PRESS RELEASE

New coating systems by AHC Oberflächentechnik protects aluminium-cast alloys from corrosion

Aluminium materials with a particularly high content of silicon can be treated for corrosion resistance only in very limited ways. Conventional anodic coatings can only partially cover this demand due to the inherent silicon structures of the surfaces in question. AHC Oberflächentechnik GmbH based in Kerpen has developed two new coating systems that offer more possibilities for corrosion-resistant functional aluminium surfaces, especially cast alloys. These systems are a combination coating of hard anodic oxidation plus PFA and a PFA double layer marketed under the name GLISS-COAT®. Components coated using these systems have performed outstandingly in corrosion tests, especially according to the standard VDA 230-214. Applications can be found where aluminium components are subjected to an acidic attack.

Hard anodic oxidation has been an established corrosion and wear protection for aluminium alloys for decades. AHC Oberflächentechnik offers this process under the trademark name HART-COAT®. The layer is formed by anodic oxidation in a cooled acid-electrolytic solution, in which the surface of the base aluminium material is converted into aluminium oxide. In this process, the oxide layer uniformly increases inwardly and outwardly, resulting in a defined dimensional change of the component. The excellent atomic bonding to the base material from which the layer is originated is of particular interest here.

PFA (perfluoralkoxyalcane) is a co-polymer made of two thermoplastic polymers and an advancement of the common PTFE (polytetrafluoroethylene). The continuous operating temperature is 260 °C and PFA possesses outstanding properties of chemical resistance. For these reasons, PFA finds typical application as a construction material in chemical apparatus engineering (e.g. heat exchange linings and housing linings). As opposed to PTFE, PFA can be processed thermoplastically. Thanks to the high fluidity of the molten mass, the plastic can be applied and spread homogeneously on surfaces in an injection process.

The novel aspect is the combination of a HART-COAT® layer and a PFA layer (Figure 1) and a so-called PFA double coat (Figure 2).

A suitable pre-treatment and process control ensure excellent bonding of the PFA to the HART-COAT® layer (Figure 1). The porous structure of the HART-COAT® undercoat offers the PFA topcoat an outstanding adherent surface, as well as a distinct and mechanically sustainable foundation for corresponding load profiles. The PFA double coat (Figure 2) bonds very well to the mechanically pre-treated base material and is also well interwoven. A dividing line between the two PFA layers can no longer be identified on the micrograph. The coating is therefore compact and overlapping.

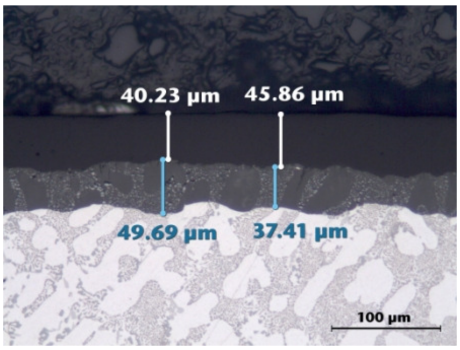

Fig. 1: Micrograph of a HART-COAT®-PFA layer

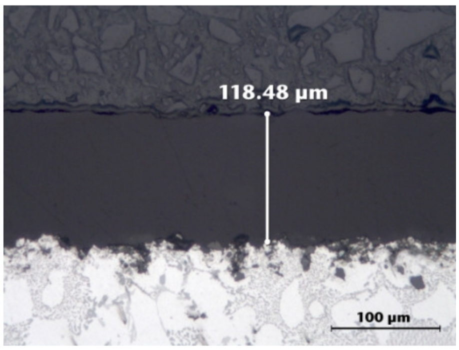

Fig. 2: Micrograph of a PFA-PFA layer

Many kinds of aluminium components coated in this way were subjected to corrosion tests according to VDA 230-214. This standard by the automobile association VDA (Verband der Automobilindustrie e.V.) regulates the resistance test of metallic materials to condensate corrosion in exhaust components. The materials were tested for resistance by subjection to a synthetic condensate K 1.1 (PFA-PFA layer) and K 1.2 (HART-COAT®-PFA layer) and alternating with a thermal load at 200 °C, in which the samples were weathered in an oven one time per week for five hours. The test alternated in cycles of one day and one week:

- Temperature load: 200°C / weekly for 5h and documentation
- Alternating corrosion load 6 days per week with cyclic repeating phases:

  - Partial dipping: 6h / daily

  - Drying: 2h at approx. 90 °C / daily

  - Steam phase: 16h / daily

During the test, the condensate temperature was 50 °C. The pH value of the condensate was checked daily to ensure that there were no changes in the composition of condensate, and the test medium was changed weekly.

The following table shows the compositions of the test condensate.

<table>
<tr><th>Test condensate</th><th colspan="3">Composition of the test condensate</th></tr>
<tr><td>K 1.1</td><td rowspan="2">aggressive system, pH = 1.2</td><td rowspan="2">mineral acids as basis (same pH levels)
• 3.4 ml nitric acid 65% p.A. and
• 1.4 ml sulphuric acid 95-97% p.A.
Dissolve in approx. 500 ml H_2O (dem.), add appropriate amount of NaCl and fill to 1000 ml with H_2O (dem.).</td><td>Additive:
16.5 mg NaCl (= 10 mg/l chloride)</td></tr>
<tr><td>K 1.2</td><td>Additive:
1650 mg NaCl (= 1000 mg/l chloride)</td></tr>
</table>

Table 1: Composition of the test condensate (according to VDA 230-214) that was used for the corrosion tests on the test pieces coated by AHC.

The entire test duration under aggressive conditions was an amazing six (!) weeks. Those are test conditions that not even stainless steel can withstand undamaged.

There was no attack of any kind of corrosion on the smooth surfaces of the PFA-PFA coated components after the test with the condensate K 1.1. Small bubbles formed at the front sides and at places that appeared somewhat rough. However, these locations are generally not functional surfaces and are covered or overlaid by other components. The outstanding corrosion resistance of the PFA-PFA double coat also proved itself in the Kesternichtest according to DIN EN ISO 6988. There was no visible corrosion on the inner and outer surfaces of the components after 4 cycles (0.2 l SO_2) (quality degree Rp10 = no flaws).

The HART-COAT®-PFA coated components displayed similarly positive results after the six-week test with the test condensate. At the end of the test, there were only a few pores found on the smooth surfaces. A somewhat stronger corrosion attack occurred on the non-functional surfaces, e.g. in drilled holes. There was no detected corrosion on the smooth surfaces following 453 hours of the neutral salt spray test according to DIN EN ISO 9227. There were only a few small points detected in the drilled holes and on the edges. Assessment: Rp 9 (flawed surface in %: $0 < A \leq 0.1$).

<u>Conclusion:</u> The coating systems HART-COAT®-PFA (GLISS-COAT® 2001-F-083) and PFA-PFA (GLISS-COAT® F495) are two processes for coating aluminium-cast parts to withstand the intense attack of acid in the form of steam and liquids over a sufficiently long period of time. They are therefore appropriate for example in coating exhaust components in automotive engines to protect from corrosion inside the engine itself. Furthermore, general applications are available for aluminium-cast parts in sectors where acidic condensation is found at application temperatures exceeding 200 °C: heating systems, air conditioning units, exhaust systems, steam pumps and

traps etc. Figure 3 shows that the coating systems possess very good hydrophobic properties as well.

Fig. 3: Aluminium-cast part: PFA-PFA coating (left) and HART-COAT®-PFA coating (right) The water-repellent property of the coatings is easily recognizable.

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