Technological developments for improvement of the environmental performance of conventional coke plants

Desenvolvimentos tecnológicos para o avanço do desempenho ambiental de coquerias convencionais

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Main background for emission reduction

- In Germany revised regulation “TA-Luft” since 2006
- In Europe revisions on the way
- In the US implementation of the 2006 Clean Air Act (CAA) according to NESHAP National Emission Standards for Coke Oven Batteries
Starting point

- New environmental rules by the authorities
  - The demanded further reduction of PM-emissions has initiated and promoted LEQT* projects in the US - Part I.
  - Demands on application of an individual oven pressure control system to reduce fugitive emissions at the oven openings and at the stack of by-product ovens - Part II.

*: LEQT=Low Emission Quench Tower
Part I : Low Emission Quench Towers (LEQT)
**Part I: PM emission limitations for quenchtowers**

**In Germany** tightened limits on filterables

- 10 g/t<sub>coke</sub> for new plants
- 25 g/t<sub>coke</sub> for existing plants instead of the former value of 50 g/t<sub>coke</sub>

**In the US** PM emission limitation based on emitted dust load per year (filterable + condensable) – after conversion to specific emission factors:

- **Former values**
  >200 g/t<sub>coke</sub> (filterable)
  >300 g/t<sub>coke</sub> (filterable + condensable)
  - Condensable approx. 30% of the total

- **Current values** (converted from actual permits):
  130 g/t<sub>coke</sub> (filterable + condensable)
  - Condensable approx. 90% of the total (strong reduction of filterables)
Types of PM (according to EPA)

- **Filterables**
  - Primary filterable PM emitted at the quench tower exhaust
  - Gravimetric determination of the filtered dust

- **Condensables**
  - Primary PM condensating under the conditions at the quench tower exhaust
  - Secondary particles forming as condensable PM in the atmosphere via complex photochemical reactions, e.g. from emitted SO2, NH3, NOx.
  - Gravimetric determination in condensation apparatuses
  - Method for determination of the “condensables” is a complex theme under continuous technical discussion and modification, because of ”double-counting”, irreproducibility or inaccuracy!
PM monitoring at the quench tower exhaust

- Definition of a representative number of sampling positions at the quench tower exhaust
- Consideration of the quench tower as a stationary source
- Measurements of the filterables/condensables according to actual standards –
  - in most countries: mainly according to former DIN 2303 - (not Din 2066 as indicated in the paper!)
  - in the US: EPA-methods (e.g. USEPA 5, 201A, 202,...)
Sources for PM emissions (1)

• Coke particulates resulting from
  – spalling of the coke pieces by “thermo-shock“
  – PM deposits at the quench tower internals and baffles

Photographs of a former, meanwhile demolished quench tower
• Fresh water
  – TDS (Total dissolved solids):
    Particle size <2 µm (molecular, ionic, colloidal or fine particle)

• Quench water
  – TDS (enriched) - EPA-limit value 1100 ppm
  – TSS (Total suspended solids):
    Particle size >2µm
  – Settleable solids
    Material of any size nor remaining suspended or dissolved
Possibilities for reduction of PM emissions in LEQT’s

- Trapping of the spalled PM ⇒ “Highspeed“ and intense cooling
- Fine distributed plume spray for pre-condensation/-separation of the ascending PM
- Baffles for separation of PM
- Flushing water sprays for regular baffle cleaning after the quenching procedure to avoid PM deposits – usage of clean water
- Improved quench water settling plant incl. automatic scraper for optimum water cleaning and reduction of PM introduced by the quench water
- Sealing of the area between quench car and tower to avoid emissions
• Filterable PM emissions as low as for a CDQ system, i.a. by application of a double baffle system
• Cost for investment and operation much lower than CDQ
• By sump-quenching better coke stabilization compared to conventional quenching

*: CSQ=Coke Stabilisation Quenching
Until today: Schwelgern, POSCO Gwangyang and Hyundai plants
New LEQT in North America
MonValley (Clairton Works)
Some features of the CSQ-system implemented in the LEQT’s

- Optimized water settling plant to clean the quench water
- USS-LOMO quenching for intense and short single spot quenching
- Greater height for generation of draught
- Double baffle system
- Upper plume spray for additional scrubbing of the plume
- Upper baffle cleaning system
PM separation efficiency using a double baffle system

- **Upper level baffles - for fine dust separation:**
  - made of plastic
  - smaller inner distances
  - deposition efficiency 74%*

- **Lower level baffles – for coarse dust separation:**
  - made of stainless steel
  - greater inner distances
  - deposition efficiency 92%*

- **Combined efficiency 98%**

*Estimates by Zeimes for the Schwelgern CSQ-system of ThyssenKrupp Steel
Part II : Individual Oven Pressure Control
Individual oven pressure control - History

- PROven™ (Pressure Regulated Oven)
  - Originally developed at DMT in the 90`s
  - Licensed exclusively to ThyssenKrupp Uhde
  - Further development and patents by ThyssenKrupp Uhde
  - In 1999 first industrial installation at a 6m battery of ThyssenKrupp Steel and in 2003 at the Schwelgern coke plant
  - Thereafter application on many plants worldwide
Oven pressure control system PROven™

- a mature system ...more than 2000 applications – worldwide

### Contracts for the PROven™-System

<table>
<thead>
<tr>
<th>Country</th>
<th>Oven height</th>
<th>no. Batteries</th>
<th>No. Ovens</th>
<th>Mio. t Coke/a</th>
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PROven™ - operating principle

• Decoupling of the pressure conditions in the oven and in the g.c.main by FixCup
• Regulation of the water level in the FixCup by the inherent available Ammonia liquor
• Individual oven pressure control dependent on carbonisation progress
• Low pressure at the beginning of carbonization minimizes fugitive emissions at the oven openings and additionally reduces any stack emissions after charging
• Increasing pressure at the end of the coking time prevents air ingress
• Suction in the g.c. main (-3.5 mbar) allows unsurpassed exhaustion of the charging gases
Retrofit – installations of PROven™

- Examination of existing design of standpipes, collecting main and instrumentation
  - collecting main prepared for operation under suction?
  - new collecting main required?
  - new standpipes required – or parts of?
  - pressure control systems prepared for suction?
  - sufficient capacity of exhauster in the BP-plant?
  - sufficient space for PROven™?
Big challenge for this first retrofit installation in North America:

- existing design for PROven™ not usable for small 5,2m ovens
- new design required („Mini“ PROven™)
Adaption of PROven™ to ovens <6m tall

- Revision of the complete mechanical construction in the area of the goosenecks and ascension pipe lids
- Downsizing of the structural PROven components and the flushing liquor supply to the smaller geometric dimensions
- Adaption of the regulation characteristics to the lower gas evolution - without loosing the accessibility of the standpipe lid area!
PROven & GCM-retrofit installation at Essar Algoma

View to the PS

View from the oven top
Conclusion

• Technological improvements of the environmental performance of conventional coke plants in good progress

• Reduction of PM emissions at new LEQT‘s – 3 for US Steel MonValley works under erection, 1 for Granite city commissioned with good environmental performance

• Individual pressure control system PROven™
  – already retrofitted successfully and with good environmental performance to battery #9 of the Canadian Essar Algoma plant and two plants in Brazil – Arcelor Mittal Tubarao and CSN/Volta Redonda
  – under erection for US Steel MonValley works for new battery C in Clairton
Thank you for your attention

• Any Questions?