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Application Example

Feeding and Material Handling for Dry Infant Formula and Milk Powders

Background

The production of dry dairy powders and infant/baby formulas requires extremely sanitary design of the equipment as well as high accuracy in the precise addition of ingredients to the formula blend. The system provided must also offer the versatility to handle a wide variety of difficult flowing and temperature-sensitive ingredients, including vitamins, nutrient additives and even probiotics. In addition, depending upon the type of process and the processing environment, the equipment must be able to be cleaned by either wet or dry cleaning methods. The hygienic designs provided by Coperion and Coperion K-Tron are easily adaptable for all of these requirements.

Process Options

In the manufacturing processes of infant/baby formula, it is important to produce an end product formulation which meets the needs of the target group. The equipment must be able to handle, transfer and feed such ingredients as whey powder, casein, lactose, maltodextrin and additional minerals.

Powdered infant formula is generally manufactured via one of two different methods: dry blending or wet blending with spray drying. In addition, in some cases the overall production can also be a combination of dry and wet processes, producing the base powder via the wet process and then using dry blending for the final blend of nutrients prior to packaging. The blending portion of these processes can be either via continuous or batch blending methods. In either type of process, Coperion and Coperion K-Tron loss-in-weight feeders, conveying systems and hygienic design rotary and diverter valves are used.

Process Option 1:

The Dry Blend Process

When dry blending, the main ingredients are often transferred pneumatically from a variety of sources such as bags, supersacks and silos. These ingredients are conveyed directly to the dry blending area. When batch blending, ingredients can be delivered via batching techniques utilizing loss-in-weight (LIW) batch feeders. Due to the sensitive nature of achieving the precise blend of ingredients in the formulation, Coperion K-Tron feeders — with their high accuracy load cells — are the feeder method of choice.

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 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 trace elements and probiotics) due to the high accuracy required as well as their ingredient cost. In some cases the LIW feeder for the probiotic material can even be located within an enclosure or glove box in order to ensure there is no contamination from the environment and provide a completely contained delivery of the ingredient to the process below.

Photo 1: Coperion K-Tron feeders over a continuous mixer

(NOTE: For more details on probiotic addition and equipment design see Application Sheet A-800315.)

In continuous blending processes, Coperion K-Tron continuous loss-in-weight feeders continuously feed individual ingredients to the mixer below in the proper recipe-controlled proportion.

Loss-In-Weight Feeding and Continuous Refill Principle of Operation

When designing the continuous mixing process, the method of delivery of the individual ingredients to that process is critical to the resultant product quality. For this reason, highly accurate gravimetric feeders are the feed method of choice. By definition, gravimetric feeders measure the flow's weight and then adjust feeder output to achieve and maintain the desired setpoint. Volumetric feeders do not weigh the flow, they operate by delivering a certain volume of material per unit time from which a weight-based flow rate is inferred by the process of calibration.

Photo 2: Hygienic Bag Dump Station with integrated glovebox

The most popular type of gravimetric feeder used in continuous processes is the loss-in-weight feeder. Loss-in-weight feeders directly measure and control the flow rate and can fully contain the material within the confines of the feeder. Loss-in-weight feeders are typically

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either mounted on weigh scales or suspended from load cells. The Coperion K-Tron load cell is a highly accurate instrument, designed specifically for the rate and accuracy requirements of dynamic feeding, and features a resolution as high as 1: 4,000,000 in 80 ms.

As shown in diagram 2, a loss-in-weight feeder consists of a hopper and feeder that are isolated from the process so the entire system can be continuously weighed. As the feeder discharges material, system weight declines. The speed of the metering device is controlled to result in a per-unit-time loss of system weight equal to the desired feed rate. A typical loss-in-weight feeder controller adjusts feeder speed to produce a rate of weight loss equal to the desired feed rate setpoint.

Pneumatic Vacuum Receivers as Refill Devices

Pneumatic receivers which operate under a dilute phase vacuum transfer principle are often used as refill devices, particularly for continuous operations. The pneumatic system utilizes vacuum to suck 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. The filter material can vary, including options on laminated membrane type materials, for quick release and easy clean properties.

It is important to note that the feeder design provided in these continuous refill systems typically also includes a special vent filter on the hopper lid to sufficiently vent the hopper during the discharging cycle. Proper venting of the loss-in-weight feeder is critical to maintain its overall accuracy. As shown in photo 3, the specialty vent filters provided also include a reverse pulse system similar to that outlined above, in order to keep the filter clean during the continuous process. *(Note: for more details on the continuous mixing process see Application Sheet A-800316)*

Photo 3: Coperion K-Tron hygienic jet filter for loss-in-weight feeders

Process Option 2: The Wet Blending Process

In the wet blending/spray drying process, ingredients are blended with water in large batches and then pumped to a heat exchanger for pasteurization. The pasteurization step ensures that any harmful materials which may be present in the batch are destroyed. This step also has the advantage of ensuring uniform distribution of the ingredients.

After pasteurization the liquid is homogenized and the product may be concentrated by passing it through an evaporator or sent directly to the spray dryer. As shown in diagram 3, the product is then atomized in the spray dryer. As droplets of product are fluidized in the dryer, water is evaporated and then dry powder deposits on the spray dryer bottom, where it is discharged with a sanitary Coperion rotary valve to a fluidized bed. There the product is typically dried further and cooled. The outlet air from the spray drying chamber still carries product (fines) which is normally ducted into cyclones and bag filters after the spray dryer. From there the product is discharged with Coperion rotary valves into the fines return line. The fines can either be transported with pneumatic conveying to the fluidized bed or back to the top of the spray dryer for agglomeration purposes. The actual conveying path is selected by the Coperion WYK diverter valve. After the fluidized bed, the finished powder passes through a sifter and is then pneumatically conveyed to storage silos or packaging lines, where it is deposited into bags or where it is canned.

Moisture and warm temperatures in the wet blending and spray drying process are conducive to bacterial growth, therefore wet cleaning is normally applied in this process while dry cleaning is often typical in the process after the fluid bed dryer.

The wet cleaning process can require extensive resources. Time and costs can be saved if the washing process can be au-

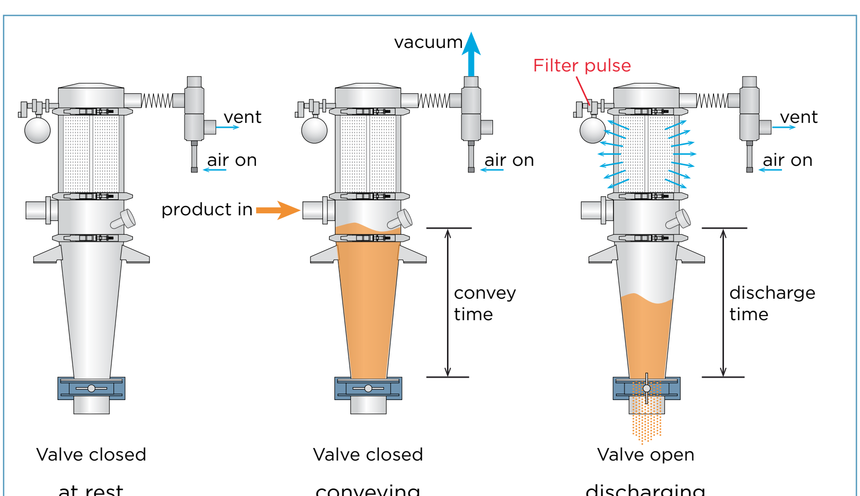

Diagram 1: Vacuum Receiver Sequence of Operation

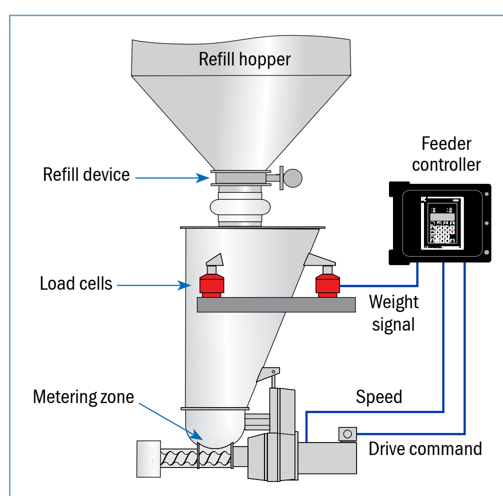

Diagram 2: Loss-in-Weight Feeding Principle

tomated (clean-in-place or CIP). Coperion offers special components that can be cleaned in the process without need for dismantling. This also reduces the risk of external contamination in the process. Coperion rotary valves are designed such that the rotor stays in the housing and discharges the washing liquids by rotating. Retention-free design including special CIP-gaskets at the inlet and outlet as well at the sideplates assure that no product or liquid remains anywhere (photo 4). Tests at authorized institutes (EHEDG) have proven that the components are absolutely clean. Photo 5 shows a rotary valve during the EHEDG test procedure for CIP suitability (type EL - Class I). The Coperion rotary valve ZRD-CIP was contaminated with a curdled milk suspension containing spores and CIP cleaned afterwards. The use of agar as a culture medium proved that the ZRD-CIP was absolutely clean and contamination free.

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.

The stainless steel WYK diverter valve was specifically designed for CIP cleaning in powder conveying pipes (photo 6). The conical rotor is switched between conveying tubes via actuator while the diverter is operated in conveying mode (diagram 4). During cleaning the rotor is extracted slightly by a second actuator which allows the cleaning liquid to reach all areas of the inside while the diverter is still closed to the outside. The WYK diverter valve does not need to be opened during or after CIP and yet is thoroughly clean afterwards, which saves time and costs.

Hygienic Equipment for Material Transfer

In each of the blending processes outlined above, Coperion and Coperion K-Tron pneumatic conveying systems and material handling components are utilized for the transfer of the raw ingredients prior to blending as well as transfer of the final blended/spray dried product prior to packaging. The conveying systems provided by Coperion K-Tron include both positive pressure and vacuum, dilute and dense phase.

Equipment Design Features for Cleaning

The specialty feeders, convey systems and valves provided for both blending processes can include a variety of options specific for contaminant free handling of the infant formula or milk powder. It is important to consider the preferred method of cleaning when defining the process to be utilized.

Dry Cleaning Options

Since the dry blending process does not require the addition of water for manufacturing, the absence of water in the environment also denies bacteria the ability for growth. However, even though the process line is dry for long periods of time, the total system and equipment supplied must be completely accessible for dry cleaning/vacuuming so that no cross contamination can occur.

Dry cleaning is usually optimal when the propensity for outside contamination is low and

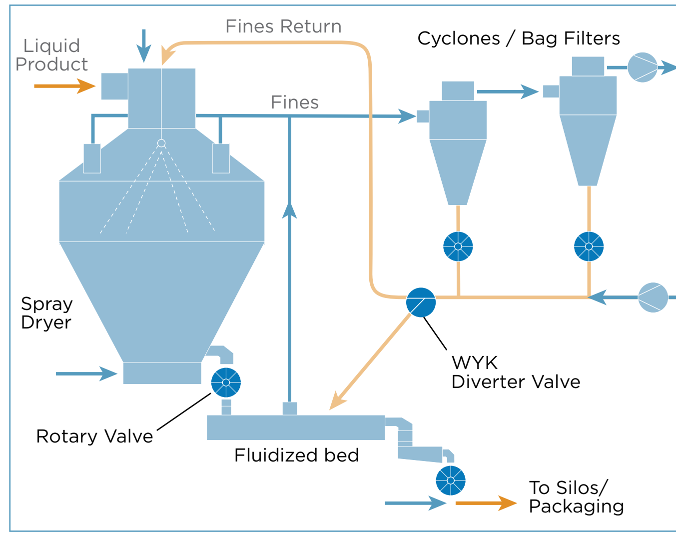

Diagram 3: Spray Drying System

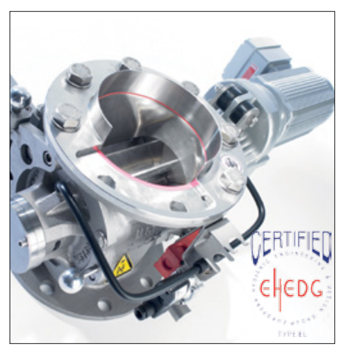

Photo 4: CIP flange design assures that no residual material remains

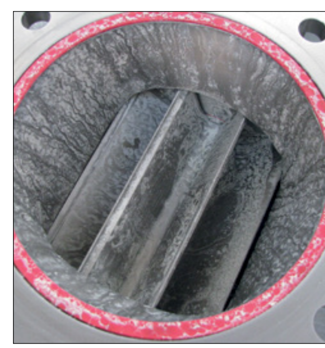
Photo 5: Rotary valve during EHEDG testing (type EL - Class I)

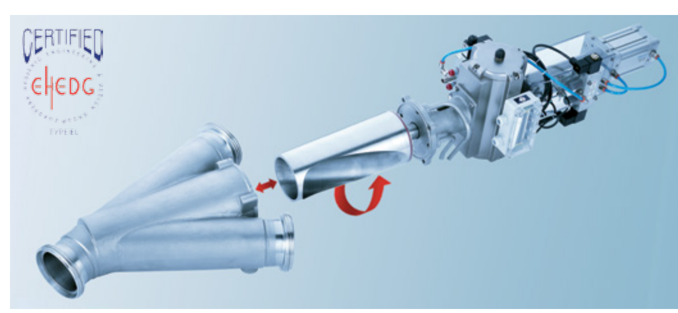

Photo 6: WYK-CIP diverter valve

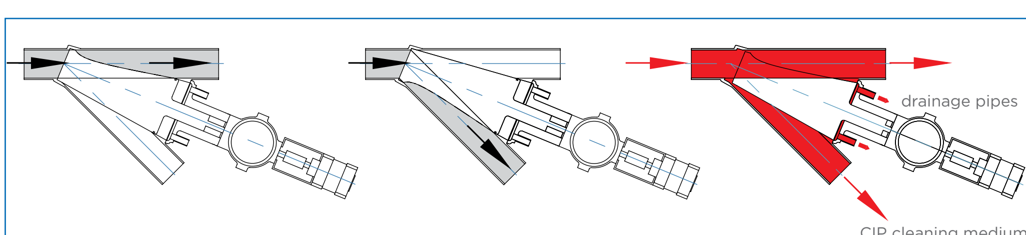

Diagram 4: WYK-CIP diverter valve principle of operation for fully automatic CIP

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the environment (and humidity) is kept low. All surfaces on the equipment supplied are designed for minimal powder buildup. Additional design features suitable for dry cleaning include the following:

- Fully welded and ground weld seams
- Frames in stainless steel without tubes, in easy clean design
- Purges on shaft seals
- If vertical agitators used in feeders, a gas tight lip seal design is used
- All brackets, junction boxes and control devices offset from the equipment to allow accessibility to clean and wipe down
- Cable conduits with grids and use of special magnetic cable ties

Wet Cleaning Options via Wet-in-Place or Clean-in-Place

Although dry cleaning is the easier cleaning option and often the method of choice, wet or CIP cleaning is also used. The proper design of the equipment used is critical in a wet cleaning process to ensure complete wettability of the product contact surfaces, and also verification that all surfaces are dried prior to start up. It is also important in cases where a true CIP design is not applicable, that all components in the system are designed to be disassembled, inspected and reassembled quickly in order to minimize overall downtime.

The key design features in wet in place or clean in place equipment include the following:

- Integrated retractable spray nozzles in feeder hoppers and pneumatic receivers with spray patterns which ensure all contact surfaces have been wetted.
- Sealed shafts or purge shaft seals to avoid ingress of the effluent
- Pitched surfaces to allow for drainage

Coperion Advantage

- Complete systems design integration of the dry milk powder/infant formula manufacturing process for one source supply.
- Global systems engineering group with extensive application experience for the entire milk powder processing line ensures optimal design with an emphasis on product safety, quick product changeover, and increased efficiency.
- Highest sanitary design according to the current guidelines and regulations.
- 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.
- 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 milk powder processing line.

Photo 7: Multi feeder continuous infant formula production complete with integrated off-line scale for feeder sampling, validation and calibration.

Photo 8: Coperion's unique quick clean rotary valve design

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