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Control of Weigh Feeder by Programmable Logic Controller: Case Study of Cement Industry

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ABSTRACT: Many cement plants are operating with control systems consisting of relay panels, hardwired interlocking control and mimic panels. But they are hard to maintain and modify. They provide the operator with poor access and display of information and do not permit centralization of many local control rooms.

In cement industry the sequence and interlock control of numerous motors and associated machinery is of major importance. Programmable logic controllers now employed are robust, reliable and easy to handle. A close loop system to sense the sound level of ball mill and give signal to programmable logic controller to adjust the feed rate and maintain the same decibel value. Thus with help of ladder diagram control results are accurate and more refined.

Keywords: Control of Weigh Feeder, Programmable Logic Controller, Cement Industry, mimic panels

I. INTRODUCTION

Cement manufacturing is one of the largest mineral commodity industries in India, with an estimated production capacity of greater than 50 million metric tons annually. The principle chemical elements required for production of cement are calcium, silicon, aluminum and iron. Calcium is provided typically from limestone usually mined on or close to the plant site. Silicon and aluminum come from clay, shale, state or sand. Iron can come from variety of sources including iron and steel mill scale. The cement industry is very capital intensive and & depends largely on construction activity for a steady source of product demand. Energy costs can account for upto 40% of total cost of cement manufacturing.

II-PROGRAMMABLE LOGIC CONTROLLER

The high degree of acceptance of Programmable Logic Controller (PLC) has resulted in a formal definition of PLC by National Electrical Manufacturers Association (NEMA) , as per NEMA standard ICS3-1978, part ICS3-304 : “a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control, through analog or digital input/output modules”, various types of machines or processes.

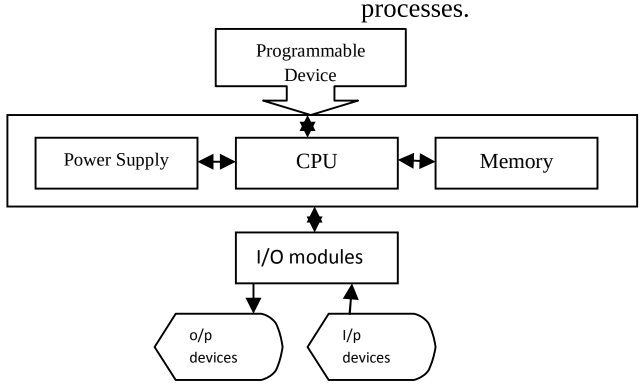

Fig. 1. Basic PLC architecture.

A digital computer which is used to perform the function of programmable controller is considered to be within this scope. Excluded are drum and similar mechanical type sequencing controllers" [1]. All hardware associated with a PLC falls into one of the two functional areas. The actual intelligence is derived from electronic computer based hardware, as shown in figure 1.

A. Functions of PLC: Every processor is designed to perform a wide variety of functions. Most of the systems offer the standard relay, timing, counting & simple mathematical functions of addition, subtraction, multiplication and division as part of their instruction capabilities. Also found in many medium to large sized systems are data and bit manipulations, including shift, rotate and compare and sensing functions, BCD to binary conversion and vice versa, analog control functions including proportional, integral, derivative control and their combination, report generation and graphics, computer, printer and intelligent terminal interfaces: subroutine, jumps, skips, sequencer and master control relay instructions as well as a complete compliment of self diagnostic instructions and trouble shooting aids. All these functions give the processor flexibility required to meet a diverse listing of applications & industrial environment [1-2].

B. Simplified Operation of PLC: Within the hardware of the I/O structure, incoming field device signals rich in electromagnetic noise and interference are scoured and reduced to electronic clean room condition prior to use by processor. These signals are transferred to the processor for use during the interpretation & solving of the users relay ladder logic program. Conversely the commands of the processor, which are based on the solution of user's program are boosted from logic voltage levels by the I/O system to drive power hungry industrial controls [3].

C. Comparison of hard wired control and PLC: The traditional hard wired system contains contractors or relays, whereas PLC system is build around a programmable controller, in hard wired system it is the wiring which defines control, any modification will involve rewiring whereas in PLC it is the program and just slight change in some command.

The quantities produced are in accordance with the limits and specification of the production equipment, ensuring that finished product comply with quality objective and production equipment donot get damaged or overloaded (surveillance of machinary). This results in a definition of goals for processes as well as for the machinery, such as required specific temperature, pressure, speed, quantity etc.

III. LADDER DIAGRAM FUNDAMENTALS

Machine control design is a unique area of engineering that requires the knowledge of certain specific and unique diagramming techniques called ladder diagramming. Although there are similarities between control diagram and electronic diagram but many of the component symbols and layout are different.

A. Basic Diagram Framework: Ladder diagram are drawn beginning with the control transformer, a protective fuse is added on the left side, fuse may often be the part of transformer itself. From transformer fuse combination, horizontal lines are extended to both sides and the drawn vertically down the page. These vertical lines are called rails or power rails or uprights. The voltage difference between the two rails is equal to the transformer secondary voltage; therefore any component connected between the two rails will be powered. Right side of the control transformer secondary is grounded to the frame of machine (earth ground), because without ground should the transformer short internally from primary to secondary, it could apply potentially lethal line voltages to the controls. All wires in a control system are numbered such as left rail wire is number 2 and right rail wire is number 1. When the system is constructed, the actual wires used to connect the components will have a label on each end (called a wire marker), indicating the same wire number. This makes it easier to build, troubleshoot and modify the circuitry. Generally control circuits are wired with all black, red or white, green is exclusively kept for safety ground wiring.

B. Boolean Logic and Relay Logic: when introducing a class to logical operations, an instructor illustrates the AND function using the analogy of a series connection of two switches, a lamp and a voltage source. Fig. 2 & 3 show the actual wiring connection and representation of the circuit in the ladder logic form. We utilize power from rails and add two push button switches and lamp in series between the rails as shown in figure. This added circuit forms what is called rung (of ladder), so now we can add more circuitry to it, resembling a ladder with uprights and many rungs. Similarly OR circuit can be made using switches in parallel rungs.

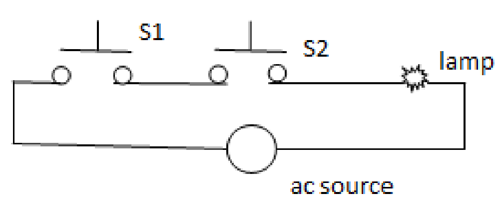

Fig. 2. AND lamp circuit.

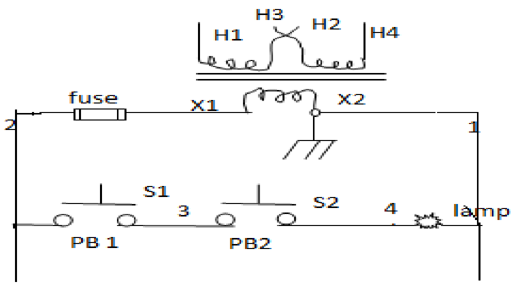

Fig. 3. Ladder diagram.

IV. WEIGH FEEDER AND ITS CONTROL METHODOLOGY

A weigh feeder in a cement industry is used to continuously feed bulk solids for grinding; these solids are clinker, gypsum and fly ash in 72.5, 2.5 and 25 percentage respectively. So weigh feeder is actually a conveyor belt through which material passes and is dropped to the mill for grinding.

Control can be of two types gravimetric control and volumetric control:

(i) Gravimetric control: Feed rate is controlled by the belt speed according to the set point. The pre feeder if any, maintains the belt load at nominal value.

The measured values of platform load (Q) and belt speed (V) are normalized to physical quantities, namely, kg & m/sec, resulting in feed rate

$$P_{\text{(feed rate in kg/s)}} = Q_{(kg)} * V_{(m/s)}$$

$$= q/(L/2) * V$$

Where L/2 is effective length of platform in meters, q is belt load in kg/m

Belt load is determined by the pre feeder (feed hopper, pneumatic pre feeder etc.) and feed rate. Feed rate depends upon

1. Height, width and bulk density of material bed on the belt.

2. Belt speed is controlled by via belt speed 'V'. The belt speed is varied as a function of the belt load that feed rate always corresponds to the desired value.

$$P = q*V$$

Where *q* varies and *V* is controlled. The load cell output voltage which represents the platform can be converted to digital information by some converter. The load distribution over the platform under ideal conditions is such that half of the force is applied to the middle idler, the weighed idler.

(ii) Volumetric control: This is independent of belt load, belt speed is controlled by pre determined set point, pre feeder if any, operates proportionally to feeder belt speed.

Feed rate = Belt load (kg/m) * Belt speed (m/s)

= Belt load * Belt speed*3600/1000

= 3.6* Belt load (kg/m) * Belt speed (m/s)

V. CONCLUSION

The project work carried out by designing and developing a software for control of weigh feeder and performance of the developed software was studied. Ladder diagram when practically implemented and one more ladder diagram was developed to evaluate three shift production in the cement factory.

VI. FUTURE SCOPE

With the help of linear synchronous module, transducers can be removed and every facility related to power monitoring in PLC can be taken. Periodical records can be maintained. Also all zero speed sensor controllers can be removed and direct proxy signals to PLC can be given for making zero speed logic.

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