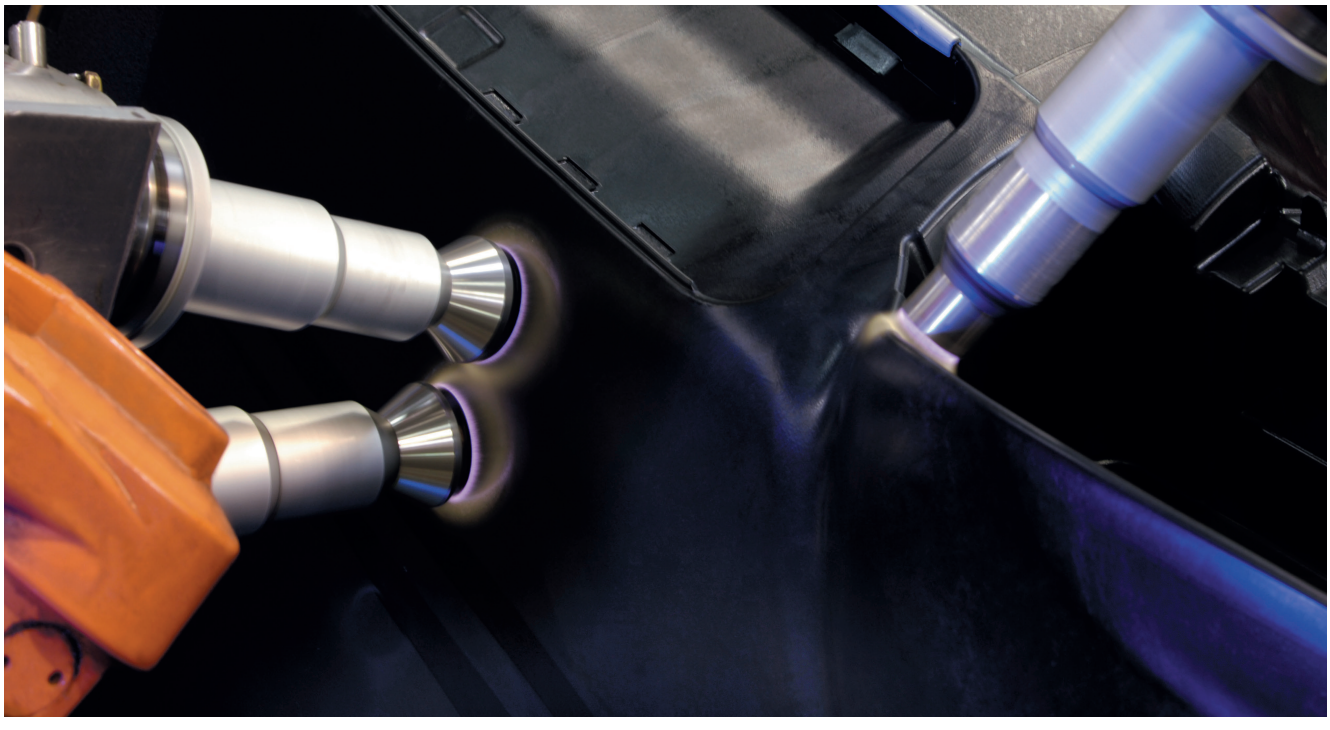
Atmospheric Plasma Technology as the Key to More Resource Conservation

Improved Processing of Recyclates

The use of recyclates confronts companies with new requirements in the processing, bonding, printing and labeling of materials and components. Atmospheric plasma technology, in which Plasmatreat GmbH has specialized, has established itself as a key technology: it often makes the use of recycled plastics possible in the first place – and also proves to be the means of choice on the way to more environmentally friendly, more resource-efficient production processes.



When using Openair-Plasma, the plasma jet works in a location-selective manner and follows the component geometry with millimeter precision. During the plasma treatment, very little heat is generated, so that the treated components remain dimensionally stable. © Plasmatreat

Responsible use of resources is a serious corporate goal for more and more companies that is right at the top of the agenda. In plastics processing, the use of recyclates as a supplement and alternative to new goods plays a decisive role in the commitment to environmental and climate protection. However, with the switch to materials with a proportion of recyclates or even to pure recycled plastics, companies are facing new challenges. Because when preparing materials for reuse, it depends on purity of type: if this is ensured, plastics can generally be melted down and used again to manufacture a wide variety of products. "In many cases, however, this is not entirely possible. Plastics such as polypropylene and polyethylene in particular cannot be separated according to type using traditional methods, as they are chemically only slightly different," explains Dr. Alexander Knospe, Head of Innovations and Patents at Plasmatreat. But even minor changes to the material can affect the entire manufacturing process.

This is where Plasmatreat's competence comes into play: the company specializes in the use of atmospheric plasma technology in industrial production. When plasma comes into contact with materials, their surface properties change, for example from hydrophobic to hydrophilic. Plasmatreat has developed various solutions for surface treatment that are used in controlled and reproducible processes for almost all materials:

- Fine cleaning with Openair-Plasma removes contaminations from the substrates.
- Plasma activation increases the surface energy and improves the subsequent adhesion of adhesives and paints.
- The PlasmaPlus process uses nanocoating to create functionalized surfaces with defined properties, such as an anti-corrosion coating or an adhesion promoter layer.

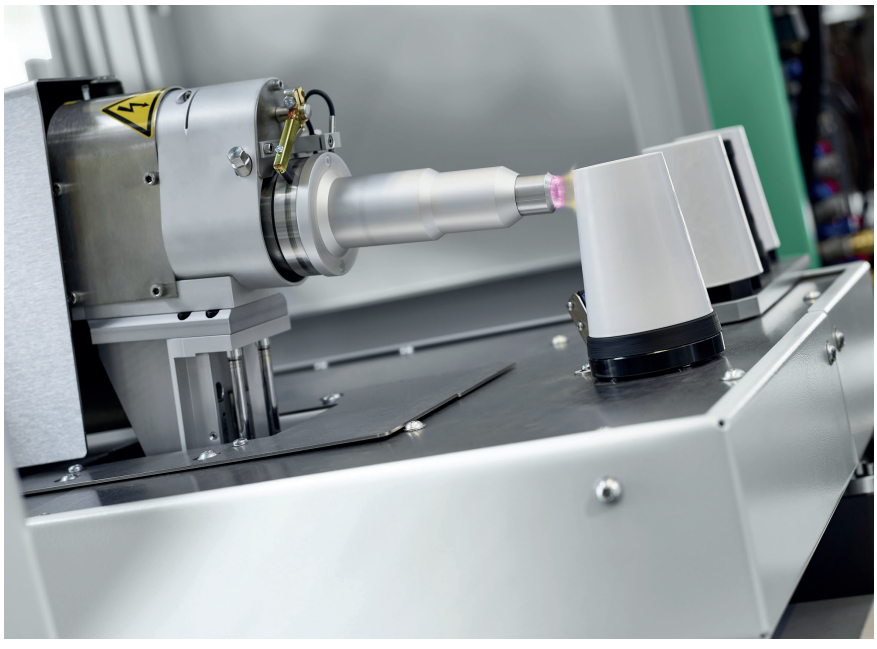


Fig. 1. The injection-molded recycling cup is treated with Openair-Plasma to increase the surface energy of the non-polar plastic. © Arburg

Numerous industries are already using the power of plasma for a wide variety of processes. When using recycled plastics, plasma technology is once again of particular importance: due to the fact that the separation is not always 100 % pure, plastics are created in the recycling process that have (slightly) different properties than new goods, for example in terms of the quality of the surface.

This has a negative effect on processes such as bonding, printing, painting, labeling, applying seals and more. "Plasmatreat offers efficient solution options with various plasma applications. These simplify the further processing of recycled plastics, for example through targeted activation of the plastic or through the application of a nano-layer that provides the surface with additional properties. In this way, we are expanding the possible uses of recyclates, using only electricity and compressed air ourselves and thus contributing to more environmental and climate protection," explains Lukas Buske, Head of Plasma Applications at Plasmatreat.

Flawless, Long-Lasting UV Digital Printing on Recycling Cups

Plasmatreat demonstrates what this can look like in practice in cooperation with injection molding machine manufacturer Arburg, among others: at the Digital Edition of Hannover Messe 2021, Arburg demonstrated how a freshly injection molded drinking cup with a wrinkled look made of recycled polypropylene (PP) can be printed using UV digital printing without the use of additional adhesion promoters. After removal from the injection mold, the recycling cup is subjected to an Openair-Plasma treatment that effectively activates the printing surface (**Fig. 1**).

The plasma activation ensures that the surface energy of the non-polar plastic increases significantly. This enables full-surface wetting of the printing surface in UV digital printing and creates the prerequisite for good adhesion of the solvent-free printing inks to the substrate, such as the recycled PP used here (**Fig. 2**). The result is a brilliant, sharp print image that is permanently resistant to abrasion and moisture.

In the project described, which Arburg realized as part of the R-Cycle initiative, this is important not only for visual reasons but also for practical ones: during production, the recycling cup is given a "digital passport" and is printed with DM codes that are easily legible even after prolonged use thanks to plasma treatment. The material information for recycling stored in the R-Cycle database can be called up via a DMC. These make the cup a recyclable material again after use and support a sustainable recycling economy.

Solid Connection in 3D Printing of Metal and Recycled Plastic

Another joint project was dedicated to 3D printing with a high-strength sustainable plastic. At the Fakuma 2021, the companies involved – Plasmatreat, the plastics specialist Akro-Plastic and Yizumi Germany, manufacturer of 3D printers for industrial applications – presented the production of a 3D component from a bio-based and carbon fiber-reinforced polyamide on a metal carrier. In the printing process, a stainless steel sheet coated with a plasma-polymerized adhesion promoter served as the substrate (**Fig. 3**).

In this case, the PlasmaPlus technology from Plasmatreat was used: depending on the application, specific additives are added to the plasma via a special nozzle head; these are stimulated by the plasma. Their reactivity is thereby increased significantly. In this way, the substances can accumulate on the material surface during the plasma coating and bind firmly. The result is a layer with functional surface properties that can be individually tailored to the process. In the example described, a PT-Bond nano-layer is deposited on the sheet metal, which creates a firm connection between the »

Company Profile

Plasmatreat GmbH is an international leader in the development and manufacture of atmospheric plasma systems for the pretreatment of material surfaces. Whether plastic, metal, glass or paper – the industrial use of plasma technology modifies the properties of the surface in favor of the process requirements. Openair-Plasma technology is used in automated and continuous manufacturing processes in almost all industries. Examples of this are the automotive, electronics, transport, packaging, consumer goods or textile industries. However, the technological, cost and environmental advantages of plasma technology are also used in medical technology and in the field of renewable energies.
The Plasmatreat Group has technology centers in Germany, the USA, Canada, China and Japan and, with its worldwide sales and service network, is represented by subsidiaries and sales partners in over 30 countries.
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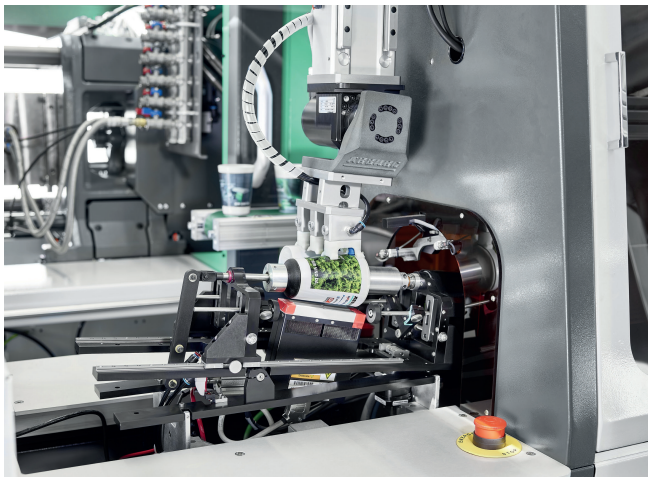

Fig. 2. A high surface energy is decisive for the wetting of the printing ink in UV digital printing and creates the prerequisite for good adhesion of the solvent-free printing inks. © Arburg

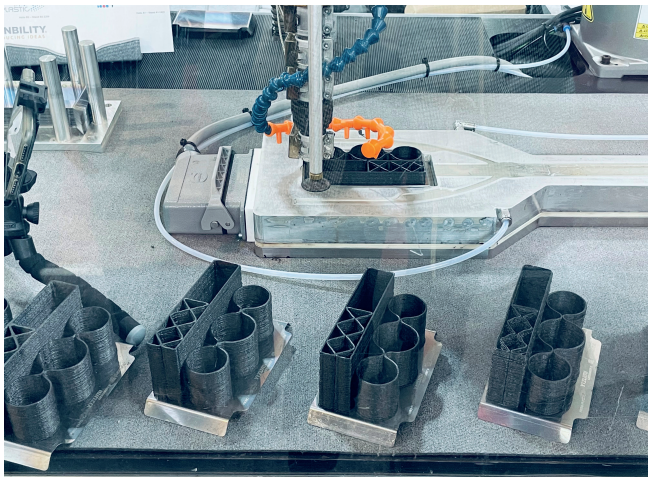

Fig. 3. Thanks to the adhesive layer, which is applied to the metal carrier using the PlasmaPlus process, the pen holder made of carbon fiber-reinforced, bio-based polyamide holds on to the surface. © Akro-Plastic

metal carrier and the first layer of the plastic melt, i.e. between normally incompatible materials. With this process, users will benefit in the future from expanded fields of application for 3D-printed components and the opportunity to use more sustainable materials.

The Automotive Industry Relies on Dashboards with Recycled Content

The use of recycled plastics has long since arrived in the automotive industry, with its high quality and strict requirements for suppliers. Many manufacturers require defined recycling quotas in their specifications. The suppliers are faced with the challenge of reliably implementing these requirements. Plasma technology has already proven itself in various ways here. When it comes to interior design, numerous vehicle manufacturers already use recycling materials to a certain extent, for example in the production of plastic instrument panels.

Various manufacturers use the plasma technology from Plasmatreat for surface pretreatment: pretreatment with plasma makes non-polar (recycling) plastics susceptible to adhesion processes and ensures that the different, sometimes even incompatible materials are firmly bonded, for example when laminating dashboards made from recycled plastics materials with powder-sintered molded skins made of soft plastic (**Fig. 4**).

More Environmentally Friendly Processes and Raw Material Savings

However, it is not only through the improved use of recycled plastics that plasma technology supports industry in its efforts for more environmental and climate protection. It also helps to replace environmentally harmful processes with less harmful ones. Well-known manufacturers, for example from the automotive industry, use plasma pretreatment as an alternative to the traditionally used surface treatment (**Fig. 5**).

Plasma technology helps manufacturers achieve significant CO_2 savings: while the flame is applied with propane or methane gas, for example, plasma nozzles are operated with electricity and compressed air. If you now use green energy, the plasma treatment takes place in a CO_2-neutral manner. But even if a conventional electricity mix is used, the CO_2 balance in relation to the treated area is at most a fifth of the emissions that occur in the event of a flame. Lukas Buske adds: "Plasma technology also makes environmentally harmful chemicals, such as the commonly use of primers for bonding, superfluous. That also improves the environmental balance."

The example of dashboard production also shows that plasma technology can score with more efficient processes and raw material savings. The flame application process requires that all areas of the components that are not to be adhered to later be covered with thermally stable masks. With the use of Openair-Plasma (**Title figure**), this work step is completely eliminated, as the plasma jet works in a location-selective manner and follows the component geometry with millimeter precision.

In addition, very little heat is generated during plasma treatment. As a result, the treated components remain dimensionally stable and undamaged even if they are designed with overall thinner walls. The environment and manufacturers also benefit from the material savings that this makes possible. The automotive industry in particular, in its striving for lightweight construction, can thus – with weight-optimized and at the same time resilient components – reduce the overall weight of the vehicles and thus the fuel consumption.

Fig. 4. The pretreatment with plasma makes non-polar plastics susceptible to adhesion processes and ensures a firm connection of the different, sometimes even incompatible materials, for example when laminating dashboards made of recycled materials with powder-sintered molded skins made of soft plastic. © Plasmatreat

Plasma Technology Drives Sustainable Developments

The examples presented show how plasma technology supports companies not only with powerful and efficient processes, but also in their efforts to conserve resources. The current possibilities of plasma technology, however, are only the beginning – at Plasmatreat and in several research institutions, further projects are in the starting blocks, which should also become series solutions.

Dr. Alexander Knospe, Head of Innovations and Patents at Plasmatreat, leads back with his outlook to the starting point of this article, recycling plastics: "Due to the large quantities of plastics used, polypropylene and polyethylene in particular play an important role in material recycling. As described, a pure separation during recycling is challenging and sometimes not economical due to the similar material properties. Today, up to 10 wt. % of cost-intensive additives are added to ensure the mixing of the materials in the extruder and to achieve acceptable material properties – thus recycling the valuable material but adding substances that produced CO_2 emissions and significantly increase the material price."

Current research that is being carried out at the Institute for Plastics Processing (IKV) at RWTH Aachen University, Germany, as part of the AiF project "Melt Functionalization" should make this superfluous in the future. Functionalization of the plastic melt with the help of atmospheric pressure plasma directly in the extruder could increase the compatibility of the materials by incorporating functional groups into the polymer chains. Knospe concludes: "Then in the future, for example, mixtures of PE and PP films would no longer have to be separated with great effort." ■

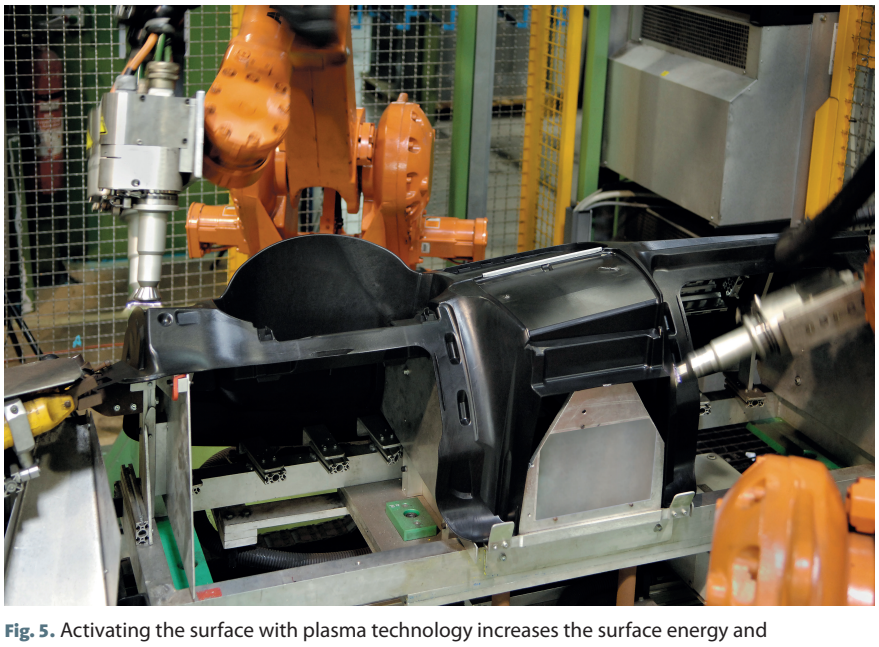

Fig. 5. Activating the surface with plasma technology increases the surface energy and improves the adhesion of adhesives and paints, even with plastic parts made from recycled material. © Plasmatreat

Info

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