Anti-Adhesive Coatings for High Temperature Applications

A. Soleimani Dorcheh, M. C. Galetz, M. Schütze

Email: soleimani@dechema.de
Funded by: AiF
Period: 01.10.2014-01.03.2017

Challenge

- Adhesion (sticking, caking) of Flue Ash Particles
- Lower heat transfer in heat exchangers
- Unplanned shutdowns
- Increasing Costs
- Corrosion
- Erosion

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 heat 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.

Motivation

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 + embedded Cr3C2
- Sol-Gel overlayer coating:
  - Method: dip coating
  - Composition: ZrO2

Flue Ash Analysis

<table>
<thead>
<tr>
<th>SiO2</th>
<th>Fe2O3</th>
<th>Al2O3</th>
<th>CaO</th>
<th>MgO</th>
<th>Na2O</th>
<th>SO3</th>
<th>other</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>12.4</td>
<td>2.3</td>
<td>32.7</td>
<td>7.7</td>
<td>1</td>
<td>6.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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

Corrosion Test:
- Embedding test under flue ash
- T= 650°C
- synthetic air

Contact angle measurement

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

High Temperature Wettability:
- However, contact angle measurements at high temperatures with a simulated salt mixture (CaSO4, K2SO4 and Na2SO4) show a much smaller contact angle indicating high wettability of the molten salt on the coating!

Results

Coating Structure:
- The final coating structure is a zirconia infiltrated FeCrAl.
- Protective Al2O3 layer forms upon oxidation at high temperatures.

Corrosion behavior:
- Cross section microstructures after 300h embedding in flue ash at 650°C.

Acknowledgement

Financial support of the German Ministry of Economics and Technology through the German Federation for Industrial Research ("Arbeitskreis industrieller Forschungs-vereinigungen", IGF-Nr. 126EN/2) is gratefully acknowledged.

Partners

- Fraunhofer UMSICHT
- MateriaNova