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Analysis of surface defects of aluminium components with hard anodized layers

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ABSTRACT

Final quality inspection regularly reveals surface defects on components after hard anodizing. The aim of the analysis was to identify the cause of the defects and unambiguously determine whether the defect is caused by the quality of the base material, manufacturing technology of the component, the heat treatment or by the final surface treatment technology (anodizing). Analysis of the chemical composition and hardness measurements were performed to eliminate the possibility of any errors during material selection and heat treatment process. The capillary test revealed two major defects and also small amount of minor defects. To determine cause of the defects, light and scanning electron microscopy including EDS chemical microanalysis was used. Detailed study of the major defect and EDS microanalysis of its interior confirmed existence of defect prior to coating formation. Further examination of the major defect and its surroundings led to conclusion, that the defect was formed during primary foundry processes when billet was manufactured.

1. Introduction

A company involved in the manufacture of air systems approached us with the requirement for an analysis of surface defects of two "STATOR SCROLL" final components. The customer required a detailed analysis of defects, with a precise specification of the origin of their appearance. The subject of the analysis was to establish whether the cause of the cracks was a defect in the initial billet or whether the cracks appeared in the course of the machining processes or in the subsequent surface finish of the components, using anodic oxidation.

Part of the submitted component is shown in Fig. 1, inclusive of the defect identified by the customer.

For the purposes of complex analysis, the customer attached all the drawing documentation of the components, for both the initial billet and the final product.

Anodizing is a process of surface treatment of aluminium and its alloys which uses its natural tendency to oxidation. The reason for the production of oxide layer (ca. 150 μm) is to increase resistance to corrosion and abrasion, improve adhesion and also to dye the surface layer and produce not only hard but also coloured layers [1–5].

In industrial practice, the process of anodic oxidation is divided into two basic types.

(i) Decorative anodic oxidation, which focuses on improving the appearance of the base surface material and slightly increasing its corrosion resistance. By contrast, (ii) hard anodic oxidation of aluminium and its alloys is performed to ensure the functional properties of the surface of component parts (increased corrosion resistance, hardness, abrasion resistance, etc.) [6–8].

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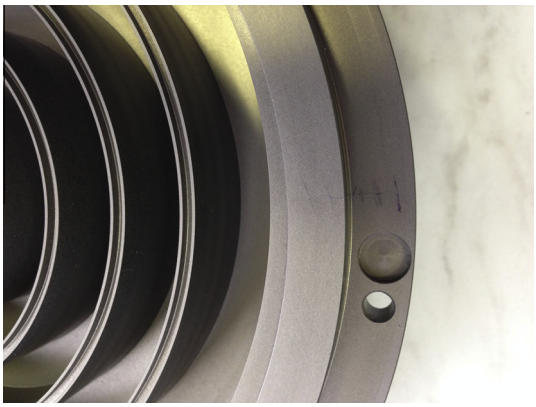

Fig. 1. Component of "STATOR SCROLL".

2. Preparation of specimens and experimental technique

To analyse the surface defects, the non-destructive capillary test was applied, which was carried out in compliance with the CSN EN 571-1 Standard. The PFINDER 890 cleaner, PFINDER 800 colour contrast penetrant and PFINDER 870 developer were used to make the defects clearly visible.

The chemical analysis was performed on a SPECTRUMAT GDS 750 glow-discharge optical emission spectrometer (GDOES) made by LECO.

The hardness of the specimen was measured by the BrinellHBW 5/250 method, CSN EN ISO 6506-1 Standard, using a HBE300 (LECO) digital hardness tester, and evaluated using an SZ61-TR stereomicroscope and the QuickPHOTOINDUSTRIAL 2.2 (Olympus) program.

Metallographic specimens were prepared using the usual techniques – wet grinding and diamond paste polishing. The final mechanical–chemical polishing was performed using the OP-Chem suspension (Struers). After etching with the Keller's Reagent etchant, the specimens were observed on an Olympus GX71 metallographic light microscope and documented with a DP 11 digital camera, using the 10×, 20×, and 500× objectives (corresponding to magnifications of 100×, 200× and 500×).

To study the fracture surface, the specimen was prepared by fracturing a segment cut out from the component (see Fig. 2). Detailed analyses of the fracture surface and of the metallographic specimen were carried out on a PHILIPS XL30 scanning electron microscope, which was also used to conduct local surface analyses using the EDAX energy dispersive X-ray analyser.

3. Results of analyses and discussion

3.1. Capillary test

The result of a capillary test conducted on one of the components is shown in Fig. 3. The capillary test detected in full extent the defects that had been marked by the customer and revealed defects that extended over almost the whole thickness of the product. Apart from the defects mentioned, the capillary test also revealed a lesser amount of surface defects of the type of pores.

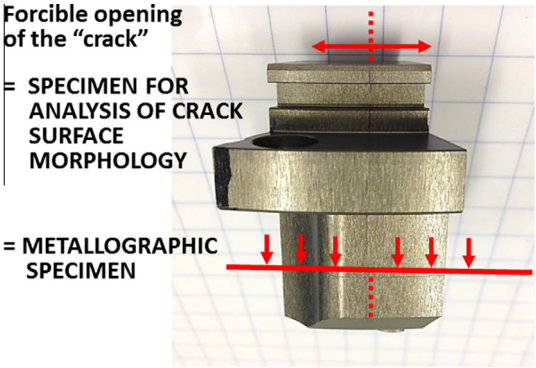

Fig. 2. Schematic of specimen acquisition for analysing the crack morphology and for metallographic analysis.