INTELLIGENT CONTROL SYSTEM OF LIME KILN PROCESS BY PROGRAMMABLE LOGIC CONTROLLERS

Y. BHARADWAJA*

*Assistant Professor, Dept. of Electronics & Control Engineering, Sree Vidyanikethan Engineering College, Tirupathi, A. P., India

ABSTRACT

In the face of strong competition, the industries are aiming at higher profitability through increased productivity and the reduction of costs. In addition, on the global scale the industry is facing increasing market demands for higher product quality, more specialty products and improved production flexibility and environmental protection. Consequently, extensive research is being conducted to improve existing processes. One alternative, which is gaining increasing attention within the industry, is the improved control of existing processes by means of intelligent systems. In this paper, an intelligent kiln control system is presented. In the system, some relays are used in conjunction with highly advanced Programmable Logic Controllers based on Ladder Logic Programming approach to the control of an industrial limekiln have been employed.

KEYWORDS: Relays, PLC, Main Drive, Emergency Drive

1. INTRODUCTION

Control of the kiln process is a demanding task and therefore most of the kilns have been and are still operated without supervisory-level control system. The absence of closed loop controls, however, results in inefficiencies in fuel consumption and variation in reburned lime quality. Furthermore, manual control increases the risk of environmental impacts, emissions of highly concentrated carbon dioxide and the probability of equipment failures such as damage to the refractory linings of the kiln.

The multivariable nature and difficult dynamics associated with the kiln process requires that an automation system employ techniques such as decoupling, dead time compensation, dynamic feed forward, optimization, and constraint compensation in order to accomplish the stated operational objectives. The goal of a properly designed kiln control solution should be to implement these techniques in a fashion that is usable and maintainable by mill operations. It is only then that the economic benefits from the control optimization can be sustained long-term.
2. PROCESS DESCRIPTION
The rotary lime kiln is a vital piece of equipment in the calcining process in the steel mill. Its operational objective is to convert lime stone (calcium carbonate-CaCO3) into calcium oxide, CaO (quick lime) that can be further used in the converter at Steel Melt Shop (SMS) in order to reduce the carbon content to its desired amount in iron ore and to produce pure liquid steel. The basic purpose of the calcining system is to convert calcium carbonate, CaCO3 into calcium oxide, CaO that is used in the steel melting process.

The lime kiln is a long direct contact heat exchanger. Heat energy is supplied by the combustion of fuel that enters with the primary air at the hot-end of the kiln. The energy is transferred to the lime mud that enters at the cold-end of the kiln, and then flows down counter current to the combustion Gases due to the kiln inclination and rotation speed. During lime kiln operation, calcination of the incoming lime mud occurs, thus regenerating the hot lime required for the steel extraction.

Maintaining good control of the kiln temperature profiles helps ensure consistently high lime quality availability, high reactivity, and uniform lime pellet size. This provides the calcining process with the ability to manufacture high quality steel in the most efficient manner.

3. CLASSICAL LIME KILN CONTROL USING RELAYS
A relay is an electrically operated switch. Figure 1 shows a block diagram of a typical limekiln process. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts. The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit.

In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. When an electric current is passed through the coil it generates a magnetic field that activates the armature and the consequent movement of the movable contact either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of
contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open.

![Block Diagram of a Lime Kiln Process](image)

**Fig. 1:** Block Diagram of a Lime Kiln Process
When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position.

**DISADVANTAGES**

1. Control relays should not be operated above rated temperature because of resulting increased degradation and fatigue
2. Undesired arcing – Switching while ‘wet’ (under load) causes undesired arcing between the contacts, eventually leading to contacts that weld shut or contacts that fail due to buildup of contact surface damage caused by the destructive arc energy.
3. Requires periodic maintenance and testing
4. Relay operation can be affected due to aging of the components and dust, pollution resulting in spurious trips
5. Operation speed for an electromagnetic relays is limited by the mechanical inertia of components
6. De-soldering of relays due to harsh working environment.

**4. LIME KILN CONTROL USING PLC**

**4.1 Replacing Relays with PLC**
The first thing that we should do is to create a ladder diagram. We have to create one of these because a PLC doesn’t understand a schematic diagram. It only recognizes code. Fortunately most PLC’s have software which converts ladder diagram into code. First Step We have to translate all of the items we are using into symbols that PLC understands. The PLC doesn’t understand terms like switch, relay, bell, etc. It prefers input, output, coil, contact, etc. It only cares if it’s an input or an output. We draw bus bars which simply look like two vertical bars
one on each side of the diagram. Next we give symbols for inputs and outputs. Second Step –
We must tell the PLC where everything is located. In other words we have to give all the
devices an address. Where is the switch going to be physically connected to the PLC? How
about the bell? The PLC has a lot of inputs and outputs but we have to figure out which
device is connected where. Final Step – We have to convert the schematic into a logical
sequence of events. The program we are going to write, tells the PLC what to do when certain
events take place.

4.2 Working of PLC
The voltage signal comes from the sensor and is connected to the terminal of the input
module (inputs of the PLC). The processor in the CPU executes the program stored in the
memory and scans the individual inputs and outputs of the controller for presence or absence
of voltage. Depending on the state of the inputs and on the program stored in the memory the
processor directs the output modules to switch voltages to the connectors of the output
terminals. The actuators and indicators are switched ON or OFF according to the voltage
states at the terminal of the modules of the PC. Total execution is done by the PLC according
to a user programming ladder. Each logic is written into the memory location in the memory.
The individual statement is executed one after the other by the processor of the PC. After
executing the last statement in the memory, the processor begins from the first statement in
the memory. This is referred as “Cyclic Processing”. This is shown in the below figure.

![PLC Operating Cycle](image)

**Fig. 2:** PLC Operating Cycle
5. CONCLUSION
Programmable logic controller is a digitally operator electronic device that uses programmable memory for the internal storage of instructions. These instructions are for implementing specific functions such as logic sequencing, timing, counting and arithmetic to control machines and processes through digital or analog input. Selection of PLC’s varies from one application to another basing on the number of I/O’s, number of controls, processing speed etc. In the Lime Kiln, a set of several PLC’s are being used to identify the faults. By using these, the fault identification became easier and the breakdown time decreased considerably, thereby increasing the production.

6. FUTURE TRENDS
AC speed control has evolved almost exponentially over the last few years primarily due to advances into the design and packaging of the modern power transistors, thyristors and large power diodes and microprocessor based switching algorithms. Maintenance cost will be reduced due to elimination of thyristor panel and relays used for conversion.

REFERENCES