



Quality concrete by process optimisation

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Moisture measurement technology from the Black Forest – tried and tested throughout the world

Concrete has long since developed into a high-tech product. Modern concrete works no longer rely on experience because different concretes have need special, accurately calculated recipes. Today, the latest technology is being used, such as the moisture measurement system from Arnold from Wutöschin-

gen-Degernau in Germany, to keep these constant and uniform. The sensors from this company operate on the basis of high-frequency capacitance measurement and calculate the moisture content even before the material is weighed directly in the silo or on the conveyer belt.

Company Founder, Gerd Arnold, stumbled on the enormous potential for automating concrete production plants more than 30 years ago when he was initially employed by a Swiss company for installing limit switches. While he was installing the switches, it soon became clear to the inventor that this industry was way behind in using technology to increase efficiency. Soon after this, he constructed his first concrete mixer for controlling the recipes – an advance unit with digital switches and programmable plain text.

From then on, the company course was set and it has focused its efforts on the concrete industry ever since. "Our concrete mixer led to a flood of orders. After that, we have concentrated solely on this sector and continued to specialize." Today, the Black Forest company is developing and producing moisture measurement systems and nothing else. It is making good progress, as the managing director, Walter Werne reports: "During the year, we have been

building up our stock of know-how in the area of capacitance moisture measurement, and this is appreciated by our customers all over the world. This not only concerns manufacture but also everything to do with the installation service. We accept the challenges on site and deal with the plant in question on an individual basis. Since we are a small team and intend to remain so, we are able to respond rapidly and flexibly in special cases."

Last year, 2002, thirty years after Gerd Arnold founded the company, Walter Werne and Andreas Thiel took over running it. It is now called Arnold automation Werne & Thiel GdB.R. Since 1997, the company has been certificated according to ISO 9001 and is also certificated for

the production of explosion protected moisture measurement systems.

Moisture measurement – a crucial factor in process optimisation

In order to remain competitive, modern concrete works have to rationalise the process as much as possible while continuing to supply high-quality products. For the mixing process, this means homogenising and delivering the largest possible quantity in the



Moisture measurement sensor on a carriage used on a conveyer belt



Moisture measurement sensor in a silo



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Sensor with knuckle boom for flexible adjustment on site

shortest possible time. Although this sounds simple, there are many variables to contend with. These include running costs, spare-part costs, service life, homogeneity of mix, data logging, shortening of the mixing cycle, definition of the target mix and the prevention of clump formation.

As well as this, the material flow chart, charging with aggregates and discharging of the mix must also be taken into consideration as must the space required, batching, measurements and the type of process control system.

Here, two parameters play a crucial role: the consistency and the moisture of the product and aggregates. This is because almost every material is either damp or has a residual moisture which stems from, factors such as, the admix of additives or the air humidity.

In concrete production, the water/cement factor has a decisive effect on the quality and strength of the product. The moisture content of the sand in particular plays a crucial role in keeping the recipe as constant and uniform as possible. The task of Arnold

measurement systems is to monitor these factors and respond appropriately. The sensors measure the water content during or even before the materials are weighed directly in the silo or on the conveyer belts. Installed in the sand silo or on carriages on the conveyer belt, the sensors measure the moisture in the relevant containers and send the data to the controller which then automatically regulates how much water is added to the mixer. In practice, several sensors are installed to optimise the controller - inside the silo for moisture measurement in the material stream of the discharge area or outside the silo in the material stream and on the conveyer belt and inside the mixer itself.

Over the years, Arnold has continued to develop its high-frequency capacitance moisture measurement system on the basis of on-site experience collected from the works with the aim of manufacturing a cost-effective, low energy, reliable and robust moisture measurement system. Lots of different types of information can be collected with the units in use today:

- the moisture and therefore the water content of the aggregates
- the moisture and homogeneity of the 'dry mix'
- the moisture and homogeneity of the 'wet mix'
- when the mix is homogeneous
- water batching behaviour (continuous or complete water addition) and
- when the silo or container is empty.

This information is an important aid to decision making in the production process. The entire mixing process can be monitored and recorded based on the parameters determined. The information also enables the water addition to be adjusted - either slowly during the mixing or all at once. Either of these two approaches will produce the optimum mixing time and homogeneity, depending on the mixer and the material in each case.

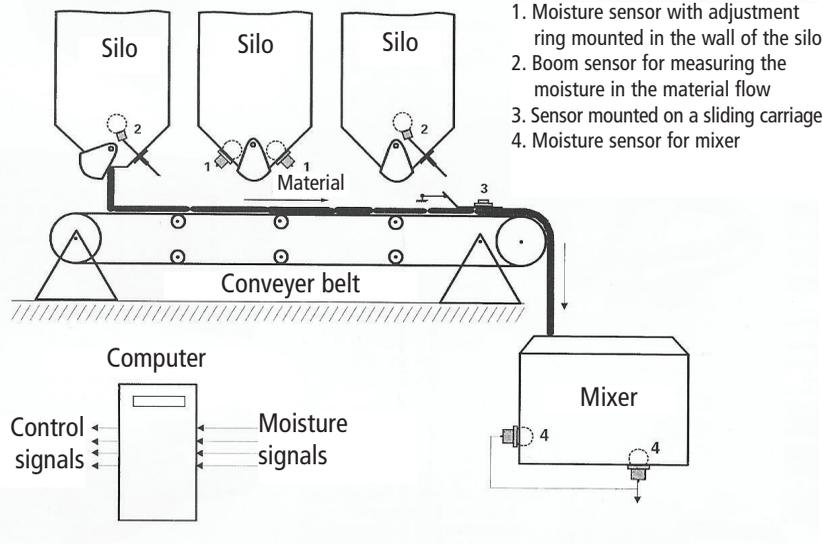
High frequency capacitance moisture measurement - accurate and reliable

Arnold moisture measurement systems operate on the principle of high frequency capacitance: the difference is calculated between the dielectric constant of water ($\epsilon = 80$) and the dielec-



Clearly indicated measurement values on the display

Installation examples:



Example of an arrangement of sensors at the concrete works

tric constant of the material. Most construction materials have a dielectric constant between $\epsilon = 3$ and $\epsilon = 10$. The proportion of water in the material being measured therefore yields a wide range of dielectric constants which can be calculated and highly resolved within the high-frequency capacitance measurement field. The signals obtained are evaluated in the electronic circuit of the sensor and output as a measurement signal (0-10VDC or 0/4-20mA) for the moisture.

For online measurement in the concrete works, the sensor is positioned so that the bulk material flows over it. Even when the material is fast flowing, a signal appears immediately - the sensor is immersed to a depth of 100-150 mm depending on the material. This means that not only is the water content picked up directly on the surface of the sensor but also a large cross section of the bulk flow is measured.

The analogue output signal of the moisture measurement sensor is either processed directly by the controller, PC or PLC during the process run or fed into an evaluation unit. The signal coming from the sensor can be processed by any software or hardware. In order for the moisture measurement systems to function properly, they must be calibrated once to the relevant material. The sensor is calibrated to the material being measured and to the installation conditions by using two reference points (dry and wet).

Conscious and correct installation is crucial for success

“Experience plays a crucial role, particularly with moisture measurement” said Walter Werne. “We have found that fundamental things have simply been done wrong, again and again. If I measure the moisture in the mixer things start to go wrong because water is already present in the sand. I must therefore make a sand/water correction beforehand.” The managing director has visited innumerable concrete works

and is therefore very familiar with the challenges on site and knows what is needed in terms of plant technology.

According to Walter Werne, a classic source of error is the position of the sensor during the installation. “The material density in front of the sensor must be uniform during batching - whatever method of measurement is being used. To avoid mistakes, it is only necessary to keep one essential fundamental principle in mind in moisture-measurement technology: none of the commonly used measurement techniques actually measures the proportion of water in a measurement medium but, instead, determines this property from various different physical effects. This also means that other, undesirable physical parameters may appear from things like density fluctuations, salt content or grading curve variations etc. which can affect the measurement.”

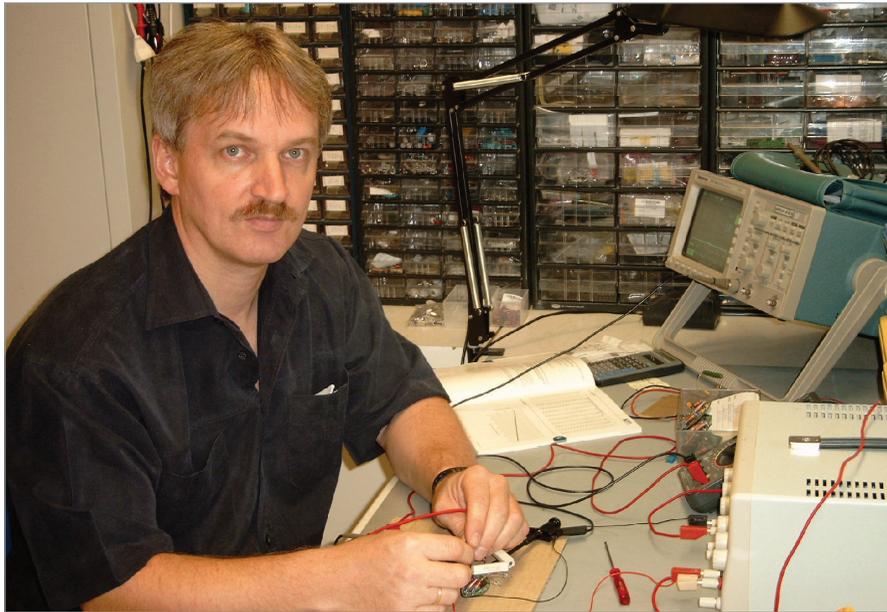
“With a high-frequency capacitance measurement system” continued Walter Werne “we utilise the fluctuations in an electric field which are caused by water molecules inside the measurement range of the sensor and these are then recorded and evaluated by the sensor’s electronic system as a moisture measurement signal. However, since additional field fluctuations can be caused by fluctuations in material density in the bulk stream and fluct-



A classic: FMG moisture measurement unit used in thousands of applications all over the world



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**In charge of development:
Herbert Siebold**

crucial for success. We therefore prefer to continue to specialise rather than grow in size."

Because of the company's on-site commitment, it has formed close customer contacts. Its technical competence has gained acceptance and is readily called upon. No wonder, since in many factories, the installation of an expert moisture measurement system has already paid for itself within a few weeks.

tuations in the air components between the sensor and the material being measured, it is clear why correct positioning of the sensor is crucial for reliable and accurate measurement."

Short routes - rapid solutions

The fact that the Black Forest company has never had a setback since it was founded is, not least, due to the inventiveness of the moisture measurement specialists. The numerous patents speak for the company's power of innovation. In order to remain efficient, the many routine jobs, such as the making of stainless steel sensor housings, are subcontracted to another company. "Our strength is research and development," said Walter Werne "and our ability to respond quickly to customer requirements. For us, this flexibility is



Company Founder Gerd Arnold with the first concrete mixer which he developed himself



The managing partner, Walter Werne (r.) and partner, Andreas Thiel

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