Engineering White Paper

MIXING CONTROL IN CONCRETE PLANTS
PENKO ENGINEERING B.V.

INTRODUCTION

This White Paper discusses the challenges, options and solutions for manufacturers creating concrete mixtures out of several components, raw materials, for the building industry.

PURPOSE OF WHITE PAPER

…is to explain why it is important to create concrete 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 concrete. So inaccurate dosing results in rejected batches, what means profit loss, product spillage, environmental pollution, 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, as it concerns products for the building industry, the requirements for constructions. This explains 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 and a consistent quality– leading to fast ROI

RUDIMENTARY

The basic element of construction for decades has been concrete. The name is derived from the Latin root word “con-crescere”, which is made up of the word “con” meaning together and “crescere” meaning to grow. It seems therefore logical to deduct that the word concrete implies growing by bringing together.
The idea behind concrete is to create buildings of any shape made of solid rock. For this purpose coarse gravel is used. The cavities between the particles are filled with fine gravel and the remaining holes with sand. This mixture is far from solid, but a “glue” of some sort is required to keep it all together. This is where Portland cement finds its use. Mixed with water the cement starts a hardening process, the combination forms long calcite crystals, effectively binding the sand and gravel to a durable and solid “stone”. This hardening process requires a few hours, which makes it possible to pour the gravel/sand/cement/water mixture into a mould of almost any shape and any size.

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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. Apart of the legal requirements for constructions, every concrete mixing plant might have 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.

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 what type of mixture you are preparing, 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 dosed within a specified accuracy. This means the size of the smallest component in a batch is critical. Below a certain value a second weigher with a corresponding capacity has to be installed.

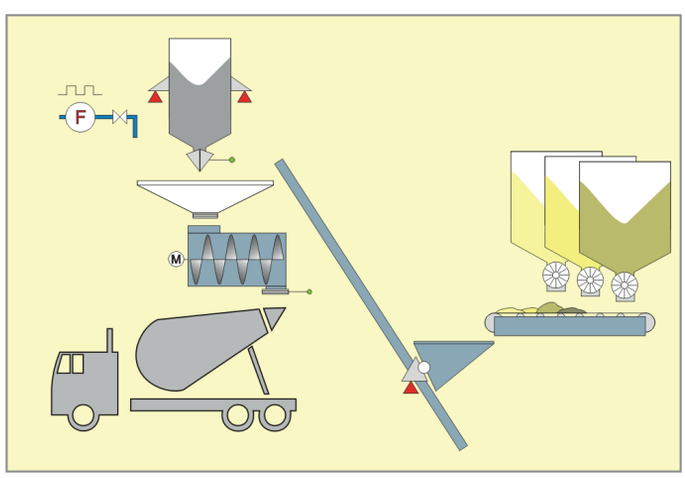

Figure 1, A complete dosing and mixing plant for concrete, using sand, gravel, cement and water.

The following, see figure 1, outlines in some detail the process sequence required to ensure consistent quality of a concrete mix. The schematic drawing describes the step by step process” veranderen in”The schematic drawing describes the process step by step

Belt Conveyor

On the right hand side figure 1 shows the belt conveyor transporting sand and gravel to the skip. In practice, the belt conveyor often includes a weighing section which is mounted on load cells. The advantage of this is twofold: firstly, due to the reduction of inflight, the dosing is more accurate and secondly it saves time as the dosing can start while the skip is on its way up and before it is in position.

Cement weigher

In the cement weigher, at the the top of figure 1, cement is dosed by means of a valve. The weigher is located on the top of the mixer. Cement is not only the most expensive component of a concrete mix, it is essential for the quality what requires accurate weighing.

Water dosing

In this drawing the water, left of figure 1, is dosed through a flow meter giving impulses per unit of volume. The controller counts the impulses. A weighing tank could be a perfect alternative instead of a flow meter. The benefit of a weighing tank over a flow meter is that temperature is of no concern. It also reduces the number of different measuring systems. On the down side however, it takes up more space.

Humidity measurement

While the humidity measurement is not shown on the drawing, it can reasonably be assumed that sand will contain a variable amount of moisture. To maintain a consistent concrete quality the formula for sand and water has to be adjusted to compensate the moisture contents in the sand. This measurement is done by means of a probe in the mixer or the storage hopper for sand measuring the resistance of the sand.

The value of sand mass in relation to the water content is determined and used for recalculation. The correct ratio is paramount to ensure an optimal hardening process. Too much water will flush the cement out of the mixture, while too little water will prohibit a successful binding process.

Weigher(s) for additives

In addition to the basic elements of a concrete mix, i.e. gravel, sand, water and Portland cement, a number of chemicals such as dyes or accelerators for the hardening process can be added, see figure 2. To allow for adding of small quantities, additional weighers, consisting of three or four small tanks or hoppers, are placed in one weighing frame. From here material is discharged directly into the mixer. Meticulous dosing of these additives is imperative, the amount has a high influence on the quality of the concrete, they are usually quite expensive and only small quantities are needed.

Mixer

Concrete mixers such as depicted in the centre of figure 1, are heavy machines with two motor drives for the mixer star and tub. Moreover the discharge valve has a hydraulic drive. Because of their size, and to prevent for start-up effects, the mixer starts early in the morning and runs until production stops in order to prevent mixtures from hardening in the tub. Careful cleaning is required.

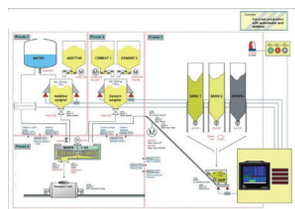

Figure 2, A concrete dosing and mixing plant, having an internal transportation system, with weighers for sand, gravel, additives and cement.

Transport of the mixture

As showed in figure 1, the mixture can be discharged directly into a mixer-truck for transport to a building site. In the case where concrete is mixed within production processes, the overhead rail system driven wagons are used to transport material to moulds, see figure 2. At the moulds, HMI's (Human Machine Interfaces) are used to control the ordering of mixtures.

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.
- production orders.
- establishment of the sequence in the formula.
- reporting of the raw material day program.
- register of eventual manual actions.
- Tracebility of the mix

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.

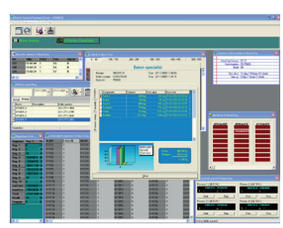

Figure 3, An example of the presentation of production data.

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DOSING/MIXING SOLUTIONS

Functions, FLEX-2100 and 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 mixing time
- Control of other measured values, by example humidity
- Store and/or print dosing results
- Automatic repeat of the dosing/blending sequence or repeat program after release

Photo 1, Discharge section of a concrete mixer.

Photo 2, Dosing hopper for cement.

BCS extra's include:

- Registration of operators
- Raw material stock control
- Silo register, 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

Photo 3, Fork lift truck for internal transport of mixed concrete.

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

MODEL 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.

MODEL RIO700 AND 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 RI0/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.

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.

CONCLUSION

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

Preparing concrete 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 building 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 those determining the safety of buildings, such as supporting structures – have their own tolerances that influence directly the requirements on the dosing and mixing process.

To engineer the most efficient way per application, 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