CHOOSING A DRIVE

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Introduction

In cement plants, variable speed drives are used to control the rotational speed of the cement kiln. In addition to speed, the drive provides controlled torque, which increases the life of the mechanical system and reduces maintenance and operating costs. The drive's digital controls also provide special load feedback signals, which improve kiln process control.

Both AC and DC variable speed drive technology have been used for kiln applications. In the past, DC drives and motors were the drive systems of choice, but with the rapid advance of power semiconductors and AC drive controls, AC drives are now used for kiln control. There are still DC kiln motors running and new DC drives have been developed to upgrade the older technology. Additionally, much effort has been put into developing advanced diagnostic features, so that drives can now reduce downtime and troubleshooting time.

Kiln drive and motor requirements

Variable speed drive products help to meet cement kiln requirements. The important drive and motor features required are listed below:

- Produce 200 – 250% starting torque for 60 sec.
- Produce a timed acceleration rate, typically requiring 60 sec to go from stationary to top speed.
- Provide current limit protection during motor starting, continuously monitor motor loading conditions, and generate an alarm output for any overload.
- Provide up to 100% continuous operating torque from 25% to 100% speed.
- Tightly regulate the operating speed, typically +/-0.5% of rated speed.
- Have an elevated ambient temperature rating and temperature monitoring detectors.
- Provide stall and ground fault protection.
- Have outdoor-weather protected motor casings.
- Have motor tachometers, shaft slingers, space heaters, and waterproof conduit boxes.

Figure 1. Variable speed drive products help to meet cement kiln requirements.

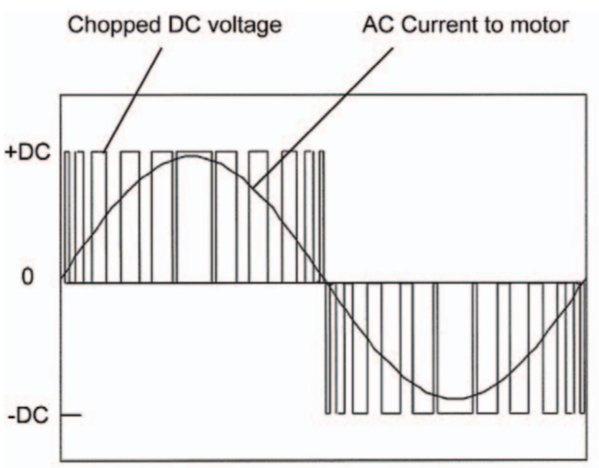

Figure 2. Pulse width modulated voltage and motor current. One phase of the three phase inverter.

Other items required for a working system include:

- Stopped/running and OK/fault indicating contact outputs.
- Remote/local testing and adjustment devices.
- Provision to follow a 4 – 20 mA speed control signal.
- Analog outputs for speed and motor load feedback to the plant process controls.
- Advanced diagnostics for quick and easy maintenance and troubleshooting.

Controlled acceleration

Compared to starting the kiln motor directly from the AC line, the controlled, timed acceleration provided by a variable speed drive is beneficial for the kiln. Starting of the kiln motor in a rapid, across the line manner could result in unwanted torsional oscillations and stresses. For example, a typical kiln could easily accelerate to a top speed in 2 – 3 sec if the motor was permitted to do so. However by doing so, the kiln's long cylindrical tube, large reduction gear, and its associated mechanisms would be subjected to excessive stresses and perhaps damage. Precisely controlled and timed kiln acceleration helps extend equipment life, and maintains consistent product output.

How the drive works

There are three main parts of a low voltage variable frequency drive. Firstly, there is an AC/DC converter supplied by 400 to 690 V AC, three phase power, consisting of three diode bridges (one for each phase), forming a three phase, full wave voltage rectifier that supplies the main DC power bus. Secondly, a voltage filtering section consisting of capacitors and resistors across the main DC power bus, which reduces the amplitude of the ripple from the rectifier. Thirdly, there is a DC/AC inverter supplied by the main DC bus, which generates three-phase, variable frequency power output to the motor.

To provide the mechanical rotary power, a three phase AC induction motor designed for service with a variable frequency drive is required.

The DC/AC inverter has three output power bridges, one for each phase. Each sine wave is created by chopping the DC power voltage with IGBTs using pulse width modulation (PWM) at the rate of 1500 pulses/sec. This voltage is impressed on the motor windings where the large inductance and resistance acts as a filter to create a current close to a sine wave. Figure 2 shows one of the three PWM phase outputs, where the square wave is the chopped voltage and the sine wave is the motor current.

The width of the pulses can be changed, keeping the DC voltage constant, which changes the amplitude of the motor current. In this way not only can the frequency be varied with PWM but also the amplitude of the sine wave current. This changes the motor output torque; therefore the inverter can control both motor speed and torque.

High accuracy Hall Effect current transformers on the three drive outputs are used to measure the current to the motor. This measurement is processed to extract the portion that produces mechanical torque, which

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is used for control. The other portion is the reactive magnetising current.

The effect of the drive on motor starting current is illustrated in Figure 3. By controlling both current and frequency, the drive prevents the motor current and resulting torque from rising to unwanted levels. Kiln mechanical stresses and motor winding temperatures are therefore limited.

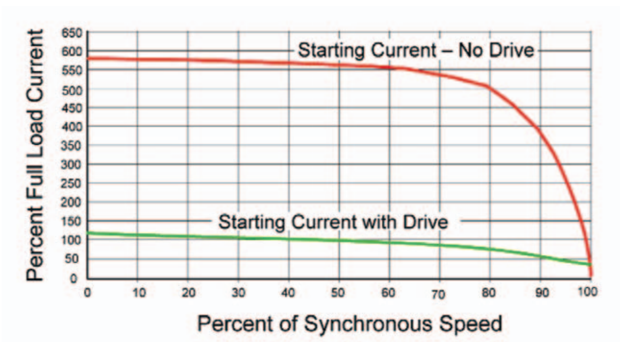

Figure 3. Starting current controlled by drive.

Table 1. A comparison of kiln drives suitable for different kiln sizes.			
Size of kiln	**Small size kiln**	**Large size kiln**	**All kiln sizes**
Suitable type of drive	AC drive – low voltage	AC drive MV	DC drive
Voltage level	Low voltage: 460 V AC or 690 V AC	Medium Voltage: 4160 V AC	300 – 1200 V DC output
Approximate power range	600 to 800 hp.	Up to 2000 hp.	Up to 2000 hp.
Isolation transformer	Required external transformer	Integral transformer	Required external transformer
Cooling	Heat pipe and forced air	Heat pipe and forced air	Forced air
Options	Optional power regeneration using an active converter	-	Optional digital front end to upgrade existing DC drives

Kiln conditions

The starting torques of 125 – 175% of motor rated torque are typically required for a normal kiln assuming the following conditions:

- There are no clinker rings or mud rings.
- The idler rolls are properly aligned.
- All of the kiln's supporting idler rolls and gear reducing units are lubricated.
- The charge in the kiln is at the minimum elevation.

The effect of clinker rings and mud rings for wet process kilns, and misaligned or poorly lubricated idler rolls (especially when cold) is to increase the starting torques needed from 175 to 225%. This has led to the practice of specifying 200% or greater starting torque for 60 sec, to assure a margin for error. Starting torques are often specified to be as high as 250% of rated motor torque lasting for 60 sec.

Feedback to the process control system

A variable speed drive can provide a useful torque signal, based on drive current, and also a kW signal based on drive current and voltage. These feedback signals can help improve the plant process control. A kiln drive torque signal provides the earliest warning of kiln conditions, such as a flush coming through the kiln or a clinker ring beginning to break up within the kiln. It can also warn of a mechanical problem, such as an idler roll bearing developing major friction. Automatic kiln control systems often use a filtered torque signal and its rate of change as part of the logic for controlling the kiln and its operating speed. Therefore, a good noise free torque signal is critical in process control, and this is dependent on the kiln drive.

Choosing a suitable drive

The type of drive required for these applications depends on the size of the kiln. For smaller kilns, a low voltage AC drive is suitable, while for large kilns a medium voltage drive is required to provide the higher hp. For kilns using DC motors and drives, new upgraded DC drives have been developed to replace the older technology, and in cases where the original DC power bridge is in good condition, a digital front end package can be added to replace the control and communication electronics. Examples of this can be seen in Table 1.