Magnetic Encoder Advantages in Metals Industry Applications

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This paper will discuss why magnetic encoders overcome limitations and provide superior reliability in metals applications.

Encoder manufacturers have made great strides in recent years to overcome the severe encoder reliability problems that have plagued metals mills for many years. No greater improvement has been made than the replacement of optical sensing technology with magnetic.

The inherent temperature, dirt, shock and vibration-related problems in metals encoder applications have been conquered in the last 10 years by replacement of outdated optical sensing technology with magnetic sensing. Further, recent improvement in the magnetization strength of the encoder core has continued to provide enhanced reliability when compared to earlier first-generation magnetic encoders.

Magnetic encoders have proven to be able to withstand some incredibly bad environmental and mechanical conditions:

Figure 1- Typical Harsh Duty Encoder Installations in Metals Application

Magnetic Encoder Basics:

Recall the optical basics:

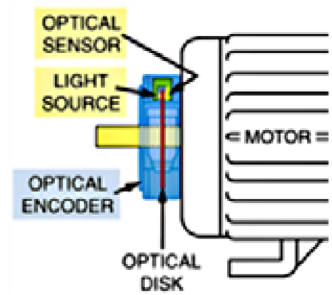

Figure 2- Optical Encoder Components

An optical light source shines through a slotted or etched disk and the light/shadow pattern generates the pulses. One slot is equal to one pulse so the number of pulses/revolution is limited by the disk size.

A magnetic encoder has a solid rotating disk which is magnetically etched with adjacent north/south poles. These poles create lines of magnetic flux between them and these lines of flux are what the sensor "sees" to create the pulses. A stationary sensor using resistors that are sensitive to magnetic fields "reads" the passing poles to generate the pulses.

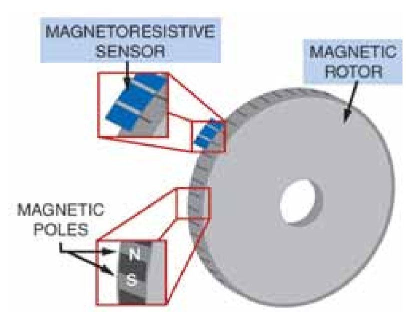

Figure 3- Magnetic Encoder Components

The real improvement comes from the magnetic sensing being able to withstand internal contamination inside the encoder. Magnetic technology enables the sensor to "see" even when conditions inside the encoder look like a rainstorm of dust, oil or water.

Optical encoders need to see tiny lines on a disk accurately; they make optical errors when there is any type of contamination on the disk. Magnetic encoders do not make errors due to contamination and can withstand dust, dirt, oil, water, and heavy temperature cycling. This leads to more reliable feedback and longer life than optical technology.

The Air-Gap Dilemma

An early limitation of magnetic sensing came from the limited air-gap distance and tight tolerance required between the rotating disk and the stationary sensor. This gap is a function of both the magnetic strength of the poles etched in the rotor and the sensitivity of the sensor to see the resulting flux lines moving past. Due to limitations with early etching and magnetically sensitive resistors, the nominal air-gap in early models was typically 0.008". This proved difficult to maintain.

Figure 4- Early Magnetic Encoder, Small Allowable Air-Gap

The allowable shaft runout specification was also small; typically 0.002" Total Indicator Runout (TIR) so the errors associated with excessive vibration and wobble were minimized.

These limitations in pole strength and resistor sensitivity combined to limit the allowable range of pulse/revolution values to 1,200. As metals industry controllers got more powerful, higher pulse rates were desired for improved performance but could not be initially attained with magnetic encoders.

Magnetization Strength = Larger Air-Gap = Enhanced Reliability and Longer Life

Over time, advances in materials properties allowed the magnetization of the rotor poles to become stronger. This resulted in maximum air-gap specs growing to 0.065" and allowable shaft runouts of 0.004" TIR. This greatly enhanced the tolerance of the encoder to vibration and wobble resulting in a more robust, longer-life encoder.

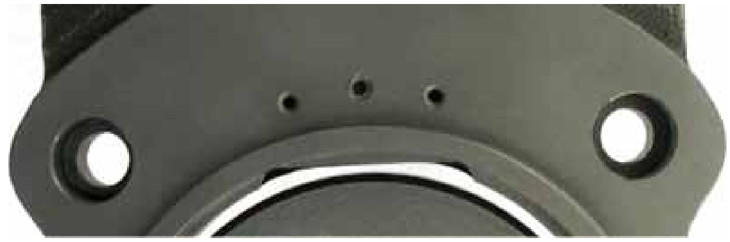

Figure 5- Later Magnetic Encoder, Larger Allowable Air-Gap

The improvement was enabled by a combination of improved Ferro-polymer materials properties available for the magnetic ring and stronger magnetization etching provided from improved IR technology. This allowed the magnetic poles to be etched stronger per unit polymer cross-section. The improvements in the allowable air-gap grew from the earlier 0.008" to 0.030" and finally to the current 0.065".

Sensor Advancements = Higher Pulse Rates = Improved Process Control

Once the air-gap dilemma was solved and encoder reliability and life were improved to meet metals industry demands, solutions to the available pulse rate limitations could be researched. The largest limiting factor in early attempts to reach higher pulse rates was the spacing of the magnetic poles in the rotor. Attempts to etch more poles on the rotor failed due to pole strength decreases as the spacing shrunk. Larger rotor diameters would have potentially solved this problem but were rejected due to the unwieldy size of the resulting encoder.

The solution came from an improved magnetic flux sensing algorithm. Early sensor technology followed the optical model of ON/OFF equaling PULSE and the sensor had a threshold for reading the magnetic pole as either ON or OFF. The improvement came from the sensor being able to read the relative strength of the magnetic line of flux as it passed the sensor head.

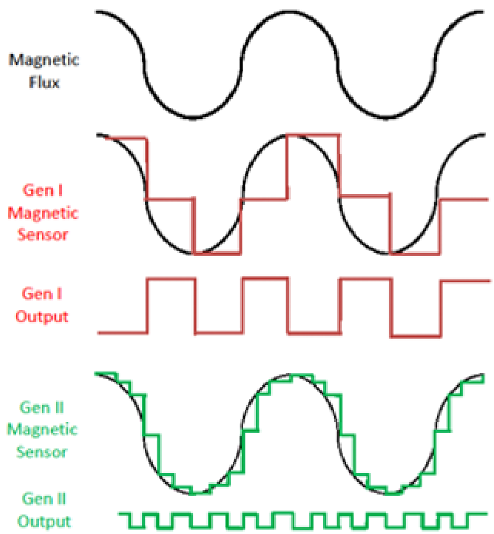

Figure 6- Gen I and Gen II Magnetic Sensor Performance

An improved sensor was designed to continuously read the flux strength between the poles instead of just considering it present or not present. Now the sensor knew the exact rotor position continuously instead of just once per pole pair. Once this was determined, the sensor could create more pulses at the correct rotor position. This allowed the encoder to have higher pulse rates. Current magnetic models have pulse rates of up to 5,000 pulse/revolution.

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