Abstract

One of the most important factors affecting the coke batteries’ life is the regime of the battery heating. Thermal abnormality in the coke oven battery heating negatively affects battery life. In this study, for longer use of coke oven battery, Level 2 intelligent system which makes coke oven battery heating regime steady is explained in Iskenderun Iron & Steel Co. (ISDEMIR) coke plant. The temperature data of the oven and temperature data of the heating wall belonging to the battery was recorded and monitored live through the Level 2 intelligent system. By using obtained data and statistical calculations of this data, coke oven battery temperature map is constituted. According to data of temperature map, warning and suggestion algorithm established and for ovens that have thermal abnormality, taking precaution become possible.

1. Introduction

Iron and steel production is one of the world’s most important and biggest industry. Main usage areas of steel are construction, transportation, energy, packaging and industrial supplies.

There are two main steel production processes; Integrated Steel Plants (Blast Furnace) and Electrical Arc Furnaces (Electrical process). In an integrated steel plant, iron ore is molten with coke in blast furnace. Iron ore may be in the form of lump ore, sinter or pellet. Coke is a residue of coal pyrolysis process, which is called carbonization. Chemical decomposition of bituminous coals by heating in absence of air, carbonization in coke oven batteries is complete extraction of coal volatile matter at approximately 1250°C heating wall temperature. Coal and coke illustration is given in Figure 1.

Coke is produced in coke making plants. A coke making plant consists of coal preparation, coke oven batteries and by – product plant. Coke making process flowsheet is given in Figure 2.

Coke oven batteries are built with refractory bricks mainly. A battery consist of gas flues and coking chamber Heating walls separates them. In gas flues, COG or mixture of COG and BFG is burnt. Generated heat is transferred via heating walls. In our case, each heating wall has 32 gas flues and the coke oven battery has 65 coking chamber. Therefore, there are 2112 gas flue in a battery.

Heating regime is a major and key operational factor in coke production. Sufficient heat must be transferred to coal
from gas flues. In order to keep under control heating regime, temperature measurements are taken periodically from gas flues by high temperature pyrometers. Conventionally, these measurements are recorded manually into a paper or a excel file.

Coal, charged into the oven, starts coking with drying and ends with coke formation at 950-1050 °C. Main steps of coking relative to temperature is illustrated in Figure 3[5]. While coking, coal particles follows four main chemical steps[1][6].

1. Coal, charged into the oven, is heated up to 100 °C and moisture is driven off.
2. There are minor changes from 100 °C to 350 °C. It is called plastic phase. Tar and oils driven off here. Plastic phase continues up to 500 °C.
3. Between 500 and 800 °C, plastic phase repolymerizes and semi – coke forms. Gases driven off at this stage.
4. Above 800 °C, hydrogen and light hydrocarbons are driven off. Semi – coke condenses to structure that is more graphitic and transforms to coke.

Figure 1. Coal to coke transformation

These steps explain what are going on when plastic layer go forward to the middle of oven while coking. It means that coking in batteries is ongoing process rather than stationary. Plastic layer leave behind semi – coke structure while it go into the moist coal[2]. An illustration of this phenomenon is given in Figure 4[5].

Figure 2. Steps of coking process

This continues carbonization process makes uniform heating regime necessary. Otherwise, plastic layer will be irregular and it causes weak coke in terms of stability and coke strength after reaction, which are cold and hot strength relatively [3][8]. As explained before, heating regime is controlled by gas flue temperature measurements. In order to understand temperature distribution of a coke oven battery well, below items should be monitored.

1. Temperature distribution of control gas flues.
2. Temperature distribution of cross – wall gas flues.
3. How many temperature measurements are out of optimum range in control gas flues?
4. How many temperature measurements are out of optimum range in cross - wall gas flues?
5. How many temperature measurements are out of optimum range in whole battery?

Checking temperature measurements manually may not be obvious the eye and not enable prioritization of maintenance works. That’s why a Level – 2 temperature monitoring system is a necessity for coke oven battery operation. There are three main coke oven battery temperature monitoring methods.

1. Temperature measurements from heating wall by pusher machine ram sensors
2. Temperature measurements from hot coke by guide car sensors
3. Temperature measurement from gas flues

Example of first method is AutoTherm - W developed by ThyssenKrupp. AutoTherm – G is the application of second method developed by again ThyssenKrupp [4][7]. In this study, measurements taken from gas flues will be monitored by Level 2, which is explained in further section.

2. Experimental Procedure

In İsdemir all facilities, manufacturing is done by entirely automation systems. All the known and applied level systems in many important industrial facilities are applied in İsdemir as well. These level systems are generally divided into five classes.

Level 0 : It represents instruments which are on site such as transmitter, temperature indicator, valve, motor. Generally, these devices do not have remote control capability. It is needed to go to the device to give any command or to read the value it shows.

Level 1 : With DCS or PLC systems, the process can be controlled and monitored by SCADA systems. PLC systems are can be programmed logically and with these systems devices belonging to Level 0 can be controlled. All operator controls and interventions in coke plants are made through Level 1 systems.
Level 2: In this layer, complex problems that cannot be solved by Level 1 are solved by enhanced programming language such as C#, C++ and outputs are sent to PLC systems. In addition, large amounts of data that cannot be held in PLC data blocks are kept in the Level 2 database through applications such as Oracle, SQL Server. Another task of Level 2 is to transfer the process information to Level 3 which is a higher system. All mathematical model calculations in coke plant are made through Level 2 systems.

Level 3: Unlike Level 2 which is peculiar to facility, Level 3 is more general. All required process data are collected in the central database. This data is summary and consists mainly of reports that managers need. Level 3 is also the center where information such as production, quality, marking is produced at every facility.

Level 4: It is the system where production planning is made. Records such as production and quality are identified here and transferred to the operation through Level 3 and Level 2 respectively.

The tasks of the Coke Level 2 system are as follows;
1- Recording information held instantaneously in Level 1 and present them in graphical screens and reports.
2- Ensuring that data such as analysis information, heat records, product quality, plant delay can be identified and monitored.
3- Ensuring that the facilities work more efficiently with model applications.
4- Transfer process information to Level 3.

Level 2 applications are two types; the server applications running on the background and the end-user application. Different applications are developed for each different targets to not affect other parties in case of disruption.

3. Results and Discussion

In this study, coke Level 2 applications and temperature maps of coke batteries were constituted. This process is carried out using the applications shown in Figure 5 with the following steps.

- The instantaneous temperature information of the coke batteries is transferred to the TagKernel application from the PLCs using the L1Manager application and the OPC communication.
- The TagKernel application keeps up to date values of all process information and provides the most accurate data with the necessary validation checks.
- With DBManager application, statistical information such as max, min, avg etc. stored on the TagKernel are written in the database at desired intervals.
- The Middleware application that creates the coke temperature map requests the data to be processed from the DBManager application and obtains the following information from the calculations made through this data:
  a. Temperature distribution at every gas flue
  b. All oven temperature distribution
  c. Temperatures outside the optimum range at every gas flue
  d. Temperatures outside the optimum range in the oven

Access to the report generated by the middleware application by these calculations is provided by the end user application. Figures 6 and 7 show the sections of this report and the graphical representations.

4. Conclusion

The coking temperature is an important variable in coke oven battery operation. The temperature affects the coke...
quality and the energy consumption. If the temperature is too low, the carbonization of coal will be incomplete. This will lead to poor coke quality, air pollution and pushing problems. If the temperature is too high, the coke stick to the oven wall. This causes pushing problems and refractory damage in the oven wall. The problems mentioned above do not occur after the temperature follow up with developed software.

References