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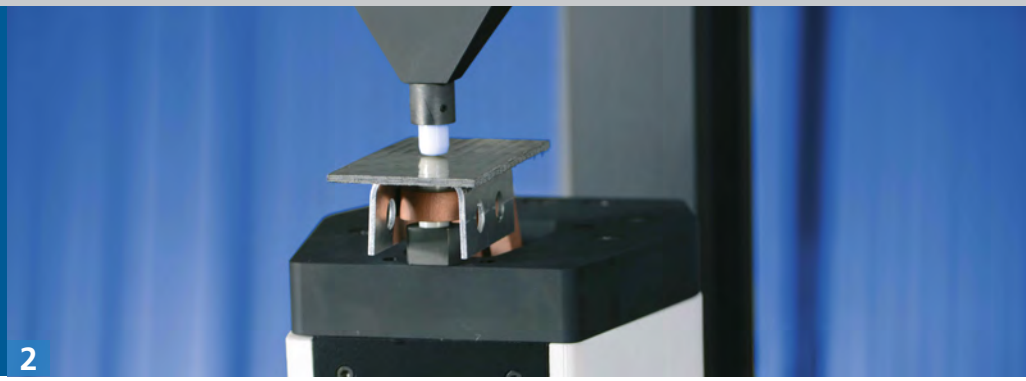
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1 *HPCi® joining gun for metal to plastic joining within seconds.*
2 *Joining of a test specimen made of glass fiber reinforced polyamide and aluminum.*

HeatPressCool integrative (HPCi®)

FAST JOINING OF METAL AND PLASTIC

Load-bearing hybrid joints made of metals and thermoplastics are becoming increasingly important for industrial applications. Efficient joining processes are required with which firm joints can be produced quickly and reproducibly according to the specific load case. The HeatPressCool integrative technology (HPCi®) enables the process-reliable joining of different materials in just a few seconds without the use of additives such as adhesives, screws or rivets.

Functional principle

The combination of rapid local heating of the metal part and simultaneous pressing to a thermoplastic component causes the plastic to melt at the contact point. It wets the metal and solidifies right after the heating process. To improve the joint strength, the metal surface can be structured or coated with an adhesion promoter, if required. The process is suitable for joining the entire spectrum of thermoplastics with all metals:

- Standard thermoplastics (PE, PP etc.)
- Engineering thermoplastics (PA6, PET etc.)
- High performance thermoplastics (PPS, PEEK)

There are also no restrictions with regard to the metallic joining part. The spectrum ranges from aluminum casting and wrought alloys to low-alloyed and stainless steels and additively manufactured titanium components. Even materials that are technically difficult to bond, such as POM or AlMg3, are excellently suited for the HPCi® process.

Heating concepts

Depending on the joint's size and geometry as well as on the required process flexibility, the heating is performed inductively, conductively or by laser radiation. When using laser radiation, dynamic beam shaping can flexibly generate different heating profiles and can thus frequently produce varying joint geometries. For higher production

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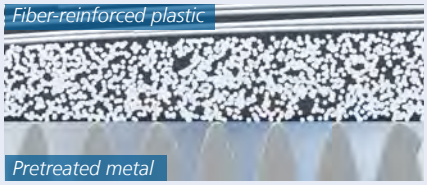
3 *The multiphysical simulation enables joining on the spot.*

4 *SEM image of a destructively tested polypropylene-aluminum joint.*

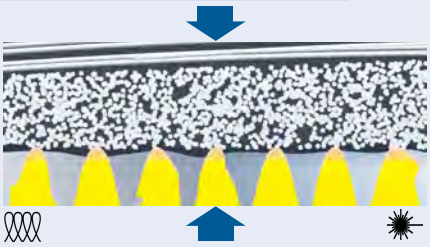
5 *Possible application: Joining of a hybrid B-pillar in car body construction.*

Initial state



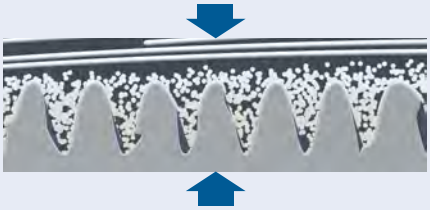
HPCi® is perfectly suited for a wide range of metal-plastic combinations. In order to achieve high joint strengths, the metal is pretreated by laser.

Heating and pressing



The joining partners are aligned and pressed together. The heat induced into the metal melts the plastic and causes it to infiltrate the metal structure.

Cooling and consolidation



During cooling, the polymer solidifies and thus enables a firm joint between metal and plastic.

quantities, volume heating of the metals with adapted inductors ensures minimum joining times and high energy efficiency. Direct access to the metallic joining partner is not necessary. The inductors can be designed with regard to the geometry and material of the joined parts.

Spot-like joining

For the integration into fully automated assembly processes, Fraunhofer IWS has developed a joining gun that preferentially produces spot-like connections. A ring inductor working in the outer field encloses the pressure die, which presses the joining partners. The process-integrated control and monitoring of the traverse path and the local joining temperature enables both the minimization of the joining time and the inline documentation of the achieved joining quality. The HPCi® joining gun operates both with onesided and two-sided accessibility and can be adapted to conventional industrial robots. The tool is thus suitable for use in car body construction to convert resistance spot-welded metal constructions into multi-material designs.

Fields of application

In addition to applications of the metal/thermoplastic compounds in lightweight construction (e. g. automotive industry, aviation or sports equipment industry), the focus of current research work and industrial transfers is on their implementation in electronics production. A further application field is opening up in industrial and household goods as well as in the furniture industry.

Sustainability

The technology also enables the repeated separation of the fundamentally extremely stable HPCi® connection. Parts can thus be repaired more easily and separated according to type at the end of their life cycle. In combination with bio-based plastics, sustainable hybrid components are thus created.

Technical data HPCi® joining gun

Traverse path of the pressure cylinder	100 mm
Joining pressure	0.5 to 5 kN
Joining range	ø 15 to 25 mm
Heating rate	> 150 K/s (typical)
Power	5 to 30 kW
Weight	15 kg