Automation of Kiln Mill Drive in Cement Industry using PLC and SCADA

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Abstract

Automation of manufacturing operations helps in increasing the production, improving the product quality, enhancing the safety of the operators as their role get transformed to supervisors and decreasing the cost of production. A Programmable Logic Controller (PLC) is nowadays key component for Industrial Automation. PLC helps in making the automation more flexible. SCADA systems became popular to arise the efficient monitoring and control of distributed remote equipment. Cement plants are one of the largest consumers of energy. Their electrical energy costs account for about 15 – 20 percent of the total production cost. The large fans and motors used in the production process consume a major part of electrical energy. With the use of Variable Frequency Drives (VFDs) the energy consumption can be reduced from 90 kWHs/ton to about 70 kWHs/ton of cement produced. VFDs offer much more flexibility in operating ranges like speed variation from 0 to 100 percent and a considerable reduction in maintenance costs Based on the above concept a control system is developed for the kiln mill drive used in Cement Industry using PLC, and which can be interfaced using SCADA.

1. Introduction

In cement plants, variable frequency drives provide controlled torque and speed to the kiln. In addition to enhanced process control, the VFD increases the life of the mechanical equipment and reduces mechanical maintenance and operating costs. The drives also provide accurate torque and speed feedback signals, which are used by the distributed control system to improve kiln process control. Important kiln drive control requirements are provided by the VFD.

The controlled and timed acceleration provided by a variable frequency drive is very beneficial for the kiln, compared to starting the kiln motor directly from the AC line. Rapid, across the- line starting of the kiln motor could result in unwanted torsional oscillations and stresses in parts of the driven machinery.

An automatic kiln control system often is used for controlling the kiln and its operating speed. Efficient speed control of equipment is a prerequisite in modern cement plants as a result of on-going efforts for process optimization. In large process organization, VFD is used to control the motor through PLC logic and SCADA for speed control, start/stop operation, intermittent operation etc. The PLC is a programmable device, which executes functions such as logic, timing, counting, arithmetic operations and data manipulations. It continuously monitors the status of input devices, processes the input data as programmed, makes decisions and modifies the outputs accordingly. The program stored in the memory can be readily modified. The novelty of PLC is that it can operate in an industrial environment with temperature ranging from 0 to 60oC and humidity ranging from 0 to 90%.

The use of PLCs with power electronics in electric machine applications has been introduced in the manufacturing automation. Many factories use PLCs in automation processes to diminish production cost and to increase quality and reliability. PLC continuously monitors the inputs and activates the outputs according to the control program. In Fig. 1 the PLC correlates the operational parameters to the requested by the user and monitors the system during normal operation and under trip conditions [1-3].

SCADA systems became popular to arise the efficient monitoring and control of distributed remote equipment. Today SCADA systems include operator-level software applications for viewing, supervising and troubleshooting local machines and process activities. Powerful software technologies are used for controlling and monitoring equipment. [5]

The cement manufacturing process consists broadly of mining, crushing and grinding, and grinding with gypsum. Two basic processes, the wet process and the dry process, are used for cement manufacturing. Basic chemical reactions in the clinckerization are: Evaporating all moisture, calcining the limestone to produce free calcium oxide and reacting the calcium oxide with the minor materials (sand, shale, clay and iron). This results in a final black, nodular product known as "clinker" which has the desired hydraulic properties. The preheater tower and rotary kiln are made of steel and lined with special refractory materials to protect it from the high process temperatures.

2. PLC as a system controller

For clinker formation squirrel cage induction motor is commonly used. Required speed range is of the order of 1:10. Starting torque required is about 200-250% of rated torque [1, 2 and 11]. Process temperatures can reach as high as 1450oC during the clinker making process [9].

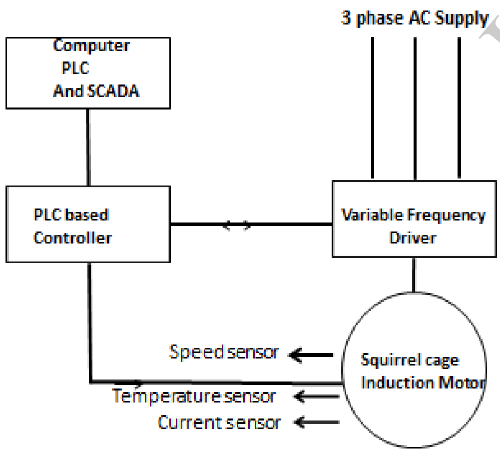


Figure -1: System block diagram for squirrel cage induction motor control

For the purpose analog output of PLC is varied from 0-10 V by using move block in the PLC ladder logic. For a 12 bit processor 4096 corresponds to 10 V is set. To provide stepped variation of speed, a timer is used and analog output voltage is varied in steps.

Continuous voltage variation can also be done to achieve continuous speed variation. Motor speed is sensed using proximity sensor which is connected to one input of the PLC. A counter, timer, multiplier and move blocks of PLC is required to calculate the motor speed. The no. of pulses for a fixed time interval is counted by the PLC and converted into speed in RPM. Speed of the motor is sensed continuously and simultaneously. Once the speed goes beyond limit a trip signal is given to stop the motor. Temperature of the motor is sensed using scale with parameter (SCP) block and RTD output. If the sensed temperature is beyond limit, a trip signal is given to stop the motor. Also various protections like single phasing, material availability, door guard, conveyor on, lubricating oil pump on, cooling fan on etc. are provided. In case any condition is not fulfilled the motor cannot operate.

Motor current is measured using current transducer and analog input of the PLC. In Figure- 2 AC current is first stepped down using current transformer and then using rectifier ac current is converted to DC current. By using one resistance this DC current is converted to DC voltage which can be fed to analog input of PLC. This DC voltage is calibrated to corresponding AC motor current. Once the motor is overloaded a trip signal is given to motor through PLC.

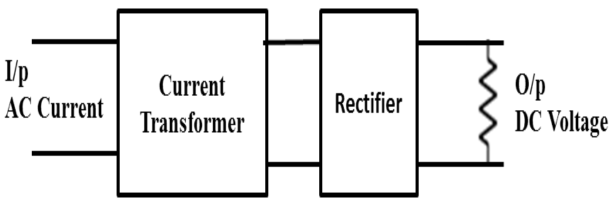
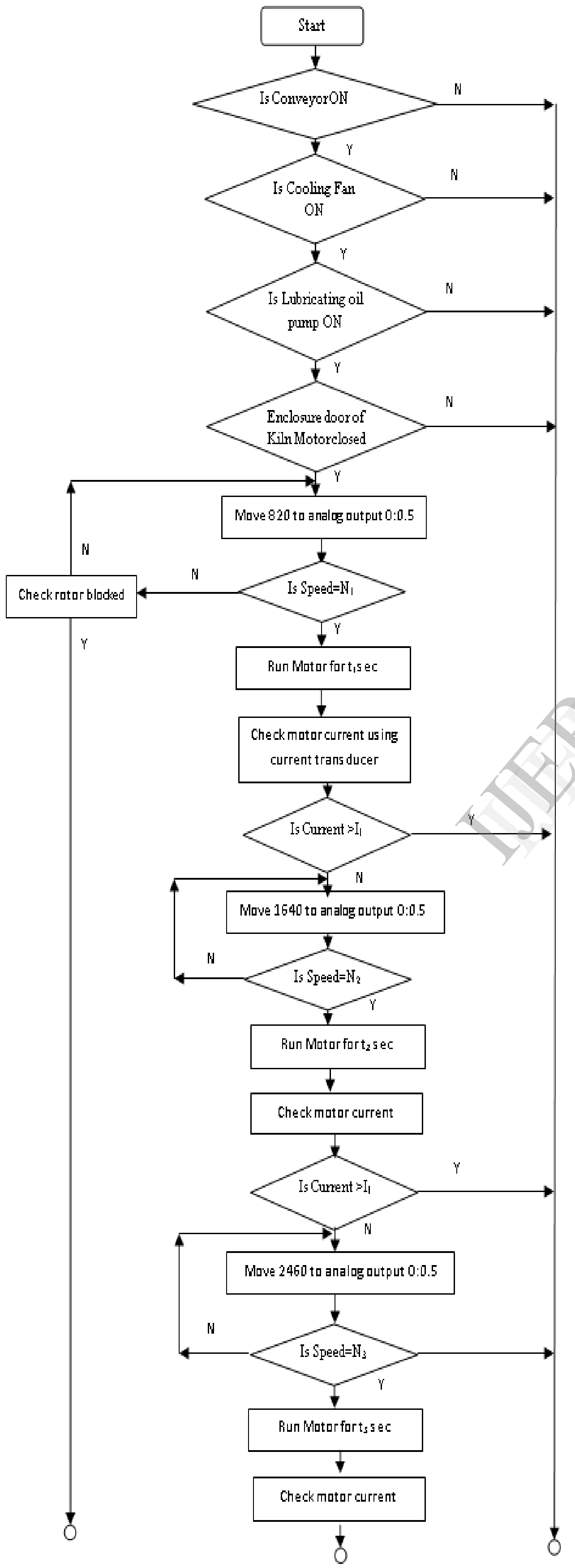


Figure -2: Block diagram of Current Transducer

Various Protections are provided in PLC ladder logic. All the faults are represented as NC contacts in PLC programme. Due to occurrence of any of the faults in the motor NC contact of corresponding fault becomes open and the bit in protection rung becomes low, and in turn supply to motor gets interrupted and motor stops [12,13].

3. SCADA implementation

SCADA graphics screens are developed for cement clinker formation process. In Fig. 4 main screen contains status of wound rotor induction motor (ON/OFF) used for clinker formation, status of supply (ON/OFF), duration of motor running, system status (healthy/unhealthy), actual motor speed, motor winding temperature, running duration of motor etc. [6].



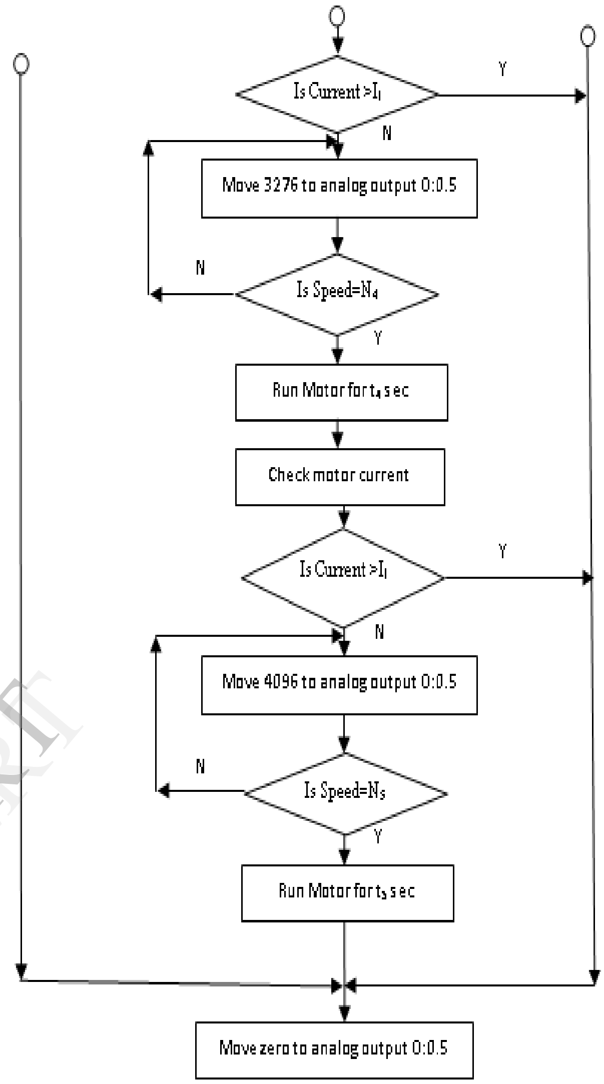


Figure -3: System Flow Diagram

One rectangle is animated for ON/OFF switch of Cement Kiln motor. Motor running status is animated using motor picture; it turns green in running condition of motor otherwise red. System healthy condition and supply ON/OFF condition are animated using circles. Using Numerical display actual running duration of the Cement Kiln motor is displayed. Using numerical input enable, in run time maximum temperature of the motor can be changed and also the actual temperature of the motor is displayed using numerical display.

Alarm for analog signals like temperature, motor current and motor speed is set. If the temperature of motor winding exceeds beyond limit one banner displaying temperature high will appear on the main graphics window. Once the alarm is acknowledged, acknowledged (ack) alarm button should be clicked. And if the alarm is attended it can be cleared by clicking at clear alarm button [7]. Similarly alarm trigger values for motor speed and motor current are set.

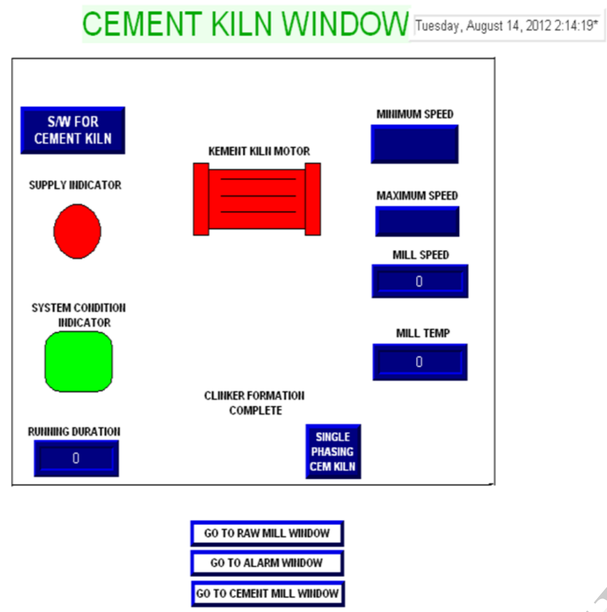


Figure-4: SCADA graphics window for Cement Kiln

Faulty conditions are displayed in the form of alarm banners. On these banners time of alarm, acknowledged or not, time of acknowledgement are mentioned.

Speed limits of the motor are tagged on the SCADA screen using numerical input enable. Before switching ON the motor, speed limit can be changed in run time. And the actual speed of the Cement Kiln motor is displayed using numerical display.

On the main graphics window of Cement Kiln, navigation buttons are provided for different windows. These are GO TO alarm window, GO TO Raw mill window, GO TO cement mill window. Using these buttons we can monitor other process in run time on the graphics window [8].

Alarms can be cleared separately by clicking at clear alarm or all together at once by clicking at clear all alarms.

4. Conclusions

PLC can be programmed to sense, activate, and control industrial equipment and, therefore, incorporates a number of I/O points, which allow electrical signals to be interfaced. In large process organization, VFD is used to control the motor through PLC logic and SCADA for speed control, start/stop operation, intermittent operation etc.

Input devices and output devices of the process are connected to the PLC and the control program is entered into the PLC memory. PLC controls analog and digital inputs and outputs in varying load operation of motors. PLC continuously monitors the inputs and activates the outputs according to the control program. Control system of drives with PLC and SCADA system has the advantage of local as well as centralized control. The monitoring control system of the kiln motor controlled by PLC and SCADA proves its high accuracy in speed regulation control and protection at variable-load operation.

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