Summary of the Heat-Up and Commissioning Activities for the New C Battery at U.S. Steel Clairton Works

Heat-up Introduction

Heating-up is a critical activity in the construction and start-up of a new coke oven battery. It plays a major role in the life and integrity of the battery refractory. The secret to a successful heat-up is the slow and uniform increase in temperature of every part of the massive refractory structure.

There are two main stages of the heat-up operation. The first stage is when the heat is supplied by external burners until the refractory mass reaches a critical gas ignition temperature. This stage is followed by burning gas in the flues of the heating walls to reach the final operating temperature.

Preparation for Heating-Up

The new installed battery is ready for heat-up when the refractory installation is almost complete, except for a few courses of the oven roof section. The oven doors are installed on both the pusher side and the coke side of the ovens. Burners are set up along the pusher and coke side benches. Each oven will have a burner on the pusher side and another on the coke side. Coke oven gas will be used as the fuel for the burners and temporary piping will be installed to supply gas to the burners. For monitoring and controlling the temperature of the refractory, thermocouples will be set up at specific locations. A data collection system is installed to gather the temperature information used for controlling the rise of temperature in accordance with preset heat-up curves which project thermocouple aim temperatures versus time.

During heat-up, the refractory expands. The silica brick, which is located in the hotter areas of the battery refractory structure, expands more quickly than the fireclay, which is located in the cooler, lower areas. There is a provision for expansion joints in the refractory design and installation, which when combined with the battery bracing system, accommodates this differential expansion rate. The bracing systems control the expansion as necessary to achieve the final dimensions and gas tightness of the heated-up refractory structure.

The battery heating system, including all gas piping, reversing system, gas, air and waste gas valves, is installed, tested and ready to be put in service once the appropriate refractory temperatures are reached.

First Stage of Heat-Up

After the installation of the battery refractory and steelwork is complete and all the preparatory work is done, the heat-up of the battery begins by lighting all of the heat-up burners.
Temperatures are continuously monitored and adjustments to the heat input are made to ensure the actual temperatures follow the heat-up curve closely over time. The most significant part of the thermal expansion of the silica refractory takes place during the first half of the heat-up. The bracing system, including the longitudinal bracing and cross bracing springs, is set to the “heat-up stage to 1,100ºF” position, and monitored closely. The system is adjusted as necessary according to the prescribed procedure. The expansion of the battery is recorded in three directions, length, width and height during the heat-up. The hot gas introduced into the oven chamber flows through special openings into the heating flues and out the through waste gas valves. This way the entire refractory structure, including the waste heat regenerators, is heated up to design temperatures.

Heating with Underfiring Gas (Normal Heating)

After about 50 days of heat-up, when the refractory temperature reaches and is stable at 1,490 ºF, a switch over to using the battery underfiring system and reversing system for heat input takes place, and the external heat-up burners are turned off. The special openings on the heating walls are closed and sealed. Special nozzles will be used during the heat-up stage to feed the proper amount of gas to the heating walls. In addition to the thermocouple readings, temperature readings will be taken in the flues using infrared pyrometers.

During this stage of heating, the gas nozzles, air and waste gas valve settings are adjusted on every heating wall, not only to increase the temperature, but also to maintain temperature uniformity along the length of the battery.

The bracing system will be adjusted to the “over 1,100 ºF” range when that temperature is reached, even before the start of “normal heating”, and the corresponding spring adjustments will be made. Once the temperature is at 1,800 ºF, the bracing system is set and adjusted to “operation” range. After about 90 days, the flues reach a temperature of 2,100 ºF. The heat-up period is over and the battery is ready for charging. At this point in time during the heat-up of C battery, Clairton’s No. 9 battery will be shut down, and 7 & 8 batteries will be reduced to about 120 ovens per day (50% of typical full schedule for 7-9), significantly reducing the total emissions from the 7-9 battery unit, and more than offsetting the emissions from C battery at the start-up production level. The 120 ovens/day schedule enables batteries 7 and 8 to be maintained hot enough to prevent the loss of beneficial sealing carbon and minimizes the development of internal thermal stresses which might otherwise increase oven-to-flue leakage and stack emissions on 7 and 8 batteries. It is preferred to hold this 120 ovens/day schedule on 7 and 8 batteries until C Battery is up to full schedule to avoid the loss of beneficial sealing carbon on 7 and 8 batteries.
Planned Steps in the Commissioning of C Battery
From First Charge to Full Production

Introduction

The initial operation of the battery during the ramping up of production (from first charge to full production level) is as important to the integrity of the battery refractory as the proper heat-up. The battery is intentionally started at a lower than normal production level to minimize the thermal stresses on the refractory. A step-by-step program is prescribed as shown in the attached "Expected capacity increase after start-up" table. It will take about three months to safely and efficiently reach full production after the first charge on the new battery.

Activities During the Ramping Up of Production

The battery is heated up to 2,100ºF and all work is done in preparation for the first charge. After the first oven is charged, the oven is connected to the collecting main, and the PROven System is ready to serve the battery operation. All the ovens are charged in accordance with the prescribed pushing schedule. Battery will be operated at 24 hour coking time during the first charge, so charging the entire battery will take 24 hours. Over the course of the following three months, the coking time will be gradually decreased to an 18 hour coking time, corresponding to "normal operation". This gradual process involves periods of stabilization after each step of coking time decrease. Each step of increase in capacity, or decrease in coking time, comes with a required increase of flue temperatures. Hence, the reason for the dwell time between steps of increase in capacity, is first to bring the entire mass of refractory to the higher level of temperature and, secondly, to make the finer adjustments to the heating system. It may even be necessary to utilize a test group of walls to determine the ideal settings of the heating system components, and incorporate the test results to the rest of the battery. These fine-tuning settings are required to adjust the heating system to the specific coal blends utilized at Clairton Works during battery commissioning.

The bracing system springs will be adjusted after every charging cycle during the early stages of the battery operation (after first charge). Similarly, the PROven System will be fine-tuned to match the operating conditions specific to the commissioning coal blends.

Charging and pushing schedules are changed at each step of commissioning to match the coking time requirements, until full production is achieved. Once full production is achieved on C Battery, 7 and 8 batteries will be shut down over a 2-to-3 day period.

Once 7 & 8 batteries are shut down, the batteries will be demolished, in preparation for the installation of D battery foundations, followed by D battery construction on the 7-9 battery site.

Full Production Performance Test
After the normal capacity level at 18 hour coking time is reached on C battery, fine tuning of the heating system will continue to achieve optimum operating conditions with regard to heat consumption, uniform heating, and environmental performance. This may take a few more months after reaching the normal capacity level. Then the battery will be ready for a Performance Test.

Once the battery has run for at least four weeks at full production under stable operating conditions, the Full production Performance Test will commence. The Performance Test will be conducted for the required number of days in accordance with the established test protocol, as agreed between the parties.