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The influence of sandblasting on the morphology of electroless deposited zinclayers on aluminum sheets

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ABSTRACT

The studies of sandblasting and the subsequent zincate treatment of Al99.5 sheets indicate that sandblasting is necessary to achieve a homogeneous coverage of the surface. Untreated and coated aluminum sheets of industrial origin exhibit poor coverage degrees of about 75%. To enhance the coating quality, two different grain sizes of SiC powder are applied in the sandblasting process. F 320 and F 80 blasting grits are used in the pretreatment procedure and the application of both results in higher degrees of coating up to 85% and 82%, respectively. Furthermore, blasting pressures in the range of 1–4 bar are used to create a rough but also uniform surface morphology. It is shown that a blasting pressure of 2 bar is an acceptable parameter to pretreat Al99.5 sheets. The investigations indicate that fine grain sizes such as F320 and an average blasting pressure of 2 bar form a successful parameter set for the pretreatment prior to the zincate process. In addition the evolution of zinc coatings on the basis of the zincate treatment is discussed within the parameter study.

1. Introduction

Due to its high affinity to oxygen [1] aluminum is instantly covered with an oxide layer at standard conditions. The zincate treatment is a useful process to remove oxide layers from the aluminum surface and protect it from repeated oxidation. Simultaneously to the dissolution of the aluminum oxide a thin zinc layer is deposited, which is capable of acting as an intermediate layer between the aluminum substrate and the electroplated metal, for instance nickel [2]. The zinc layer improves the adhesion of the electroplated metal film [3].

Motives for coating aluminum surfaces with zinc are to enhance optics and to minimize corrosion [4]. The application of the zincate pretreatment does not only result in high-quality coatings by dissolving oxides, but also provides the possibility of improving the corrosion resistance of aluminum, especially against sodium hydroxide [5].

Further possible applications can be found in the field of aluminum-compound casting [6], which aims at bonding a solid inlay and a casting alloy by forming intermetallic phases and diffusion zones. The substrate material of the inlay is utilized to place piezoelectric modules upon them and to incorporate the created insert into aluminum castings. To guarantee high efficiency of the integrated device, the support structure has to be firmly attached to the casting matrix. A sound intermetallic interface can ensure the mechanical stability of the composite structure, but the oxide layer acts as barrier and prevents the formation of metal bonding. Thus, providing oxide-free surfaces is a main goal in order to achieve high-quality metal–metal bonding [7].

As homogeneous coatings are the main aim of this study, the surface morphology prior to the zinc coating process is of utmost importance.

Hence, the present study focuses on the aspect of pretreatment by means of sandblasting and its influence on the subsequent zincate treatment of aluminum sheets.

2. Material and methods

2.1. Substrate material

The experiments are performed with aluminum sheets, which are cut to obtain dimensions of 100 mm × 30 mm. Aluminum sheets (EN AW-1050A (Al99.5), see Table 1) are rolled to reach a thickness of 1 mm and annealed at 320–350 °C for 0.5–2.0 h.

2.2. Preparation of sheet plates

Prior to the coating process, dirt and oils have to be removed from the aluminum surface. The industrial cleaner Curatech (Arnsperger Inc.: 6.0% Curatech TN249, 0.4% Curatech TN400, stirred for 6 min at 50 °C) is used to perform this cleaning-step.

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Table 1
Composition (wt%) of EN AW-1050A aluminum alloy.

min.	max. or range							
Al	Si	Fe	Cu	Mn	Mg	Zn	Ti	Other
99.50	0.25	0.40	0.05	0.05	0.05	0.07	0.05	0.03

Table 2
Material information – SiC blasting grit [13,14].

Grit labeling	d_{s3}-value max. (μm)	Median grain size d_{s50}-value (μm)	d_{s94}-value min. (μm)
F 80	212	–	150
F 320	74.1	35.3–39.1	17.1

After removing organic and loose inorganic material, the surface is roughened to eliminate surface defects and rolling texture. This is achieved by sandblasting the surface with a SiC grit of two grain sizes (Table 2) and at four different blasting pressures.

For the sandblasting process blasting pressures ranging from 1 to 4 bar are applied in one-bar steps. As reference, aluminum sheets not subjected to sandblasting are also coated with zinc. Subsequently, the sheets are cleaned in an ultrasonic acetone bath for 15 min, rinsed with deionized water and dehumidified using a dryer.

2.3. Zincate treatment

Following the roughening and homogenization of the surface, zinc coatings are created by immersing the sheets in a water-based zincate solution CNF11 (Schlötter), consisting of NaOH (25.0–50.0 wt%) and ZnO (5 wt%) is applied. The complete process sequence is illustrated in Fig. 1.

Fig. 1 shows a double zincate treatment process in detail. Prior to the coating steps, aluminum sheets are dipped into a cleaning bath to remove organic substances from the surface. The sheets are then sandblasted with a SiC grit of a defined particle size. In the following step, the oxide layer is removed by immersion in a 10% NaOH solution for 50 s at 55 °C. Afterwards the pickling deposit is eliminated from the surface by acid cleaning using a 40% HNO_3 solution for 50 s at room temperature. As the surface is free of oxides, primary zinc layers are generated by dipping the samples into a CNF11 zincate solution for 60 s at room temperature. Subsequently, the zincated aluminum sheets are etched in a 40% HNO_3 dipping bath for 50 s at room temperature to remove and reduce the first zinc crystals. In the second zincate immersion step (30 s), reduced crystals act as nucleation agents to decrease the size of zinc crystals as well as the dipping time in contrast to the first zincate step. To avoid contamination among the chemicals the aluminum sheets are rinsed with deionized water between each treatment step. The dipping baths are agitated with magnetic stirrers and as a final step a dryer is used to dehydrate the sheets.

2.4. Experimental analyses

Images with a secondary electron microscope (SEM) are taken to characterize the quality of the zinc coating. Furthermore SEM images are analyzed with ImageJ to determine the percentage of the coated area, which is possible due to the different gray scale values of deposited zinc and non-coated aluminum. Thus, an arithmetic average of surface coverage can be calculated to obtain suitable coating parameters.

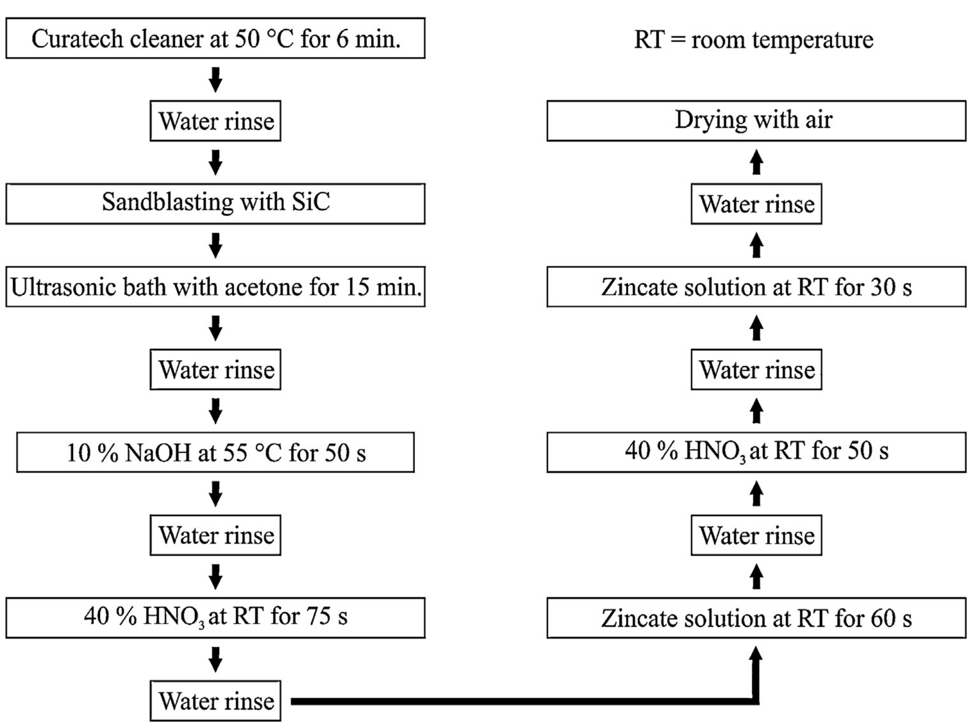

Fig. 1. Experimental zincating steps and parameters.