Can you go with the flow? Solids flowmeters for industrial applications

Solids flowmeters are an interesting solution for indication of flow rate in pipes or chutes. I say “interesting” because they are only moderately accurate, are costly, require a lot of tuning after installation, and are usually only as good as the whole process around them. That being said, one of the reasons the technology exists is because there isn’t anything else that can do the job.

Just like my dad used to say when I showed up with a rubber mallet when he asked for a hammer, “You have to have the right tool for the right job.” For measuring the flow rate of many solids, flowmeters are exactly the right instrument.

There are several versions of solids flowmeter for industrial flow applications:

1. **Impact flowmeter** - The most popular form of solids flowmeter, impact meters (as they are often called), guide the material through an infeed pipe or chute and create a specific trajectory so that it strikes a flat sensing plate.

   The amount of force this impact creates is measured by load cells or an LVDT (linear variable differential transformer). As the plate deflects against the force of the material, the load cells or LVDT deflects and creates a signal, which is translated into a flow rate by an integrator (Figure 1).

2. **Centripetal flowmeter** - A variation on the impact design, this guides the material through a curved sensing plate which is connected to one or more load cells. The guiding must be parallel to the sensing plate as it enters the curve and the tangential force exerted on the load cells is transmitted to the integrator and then converted to a flow rate (Figure 2).

3. **Coriolis flowmeter** - The solids coriolis flowmeter does not use the same principle as a liquid version. In a solids application, material enters the flowmeter and is then consumed by motor-driven rotating vanes. The motor is
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connected to a torque arm, which is mounted to a load cell. As the amount of material feeding into the meter increases, so does the torque on the motor. The load cell detects this increase, and sends a signal to an integrator, which translates it into a flow rate (Figure 3).

4. **Flow force flowmeter** - This unique solution uses two flow channels to calculate solids flow. One chute attached to a load cell measures the mass of the material on an angle, while another vertical chute measures the impact force for velocity input and the two signals are integrated for an instantaneous flow rate. (Figure 4)

5. **Microwave**
One of the lesser-used technologies, microwave or radar flowmeters, emits a 24 or 125 Ghz microwave into the material flow in a pipe or chute. Based on the Doppler principle, the change in microwaves reflected to the sensor is measured and transmitted as a 4 to 20 mA signal for scaling in a PLC system to become a flow rate. Microwave-based products can be used in pneumatically fed systems, as the extra force of the material flow will not affect the measurement as with the above three technologies (Figure 5).

6. **Capacitive**
Solids flow sensors using capacitance are based on two independent measurements. One is the change in capacitance from an empty pipe to a full pipe, which is proportional to the concentration of the material. The other is a velocity measurement, which uses two sensors to indicate the time it takes the material to move from the first sensor to the second. The signals from these measurements are then fed into an integrator, which will output flow rate. Capacitive measurement can also be used with pneumatic systems (Figure 6).

**Flowmeter technology: the good, the bad**

Of course, there are many advantages and disadvantages to each technology. Here are some of the more critical aspects to consider when trying to identify the best product fit for your application.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Accuracy</th>
<th>Flow rate range</th>
<th>Works in gravity-fed flow</th>
<th>Works in pneumatic-fed flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>± 1%</td>
<td>0.2-900 tph</td>
<td>Works well</td>
<td>Not recommended</td>
</tr>
<tr>
<td>Centripetal</td>
<td>± 0.5%</td>
<td>1-35 tph</td>
<td>Works very well</td>
<td>Not recommended</td>
</tr>
<tr>
<td>Coriolis</td>
<td>± 0.5-1%</td>
<td>4-600 tph</td>
<td>Works well</td>
<td>Not recommended</td>
</tr>
<tr>
<td>Flow force</td>
<td>± 0.5-1%</td>
<td>2-500 tph</td>
<td>Works well</td>
<td>Not recommended</td>
</tr>
<tr>
<td>Microwave</td>
<td>± 5%</td>
<td>0.1-20 tph</td>
<td>Works moderately well</td>
<td>Works moderately well</td>
</tr>
<tr>
<td>Capacitive</td>
<td>± 3-5%</td>
<td>20-50 tph</td>
<td>Works moderately well</td>
<td>Works moderately well</td>
</tr>
</tbody>
</table>

**Impact flowmeters: two distinct advantages**
The first advantage of the impact flowmeters is that they can handle very low to very high flow rates. Secondly, their accuracy or repeatability is not affected by material buildup on the sensing plate, as only the horizontal force of impact causes a deflection on the sensor. Any additional weight that results from material sticking to the device does not shift the output of the system.

The oldest of all of these technologies, impact meters have been in use for over 60 years. Impact solids flowmeters can be very compact – some only 650 millimeters in height, while others are suited for aerated gravity conveyor input and are 2500 millimeters tall. With the size of the unit, the cost factor is also driven up, but the enclosures are designed to be dust-tight and very easy to clean and calibrate.

**Centripetal flowmeters: higher accuracy**
Centripetal solids flowmeters take the accuracy prize, but caution must be taken when applying this type of product. With the right characteristics and flow of the
For measuring the flow rate of many solids materials, flowmeters are exactly the right instrument.

material, centripetal solutions can be extremely accurate. However, if the material is sticky in any way and begins to build up on the sensing plate, a centripetal flowmeter’s signal will begin to shift as the tangential force is measured. Flow rates are also limited with centripetal designs, but this technology also offers dust-tight enclosures and easy calibration.

**Coriolis flowmeters: high flow/accuracy, more power use**

Coriolis solids flowmeters are a nice alternative for high flow rate and high accuracy applications. Higher flow rates and demands for accuracy seem to be the norm as process instrumentation evolves. The coriolis design is also tried and true but it has some disadvantages. Material that is abrasive can prematurely wear out the blades of the meter, requiring replacement. Large particle sizes can be a problem for jamming or clogging the discharge. The other disadvantage of a coriolis meter is that the unit is driven by a high-voltage motor. With all the other styles, typical instrumentation power is required for the device, whereas AC motors will need anywhere from 120 to 600 VAC.

**Flow force: Multiple measurements with multiple maintenance points**

Flow force flowmeters are only offered by one or two companies in the world because the geometry and angles at which the material flows through the chutes requires precise alignment and manufacturing tolerances which drives the cost up. The infeed and outlet chutes are vertical, but they are also offset, which means integrating this unit into an existing installation requires flow pipe re-work. The accuracy can be good when material characteristics do not change over time.

**Microwave flowmeters: low cost but lower accuracy**

Microwave flowmeters are beginning to gain some ground as a low cost, low accuracy alternative to the large bulky units already discussed. A product that fits in your hand and that can be installed in less than an hour versus having to crane in a unit taller than you has its advantages. Calibration is quick and simple and with no mechanical parts to worry about moving or rotating it becomes very appealing. However any process where accuracy is required will not benefit from this type of product Microwave units can also be used in any type of system whether it is gravity-fed solids, dense phase or dilute phase pneumatic conveyors. The microwave solids flowmeters generally look similar to a microwave level sensor.

**Capacitive flowmeters: simple installation, lower accuracy**

Capacitive-based flowmeters have also been on the market for some time. The use of two measuring principles helps increase the accuracy of the total flow measure-
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One of the biggest advantages of solids flowmeters is measurement in-line with material flow, something that feeders or scales cannot do.

St. Marys Cement in Canada has been using the E-300 solids flowmeter from Siemens for over two decades! Now called the SITRANS WF330, this flowmeter is still providing accurate and reliable measurements.

One of the biggest advantages of solids flowmeters is measurement in-line with material flow, something that feeders or scales cannot do. Installation is simple and straightforward, as a section of pipe is removed and the flowmeter installed. Calibration is also easy but the accuracy is not as good as the large mechanical type units. Capacitive units can be used with gravity-fed or dense phase pneumatic systems and are also a very price competitive solution compared to the large mechanical devices. The capacitive solids flowmeter is the most similar to a liquid-based meter, as it looks almost exactly like an electromagnetic meter.

**Choices, choices: how to decide?**

Selecting the right product will come down to the age-old triple constraint: price, accuracy, and fit. If you can afford to spend the money, you don’t have to sacrifice what you need for what you can afford.

Accuracy is based on what is demanded from your process. Fit comes down to how the product would perform with the variables of material density, flow rate, temperature, moisture content, particle size, installation space, pre-feed device, material compatibility, and don’t forget about hazardous approvals!

**To be an expert, or not to be an expert**

I have been working with flowmeters for eight years and I consider myself to be well versed. I have colleagues who have been working with this technology for 35 years and they consider themselves to be experienced. However, I have yet to meet anyone who considers himself or herself a flowmeter expert!

There are just so many variables to consider, many of which can change over seasons or even with the daily change in weather. Unfortunately, there are no quick and easy answers. Understanding the application in great detail is required to apply the right product and options.

My recommendation is to talk to your local supplier and provide as much information as possible. At Siemens we offer an application questionnaire that gathers all of the required data. After this, we supply a proposal for the application and highlight anything that we may wish to investigate further. Our goal at all times is to ensure the best performance of products in your application.

**Sometimes you just need a hammer**

As I said earlier, solids flowmeters may not be the world’s most amazing piece of technology. However, they are an essential part of many industrial flow applications for the sheer reason that nothing else can do their job.

Sure, for your day-to-day home repairs, you could purchase a top-of-the-line nail gun with laser accuracy and power enough to shoot nails hundreds of meters per second. Realistically though, sometimes you just need a hammer. Similarly, sometimes you just need a solids flowmeter – the right tool for the job.

Siemens AG
Industry Sector
Sensors and Communications
76181 KARLSRUHE
GERMANY

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