plasmatreat


APPLICATION INFORMATION

# Atmospheric plasma for strongly bonded hard-soft combinations in multi-component injection molding

InMould-Plasma® – 2-component injection molding with integrated plasma pretreatment

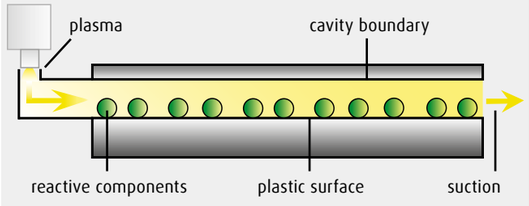
## 2-component composites with Openair-Plasma®

Molded parts made from thermoplastics and thermoplastic elastomers (hard-soft composites) are increasingly used in automotive engineering, medical engineering and consumer goods, where they satisfy growing quality standards for the look, feel and function of components. The plastics processing industry is increasingly turning to multi-component injection molding as a manufacturing technology for hard-soft combinations.

In composite injection molding, achieving a covalent bond between the different materials is key to ensuring adhesive strength. Adhesion is based on intermolecular interactions, adhesion and diffusion processes as well as chemical bonds, which vary depending on the types of polymer used. Openair-Plasma® technology has been used successfully for several years in 2-component injection molding to produce strongly bonded hard-soft combinations.

With the aim of extending the spectrum of materials and rationalizing the process, Plasmatreat has developed the InMould-Plasma® process in conjunction with the Institute of Polymer Engineering (KTP) at the University of Paderborn. This process can be used to join previously incompatible materials such as PP and TPU (polypropylene to thermoplastic polyurethane) to create diverse plastic combinations. With the InMould-Plasma® process, the plasma is activated inside the injection mold. This greatly reduces the number of process steps, such as downstream bonding or the insertion of a separately manufactured seal.

### Integrated plasma activation of thermoplastics




Plasma emitted from the plasma nozzle flows over the surface of the plastic in an enclosed channel, aided by a suction system. This process activates the component surface. Since nitrogen is used as the process gas, functional groups containing nitrogen and oxygen form on the component. These groups act as reactants for the reactive constituents of the elastomer component.

## New opportunities for material combinations

In conjunction with the University of Paderborn's Institute of Polymer Engineering, conventional and new material combinations have undergone extensive mechanical testing using a 2-component peel test specimen (designed to VDI Standard 2019).

2-component peel test specimen made from TPU and PP – complete cohesive failure of the elastomer component (TPU – Desmopan 6064A on PP – Purell HP 570M), both not adhesion modified

**Summary of the peel forces obtained with different hard-soft combinations**

| Thermoplastic | Elastomer | Change in adhesive strength |
|---|---|---|
| PP | TPU | Adhesion only possible with InMould-Plasma® > 5 x peel strength |
| PP40talc | TPU | Adhesion only possible with InMould-Plasma > cohesive failure |
| PBT | TPU | Better adhesion > 3 x peel strength |
| PBT/ASA | TPU | Better adhesion > 5 x peel strength |
| POM | TPU / TPE-S | Better adhesion |
| PBT | TPE-S | Better adhesion > 3 x peel strength |
| PC | TPE-S | Better adhesion > 3 x peel strength |

Thermoplastics:
Polypropylene (PP), polybutylene terephthalate (PBT), acrylonitrile styrene acrylate (ASA), polyoxymethylene (POM), polycarbonate (PC), thermoplastic polyurethane (TPU), styrenic block copolymer (TPE-S)

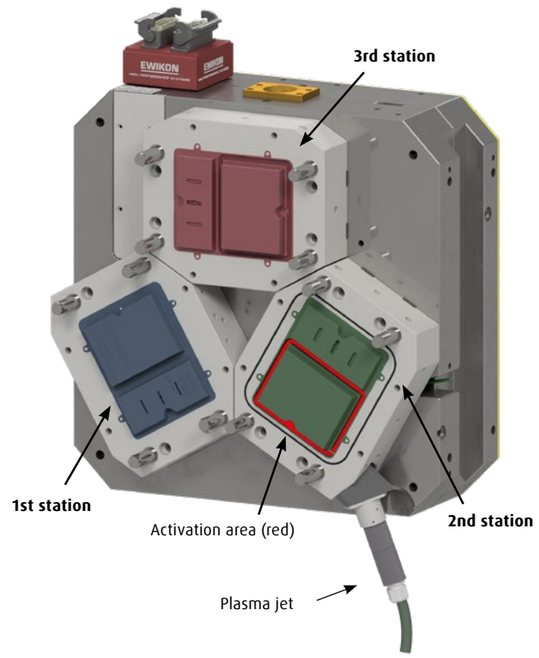
## Integrated, reliable process with rotary disc technology

For 2-component parts, plasma activation is integrated into the *lid with seal* demonstration model illustrated (see title image) using tried and tested rotary disc technology. The mold is designed with three stations:

**1st station:** Production of pre-molded part (lid)
**2nd station:** Plasma activation
**3rd station:** Overmolding of elastomer component

Plasma treatment takes place in an activation channel in the 2nd station of the rotary disc mold. The pre-molded part from the 1st station stays on the moving half of the mold and moves with the rotary disc into the 2nd position. A powerful, cold plasma source combined with suction ensures that the plasma is conducted along the entire length of the channel. The plasma reacts with the surface of the substrate as it passes over, activating it in seconds before the elastomer component is overmolded in the 3rd station.

The compact design of the plasma nozzle allows for standardized, space-saving integration into the system. At the same time it is powerful, highly reactive and generates only a slight heat input into the polymer.




## Cycle time-neutral production

The duration of the plasma cycle depends on the material combination and the specific component geometry. The *lid with seal* demonstration model has a plasma cycle of 7 to 10 seconds, including final extraction.

The total injection molding cycle is determined by the cooling time of the thermoplastic component, which is approximately 35 seconds, depending on the material (in this case the demonstration model) and the component wall thickness. As a result, plasma activation is cycle time-neutral since it is generally completed in less time than the maximum time required to cool the two components (thermoplastic substrate and elastomer component).


InMould-Plasma® mold integrated into an ARBURG Allrounder 570S.

## Full process control

The plasma cycle is monitored by a plasma control unit (PCU). The PCU records the plasma power and adjusts it as required. This ensures that the activation conforms to the specified process parameters.

Pressure and temperature sensors additionally monitor and control the injection molding process.

The plasma control unit (PCU) monitors the plasma nozzles to ensure full process control and documentation.

# InMould-Plasma®: Advantages of multi-component injection molding

- **New material combinations:** Significantly enhances the adhesive strength of material combinations that were previously difficult or impossible to join. Extends the material spectrum to include PP+TPU, PBT+TPU and TPE-S or PC+TPE-S without the need for adhesion promoters, thereby improving the compression set of the elastomer, for example. Adhesive strength is maintained even after accelerated ageing or storage in warm water.

- **Protection against seal loss:** Soft components such as sealing gaskets remain in position to ensure reliable assembly with minimum risk of failure.

- **Fully integrated and controlled process for quality assurance:** PCU and pressure and temperature sensors for complete control of the plasma-assisted 2-component injection molding process.

  InMould-Plasma® provides the basis for a high-quality technical process which can be monitored, controlled and documented entirely by process parameters.

- **Allows for different mold concepts:** Rotary discs, sliding tables, cube or stack turning technology – diverse tool concepts can be used with InMould-Plasma® systems. Since the process does not require any clamping force, it can also be used outside the area between the machine's clamping plates.

- **Increased design flexibility:** Soft components can be applied where they are needed or should ideally be located, for example on rotationally symmetrical components. This removes any restrictions due to geometric constraints or anchoring points for soft components.

- **Reduced production costs:** The production of multi-component parts on an injection molding machine inline without the need for additional assembly processes, extensive opportunities for process and quality control, advantageous use of standard plastics – the InMould-Plasma® technology offers diverse solutions for cost effective and sustainable production.

Hard-soft composites satisfy diverse electromoblity requirements: In charging plugs, thermoplastics provide mechanical strength while elastomers provide good grip and high media resistance.


Hard-soft composites in electrical appliances: Non-slip, oil-resistant handles and impact-resistant battery housing.


Use of multi-component soft touch parts in the automotive industry: Dashboard, interior door panels and gear knob.


The InMould-Plasma® process has been developed in cooperation with the Institute of Polymer Engineering (KTP) at the University of Paderborn.

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