Application Example

Loss-in-Weight Feeding in Fish Food Production

Introduction

The production of quality fish food for a wide range of species requires a number of factors to be taken into consideration, such as: density, water stability, nutritional composition (recovery of essential amino acids and vitamins) and digestibility. Actual fish pellet density, for example, is critical when manufacturing fish food pellets for specific types of fish, such as bottom tank feeders versus those that tend to feed from the top of the tank.

In such critical applications the efficiency and accuracy of the ingredient feeding system is crucial to meeting the criteria for each formulation. The use of Coperion K-Tron Loss-in-Weight (LIW) feeders featuring the highly accurate Coperion K-Tron SFT load cell technology is ideal for meeting the variety of criteria in fish food extrusion and pelletizing. In addition, the minimization of ingredient loss by providing exact accountability of ingredients fed, provides the manufacturer with maximum process profitability.

Application and Process Details

One of the more common methods of producing fish feed pellets from fish meal is extrusion. The extrusion process can basically be accomplished in two ways.

In the most common designs, several loss-in-weight (LIW) feeders are used to feed individual ingredients such as fish meal, protein sources, cereals, vitamins, pigments, etc., directly into a continuous blender. In addition to the dry components, fish oil is also added to the blend. The final mixture is then delivered to another LIW feeder, feeding directly to the extruder as shown in the flow diagram on the reverse.

Alternatively, individual feeders can be used to feed the individual ingredients directly into the extruder. This process is sometimes used to avoid any issues of segregation that may occur when delivering and handling a premixed material. It also can be beneficial as it removes the mixing step, thus improving overall production yields and decreasing process and handling times.

In addition to the dry components, water is also added to this dry feed mixture in order to give a homogeneous composition. Liquid loss-in-weight (LLIW) feeders are used to accurately deliver the water or oil to the extruder.

Steam is introduced into the mixture in order to force the starch in the cereals to gelatinize. During the extrusion process a high pressure is built up in the product mixture and the temperature increases at the same time. When the product has passed through the extruder the pressure is lowered and part of the water is vaporized at the same time as the formed pellets expand, resulting in a porous structure which will absorb oil. By subsequently coating with oil, the fat content of the feed product may be increased to 20-30%. After extrusion, the water content is high, 20-30%, so the addition of oil is preceded by warm air drying which brings the water content of the finished product down to less than 10%.

Fish food is manufactured in a variety of forms: flakes, pellets. clusters, etc.

K-ML-S60 Single Screw Loss-in-Weight (LIW) Feeder

Loss-in-Weight Feeding Principle

Coperion K-Tron screw feeders can be supplied in either volumetric or gravimetric configurations. Due to the high accuracy requirements of feeding in continuous extrusion or blending processes, the gravimetric feeding principle via loss-in-weight feeding is a necessity. For example, when feeding materials with high variations in bulk density, volumetric feeders can

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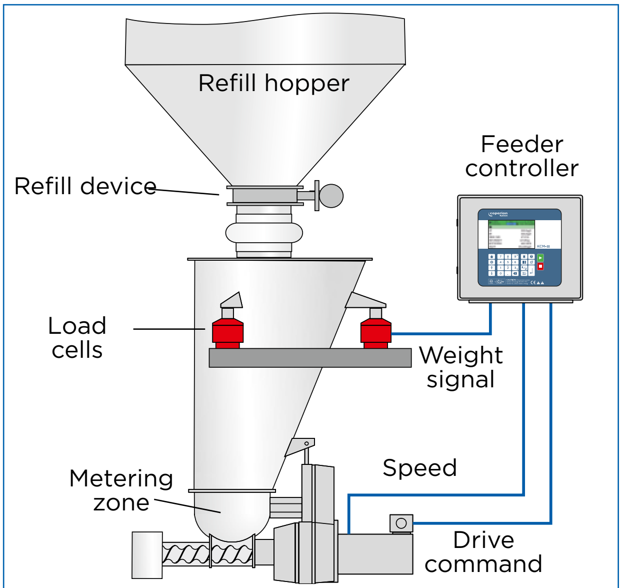
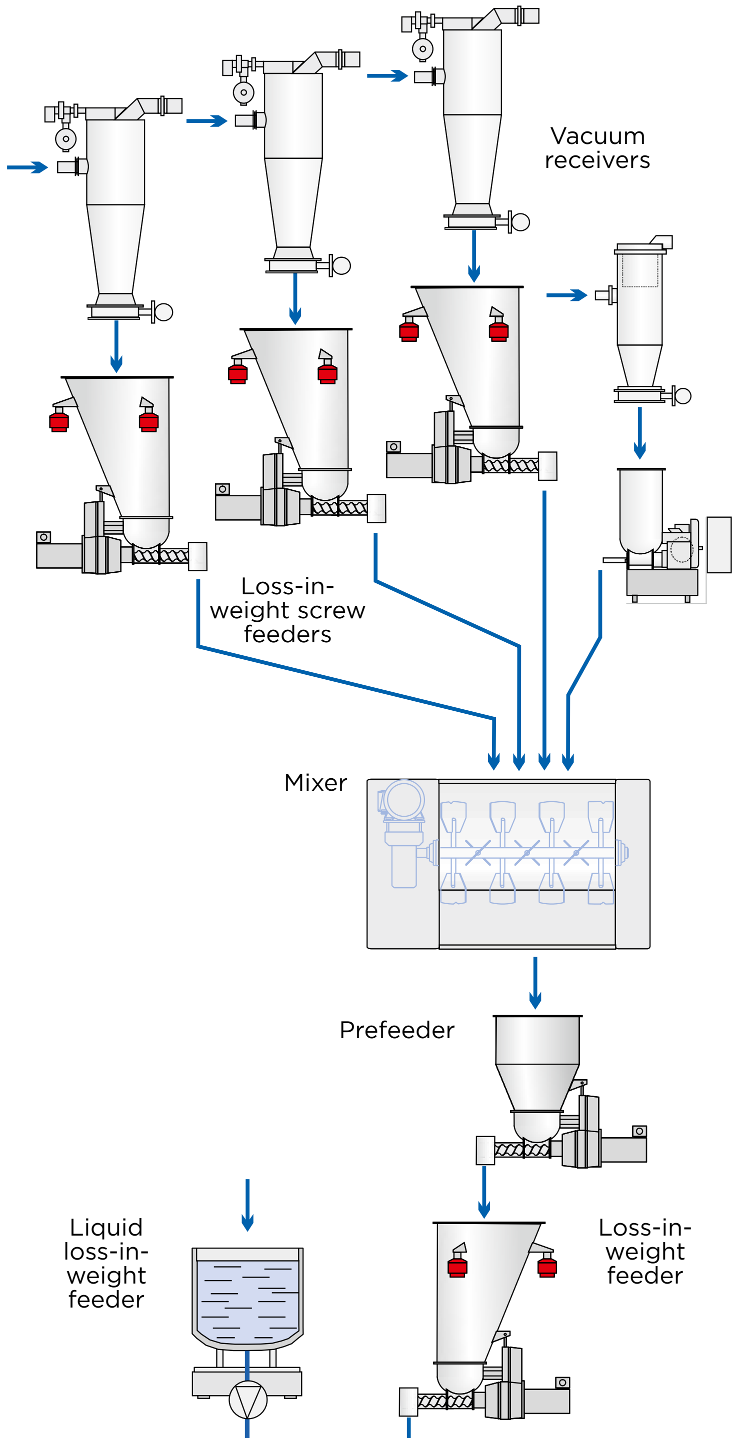
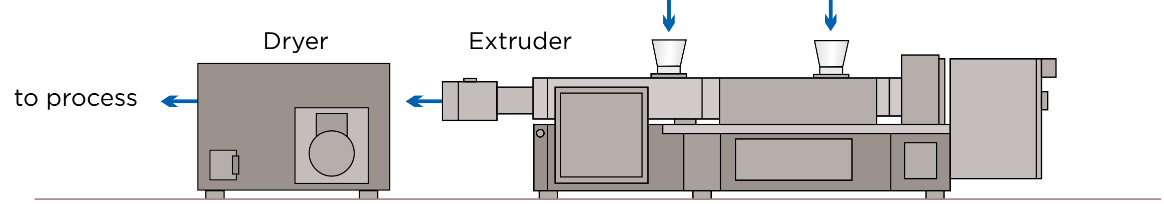


Loss-in-Weight (LIW) Gravimetric Feeding Principle

Loss-in-weight screw feeder feeding into a mixer





The production of fish food often requires both dry and wet ingredients 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 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.

P10 vacuum sequencing receiver refilling a KT20 twin screw loss-in-weight feeder

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. 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 mixer/blender.

Liquid LIW Feeding

The LIW Principle is also used for the accurate delivery of the liquid medium to the extrusion process. Liquids are typically fed through a gear pump with variable speed drive. The mass flow rate can be measured and controlled by placing the liquid tank on a weigh scale with the same loss-in-weight control algorithm described above. Instead of changing the screw speed, the same signals are used to control the pump speed/stroke.

A gear pump is capable of metering accurately many types of liquids, particularly liquids that have some viscosity such as vegetable or coconut oil. Gear pumps have accurately cut, intermeshed gears that are slightly sealed in the housing along their sides. Fluid enters the pump through the inlet port located in the front plate and fills the gear pocket. As the gears rotate, a precise amount of fluid is trapped by the side walls of the gear pockets and gear teeth. This precision rotary external spur gear dispenses an exact volume of fluid per revolution. By adjusting the speed of the revolution through the pump motor, the flow is increased or decreased.

In the plot of weight vs. time, feed rate setpoint is represented as a downward sloping line. The negative mathematical slope ($\Delta W/\Delta T$) indicates the desired loss of system weight per unit time. The feeding cycle begins with a fully filled tank where weight is at a maximum. As feeding proceeds the measured weight is continually compared against the setpoint line‘s target weight. Any difference between the two values triggers a change in the pump speed.

The benefits of this gravimetric arrangement as opposed to a mass flow meter include easier calibration, lack of a pressure drop experienced by the measuring device, suitability for liquids in excess of 150°C, and most importantly, higher accuracy in feed and control.

Vacuum Receivers for LIW Feeder Refill

The refill of product to a LIW feeder that is feeding a continuous process (blending or extrusion, eg) can be almost as critical as choosing the right feeder technology. The objective of feeder refill is to complete the process as quickly as possible. Pneumatic receivers which operate under a dilute phase vacuum transfer principle are often used as refill devices. The photo at left illustrates a Coperion K-Tron Premier P-Series receiver above a Coperion K-Tron feeder.

The pneumatic system utilizes a negative pressure via a vacuum pump to suck the material required for refill into a separately mounted and supported vacuum receiver. The receiver is filled to a determined level and then holds this material charge until the feeder below requests a refill. The level of fill in the vacuum receiver is determined by level sensors. At the point of refill request by the feeder below, the discharge valve opens and the receiver contents are discharged into the feeder hopper. At the same time of this release, a gas pulse is sent through the filter housed in the vacuum receiver, in order to release any entrained particulate or material which may have settled on the filter.

After discharging the material into the feeder hopper below, the receiver discharge valve is shut, and the vacuum cycle begins again, so the vacuum receiver is instantly ready for the next feeder refill request. 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.

Advantages of Vacuum Sequencing

A continuous vacuum system utilizes a continuous vacuum source and the use of a rotary airlock at the base of the receiver to keep the vacuum within the receiver while maintaining constant output. In a vacuum sequencing system the vacuum receiver is fitted with a discharge valve. When closed, the system transfers the material until a preset time or fill level is reached. Once

Liquid Loss-in-Weight (LLW) Feeder

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the vacuum receiver is full, or the time elapsed, the vacuum is broken, and the discharge valve on the receiver opens and discharges the material. In the case of the Coperion K-Tron Premier sequencing receivers, a pulse of air is blown thru the filters within the receiver during this discharge, in order to avoid material build up on the filter media and optimize conveying efficiency. The process is sequenced and repeated until the destination hopper is full.

Vacuum sequencing systems typically allow for more versatility in product pickup and destinations, and can often utilize a single vacuum source for several receivers, depending upon the demands of the downstream process.

Dilute Pneumatic Transfer - Positive or Negative Pressure

When transferring raw materials from their sources, either positive or negative pressure conveying systems can be utilized. Positive pressure systems are typically used to transport product over long distances and 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 or "supersacks".

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 powder. 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 due to the limitations in the level of vacuum that can be generated, the distances and throughputs on a vacuum system can be limited. Often times a combination of pressure and vacuum conveying techniques are used for a system, taking full advantage of the process and efficiencies of each technology.

Material Handling Experience

- The Coperion K-Tron Systems Group can supply a completely integrated systems approach in material handling and product delivery
- Each solution is custom designed according to the process requirements and based on Coperion K-Tron's extensive experience in providing superior material handling solutions.
- Coperion K-Tron Premier vacuum sequencing receivers offer a wide variety of design options and versatility for installations
- One source integrated controls for both the feeders as well as refill receivers ensure optimal process accuracy and efficiency

Coperion K-Tron Advantage

Coperion K-Tron loss-in-weight gravimetric twin screw feeders offer the following advantages:

- Constant feed rate with high short term accuracy and low setpoint deviation
- Coperion K-Tron's patented SFT digital weighing technology delivers a resolution of 1:4,000,000 in 80 ms, as well as built in immunity to fluctuations in plant vibration and temperatures
- Gravimetric control continuously checks the hopper weight thus alerting of any problems in flow to/from the feeder hopper
- Coperion K-Tron's refill array provides for accurate feeding even during refill periods
- Wide variety of feed screw and agitator designs provide flexibility for a high variety of ingredients
- Ergonomic designs for easy cleaning and maintenance

2400 Series Vacuum Sequencing Receiver

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