ACCURATE MEASUREMENT FOR GYPSUM

NEW TECHNOLOGY FOR ACCURATE MEASURING AND FEEDING OF GYPSUM, STUCCO, AND FLY ASH IN PROCESS APPLICATIONS

BY KEVIN C. BOYLE, SCHENCK WEIGHING SYSTEMS, US

GG Accurate measuring and feeding of gypsum, stucco, and fly ash is essential for the production of high quality end products such as cement, lime, plaster, and gypsum wallboard. A new mass flow measuring technology utilizing the Coriolis principle is now available from Schenck Weighing Systems.

GG Exakte Abmessungen und Zufuhr von Gips, Stuck und Flugasche sind von entscheidender Bedeutung für die Herstellung von qualitativ hochwertigen Endprodukten wie Zement, Kalk, Putzmörtel und Gipskartonplatten. Die Firma Schenck bietet dafür jetzt ein neues Massendurchflussmessgerät mit Coriolis-Technik an.

GG La précision de la mesure et de l’apport en gypse, stuc et cendres volantes, est essentielle pour élaborer des produits finis de haute qualité tels que le ciment, la chaux, le plâtre et les plaques murales de gypse. Une nouvelle technologie pour la mesure de débit massique selon le principe de Coriolis est désormais disponible chez Schenck Weighing Systems.

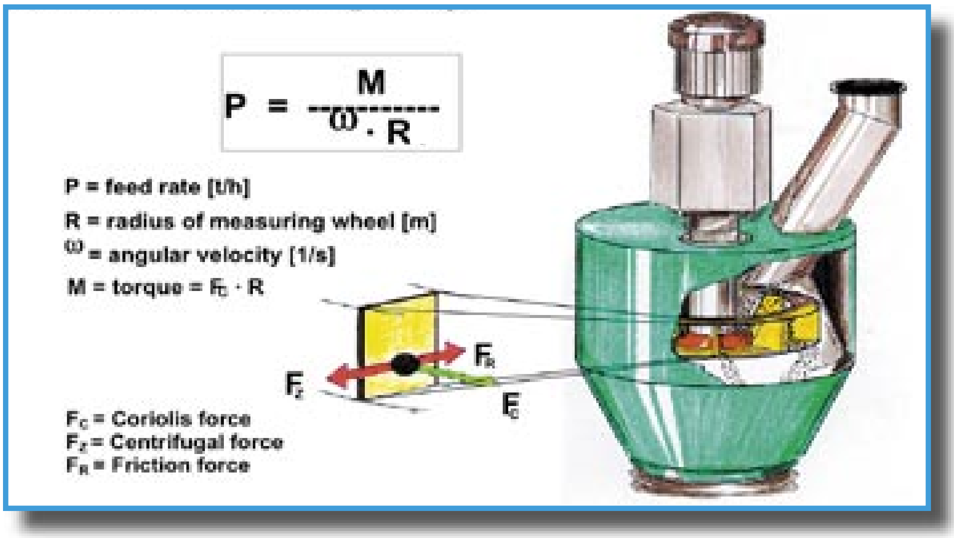
GG La medición y la alimentación precisas del yeso, el estuco y el polvillo de cenizas resultan esenciales para la elaboración de productos finales de gran calidad tales como el cemento, la cal, la argamasa y la fibra prensada de yeso. Schenck Weighing Systems ofrece actualmente una nueva tecnología que mide el flujo másico y utiliza el principio de Coriolis.

Accurate measuring and feeding of gypsum, stucco, and fly ash is essential for the production of high quality end products such as cement, lime, plaster, and gypsum wallboard. High accuracy, repeatability, reliability, and simplicity are some of the essential requirements of these measuring and feeding systems. A new mass flow measuring technology utilising the Coriolis principle is now available for these tasks. This technology has been successfully applied to the feeding of additives in cement mills, feeding of stucco and additives to mixers, and measuring, feeding, and blending at load-out stations. Data from several installations will show the benefits realised through the application of this technology.

Coriolis mass flow meter

The Coriolis measuring principle was developed by carefully studying the science of particle acceleration and its resultant forces. The Coriolis force is the force that acts upon a particle accelerating radially outward in a rotating system. This force acts perpendicular to the direction of motion of the particle and is directly proportional to the torque required to accelerate that particle to the circumferential velocity of the rotating system. As seen in Figure 1, the Coriolis force is also directly proportional to the mass flow rate of a continuous stream of such particles. The relationship of the Coriolis force and the mass flow rate of the particles is independent of most process variables including the bulk density, friction coefficient, and moisture content of the particles.

Figure 1: The Coriolis measuring principle



The Coriolis measuring principle provides a simplified solution to mass flow measurement in industrial process applications. Figure 2 shows an internal view of the Coriolis mass flow meter, which consists of a rotating measuring wheel with several vertical guide vanes surrounding a central deflection cone. The measuring wheel is mounted on a drive shaft, which extends upwards from the deflection cone. These components are housed in a dust-tight enclosure. The shaft is driven by a swivel-mounted electric motor located above and outside the enclosure. This motor is connected to an electronic force-measuring system capable of determining the instantaneous torque delivered to the drive shaft. An off-centre feed inlet above one side of the wheel and a central outlet below the wheel provides the flow path for the bulk solid to be measured.

In operation, the motor of the mass flow meter drives the shaft causing the measuring wheel to rotate at a constant angular velocity. Material flows downward through the inlet into the top of the wheel and the deflection cone diverts the particles outward in the radial direction. As the particles move along the vertical guide vanes, they are accelerated in the circumferential direction. As shown in figure 1, the rotation of the measuring wheel causes three forces - centrifugal, frictional, and Coriolis - to act on the particles as they move along the guide vanes.

- The centrifugal force acts in the radial direction
- The frictional force acts in the opposite direction with a magnitude equal to the centrifugal force
- The Coriolis force acts in the tangential direction and produces a measurable reaction torque in the measuring wheel's rotation that is directly proportional to the mass flow

Microprocessor-based electronics analyse this torque signal and continuously compute the instantaneous material flow rate. A speed sensor is also incorporated into the system to precisely monitor the angular velocity of the measuring wheel.

The following discussion[1] illustrates the mathematical relationship of the relevant system variables:

The drive input into the drive shaft is equal to the energy imparted to the material as it passes over the guide vanes:

$$E = \int M * w * dt = \int dE$$

Where E is the energy imparted to the material, M is the drive torque, w is the angular velocity, dt is time, and dE is the change in energy.

The energy required to move a particle with the mass dP out of the measuring wheel is:

$$dE = dP * w^2 * R^2$$

Where R is the radius of the measuring wheel. From these equations, it follows that the drive torque M can be measured as:

$$M = P * w * R^2$$

Where P is the mass flow rate.

As these equations show, M, which depends on the Coriolis force, is directly proportional to the mass flow rate P. Thus, by measuring the torque, the Coriolis mass flow meter accurately measures the mass flow rate.

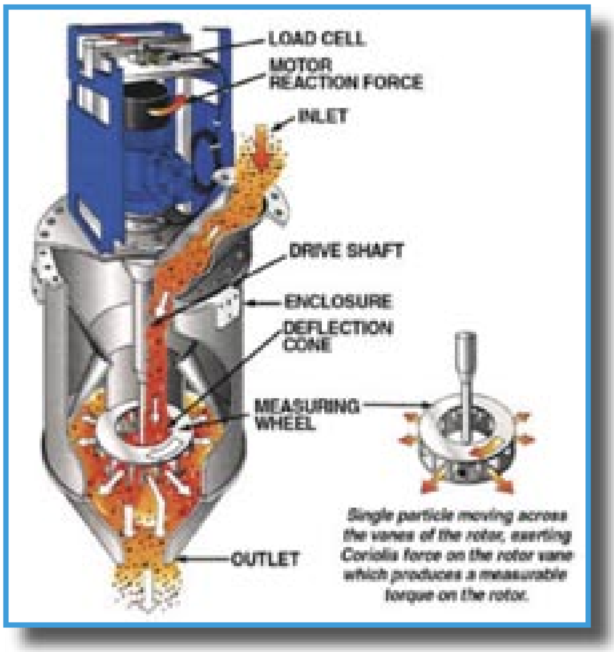


Figure 2: The Coriolis mass flow meter

This measuring technique ensures that frictional forces between the material and the measuring wheel or between different layers of material do not influence the mass flow measurement. In addition, the physical properties of the material, including density, friction and impact coefficients, particle size, and moisture content do not influence the accuracy or sensitivity of the meter. Variations in flow rate within a specified range have no influence on the measurement, ensuring that the measuring results are highly repeatable. The measuring system is also immune to external influences such as wind, vibration, and physical contact with the housing, leading to simple installation requirements and high reliability. The system is completely dust-tight and is virtually maintenance-free.

Lab accuracy tests

Accuracy of the Coriolis mass flow meter can be determined in the laboratory by either pre-weighing (Loss-in-weight feeder) or post-weighing material (gain-in-weight check scale). Accuracy test results[2] using dry quartz sand are shown in figure 3, which plots the error in the mass flow measurement (percent of the actual flow rate) versus the actual flow rate in the range of 1.0 to 10.0t/hour. As can be seen, the accuracy of the Coriolis meter is generally better than 0.5% of the actual flow rate, and the percentage error diminishes as flow rates are increased.

Field test results

The production of gypsum wallboard involves feeding stucco at rates of up to 100t/hour into a mixer with other minor ingredients. Water is added,

Figure 3: Laboratory Coriolis mass flow meter accuracy test.

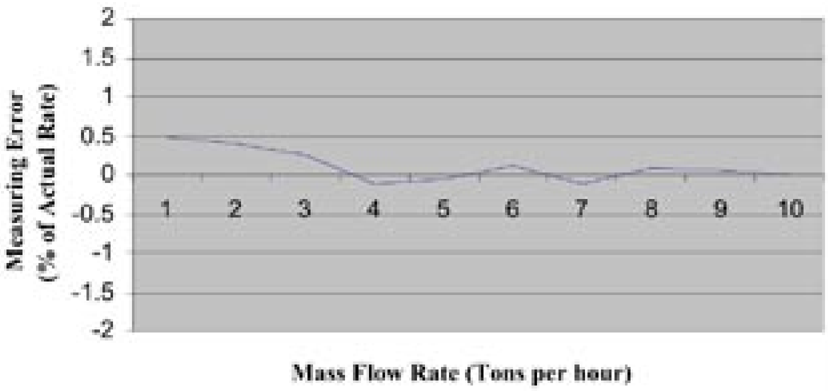
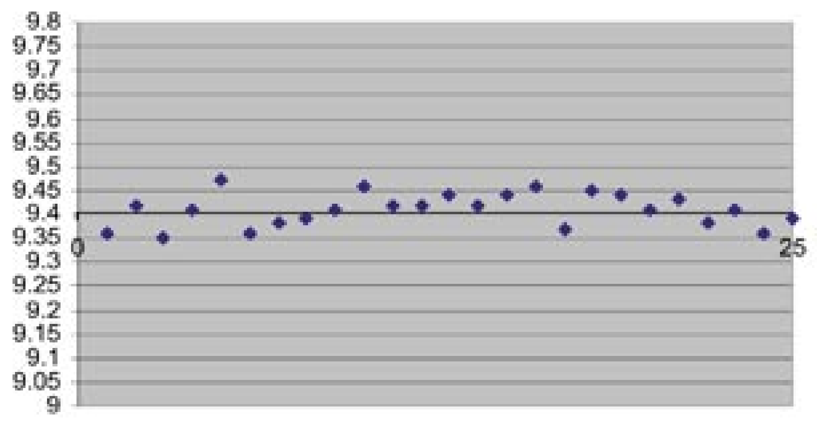
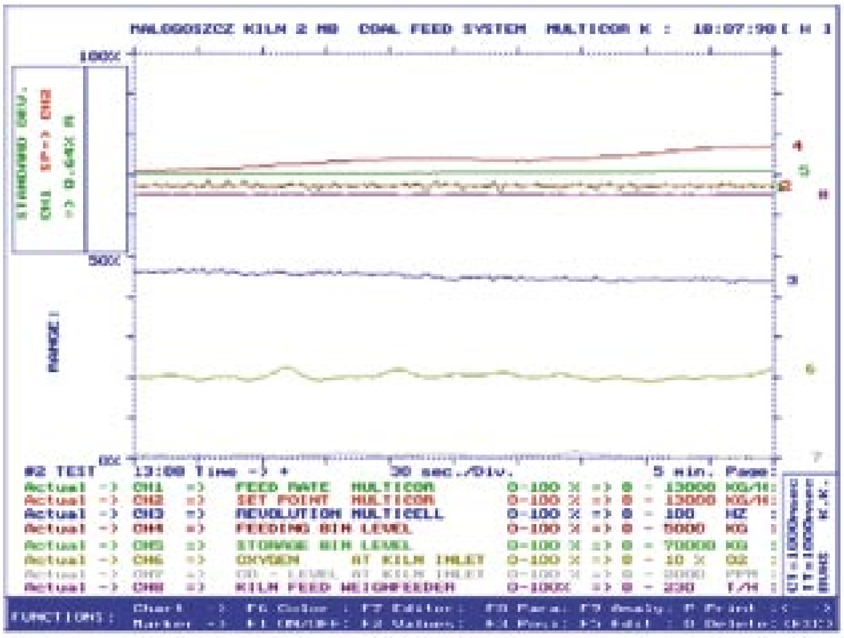


Figure 4: Gypsum wallboard weights (kg/m^2)





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Actual -> CH2  =>  SET POINT   MULTICOR       0-100 % => 0 - 13000 KG/H:
Actual -> CH3  =>  REVOLUTION MULTICELL       0-100 % => 0 - 100   HZ  :
Actual -> CH4  =>  FEEDING BIN LEVEL          0-100 % => 0 - 5000  KG  :
Actual -> CH5  =>  STORAGE BIN LEVEL          0-100 % => 0 - 70000 KG  :
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Actual -> CH7  =>  CO - LEVEL  AT KILN INLET  0-100 % => 0 - 2000  PPM :
Actual -> CH8  =>  KILN FEED WEIGHFEEDER      0-100%  => 0 - 230   T/H :
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Figure 5: Pulverised fuel feeding data

and the resulting slurry is pumped in between sheets of paper to form the board. One quality measurement involves sampling random finished boards and comparing their actual weights to a pre-determined target weight. Boards that do not meet a minimum weight must be rejected, and overweight boards indicate a waste of raw materials in the form of 'give-away.' Although many factors influence the outcome of the board weight tests, the accuracy of the stucco feeding system is the most important since it represents the majority of the weight of the board.

Figure 4 shows the weights (in kg/m^2) of 25 boards manufactured at a commercial wallboard manufacturing plant using a Coriolis mass flow system for feeding stucco. The target board weight for this plant is 9.4 kg/m^2, and as can be seen from the graph, all samples are within ±1.0% (most within ±0.5%) of this target. Previous experience at this plant with a volumetric stucco feeding system yielded variations in board weights as high as ±10.0% resulting in a significant raw material 'give-away' to ensure that all boards met the minimum weight.

Short-term pulverized fuel feeding accuracy is also critical for the economical operation of a cement kiln and for the production of high quality cement. Figure 5 shows the feed rate of a Coriolis mass flow pulverized fuel feeding system compared to the plant set point over a five-minute period. A total of 300 samples are included at one-second intervals. Statistical analysis of this data shows that the standard deviation of these samples is less than 0.45%, resulting in extremely high short-term feeding consistency of the fuel. As can be seen, the level of the material feed bin does not influence the feeding system. It should also be noted that the stable O_2 and CO levels during this test run are due in part to the consistent fuel feed from the Coriolis feeding system.

Applications

Coriolis measuring systems can be applied to almost all kinds of pulverised material, dust, meal, and granules including cement, gypsum, stucco, fly ash, filter dust, lime powder and hydrates, coal dust, ground slag, silica, and marl. Present designs can handle feed rates from 0.5t/hour to up to 300t/hour.

The Coriolis mass flow meter can be installed in a material flow path to continuously measure flow of a dry bulk solid. A typical installation would be between the outlet of a storage silo and the inlet of a blender, mixer or mill. The Coriolis meter can continuously indicate the instantaneous material flow rate, monitor a process, and trigger alarms such as minimum/maximum flow rate and

Figure 6: Coriolis loading station.

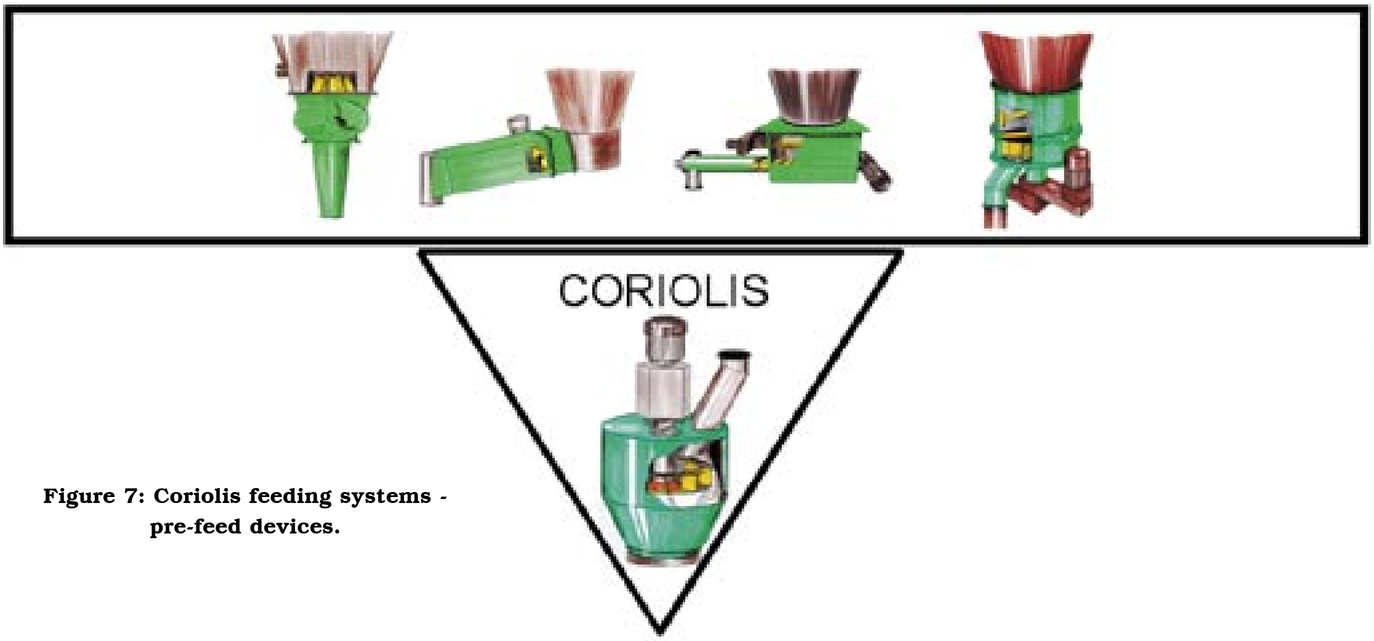

Figure 7: Coriolis feeding systems - pre-feed devices.

deviation. Minor ingredient feeders can be slaved to the mass flow meter to realise proportional additive (master/slave) control and blending.

The Coriolis mass flow meter can be used to totalise material flows for batch control and load-out applications. Figure 6 shows a Coriolis mass flow meter used at a load-out blending station. A Loss-in-weight feeder is also used in this application to portion a minor ingredient. As a side benefit, the Coriolis meter provides excellent homogenization of the two materials.

Feeding and blending

Combined with a suitable variable-speed pre-feeding device (such as a screw feeder, rotary feeder, position-controlled feeder, or horizontal star feeder – see figure 7), the Coriolis mass flow meter can also be used as a precise mass flow feeding system. In this application, the flow rate measured by the meter is compared to a demand set point, and a variable speed pre-feed device is continuously adjusted to match the demand. By separating the pre-feed and measuring devices, the optimum feeding device can be selected for the specific material. Figures 8b and 8b shows a Coriolis mass flow feeding system with an inclined screw feeding stucco in a gypsum wallboard manufacturing process.

Conclusion

The Coriolis measuring principle has been successfully applied to provide accurate measurement and feed rate control of gypsum, stucco, fly ash, and many other bulk solids in process applications. The Coriolis flow meter is a direct mass flow measuring device that is not influenced by variations in material properties or outside forces. It can be used for continuous flow rate measurement, totalisation, batch control, and continuous feeding. It is simple to install, reliable, and virtually maintenance-free.

References

1 Boyle, Kevin C. "Mass-flow meter: Measuring material flowrates the gravimetric way", Powder and Bulk Engineering, February 1996.

2 Tests conducted at Schenck Process, Darmstadt, Germany.

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Figure 8b and 8b: Coriolis feeding systems with inclined feed screws for gypsum and stucco.