Fraunhofer IWS

Direct Thermal Joining for Lightweight Construction

Fast Joining of Metals and Plastics with HPCi®

Load-bearing hybrid joints made of metals and thermoplastics are becoming increasingly important for industrial applications. Efficient joining processes are required to enable the rapid and reproducible production of load-compliant composites. The HPCi® technology (short for "HeatPressCool-integrative") enables process-safe joining of a wide materials range in just a few seconds and without additional tools.

Operating principle

A polymer matrix plasticizes with simultaneous pressing of the thermoplastic and metallic joining partner as well as metal-side heating at the contact surface. It wets the metal and solidifies immediately after the heating process. To improve the strength of the resulting bond, the metal surface is textured or coated with an adhesion promoter. The process fits the bonding of the entire thermoplastic spectrum with all metals:

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

There are hardly any restrictions with regard to the metallic joining part. The spectrum ranges from cast and wrought aluminum alloys through low-alloy and stainless steels to additively manufactured titanium components. Even materials considered technically challenging to join, such as POM or brass, provide excellent suitability for the HPCi® process.

Fields of Application

In addition to applications of metal-thermoplastic bonding in lightweight construction (e. g. automotive industry, aerospace or sports equipment industry), current research work and industrial implementations focus on its use in the electronics industry and energy technology. A further field of application is opening up in industrial and household goods as well as in the furniture industry. HPCi® technology is already being used in industrial applications as well as in current industrial and publicly funded projects.

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Performance

The basic material used and the surface pretreatment of the metallic joining partner essentially influence the achievable strength of the HPCi® joint. For a conventional composite of aluminum and PA6, shear tensile strengths of approximately 25 MPa can be achieved. When high-performance materials such as titanium and CF-PEEK are used, structural joints with strengths of more than 50 MPa can be achieved with the process. In addition to the mechanical properties, the methode also enables the achievement of high requirements for media tightness. Depending on the base material, operation under corrosive environmental conditions presents no difficulties either.

Current Research and Development

For the advanced fiber composite manufacturing of hybrid lightweight structures, the use of HPCi® joining technology is expected to prove an energy- and resource efficient manufacturing method while enabling weight savings of up to 30 percent. JOASIS, a transnational »2+2 project« with South Korea, is focusing on the

- multi-stage development of a novel, disruptive seat design made of composite and metal parts,
- FE-based design of joining interfaces,
- development of joining and disassembly processes,
- design and implementation of a multi-functional joining station, and the
- final manufacturing of the prototype seat.

The focus is to develop and manufacture an automotive lightweight seat structure made of CFRP recyclate, fiber-reinforced plastic and dual-phase steel. The project thus contributes to strategic cooperation between Germany and Korea with the aim of developing energy- and resource-saving processes along with products for greater sustainability and climate protection.

A seat frame with a weight saving of more than 15 percent has already been produced by combining a hybrid design with HPCi® joining technology. Improved pretreatment methods have also allowed strength increases in the joints of around 38 percent compared with previous concepts, particularly in the tensile direction. This permits meeting the requirements of the automotive industry both on the static requirements side and on the economic level.

Funding

The contents of the results presented were partly developed within the framework of the project »JOASIS – Development of 30 Percent Lightweight Electric Vehicle Seat Frame Using HPCi® Connection Technology« under the funding code 01DR21023A of the funding measure: IB - ASIEN, funding area: Korea 2+2, robotics, lightweight construction/carbon funded by the German Federal Ministry of Education and Research (BMBF).

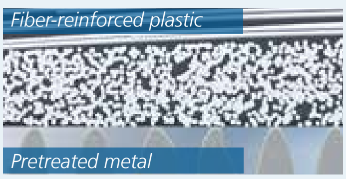
HPCi®-joined seat frame hybrid composite structure.

Founded by

Federal Ministry of Education and Research

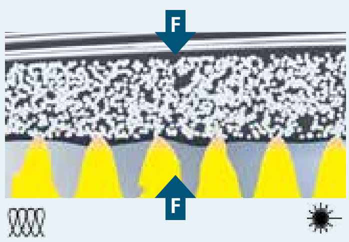
Process Flow HPCi®

Initial State



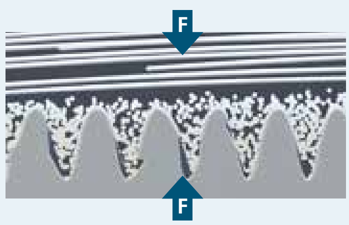
HPCi® is perfectly suited for a wide range of metal-plastic combinations. In order to achieve high joint strengths, the metal is pretreated by laser.

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.