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Automation of Raw Material Transfer Process from Quarry to Silos in Cement Plant

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ABSTRACT:*Cement is an essential component of infrastructure development. The market demand of cement is increasing continuously but still now most of those plants aren't up to the mark technologically, an integrated solution of material handling in cement plant is presented in this paper to meet the increasing production needs. This innovative thinking will help to reduce energy consumption and improve operational efficiency as most of the energy is consumed to transfer the bulk materials between intermediate stages. The automation process is done using programmable logic controller (PLC)[1]. The focus of this paper is to implement ladder logic for automation process in cement plant and the hardware used for it.*

Keywords: *Automation, PLC, ladder logic, level detector, silos.*

I. INTRODUCTION

India is the second largest producer of cement in the world but still it is not enough for our increasing needs. The overall concept of manufacturing process is taken from ACC CEMENT LTD and various cement manufacturing groups of India. This paper only reviews the flow of materials through the various stages to a particular place.

The whole operation is timing controlled, the devices are turned on sequentially one after another by on delay timer and also turned off sequentially one after another by off delay timer. There are various types of sensors and level detectors are used in each and every critical point to control the entire operation and to reduce the unwanted running of machineries. [3] cement plant has various process in manufacturing we will discuss the process automation of raw material transfer from quarry to silos. The word automation is used frequently in modern discourse to describe all manner of things that involve machines and electronics performing tasks previously performed by humans. Nonetheless, automation still has a finite and quantifiable meaning when referring to its implementation in a modern cement manufacturing facility.

This paper will focus on offering an overview of industrial automation that gives the reader a framework for about the equipment, systems, programming used for automation and methodologies involved in implementing a modern automation system. [2]. Automation is defined as ‘‘automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human organs of observation, effort, and decision. [4]

II. HARDWARE

1. Instruments, Actuators, and Sensors

The sensors connected to the process can be as simple as a limit switch or can be as complicated as an on-line X-ray analyzer. Examples of traditional discrete (switch) sensors include the classic limit switch, temperature switch, pressure switch, flow switch, level switches of numerous designs, photoeyes, and input devices such as push buttons and pilot lights. Switches are digital devices that provide a simple contact which indicate their state: on or off. Instruments such as thermocouples or pressure transmitters are analog devices capable of providing a continous range of measurement readings from 0 to 100% of range and reporting their data with a changing voltage or current output. As for outputs, motor starters and solenoids are generally digital devices, opening or closing depending on whether they are fed with power from a system output or not. Other actuators, such as valve positioners and adjustable speed drives, are variable and will accept a 4–20-mA control signal to command them to go to 0–100%of their range.

Most instruments today can be enhanced in with intelligent versions. These intelligent instruments have on-board microprocessors that allow for functionality beyond the basic measurement of the primary variable. They can monitor and report additional process variables, support multiple configurations, totalize flow, and monitor and report on their own health. Often, they have significant on-board diagnostics. Motor starters can now monitor various aspects of the health of the motor. They can report current, phase voltage, motor power, motor power factor, and running hours and can tell you exactly why a trip occurred (i.e., overload, ground fault, or short circuit?). They can even tell you when the coil in the contactor is about to fail. Likewise, variable frequency drives can report the same information and even more.

On the plus side, these intelligent instruments can tell you far more about your process than simply the temperature or pressure at a single point. The information given by an intelligent motor starter can help in managing energy costs and predicting motor failures before it happens. Furthermore, if you suspect a fault with one of these instruments, the on-board diagnostic information can often lead you directly to the cause if the device has not already notified you of the problem on its own. To setup and configure intelligent instruments correctly we need to have proper knowledge about the instruments. For all of these types of instruments, the additional information can only be accessed remotely or in real time if you add a serial communication line to the instrument in addition to or in lieu of the primary voltage, current, or contact output. Otherwise, data are trapped in the device and only available at the local display. [2]

2. Intelligent Devices and Integrated Subsystems

In addition to the sensors and actuators that one would typically relate with an automated system, vendors are continually striving to provide tighter integration and communication between the controller and some of the newer, more specialized, and more complex systems that one may find in an automation system. To narrow the communications gap between these complex subsystems and the rest of the control system, vendors have started to offer interface cards that reside in the same card rack with the PLC or HDCS controller. Putting these two elements in the same rack allows them to communicate over the backplane of the chassis, thus enabling the passing of large amounts of control and process data at high rates of speed. The PLC can then use this information from the subsystem in its control program and can execute various commands in the subsystem program without going through a hardwired interface.

Numerous intelligent subsystems are available in the market with controller cards that will reside in the same card rack as the PLC. These include scales and load cell controllers, radio frequency identification tag readers, motion controllers, and numerous forms of communication interfaces, from basic RS-232 to proprietary network protocols. Another interesting development is the availability of actuators with small amounts of I/O that are equipped with the ability to communicate over I/O networks. An example of this is the availability of intelligent valve controllers that will reside on the I/O network. No individual wiring of the individual solenoids or switches back to I/O modules is required. By simply connecting the serial I/O network cable to the valve controller and doing some configuration, limit switches and position status can be read and each solenoid becomes individually addressable and can be actuated directly from the program. This cuts down on the field wiring required to install and operate the valves. [2]

3. I/O Systems

Your I/O system is the equipment that takes input signals from the sensors and turns them into digital bits for your process controller to read. It also takes the bits from your process controller and turns them into voltage signals to drive your motor starters and valves. Traditional I/O systems involve a card rack that is populated with individual input and output cards. Each card usually handles 8, 16, or 32 points and is tailored to the specific voltage and current characteristics of the signals it will accept: 24 Vdc, 120 Vac, mV (for thermocouples), or 4–20 mA for other analog instruments. Many vendors offer diagnostic versions of their cards. These diagnostic cards not only tell you if the input signal from the device is present but also tell you if the signal wire is broken or short circuited. Generally, I/O racks are placed in an electrical room or marshalling panel that is centrally located to the majority of the sensors on the process. Since a single rack can handle several hundred I/O points, often there is several hundred feet of signal wire from the rack to each device. With this concentration of input capability, one or two rack locations can then cover the entire facility, with hundreds of individual wiring runs going from the rack to each device.

An option to concentrating all of the I/O into several centrally located racks is the concept of distributed I/O. In this arrangement, several small I/O modules of 8–16 points each are located in the field, nearer to the devices they monitor. This concept reduces the amount of field wiring from the device to the I/O module and puts the module close to the monitored process or equipment. Often, skid mounted equipment can be supplied with all I/O factory wired to one of these modules mounted on board the skid.

Regardless of whether it is rack, distributed, or point I/O, all of these solutions need to communicate back to the PLC over a serial network. In the past, vendors provided separate proprietary networks that talked only to their I/O and to devices from selected partners. These original networks ran at baud rates in the 50–200 K range.

Modern I/O networks now run in the 2–4 MBd range. Other developments include the growing use of the Ethernet as an I/O device network. Another consideration with proprietary I/O networks is the ability to place intelligent devices directly on these networks. Often, equipment such as variable frequency drives or scale controllers contain a large amount of data that is of value to the control system and operator. Placing these devices on the PLC's I/O network allows these data to be easily communicated to the PLC for use in controlling the process or for passing data through for display on the system HMI.

To manage the amount of data available in intelligent instruments, vendors have introduced a number of networks that are designed to connect directly to the instruments themselves. These networks are generically referred to as field buses and are intended to run from the controller to the instrument, then on to the next instrument in daisy chain fashion. In this configuration, they replace both the I/O modules and the individual runs from the I/O module to the devices. Currently, there are several competing standards for these device networks. Some, such as Device Net and ASI, are designed primarily for digital data and are intended for simple devices such as limit switches or photoeyes. Others, such as Profibus and Foundation Fieldbus, are intended for analog instruments with greater amounts of data to transmit. All of them have special cabling installation and connection requirements, require engineering configuration and setup of both the instruments and the networks themselves, and work only with instruments specifically manufactured and certified for that network.

As you can see, there are numerous options when it comes to I/O solutions. Each has its advantages and disadvantages. The traditional rack I/O usually provides the lowest per point cost and allows you to centralize all of your I/O equipment in one clean, secure, and environmentally controlled room. On the other hand, unless your process is concentrated in a small area, it requires long wiring runs to connect to the devices in the field. Distributed I/O modules allow you to reduce the length of the wiring runs to your devices. However, they are slightly more expensive, often place the module in the field in a hostile or even hazardous environment, and require that the I/O communication network be run out in the field to their location. Finally, field bus networks offer savings in the costs of installation wiring, allow the instruments to provide large amounts of data to the controller and operator interface, and ease the configuration of the instruments by allowing the maintenance technician to access all instruments from one PC connected to the bus. On the minus side, the instruments can be more expensive, the instruments and network require engineering to configure and setup, and the networks can be difficult to trouble shoot if problems arise. [2]

III. RAW MATERIAL TRANSFER FROM QUARRY TO DIFFERENT SILOS

Cement industries typically produce Portland cement. Most of the raw materials used are extracted from the earth through mining and quarrying. Those are lime (calcareous), silica (siliceous), alumina (argillaceous), and iron (ferriferous). As limestone is the prime constituent of cement, the major cement plants are located near the good quality lime stone quarry. At first lime stones and quarry clays are fed to primary crusher house for raw crushing. Then the materials are transferred to secondary crusher house. After that the crushed materials are fed to the stock pile. Inside the stock pile there is a stacker/reclaimer which segregates the raw material quality wise in to different stacks. The stacking and reclaiming systems operate independently. There are also four additives- iron ore, bauxite, laterite and flourspar into the stack pile to get required composition of cement. The additives are brought to the stack pile by conveyor C4. Then according to the requirement limestone, iron ore, bauxite, laterite and flourspar are transferred to different silos by their respective conveyors. Inside each silo there are three level detectors which detect the level of materials inside it. [1] The process is shown in fig.1

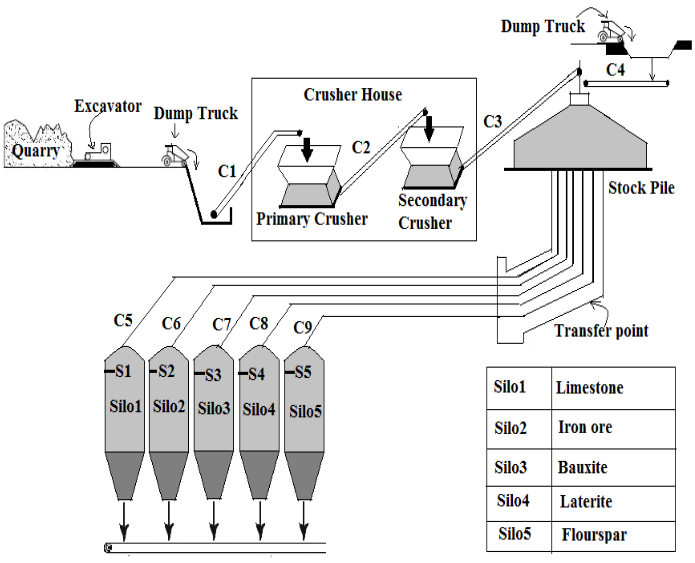

Fig 1. Raw Material Transfer from Quarry to Different Silos

IV. Process Automation

To make this process fully automatic a PLC unit is used. PLC takes real time decision depending upon the various field level input signals from various sensors placed in different critical points and sends the decision to the output devices.

1) Input

Pushbutton [PB(1-9)],Upper level detector [S(1-5)], conveyor[C4].

2) Output

Conveyor [C (1-3, 5-9)], Primary crusher(PC), Secondary crusher(SC), Stacker/reclaimer system(S/R)

3) Process Description

At first an operator starts the entire process by pressing a push button PB1. As soon as the operator presses PB1, conveyor C1 starts rolling and the bulk materials i.e. lime stones are taken from quarry by conveyor C1 to primary crusher (PC). The primary crusher will start by an on delay timer TT1. After some time delay, required for primary crushing C2 starts running and the raw crushed materials are transferred to secondary crusher (SC). This time on delay is defined by timer TT2. The secondary crusher (SC) is started together with C2. Conveyor C3 will start after a time on delay (TT3) of starting the secondary crusher to transfer the material from crusher house to stock pile. There are two pushbutton switches PB3and PB4 inside the stock pile. Now if PB3 is closed manually, the stacker /reclaimer system (S/R) starts directly or after a time on delay(TT4) of starting either conveyor C3 or C4.

Pushbutton PB4 is provided to stop the stacker/reclaimer system manually. For safe operation each and every process should be turned off sequentially. So to achieve these five off-delay timers are used i.e. TT5, TT6, TT7, TT8, TT9. When conveyor C1 are on, the timer TT5 is true. The Done bit of TT5 is latched with PC. When the primary crusher (PC) is on, the timer TT6 is true. The Done bit of TT6 is latched with C2. TT7 is latched with the secondary crusher (SC) which remains true till C2 remains on. Timer TT8 remains true till SC is running. The done bit of TT8 is latched with the C3. TT9 remains true till conveyor C3 is on. There are also an off delay timer TT10 which remains true till C4 is on. Now due to any fault or any other reason if emergency plant shutdown is required, the operator presses PB2. As soon the operator presses PB2 at first conveyor C1 will stop.

Then according to the PLC programming the primary crusher(PC), conveyor(C2), secondary crusher(SC), conveyor(C3) and S/R will goes off sequentially. The same things will happen in case of conveyor C4. Push button switches PB5, PB6, PB7, PB8, PB9 are the operating switches of limestone conveyor (C5), iron ore conveyor (C6), bauxite conveyor (C7), laterite conveyor(C8),fluorspar conveyor(C9) respectively.

Through these conveyors the materials are transferred to their respective silos. S1, S2, S3, S4, S5 are the upper level detectors of different silos. If upper level detector is high, the corresponding conveyor i.e. C5, C6, C7, C8, C9 will be off. [1]

V. PLC Ladder Logic Program

The PLC is programmed using ladder logic which is used to control the whole process of automation i.e. raw material transfer from quarry to silos.

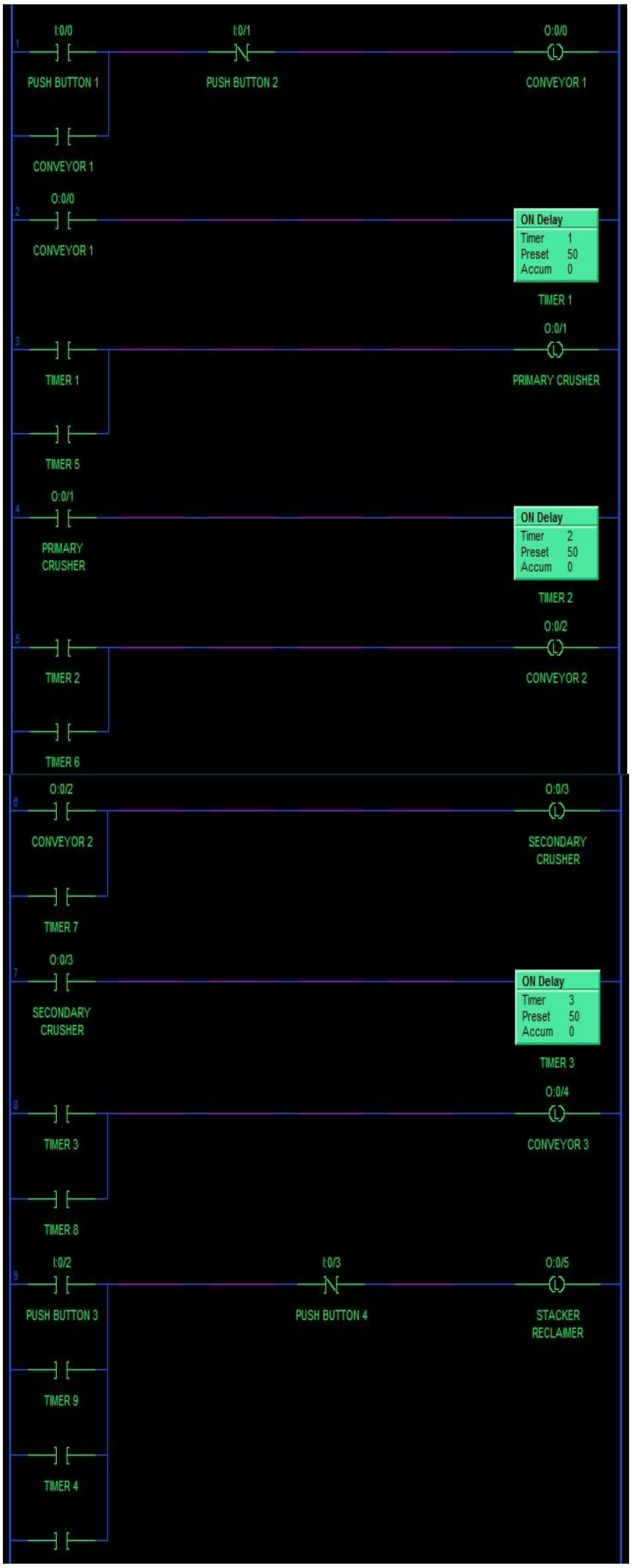

Fig -2(a) Ladder logic for raw material transfer from quarry to silos

Fig -2(b) Ladder logic for raw material transfer from quarry to silos

VI. CONCLUSION

Though India is the second largest producer of cement in the world, still those industries need to further concentrate on modernization and upgradation of technology, optimization of operations and increased application of automation and information technology which reduces the energy consumption, production cost and increases the production speed [5]. So this paper is appropriate to fulfil those requirements of the cement industries. This innovative automation process is highly flexible and easily adaptable to new and existing situations. Automation provides some form of monitoring capabilities and provisions for programmable troubleshooting which reduces the downtime. The automation process also has flexibilities in programming and control techniques. As the PLC does intelligently the overall operation and as it has centralized control futures. So it also helps to reduce the manpower and at the same time it reduces the workers' strain. [6]

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