Corrosion-resistant coatings for refractory lining anchors in aggressive high temperature environments

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Funded by: BMWI via AiF
Period: 01.04.2012 – 31.07.2015

Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

Motivation

Fig.1: Anchors for refractory linings

In a large number of technical incineration processes metallic components are in contact with aggressive gases and deposits. Especially critical are atmospheres containing halogens such as chlorine, alkalis, and heavy metal compounds, all of which cause severe corrosion damage.

Aluminizing of the metallic components is a promising way to protect them. Slurry aluminizing was chosen as coating technique because it is a well established, low-cost process even for large components.

The challenge in the present project is to develop corrosion-resistant slurry diffusion coatings in situ, directly in plants, using the process-inherent energy for the diffusion process.

The protection of refractory lining anchors is of special interest (Figs. 1 and 2), but the coating solutions for this application can also be transferred to other metallic components such as sheets or tubes.

Fig.2: Bursting of the refractory lining and corroded anchors

Coating concepts for Al diffusion in aggressive environment

Based on a two-layer system of layer 1, diffusing metal (AlSi slurry) and layer2, protection of the base material and the diffusing metal from oxidation/corrosion, three coating concepts are evaluated (Fig. 3):

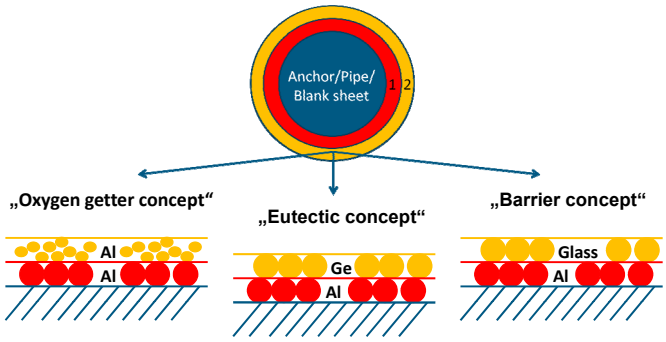


Fig.3: Three coating concepts based on a two-layer system

- Oxygen getter concept: Large AlSi powder particles are used for the diffusion layer, smaller Al powder particles (3-5µm) with larger surface are used as oxygen getter
→ Formation of Al_2O_3 on top

- Eutectic concept: AlSi powder particles are used for the diffusion layer, Ge powder particles as second layer are used to form a eutectic composition with a low melting point (≈420°C)
→ A dense liquid phase forms on top and the Al in the eutectic composition can form Al_2O_3

- Barrier concept: Forming a glas barrier on top of the aluminum particles
→With a dense glass/ceramic layer only a small amount of oxygen can reach the aluminum or the base material, so the oxygen diffusion is restrained

Testing parameters in the laboratory

Material: 1.4876 / alloy 800H / X10NiCrAlTi32-20
Atmosphere: N_2/ 200ppm HCl/ 20ppm SO_2/ 8Vol%O_2/15Vol%H_2O
Diffusion time: 300h → solid state diffusion to form stable phases
Heating process: similar to the heating up in waste-to-energy plants

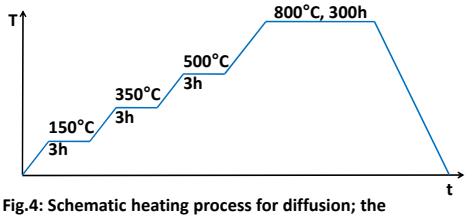
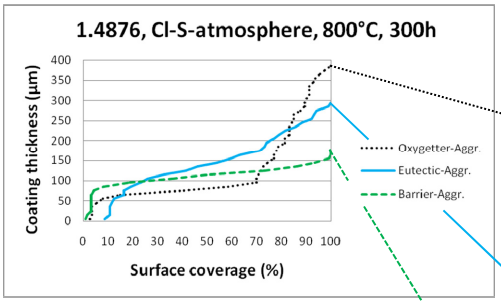


Fig.4: Schematic heating process for diffusion; the parameters were chosen similar to the heating up in waste-to-energy plants; the long diffusion time is due to solid state diffusion in order to form stable phases

Results – laboratory



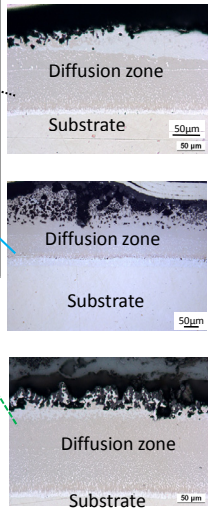


Fig.5: Relationship of the cumulative probability of the surface coverage and the coating thickness; only the barrier concept leads to a homogenous diffusion coating, whereas the other coating concepts lead to a broader distribution of varying coating thicknesses; the cross sections on the right side show exemplarily the resulting coatings: Severe Cl-attack arises with the eutectic concept – especially $(Fe,Ni)_2Al_5$ is leached out – whereas hardly any attack occurs with the barrier concept, where nearly all of the coating transformed into the more corrosion resistant (Fe,Ni)Al-phase

Results – coating behavior in a cement plant

Test conditions:
- **Temperature** at the **anchor tip ≈ 800°C**, **10 month**
- Anchors coated with the **eutectic** concept and the **barrier concept**
- <u>Prediffusion in **air** or coated **directly in the plant**</u>
- Measurement of diameter-loss at the anchor tip and 15 mm below

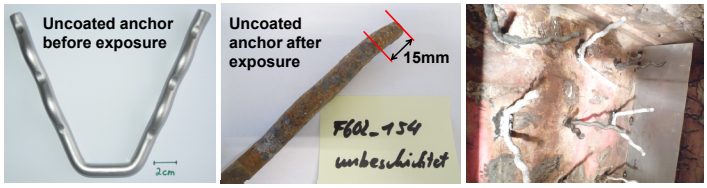


Fig. 6: Uncoated anchor before (a) and after (b) exposure as well as anchors after slurry coating directly in the plant before exposure (c)

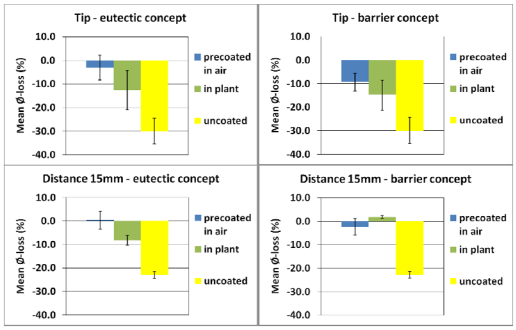


Fig.7: Mean diameter loss of anchors after exposure in the plant

<u>Both concepts show a significant reduction in comparison to uncoated samples</u>

Acknowledgement

This work was funded by the German Ministry of Economics and Technology through the German Federation for Industrial Research (“Arbeitskreis industrieller Forschungs-vereinigungen”, IGF-Nr. 17471 N), which is gratefully acknowledged.