RESEARCH INTO THE DIRECT ADHESION OF PA66 TO STEEL USING STRUCTURED METAL SURFACE

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Abstract

By facilitating a structuring on the metal surface a direct adhesion of PA66 to steel or aluminum without the use of primers or other additional adhesive materials can be achieved. Experiments show that the structured surface gives a stable bond even in the presence of high stresses due to different thermal expansions.

1. Introduction

Polymer-metal-hybrid parts are of high interest because they can combine a high functional integration with a lower weight compared to pure metal parts. These qualities make them popular in the automotive industry. Traditionally the polymer is bonded to the metal part using some sort of form-closure like overmolding techniques or riveting methods. These methods have known setbacks like the diminished structural integrity at least on the metal side of the part. Additionally overmolding requires that both sides of the metal are accessible for the polymer. Another method is bonding using an adhesive which usually increases the processing time. Quite new is the use of primers, which are applied onto the metal surface some time before a direct molding onto the surface. The upshot with that method is that the metal only has to be accessible from one side. The method introduced here retains these benefits but avoids additional chemical agents for the adhesion.

1.1. Structuring the metal part

In the presented method the structuring of the metal side of the joint is crucial for the success of the bond. An example of a polished cross section of a structuring of a steel surface using a laser is shown in figure 1 prior to the joining to the polymer. Similar to bonding methods where a sufficient area has to be coated with the adhesive an adequate area of the metal has to be structured.

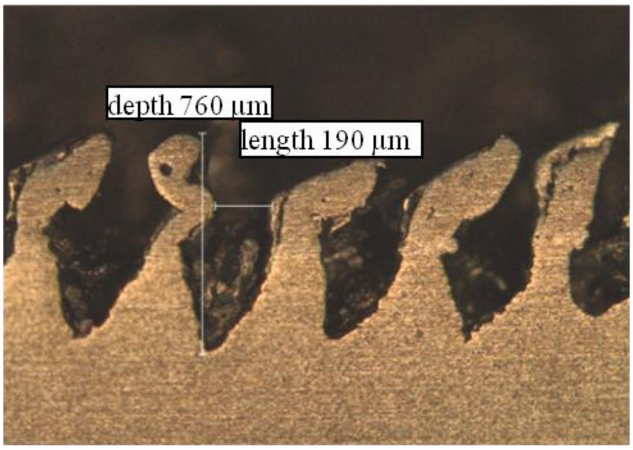

Figure 1. Polished cross-section of a structured steel surface.

The rough metal structure includes undercuts and provides an interlocking with the polymer.

2. Results

The joining method was tested on a range of test specimens with a T-joint using pull-off and shear loadings. Figure 2 shows a test specimen with 5 mm foot (joining width) in the test rig for pull-off tests. Tests with similar specimens using completely structured joining areas between polymer and metal with 2 mm and 16 mm feet width were also conducted.

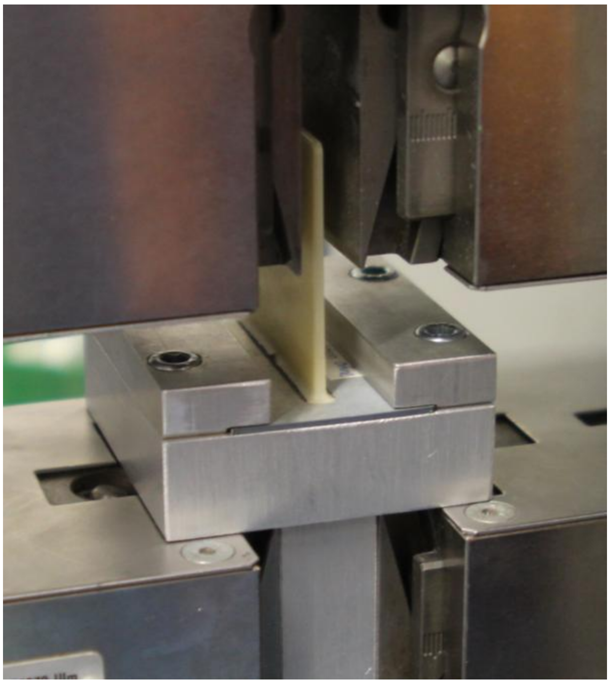

Figure 2. Test specimen with 5 mm foot in test rig for pull-off test.

Extensive tests with the material combination PA66GF50 and steel show strengths similar to bonding with adhesives. Furthermore, the bonding strength shows very good performance after preloading with temperature cycles or after a corrosion test. Although the metal surface is fully rusted the bonding strength between polymer and steel remains nearly undiminished because the form closure is still active. Figure 3 gives the results for the joint strength performance relative to the reference at 23°C after manufacturing. Unsurprisingly the joint strength at cold temperatures is best and at 100°C worst, a quality which can be clearly attributed to the behavior of polymers. This is also true for the results after simulating coating temperature load (30 min at 190°C) at all test temperatures as well as for pull-off tests after corrosion loading and even after cyclic temperature load (50 cycles between -40°C and +100°C ~ 3,2 weeks).

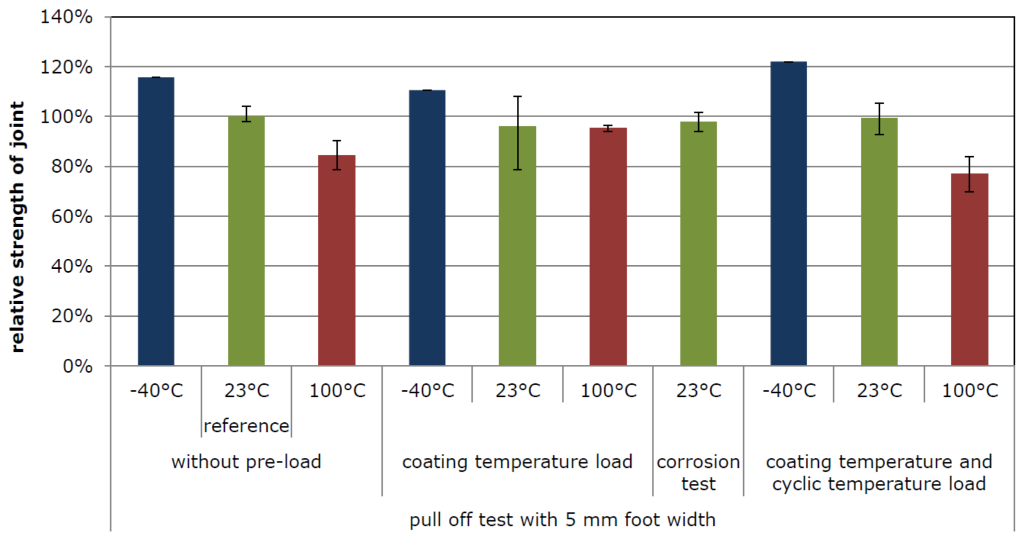

Figure 3. Influence of temperature and pre-loading on joint strength.

This excellent aging behavior after severe loading can be ascribed to the characteristics of the joint. Due to the structuring of the metal an interlocking of polymer and metal is achieved. The adhesion between different surfaces can be neglected for this kind of joint. As long as the structured metal surface and the polymer which fills the structure are not damaged the joint will stay safe.

This interlocking of polymer and metal is especially relevant for the very good results after cyclic temperature loading. The usually very high stresses in the boundary of a bond can be damped through the flexibility and the mobility of the polymer in the metal cavities. In this way damages to the polymer as well as to the metal are avoided and the load capacity at the end of the test is unimpaired.

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