Improvement of the environmental performance of coke quenching

Presentation at the AIST Cokemaking Committee Meeting, Pittsburgh 18/09/2013

Based on a lecture given at the AISTech2012 Congress

(including some modifications & extensions)
Targets of a quenching system - after pushing the coke has to be cooled down for further processing and transportation.

Cokemaking – heating up and cooling down.
Technology for coke quenching
Principal Routes

Wet Quenching

Coke Dry Quenching
Principle routes for coke quenching (I)
Coke Dry Quenching (CDQ)

Pro‘s:
- Recovery of heat
- Slight improvement of coke quality (maybe?)
- Practical in frosty countries

Con‘s:
- High Investment Costs (CAPEX)
- Economic only in countries with high energy prices
- Dust emissions during coke handling!
- Complex Technology
Principle routes for coke quenching (II)

Wet Quenching

Pro‘s:

- Low Investment Costs (CAPEX)
- Technique quite simple
- Most applied technique in Western world

Con‘s:

- Sensible heat of the red hot (i.e. 50% of the underfiring heat!) lost as steam – no heat recovery!
- Not practical in frosty countries – risk of ice formation!
- Without internals (louvres/baffles) quite high PM emissions
Environmental improvement of wet quenching

- In Germany revised regulation “TA-Luft” since 2006, in other European countries 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
  - In many industrial areas non-attainment (■) concerning PM2.5 (particulate matter <2.5 µm)
  - Programs for reduction of the PM-emissions by industrial sources initiated
- The worldwide tightened environmental limit values initiated and promoted many LEQT-projects (e.g. in UK, Germany, Italy, Sweden and USA)
- Most important target for usage in a BF: moisture content consistently <5%
Objectionable consequences of quenching – emissions (I)

Gaseous and odor emissions

- VOC’s and PAH’s - mainly resulting from coke not fully carbonized
- “Exotic” components as Dioxines, Nitrosamines were proven as of negligible influence
- Gasification reactions C+H2O=H2+CO
- Consecutive reactions forming H2S, NH3, etc.
- Coke burnoff (0.2-0.5%) resulting in CO2, SO2

PM emissions

- Main focus: Respirable dust as PM10 (<10µm) and PM2.5 (<2.5µm)
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
- Discrimination between anorganic and organic condensable PM (e.g. PAH, in particular from “green” pushes)
- **Secondary** PM emitted as vapor at the exhaust, but condensing in the atmosphere and forming PM 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 emissions limitation for quenchtowers

In Germany tightened limits on **filterables**

- 10 g/t\text{coke} for new plants
- 25 g/t\text{coke} for existing plants

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

- **Former** values (from emission factors documentation AP 42):
  - >200 g/t\text{coke} (filterable)
  - >300 g/t\text{coke} (filterable + condensable)
  - Filterable approx. 70\% of the total

- **Current** values (converted from actual permits):
  - 130 g/t\text{coke} (filterable + condensable)
  - Filterable approx. 10\% of the total
PM monitoring at the quench tower exhaust

Consideration of the quench tower as a stationary source
Definition of a representative number of sampling positions at the quench tower exhaust
Traversing of the sampling equipment
General principles for monitoring of filterable PM at the quench tower exhaust

- Mainly passive sampling according to former standard VDI 2303, for a few new LEQT’s active sampling according to isokinetic standard VDI 2066 under discussion
- Isokinetic conditions easy to realize only in conventional stacks
- For a quench tower such conditions are difficult to realize:
  - Strong flow disturbance
  - Highly non-steady state flow conditions, flow velocity > 30 ft/sec at the beginning, but less than 5 ft/sec near the end of quenching!
  - For a true isokinetic measurement procedure an online control of the suction velocity would be necessary – complicated apparatuses!
Discussion on isokinetic PM monitoring in Europe

- Isokinetic sampling leads generally to higher PM values because more fine PM is sampled.

- Current discussions on simplification of the monitoring in Europe:
  - Use of Mohrhauer (VDI 2303) and application of an isokinetic correction factor.
  - Another alternative: Isokinetic monitoring only during quite steady phase.

**Personal Comment:**
As we are at an industrial plant and not in the laboratory the effort for measurement should be held not to complicated!
Sources for PM emissions (I)

- Spalling of the coke pieces by “thermo-shock“
- PM deposits at the quench tower internals and baffles

Conclusion: Regular cleaning after the quenching procedure absolutely necessary!
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

Sealing between quench car and quench tower
Sources for PM emissions (II)

- **Make-up 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 > 2 µm
  - Settleable solids: Material of any size, nor remaining suspended or dissolved

**Conclusion:** Advanced quench water treatment plant absolutely necessary!
Typical components of a modern LEQT

- Quenching Tower
  - water sprays for cooling
  - height for generation of draught
    (Port Talbot 40m)
  - emission reduction facilities
    (baffles/grit arrestors for dust separation)
  - baffle flushing sprays for baffle cleaning
  - vapor spray

- Water settling plant to clean
  the water from breeze

- Coke breeze scraper
  to remove the breeze from the settling plant
Features of the advanced new USS LEQT’s

Optimized water settling plant to clean the quench water

Combined USS-LOMO spray and sump quenching

- intense and short single spot quenching
- leads to a flat surface of the coke bed and hereby to a homogeneous coke moisture

Double baffle system

Greater height for generation of draught

Upper plume spray for additional scrubbing of the plume

Upper baffle cleaning system
Efficiency of a double baffle system for PM separation

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
Most advanced LEQT-system CSQ*

The CSQ-system consists of the LEQT plus the sump quenching car plus a sealing and has to be considered only as a unit!
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
CSQ – Installations:

Schwelgern, POSCO Gwangyang and Hyundai plants
CSQ-car and hopper-like sealing to CSQ-tower
ThyssenKrupp Uhde’s latest references for LEQT

Applied Standard for PM measurement

<table>
<thead>
<tr>
<th>Project Details</th>
<th>Year</th>
<th>PM (g/t)</th>
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<tr>
<td>2 CSQ-Quenchtowers for ThyssenKrupp Steel Duisburg</td>
<td>2003</td>
<td>10g/t&lt;sub&gt;coke&lt;/sub&gt;</td>
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<tr>
<td>5 CSQ-Quenchtowers China</td>
<td>2007</td>
<td>-</td>
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<td>2009</td>
<td>25g/t&lt;sub&gt;coke&lt;/sub&gt;</td>
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<td>2 LEQT for Dragon Steel/Taiwan</td>
<td>2012</td>
<td>50g/t&lt;sub&gt;coke&lt;/sub&gt;</td>
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<td>2 CSQ-Quenchtowers for Posco Gwangyang/ S. Korea</td>
<td>2010-2011</td>
<td>50g/t&lt;sub&gt;coke&lt;/sub&gt;</td>
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<td>4 CSQ-Quenchtowers for Hyundai Steel/ S. Korea</td>
<td>2009-2013</td>
<td>10g/t&lt;sub&gt;coke&lt;/sub&gt;</td>
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<td>1 LEQT for USS Granite City</td>
<td>2012</td>
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<td>3 LEQT’s for USS Clairton</td>
<td>under erection</td>
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<td>3 LEQT’s for ILVA-Taranto</td>
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<td>under negotiation</td>
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<tr>
<td>1 LEQT for SSAB / Sweden</td>
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Conclusion

Technological improvements of the environmental performance of LEQT’s worldwide in progress

Installation of LEQT‘s is an efficient tool for improving the environmental performance of a coke plant

Hereby the public acceptance of our industry can be enhanced considerably!
Thank you for your attention

Any Questions?