Figure 2: new kiln and preheater-precalciner tower

Qinghai's DeltaV

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The succession of control systems through 25 years at the Qinghai Cement plant mirrors not only the advancement of the cement industry in China, but also the evolution of automation technology in the industry worldwide. Controls for the newest production line use the Chinese- language version of Emerson's DeltaV™ digital automation system. It allows implementation of the latest generation of automation architecture, represented by Emerson's PlantWeb® digital plant architecture. In a year of operation in a harsh environment, the system has greatly facilitated increases in product variety, product quality, and operating efficiency – all with very little technical assistance from outside the company.

The Qinghai Cement Company plant (Figure 1) is located near the town of Datong, 30km north of Xining, the capital of China's Qinghai province. The business is owned by Qinghai Investment and Holding Company, an enterprise of the provincial government and China's Gintian Industry Group. With 700 employees and a capacity of 3500tpd on a 50ha site, this facility is one of the top 500 enterprises in the entire country. It is the largest cement plant in Qinghai province, which occupies the northeastern third of the Tibetan plateau, in western China.

The plant is distinguished not only by its size, but also by use of advanced technology – including the DeltaV system described in this article – and an unusually large variety of cement products (Table 1), some of which are not widely available. Those products have recently been used in a number of important projects in this part of China, including a railway between Qinghai and Xizang (Tibet), a hydroelectric dam on the upper Yellow River, and various roads and bridges. Plant output is shipped both in bulk and in bags.

Despite climate extremes and high altitude – 2400m above sea level at Datong – the region around Xining is rapidly developing as a centre of minerals-based industries. Coal fuel and most of the principal raw materials for the Qinghai Cement plant – limestone, chalk, and quartzite – are hauled by trucks from mines and quarries operated by the company within a few kilometres.

Outsourced materials include iron stone, gypsum, and fly ash. Because of the altitude, design and operation of the equipment must allow for atmospheric pressure and oxygen content about 25 per cent less than at sea level.

Growing with the industry and technology

Qinghai Cement Company was formed in 1977 to build and operate this plant. Production commenced in the same year with a plant capacity of 700tpd. Controls for the single kiln line were based on electro-mechanical relays, which had long been the prevalent method in the cement industry worldwide.

As demand increased in step with the needs of China's burgeoning infrastructure development, the country's cement production passed that of the USA in 1980, Japan in 1982, and the Soviet Union in 1985, putting China in first place worldwide. In

Figure 1: the main part of the Qinghai Cement plant early in 2002. The shorter preheater-precalciner tower on the left is the new one for the upgraded 2000tpd line. The control room is in the low building partly concealed by the embankment in the foreground

1987 and 1988, when national cement production was approaching 200Mta, Qinghai Cement Company added a second kiln line with capacity of 1500tpd, bringing annual production up to about 500,000tpa.

Meantime, networks of programmable logic controllers (PLCs) had become the generally accepted automation method in cement plants. Originally a direct replacement for relay logic, PLCs are oriented mainly toward the discrete or on-off functions that predominate in cement plants. By contrast, distributed control systems (DCSs) were developed for applications such as chemical plants and refineries in which discrete functions are secondary to continuous control of temperatures, pressures, flow rates, and so forth.

By the late 1980s, however, the importance of continuous control in cement plants had risen on account of demand for greater fuel efficiency, throughput, and operator productivity, as well as reduced emissions. At the same time, distributed control systems had advanced considerably in their discrete control capabilities. Thus, for controlling the new kiln line in 1987, Qinghai Cement decided against the prevailing PLC technology and chose instead a popular DCS of that era – Honeywell's Micro TDC 3000. That line continues in operation under control of the Honeywell system with generally satisfactory results.

Figure 3: the clinker end of the new kiln

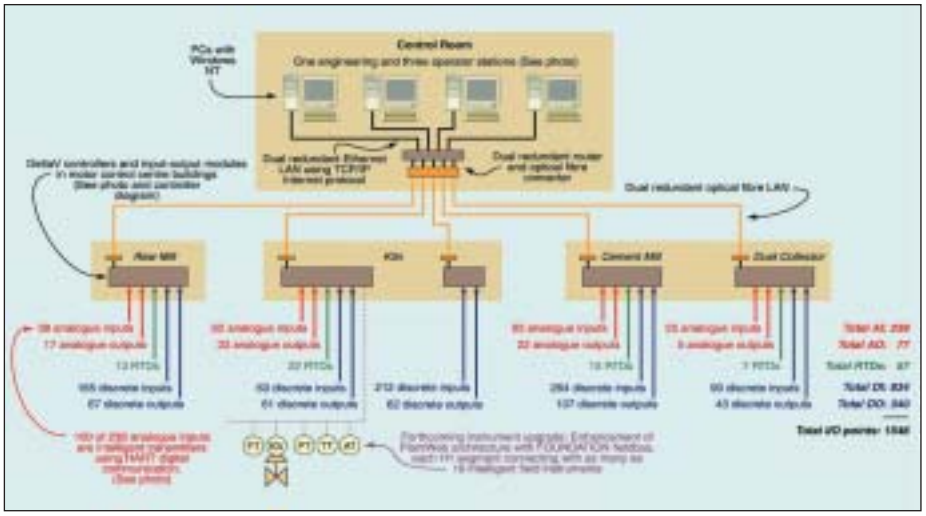


Figure 4: simplified diagram of the DeltaV™ system network

Figure 5: DeltaV controller assembly for the cement mill dust collector, seen at far right in the network diagram (see Figure 6 for identification of modules)

A new kiln line and automation system

By 2000, China's cement production had surged past 500Mta – a third of the world's output. In that year, Qinghai Cement embarked on a project to upgrade the original 1977 production line from 700tpd to 2000tpd, bringing the plant's annual output up to 800,000t. Besides greater production, a major goal was to increase the variety of products from four to nine, as listed in Table 1. The company expected significant gains in product quality and operating efficiency from use of the latest available technologies for the processing equipment and automation system. Advanced controls would be especially important for smoothly switching kiln production from one product to another. About 80 per cent of the old equipment was replaced with new units of higher capacity and efficiency – including kiln, raw mill and cement mill. The raw mill and reciprocating-grate clinker cooler were provided by Sichuan Mining Machinery. The preheater system was supplied by Suzhou Installation and Engineering Company. The kiln itself was likewise made in China.

Project design and engineering – including kiln specifications – were provided by Chendu Industrial Design Institute of Building Materials. Located in the city of Chendu, Sichuan Province, the organisation is one of three major design institutes of the national building materials bureau. Most of its work involves cement plants.

In selecting a control system, Qinghai Cement considered a number of alternatives. Among them were a Quantum PLC-based system network from Schneider-Modicon, a CENTUM CS 1000 distributed control system

Table 1: main products of Qinghai Cement Company

The numbers in the Chinese system of product description are ten times the ultimate strength in megapascals according to standard mortar tests. Common (ordinary) denotes up to 15 per cent intergrind additives. Road cements contain air-entraining agents.

Products before 2001

Common Portland cement, P Co 325
Common Portland cement, P Co 425
Portland road cement, P 425R
Portland road cement, P 525R

Products added with new kiln line in 2001

Portland cement, P 525
Moderate-heat Portland cement, P 525
Low-heat fly-ash Portland cement, P Fl 425
High-sulphate-resistance Portland cement, P 525
Moderate-sulphate-resistance Portland cement, P 525

from Yokogawa, and three distributed control systems from Honeywell: Micro TDC 3000 as in the 1987 kiln line, TotalPlant Solution (TPS), and PlantScape. The Yokogawa and Schneider-Modicon solutions were included because each had a substantial installed base in cement plants in China. Micro TDC 3000 was considered because of its familiarity to plant personnel and compatibility with the existing installation. PlantScape was especially appealing because it offered newer Honeywell technology.

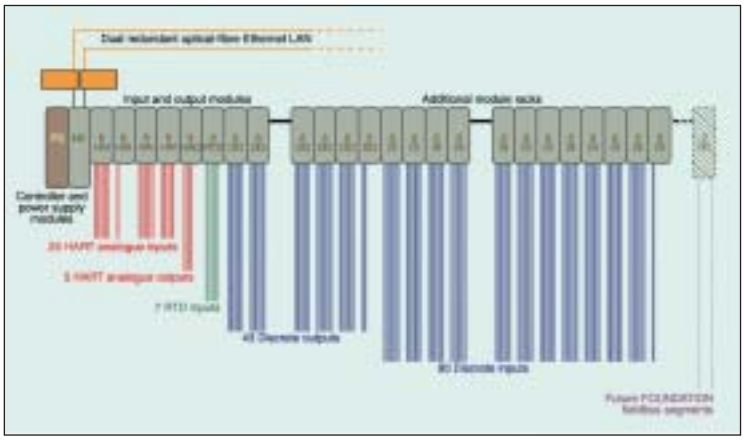


Figure 6: identification of modules in the DeltaV controller assembly for the dust collector (Figure 5)

In the end, Emerson's DeltaV digital automation system was chosen because it represented even more advanced technology, and easier operations while being cost-competitive. As a special bonus, the DeltaV system incorporates the Chinese language in the software.

Construction began in June, 2000. Installation of the automation and field instruments (transmitters, control valves, etc) was done by Suzhou Installation and Engineering Company. Configuration and commissioning were undertaken in roughly equal parts by Chendu Industrial Design Institute and plant personnel, with consultation by Emerson Process Management. Emerson also provided training of engineers, operators, and maintenance technicians. Finally, the new 2000tpd kiln line started up in November, 2001 (Figure 2).

Applying the DeltaV system in a cement plant

The layout of the DeltaV system at Qinghai Cement is shown in Figure 4. As in a conventional DCS of earlier times, field instruments (transmitters, control valves, switches, motor starters, etc) are connected to the system through distributed processors called controllers. There are five of these units, located in cabinets in motor control centres near the equipment they serve. As seen in Figures 5 and 6, a DeltaV controller is a compact, modular assembly mounted on DIN rails. At present, this system has 238 analogue inputs from transmitters, 77 analogue outputs to control valves, 57 inputs from resistance temperature detectors, 834 discrete (switched) inputs, and 340 discrete outputs. However, input-output modules are available for nearly any type of signal.

Figure 7: DeltaV operator and engineering stations in the control room

The controller assemblies are linked into a standard Ethernet local area network (LAN) with dual redundancy, using open, interoperable TCP/IP communications protocol. Dual redundancy is also available for the controller and power-supply modules but was not considered necessary in this case. That portion of the network running through the field uses fibre optic cables for immunity to electromagnetic interference. The engineering and operator stations in the control room (Figure 7) are standard personal computers with a standard Chinese-language Windows operating system, running mostly Emerson software. Human interface with the DeltaV system is almost entirely in the Chinese language, as seen in Figure 8.

Referring to Figures 4 and 6 again, all of the analogue input modules are capable of communicating with intelligent (computer-based) transmitters by HART digital traffic superimposed on conventional analogue signals. One hundred of the transmitters are intelligent HART® devices such as the Rosemount® Model 3051 differential-pressure transmitter shown in Figure 9. In a forthcoming automation upgrade, intelligent transmitters and digital valve controllers (DVCs) that communicate by Foundation fieldbus will be added, using appropriate I/O modules in DeltaV controller assemblies. Each module serves two Foundation fieldbus segments of the type called H1. Each segment, in turn, is a twisted-pair cable handling communication and power for as many as 16 instruments on a multidrop basis. Other types of fieldbus, such as Profibus, can also be easily accommodated.

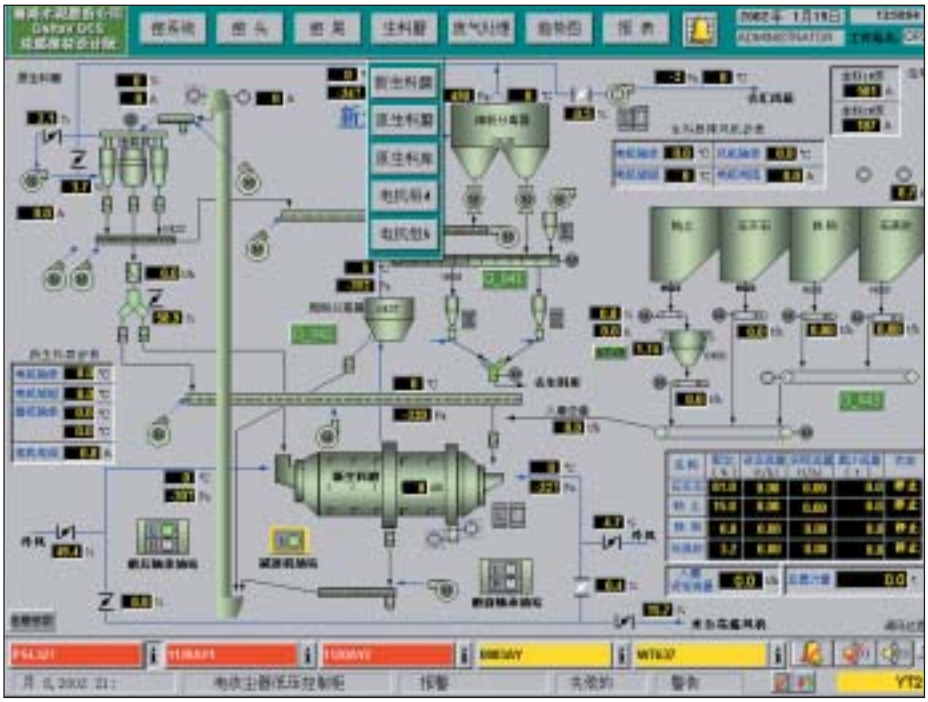
By these means, intelligent field instruments become nodes in a digital automation network. Their considerable processing power can be utilised to the fullest through modular software that is available in DeltaV systems. For instance, Emerson's (AMS) asset management software allows remote configuration, calibration, commissioning, diagnostics, and preventive maintenance of intelligent instruments. The network can be scaled up as large as required in convenient increments, on the fly, by adding I/O and digital fieldbus modules, controller assemblies, and computers. If desired, a separate DeltaV network such as the present one for the new kiln line can be set up for each major section of the plant, with the networks linked by standard means such as OPC (OLE – object linking and embedding – for process control). OPC is also useful for incorporating separate automation systems and software built into special cement plant equipment such as precipitators. Emerson's trademark for an automation architecture of that advanced type based on intelligent field instruments is the PlantWeb® digital plant architecture.

Pioneering a new era of automation in the cement industry

Outwardly, Emerson Process Management 's DeltaV system may seem to resemble a conventional distributed control system or a so-called 'hybrid' DCS – one that also incorporates certain aspects of PLC-based systems. Instead, however, the DeltaV system is built

on a more modern approach based on advanced digital technologies. These technologies include field buses, embedded advanced control, integrated batch control, and enterprise networking built on Internet and XML (Extensible Mark-up Language) methods. A major aim is to provide a key component of the PlantWeb digital plant architecture.

While delivering enormous automation power, the technology of the DeltaV system is much easier to use than others. Qinghai Cement has shown that sophisticated results can be achieved by plant personnel on a routine basis. There was nothing in the initial system engineering, installation, configuring, and commissioning that Qinghai Cement people could not have done by themselves – with consultation by Emerson engineers. Afterwards, in day-to-day maintenance of the system, in refining and adjusting it for optimum plant performance, and in adapting the system to changes and expansions, plant personnel have done nearly everything in-house – occasionally getting advice from Emerson. Operators have found the DeltaV system to be very comfortable, friendly, responsive, and simple to learn. It has been amazingly easy to achieve high performance with Qinghai Cement's digital plant architecture.



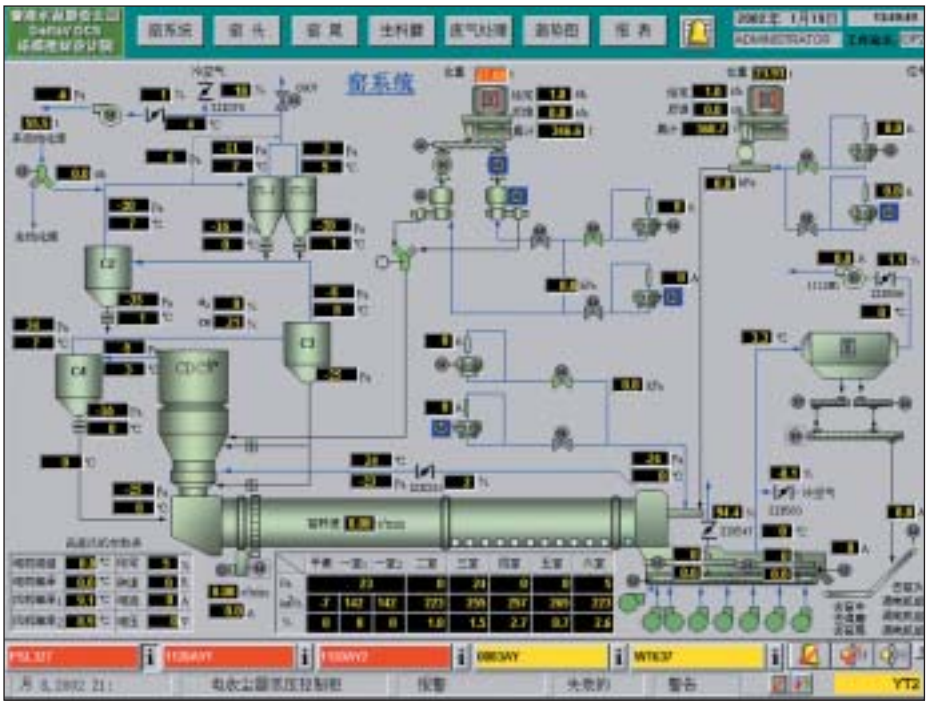


Figure 8: examples of graphic operator overview displays in the Chinese-language DeltaV system: the new raw mill (above) and kiln (below)

Figure 9: 100 of the 238 transmitters on the new kiln line are intelligent ones with HART digital communication capability, such as this Rosemount® Model 3051 differential pressure transmitter

As to other aspects of performance, the DeltaV system has satisfactorily withstood the challenges of a 25-year-old cement plant in this remote location through all seasons of the year. It has proven highly reliable in spite of thin air, dusty conditions, unusually high and low ambient temperatures, frequent power upsets, and strong electromagnetic interference, to name a few tough issues.

Just as important, the DeltaV system has shown itself very well suited to the special requirements of a modern cement plant in terms of controlling both discrete and continuous functions with a practical balance of automation and human oversight. It provides a wide range of useful control strategies. Moreover, it opens the door to unprecedented levels of automation such as in 'one-button' start-up and shutdown sequences, leading to great benefits in terms of throughput and product quality. There are even better things to come from the DeltaV digital automation system at the Qinghai Cement Company plant as more of the digital technologies are used. ❐

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