Detection and Diagnosis of faults in Coke Oven using Wireless LAN Communication at Steel Works

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Abstract: - This paper will provide an overview of a application using a wireless data network to monitor and control the mobile machines for coke ovens in a steel mill. This system uses Siemens PLC on the mobile coke oven machines to send real-time data via wireless modems to fixed bases PLC. The data from the fixed base PLC is send to a computer system. This paper will Provided the reader with reasons why the customer applied wireless communications in this harsh industrial environment. The coke oven plant on a steel works has not, in the past, been regarded as a prime user of modern instrument technology. The reason for this perception may be due to the fact that the basic design of the coke battery has been changed little over the years. The recording and analysis of oven pushing force on a routine basis is seen as a means of monitoring plant operation. A torque sensor is set up at the shaft of the rotor for measuring pushing force. One of the most important features of this work is that it allows problems in the ovens to be identified at an early stage and for corrective action to be taken before it may develop into a refusal to push. The mechanical loads imposed on the battery structure can be maintained are necessary minimum controlled by the coal blending design, so helping to prolong its service life.

Key-Words: - Wireless Data Communication, Pushing Force, Monitoring System, Coke Oven Plant

1 Introduction

Pohang Iron and Steel Company(POSCO) is building one of the largest metallurgical works in the world in Kwangyang at the south coast of South Korea.

Process control systems have been planned and installed for all plant units(raw material, coking plant, sinter plant, blast furnace, steel mill)which are connected via a common data highway into a production planning and controlling system, for the total plant running on the so called business computer. An integral part of this metal-urgical works are the coke oven batteries with a planned overall capacity of 6.0 million tons coke a year. Then Kwangyang coking plant will be the largest plant existing worldwide.

This paper will describes the implementation of a wireless communication network at a coke making facility. The purpose of this network is to collect Charge, Leveling and Push cycle data from the machine used on a coke battery. The data is electronically transferred to a computer system to be complied and trended.

A pushing force measuring system has been developed for the pushing machine in preparation for the feet that pushing may not be possible due to heavy charging by the moisture control operation in 1999.

The current of the pusher ram motor had been used to estimate the pushing force. But there is a lot of difference between the estimated pushing forces and the actual measurement.

In order to obtain more accurate measurement of the pushing forces, we have developed a pushing force measuring system which is mounted on the drive shaft of pinion of the pushing machine.

2 Coking Plant

The coking plant were built and put into operation by Dr. C. Otto. To each single stage of the metallurgical works belongs a coking plant comprised of two coke oven batteries each with 66 ovens. Each battery is equipped with a set of oven machinery.

He plants will be supplied with coal from a common coal storage yard accommodating some 60 different coal type. The pre-selection for the coal charge blending consists of up to 14 different components and is determined by the business computer.

The coal charge is carbonized in the air-stage coke ovens(43m effective volume)which can be heated optionally with rich or lean gas at approx. 1,295C heating flue temperature for rich gas heating.

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 four charging holes on top to allow coal to be dumped into the oven. Doors are located on 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 Car and Back Door Machine. All of the machines are mobile and travel the length of the battery on tracks.

Each machines is powered by 480VAC electrical "hot" rails. The Pusher is located on the front 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.

The Charge Car is equipped with four 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 debris from the door jamb of the coke oven. The door cleaners is used is used 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. 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.

A typical charge cycle consists of the Charge Car filling its hoppers wit 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 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 from 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 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 Siemens 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 send to the computer

Clocks in the remote PLCs are synchronized by the Master 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.

3 Background

Wall Roughness and heating have been identified as contributing to variation in pushing force. Typical pushing force trends for a normal and a heavy push are shown in figure 1. For different ram motors and oven sizes the magnitude of the peaks may change but the general shape of the curves shown in figure 1 is valid for all constant speed rams. A heavy push is an oven that requires above normal levels of force to make it move. Heavy pushes are ovens that are almost stickers.

Cokemakers will often limit the pushing force, and therefore the force, used by the ram to push an oven. This is done to avoid wall damage but will result in more stickers because ovens which needed slightly more force to push are denied that force. It can therefore be seen that the same oven can be either a sticker or a heavy push depending on the force limit set by the cokemaker. The level set can greatly affect battery asset lift.

The force the ram applies to the coke is related to the pushing force

The ram force was calculated by measuring both the ram strain gauge signal and ram beam displacement with time and encoder.

The factors that cause stickers will affect pushing force. However with so many variables causing variation in pushing force, it is often difficult to determine what is the problem; the coal or the battery. If this variation can be understood then the ram beam pushing force could be made into a more useful oven diagnostic tool. Ram pushing force was measured on Kwangyang steel's POSCO 4 coke battery, Korea.

4 Data Acquisition System

Signals were acquired at various position of the electric motor and current, power peak. The output analog signal was connected to the terminal block of a data acquisition system.

The data acquisition system consist of a transducer, charge amplifier, terminal block, data acquisition board and a personal computer installed with Labview.

4.1 Labview Software

Labview, a graphical programming software for instrumentation is used as the data acquisition system. Labview serves as on-line monitoring of the system in order to identify faults at an early stage and prevent system breakdown. It is a program development application, similar to various commercial Visual-C programming application, that integrates data acquisition, analysis and presentation in one system.

Programming is done using block diagrams that compile into machine code as compared to order programming applications that use text based languages that create lines of code. In this study, the Labview program is capable of monitoring and displaying the acquires signal.

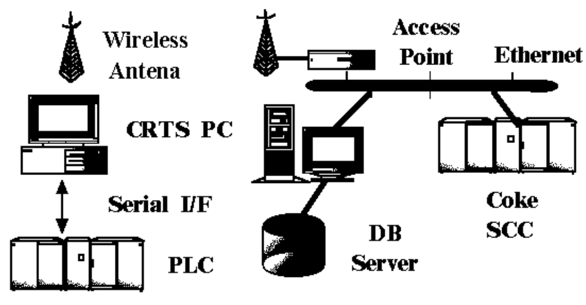

Figure 1. Configuration of Basic System

4.2 Labview Program Testing

The Labview program was also tested by inputting a known signal source from a Function Generator.

The signal, a sinusoidal waveform of 1.5 KHz, from the Function Generator was directly input to the terminal block of the Labview.

Using the signal source from the Function Generator, the filtering capabilities of the program was also tested. From these tests, it was concluded that the Labview Program was capable of performing the required task as a vibration means of data acquisition and analysis.

5 System Configuration

This system senses the torque of the drive shaft of the pusher machine to measure the pushing force.
The degree of twist of the shaft is measured using strain gauges and the results are transmitted to a stator with a low frequency telemetry system (Fig.2)

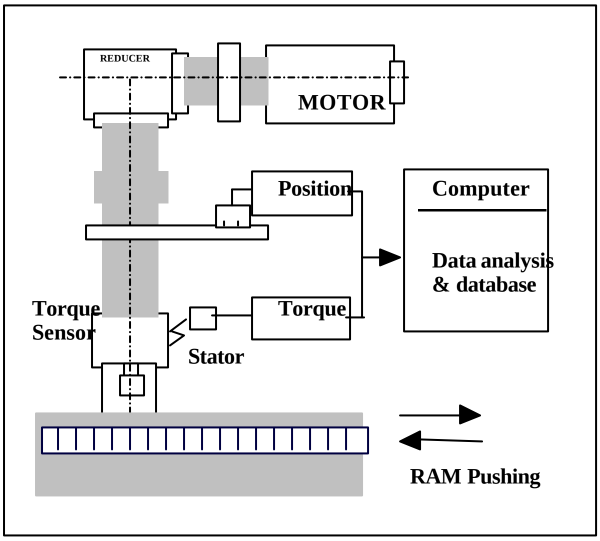

Figure 2. Configuration of pushing measuring system

This transmits, in the same principle as the radio, electric wave via small antenna from the strain signal modulated in the oscillator installed on the revolving body.

The electric wave is then received by the receiver fixed near and modulated. This method generally adopts FM method and used not only for a revolving body but also for a moving body. The transmitted electrical signal is transformed to pushing force by calibration to standard value and provides the ram force to the operator during the pushing stroke. The ram force required to discharge the coke in an oven could be composed of the resultants of the force needed to make the coke mass slide on the even sole and the ram beam moving force when it slides on the oven sole.

In addition to those, a further force is required initially to compress the coke in order to overcome the friction force between the coke and the oven side walls. This friction force could depend upon the charging coal characteristics which mean the extent of the coke spreads under the pushing pressure

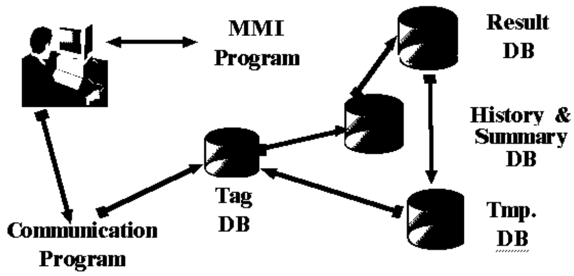

Figure 3. Data protocol of system

6 Man Machine Interface System

The recording and analysis of the pushing force of an oven on a routine basis are done automatically as a means of monitoring plant operation.

Pushing force trends which are measured by this system are shown on the MMI screen (Fig. 4), and the operator can analyze the pushing force historically using the computer system.

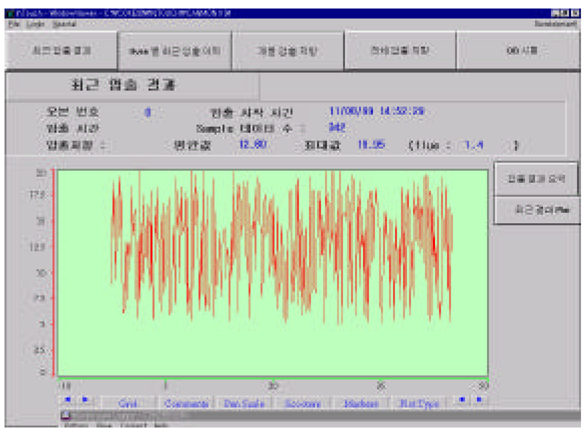

Figure 4. MMI screen of system

After starting the program, the Main Menu will appear on the screen follows;

The main menu function is consist of follows; Result screen of recent pushing(Fig. 5), Recent result of each ovens(Fig. 6), Summary of each ovens pushing result(Fig. 7), Characteristics of individual oven(Fig. 8), Total pushing result of ovens and battery(Fig. 9).

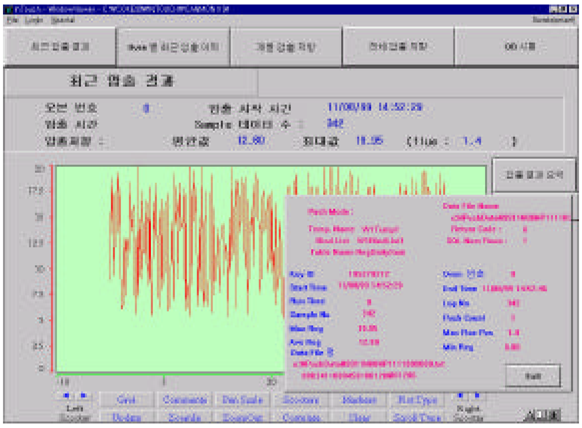

Figure 5. Result screen of recent pushing

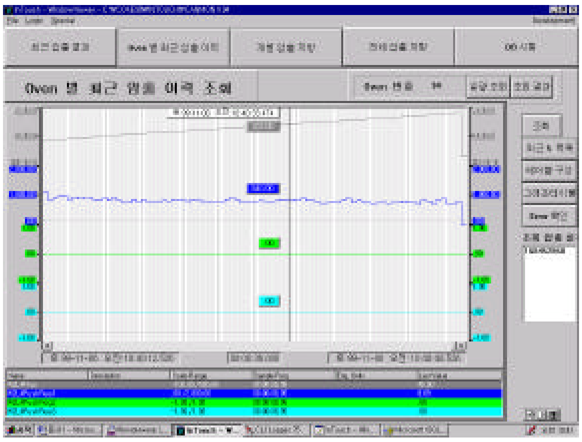

Figure 6. Recent result of each ovens

Figure 7. Summary of each ovens pushing result

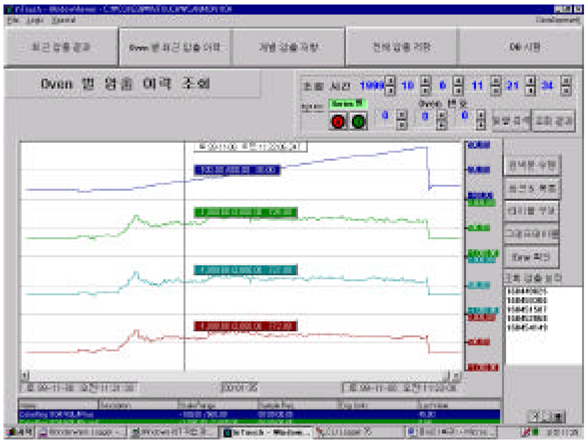

Figure 8. Characteristics of individual oven

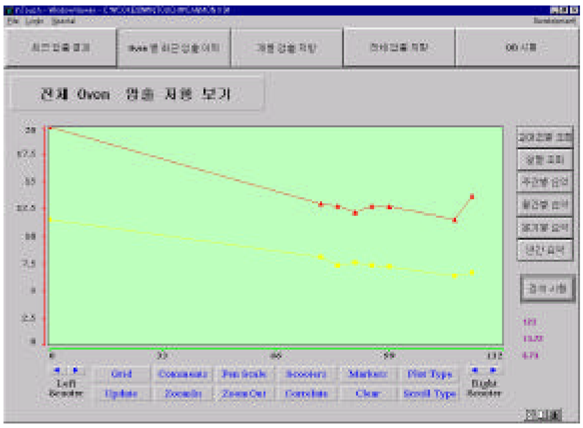

Figure 9. Total pushing result of ovens and battery

7 Conclusion

In recent years several older coke oven plants have been replaced new plants which are better suited to the ecologic and economic requirements of the future. Particularly under the extremely difficult economic situation in the coal/steel industry it is necessary to detect initial damages at an early stage and to take counter-measures because of the high investment costs for these new plants.

Perhaps the most important feature is that is allows a problem oven to be identified at an early stage and for corrective action to be taken before it develops into a refusal to push.

In this way the mechanical loads imposed on the battery structure can be held to a necessary minimum, so helping to prolong its service life. Such a system was successfully operation at No.2 coke oven in POSCO, Korea.

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