PLASMA CLEANING TO REMOVE RELEASE AGENT FROM CFRP SURFACES

THE TASK

Carbon fiber-reinforced plastics (CFRP) are being used more and more in the aircraft and automotive industries thanks to their extraordinary material properties. To utilize their lightweight potential to the full extent, established joining technologies, such as riveting or screwing, have to be replaced by new adhesive bonding technologies tailored to the CFRP materials. Adhesive bonding technology is characterized by its simple feasibility and reduction of stress concentrations inside the component. Surface pre-treatment is the basis for successful adhesive bonding of the components. Pre-treatment of CFRP materials does not only address fine-cleaning but also the complete removal of release agent residuals due to fabrication.

To reduce manufacturing costs, the currently established removal of release agent residuals by manual grinding is to be replaced in the future by a plasma pre-treatment. The plasma technology must have a wide technological range in terms of the manufacturing distance, because large, complex and slightly shaped surfaces have to be treated.

OUR SOLUTION

For the removal of the release agent from CFRP surfaces, a specific linear arc plasma source (LARGE) with adaptable working width has been developed at Fraunhofer IWS Dresden. With the LARGE plasma source, Fraunhofer IWS provides a plasma technology for large surface applications at atmospheric pressure (Fig. 2). The plasma source generates a homogenous linear afterglow plasma sheet of maximal 350 mm length. The source works at atmospheric pressure making it very easy to integrate the system into existing process chains.

A special feature of the LARGE plasma source is that a variety of usable plasma gases and their mixtures, such as compressed air, Ar + O₂, N₂, CO₂, H₂, NH₃ etc., can be employed. This makes it possible to modify the plasma treatment intentionally for the CFRP surface to be treated.

Another advantage of the LARGE plasma source is its long torch length of up to 20 cm. Thus, even shaped components can be treated without great positioning efforts.

RESULTS

For the removal of release agents, representative CFRP samples were treated with the LARGE plasma technology. The working distance to the plasma source, the plasma gas composition, and the speed were optimized to achieve the maximal adhesive bond in the adhesive joint to be created subsequently. Both liquid release agents (Marbocote) and release films (Super Release Blue) based on silicone were examined and tested.
The chemical composition of the CFRP surface was determined both before and after the plasma treatment by X-ray photo-electron spectroscopy (XPS). The bond strength of the adhesive joints was found by the pull off test according to DIN EN ISO 4624, as well as the G1C test (industrial aircraft standard). The reference samples were ground and cleaned with acetone afterwards. The XPS results show that the silicone content in the CFRP surface clearly decreases after the plasma treatment (Fig. 4). Due to the high plasma activity of the source, silicone-based release agent residuals are converted to silicates. These layers, which are similar to fused quartz, act as an additional bonding agent in the subsequent adhesive bonding process, thus enhancing the bond strength.

The pull-off tests to quantify the bond strength were performed on a Lumifrag centrifuge. The best bond strength was achieved at treatment distances of 40 mm and 60 mm. Even if the treatment distances are 80 mm, the bond strengths achieved were clearly higher than those of the reference samples (see Fig. 5).

The results of the G1C adhesion tests confirmed the findings of the pull off tests. In comparison with the reference sample, here clearly higher G1C energies for processing distances from 4 cm to 8 cm were obtained (Fig. 5).

In addition to the adhesive energies, the fracture surfaces of the adhesive joints according to DIN EN ISO 4624 were examined. In all the samples, either a cohesive failure in the adhesive or inside the matrix material was found.