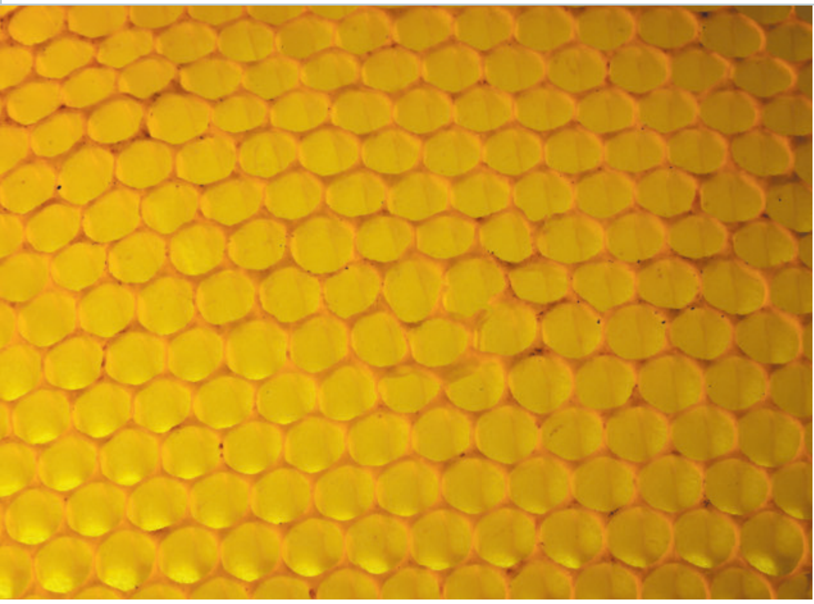

The natural and masterful structure of a honeycomb serves industry as a model for the core layer in sandwich panels (photo: Plasmatreat)

Cold Plasma Opens Up New Dimensions

Lightweight Construction. In Thueringen, Germany, a manufacturer of sandwich panels celebrated a world premier. A new technique makes it possible to treat large lightweight sandwich panels with potential-free atmospheric plasma in a continuous process.

INÈS A. MELAMIES

Conservation of resources and energy efficiency must be counted among the most important strategies for the future today. Achieving these objectives requires new approaches, the models for which can often be found in nature. Plant haulms and honeycombs, for example, have a special structure that is unique in terms of strength and the amount of material required, while simultaneously achieving minimal weight. What is more obvious than making use of "nature's patents" for industrial applications?

Nature as Model

When producing plastic panels, bionics has served as a model since their initial development: honeycombs served as a model from biology (Title photo), chemistry contributed with the material polypropylene (PP). Honeycomb panels are finding increasing use as the core for lightweight sandwich panels, since they are water-resistant and very rigid. The most important property, however, is without a doubt their light weight.

Reducing weight is especially important when it comes to building trucks, since the reduced fuel consumption lowers CO_2 emissions over the entire lifetime of the vehicle. At the same time, vehicle wear is reduced and load capacity is increased. In addition, even at the end of a truck's service life this material provides benefits, because of the recyclability of the panels.

Plasma technology uses a different natural phenomenon in the form of technical plasmas generated in imitation of natural discharges in the atmosphere. With the invention of Openair potential-free atmospheric plasma technology in 1995, the German company Plasmatreat was able to use plasma nozzles to exploit what was an almost never used state of matter for industrial production processes inline and in a normal atmosphere. The technology, which is used worldwide today, is characterized by three features: it activates surfaces through controlled oxidation processes, discharges them at the same time and provides environmentally friendly, extremely fine cleaning that usually can replace chemical precleaning processes completely. The typical temperature increase when treating plastic surfaces is $\Delta T < 20\,°C$.

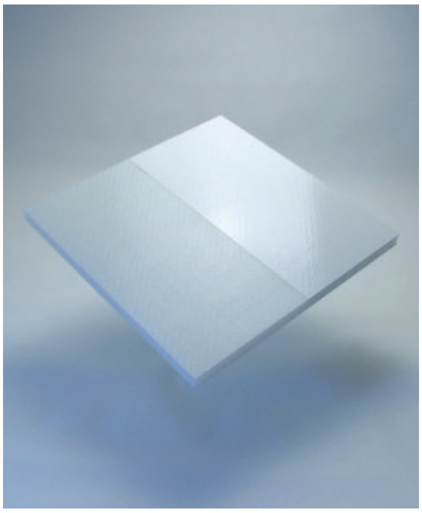

Fig. 1. Comparison of MonoPan panel unpainted (on the left) and painted (on the right). To increase adhesion of the paint to the glass fiber-reinforced polypropylene facing, the facing is pretreated with the Openair plasma process, which increases its surface energy severalfold (photo: Wihag Composites)

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Lightweight PP Panels for Motor Vehicles

Wihag Composites, Rottenbach, Germany, specializes in production of PP honeycomb panels for special containers and rooftop carriers for automobiles. The newly developed panels called MonoPan are manufactured in a continuous production process in sizes up to 13.60 m × 2.75 m in various thicknesses and may be painted in-line as an option (Fig. 1). They consist entirely of polypropylene and have – for the same stability – only a fraction of the weight of conventional sandwich panels. The interesting aspect: the honeycomb PP core in the MonoPan panels is welded to the glass fiber-reinforced PP facings by means of a proprietary process. Delamination is impossible.

The Requirements

New panel technology can be used to its full potential, however, only when components can be manufactured at low cost, used effectively and in an environmentally friendly manner in equal measure. Wihag Composites planned to build a new coating and production facility in 2007. Since good pretreatment is absolutely necessary to ensure long-term adhesion of paint on the nonpolar resins used, a pretreatment process had to be taken into consideration from the very start. To keep costs low during the early years of the company, the panels had been treated with a primer until now, i.e. using a wet chemical approach. At the same time, the plans for the new investments were supposed to ensure not only the required effectiveness but also an environmentally friendly solution. On the basis part geometry and required production rate, various other pretreatment processes were eliminated early on; in contrast, the Openair plasma technology was on the evaluation list from the beginning.

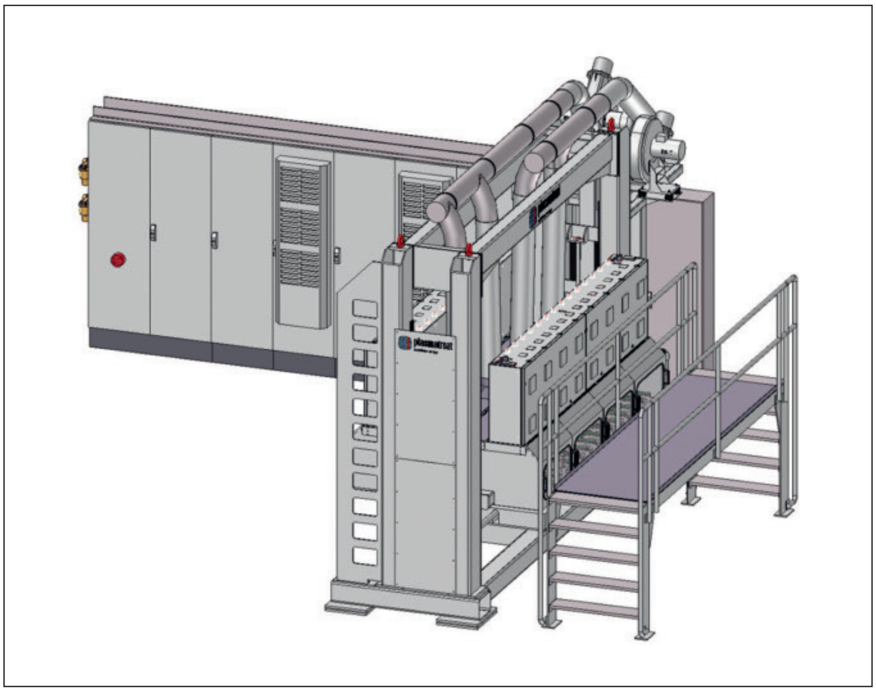

Fig. 3. The large-panel plasma treatment system consists of three major components: the generators (on the left), the pretreatment system (at the center) and a vertically adjustable maintenance platform (on the right). Because of the large area treated by the plasma, it will also be possible in the future to replace the core material in panels with lower-cost materials such as recycled plastics (graphic: Plasmatreat)

"We have been aware of the technology since 2002. In 2007, we took a look at the process once again" stated Dr. Stefan Maier, General Manager of Wihag Composites. Initial trials already demonstrated that plasma treatment represented an effective method for increasing the surface energy of nonpolar resins prior to painting, thus ensuring optimal paint adhesion. The laboratory tests with atmos-

Fig. 2. The newly developed rotary nozzle system from Plasmatreat can pretreat sandwich panels up to approx. 3 m wide at a speed of 25 m/min in a continuous production process (photo: Plasmatreat)

Surface Energy

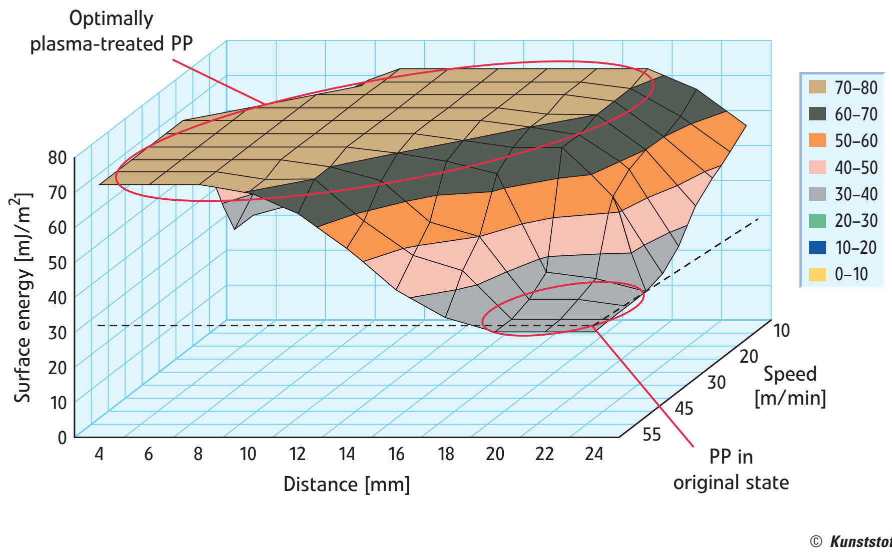

Fig. 4. The figure shows a plastic surface that was pretreated as a function of distance and speed with plasma. Treatment renders the surface polar and the surface tension rises to >72 mJ/m² with a large process window (photo: Plasmatreat)

pheric plasma lasted about one year. Then, the decision was made in favor of plasma technology, because of the positive results. Dr. Maier: "Moreover, this plasma technology simplifies in-line use while providing very high process reliability".

The Solution

The requirements included pretreatment of complicated geometries, a very high production rate and, of course, reliable adhesion of the coating – Plasmatreat promised to satisfy these requirements with a new plasma system.

For extremely fine cleaning and activation of the surfaces on large lightweight composite panels, Plasmatreat developed a new industrial-scale rotating nozzle technology that is capable of pretreating a width of up to approx. 3 m at a processing speed of 25 m/min in-line during continuous production (Figs. 2+3).

The primary objective of treating plastic surfaces is surface activation, i.e. increasing the surface energy. This is the most important measure for assessing the probable adhesion of a coating or adhesive layer. In general, plastics have a low surface energy, usually between 28 mJ/m² and 40 mJ/m². Experience has shown that good prerequisites for adhesion are first achieved at 38–42 mJ/m². With a plasma treatment, i.e. high-energy activation of the material's surface, however, the surface energy can be increased significantly. Trials at Plasmatreat demonstrated that with most resins values of over 72 mJ/m² were possible (Fig. 4). The consequence: it is possible not only to bond previously incompatible substrates. Adhesion of water-based adhesive or paint systems on very plastic-unfriendly surfaces such as non-polar resins becomes possible in most cases.

The large-panel plasma treatment system was designed with two rows of adjacent plasma nozzles in a way that permits pretreatment of panels with maximum width (Fig. 5). The entire system is first adjusted to the height at which the panels are to be treated. The panels are transported through the pretreatment system on a vacuum conveyor belt, with the ability to adjust precisely for height differences of 1 mm in the plasma system. The system detects the width of the panels to be pretreated automatically and enables only the appropriate plasma nozzles for the current application. The entire system has been designed to be service friendly by allowing the plasma nozzles to be adjusted ▶

Fig. 5. The new in-line plasma panel treatment system from Plasmatreat was designed to treat large widths at a high throughput rate: 28 rotary nozzles ensure a high degree of activation of the plastic surface (photo: Plasmatreat)

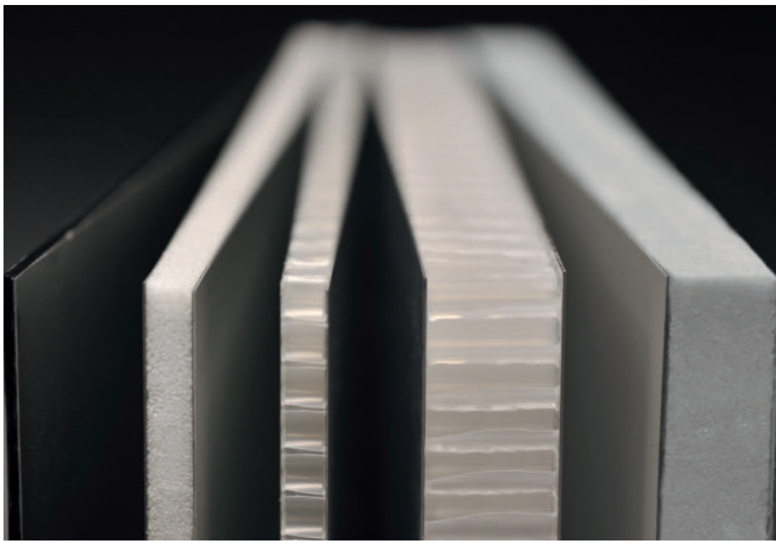

Fig. 6. The honeycomb composite panels manufactured by Elytra (center) are currently being tested by the research institute OCAS with regard to use of the Openair plasma approach for pretreatment of the PP resin (photo: Elytra)

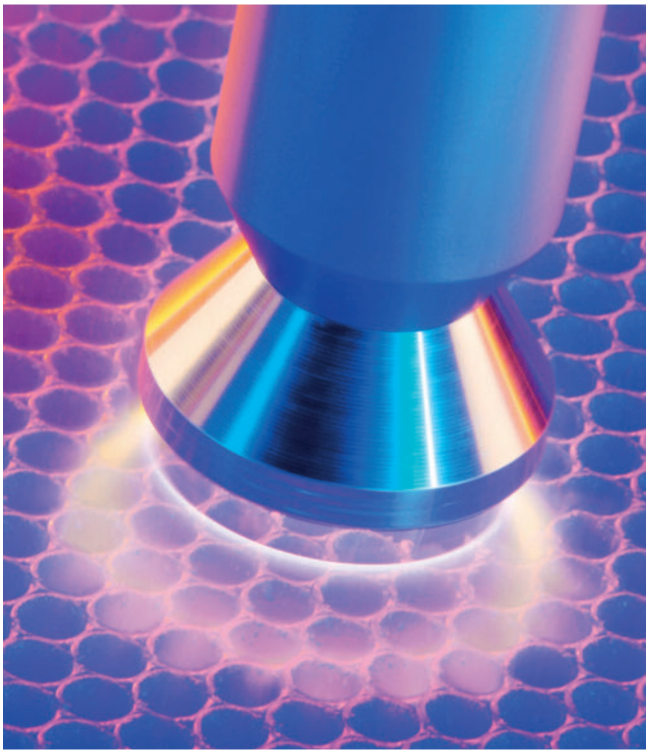

Fig. 7. Plasma treatment of the narrow ribs in the PP honeycomb ensures optimal bonding of steel and plastic facings (photo: Plasmatreat)

Fig. 8. The steel-faced honeycomb PP panels are manufactured at Elytra in a fully automatic production process (photo: Elytra)

to the desired height for maintenance and accessed via two bridges.

New Adhesion in Honeycomb Composites

What is already a reality in the German state of Thueringen, could also become a reality in the future at Elytra, a manufacturer of sandwich panels with a lightweight core in Geel, Belgium. The company is a subsidiary of the research Institute OCAS, a joint venture project between the Flemish region and the steel giant ArcelorMittal. Always searching for innovative applications and solutions for the metal industry, OCAS tested the adhesion performance of large honeycomb PP composite panels for Elytra after treatment of the plastic core with plasma at atmospheric pressure (Fig. 6). The trials are being conducted at OCAS with the Openair process as well. In this case, however, the focus is not on the facings, but rather on pretreatment of the honeycomb core itself – more exactly, on the narrow ribs of the plastic honeycomb (Fig. 7). Here, too, the intent is to increase the low surface energy of the nonpolar resin, but this time with the objective of achieving even stronger and more long-term adhesion by the adhesive and thus of the facing to be applied.

Production of sandwich panels takes place fully automatically at Elytra (Fig. 8). What is innovative is the combination of the honeycomb PP core with a wide variety of different facings. Steel is used above all; other production involves facings of SRPP (Self-Reinforced Polypropylene) or glass fiber-reinforced polypropylene. For the facings bonded to the top and bottom of the honeycomb, optimal adhesion to the narrow ribs of the honeycomb structure is extremely important. The series of trials conducted at OCAS have shown that there is basically no alternative to use of a plasma system incorporated inline. Other systems such as primers, flame- or corona-treatment proved to be unsatisfactory: Adhesion primer because of its poor environmental compatibility, flame treatment would be too dangerous and corona treatment too difficult. "Use of an inline potential-free atmospheric pressure plasma system to activate the PP core would fit very well into our fully automated production line," stated Hans Maenhout, General Manager of Elytra. "The process is not only faster than others, but also provides adhesion results that are clearly superior to what is obtained with other pretreatment methods."

Conclusions

The world's first in-line plasma system of the type and size described here simultaneously represents a breakthrough for future cost effective production of composite panels. And more: In addition to the high throughput, it will now also be possible in the future, because of plasma treatment of large areas, to exchange the core material in panels for lower-cost materials, e.g. recycled plastics. Recycled plastics and wood/plastic composites have largely difficult-to-bond surfaces, which made them almost impossible to use for industrial processes occurring at high speeds. ■

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