Engineering White Paper

MIXING CHAMBER CONTROLLERS
PENKO ENGINEERING B.V.

INTRODUCTION

This White Paper discusses the challenges, options and solutions for process manufacturers creating mixtures out of several components, raw materials, for the consumer and/or processing industry.

PURPOSE OF WHITE PAPER

…is to explain why it is important to create mixtures out of components in the correct amount. Whether a dosing system is automated or non-automated, or whether it is of industrial proportion or simply a small system on shop level, similar challenges regarding accurate dosing apply which have a direct effect on cost and profit margins for the process manufacturer. Overdosing as well as under dosing directly influences the ratio between the components. As a result a wrong composition, so an end product with a poor quality, even might cause disapproval of the batch. So inaccurate dosing results in rejected batches, what means profit loss, product spillage, delayed shipments, unhappy customers and may even cause a legislative fallacy.

In addition to such losses, there is the added argumentation of operating inside a quality management system, the international legislation on product safety and, where it concerns products in the nutrition chain, the need for a tracking and tracing system from the beginning to the end.
The advantages of fast weighing (PENKO instruments weigh at 1600 samples per second) are faster throughput, less spillage, continuous processing possible – leading to fast ROI

BACKGROUND ON DOSING CONTROL

Controllers for dosing processes are designed to ensure the exact amount of mass per raw material is dosed. This dosing process is usually found in the “kitchen” of any given process flow. Though there are no legal requirements, every processing industry has its own quality requirements, supervised by a management system and accordingly controlled by qualified measuring instruments. The ever increasing cost of materials, growing stringent environmental regulations, consistent quality and tracking and traceability, are insisting that process industries pay more attention to their quality conformity. The basic and most reliable measuring method to warrant all of the above is still defined by weight, regardless of whether the product is a liquid, a solid mass, granules or a powder, and gasses.

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Weight provides, from a chemical point of view, correct data. Each type of molecule has its own specific mass. So by weighing you are in a way counting molecules. It does not matter if you are preparing a mixture, filling packages or charging or discharging bulk material, the weight always is the truth. This way you are excluding a number of factors, such as:

1. temperature influences (expansion respectively shrinking).
2. compressibility.
3. changes in density.
4. aeration.

As a standard any component should be controlled within a 1 % accuracy. This means the size of the smallest component in a batch has to be ≥ 100 d (d is the unit of indication). Below this value a second weigher with a corresponding capacity must be selected.

For batching the choice is out of weighing/dosing:

a. in the mixer

When the dosing takes place in a mixer process and production requirements can make it necessary to dose whilst the mixer is rotating. The rotation will cause vibrations which will be noticed by the weighing system. To mass measuring systems with strain gage load cells vibrations only will cause damage when the amplitude of the vibration exceeds the carrying capacity. But influence on the measuring result, instability, will be noticed. Digital filters will eliminate this effect noticeable. Controllers offer the facility to mix during dosing coarse and stop the mixer at the start of dosing fine. Disadvantages of this plant lay out are;

1. the dead weight of the mixer might require a high carrying capacity, so less absolute accuracy,
2. during dosing the mixing time will be limited and vice versa.

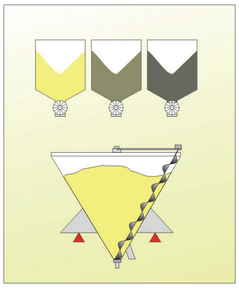

Figure 1, dosing directly into the mixer

b. in a separate hopper weigher before the mixer

This requires more height, the raw materials must be stored higher above the mixer. Advantages of this way of operation are;

1. time delays are avoided,
2. limited dead weight improves the accuracy.
3. no separate means of transport is required.

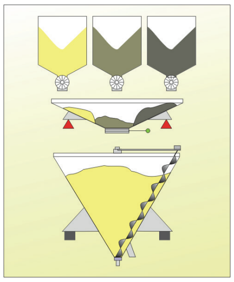

Figure 2, dosing in a hopper weigher

c. on the conveyor to the mixer.

The routing of the raw materials to the mixer not always permits dosing directly into the mixer on gravity or, before the mixer, into a hopper. This makes a separate means of transport necessary. Many means of transport, such as belt conveyors, can easily be made weighing. As a matter of course the means of transport should have sufficient space for one batch. Advantages of this way of operation are;

1. time delays are avoided,
2. a special weighing device is superfluous,
3. the limited dead weight improves the accuracy,
4. the means of transport is more efficient utilized.

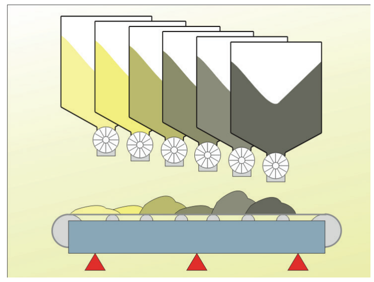

Figure 3, dosing on a belt conv

An alternative for this example is the combination of automatic and manual operations, as showed in this picture:

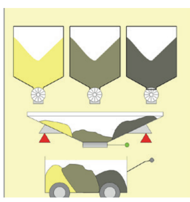

Figure 4, automatic dosing before manual processing

Negative dosing is another option, as showed for two liquids in this picture.

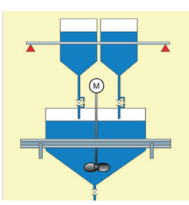

Figure 5, negative dosing of liquids out of a common weigh frame

As a matter of course all kind of combinations are possible, such as

1. a combination of solids and liquids.

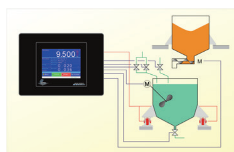

Figure 6, a dosing system for the combination of solids and liquids

2. dosing combined with a pneumatic conveyor system.

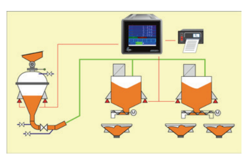

Figure 7, automatic dosing combined with a pneumatic conveyor system

3. a complete dosing and mixing plant with sand, gravel, cement and water for concrete.

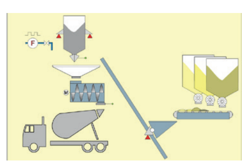

Figure 8, a complete dosing and mixing plant for concrete

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For a good dosing result the feeders must have a capacity in accordance with the indicator, the speed of measuring and the required accuracy. At the moment the weigher reaches the set point, a certain amount of material will be on its way. That's because of feeders don't stop immediately, valves don't close directly and some material is in the air. This amount of mass fulfils the free fall formula:

$h = ½ g.t^2$

in which

h = height.

g = acceleration of the free fall.

t = time.

So the time during which the material is falling is:

$h = ½ g.t^2 \Rightarrow t = \sqrt{(2h/g)}$

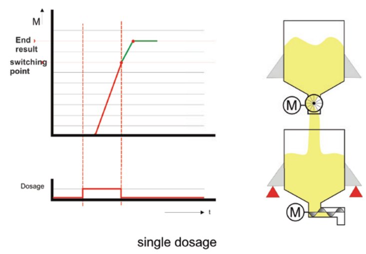


Figure 9 origination of in-flight

This means the amount of in-flight is straight away dependent of the square root of the height. Of this value we must deduct the apparent mass, caused by the kinetic energy, absorbed by the weighing system. As the kinetic energy is equal to the potential energy, it is:

$W = m.g.h.$

So the kinetic energy is directly related to the height and the falling mass.

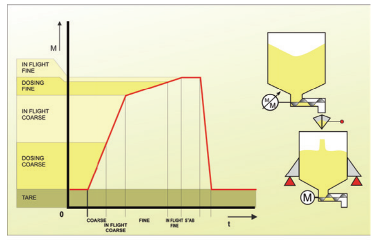
At landing this energy is converted into heat. Apart of that the weighing system notices a force, which is indicated as a mass. The difference between both effects can be positive, exceptionally zero, or negative. Usually however you will see a positive influence, as indicated in the figure.

The start-up has no effect on the dosing accuracy. The time, needed to stop, may be neglected for most valves as well as for motors with an electric or mechanical brake. So this we don't incorporate into the approach.

The real problem is the height the material is falling nor the mass flow is constant. This is by example caused through the differences in static pressure on the discharge opening for liquids and the flow characteristics for powders; for both types the required amount is a cause. As they directly affect the capacity, the influence of the viscosity of liquids and the flow characteristics of powders are troublesome. Specific for powders is the height they fall being affected by the cone of the weigher.

In order to achieve a high production in combination with an acceptable accuracy it is a necessity to reduce the amount of in flight. This can be done by dosing fine at the end of the sequence. This reduces the dosing error.

When dosing liquids a coarse/fine dosing is created by means of valves with a big and a small opening, or with a big by pass and a small one. For granulates and powders one can apply frequency controlled dosing equipment such as rotating valves, screws and feeders.



DOSING COARSE AND FINE

Figure 10, reduction of in-flight by dosing coarse and fine

The figure graphically shows the relation between mass and time in a dosing sequence. Very clear is the variable influence, the in-flight, in the fine compared with the coarse dosing has been reduced substantially. The minimum required amount in the fine dosing has to be the sum of the in-flight in the fine and the coarse dosing. The production capacity improves when the components are dosed in a sequence, similar to the mass. This reduces the average in-flight and so the time for the fine dosing. In today's dosing controllers an automatic in-flight correction, self-learning, is a standard. Just as the switch over to fine dosing this is related to the set point of the component. In spite of this it makes sense to consider these design criteria. A reduction of the bandwidth of the in-flight in general improves the dosing accuracy.

The next figure graphically shows how the dosing in a sequence of three components takes place. It clearly shows how one component influences the next one. In this example product 2 has a lack whilst product 3 gets an overdoses. Apart of that the relation between the components is disturbed. This underweight can be prevented by dosing the net selected mass of each component, from 0 off.

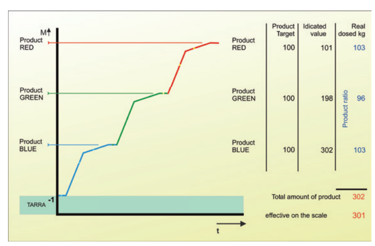


Figure 11, cumulative, gross, dosing of three raw materials

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In other words, at the moment the feeder starts, the weighing system calculates from a zero level off what needs to be dosed. When we compare the previous figure with the next one we see the huge advantage of this way of operation. Each component only has one dosing error instead of two. Moreover the ratio between the components is better maintained what means an improved end product.

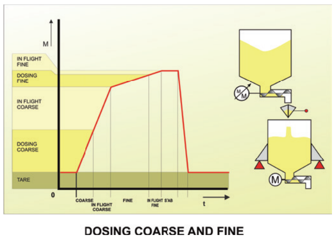

Figure 12, nett dosing of three raw materials with automatic taring

Prefer prevention above curing.
Where most quality control systems aim to register exactly and eventually cure afterwards the mistakes made, PENKO weighing goes for prevention. The connection between the BCS quality control system and the dosing controller(s) takes place on the following areas

- production planning.
- formulas.
- reporting.
- administration of used raw materials.
- control of the raw material stock.
- variable storage of raw materials (silo register).
- production orders.
- establishment of the sequence in the formula.
- reporting of the raw material day program.
- register of manual additions.
- traceability of the mix.

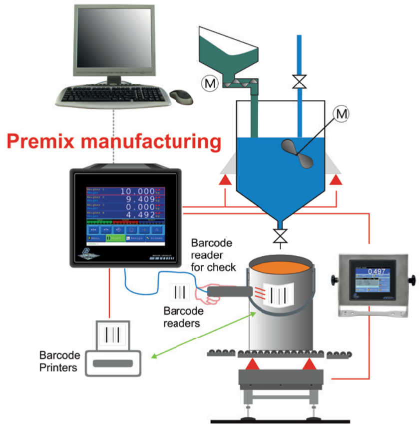

Figure 13, preparation of a semi-finished product.

By means of such software modules the personal computer is the ideal man/machine interface and a solid start for a quality control system. Moreover the management possesses at any moment full information about the production process and the material flow.

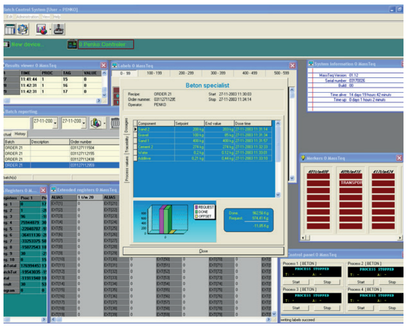

Figure 14, example of the presentation of production datas

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DOSEER/MENG-OPLOSSINGEN

Functions, FLEX-2100 en FLEX

- Positive(in)/negative(out) weighing
- Dosing net or gross
- Coarse/fine dosing with optional analogous speed regulation
- Active taring and in-flight calculation
- Control on tolerance
- Dosing time control and set alarm
- Mixing time control
- Repeat a dosing sequence
- Control of all kind of analogous signals
- Control of manual additions
- Manual interventions with interlock
- Monitoring of valve positions
- Overload protection
- Level control of raw materials in silo's and/or tanks
- Routing of raw materials
- Routing of premixes
- Additional processing, such as cooking, drying and so on
- Control of other measured values, by example temperature and pressure
- Store and/or print dosing results
- Automatic repeat of the dosing/blending sequence or repeat program after release

installation for the production of concrete.

system for the preparation of confectionery.

BCS extra's include:

- Registration of operators
- Raw material stock control
- Silo register, interchangeability of material per silo
- Library with formula's
- Day production programs, number of batches per formula and required sequence
- Interruption facility in the day program
- Tracking and tracing
- Batch reports
- Report of additional process parameters
- Alarms registration
- Macro's, preprogrammed standard process sequences

mixing plant for dairy products

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COMPETITIVE ADVANTAGE

A high resolution filtering system combined with high speed – high accuracy measuring, offers smart weighing results for any operation environment.
All instruments are designed and manufactured with an accuracy of 10.000d. The combination of measuring at high speed (1600 conversions/s) with a high internal resolution (16.777.216), smart filters and sufficient computing capacity, make the SGM700, 1020 and the FLEX range suitable for any dosing, mixing and blending application. The combination of the high resolution and conversion speed guarantees the best achievable weighing accuracy, even when dosing at high speed, and thus prevents wastage because of wrong compositions.

PRODUCT SOLUTIONS

SGM700

The SGM700 range of digitizers is a compact device for use as standalone converter between the load cell(s) and any PENKO controller. A selection can be made, depending on the model, out of 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 between PENKO devices are available on Ethernet (TCP), CAN, RS232/422 and USB portals.

RIO700 EN RIA700.

Type RIA700 and RIO700 are universal, compact, remote I/O sets, meant as extension for the controllers FLEX and FLEX-2100. For mapping to the controller no software changes are required. The display shows the live input and output status. When the connection fails, the display shows an error and the outputs are switched off. The RIO and RIA 700 are easy DIN-rail mountable. They can be used single or as a buslink system. Up to 40 RIO/RIA's can be coupled into one buslink system. RIO700 offers 8 digital inputs and 8 digital outputs, RIA700 4 analogous inputs and 2 analogous outputs.

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PENKO
an ETC Company

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 communication portals including RS232 and RS422/485 with protocol Modbus and ASCII as well as optional portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration software between PENKO devices are available on CAN, RS232, RS422/485 and USB portals

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, an integrated plc, communication via an Ethernet (TCP) portal with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232, RS422/RS485 with the protocols Modbus and ASCII. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422 and USB.
Additional options are an analogue output and a portal Profibus with protocol Profibus-DP.

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 an Ethernet (TCP) portal with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232 and RS422/RS485 with the protocols Modbus and ASCII, as well as optionally a portal Profibus with protocol Profibus-DP. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422, and USB, making it highly suitable for complex weighing applications. Digital and analogue inputs/outputs are optional.
The FLEX range has all the features of model FLEX-2100.

Model FLEX MultiChannnel

This most versatile apparatus possesses all the features of the models FLEX and FLEX-2100 with additionally the capacity to control up to four weighing systems in one instrument simultaneously and, where necessary, cross linked.

CONCLUSIE

PENKO instruments control the dosing system(s) as well as the mixing application all in one. All PENKO systems are “Slave” systems.

Preparing mixtures to correct and specific weights within the requirements of a quality management system in the shortest time possible and 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 challenges of the prevention for wrong compositions, but each product – particularly natural products – has its own intrinsic weight and volume that influences the dosing and blending process.

To engineer the most efficient way per industry, per product, per manufacturer, there is no “one-size-fits-all” solution. Engineers at PENKO work out the best and most effective way this can be done.

Following White Paper will discuss Non Automatic Weighing Systems, Check Weighing Systems, Filling Systems, continuous totalizing with Loss-in-Weight and Belt Weighing, discontinuous totalizing with Hopper Weighers and Grading Systems by means of Weighing.

For more information: www.penko.com