Automation of Cement Industries

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Abstract

The cement industry is growing rapidly on account of the overall development of the Indian economy resulting into increased civil constructions activity due to expanding investment in the infrastructures. The cement industry experienced a complete shift in the technology of production from wet process to dry process. The automations are not only cost effective method but also improve the longevity and reduce the total cost of operation over the life of the system. The focus of this paper is to discuss automation process and hardware for cement plant.

Key Words: Cement, cement production, automation in cement SCADA in cement industry.

Introduction

Cement is a component of infrastructure development and an important ingredient of civil construction. The Indian cement industry is the second largest producer of cement in the world, ahead of the United States and Japan. It is considered to be a core sector accounting for approximately 1.5% of GDP and employing large man power. The cement market is increasing at of 20% a year due to residential building constructions.

The paper focuses on offering an overview of industrial automation that gives a framework about the equipment, programming used for automation and methodology involved in implementing it a modern automation system. This paper Jianwei Xu Guangzhou Shijin [1] summarizes the recent developments within the cement industry and implementation of computational technologies into the automation of production processes. Many recently built or renovated medium and large-scale cement industries have adopted Distributed Control Systems (DCS). But, many of the smaller plants are depending heavily on traditional instrumentation. Some such plants monitor and control the process manually.

Since I-7000 series modules can communicate using the RS-485 (that is they can communicate at a long distance)

All of the modules in the system can be connected via twisted-pair wires. The system has many advantages such as faster communication speed, high sampling resolution, intelligent operation, photoelectric isolation, strong protection against interference and dual watchdog timers. Since accomplishing the application to the vertical system one continues to use I-7000 modules to implement the network in other subsystems because this kind of system can meet the product requirements and obtain the best price/performance ratio. On the whole the implementation of the system is an achievement in the automation and management.

In this paper Prof. Susana Arad, Prof. Victor Arad & Eng. Bogdan Bobora [2] summarize the production process, equipments and installations improvement. Besides the technological flow modernization measures, certain solutions for improving the performances linked to the technological process automation and optimal control have been adopted. A local control in each particular operation and an optimum control of entire plant are enforced.

The objectives of the modernization of the technological flow are: Reduction of energy, specific fuel consumption Reduction of maintenance costs and unplanned shut downs Improving the work condition, management, work safety, cement quality and client satisfaction, the renewing the technology by Modernization of the great cooler made by introducing the IKN cooling technology for clinker, Modernization of the shields and grinding balls at the cement mills.

Introduction of a new injector for all types of fuels: solid, liquid and gas commissioning of the alternative fuel equipment for the burning of the solid alternative fuels (ECO-Fuel).

The technological flow from Cement Plant is controlled automatically by ECS system. This software program enhances the operator to control (using a computer network) the whole technological flow, which is the continuously monitoring system of the entire process.

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Insufficient knowledge in process dynamics and interactions, and lack of adequate experience in utilizing the existing control system are reasons for incorrect operations. The consequences of this may result in low quality, interruption, equipment damage, and risk to human safety.

This paper by Vandna Kansal, Amrit Kaur [3] presents the mamdani type fuzzy inference system (FIS) for water flow rate control in a raw mill of cement industry. Fuzzy logic can be used for imprecision and nonlinear problems. The fuzzy controller designed for flow rate control is two input and one output system. It is essential to control water flow rate efficiently to produce high quality cement. Raw mill is used to grind the raw materials which are used for manufacturing cement. In this paper, the system is designed and simulated using MATLAB Fuzzy logic Toolbox. The experimental results of the developed system are also shown.

In this paper, it is shown that mamdani type FIS provides an efficient control for water flow rate control system. Mamdani FIS uses centroid method to calculate output value. Therefore it is complex and time consuming. But fuzzy logic system is superior to conventional algorithms.

The paper by Moin Shaikh [4] explores the changing roles of traditional distributed control systems (DCS) and programmable logic controllers (PLC) used to automate cement manufacturing processes. The two technologies initially served two different control requirements. However, improvements in microprocessor-based controllers created conditions for two technologies to merge. The shift toward commercial, off-the-shelf automation technology, software-based control verses hard control and use of non-proprietary networks has created a new class of systems called hybrid process automation systems.

The integration of energy and asset management information is now available in one central location, increasing operability and streamline plant cost of operation. It is not a question of whether or not cement plants will embrace new technologies; the plant economics will make it inevitable.
Moin Shaikh, (2009) (Company: Siemens Energy & Automation, Inc.) Cementing the relationship between DCS and PLC: *A review of emerging trends in plant control systems*
The paper by E. Vinod Kumar [5] discusses Process Automation as an important component of modern cement production. ABB's Distributed Control System (DCS) has been widely used across all industry segments for many decades. ABB's philosophy in this field has been a path of continuous evolution protecting existing customer's

investments as well as bringing the latest IT technologies in a safe and secure manner to the industrial world. The software engineering and visualization graphics is standardized by using cement process control libraries.

ABB's System 800xA DCS platform has many enabling hardware and software interfaces and libraries to implement a tightly integrated modern cement plant automation system. The ABB CPM solutions suite extends the plant automation capability to optimize the production process and to provide seamless bidirectional connectivity with ERP systems for real time business decision making. An efficient & informative control system like the ABB System 800xA provides great operational advantage for modern cement plants.

In this paper ATUL, SNEHA GHOSH, S. BALA-MURUGAN [9] present a cement plant simulator designed on Lab VIEW platform. It generates process data and electrical parameters for all the lines of workshops in the cement industry. The simulated design is universal and applicable to all kinds of cement plants. Client-server architecture is established and the generated parameters are communicated to Matrikon OPC client. Single Line Diagram of the electrical distribution of cement plant has also been developed using MS Visio. An exclusive user interface has been designed to monitor and analyze the electrical parameters in detail. The KWh/tonne consumption and percentage energy consumed by the workshops have been observed and tabulated.

In the simulated design, all the process data for all the workshops and all the electrical parameters for all the machines and equipments are generated. Thus, a plant manager can easily monitor and analyze the entire plant and develop strategies to optimize the plant. Since Lab VIEW is used, the graphical programming is very advantageous. The UI's are very user friendly.

In this paper [6] Michael J. Gibbs, Peter Soyka and David describe, Carbon dioxide (CO2) a by-product of a chemical conversion process used in the production of clinker, a component of cement, in which limestone (CaCO3) is converted to lime (CaO). CO2is also emitted during cement production by fossil fuel combustion and is accounted for elsewhere. However, the CO2from fossil fuels are accounted for elsewhere in emission estimates for fossil fuels. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) provide a general approach to estimate CO2emissions from clinker production, in which the amount of clinker produced, is multiplied by the clinker emission factor.
In this paper [7] A K Swain discusses the development of a novel raw material mix proportion control algorithm for a cement plant raw mill, so as to maintain preset target mix

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proportion at the raw mill outlet. This algorithm utilizes one of the most basic and important tools of numerical linear algebra, the singular value decomposition (SVD), for calculation of raw mix proportion. The strength of this algorithm has been verified by comparing the results of this method with that of the results of the QCX-software developed by EL. Smidth of Denmark.

This article presents a novel raw mix proportion control system. To demonstrate the efficacy of this method the results are compared with that of FLS of Denmark. The distinct features of the control algorithm are that it works for any number of feeders is highly flexible and easily adaptable to new situations operates on PID control strategy, giving faster response is easy to implement in any new plant or any change of the takes care of the process dead time delays takes into account the limiting values for feeder capacity and control action is highly economical

In this paper Eugene Boe, Steven J. McGarel & Tom Spaits, Tom Guiliani [8] discuss about a series of software automation applications implemented at Capitol Cement's plant in San Antonio, Texas. These control and optimization applications are implemented on two finish mills and one dry kiln line (including the pre-calciner and grate cooler). The kiln-cooler controller is designed to maximize production and reduce fuel consumption. It reduces NOx emission as part of a multivariable control solution and improves clinker consistency. The project took basically 3 months to execute, and has resulted in sustained benefits to production, stability, and quality. The project benefits have paid for it in less than 6 months.

Production

A cement production plant consists of the three processes.
1. Raw material 2.Clinker burning 3.Finish grinding
The raw material and the clinker burning process are classified as the wet process and the dry process respectively.

Transfer of Raw Material from Quarry to Different Silos

Most of the raw materials used for making cement are extracted through mining and quarrying. Those are lime (calcareous), silica (siliceous), alumina (argillaceous), and iron (ferriferous). Limestone is the prime constituent of cement; the major cement plants are located near the good quality lime stone quarries. First, the 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 in to different stacks. The stacking and reclaiming systems operate independently. Four additives: iron ore, bauxite, laterite and fluorspar are in the stack pile to get required composition of cement. The conveyor C4 brings the adding the stack pile, then as per the requirement limestone, iron ore, bauxite, laterite and fluorspar are transferred to different silos. Inside each silo there are three level detectors which detect the level of materials inside it. Figure 1 shows the process.
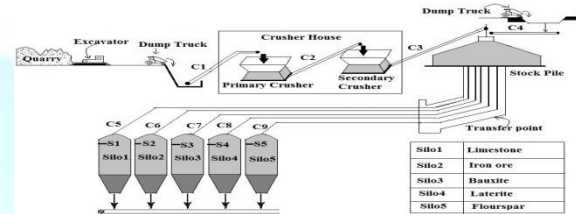

Fig Raw Material Transfer from Quarry to Different Silos
Reference: D.R. Pongallu, P.H. Zope and S. R. Suralkar

In the wet process, raw materials other than plaster are crushed to a diameter of 20 mm by a crusher and mixed in an appropriate ratio. Then, with water added, the mixture is further made finer by a combined tube mill with a diameter of 2 to 3.5 m and a length of 10 to 14 m into slurry with a water content of 40%. The slurry is transferred to a storage tank then mixed to be homogenized and sent to a rotary kiln for clinker burning. In the wet process, the slurry can be easily mixed but greater energy is consumed in clinker burning due to water evaporation.

For the dry process of manufacturing cement, crushed raw materials are dried in a cylindrical rotary drier, mixed, ground and placed in storage tanks then sent to a rotary kiln for clinker burning. For the wet process, plant construction cost is low and products are high-quality: but the dry process consumes less energy and its running cost is lower therefore it is preferred.

Actuators and Sensors

The sensors connected to the process are simple but can be complicated as an on-line X-ray analyzer. Examples of traditional discrete (switch) sensors include the limit switch, temperature switch, pressure switch, flow switch, level switches, photo eyes, and input devices such as push buttons and pilot lights. Switches are digital devices that provide a simple contact which indicate their state of on or off. Instruments such as thermocouples or pressure transmitters are analog devices capable of providing a continuous range of measurement readings from 0 to 100% of range and reporting their data with a changing

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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.

These intelligent instruments have microprocessors allow for functionality beyond the basic measurement of the primary variable. They monitor and report additional process variables, support multiple configurations, monitor and report. Motor starters now monitor various aspects of the operator of the motor. They report current, phase voltage, motor power, motor power factor, and running hours and can tell exactly why a trip occurred (i.e., overload, ground fault, or short circuit?).

Intelligent Devices and Subsystems

Intelligent subsystems are available with controller cards that will reside in the same card rack as the PLC. These include scales and load cell controllers, radio frequency tag readers, motion controllers, and forms of communication interfaces, from basic RS-232 to any network protocols. Actuators with small amounts of I/O are equipped with the ability to communicate over I/O networks. For example intelligent valve controllers that will reside on the I/O network.

Automation of Process

To make this process fully automatic PLC is provided to take real time decision depending upon the field level input signals from sensors placed in different critical points and sends the instructions to the output devices. Conveyor C1 starts rolling and the bulk materials i.e. lime stones are taken from quarry by conveyor C1 to primary crusher (PC). After some time delay, required for primary crushing C2 starts running and the raw 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. The pushbutton switches PB3and PB4 are provided 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, to achieve this 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 if emergency plant shutdown is required, the operator presses PB2 this will stop conveyor C1.

Material Transfer from Different Silos to Homogeneous Silo

Normally there are various types of lime stone quarry so the quality of limestone differs. In order to get homogeneous mixture those four additives with required percentage, as suggested are mixed with the lime stone. This is done using a RBF placed in each silo and with the help of conveyor C15. The RBFs and corresponding conveyors (i.e.C10, C11, C12, C13, C14) will move with a speed to maintain the actual ratio of the five components i.e. user defined. C15 transferred the raw materials to the vertical roller mill (VRM) as the raw materials should be finish-ground before being fed into the kiln for clinkering.

This process is done in the VRM. The raw materials are simultaneously dried using hot air in order to get good quality cement. The Hot air is comes from conditioning tower or from grate cooler. Hot air along with the dust is introduced in the electrostatic precipitator (ESP). Then the exhausted air existed in the air, through chimney with the help of ID Fan. After grinding, the materials are transferred to homogeneous silo with the help of bucket elevator (BE). There is a screen vibrator (SV) in between the BE and homogeneous silo for Proper blending and to sort-out the large granules. Then the large granules are feedback to the VRM by Feedback conveyor C18. The process is shown in the fig2
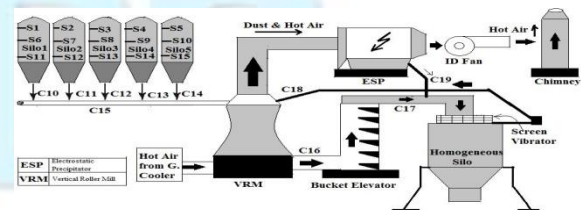

Fig shows Raw Material Transfer from Silos
Reference: D.R. Pongallu, P.H. Zope S. R. Suralkar

Bucket elevator, screen vibrator and conveyor C16 are used to transfer the raw materials to Homogeneous silo. The large granules are fed back to the VRM by conveyor C18, to remove the dust particles, exhausted gas produced during cement making is sent to electrostatic precipitator (ESP). The gas is sent to the co-generation power plant for

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captive power generation, then the exhausted clean gas is removed by fan through chimney and the fine dust is fed back to the homogeneous silo.

Pyroprocessing and Finish Milling

The raw mix is heated up to (1600-1700) °C to produce Portland cement clinkers. Clinkers are created from the chemical reactions between the raw materials. The pyroprocessing takes place in a kiln. It is basically a long cylindrical pipe which rotates in a horizontal position having (1600-1700) °C temperature. The clinker is sent to the cooling section for cooling to room temperature. The cooled clinker is then transferred to the storage silo. The Clinkers are hard, gray, spherical nodules with diameters ranging from 0.32 - 5.0 cm. To reduce the size and to impart special characteristics to the finished cement, the clinker is ground with other materials such as 5% gypsum and other chemicals which regulate flow ability. The finished cement is finally transferred to the packaging section. The process is shown in the figure3

Export

The export of Indian cement has enhanced over the years mostly after decontrol, this has given boost to the industry. The demand for cement depends on industrial, real estate, and construction activity. Since growth is taking place around the world in Indian export of cement is increasing. India has potential to take up cement markets of in the Middle East and South East Asia.

Conclusions

Since energy cost of cement production is large, energy conservation is important. The wet process is cheaper than the dry process as regards energy consumption. At the technical level of quality and productivity, the dry process is superior. This innovative automation process is flexible and easily adaptable. Automation provides and monitoring capabilities and provisions for programmable troubleshooting, reduces the downtime. The automation process provides better control. The environment of cement plant is temperature, with dust and electromagnetic interference (EMI).

The process automation improvise environment for the workers and prevents direct contact with the gases and dust that are emitted during cement manufacturing. As the PLC performs the operation intelligently and as it has centralized control features; it also helps to reduce the manpower and at the same time it reduces the workers' load.

About the Authors

Anil Kumar Udugu is a research scholar at Bhagwant University. Formerly, he has is conducting research for his PhD project. He has completed MSc Electronics in Andhra University in the year 2011.
Dr. Anand Khare has obtained his PhD in Electrical Engineering from London University. He worked as a lecturer at London then as a faculty at Indian Institute of Science Bangalore. Presently he is director in The MRPC Company Hyderabad where he is directing research.

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