Anti-Adhesive Coatings for High Temperature Applications

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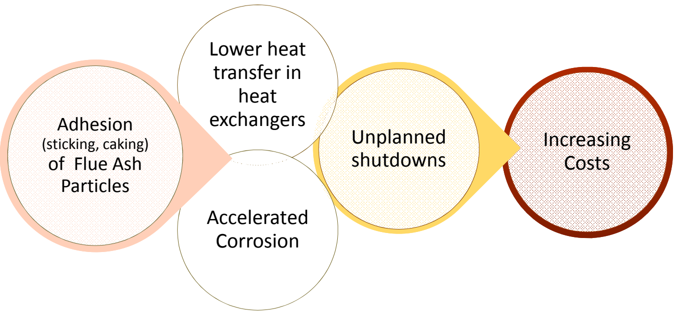
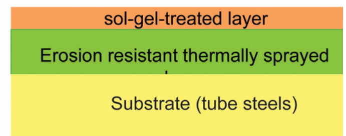
Motivation

Challenge

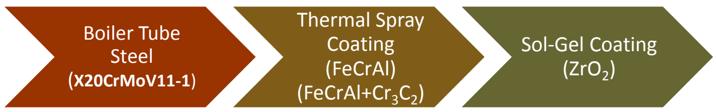


Corrosion, erosion, sticking and caking are wide spread problems in power plants, caused by aggressive flue ashes with corrosive components such as sulfur, chlorine and alkali based salts. Furthermore, the use/co-firing of a diversity of biomass or alternative fuels with lower quality enhances the problems arising from adhesion (caking, sticking) corrosion, and erosion issues. As a result, the efficiency of the power plant decreases (lower heat transfer) and periodically service maintained shutdowns have to be planned to clean the facilities and to change damaged parts generating costs from 100,000 to €1 Million/day.

Proposed Solution



The innovative concept proposed in this research project combines thermally sprayed coatings functionalized with a sol-gel layer providing low wettability/sticking.
FeCrAl alloy based thermally sprayed coatings including targeted hard materials, such as Cr-carbides, are investigated to evaluate their potential for corrosion and erosion protection.
The thin sol-gel layer, in combination with the thermally sprayed coatings, should reduce the sticking ability of aggressive liquid phases or solid flue ash particles.



Materials and Methods

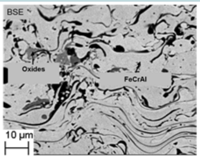
Coating process

Thermal spray coatings:

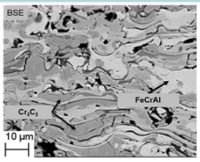
- Method: Arc Plasma Spray
  - FeCrAl
  - FeCrAl + embeded Cr_3C_2

Sol-Gel overlayer coating

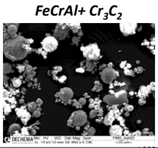
- Method: dip coating
- Composition: ZrO_2



FeCrAl



FeCrAl+ Cr_3C_2



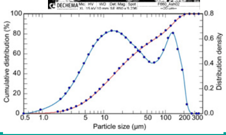
Flue ash particles

Flue Ash Analysis

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	SO_3	other
37	12.4	2.3	32.7	7.7	1	6.4	0.5

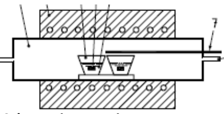
Ref.: RWE Power AG

- Sulphates, silicates, and oxides
- More than 80% of the flue ash particles are smaller than 10 µm.

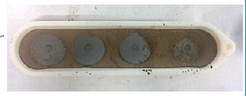


Corrosion Test

Method: ISO 17248:2015
Embedding test under flue ash
T= 650°C
synthetic air

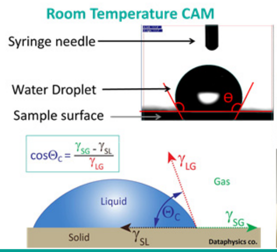


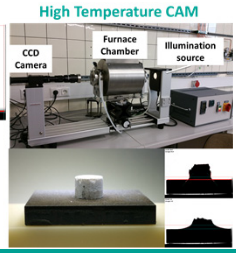
Schematic corrosion test set up



Corrosion specimens before being fully embedded in the ash

Contact angle measurement

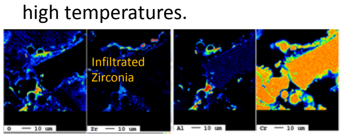


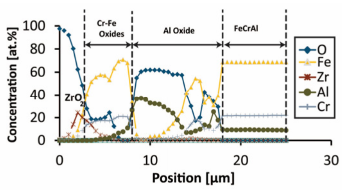


Results

Coating Structure

- The final coating structure is a zirconia infiltrated FeCrAl.
- Protective Al_2O_3 layer forms upon oxidation at high temperatures.

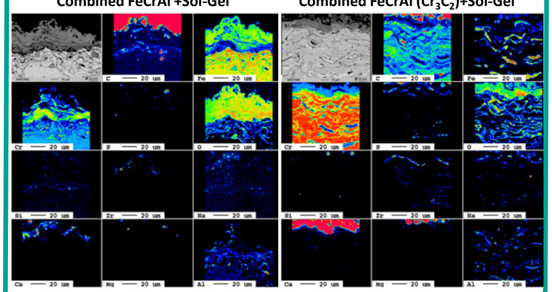




Corrosion behavior:

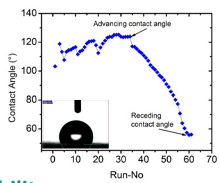
Cross section microstructures after 300h embedding in flue ash at 650°C.

Combined FeCrAl +Sol-Gel | **Combined FeCrAl (Cr_3C_2)+Sol-Gel**



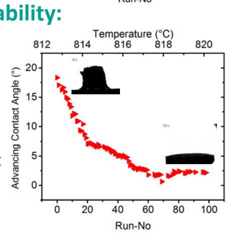
Room Temperature Wettability:

- Dynamic contact angle measurements reveal maximum contact angle of water droplet (124°) on the coating surface showing its hydrophobic nature at room temperature.



High Temperature Wettability:

- However, contact angle measurements at high temperatures with a simulated salt mixture ($CaSO_4$, K_2SO_4 and Na_2SO_4) show a much smaller contact angle indicating high wettability of the molten salt on the coating!



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Partners

Fraunhofer UMSICHT
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