Engineering White Paper

CHARACTERISTICS OF FILLING SYSTEMS
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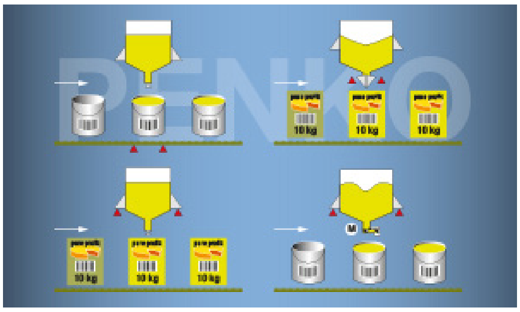
INTRODUCTION

This White Paper discusses the challenges, options and solutions for process manufacturers when packaging products for consumers and/or the processing industry. Product can be sold in bulk or in small packages for trade.



PURPOSE OF WHITE PAPER

There are various validated reasons as how packages are filled. This paper explains why it is important to dose the correct amount of material/product, – be it small individual packages, bottles, cans cans or any other container. Challenges regarding accurate filling apply regardless of whether the process is run on a standalone small shop-floor level installation, or a 24x7 h industrial filling process, remain the same, irrespective of automated or non-automated systems. The filling accuracy has a direct effect on cost and profit margins for any process manufacturer. Overfilling evidently results in profit loss and product wastage and under filling leads to unhappy customers and in some cases even constitute a legislative fallacy. The opening of European boarders resulted in international regulations of trade that warrant a scrutinizing view on accurate, fair and proper filling of packages of any type The directive for prepackaged products has been brought to life and applies to packages of up to 10kg and is based on average weight. While the directive is aimed to standardize and control trade in Europe, the e-mark principle is beneficial to any process manufacturer, guaranteeing real savings on finished product by over or under filling of packages which leads to savings on bottom line. But there is more; an automated administered e-mark protocol makes additional checks redundant, saving valuable time and resource. The opportunity to do business in the EU market is an added benefit directly resulting from filling with in accordance with the e-mark principle. A process manufacturer will take care to maximize on ROI by choosing the most appropriate controller system for his purposes to minimize spillage and augment output.

THE FILLING PROCESS

Controllers for filling processes are designed to ensure the exact amount of a package content, based on weight, is dispatched. The filling process is usually found at the end of a production process in any given process flow. International trade applications make legal requirements obligatory. These rules are defined by the worldwide organization OIML (International Organization for Legal Metrology) in recommendation R61.

SPECIFIC CHARACTERISTICS OF FILLING SEQUENCES IN GENERAL.

In practice the weighing accuracy rarely is the problem. In fact, the weighing indicator will indeed display errors created by other parts (mechanical noise) of the filling system. The deviation is in general caused by the combination of supply speed/measuring speed and the properties of the product.

In principle, filling is a dosing process, only much faster. Production that has been produced in one batch, is now filled in multiple packages in succession or simultaneously. The filling process typically is done in a matter of seconds per package as opposed to minutes or hours.

The following examples explain factors responsible for the deviation due to additional mass/time characteristics. Figure 1 below, a bag filling application, shows the ‘in-flight’ product deriving from the moment the supply valve is closed, up to the moment that the product reaches the weigher.

EXAMPLE 1

A screw conveyor supplies the product. When the preset weight is reached, the system stops the screw conveyor which typically does not stop abruptly, but gradually slows down until it finally comes to a halt. Until the conveyer has stopped completely, there will always still be some material in motion falling from the feeder into the package. Therefore, the final fill weight will be greater than the pre-set weight. Curtailing this in-flight material flow subsequently will reduce the deviation and increase the actual weight accuracy. Once the feeder has stopped completely, the in-flight mass conforms to the following kinematic equation:

$h = \frac{1}{2} g.t^2$

whereas:

h = height

g = acceleration of the free fall.

t = time.

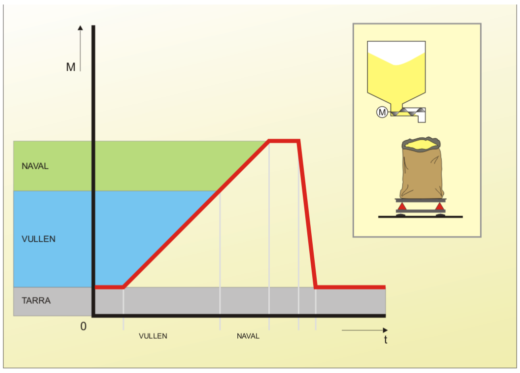


Figure 1:

The time during which the material is falling is: $t = 2h/\sqrt{g} = 2h/\sqrt{9,81} = 0,45\sqrt{h}$
This means that the amount of falling material is directly dependent of the square root of the height. From this value the apparent mass caused by the kinetic energy and absorbed by the weighing system, must be deducted. The kinetic energy, which is directly related to the height and the falling mass, is equal to the potential energy: $W = m.g.h$. The result is in fact a phenomena whereby the actual weight is less than the weight measured. In typical situations, a controller system will initially check the stability of the net weight, following a deduction of the automatic tare. By so doing, differences in weight between the empty packages will not influence the fill result during gross dosing. The same applies for net dosing where "pollution" of the weigher is ignored.

EXAMPLE 2

One of the ways to achieve a reduction in in-flight mass, is to reduce the distance between the weigher and the supply source. In addition, installing a fast cut-off valve as well as installing a control mechanism for the cross-over between coarse filling and fine filling will add to an even greater reduction in product output.

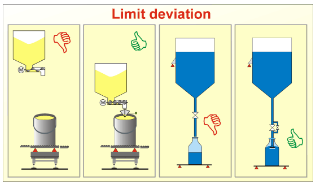


Figure 2

In the Figure 3: Mass/Time Tolerances the top part shows a material spread in high speed and a reading of multiple samples per time frame. The effect of this is that material can be dosed within a given acceptable tolerance weight. The lower image shows an opposite scenario. Here material is dosed using a slow process and the number of samples are much less than in the aforesaid example. This results in a much wider tolerance weight, indicating spillage, over filling and time consuming behavior.

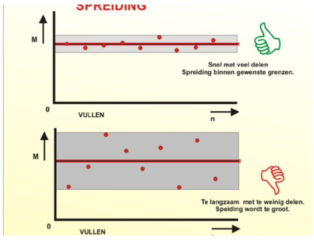


Figure 3

Figure 4: Coarse and Fine Filling, explains that the combination of a fast cut-off valve with a coarse/fine speed regulator, significantly reduces in-flight material, respectively resulting in a deviation reduction.
If the dosing quantity during the coarse dosing faze is high, it frequently happens that the kinetic energy of the in-flight material of this coarse faze actually exceeds the amount of fine dosing material. To avoid this, it is necessary to set up a special arrangement, to prevent a valve from switching off too early. This phenomena is known as the "Kinetic Energy Blind Time" or KEBT.

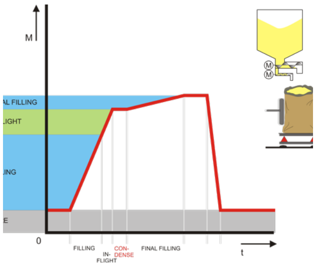


Figure 4

See Figure 5 Kinetic Energy Blind Time (KEBT)
Correcting the The Kinetic Energy Blind Time is achieved when the controller pauses for a specific period of time to allow for the dosed mass to stabilize below the pre-set weight, after switching over from coarse to fine filling. So doing in this combines a high speed filling sequence with an accurate material cut off, offering a perfect dosing accuracy.

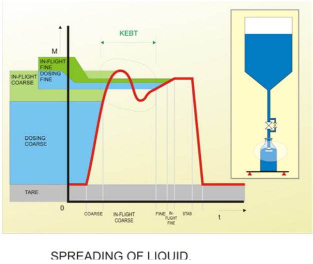


Figure 6 below shows a complete gross dosing sequence. The sequence shows the following elements:

- Empty weigher.
- Arrival of the empty package.
- Stabilizing and automatic tare.
- Dosing coarse and in-flight of the coarse dosing
- Kinetic energy of the coarse in-flight.
- Dosing fine and in-flight of the fine dosing.
- Stabilizing time and calculation of the in-flight.
- Removing the filled package.

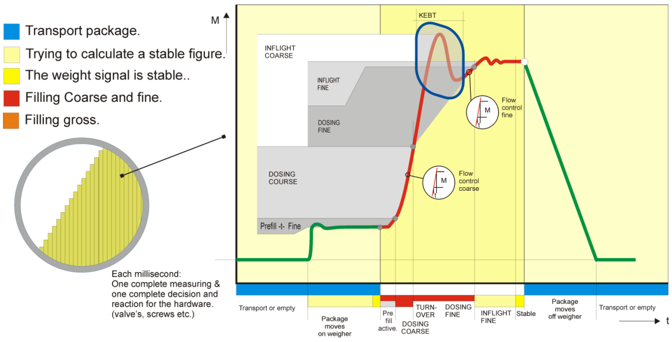


Figure 7 A Complete Net Dosing Sequence

- The empty weigher.
- Stabilizing and automatic tare.
- Positive filling of the weigher gross on one, high speed.
- Effect of the kinetic energy after cut off.
- Stabilizing and automatic tare.
- Dosing negative coarse and in-flight of the coarse dosing
- Kinetic energy of the coarse in-flight
- Dosing negative fine and in-flight of the fine dosing.
- Stabilizing time and calculation of the in-flight.
- Discharge of the weigher.