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?

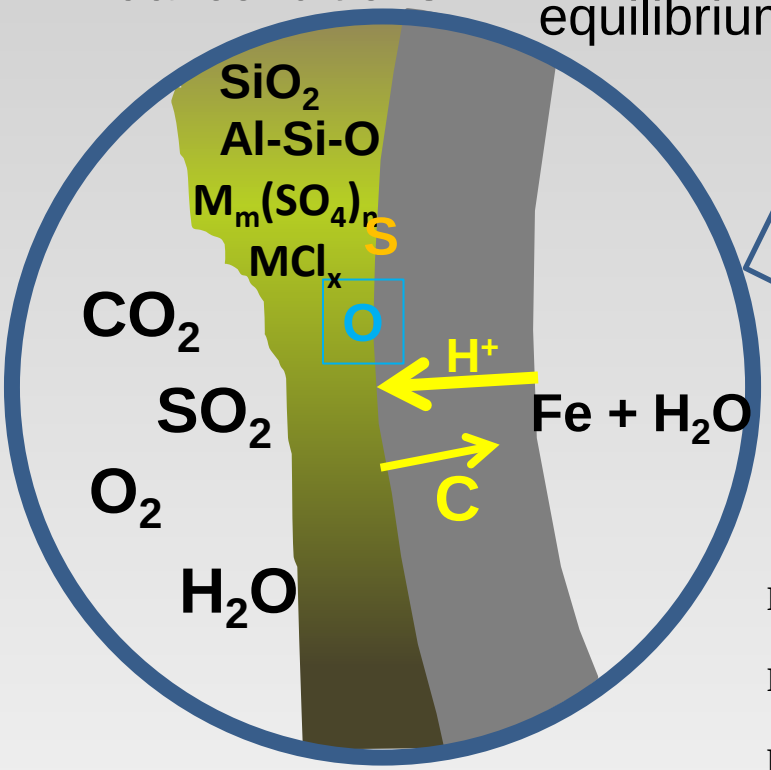
Example: Tube with inner pressure

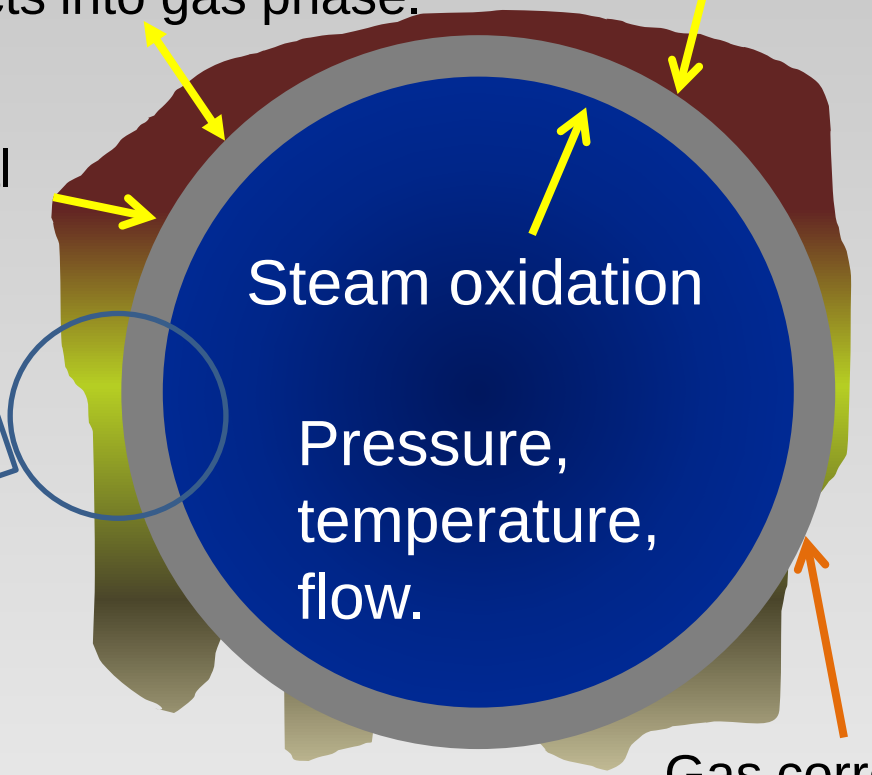
Gas diffusion.
Educt towards steel.
Products into gas phase.

Ash-Magnetite reaction.

Oxyfuel-Steam
Dual conditions

Local gas-ash/slag/Metal equilibrium.





Gas corrosion.

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

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

$$m = 2, n = 1 : M^{+} \subset \{Na, ...\}$$

Let us look on OCC1 and OCC2!

Unfortunately some files my system can t open in the OCC archive.

OCC1

A. Hjörnhede et. al.
- Strong indication of higher material wastage rate in Oxyfuel
- **Increased S on corrosion front**
- Carburisation od 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: (H_2O-CO_2 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 CO_2 partial pressure -> formation of $CaCO_3$ and $FeCO_3$
- Higher Sulfur intrusion
- Carbonate formation
- **Scale appears less stable … therefore higher gas diffusivity towards material**

OCC2

G. Stein-Brzozowska et al.:
- **Higher Sulfur in corrosion scale/deposit region**

A. Kranzmann et. al:
- Generall **Sulfur containing atmosphere less corrosion than in sulfur free Oxyfuel gas composition**
- T24 shows high Sulfur concentration at interface metal-scale
- Competitive reaction between H_2O, O_2, CO_2 and SO_2 but **water enhances diffusivity of all species**
- The influence of ash can be positive if dense reaction layers with low permeability for SO_2/SO_3, CO_2,CO, H_2O, O_2 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 Na_2SO_4

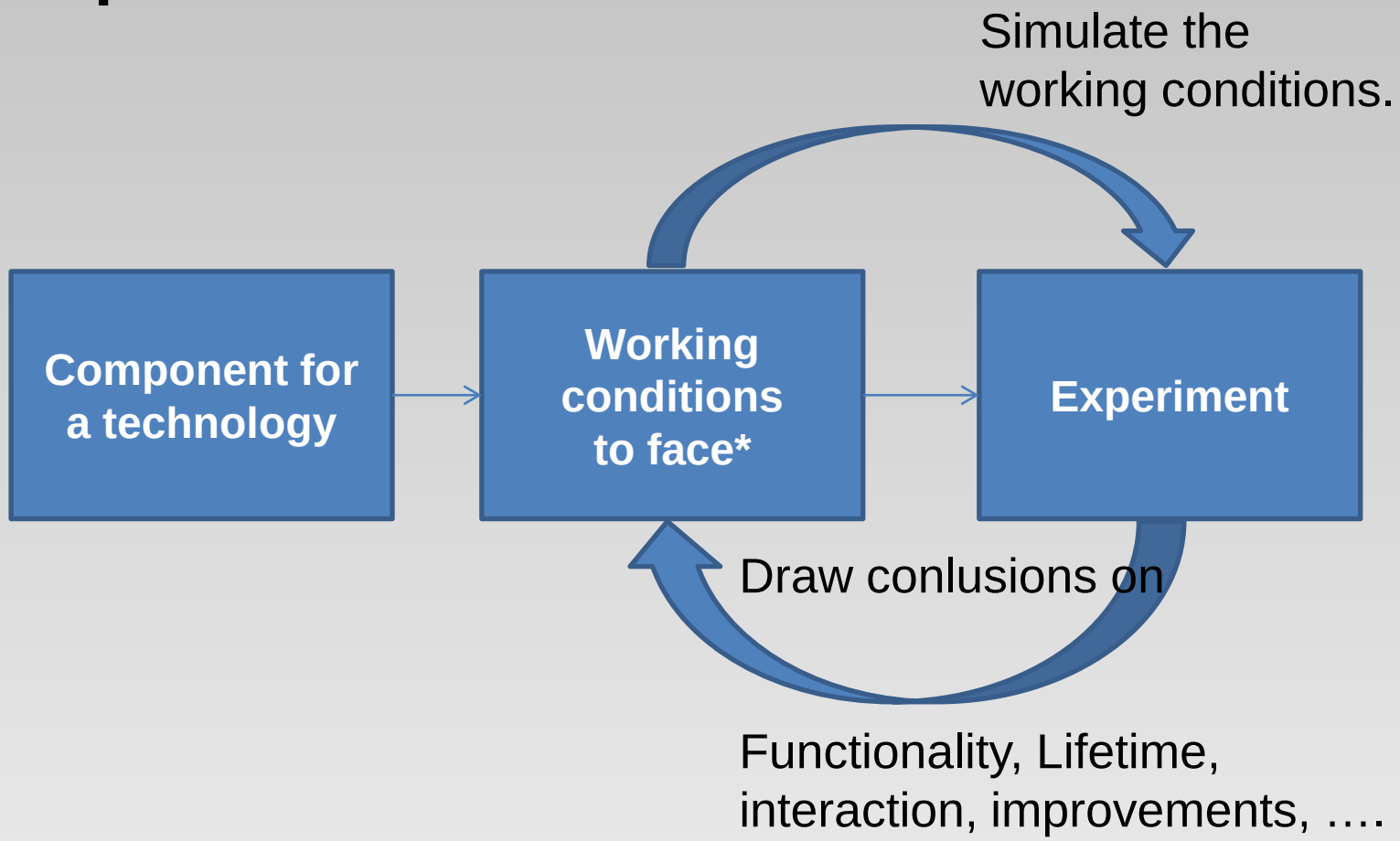
W. Morris:
- More basic Oxides (additional remark Fe_2O_3, CaO, Al_2O_3, SiO_2….)
- Implications for fouling

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

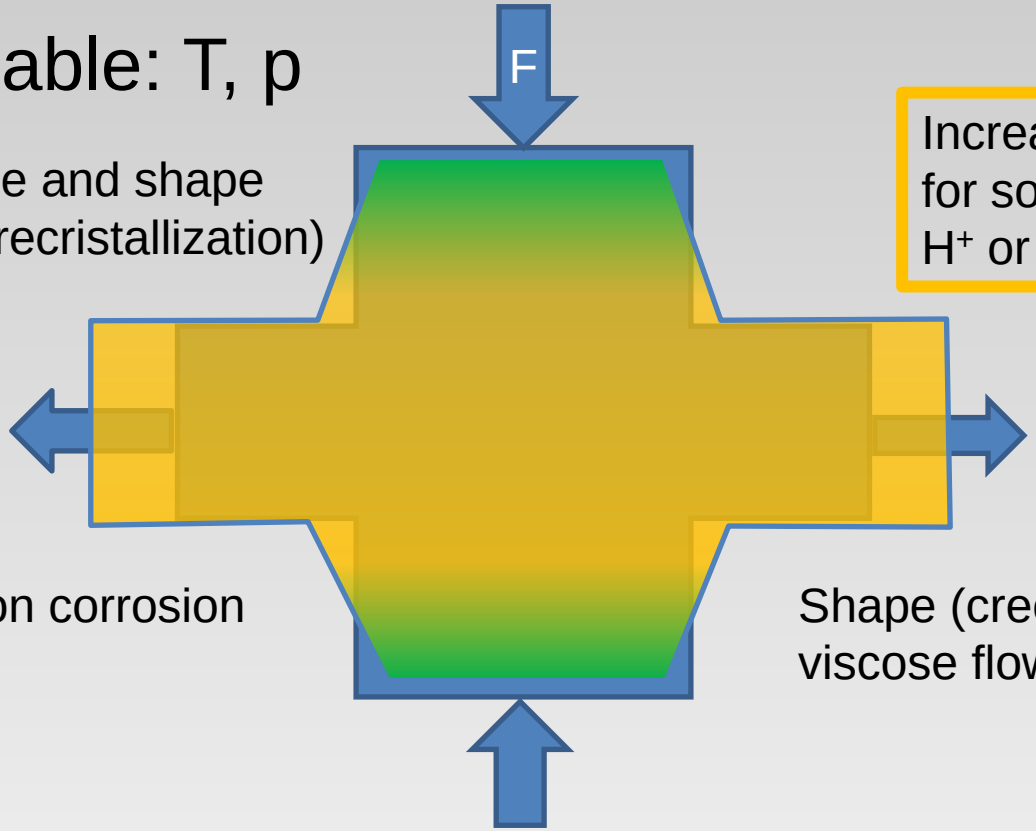


Do we perform the experiments which are needed for material qualification?

* 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

Grain size and shape
Growth, recristallization)



Increased solubility for soluble atoms like H^+ or C in Fe

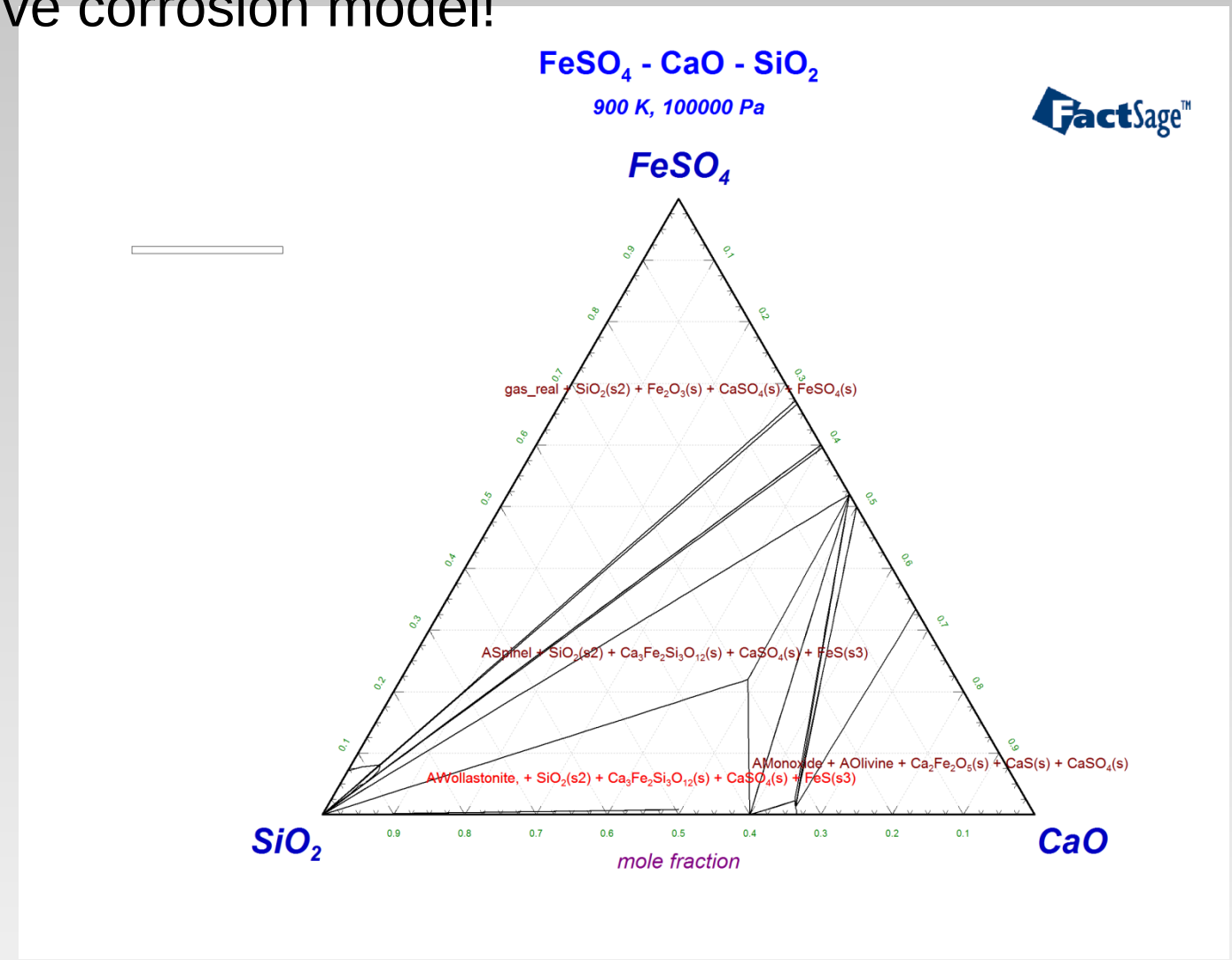
Influence on corrosion

Shape (creep, plasticity, viscose flow)

World	Waterwall tube	Super-heater tube	Steam cylinder	Water wall	Steam turbine blade	Gas turbine blade
Ash, Slag						
Steam						
Flue gas						
Stress						
Air						

Laboratory	Coupon (ISO)	Dual corrosion coupon	Tube simulation exp.	Double ring test	Tensile Test
Ash, Slag				Or	
Steam	Or			Or	Or
Flue gas	Or	Or	Or	Or	Or
Stress	Not in Standard				
Air	Or	Or	Or	Or	Or

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 laboratoy data to the field ?
- Are all parameters and there interaction known?
- What is the impact of carburization for a long time?
- Can corrosion/carburization impact the fatigue life?

- …Open questions discussion….