Just the right dose

Di Matteo's award-winning **ODM-Weightube** is novel concept for the accurate and efficient dosing of alternative fuels and other bulk materials. Here, the company's Dr. Dominik Aufderheide and Dr. LuigiDi Matteo, provide an insight.

The cement manufacturing process and all related transport and logistic systems are driven by strict requirements regarding the accurate proportioning of bulk materials from various sources. The corresponding integration of adequate parts of equipment requires the systematic selection of dosing and/or metering devices or scales. If the complete chain from the quarry and subsequent handling of raw materials to the dispatch of the final product in bags or as bulk cement is analysed, it is obvious that the applied dosing equipment needs to be able to handle a great variety of different types of bulk materials in terms of their general appearance (powdery, granular, flaky, fibrous etc.), their followability (free-flowing, cohesive, etc.), their granularity (size of smallest and biggest 2D or 3D particles) and their general bulk material properties (e.g. density, humidity, etc.).

Di Matteo developed since its establishment in 1961 an immense experience with the implementation of all kinds of proportioning devices for a great variety of bulk materials in numerous different application fields. From the efficient feeding of alternative fuels (AFs) (e.g. RDF, shredded tyres, sewage sludge, etc.), over the classical dosing of raw materials (limestone, clay, sand, iron ore, etc.) to the implementation of all kinds of weighing hoppers and silos, all types of possible projects were already successfully engineered and realised. Furthermore, the company acted also as a driver of innovation within this field, with the successful introduction of the award-winning patented new tubular gravimetric dosing system ODM-Weightube in 2010 *[1]* and the development of the modular and comprehensive ODM-GravitAS control platform and software library *[2]*.

Figure 1: ODM-Weightube RWS series

ODM-WEIGHTUBE – AN INNOVATIVE TUBULAR WEIGH FEEDER

The initial base for the development of the ODM-GravitAS control system was the introduction of the innovative ODM-Weightube platform. Even if the first installations of the novel dosing system were mainly focused on plants for problematic bulk material, actually more than 150 units of the ODM-Weightube are successfully integrated around the world and have been also used for more conventional bulk materials, such as raw meal, fly ash, iron core or clinker.

Figure 2 provides an overview of the ODM-Weightube RWS series, in the German production facility of Di Matteo. Up to now, there are three different models of the Weightube available (RWS 500, RWS 400, RWS 250) depending on the type of bulk material and the intended dosing range.

A key for success is the innovative mechanical concept based on a single shafted complex screw feeder which is used for both, the actual dosing from a feed intermediate buffer hopper and the dosing of the actual mass flow. *Figure 2* illustrates the closed mechanical design of the weigh feeder and its main elements.

The feed hopper acts as a material buffer during normal dosing operation. Due to the special requirements of problematic bulk materials (e.g. alternative fuels), the hopper can be equipped with an agitator and the buffer geometry is well suited in order to avoid impermissible compaction of compressible material. During the normal state of operation, the amount of material within the feed hopper is continuously acquired by a set of three strain gauge-

>>>

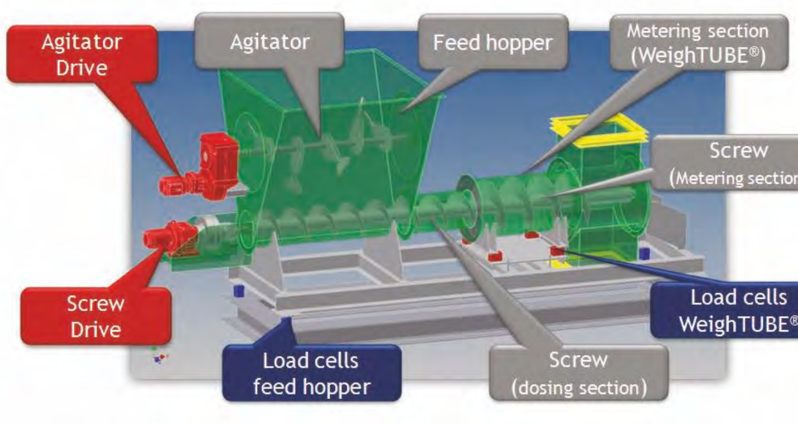


Figure 2- Design of the tubular ODM-Weightube RWS

based load cells (shown in blue in Figure 2). This weight is used within the GravitAS control system for two main functions: (i). the continuously control of the speed of all pre-feeding units in order to achieve a constant buffer fill level and (ii). the adaptive online calibration routine. It should be noted, that Di Matteo also realised already installations, where a single intermediate hopper is used for feeding two or more separate ODM-Weightubes.

During the dosing and metering process, the screw discharges continuously material from the feed hopper and through the dosing section, which is located between the buffer and the actual metering section. In comparison to a typical belt weight feeder the major advantage of using a screw is the quite exact volumetric discharging from the intermediate buffer. From empirical evaluations, it can be shown that the deviation of the delivered material volume per time unit V [m^3/h] for a constant screw speed n [1/min] lies below ±5%. If this is taken into consideration, it can be concluded that the feeding to the metering section is already quite constant from a volumetric point of view. Thus, the gravimetric controller is typically working much more stable in comparison to other continuous weigh feeding systems.

The tubular metering section, from where the name WeighTUBE is derived, is the actual weigh feeder, since it is mounted on a set of load cells *(indicated as red boxes in Figure 2)* which are used for the continuous acquisition of the total material weight within this section.

The innovative mechanical design provides a maximum insensitivity against harmful impurities and allows easy maintenance within compact dimensions *(see also [1])*. One major advantage is the complete closed system design and therefore a complete separation of the weighing units from the conveyed material. The complete system is also available for hazardous areas (ATEX classification) and/or in pressure shock-proof design for specific applications.

ODM-GRAVITAS – ADAPTABILITY AS A KEY FOR PRECISE DOSING

Besides the innovative mechanical concept of the ODM-Weightube RWS series, ODM developed a novel concept which is able to compensate typical practical dosing problems, such as limited flowability or varying material properties (i.e. bulk density and humidity). Besides that, it was obvious that many existing weigh feeders on the market are distributed with a proprietary controller architecture and hardware, which typically limits the degrees of freedom for the integration of a weigh feeder within an existing automation system.

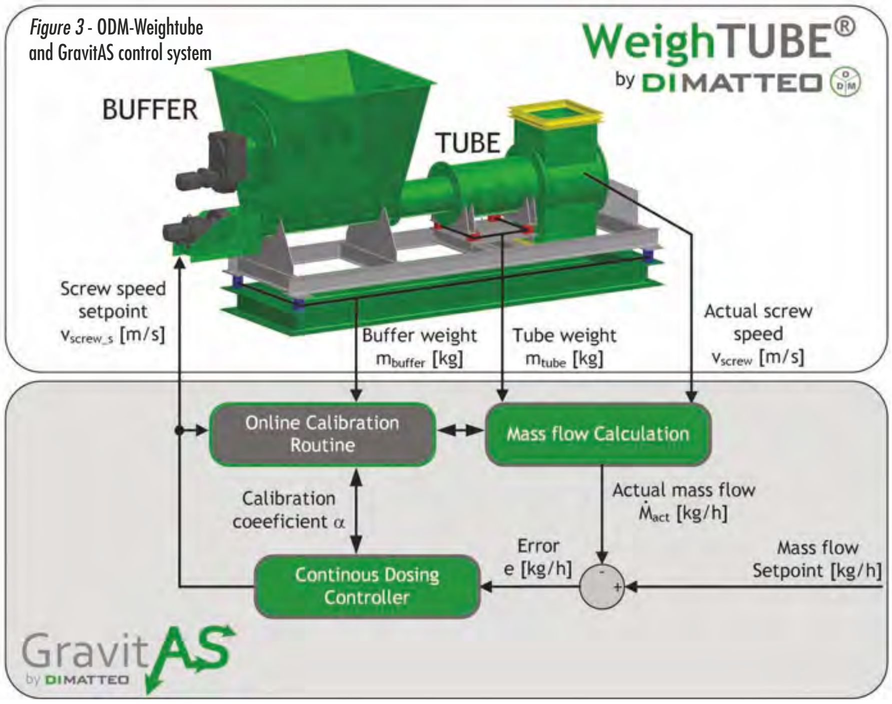
Thus the development of the ODM-GravitAS control system for ODM-Weightube was driven by the aim to provide a highly accurate and robust dosing controller which can be implemented in an open and highly modularised electrical automation platform. A scheme, which shows the main controller elements, is visualized in *Figure 3*.

The continuous dosing controller of the GravitAS control system is responsible for the screw speed adaption based on the actual tube weight. Here, an inverse relationship between measured weight and actual screw speed leads to a continuous, stable and constant massflow. The controller itself is based on a classical discrete PID-control structure, but contains certain interfaces to an additional online calibration routine, which is responsible for a continuous auto-tuning of the controller parameters.

An implemented process observer calculates from actual process entities the current massflow indication, which is than the base for a readjustment of screw speed.

As it was already stated above, all existing dosing methodologies are suffering immensely from the time-variant material properties of problematic bulk materials. This leads in practical applications to a non-negligible drift in the dosing accuracy over time. So, classical weigh feeders, such as belt weigh feeders, need to be recalibrated on a regular basis (e.g. once a month) in order to guarantee a long-term stability of the feeding process. This re-calibration needs to be done manually

Figure 3 - ODM-Weightube and GravitAS control system



>>>

by service technicians in a time-consuming process, during that the machine has to remain offline.

In comparison to that, the ODM-GravitAS control system implements an automatic calibration routine, which provides the possibility to estimate properties of the dosed bulk material and automatically adapt the controller parameters in such a way that the dosing accuracy remains stable over time. The actual process operation is not influenced by the execution of the automatic calibration routine, so that the available machine time can be increased.

During the automatic calibration routine the intermediate buffer hopper of the ODM-Weightube is filled to a certain maximum in a first stage of operation. Within the second phase the buffer hopper is emptied by normal dosing operation (and parallel stopped feed of material to the buffer) up to a predefined), the actual control parameters of the continuous dosing controller are automatically adapted. To avoid possible undesired influences, all controller parameters are checked for plausibility based on a probabilistic analysis of former calibration cycles, before they become active in the system. A typical calibration process, with its three phases, is shown in the following figure, where the actual buffer weight m_{plant} [kg] is visualised over time.

The decreasing buffer weight in phase II of the calibration process follows an almost exact linear pattern, which can be interpreted as a manifestation of the highly constant material throughput of the device. A possible deviation between the actual and the desired massflow during this phase is evaluated for the probabilistic adaption of the controller parameter.

By the combination of the ODM-Weightube platform with the GravitAS control system a high dosing precision of <±1% related to the nominal throughput can be guaranteed.

TAILOR-MADE OPEN CONTROLLER

The GravitAS control system follows a highly modularised and open concept, which allows integrators and users of the ODM-Weightube to get exactly the system, they want to. Instead of using a closed and proprietary system setup, all electrical components can be chosen based on the standards and needs of each individual plant. *Figure 5* gives an overview of the different modules of the GravitAS control system (four mandatory modules (green) and two optional elements (grey)).

The main element is the GravitAS GPU, which is the central processing unit and implements all program routines of the used control algorithm. ODM provides a great variety of standard PLC systems, which can be chosen as the main platform (Siemens S7, Schneider Modicon, Allen-Bradley Logix, Beckhoff TwinCAT etc.). In order to be more cost-effective it is also possible to integrate multiple ODM-Weightube controllers within a single PLC.

As optional modules, the GravitAS CON contains all necessary elements for a field bus driven signal exchange (e.g. Profibus, EtherCAT, DeviceNet, etc.), while GravitAS RA allows a GSM or Ethernet based remote access and maintenance. All these elements are combined within an electrical cabinet, which is tailor-made for every new customer.

CONCLUSION

The ODM-Weightube is a novel, innovative and award-winning system for the accurate dosing of all kinds of bulk-materials. It was already proven in more than 150 installations that the ODM-Weightube can be a more reliable alternative for specific applications if it is compared to classical belt weigh feeders. Especially if a completely sealed and closed system is preferable due to the characteristics of the conveyed bulk material and/or environmental or safety regulations.

The corresponding ODM-GravitAS control system contains the possibility for an automatic online calibration, which guarantees long-term stability and a maintenance free operation of the dosing unit. By this the availability of the ODM-Weightube is much higher than for other comparable systems, since the time-consuming offline calibration methods can be neglected [3].

For more information visit:
www.dimatteo.de

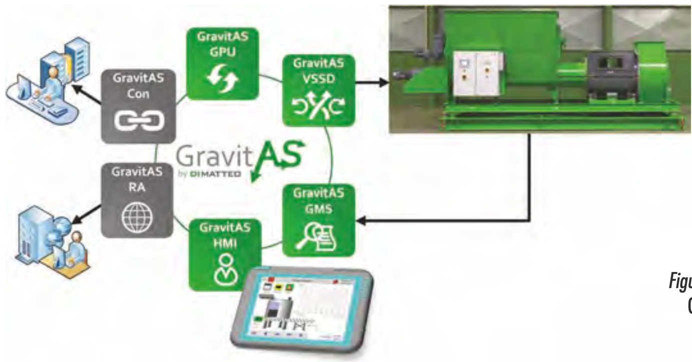


Figure 5 - Modularised structure of ODM-GravitAS contains mandatory modules (green) and optional elements (grey)

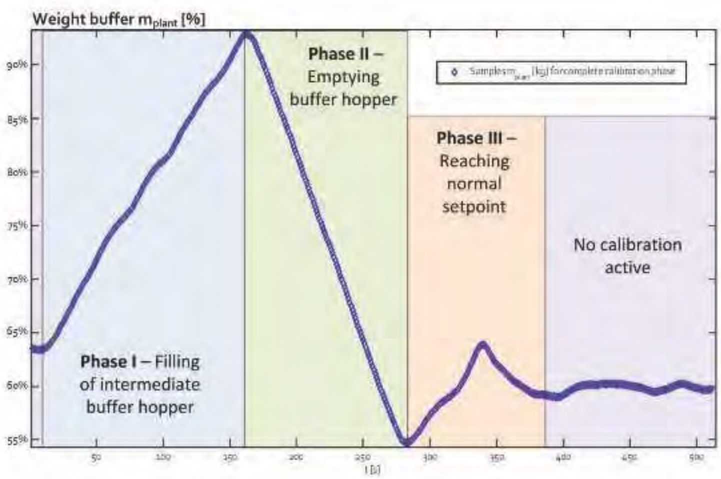


Figure 4 - Three phases of a calibration routine

REFERENCES

[1] Di Matteo, L., Marotz, G., Strotkamp, U.: A dosing system for good measure. In World Cement 1 (2012), pp. 57-60.

[2] Aufderheide, D., Di Matteo, L.: Full Modular Control System for Gravimetric Dosing Applications. In ZKG 11 (2014), pp. 44-49, Bauverlag, Gütersloh - ISSN 0949-0205

[3] Aufderheide, D., Di Matteo, L.: Remote and preventative maintenance. In International Cement Review 4 (2016), pp. 60 – 66, Tradeship Publications – ISSN 0959-6038.