For ensuring a homogeneous paint gradient and strong, long-time stable adhesion of the paint, the polyamide shells of a design key are pretreated with atmospheric plasma

With Plasma Ready For Series Production

Coating. Until just recently it was not possible to give glass-fiber reinforced plastic materials a wafer-thin and yet strongly adhering, transparent coating of high-gloss paint. Through the use of atmospheric pressure plasma, a plastic finisher managed to coat the design product of an automotive manufacturer with a high-gloss hardcoat paint in a durable and impact-resistant manner.

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If additive-free plastic materials cannot or only poorly be bonded or coated in spite of a clean surface, this is most probably due to their low polarity and the resultant low surface energy (mJ/m²). Surface energy is the amount of energy required for breaking up chemical bonds when producing new material surfaces. It is the most important measure for assessing the probable adhesion of an adhesive layer, paint or coating. In general, plastic materials have a low surface energy, usually between < 28 mJ/m² and 40 mJ/m². Experience, however, has shown that good prerequisites for adhesion are first achieved with surface energies greater than 38-42 mJ/m².

Secure adhesion of a coating is conditional on the surface energy of the solid material being higher than the surface tension (mN/m) of the liquid adhesive or paint. There are several methods for increasing the surface energy, the most frequent one still being the use of solvent-containing and thus environmentally harmful substances. One method that completely substitutes wet chemicals in the pretreatment process is the Openair plasma nozzle technology which was developed by Plasmatreat GmbH, Steinhagen, as early as in 1995. This technology works under normal ambient air conditions. Trials at Plasmatreat have demonstrated that surface energy values of over 72 mJ/m^2 are achievable when pretreating plastic materials with Openair plasma. The result: Not only previously incompatible substrates can be bonded but also adhesion of water-based adhesive or paint systems on very adhesive-resistant sur-

With a perfect paint appearance: The finished design key presents itself with a deep black, high-gloss optical effect

faces thereby becomes possible.

Since 2007, the atmospheric plasma process that is employed all around the globe, has also been in use by GfO, Gesellschaft für Oberflächentechnik AG, a subsidiary of the Nanogate Technologies Group located in the state of Saarland. This is where hundred thousands of display front panels a year are being treated with plasma prior to coating (see ***Kunststoffe***, edition 3/2009, page 108). It's only very recently that GfO has started employing this plasma technique also for a product that has never been manufactured in this form before.

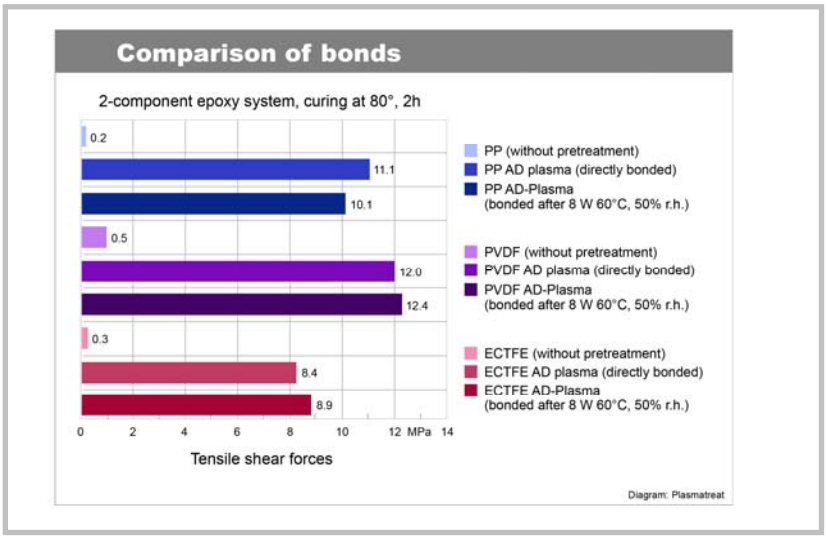
Stringent requirements

The requirements were high. In 2009 the automotive manufacturer Volkswagen was seeking a never-seen-before optical surface effect for its new design car key. The paint which was supposed to be a deep black and, at the same time, transparent and high-glossy, had to provide the best scratch and impact resistance the world market could offer. A perfect paint appearance and long-time stable adhesion were given topmost priority. The order for this world debut was awarded to one of the internationally leading specialists in the field of plastic finishing, the GfO located in Schwäbisch Gmünd. For this company the order meant 'making the impossible possible' and all that within a timeframe of six months only. Thereafter, readiness for series production had to be ensured.

The part on the left shows the pretreatment of the PA key bottom shell with Openair plasma. The part on the right is the same part after application of the transparent scratch-resistant coating (Photos: Plasmatreat)

New injection molding solution

At first glance, the material of the delivered raw products, namely the unpainted top and bottom shells of the key, does not appear to be unusual: a polyamide PA 66 GF30 (reinforced by a 30% glass fiber portion). This was the material that had been chosen in order to meet the high impact strength requirements including, among others, the successful passing of drop and fracture tests. There was also the requirement that the extended key bit had to be unable to break out of the shells at some specific load. The developers were quite aware that glass fiber is actually not suited for high-gloss coating - and certainly not by applying a 1-component nano paint system in the 10µm range which is the maximum film thickness of the paint to be applied by GfO. As Norbert Weiss, Sales Manager at GfO, comments: "It happens that glass fibers "are standing up" in the injection molding process and make their way up to the paint finish. The consequences are pimple-like irregularities and immediate scrapping." In order to enable painting of the key shells according to specification against all odds, a decision was made to change the plastic manufacturing process. Instead of using the conventional injection molding method and the usual grain on the key surface for concealing



Example of the long-time effect of the Openair plasma activation on various plastic materials

irregularities, the shells were produced by applying a MuCell injection molding process which is a physical foaming process for thermoplasts. With the aid of this process, not only a perfect reproduction of the mold surface could be realized but the usual sink marks and irregularities could be avoided as well. But even here a problem arose: The foaming process left visible streaks on the workpiece, and the surface, after injection molding, was anthracite rather than deep black in color.

The challenge

Now it was up to the plastic finishing company to demonstrate its skills. It was obvious to GfO that two proven methods could be relied on: Firstly, there was their own Sicralan inkjet process, a worldwide unique and patented 1-component nano paint system for selective, transparent and high-gloss scratch-resistant coating. Secondly, there was the process-secure, fully trusted Openair plasma technique for ensuring a 100% homogeneous paint gradient and strong, long-time stable adhesion. The test catalogs of automotive manufacturers contain a plethora of test specifications such as climatic change tests, hydrolysis tests, media, acid and cream tests, and many others more. Decisive for the adhesion are the adhesive strength tests such as the well-known cross-cut test. But over and above all these tests, Volkswagen demanded yet another specific test: the highly abrasive drum test.

Adhesion through plasma activation

Without the high degree of activation received by the polyamide in the plasma process, wetting problems would arise and make coating impossible. Dr. Alexander Knospe, Head of Development at Plasmatreat, explains the chemical processes: "Plasma pretreatment strongly increases the surface energy of the plastic material since polar groups, such as hydroxyl functions, are formed on the surface. In this application, not only complete surface wetting with a given paint or adhesive is improved, but also the creation of a covalent bond, which is a very stable atomic bond, is made possible on the surface". The results are homogeneous paint gradients and long-time stable adhesion of the scratch-resistant coating even under highest stresses. By the way, the typical rise in temperature of a plastic surface during treatment is less than 30°C.

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Conclusion

The results of the test series confirmed the trust placed in the high-tech technologies: A quick steel wool test could do no harm to the Sicralan MRL UV high-performance surface.

Another difficulty, namely stopping the pressure of the scratch-resistant coating in a descending radius - unmasked in a design joint - was also mastered.

Thanks to the plasma pretreatment, the cross-cut test was passed with the best possible value Gt0 (no adhesion pull-off), and even when exposed to the drum test, the coating would not separate. The other tests provided an equally positive result. The streaks had disappeared, the surface was immaculate, deep black in color, and high glossy. The world's first radio car key with this optical effect and of this quality, destined for the Phaeton car model, could go into production in time. ■

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