REDUCTION OF LIME KILN RING FORMATION

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BACKGROUND

Lime kiln ring formation occurs at many mills. Severity of the problem can vary. In the worst case, a mill shutdown will occur if sufficient purchased lime is not available to replace produced lime. Unscheduled shutdowns are a significant expense due to additional labour costs, lime purchases and lime mud disposal costs. Decreased kiln production from ring formation is a significant expense at mills where the kiln is a process bottleneck.

The mechanism of ring formation depends on the location of the ring in the lime kiln. It is critical to understand the factors that lead to ring formation in order to reduce the problem.

Near the middle of the kiln, melting of sodium compounds near 800°C can create a “sticky” kiln surface that picks up lime particles and begins ring formation. These deposits are relatively weak but become harder from reaction with carbon dioxide (recarbonation). Recarbonation typically occurs when the deposit temperature drops below 800°C, as calcined lime mud particles (as CaO) react with CO_2 to form $CaCO_3$. This recarbonation reaction results in sintering, which is bridge formation between lime particles that increases the compressive strength of the deposit. It is important to consider that sodium may be present as soluble sodium compounds (poor mud washing) or from insoluble sodium compounds such as pirssonite.

High sulfur concentrations in the kiln fuel can contribute to ring formation from the kiln midpoint to the kiln hot end. Ring formation when burning NCGs and SOGs can vary from slow to rapid ring growth at different mills.

Kiln rings can also occur within and immediately after the chain section of the kiln. This can occur if mud moisture content is too high (mud ring formation) and can be promoted by high lime content in precipitator catch recycle.

Kiln rings can also occur in other locations where conditions exist for sintering reactions to occur. Cold-end rings can form in the region between mid-kiln rings and the chain section of the kiln.

STRATEGY

Detailed chemical analysis of the kiln ring material is used to determine the major factors causing ring formation in a specific location in the kiln. With a good understanding of the formation mechanisms, mill personnel can focus on the main causes of the problem and extend the time required between kiln shutdowns. This can often be done with only changes to operating conditions.

RESULTS

Example 1.

At a 700 tonne/day lime kiln, rapid ring formation occurred immediately after the chain section over a two day period, causing a mill shutdown. Lime mud solids content remained at 75 to 80 wt% during this event. The ring material was relatively soft and extended for a distance of approximately 20 meters from the chain section. This kiln did not have a history of ring formation. The ring material was examined in detail by X-ray diffraction analysis, elemental analysis and scanning electron microscope/energy dispersive x-ray spectroscopy.

Results showed that the kiln ring material was formed by growth of calcite crystals that acted to bridge particles and increase compressive strength. The likely reaction mechanism is reactive precipitation of calcite. Kiln precipitator dust recycle was a contributing factor. Based on the results, operating conditions of the kiln were modified and ring formation has not recurred.

Example 2.

A mill with two kilns of 200 tonne/day capacity burns NCGs in the #2 kiln. In the #2 kiln, a hard ring rapidly formed from the kiln midpoint to about 40 feet from the hot end (kiln length is 250 ft). PowerShot sockets are installed in the kiln but were not able to remove the kiln ring. Samples of kiln ring material were collected from the PowerShot holes and were examined in detail. Process modifications were recommended that reduced the rate of ring formation by half. In addition, the ring was softer and more easily removed by PowerShot treatment.

Example 3.

Rapid ring formation occurred from 60 to 70m in a 105m kiln. Kiln capacity was 300 tonne/day with natural gas fuel. Previous work to minimize mid-kiln ring formation had no effect. Temperature profile modeling suggested that the ring was forming at temperatures below the melting point of sodium compounds. Detailed analytical measurements were made to determine the formation mechanism of this cold-end ring. Process modifications were made that significantly reduced the rate of ring formation in the 60 to 70m region of the kiln.