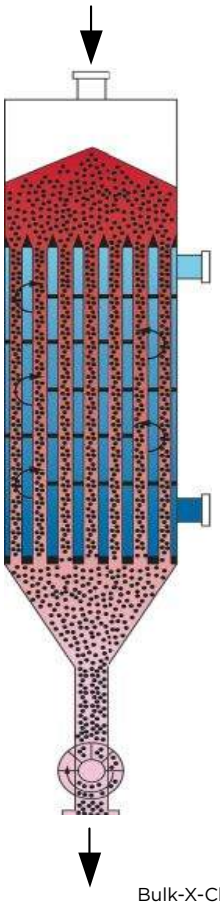
## Metering Chocolate Crumb before Refining

In the chocolate manufacturing process, Coperion K-Tron smart weigh belt feeders are used for continuous metered weighing of the chocolate crumb prior to going to the refiner for further processing. The weigh belt feeder design has the added option of a secondary weigh-bridge for continuous on-line taring. The secondary weigh-bridge prevents any deviations in feeder accuracy which may result if build-up of the crumb on the weigh belt occurs. The easy access design of the SWB also permits for quick change-over and complete washdown cleaning.

## Conditioning of Sugar

Crystalline sugar tends to cake in storage silos when stored at high temperatures or if the moisture content is too high. In order to eliminate these storage problems, the Coperion Bulk-X-Change® heat exchanger is used to cool the sugar before storage. In the Bulk-X-Change the crystal sugar flows slowly and gently downwards through vertically arranged tubes, while the cooling water flows through the shell surrounding the tubes. The patented product distribution plate above the tube bundle guarantees clean and even discharge without product residuals. Each 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.

A high efficiency Coperion rotary valve discharges the bulk material in a controlled manner. Using the rotary valve as a pressure-tight element makes it possible to inject air into the heat exchanger's discharge cone. By doing so, the air is evenly distributed and flows upward into the tubes countercurrent to the bulk material. As a result any residual moisture in the bulk material can be removed in the product buffer above the heat exchanger, preventing condensation of the moisture on the walls of the heat exchanger.



Bulk-X-Change heat exchanger

## Coperion Advantage

- Complete systems design integration of the confectionery manufacturing process for one source supply.
- Global systems engineering group with extensive application experience for the entire confectionery processing line ensures optimal design with an emphasis on product safety, quick product changeover, and increased efficiency.
- Use of Coperion's high efficiency ZSK extruders ensures maximum throughput.
- 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.
- Innovative, custom engineered Coperion rotary and diverter valves ensure reliable, long-term and safe operation.
- 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 confectionery processing line.


Main offices:

**Coperion GmbH**
Compounding & Extrusion
Theodorstrasse 10
70469 Stuttgart, Germany
Tel.: +49 (0) 711 897-0
Fax: +49 (0) 711 897-3999

**Coperion GmbH**
Materials Handling
Niederbieger Strasse 9
88250 Weingarten, Germany
Tel.: +49 (0) 751 408-0
Fax: +49 (0) 751 408-200

**Coperion K-Tron Pitman, Inc.**
590 Woodbury-Glassboro Rd
Sewell, NJ 08080, USA
Tel +1 856 589 0500
Fax +1 856 589 8113

**Coperion K-Tron Salina, Inc.**
606 North Front St.
Salina, KS 67401, USA
Tel +1 785 825 1611
Fax +1 785 825 8759

**Coperion K-Tron (Switzerland) LLC**
Lenzhardweg 43/45
CH-5702 Niederlenz
Tel +41 62 885 71 71
Fax +41 62 885 71 80

www.coperion.com info@coperion.com