Summary of how MANTRA’s model predictive control technology could be used to control the rotating lime kiln temperature and the excess oxygen.

ControlSoft’s MANTRA Advanced Process Control System has the necessary tools to implement a complete model predictive control solution in a rotating lime kiln. Because of the complexity of the rotating lime kiln, a complete summary of the different pieces of lime kiln control would require a much longer description than the one contained in this application note; this section does, however, cover a few of the important variables. The following summarizes how MANTRA’s model predictive control technology could be used to control the rotating lime kiln temperature and the excess oxygen, with a constraint from the TRS emissions.

Figure 2 shows part of a MANTRA function block diagram containing five controllers. Because flow loops are typically easy to control, regular PID controllers are used to control both the primary air flow and the fuel flow. However, because of the large deadtimes inherent with many other loops in the rotating lime kiln, the Coordinated Controller (CC) and the Internal Model Controller (IMC) were chosen to control the other variables.

The IMC controller is MANTRA’s version of model predictive control. The CC controller is basically an IMC controller that can handle more than one controller output. These other controller outputs can be configured to implement a smart feedforward. This smart feedforward is another way to compensate for large deadtimes in disturbance variables. The time delay between a change in the lime mud feed rate and the result on the lime exit temperature, for instance, is an excellent example of where a smart feedforward would be useful.

The diagram below uses the kiln temperature controller output to establish a firing rate demand for both fuel and primary air flow. The feedforwards used are the mud feed rate and the kiln rotation speed. This firing rate demand is then scaled to predetermined fuel and primary air flow setpoints, based on the kiln’s design values for excess oxygen.

Figure 2. MANTRA block diagram showing how CC block is used for the temperature controller output to establish a firing rate demand for both fuel and primary air flow in a rotating lime kiln
Summary of how MANTRA’s model predictive control technology could be used to control the rotating lime kiln temperature and the excess oxygen.

The scaling of the primary air setpoint is just an estimation of the amount of air needed to burn the fuel being supplied. The excess oxygen controller modifies this estimation by adjusting the process variable for the primary air flow controller. If the amount of excess oxygen is too high, then the excess oxygen controller makes the adjusted primary air flow appear higher than the actual primary air flow. The primary air flow controller will detect an error, and will decrease the primary air flow until the adjusted primary air flow equals the setpoint of the primary air flow.

The TRS emissions controller (IMC block) is used only when the TRS emissions exceed allowable limits. If these emissions are too high, this controller will increase the excess oxygen setpoint until the emissions get to a reasonable level. At this point the control goes back to normal and the minimum allowable level of excess oxygen is used as the setpoint. Remember, minimizing the excess oxygen will minimize the amount of heat lost by the kiln.