Cement used by the construction industries today is known as Portland cement, derived from a process established late in the 19th century. This process utilizes calcium carbonate (limestone), silica (clay), and minor amounts of other materials heated to a temperature of 1,450 °C, at which point calcination occurs forming the “clinker” that will be milled to a fine powder with other additions to the final cement product.

The cement kiln is the “heart” of the cement process lying midstream between the raw material preparation and the final product grinding for packaging or shipment. The cement plant is a continuously operating plant, where equipment availability is absolutely critical. Cement plant operators will schedule periodic shutdowns, during which all required scheduled maintenance procedures are carried out. Unscheduled shutdowns present extreme challenges in time, cost, and production losses.

A modern cement kiln is a rotary kiln, set upon piers across its length. The kiln, installed at a slight pitch, is rotated slowly transporting the material the length of the kiln. Over the years, the standard configuration of the kiln used has evolved with advancements in the process, lowering overall energy requirements and improving the overall plant efficiency.

The original kilns introduced limestone as a slurry directly into the kiln. This required that the kiln first act as a dryer before it could perform the calcination process. These “wet kilns” were widely used until the 1960s and 1970s when improvements in dry milling of the limestone allowed dry raw material to be fed into the kiln. Further design changes led to the design of pre-heater towers which utilized the “waste” heat from the process in progressive stages of cyclones to preheat the raw materials prior to kiln entry. The latest improvement implements a fuel driven “pre-calciner” incorporated into the tower in line with the pre-heater cyclones. Each of these improvements increases the temperature of the material entering the kiln and thus reduces the necessary length and overall fuel consumption of the kiln itself.

**Kiln drive system criteria**

With most modern kilns utilizing either two or three support piers along the length, the pier typically closest to the kiln inlet will support the kiln drive system. The other piers will have large bearings in place on either side of the kiln that engage with a smooth “tire” around the circumference supporting the kiln. The drive system is installed at the same pitch angle as the kiln itself for proper alignment.
Older designs tended toward a girth gear being installed at the location of the drive system pier. This girth gear was then driven by either one or two drive systems with pinion gears to engage the girth gear. These pinion gears were driven by drive systems based either on electric motors (DC originally, then AC with modern drive systems) or in some instances hydraulic motors. The vast majority of the DC drive systems have been replaced over the years, primarily due to maintenance costs and downtime issues.

The modern approach, known as the friction drive, is seen typically with kilns that utilize two support piers. The closest pier, again, supports the drive system. With this newer friction drive approach, instead of a girth gear, a "smooth tire" is in place. The tire is engaged by the rollers themselves, which are in turn driven by the electromechanical drive system. When driven by an AC motor with a VFD for control, this approach greatly minimizes any harmonics being transmitted to the kiln from the drive system.

A cement kiln is considered to be a constant torque load up to nominal speed, and a constant power load above nominal speed. The ability of the drive system to provide sufficient breakaway torque is a critical requirement of the drive system. In addition to the sheer mass of the kiln, consideration must also be given to friction, product present in the kiln during start, and lubrication or alignment issues with the kiln drive and support system. Typical kiln manufacturer specifications require the system be able to provide 250% of full load torque for up to 60 seconds to accommodate for all potential inertial loads. Full consideration of this parameter must be given when sizing the motor (vs. breakdown torque) and when sizing the current capacity of the VFD.

The primary concern from a process control point of view is to control the speed of the kiln. The speed will determine the flow of material through the kiln, as well as the residency time of the raw material in the "calcination zone". It is this time that is critical to the quality of the final product. The current technology used for speed control is an AC motor driven by a variable frequency drive system. Linear encoders are also typically employed at the kiln shell to provide direct speed feedback. Improvements in performance and the simple economic justification of using standard AC induction motors have driven this solution to become the defacto standard for kiln control.

The typical speed of a kiln running at steady state is 3-5 rpm. In starting or stopping a kiln, the rate at which the kiln’s speed is changed is very critical to the amount of mechanical stress that is placed on the entire length of the driven equipment. Failing to properly control the speed could result in severe damage to mechanical components through the entire drive train. For this reason variable speed controllers are universally used to control this critical parameter. A typical time of 60 seconds to accelerate from zero to full kiln speed is often cited to prevent this type of damage.

When dual drive systems are used for kiln control, it is very important that they operate in a synchronized mode. A drive system must provide load sharing between the two systems. This reduces the chance for mechanical stress or wear on the components caused by differences in speed and/or torque. It is very common with AC motors with VFDs to employ a control strategy that employs speed as the outer control loop for the master and the slave controller, with the master providing an reference torque signal to the slave controller as setpoint to the inner control loop in order to ensure they provide equal torque to the kiln.

The size of the actual motors, drives, and gearboxes is dependent upon the size of the kiln and whether the drive systems are single or dual. A newer “pre-calciner” kiln producing roughly 4000 tons per day of clinker, with dual drive systems, would employ 400 hp motors with appropriately sized drives and gearboxes. A very large modern kiln producing 12,000 tons per day, for example, utilizes dual 1250 hp motors. Because the size of the older technology kilns is larger per ton, the size of these drive systems is also larger.

**Environmental conditions**

In addition to the above considerations, another important element for a kiln drive system is that key components including the motor, couplings, gearbox, and the driven system itself are fully exposed to the outdoor ambient conditions. When running, this can include temperatures up to 48 °C. Like all motors in a cement plant, a protection rating of IP54 or greater is used to protect the motor from dust and other contaminants.

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**Benefits of an integrated kiln drive system**

When given the ability to specify the complete drive system, Siemens ensures that complete consideration is given to all factors. This allows for matching the motor, drive, gearbox, and coupling specifications to meet or exceed all known factors. This provides the operator with a system that is designed to provide optimized performance, efficiency, and maintenance free operation. The fact that this can be provided by a single vendor provides more efficient procurement, engineering, commissioning, and maintenance; with no coordination between multiple vendors required.

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