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 must faster. Production that has been produced in one batch, is now filled in multiple packages in succession or simultaneously. The filling process is 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 a 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 if 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.

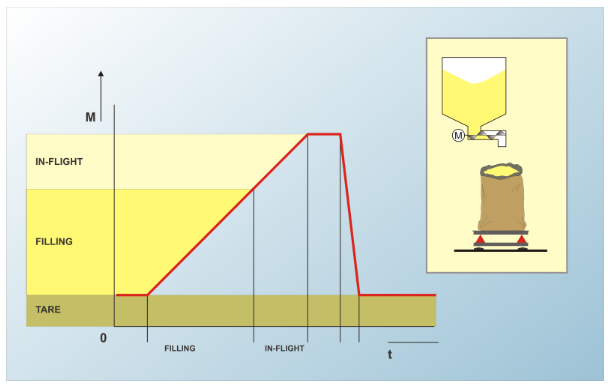

Figure 1: In Flight Bag Filling Application

Once the feeder has stopped completely, the in-flight mass conforms to the following kinematic equation:

$h = ½ g.t^2$

whereas:

h = height
g = acceleration of the free fall.
t = time. The time during which the material is falling is: t = 2h/√g = 2h/√g=2h/√9,81 = 0,45√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 of 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: Reducing in-flight quantities can be done in various ways as is shown in *Figure 2*.

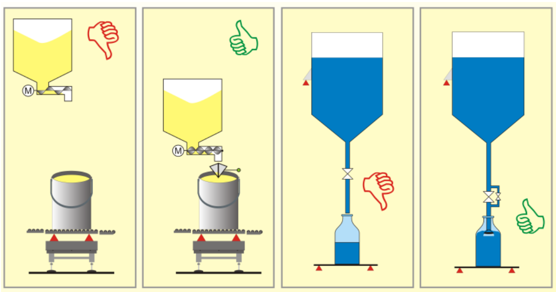

Figure 2: Reduction of in-flight mass

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 and even greater reduction in product output.

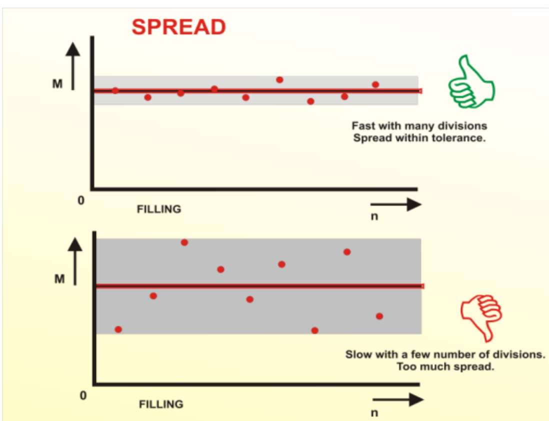

Figure 3: Mass/Time Tolerances

In the *Figure 3: Mass/Time Speed* the top part shows a material spread in high speed and 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.

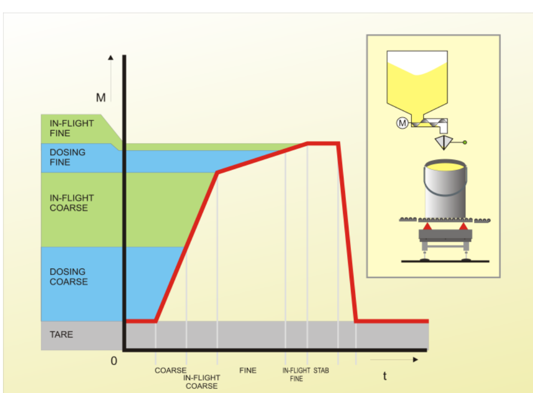

Figure 4: Coarse and Fine Filling

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. See *Figure 5.*

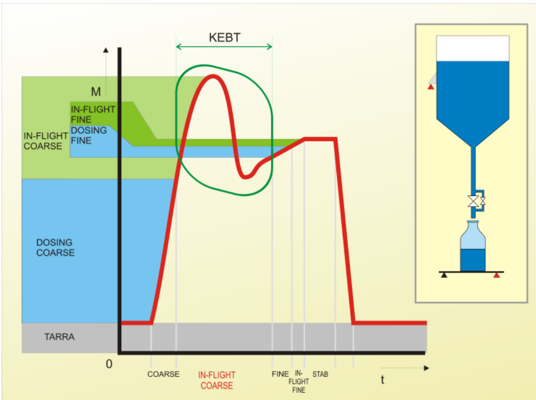

Figure 5: Kinetic Energy Blind Time (KEBT)

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. Doing in this way 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.

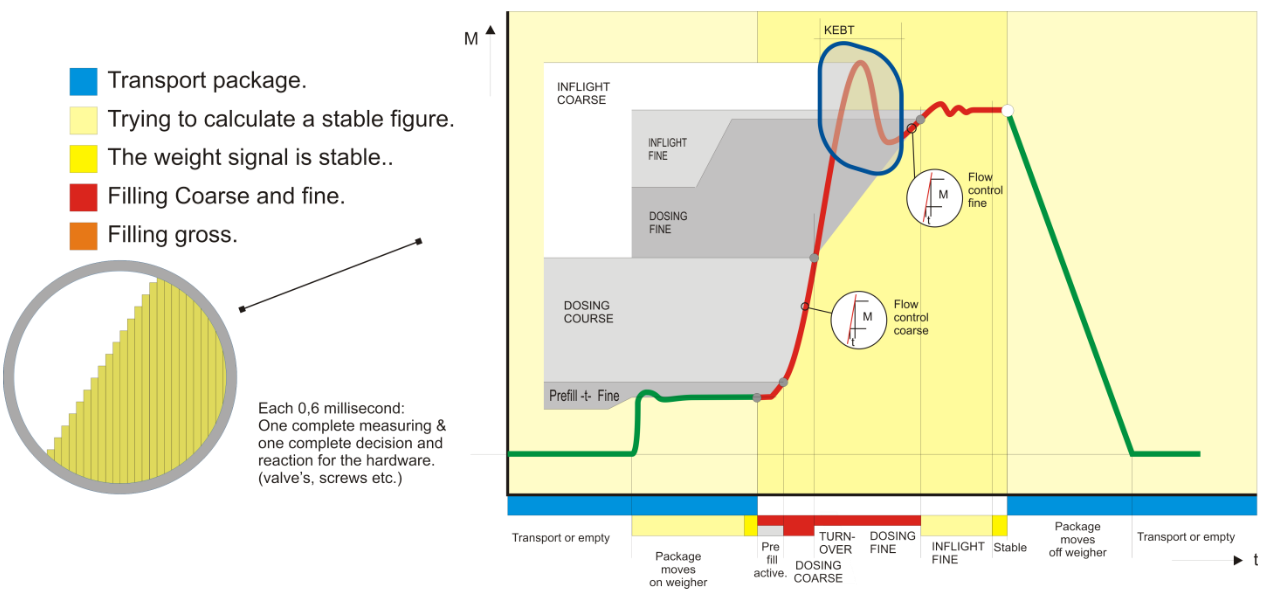

Figure 6: A Complete Gross Dosing Sequence.

Figure 7 below shows a complete net dosing sequence. The sequence shows the following elements:

- 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.

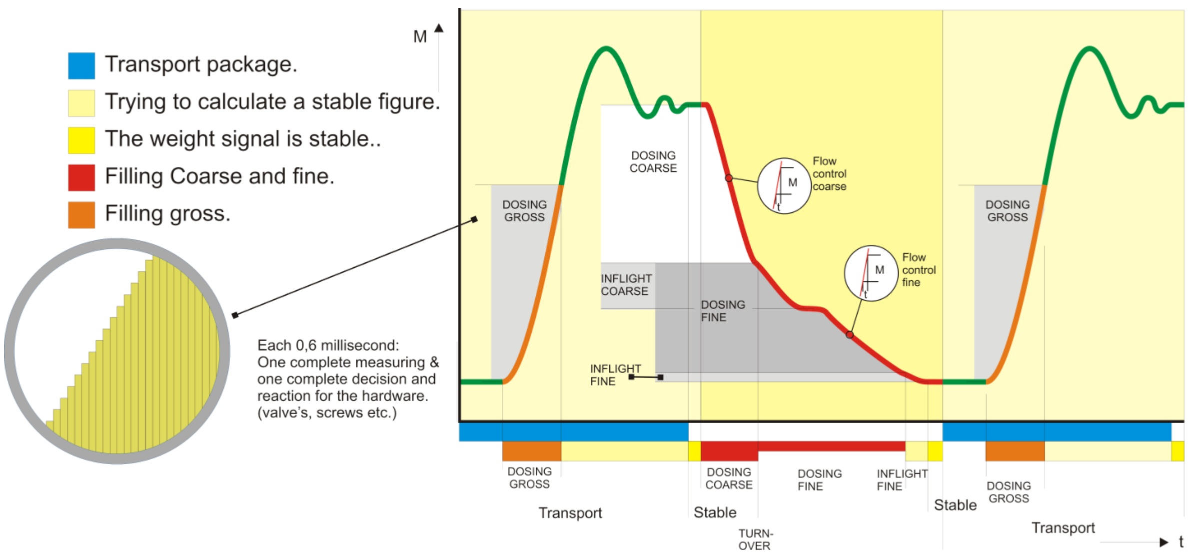

Figure 7: A Complete Net Dosing Sequence

Specific characteristics of filling liquids

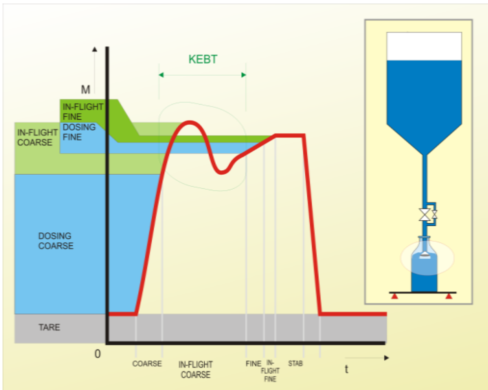

Figure 8: Spreading Liquid during a Fill Process

A typical problem occuring during a coarse dosing faze when filling liquids, is that during the filling process, the liquid moves upwards through the bottle neck with the same speed as the liquid is being dosed.

This can be prevented by using a spreader as shown in Figure 8. This result in spreading the liquid during the filling process and thereby avoicing the "back splash".

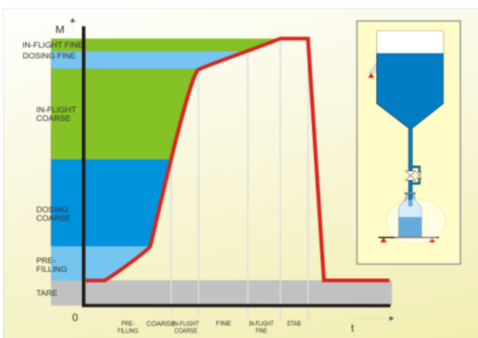

Figure 9: Fine-Coarse-Fine Filling

However, some liquids cause foaming when using a spreader. In this case – as seen in Figure 9 - it makes sense to fine dose first, until the bottom of the bottle is covered and then to commence with the usual coarse and fine cycle.

When, in spite of using a spreader, or when starting the fill process on a 'fine' cycle, the liquid still creates foam, the solution is to fill the bottle from the bottom up. This means that the process begins with coarse filling whereby the fill-needle initially descends to the bottom of the bottle and moves upwards slowly as the filling proceeds. This is shown in in figure 10.

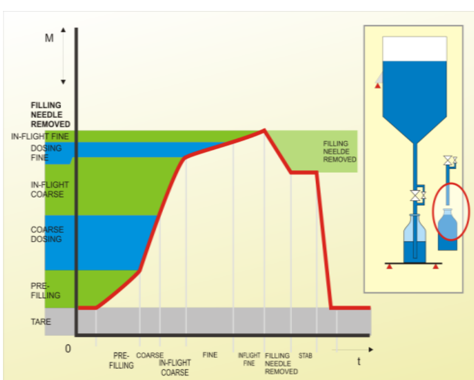

Figure 8: Bottom-up Filling Process

Controllers can regulate this lift relation to the filling speed. If required this procedure can be integrated in a fine- coarse-fine dosing cycle. The Archimedes principle is responsible for a possible misreading if the needle is not pulled up in perfect relationship to the fill volume.

The Archimedes'principle states that the volume of the needle under the liquid surface multiplies with the density of the liquid, thereby giving an incorrect volumetric measure. Optically, it appears that the liquid volume reduces during the fill process as the needle is extracted from the bottle.

This requires the necessity of a "negative in flight" correction. In spite of this correction, bottom up filling prooves to be less accurate, resulting in a bigger standard deviation. This is caused by differences in the size of the needle under the surface as for example, liquid starts sticking onto the tube.