Rotary Paddle Bin Level Indicators: A Favorite Flavor?

By Joe Lewis

While some users gravitated away from rotary paddle bin level indicators, industry market reports still tell us that they are one of the most popular choices for point level monitoring of powders and bulk solids; some 64,000 units were placed in service worldwide in 2008. Annual growth was projected to be 6% from 2004 through 2009 and it has been close to this. And with a 70-year history and over a million units installed, the rotary paddle bin level indicator continues to show extraordinary resilience.

Figure 1: Typical rotary paddle bin level indicator featuring power-pack, mounting plate, and four-vane paddle *(Photo courtesy of K-Tek Corp.)*

Why Use a Bin Level Indicator

Whatever the name, bin level indicator, point level sensor, Bin-dicator, generic or brand name, a bin level indicator is essentially a device used to monitor the presence and absence of material at a predetermined point. Bin level indicators can be used for high-level detection, low-level detection, intermediate-level detection, and plugged-chute detection.

Bin level indicators used for high-level detection provide indication of the presence of material as an alarm condition. For low-level detection, the absence of material is indicated as an alarm condition. High-level-detection is a type of process control application, i.e., controlling the fill process and preventing the bin from overfilling. Low-level detection units can indicate that a material outage condition will soon occur and that reordering of material is needed to prevent disruption of the production process.

Plugged-chute detection is a less common application. That method uses a bin level indicator to detect the presence of material within the chute as a result of a plug or some other condition that makes the material back up into the chute rather than continuing to flow. This is a relatively inexpensive way to monitor faulty conveying systems or material flow problems.

The output from the bin level indicator in these cases can be used to activate process equipment and sound local alarms, but most often are tied into a control system. Material outage, bin overfilling, and material backup can be costly events that need to be prevented or immediately detected.

The Leader of the Pack

Bin level indicators come in several flavors. The two most popular flavors are the vibrating element and the rotary paddle bin level indicator technologies. These two represent nearly two-thirds of all bin level indicators installed annually. However, with a long history of refinement, acceptance, and credibility, the rotary paddle is the leader of the pack and by far the favorite over time. The rotary paddle bin level indicator is arguably the best choice for point level detection of bulk solids; over a million units have been installed. Long-term popularity of rotary paddle units is well deserved because of simplicity of design, universal application nature, low cost, and application reliability.

Simplicity of Design

The rotary paddle unit (Figure 1) has a simple principle of operation. The assembly includes a sensing element (the paddle) that will be invasive to the material within the bin. The paddle is attached to the output shaft from the sensor enclosure (the power pack). The unit is mounted to the bin using its 1¼-in. NPT process connection via a coupling welded on the bin or a mounting plate bolted to the bin. Inside the power pack is a drive motor. The motor is a synchronous type and is powered by the line voltage of the unit.

There are two types of synchronous motors used by suppliers—permanent magnet and hysteresis (discussed further below). When power is applied, the drive motor turns the output shaft at 1 rpm, which rotates the paddle inside of the bin when material is not present at the paddle. The electrical output will indicate no material present in this condition. When material impedes the paddle rotation, the motor will rotate on its mounting plate inside its enclosure and

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reverse the electrical output state to indicate that material is now present. When material falls away from the paddle, it will resume its rotation and the electrical output is again reversed, indicating material absence.

The type of electrical output is either mechanically actuated switches or an electromechanical relay. Units using a relay output can offer fail-safe operation, upon power failure, by de-energizing the relay in the alarm state. Fail-safe operation is switch selectable for high- or low-level applications as shown in Table I.

Fail-Safe Switch Position	Paddle Uncovered	Paddle Covered
High	Relay Energized	Relay De-Energized
Low	Relay De-Energized	Relay Energized

Table I: Relay condition based on fail-safe switch selection

More about the Drive Motor… Dispelling the Myth

A drive motor in a rotary paddle unit is a synchronous motor, which is defined by Wikipedia as "an ac motor distinguished by a rotor spinning with coils passing magnets at the same rate as the alternating current and resulting magnetic field which drives it." Synchronous motors are great for application as a drive motor in a rotary paddle unit. They operate consistently and run at a constant speed.

Two types of synchronous motors are used —permanent magnet and hysteresis. The latter is more expensive and is used in bin level indicators that stall the motor when the material in the bin impedes paddle rotation. The permanent magnet type is used in designs that shut off power to the motor rather than stall the motor when material is present. Hysteresis-type motors are used because of their ability to provide smooth constant torque, in addition to providing constant speed and accurate rpm. The hysteresis motor can be safely stalled, thereby eliminating the need for a motor shutoff circuit.

Both motor designs are very appropriate for use in a rotary paddle unit. Stalling a hysteresis motor is perfectly fine, and there is no need for the motor shutoff circuit, despite what certain brands may promote. Suppliers using this motor design pay more for this type of motor so that they have a somewhat simpler design by eliminating the motor shutoff circuitry. Conversely, those brands using permanent magnet motors need to shut off power to the motor in order to maximize the life of this type of less-expensive synchronous motor. All things being equal, both motor types can have a similar life expectancy.

Bin Level Indicator Technology	Average Purchase Cost
Rotary Paddle	$200
Vibrating Element	$500
RF Capacitance/Admittance	$350
Tilt Switch	$370
Diaphragm Switch	$150

Table II: Average purchase cost of bulk solids bin level indicator technologies

Universal Use and Resiliency

Powders or granular materials, light or heavy in weight, dry or moist: the rotary paddle unit is used to measure a wider spectrum of bulk solids than any other point level technology. The reason is the principle of operation. The paddle can be virtually any size and shape. By varying the surface area of the paddle, the unit adapts to lighter or heavier material very easily. It is used with materials from 5 lb/cu ft to more than 100 lb/cu ft, and one paddle design can be used throughout most of that range.

The rotary paddle unit typically uses stainless-steel construction for most of the wetted parts, such as the output shaft and the paddle. The limiting factor for corrosion resistance is the cast aluminum process connection used in most brands. However, some offer PBT (polybutylene terephthalate), glass-filled nylon, or an optional stainless-steel process connection.

The rotary paddle principle of operation is immune to most physical changes in the material. Changing bulk densities is not a problem, and the technology is not dependent on dielectric or other electrical properties of the material to be detected. In addition, the rotary paddle unit operates in a wide range of process temperature conditions. They are available for applications with internal bin temperatures from -40 to nearly 1472˚F.

The rotary paddle unit is closer to being a universal point level sensor for bulk solids than any other technology. From the rotary paddle invention by Herbert Lenhart (patent issued May 3, 1938), there have been countless improvements in design. Several major competitors have been instrumental in evolving the technology and providing long-term success of the technology.

Low Cost

A Rotary paddle unit (powerpack and paddle) can be purchased for about $200. A mounting plate adds $20 and a flexible coupling $30. Extensions for top-mounted applications are not expensive.

Installation is fairly simple, especially if replacing an existing rotary paddle unit because of the industry-standard 1¼-in. NPT process connection. Mounting plates and mechanical installation are independent of brand. The electrical installation is fairly universal as well. Typical wiring connections include hot, neutral, and ground for the power supply and a single output connection. The installed cost of a rotary paddle unit can be less than $300, depending on application (conduit not included). Table II illustrates a comparison of typical purchase cost by technology.

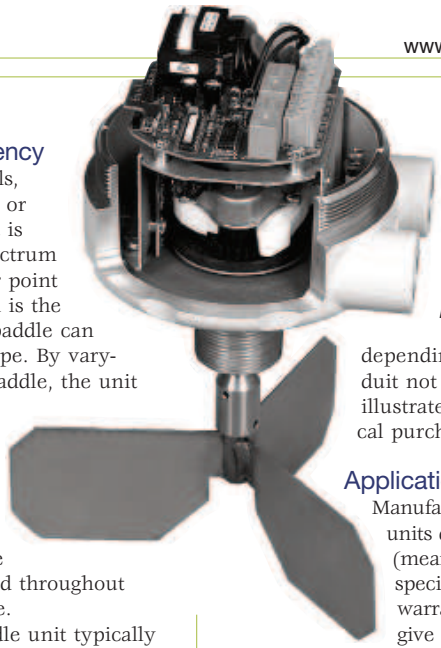

Figure 2: Real fail-safe rotary paddle bin level indicator continuously monitors its internal functions *(Photo courtesy of Monitor Technologies LLC)*

Application Reliability

Manufacturers of rotary paddle units do not publish MTBF (mean time between failures) specifications. However, warranty statements can give some indication of life expectancy. Many suppliers of rotary paddle units provide a two-year warranty. Personal experience indicates that they last much longer, though it is often application and installation dependent. The 70-year history of the technology suggests an excellent value in terms of life versus cost.

The rotary paddle unit is available in a real fail-safe version (Figure 2); That version continuously monitors electrical and mechanical functions of the unit and indicates its health status with a local indicating light and an electrical output distinct from the primary level sense output. By monitoring the level sensing and health status outputs, the user immediately knows if the rotary paddle unit fails.

This forewarns and provides an opportunity to prevent costs associated with unexpected bin overfilling or material outage.

Conclusion

The rotary paddle bin level indicator continues to be the leader of the pack among point level sensors for bulk solids. It is effective in the application, affordable, and extraordinarily proven with decades of continued refinement. It provides virtually universal solutions and is not going away.

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