PID COMBUSTION – DEDICATED CONTROL FOR AIR ADMISSION IN A HEAT RECOVERY COKE OVEN

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Overview

- TKCSA Coke Plant Video
- Influences in the Heat Recovery Process
- Valves controlled by Time
- Process efficiency
- PID Combustion
- Results
- Conclusions
TKCSA Coke Plant Video
Influences in the heat recovery process

Basic Principles of HR-Coke Oven Technology

Influences on net coking time:

- coal basis
  - volatile matter
  - coal moisture
  - ash

- oven design
  - design of oven sole
  - thickness of insulation layers
  - air-tightness of oven doors
  - number & design of air inlets
  - quality of oven refractory

- process control
  - start temperature profile
  - coal bed height
  - coal density
  - heat loss
  - chamber volume
  - ash thickness
  - oven negative pressure
  - air volume flow
  - air flow division into primary/secondary shares
  - residence time
  - leakage air amount
  - skill of employees
  - availability of machines & utilities
Heat Recovery coke oven process

The oven has only 2 temperature sensor at Top and Sole Flue.

How to add air in the oven by only measuring temperature at 2 points and have a mix air/gas at the correct point?
First Option: Add air based on cooking time

tkCSA has automatic valves which are controlled by a PLC.

Air can be added based on the theoretical curve of gas flow or by the cooking time.
Process loss of efficiency at Sole Flue

Adding air based on the theoretical curve will lead to some loss of efficiency due to the influences not been considered in the control. Two scenarios can happen:

1. Gas coming from the Downcomers;
2. Sole Flue valve closing, decrease air flow;
3. Not all gas burned at the Sole Flue
4. Gas goes to the collector, damaging it.
Process loss of efficiency at Sole Flue

Adding air based on the theoretical curve will lead to some loss of efficiency due to the influences not been considered in the control. Two scenarios can happen:

1. Gas flow to Sole Flue decrease;
2. Sole Flue valve not moving;
3. All gas burned at the first stages;
4. No combustion at last stages due to no gas. Temperature decrease.
PID Combustion

By studying the process and using advanced process control, PID was developed by tkCSA team.

Objectives:
- Only add the necessary air in the oven to have an optimized combustion;
- Decrease the net cooking time by 4 hours (from 72 to 68h);
- Keep temperature at Sole Flue;
- Optimize the share of primary and secondary combustion;
Difference in the control Time X PID

The Time control (green):
- Do not take in consideration the variation in the process.
- The valve will close every cycle in the same way based on the net cooking time.

The PID Combustion (red):
- Check the variations in the process and optimize the opening of the valve.
- If any gas goes to the Sole Flue the valve can open again to burn it.
Difference in the control Time X PID

The Time control (green):
- Close the top valve based on the net cooking time of the oven.

The PID Combustion (red):
- Start closing the top valve based on the temperature of the Top and Sole Flue.
- Share some gas to be burned on the Sole Flue, keeping it hot.
Results

Average Temperature and valves position

Stage 1: Valves 100% open, too much gas to be burned;
Stage 2: Start of gas decreasing, Sole Flue valves change position to optimize burning;
Stage 3: Top valve start to close to reduce burn on first chamber (reducing burn loss) and keep Sole Flue with high temperature.
Increase in ovens temperature resulted in a higher cooking speed and consequently reduced the net cooking time by four hours.
Results

Decrease in gas burning at collectors

NTE is a KPI to represent how many hours the temperature at the collector is higher than the upper limit.
Results

Production x NTEs on Collectors

Jun/15 to Dec/16: PID in tests at some blocks. Production with high variation and NTE at 14;
Jan/16: All 3 batteries with PID Combustion;
Feb/16 to Jun/16: Production increasing and kept at high level, NTE increasing slowly;
Jul/16: Process problems led to highest NTE;
Aug/16: Production back at high level and lowest NTE.

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Conclusions

- Decrease gas burning at collectors. Preservation of assets.

- Ovens temperatures increased at Top and Sole Flue.

- Net cooking time reduced by 4 hours. Increase coke production capacity.

- Production at 1.7Mton (project 1.8Mton) was achieved with high machines availability and process improvement.
Thank you.

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