APPLICATION PAPER

Wireless Coke Oven Control And Data Acquisition

D. Brent Strecker
Engineer
Electronic Systems Technology, Inc.

Kevin Pounders

Digital Interface Systems, Inc.

This paper describes the implementation of a wireless communications network at a coke making facility. The purpose of this network is to collect Charge, Leveling and Push cycle data from the machines used on a coke battery. The data is electronically transferred to a VAX computer system to be compiled and trended. To comply with EPA regulations.

At the facility, several coking ovens are constructed side by side into what is called a battery. Each oven is approximately 2 feet wide by 22 feet high by 46 feet deep with three charging holes on top to allow coal to be dumped into the oven. Doors are located on the front and back of the oven. The front door has a smaller door near the top to allow access for the Leveler Bar (located on the Pusher).

Although this facility contains two batteries of coke ovens, for explanation purposes only one battery will be referenced. The coke battery has a minimum of three machines, Charge Car, Pusher and Back Door Machine. All of the machines are mobile and travel the length of the battery on tracks. Each machine is powered by 480 VAC electrical "hot" rails. The Pusher is located on the front side of the battery, called the Pusher side. The Back Door Machine is located on the opposite side of the battery from the Pusher, called the Coke side. The Charge Car (also called a Larry Car) is located on top of the battery (see Fig. 1).

The Charge Car is equipped with three hoppers to hold a pre-measured amount of coal. At the bottom of each hopper there is a tubular guide, called a sleeve, which is lowered into each charge hole to prevent spillage of coal as it is dumped into the oven.

The Back Door Machine is equipped with a door extractor, jamb and door cleaners, and a coke guide. The door extractor is used to remove the door from the oven. The jamb cleaner is used to remove debris from the door jamb of the coke oven. The door cleaner is used to remove debris from the oven door. The coke guide is aligned with the face of the oven to guide the coke as it is pushed from the oven into the Quench Car. The Quench Car transports the coke to a quenching station for further processing.

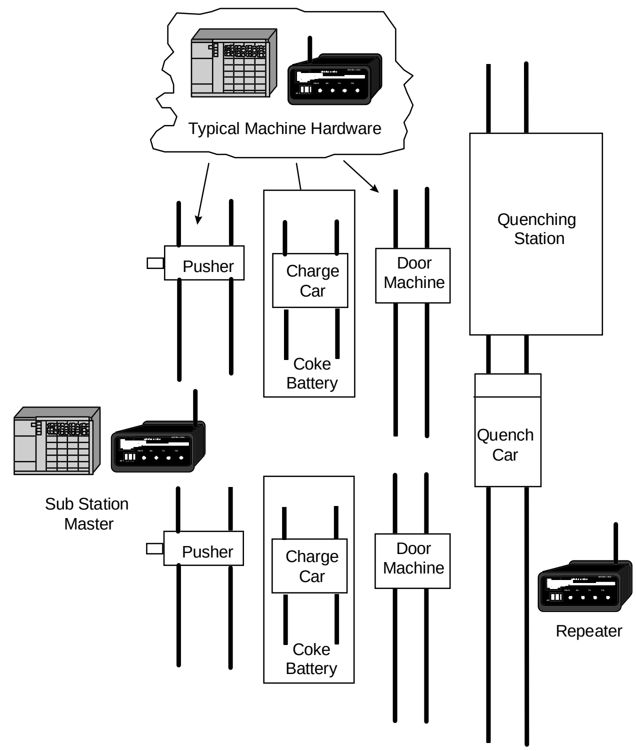

Figure 1: Coke Facility Site Layout Diagram

The Pusher is equipped with a door extractor and jamb and door cleaners similar to those on the Back Door Machine. In addition, the Pusher has a ram that "pushes" the coke out of the oven and into the Quench Car. The Pusher is equipped with a Leveler Bar to "level" the peaked piles of coal dumped into the oven by the Charge Car.

Each of the machines on the battery is equipped with an Allen-Bradley PLC-5/30, ESTeem 96C radio modem, and an Allen-Bradley Panel View operator interface terminal. The Master PLC-5/30 is located between the two batteries (on the Pusher side) and is equipped with an ESTeem 96C radio modem and Allen-Bradley 1771-KF module to provide serial communications to the VAX computer system. A repeater consisting of an ESTeem 96C radio modem is located between the two batteries (on the Coke side) to provide line of site (LOS) radio communications between the Back Door Machine and the Master PLC. A radio solution was chosen for the following reasons:

- Since the machines are mobile and travel the length of the battery, a cable solution is impractical and "hot" rail communications is unreliable in this type of environment.
- Allen-Bradley hardware was adopted as a company standard by the customer because of its high level of reliability in harsh environments.
- ESTeem radio modems were chosen for their built-in Allen-Bradley DF-1 protocol emulation, thus reducing engineering time required to develop a custom communication interface.

A typical charge cycle consists of the Charge Car filling its hoppers with coal and traveling to the oven targeted for charging. An operator, called a lidman, will remove the lids from the charge holes located on top of the oven, position the Charge Car over the charge holes and lower the sleeves into them. Once the sleeves are lowered, the hoppers will be dumped into the oven following a predetermined sequence. When the hoppers are dumped, the sleeves are raised and the lids replaced.

After coal has been dumped (charged) onto an oven, it will form peaked piles. At this point a leveling cycle will be performed. The door located near the top of the oven door on the Pusher side will be opened. The Pusher moves the Leveler Bar back and forth across the peaked coal piles to level them. After leveling the Leveler Bar door will be closed and the coking process begins.

The coking process is the destructive distillation of coal. This is where coal is heated to a high temperature in the absence of air, causing the breakdown of complex organic molecules leaving a carbonaceous residue known as coke. After the coking process is complete (approximately 18 hours), the oven will be "pushed" and the coke will be quenched. The Back Door Machine will remove the Coke side oven door and place the coke guide in position. The Quench Car will move into position to receive the coke as it is pushed from the oven. The Pusher will remove the Pusher side oven door and position the ram. The ram will advance through the oven to "push" the coke out of the oven, through the coke guide and into the Quench Car. The Quench Car will transport the coke to a quenching station where water will then be sprayed on the coke.
Once the Push cycle has been completed, the doors and jambs will be cleaned by their respective machines and the doors replaced. At this point the oven can again be filled with coal and the operation repeated.
Each machine makes use of the Allen-Bradley PLC and Panel View hardware to control its operation. In addition, Push, Leveling and Charge cycle information is collected by the remote PLC's and transferred to the Master PLC. The Push, Leveling and Charge cycle data consists of the duration the oven was exposed to the atmosphere. The Push cycle information also contains periodic samples of the ram position, Pusher motor current, and pyrometer readings from the Back Door Machine. After the Master PLC collects the data, samples are aligned by a time stamp into a data table and sent to the VAX computer.

Clocks in the remote PLCs are synchronized by the Master PLC to ensure the proper alignment of cycle data. The Master PLC constructs a message containing the current time with a message number that is sent to each remote PLC. When the remote PLC receives this message, it will synchronize its internal clock to the time contained in the message. A Message Scheduler has been implemented in the Master PLC to coordinate message transmissions between each of the machines and the Master PLC. This prevents a message from being initiated until a response has been received from a previously initiated message, or a message timeout has been reached. A timer logic routine has been added to the Master PLC to bypass the default message timeout. This was done to ensure that data is collected in an optimal manner.

The following was learned during the implementation of this project:

- A site survey should be performed by the radio modem equipment manufacturer prior to installation. This will assist in determining the location of modem equipment away from high powered transmitter equipment and electrical "hot" rails.
- An uninterruptable power supply should be used to power the modem equipment located on each of the machines to avoid power fluctuations associated with electrical "hot" rails.

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