Adapted version from the German original. PLASTVERARBEITER October 2007, pp. 156-158

PRODUCTION

For painted surfaces to have an immaculate appearance the coating must adhere in optimum fashion and the substrate must be clean.

Taming recalcitrant surfaces

Author: Inès Melamies, freelance journalist, Bochum

ATMOSPHERIC-PRESSURE PLASMA TREATMENT TWICE AS EFFECTIVE. Openair plasma technology conditions surfaces in two respects. Depending on the process and product the aim here is either to clean or to activate the surface. Both aspects improve adhesion of the coatings to be applied which affects the cost-effectiveness of the process, product reliability and quality. In the metallisation of plastics the benefits manifest themselves through a marked reduction in rejects.

In the metallisation of plastics the plasma process has a positive effect on the adhesive properties of the sputtered metal coating. The surface of the plastic is uniformly conditioned and simultaneously freed from adhering particles. Due to this cleaning effect the quality of the final product is significantly increased and the number of rejects can be reduced. For the cleaning effect the user exploits the high electrostatic discharge effect of a free plasma beam. This effect is further positively influenced by the very high speed at which the stream of plasma is emitted. This also very effectively removes loosely adhering particles from the surface. In addition it is possible selectively to remove a layer already applied by vapour deposition by means of a highly focused plasma beam and low treatment speeds.

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TECHNOLOGY

Facts about the plasma process

- Operation of the plasma jets with air, with process gas if required, and high voltage.
- The emergent plasma beam is electrically neutral and so simple to install in-line in the process because the treated surface remains electrically neutral. The surface is electrostatically discharged.
- Treatment speeds of several 100 m/min for fixed single jets due to the high intensity of the plasma beam.
- An individual plasma beam can be up to 50 mm long and achieve a treatment width of 25 mm.
- By using rotating plasma jets an operating width of up to 130 mm per jet at treatment speeds of up to 40 m/min can be achieved.
- When combined rotary systems are employed surfaces up to 2000 mm wide can be treated in a single pass.
- Typical rises in temperature for plastic surfaces are less than 20 °C.
- The resultant activation of the plastic remains stable for long periods.

Ultrafine precleaning and activation in injection moulding technology. The metal pin is subsequently encapsulated in plastic.

Activating and cleaning surfaces

Openair atmospheric-pressure plasma technology patented ten years ago generates a zero-potential plasma for treating surfaces under normal atmospheric conditions. The plasma beam is formed and focused at the jet outlet and gives up its energy on contact with a surface. The most important components of the plasma installation are the plasma jets and generators. Inside the plasma jet the atmospheric-pressure plasma is generated by high-voltage discharge. A directed stream of air along the discharge pathway isolates parts of the plasma and transports them through the jet head to the surface of the material to be treated. The jet holds back those parts of the plasma stream carrying charge. In addition it determines the geometry of the emergent beam.

The surfaces of plastics are often chemically inert since their long polymer chains have low surface tension and possess no or only few functional groups. As a result they are very difficult to bond adhesively, paint or coat. The ions and free electrons in the plasma beam cause the attachment of nitrogen and oxygen to the surface of the polymer. Functional groups such as –OH and –NH are formed. In this way the plasma activates the surface by selective oxidation processes, discharges them and brings about ultrafine cleaning. “On the whole, activation of the surface takes place and this has a very positive effect on adhesion,” declares Dipl.-Ing. Christian Buske. The process can be employed on the surfaces of metals, plastics, ceramics and glass.

Good adhesion is decisive

The adhesive properties of a surface among other factors are decisive in the production of adhesive joints. Alternative processes, such as the use of chemical bonding agents (primers) or plasma methods at low pressure or in vacuo, are less environmentally friendly and more cost-intensive. Precision pretreatment and ultrafine cleaning of surfaces to be bonded by the atmospheric-pressure plasma process makes it possible for the user to employ either modern solvent-free UV adhesives or water-based systems. Due to the high-energy activation of the surfaces even hitherto incompatible substrates can be made to bond so that just such adhesives adhere to surfaces that are very difficult to bond, those of non-polar plastics for example. Additional pretreatment by means of chemical primers or scrubbing and rinsing off can be dispensed with completely. As a result VOC (volatile organic compound) emissions in production are avoided. Treatment is carried out uniformly and can be precisely checked in the course of the ongoing process.

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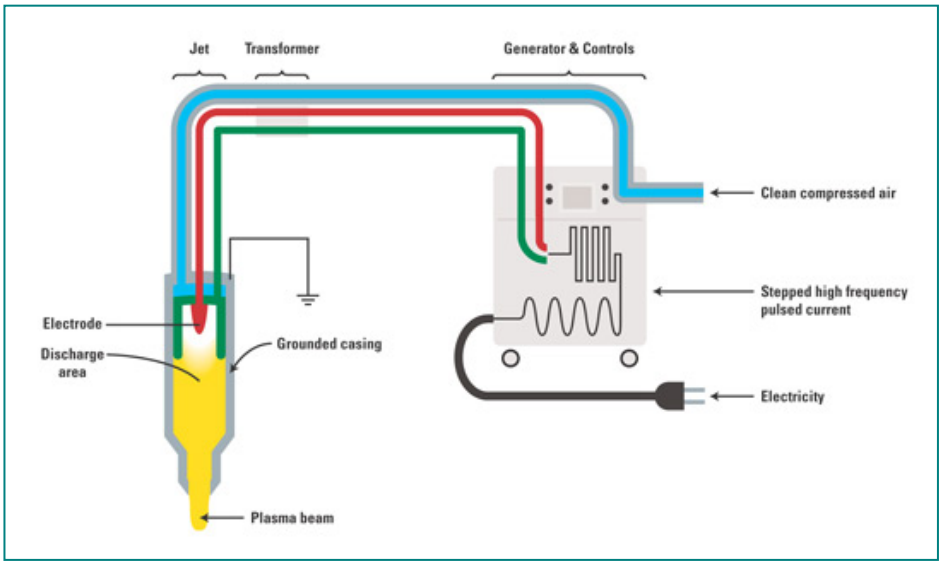
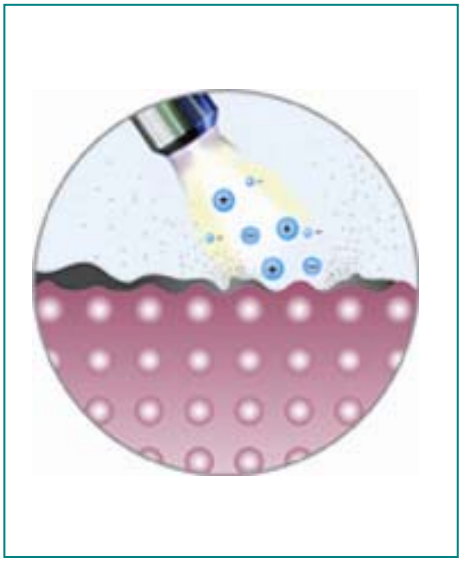
PRODUCTION





Operation of an atmospheric-pressure plasma installation. On the right the principle of cleaning using a plasma beam: ions and free electrons break down contaminants; organic compounds are oxidised and converted to water and CO2.

Modern products require high-grade coatings

Nothing is more annoying for a customer than flaking paintwork which in many high tech products may even be associated with faulty operation. Especially in automotive engineering there is a great deal of painting and coating: switches with laser-etched symbols, high-gloss trim strips and covers, scratch resistant display windows and sparkling dials, ventilator grilles or glove compartments handles. Even plastic parts in car interiors are now provided with very expensive coats of paint. Plasma technology can be employed here as a pretreatment process both for adhesive bonding and for painting. This the case, for example, in vehicles manufactured by BMW and Rolls Royce.

Today the very highest demands are imposed on the painted surfaces of mobile telephones. The paint finish must be absolutely flawless and under no circumstances may the overall impression be adversely affected by contaminants. Even a scarcely visible grain of dust on the surface of the housing results after painting in an unsightly bump which customers in general will not accept. Electrostatic effects are the principal cause here for the adhesion of dust particles. Well known suppliers to the mobile phone industry responded to this requirement a long time ago. They installed lines for cleaning mobile phone housings which allow highly efficient cleaning in an in-line process. Immediately before painting several rotating plasma generators clean the plastic surfaces with great efficiency. In this way users were able to reduce wastage levels from 12 % to less than 5 %.

Better adhesion allows more advantageous materials

Since the atmospheric-pressure plasma process described here can be integrated relatively easily into existing processes it can be used for improvements in the injection moulding process inter alia. PLASTVERARBEITER carried a report on this in its 12/2005 issue. Today, moreover, the process allows the use of low-cost structural components in rigid-flexible composites. In order to achieve firm joints between normally uncombinable plastics it is possible with plasma surface pretreatment to replace expensive ABS/PC, for example, by the lower-cost structural component polypropylene (PP) in rigid-flexible composites with TPUs (thermoplastic polyurethanes). The process has equally great potential for deep cleaning and improving adhesion in multicomponent technology in plastic-plastic and plastic-metal composites. Accordingly, the process is employed today for both thermoplastic-thermoplastic applications and thermoset applications (thermoplastic-LSR, TP-rubber).

Contact
Dr. Alexander Knospe, R&D Steinhagen
alexander.knospe@plasmatreat.de
Tel. +49 (0)5204 9960-0

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COST-EFFECTNESS

Surface-pretreatment with atmospheric-pressure plasma technology

“Openair” atmospheric-pressure plasma technology is more economically efficient since in contrast with low-pressure methods it can be carried out without a low-pressure chamber. Other reasons for its greater cost-effectiveness are set out below.

- Components treated at low pressure, that is in vacuum, are restricted both in terms of piece numbers and size by the chamber needed. Processes for producing these parts must be interrupted for the pretreatment operation.
- With low-pressure plasma neither cleaning processes for strip materials, as in the coil coating process, nor large-area pretreatment for adhesive bonding processes can be implemented.
- Atmospheric-pressure plasma technology is compatible with the use of robots and capable of in-line integration.
- Chemical treatments require consumables and often leave behind residues that are difficult and very costly to dispose of. The plasma technology described completely replaces chemical methods usually used for cleaning purposes.
- Mechanical pretreatment methods (scouring) are very difficult to implement reliably and also operate with consumables.

Atmospheric-pressure plasma technology is not suitable, however, when surfaces are not accessible to the atmospheric plasma beam due to complicated geometry or when the production approach is already designed for chamber-based processes.