Material Probe and Corrosion Probe:
Boiler Optimisation in terms of Corrosion and Fouling

W. Spiegel, D. Schneider, G. Magel

www.chemin.de
Profile of CheMin: “Che” for Chemistry, “Min” for Mineralogy

**Started in 1996:**
- Ltd, 100 % private company, located at Augsburg (near Munich, Germany)
- 4 operational teams (each 4 to 6 persons)
- 3 publicly appointed and sworn experts
- 2 associated senior experts

**Strategy:**
- Widely accepted position: neutral
- Exchange of experience in networks, national and international
- Cooperation with universities
Profile of CheMin: Competence

Our competence

- Longterm consulting, expertise and failure studies
- Expert Report
- R&D

For

- Power plants (e.g. waste, RDF, biomass, peat, coal, solar)
  Clients: operator, manufacturer, suppliers, insurer, courts
- Companies that deal with thermic-chemical processes (various branches of industry)

Subject matter

- materials, fuels, residues, thermic process engineering, thermo-chemical processes
Profile of CheMin: Work at power plants from 2010 to 2014
Material Probe and Corrosion Probe

Profile of CheMin: Support for operators and plant manufacturers

Damage investigation
Expert Witness

Shutdown
- Boiler inspection (with fouling + shotblasted)
- Sampling
- Selective measurements (e.g. thickness of tubes)
- Inspection with grazing light

Goals:
- Higher Availability
- Longer operation periods
- Higher energy efficiency

Quality Optimization
Metalli c protective layer
ceramic protective layer

Laboratory Tests
(„corrosion lab“)

Online
CheMin-Probes
Material Probe
Corrosion Probe
Fouling Probe
Grid Probe
Fin Probe
CheMin-Methods
Ash-Salt-Proportions
CheMin-Sensors
Heat Flux Sensors
Material Probe and Corrosion Probe

Schedule for optimisation

1. Inspection
2. Probes
3. Preparation of measures
4. Quality Optimisation
Material Probe and Corrosion Probe

Schedule for optimisation

1. Inspection
2. Preparation of measures
3. Quality Optimisation
4. Probes
# Online Probes and Sensors

<table>
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<th>Probe Type</th>
<th>Description</th>
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<td><strong>Material Probe</strong></td>
<td>Test of metallic or ceramic material along temperature profile</td>
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</table>
| **Corrosion Probe** | Cause and mechanism of corrosion applicable for different kinds of corrosion (e.g.):  
- high temperature chlorine corrosion  
- salt melt corrosion  
- due point corrosion  
- deliqueszence corrosion (hygroscopic salts) |
| **Fouling Probe** | Collection and analysis of fouling and corrosion products formed on the probe surface along a temperature profile                                |
| **Grid Probe**   | Collection and analysis of saturated salts being deposited at different temperatures in the boiler                                              |
| **Fin Probe**    | Formation of fouling and corrosion in the radiative part                                                                                      |
| **ASP**          | *(Ash-Salt-Proportions)* Chemical composition of flue gas particles taken at the end of the boiler                                              |
| **Heat Flux Sensor** | Measuring the heat transfer at membrane walls                                                                                                   |
CheMin-Probes: **Grid Probe**
Online Probes and Sensors

CheMin-Probes: Fin Probe

Cl  Fe  Zn  K
Online Probes and Sensors

CheMin-Sensors: Heat Flux Measurement
### Material Probe
Test of metallic or ceramic material along temperature profile

### Corrosion Probe
Cause and mechanism of corrosion applicable for different kinds of corrosion (e.g.):
- high temperature chlorine corrosion
- salt melt corrosion
- due point corrosion
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### Fouling Probe
Collection and analysis of fouling and corrosion products formed on the probe surface along a temperature profile

### Grid Probe
collection and analysis of saturated salts being deposited at different temperatures in the boiler

### Fin Probe
Formation of fouling and corrosion in the radiative part

### ASP
(Ash-Salt-Proportions) Chemical composition of flue gas particles taken at the end of the boiler

### Heat Flux Sensor
Measuring the heat transfer at membrane walls
Probes with a temperature profile: How does it work?

CheMin-Probes can be applied as:
- Corrosion Probes
- Material Probes
- Fouling Probes
Properties of CheMin-Probes

Corrosion Probe – Material Probe – Fouling Probe

• Geometry of a real boiler tube, application of protective layer possible.

• Temperature range on the Probe surface can be set due to internal cooling

• Temperature range can be recorded simultaneously

• Temperature control will keep temperature constant

• Probes can be installed and uninstalled during operation

• Simulation of variation of boiler parameters (e.g. steam temperature, temperature of feed water, etc.)

• Further investigation (e.g. of fouling or metallurgic) in the lab possible
Material Probe and Corrosion Probe

Cause and Mechanism of Corrosion

Corrosion Probe (application at higher temperature)

Operating time: 670 h
Flue gas temperature: 600°C
Near to explosion cleaning
Material Probe and Corrosion Probe

Threshold of Deliqueszence Corrosion

Corrosion Probe (application at lower temperature)
• Deliqueszence corrosion of hygroskopic salts

Operating time: 15 h
Flue gas temperature: 260°C
Material Probe and Corrosion Probe

Threshold of Deliqueszence Corrosion

Corrosion Probe (application at lower temperature)

• Deliqueszence corrosion of hygroskopic salts

Operating time: 2,640 h
Flue gas temperature: 260°C
Material Probe and Corrosion Probe

Test of Various Materials

Material Probe

Application of inside thermocouples:
Before or after coating of the tube
Material Probe and Corrosion Probe

Test of Various Materials

Material Probe
Material Probe and Corrosion Probe

Test of Various Materials

Material Probe
Material Probe and Corrosion Probe

Cause and Mechanism of Fouling

Fouling Probe

Flue gas temperature: 700°C

Flue gas temperature: 600°C

Flue gas temperature: 550°C
Material Probe and Corrosion Probe

Material Probe

Example:
Installation in MSWI Augsburg before superheater,
Flue gas temperature: 680°C

Temperature window
on the probe surface: 380 to 480°C
Example:
Installation in MSWI Augsburg before superheater,
Flue gas temperature: 680°C

Temperature window
on the probe surface: 380 to 480°C
Material Probe and Corrosion Probe

Material Probe: Corrosion depending on surface temperature

Surface Temperature [°C]

SH-Temp. 410°C

Little Corrosion (high temperature chlorine corrosion) due to chlorine gas

Local “Pitting” due to salt melt

Before installation (All pictures show same magnification)

Surface of Probe [cm]

Before installation (All pictures show same magnification)
Material Probe and Corrosion Probe

Material Probe: Corrosion depending on surface temperature

Material Probe (thermal spray coating)
Corrosion rates strongly depend on material temperature.
Same results after about 670 h and 1750 h of exposure (in wte plant).
CheMin Probes

- Corrosion Probe
- Material Probe
- Deposit Probe

Prevention is better…