APPLICATION PAPER

Wireless Control Maximizes Aluminum Production

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Nothing has impacted the mobility in the 20th century like the discovery of how to effectively process aluminum. Until just over 100 years ago, the production of aluminum was so cumbersome it sold for about the same price as silver, greatly restricting its use. With advanced refining and smelting processes dropping the price of aluminum, this strong yet lightweight metal is now widely available for use in automotive and aerospace industries.

As the aluminum industry continues to grow, so does the competition. The world's first aluminum company, Aluminum Company of America (ALCOA), is still the leading producer of aluminum, but the competition has intensified in recent decades. ALCOA has responded by perfecting processes, lowering costs, and increasing the technological base in all their plants. Efficiency in a large aluminum plant can only be accomplished by the efficient workings of the smaller systems within. ALCOA's Point Comfort, Texas Refining Plant has implemented several wireless control systems throughout the plant to provide a means to this efficiency. Wireless modems have provided solutions for programmable logic controller (PLC) networks in areas otherwise inaccessible or too cost prohibitive to integrate.

History

The history of the Aluminum Corporation of America is the history of aluminum production itself. Throughout the 19th century, aluminum was a semi-precious metal and scarcer than silver. In 1886, Charles Martin Hall discovered that when electrical current was passed through a cryolite bath containing aluminum oxide (alumna), he was able to produce pure aluminum. This discovery revolutionized the possible uses of aluminum, which up to this point had been too costly to otherwise pursue. With his discovery and financial backers from Pittsburgh, the Pittsburgh Reduction Company was born. Hall kept improving his process and reduced the cost of aluminum ingot from its $545 per pound cost at the beginning of his century to 78 cents per pound by 1893.

As business began to grow, aluminum was soon fabricated into cooking utensils, foil, electric wire and cable. Because of its lightweight and strength, aluminum was used in the first automobile bodies and engine parts. In 1907 the name was changed to what we now know as - Aluminum Company of America. In the 1930's a pound of aluminum cost 20 cents and the company counted more than 2,000 uses for its products. World War II doubled the demand for aluminum and doubled ALCOA's production. The wartime plants were sold off to competing companies, but ALCOA still remains the world's leading aluminum company. ALCOA currently has over 86,000 employees working at 187 operation locations in 28 countries. Their 1997 revenue was 13.3 billion dollars.

Aluminum Production

Aluminum is the most abundant metal in the earth's crust, but it is also one of the most difficult to extract. Aluminum is most often locked with other elements such as oxygen or sulfur, and found in aluminum-bearing material such as bauxite. Bauxite is the raw ore mined from the earth and refined through an intricate chemical process to produce aluminum oxide, better known as alumna. Alumna is a white powdery material with the consistency of granulated sugar and usually about 30% of the bauxite ore. Alumna is a valuable compound in its own right, but is primarily smelted to aluminum.

Aluminum is sold to packaging, automotive, aerospace, construction and other markets in a variety of fabricated and finished products. Some of the qualities that make aluminum unique in the world:

- Lightweight material that is about a third as heavy as copper or steel
- Highly resistant to corrosion
- Excellent conductor of heat and electricity
- Nonmagnetic
- Nontoxic - can be used to store and cook food

- Highly workable material, capable of forming by all known metalworking processes
- Very recyclable - by using only about 5% of the energy compared to new production, this could be one of aluminum's greatest assets in the future

Point Comfort Operations

The first step in aluminum production is refining of the bauxite ore to alumna. This process is very complex and labor intensive. The ALCOA Point Comfort Operations Plant in Point Comfort, Texas is dedicated to this refining process. To maximize efficiency plant-wide and remain competitive in today's market, ALCOA has incorporated PLC based control systems that can communicate their process or control information via radio modems. The wireless modems have allowed plant operations engineers to design control networks for mobile or otherwise inaccessible equipment and cover distances up to 8 miles without cables or leased phone lines.

They all use a common radio modem technology and PLC vendor that reduces system spares and allows personnel to become familiar with their programming and operation. The following are a few example applications where wireless modems are installed at the Point Comfort plant.

Bauxite Reclaim System

The bauxite reclaim system consists of two moving belts that bring the raw ore to the storage bins in the plant. Two moving trippers, one for each belt, feed any of eight, 18' diameter storage bins with the bauxite ore. The tripper's movements along the belts are controlled with a Modicon® Model 984 PLC mounted on the machine. Although the positioning is determined by set points stored in the PLC, each bauxite loading job is controlled and monitored by personnel in the Control Room via a Human Machine Interface (HMI) terminal (Figure1).

The trippers can move up to 200 feet from the control room, but must maintain constant communication to receive further instructions and data from the level sensors mounted in the loading bins. This communication is provided by an ESTeem Model 192C, UHF radio modem mounted in the same controller cabinet as the PLC on the tripper. The wireless modem allows communication between the controller and the HMI terminal in the control room in the native protocol of the PLC. This emulation allows the PLC to communicate without custom programming.

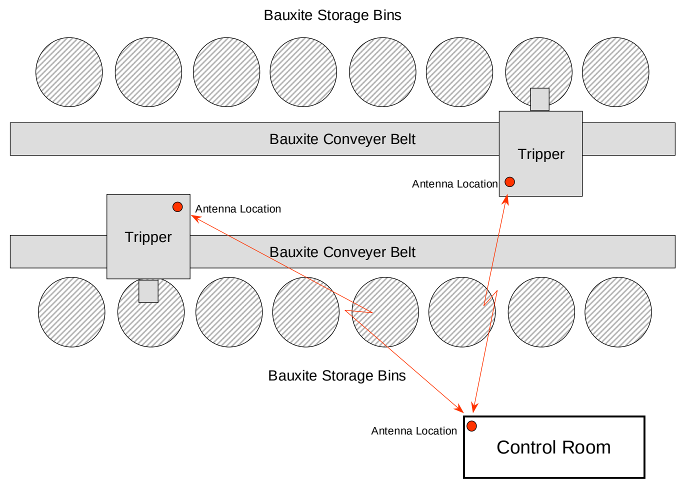

Figure 1: Bauxite Reclaim System Diagram

The HMI terminal provides operations personnel with a graphic display of the status of material in each of the 16 bauxite bins and allows them to adjust loads with the touch of a button. The Wonderware® HMI software is run on a personal computer (PC) which communicates via a high speed buss connection to a serial converter called a Modicon Bridge Mux Model 984 (Figure 2). This bridge allows four serial connections to be "dropped" off the high speed data buss. Attached to one of the serial ports is another wireless modem that provides the communication link to both trippers. The radio modem distinguishes the remote PLCs by address and thus allows multiple remote sites to share one port in the bridge.

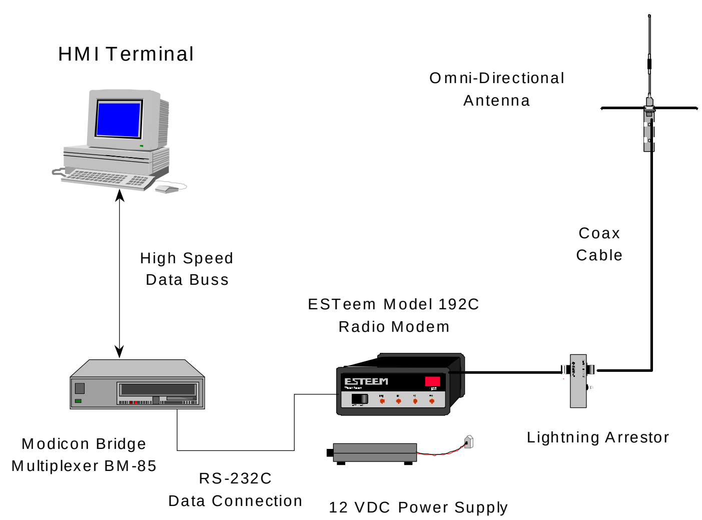

Figure 2: Control Room Equipment Diagram

A private radio system was selected due to the constant movement of the trippers. The other solutions considered were festoon cabling, which could be easily damaged in this application, and would eventually wear out and require costly replacement. Cellular or commercial radio service (such as CDPD or ARDIS) would require residual costs for the life of the system beyond the original capital costs. The control system was first installed with 9,600 baud radio modems in 1994 and upgraded to the latest 19,200 baud radio modems in January of 1998. The update time for status on the two trippers, on the HMI terminal, was decreased from 3 seconds to less than 1 second. The success of this original wireless project provided confidence in the technology to expand to other areas of the plant.

Early Warning and Potable Water Systems

There are two unique control systems mounted in the guardhouse of the Point Comfort Operations Plant that share a common buss connection. The first PLC gathers data for an early warning system and the second PLC on the buss controls the potable water system (Figure 3).

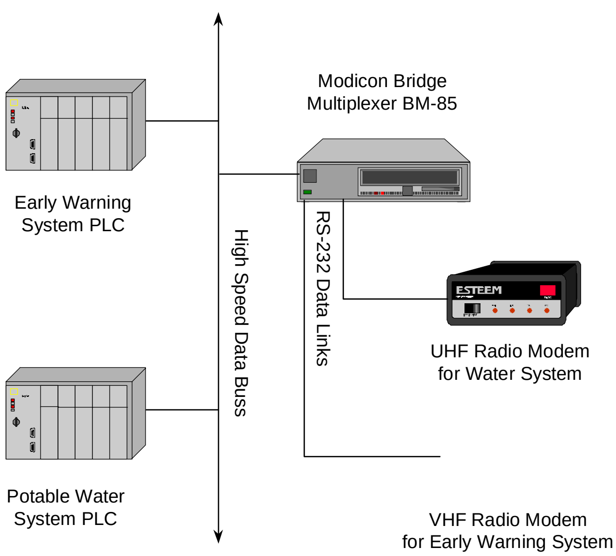

Figure 3: Security Office PLC Network Diagram

Due to the ALCOA Plant's close proximity to a plastic manufacturing facility, an early warning system for airborne toxins is mounted along the fence line between the two plants. Another PLC, mounted on the fence, gathers the data from numerous sensors mounted along the fence line. If an emergency were to happen at the plastics plant, the sensors would trigger an alarm in the PLC and it would be sent to the PLC in the security office (Figure 4). The PLC at the security office monitors the status of the PLC on the fence and the communication

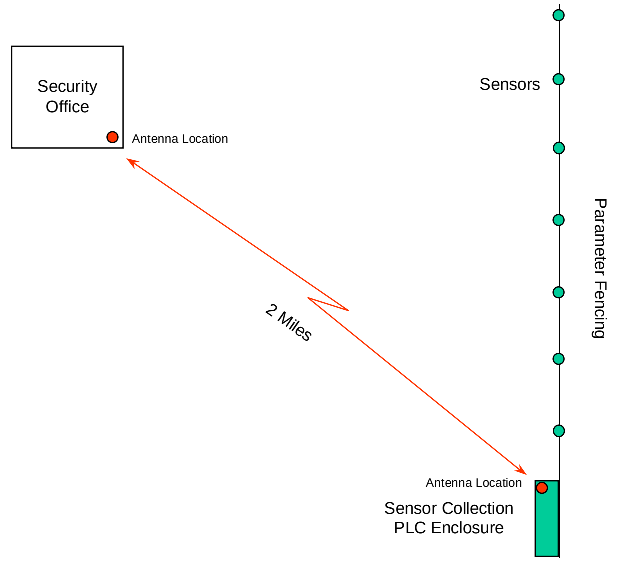

Figure 4: Early Warning System Diagram

link between the two PLCs. The two PLC's are over two miles distant and use the VHF version of the wireless modems to communicate.

Any Alumna refining plant requires potable water to operate, but Point Comfort's wells are 8 miles from the plant. A PLC is mounted at the well station that controls the pumping and status of the well. Another PLC is mounted in a storage tank about 1 mile outside of the plant. The PLC in the guardhouse acts as the master station in this small Supervisory Control and Data Acquisition (SCADA) system (Figure 5). Each of the remote PLCs can act autonomously to control their local stations, but the complete system is monitored and controlled by the PLC in the guardhouse via communication provided by UHF wireless modems.

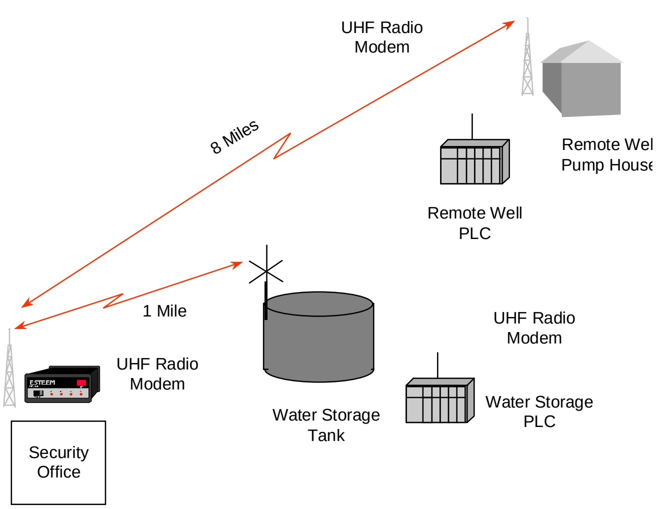

Figure 5: Potable Water System Diagram

Residue Disposal Area

To extract the alumna from the bauxite ore requires a complex chemical process. The chemicals used in this process are very expensive, but washing the bauxite after the original processing can reclaim them. After the ore is washed to remove the caustic, it is moved into large storage areas called residue disposal areas (RDA).

When the wind blows over these storage areas, the top layer will dry and turn to dust that can be moved by the wind. To eliminate any dusting possibilities, ALCOA has installed an elaborate system of sprinklers to keep the material moist. The storage areas are approximately ½ mile square with a forty foot levee on all sides. The large sprinklers, that can each spray 150 feet, are configured in 10 overlapping zones of 10 sprinklers each.

Each of the two residue disposal areas is fully automated with a PLC that controls the flow of water to each sprinkler. A PLC in the control room communicates to the PLC in the RDA and also to a PLC at the booster pump for each system (Figure 6). When the operations personnel decide that sprinkling is required, they instruct the system which zone needs water for how long and this information is processed by the PLC in the operations room and sends instructions to the PLCs in the RDA. All communication for each of the two RDA systems is sent through UHF wireless modems.

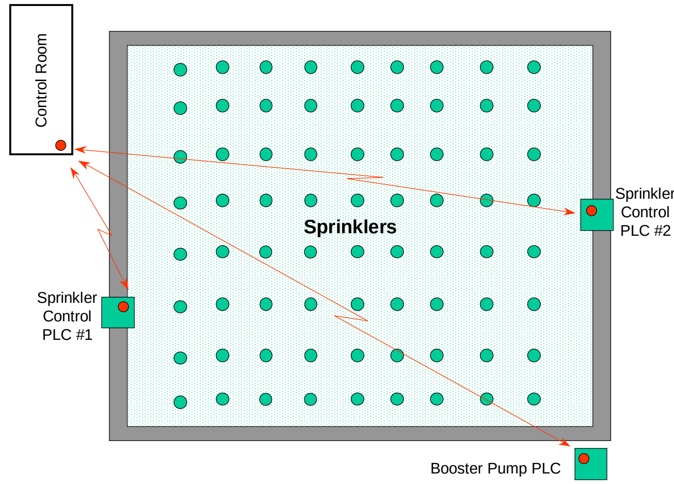

Figure 6: Residue Disposal Area Diagram

Conclusion

The future of aluminum production looks bright, but there will be more and more competition from both domestic and foreign producers. For a large aluminum producer such as ALCOA to stay on top, they will need to stay on the cutting edge of technology. The Point Comfort Refining Plant is a model of how effective implementation of the latest technology can maximize efficiency and production. Their innovative use of radio modem technology gives them flexibility when designing tomorrows control systems.