Detailed Investigation of Lime Kiln Mud Ring Formation

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Abstract: 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 (XRD), elemental analysis and scanning electron microscope/energy dispersive x-ray spectroscopy (SEM-EDX). To the best of the author's knowledge, this type of study has not been previously reported for a kiln ring at this location.

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. This mechanism is compared with mid-kiln ring formation that occurs by recarbonation and sintering of calcite crystals. Based on the results, operating conditions of the kiln were modified and ring formation has not recurred.

Lime kiln ring formation occurs at many Kraft 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, lime purchases and lime mud disposal costs [1-3]. Decreased kiln production from ring formation is a significant expense at mills where the kiln is a process bottleneck. Increased frequency of scheduled kiln shutdowns can occur with minor ring formation problems.

The problem of lime kiln ring formation has been extensively studied. Early work on ring formation mechanisms was published by Tran and coworkers [1,2]. Notidis and Tran [3] surveyed lime kiln ringing problems at 134 mills in Canada, the United States, Finland and Sweden. More recently, Björk [4] examined the effects of process variation on ring formation at 14 different European mills.

The location of a kiln ring is very important in understanding its formation. Rings near the center of the kiln typically form due to the melting of sodium compounds near 800°C. The liquid phase promotes particle agglomeration that can lead to the initial formation of a soft ring [2,4]. Mid-kiln ring hardening can then occur by recarbonation reactions with CO_2 [2,5]. 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 particles that increases the compressive strength of the deposit. In mid-kiln rings, ring hardening by sulphation is negligible at temperatures below 1000°C [2]. Temperature variations in the kiln and high sodium levels tend to promote ring formation near the center of the kiln [2]. Formation of these rings is well understood.

Kiln rings near the burner end of the kiln are more likely to be caused by sulphation reactions. Calcium oxide can react with sulphur dioxide or sulphur trioxide at temperatures from 1000 to 1100°C [6]. This reaction is slower than the mid-kiln recarbonation reaction and results in hardening of the deposit at temperatures closer to 1100°C.

Lime kiln rings that occur directly after the chain section are often called "mud rings". One way these rings form is simply from wet lime mud leaving the chain section as a result of mechanical failure of the lime mud filter. However, rings can form in this region where wet lime mud is definitely not the cause. Formation mechanisms for these rings are the least understood of the different ring types [1,5]. To form a ring in this region, a mechanism is required that can increase the compressive strength of the lime mud at temperatures between 100 and approximately 500°C. Calcium oxide will react with water (liquid or vapour) to form $Ca(OH)_2$ (slaked lime or portlandite). This

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