Shielding Sensors

Dust, lubricants, extreme weather — no matter what environment your sensors operate in, there are bound to be elements you have to protect them from. Here's how Heidenhain designs their encoders to specifically meet those challenges.

Alex Cannella, Associate Editor

One of the most sensitive components in a machine is likely the sensor. Even more so than with other components, precision is a top requirement for sensors, which also means that of all components, it takes the least amount of interference to disrupt them. Extreme temperatures, dirt, even a few simple motes of dust can interfere with an encoder's operation, meaning one of the most important challenges when designing an encoder is making sure it's as resistant to the elements as possible.

We sat down with Heidenhain to see how they tackle this issue. As it turns out, the answer is one environmental hazard at a time. According to Jonathan Dougherty, business development manager for automation at Heidenhain, most solutions are situational and about combating specific threats on a per-environment basis.

"From a wide view, you want to know environmental conditions, and from there, it's time to sit down and see ok, what kind of contamination is possible in these conditions?" Dougherty said.

No matter the environment, dirt contamination is one of the most frequent disruptions of an encoder's performance. But heavy-duty applications such as mining and oil/gas can easily be the dirtiest.

The easiest way to break down those conditions is with a simple question: is your machinery operating indoors or outdoors? Depending on the answer, you'll be dealing with your own set of challenges.

Out in the great wild, of course, is where the "most extreme" environmental conditions exist. You're subject to weather and local climate conditions, and many of the heaviest duty (aka dirtiest) applications like oil and mining are conducted outdoors.

For Related Articles Search
encoders
at www.powertransmission.com

Extreme temperatures, however, are one of the greatest stressors on Heidenhain's sensors. Try an offshore oil rig in Siberia, for example. Out there, temperatures can drop well below zero and get so cold that the lubricants in the bearing freeze solid. When that happens, the whole bearing locks up and can't turn properly. And then there's the concern of how the cold will cause the components to contract.

And on the opposite side of the equation is a mining application in Brazil. Small surprise, when in such a hot environment, it's easier than ever for components to overheat. Heat dispersion becomes an absolute priority concern.

"It's just making sure that you have proper heat sinks and dispersion in the encoder itself so that the electronics don't overheat," Dougherty said.

That simple solution, however, is complicated by the extreme amount of contamination (read: dirt) that gets kicked around in a mining application. And that requires its own set of tactics to combat.

Just because these environments are more extreme doesn't mean you can just go without encoders in these applications. Instead, Heidenhain's had to come up with ways to keep their encoders as well-protected from the elements as possible. But every solution needs to be tailored for the specific environment the encoder is going to be working in, because no one solution fits all, and any adjustments designed to tackle a problem are going to come with tradeoffs.

Take the Siberian oil rig. In those extreme colds, a bearing becomes as much a liability as a boon. Heidenhain's first response is to skip the bearing and mount the encoder directly on the shaft, but this leaves the encoder vulnerable to other issues. After all, that bearing is there for a reason: it helps protect against runout, which can produce noise and disrupt the encoder's readings. Removing the bearing isn't fatal, but it does leave the encoder more susceptible to being affected by runout, requiring a more restrictive overall design.

For dealing with contamination, meanwhile, Heidenhain has two solutions. The first line of defense is to sidestep the issue entirely by using inductive scanners like the ones featured on their ECI/EQI 1100 and 1300 series encoders.

The general standard for encoders is to work with optical scanning, which operates by shining an LED light on a disc with graduations on it. The obvious problem is that as contamination find its way onto the disc, it disrupts that light. Inductive scanning sidesteps the issue by instead utilizing measurements between the inductive sensor (encoder head) and measuring scale, which periodically changes the mutual inductance of each coil and generates the signal.

"If you don't have any light, the materials and contamination getting in don't affect it," Dougherty said. "So you're able to still operate even in some more contaminated environments."

As always, however, there's a tradeoff for these more durable solutions, and the downside in this case is that inductive scanners haven't quite matched the accuracy of their optical cousins yet.

"If your application needs high accuracy, you still want to go with the optical," Dougherty said. "And in that case, you try to minimize the risk of something happening, whereas if the accuracy of the inductive solution is good enough, you go with that and you don't have to worry about the contamination. It's kind of a give and take situation, so we really try to provide options and go with the one that suits the application the best."

And in cases where optical encoders are a must, Heidenhain's next solution is their Advanced Diagnostic System (ADS), software which is specifically designed not just to monitor the encoder itself, but also the encoder's environment. It's meant to identify an encoder's most pressing contamination threats and alert operators when a problem is brewing before it becomes so pronounced that it starts affecting a machine's performance.

Cold temperatures can be one of the greatest threats to an encoder, and combating them requires tradeoffs.

"The goal of that is to help our customers to move from something like preventative maintenance structures where you replace on error towards more predictive and proactive maintenance," Dougherty said. "So that you can predict 'ok, this is becoming an issue that will be causing an error down the line.'"

Heidenhain most commonly utilizes ADS in oil/gas operations, mining applications, and wind turbines, some of the harshest conditions their encoders can end up operating under.

Looking back at that specific mining application in Brazil, Heidenhain's encoder kept notifying the operators of a critical issue where vibrations were disrupting its ability to work, but

the encoder itself seemed perfectly fine. It took Heidenhain's ADS system for the operators to locate the real source of the problem: the concrete base the encoder's motor was installed on. The base had a crack in it, and every time the machine turned on, that crack grew just a little bit, and as the crack got worse, so too did the vibrations, in turn, until finally the issue became bad enough to hamper the encoder.

Indoors, things are a bit tamer. Indoor environments can actually be controlled to a degree. The humble dust mote is usually the greatest threat here, but a significant threat, it remains. Even when working with machine tools, dust is a challenge sensors have to contend with, even though you would think machine tools working inside sealed, automated machinery would make for the most controlled and safest environment of all for a sensor.

But on the contrary, that need for a controlled environment instead exacerbates the issue. Many components these days are manufactured with an acceptable deviation of mere microns, and when you're striving for that level of accuracy, suddenly even a little bit of dust can become a credible threat, and even minor contamination of a sensor can lead to errors in a component's surface finish just as surely those extreme contamination conditions in Brazil could. And that's to say nothing of how lubricants can splash around and cause the same issues.

Here again, inductive scanning can be a helpful solution, but it still comes with the same tradeoffs as when used outside. Sometimes, handling this issue is instead as simple as using a bit of foreknowledge. The easiest way to avoid something like lubricants contaminating an encoder is to design ahead of the issue by ensuring the encoder doesn't have to be installed directly in their path.

That might sound like sense so common as to barely be worth mentioning—gee, who would have thought the easiest way to stop lubricants from contaminating your encoder would be to just put the encoder somewhere away from the lubricants! But actually doing that requires forethought during a machine's design process, which means communication with your component manufacturers. As with numerous other issues that can crop up in manufacturing, a primary way to avoid a problem from occurring in the first place is to just get your suppliers onboard early and communicate with them often about design parameters they have to be aware of.

This holds true for every environment highlighted in this article, even the most stressful ones. After all, a manufacturer like Heidenhain can't plan for environmental factors that their customers don't tell them about. When designing a machine, how your encoders might function in the cold probably isn't the first question at the front of your mind, if indeed it's something being considered at all.

It's just one of a thousand other design questions that need to be incorporated into the design process, but it's an important one to ask that can save you a lot of headache later down the line. Properly identifying those threats is the hard part, and once you figure out what you're up against, you'll be able to find a solution that works for you.

For more information:
Heidenhain
Phone: (847) 490-1191
www.heidenhain.us