What questions on Corrosion are Left after Three Conferences Concerning Oxyfuel

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Messages heard (might be misinterpreted)

Foster Wheeler, „we can build a commercial oxyfuel plan!“.

Alstom, „ready to sell an Oxyfuel plat“.

Vattenfall, „Corrosion is no game stopper! We did not see any severe corrosion. „

...

Industry seems to see no open questions on material use?.
Objective

• Find open questions?

• Research Gaps or risk which are linked to corrosion?

• Are open questions existing?
Example: Tube with inner pressure

Gas diffusion.
Educt towards steel.
Products into gas phase.

Pressure, temperature, flow.

Steam oxidation

Local gas-ash/slag/Metal equilibrium.

Ash-Magnetite reaction.

Gas corrosion.

Oxyfuel-Steam Dual conditions

Steam oxidation

H+ + CO2 + O2 + H2O -> Fe + MClx + SiO2 + Al-Si-O

m = 2, n = 3: M^{3+} \subset \{Fe, Cr, \ldots\}

m = 1, n = 1: M^{2+} \subset \{Fe, Mn, Ca, \ldots\}

m = 2, n = 1: M^{+} \subset \{Na, \ldots\}
Let us look on OCC1 and OCC2!

Unfortunately some files my system can’t open in the OCC archive.
A. Hjörnhede et. al.
- Strong indication of higher material wastage rate in Oxyfuel
- **Increased S on corrosion front**
- Carburisation of austenitic steels, Ni-based
- Alumina former nop carburisation
- Superaustenitic steels (30 %Cr, 30%Ni, 30% Fe form protective scale

H. Klingelhöffer et al:
- **Strong interaction between corrosion and fatigue with potential to reduce lifetime**

H. Hünert: (H2O-CO2 basic gas)
- **Carburization of martensitic steels and enhanced oxidation rates**

R. Irons (E.ON): (coal with 2% S and low Cl)
- **Potential for severe increase of corrosion rate especially for high Cr alloys**

G. Scheffknecht: (keynote lecture – research gaps)
- Slagging, Fouling and Corrosion
- Higher CO2 partial pressure -> formation of CaCO3 and FeCO3
- Higher Sulfur intrusion
- Carbonate formation
- **Scale appears less stable ... therefore higher gas diffusivity towards material**
G. Stein-Brzozowska et al.:  
- **Higher Sulfur in corrosion scale/deposit region**

A. Kranzmann et. al:  
- General **Sulfur containing atmosphere less corrosion than in sulfur free Oxyfuel gas composition**  
- T24 shows high Sulfur concentration at interface metal-scale  
- Competitive reaction between H2O, O2, CO2 and SO2 but **water enhances diffusivity of all species**  
- The influence of ash can be positive if dense reaction layers with low permeability for SO2/SO3, CO2, CO, H2O, O2 can be formed.

A. Fry et al.: (T22, T91, 347H – 761K)  
- **Low corrosion rates** – 3 to 16 µm per year (exception T22 and Illinois coal)
Slag, fouling

F. Wigley:
- Oxyfuel deposits are different

B. Adams:
- Impact on Fouling by Na2SO4

W. Morris:
- More basic Oxides (additional remark Fe2O3, CaO, Al2O3, SiO2....)
- Implications for fouling
Result of summary OCC1 and OCC3:

- Strong potential of higher material wastage if wrong choice
- Strong dependency on fuel (S, Cl) for low Cr (< 2.5 mass%)
- 9 to 12% Cr steels seems to work but is very much depending on ash layer and formation of FeCr-Spinell
- Cr-contents beyond 16% and Austenits perform well under the tested conditions.

- OCC3 – oral ad-hoc message
Expectation

Simulate the working conditions.

Component for a technology → Working conditions to face* → Experiment

Draw conclusions on Functionality, Lifetime, interaction, improvements, ....
Do we perform the experiments which are needed for material qualification?
Knowledge on the external influences and the ageing of the material. Corrosion: material composition, corrosion rates in relation to chemical activities or fugacities, solubility of impurities in the surface near volume, Diffusion constants, microstructure change during exposure, influence of stress

Variable: T, p

- Increased solubility for soluble atoms like H⁺ or C in Fe
- Grain size and shape growth, recrystallization
- Influence on corrosion
- Shape (creep, plasticity, viscose flow)
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<thead>
<tr>
<th>World</th>
<th>Waterwall tube</th>
<th>Superheater tube</th>
<th>Steam cylinder</th>
<th>Water wall</th>
<th>Steam turbine blade</th>
<th>Gas turbine blade</th>
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<tr>
<th>Laboratory</th>
<th>Coupon (ISO)</th>
<th>Dual corrosion coupon</th>
<th>Tube simulation exp.</th>
<th>Double ring test</th>
<th>Tensile Test</th>
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Should we use current results to develop to integrate kinetic + thermodynamic tools into a predictive corrosion model!
Open questions in corrosion

- Is corrosion a limiting factor or not? Who will give a definite answer?
- Influence of dual conditions like both side on a separating wall (pipe wall in steam power plants).
- Influence of an ash layer on high temperature corrosion.
- How to extrapolate from laboratory data to the field?
- Are all parameters and their interaction known?
- What is the impact of carburization for a long time?
- Can corrosion/carburization impact the fatigue life?

... Open questions discussion....