Engineering White Paper

FILLING SYSTEMS FOR LIQUIDS, ≤ 10 KG
PENKO ENGINEERING B.V.

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. Packages for trade may be filled according to a defined weight, or the packages can indicate the actual net weight of the content. This white paper focuses on packaged liquids in units smaller than 10kg.

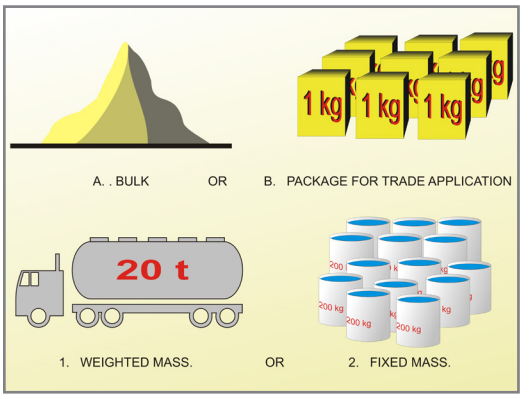

Figure 1 Productcan be sold in bulk or in small packages

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 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 76/211/EEC dated January the 20th 1976 “on the approximation of the laws of the Member States relating to the making-up by weight or by volume of certain prepackaged products” has been brought to life and applies to packages of up to 10kg and is based on average weight. Though the aim of directive is removing barriers to trade by standardizing and controlling of goods inside in Europe, the e-mark principle is beneficial to any process manufacturer, guaranteeing real savings on raw materials and finished product. Over or under filling of packages is reduced 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 EU-directive.

In spite of the fact, the directive prescribes the sales of liquids based on volume, filling on weight is advisable. There is no need to take differences in density into account. Changes in temperature and aeration haven’t influence. Moreover weighing instruments are more accurate and there is no need to recalculate the volume to 20 °C.

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.

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International trade applications make legal requirements obligatory. These rules are defined by the worldwide organization OIML (International Organization for Legal Metrology) recommendation R61. In Europe, the MID (Measurements Instruments Directive) 2014/32/EU is applicable, whiles the NIST Handbook 44, edition 2014, covering mass filling instruments in chapter 2.24 applies to the United States. For the contents of prepackages OIML recommendation R87 of 2016 is applicable. The required filling accuracies according to the MID, appendix VIII, chapter III, table 5, are as follows:

Value of the mass of the ills, F (g)	Maximum permissible deviation of each fill from the average class X (1)
m ≤ 50	7.20 %
50 < m ≤ 100	3.6 g
100 < m ≤ 200	3.60 %
200 < m ≤ 300	7.2 g
300 < m ≤ 500	2.40 %
500 < m ≤ 1 000	12 g
1 000 < m ≤ 10 000	1.20 %
10 000 < m ≤ 15 000	120 g
15 000 < m	0.80 %

This tabel is similar of the one of OIML recommended in R81 and R61

TYPES OF FILLERS BASED ON WEIGHT

Since packaging or filling liquids requires a different approach to filling solids, and one needs to distinguish between non-automatic and automatic filling processes, taking various elements into consideration. Also, the filling process is distinguished between automatic and non-automatic filling.
During the non-automatic filling process, the final weight of package content is determined by an operator, while during an automatic filling process this is done by a machine.

In accordance with the directive, filling packages of ≤ 10kg is done based on average weight.
We therefore distinguish between 2 major filling processes:

1. Net fillers: the mass is dosed into a container and weighed prior to being dumped into an emptypackage.
2. Gross-fillers: the mass is dosed directly into the package and then weighed.

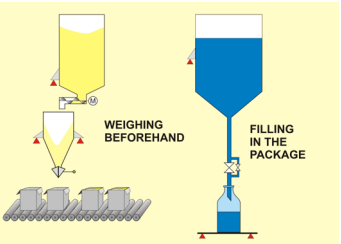

Figure 2
Net Filler *Gross Filler*

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The weighing accuracy rarely is the problem. In most occasions the weigher very accurately shows the deviations, caused by the other components of the filling system. The spread therefore largely is due to the combination of feeding speed/measuring speed and the product characteristics. Based on a few examples, completed with mass/time graphs, we explain the factors that determine the spread. When the preset weight is reached, the filling controller stops the supply. At that moment still material is on its way, a pump does not stop at once and a valve cannot close immediately. That is why the final weight is above the preset weight. Limiting this inflight reduces the spread.

That brings us to figure 3. With a coarse/fine arrangement, as you can see, the inflight can be reduced. By doing so you limit the fluctuations in inflight and in spread.

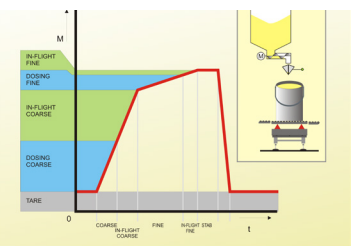

Figure 3 Filling course and fine

If the material is supplied very rapidly when dosing coarse, it is conceivable that the kinetic energy of dosing coarse exceeds the fine range, see figure 4.

In this case, special provisions are necessary to prevent premature switch off. Despite the aforementioned complication remains the combination of high filling accuracy with sufficient capacity.

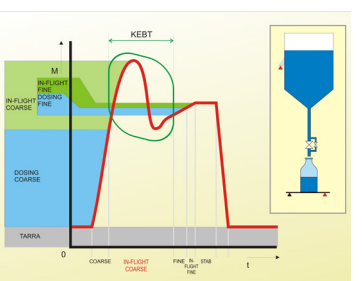

Figure 4 Effect of kynetic energy

Figure 5 shows the filling of bottles. A problem here may be that the liquid dosed into the bottle during dosing coarse blows through the neck with the same speed. This can be prevented by spreading the liquid. This result in spreading the liquid during the filling process and thereby avoicing the “back splash”

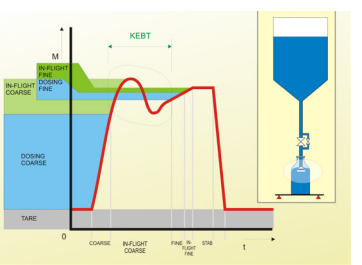

Figure 5 Filling and spreading the liquid

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However, some liquids cause foaming when using a spreader. In this case – as seen in Figure 6 - 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.

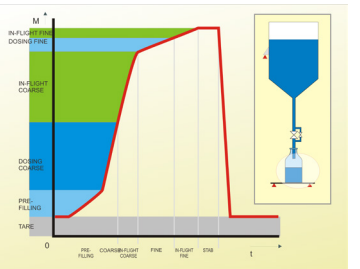

Figure 6 fine coarse fine Process

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 fillneedle initially descends to the bottom of the bottle and moves upwards slowly as the filling proceeds. This is shown in in figure 7.

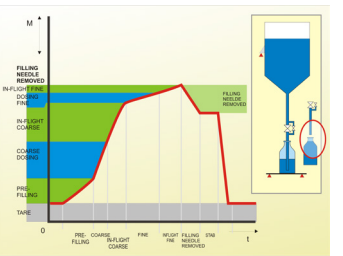

Figure 7 Bottom-up Filling Process

Controllers can regulate this lift in 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 misreading as the needle is partially covered by liquid. The Archimedes'principle states that this misreading is the volume of the needle under the liquid surface multiplied with the density of the liquid, so causing an incorrect weight info. Optically, it appears that the weight reduces when after the fill process 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.

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FUNCTIONAL REQUIREMENTS: NET FILLER CONTROLLER

- Positive(in)/negative(out) weighing
- Negative weighing checks stock
- Fill-time control with alarm
- Coarse/fine dosing with optional analogous speed regulation
- Active in-flight calculation/package – or passive inflight calculation/lot
- Control on tolerances
- Signal “weighing ready/release discharge”
- Store and/or print filling results

SOME DESIRABLE BUT NOT MANDATORY EXTRAS INCLUDE:

- Automatic stock replenishment
- Display a “dosing active” signal
- Automatic weigher unload, includes package check
- Restart option

FUNCTIONAL REQUIREMENTS: GROSS FILLER CONTROLLER

This includes bottles, drums, and buckets

- Check for package present
- Check package empty
- Control fill time and set alarm
- Coarse and fine dosing with optional analogous speed regulation
- “top-up” fill if required
- Active tare and in-flight calculation/package – or passive tare and in-flight calculation/lot
- Control on tolerances
- Signal “weighing ready/release discharge
- Store and/or print filling results

SOME DESIRABLE BUT NOT MANDATORY EXTRAS INCLUDE:

- Display a “dosing active” signal
- Move filling needle up or down; allows for “bottom-up” filling
- Automatic repeat filling program or repeat filling program after release
- Check stock
- Lift or lower packages from conveyor system
- Up/down control of filling needle for “bottom-up” filling.

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COMPETITIVE ADVANTAGE

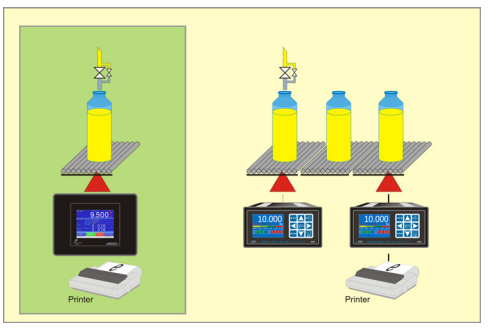
A filtering system, using a measuring system with high internal resolution in combination with the fastest possible speed, offers an immensely accurate control system. It filters out unwanted mechanical noise and takes much more samples per second, inevitably resulting in a smart way of weighing for any industrial operational environment.

Certified and approved instruments will give the manufacturer a competitive advantage to distribute products across the European region and promises customer satisfaction time on time.

Saving on filling time, by means of a fast and accurate process, as well as saving product or raw material due to precise quantity filling, manages wastage, spilling and unwanted pollution of the process line. Any system down time for cleaning and/or maintenance results in undesired losses in revenue, while product and material savings add up directly to bottom line.

PRODUCT SOLUTION

Sophisticated state-of-the-art filtering processes allow PENKO instruments to excel in these applications. All instruments are certified with an accuracy of 10.000d and approved in accordance with the MID directive and OIML recommendation R61. Unique software, providing an e-mark protocol, is available for registration purposes. The software allows for data to be sent directly to a printer or alternatively to a centralised storage base on a personal computer as an e-mark registry. This process eliminates expensive and time consuming check weighing and allows for easy export into the European Economic Area (EEA).



In an event where filling on average weight is not permitted, this feature still offers an excellent data analysis opportunity on filling results.

As a matter of course, PENKO instruments are equipped with a high resolution filtering system using a measurement system with an internal resolution of 24bit, combined with high measuring speed of 1600 samples per second, what results in an immensely accurate controlling system.

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SGM800

The SGM800 range of digitizers/controllers is a compact device for use as standalone controllers in network configurations, fulfilling a specific filling function. Models offer either 3 inputs or 4 outputs except for the SGM810 which only has one analogue output. Depending on the requirements, various models are available including portal Ethernet (TCP) with protocols Modbus, FINS, Ethernet-IP and ASCII, portal RS232/422 with protocol Modbus and ASCII as well as portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration-software. PENKO devices can be connected using Ethernet (TCP), CAN, RS232/422 and USB portals.

Model 1020:

The basic indicator is compact, durable and user friendly. It offers 3 inputs and 4 outputs as well as Ethernet and USB communication portals. As an option the 1020 allows for an analogous output and various communication portals including RS232, RS422/RS485, CAN Interface and Profibus-DP.

Model FLEX 2100

This three-in-one device combines a stunningly-simple touchscreen interface, a core of sophisticated hardware and a clever calibration system. It offers 8 inputs/8 outputs, communication via RS232, RS422/ RS485, CAN interface, Ethernet-IP and USB. Additional options are analogue output and Profibus.

Model FLEX

This most versatile apparatus is an all-in-one compact, reliable and user friendly indicator/controller, suitable for automatic and non-automatic weighing. The FLEX has an integrated PLC, offers an expandable number of inputs/outputs including remote I/O's; its communication portals include RS232, RS422/RS485, CAN interface, Ethernet-IP and USB, making it highly suitable for complex weighing applications. Digital and analogue inputs/outputs are optional, as well as Profibus-DP communication. The FLEX range has all the features of the models 1020 and FLEX-2100.

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CONCLUSION

PENKO instruments control the filling system and the checking application all in one. All PENKO systems are “Slave” systems.

Filling packages to correct and specific weights while adhering to legislative regulations in the most effective way, remains a challenge throughout the processing industry and will vary from one manufacturer to another. Consideration not only needs to be given to over/under filling challenges, but each product – particularly natural products – has its own specific weight what influences the packaging process.

At PENKO we understand that there is no “one-size-fits-all” solution. We engineer the most efficient way per industry, per product, per manufacturer, working out the best and most effective way this can be done.

For Non Automatic Weighing Systems, Check Weighing Systems, continuous totalizing with Loss-in-Weight and Belt Weighing, discontinuous totalizing with Hopper Weighers, Grading Systems by means of Weighing and Batch Control on Weight for Mixing Plants,

Please read the related White Paper found on our website.
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