DECHEMA FORSCHUNGSINSTITUT

High Temperature Materials

On-site slurry coatings for aggressive high temperature environments

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Funded by: BMWi via AiF
Period: 01.01.2014 - 31.12.2016

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

Motivation

Al source particles are deposited via slurry onto steels in order to produce an inter-metallic aluminide coating after heat treatment, which protects the substrate from corrosion at high temperature.

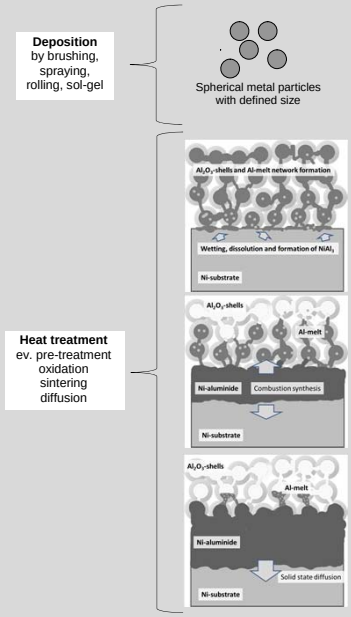


Figure 1: Steps for the application of slurry-based aluminium coating.

Slurry coatings are applied by spraying, painting, or dipping (Figure 2). While industrial slurries contain toxic chromates and phosphates, in this project the slurry is dissolved in a environmentally friendly water-based solution.

Figure 2: Photo of slurry application on a compound

The heat treatment of a slurry-coated component in industrial processes has usually to be performed in inert atmospheres in a closed furnace (Figure 3).

Figure 3: Industrial heat treatment of a component.

In this project slurry coatings applied by surface heat treatments are developed, using an induction furnace (Figure 4a), a burner flame (Figure 4b), or a heating mat. Thus components can by coated locally, which minimizes the heat-affected zone of the component.

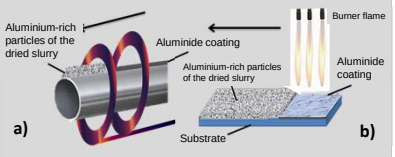
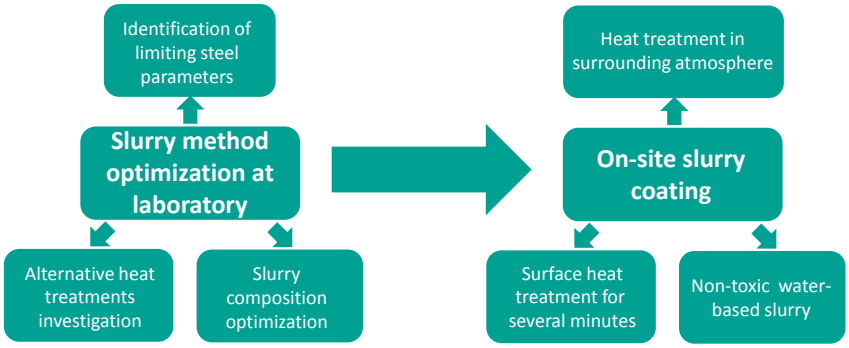


Figure 4: Schematic of heat treatment via a) induction furnace and b) burner flame.

Approach

The goal of this project is the optimization of the industrial slurry coating process by developing a slurry coating which combines a non-toxic water-based slurry with a surface heat treatment in air.



Results

Aluminium (Al) coatings are developed on P91 (Fe, 9%Cr), Alloy 800 (Fe, 32%Ni, 21%Cr), and Alloy 602 (Ni, 25%Cr, 9%Fe, 2%Al) by Al slurries, which consist of several Al powders or Al powder mixtures. The heat treatment time is 5 minutes.

Heating methods

Depending on the shape, size, and application of components different heating methods for the coating manufacturing are needed. All tested methods lead to comparable coating thicknesses and quality. Higher temperatures result in an increase of the coating thickness.

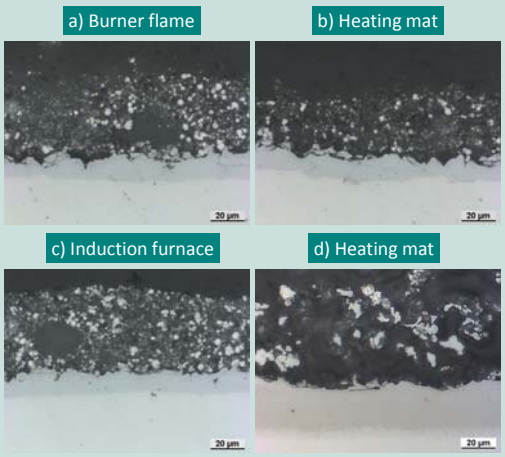


Figure 5: Alloy 800 aluminized with different heating methods at 700°C (a-c) and 1000°C (d) in air.

Coating elements co-deposition

In order to improve the Al coatings, elements can be added to the Al powder to adjust the coatings for different corrosive high temperature environments. Ni, Co, Cr, and Si have been introduced into the coating.

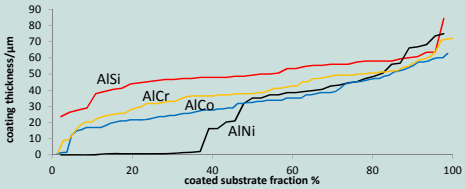


Figure 6: Coating thickness co-diffusion aluminides deposited onto IN 602 by induction heat treatment in air at 1000°C

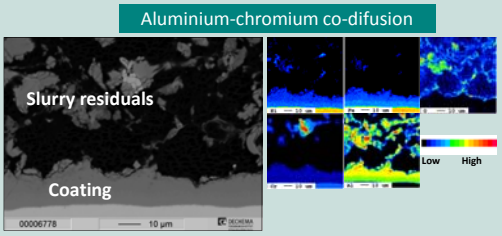


Figure 7: AlCr-coated IN 602 cross-section after induction heat treatment in air at 1000°C

Influence of steel composition

Alloy	Ni	Cr	Fe	Al
IN 602	bal.	25	9.5	2.1
IN 800	32.5	21	39.5	0.4
P91	<0.4	9	bal.	<0.04

Al-based slurry (with or without co-deposition) is applied on P91, IN 800, and IN 602 and heat treated by induction heating between 700 and 1000°C.

- Ni-based steels show thicker and more homogeneous coatings
- Coatings manufacture improves when Ni is present in steels composition

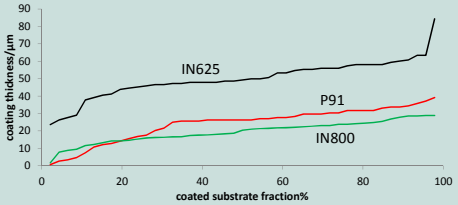


Figure 8: Coating thickness siliccon-aluminides deposited onto IN 602 by induction heat treatment in air at 1000°C

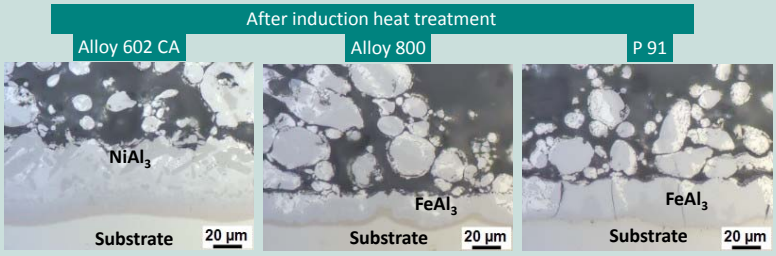


Fig. 9: Different substrates coated with Al-Si slurry after heat treatment by induction at 1000°C in air.