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Leightweight Design

Barcode zu Ansprech- partner und Infomaterialien

Motivation

As the focus of the research and development of composites at the Institute of Polymer Technology (Lehrstuhl für Kunststofftechnik, LKT) lies in the area of high-volume production, mainly thermoplastic composites that allow for short cycle times in processing are used. The possibility to combine different fiber and matrix materials allows for a wide range of composites that can be used for various applications with diverse demands. Thus, aside from commercially available organo-sheets, custom sheets with individually tailored properties are part of the research at the LKT. Thereby, new areas of application and a deeper understanding of the related shaping processes shall be achieved.

Thermoplastic Composites

For established processes, such as In-Mold Forming or thermoforming of organo-sheets, the focus of research is to generate a deeper process understanding for series production. Related questions are, for example, the influence of moisture on the heating, reconsolidation and part properties. Here, it is essential to characterize the forming behavior of continuous fiber reinforced thermoplastic composites under conditions comparable to actual processing, including high heating and cooling rates, high deformation speeds and high levels of deformation and processing in thermodynamically transitional regions. The LKT is constantly working on refining already established and developing new methods to generate valid material data as shown in Fig. 1, which are a prerequisite for high-precision simulations and conduct such simulations.

In the style of traditional “hybrid-techniques“, new processes to produce lightweight design parts are developed at the LKT as well. Therefore, established technologies for design and processing are combined into new innovative processes that enable new designs. This is realized, for example, by the use of gas pressure for the forming of the organo-sheets enabling the net-shape production of closed hollow bodies in combination with injection molding. Another approach is direct impregnation of reinforcement weaves in injection molding using regular injection molding granules. Goal of all integrated processes is a shorter process chain and the avoidance of extra assembly or joining operations. If separate joining of parts is necessary because of their size or complexity, standard processes like fusion or adhesive bonding are possible. With new joining processes, joining with adhesive bonding in combination with form fit is possible e. g. for higher energy absorption. One example is the FiberSew process that combines sewing and fusion bonding into one process as shown in Fig. 2.

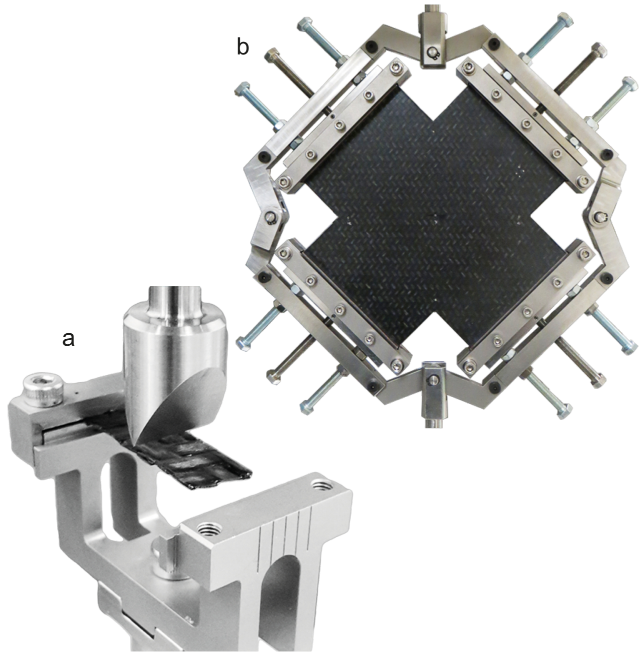

Fig. 1: Different testing setups used for characterization of the processing properties of thermoplastic composites under conditions comparable to actual processing
a) Adapted two-point bending test
b) Custom picture frame with adjustable clamps for intralaminar shear testing

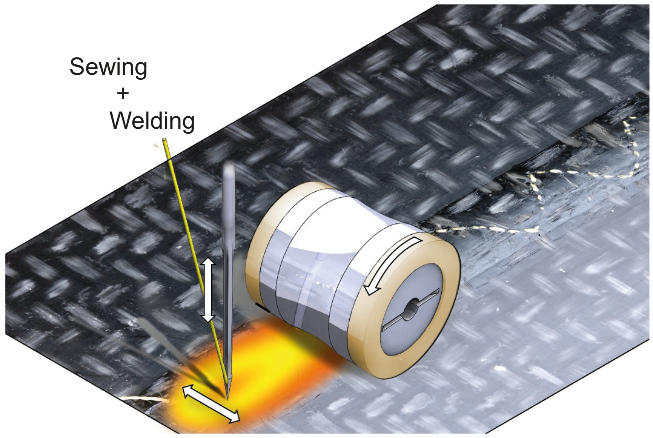

Fig. 2: FiberSew Process (illustrated)

Polymer-Metal Hybrid Structures

Polymer-metal hybrid structures combine the different advantages of the individual materials to components with properties which cannot be achieved with a single material solution (Fig. 3). As a result, the mechanical properties can be increased or weight can be reduced. Furthermore, a high functionalization is possible, for example by integrating electronic components or fastening elements via injection molding. Hence, the number of single components can be reduced significantly. This allows for applications of polymer-metal hybrid structures in all areas of life with high requirements on the components, especially in the automotive sector (Fig. 3).

As previously stated, manufacturing processes with short cycle times, such as the In-Mold-Assembly (IMA), are main focus of the LKT and different joining strategies are researched and qualified for production. In IMA, preformed metal inserts are placed manually or partly automated into the open injection mold. Next, the mold is closed, followed by the injection of the polymer melt into the cavity which is built by the combination of metal insert and mold wall. In general, different proceeding variants, adapted to the joining mechanism, are used.

The connection technology of distinct incompatible materials can be divided into the three joining mechanisms form fit, force fit and adhesive bond (Fig. 4). Form and force fit joints can be produced simply and economically with the robust production processes of sheet metal forming and injection molding. Here, the component quality depends, for example, on the form, quantity and position of the used apertures. On the contrary, joints with an adhesive bond do not require geometric undercuts in the metal insert which weaken the joint especially under dynamic load. Instead, the surface is adjusted to the polymer, for example with adhesive promoters that adhere to the metal insert and to the injection molded polymer above the whole joining surface. Furthermore, applied micro structures on the surface of the metal insert can be used to generate a joint with an adhesive bond according to the mechanical theory of adhesion. The basic requirement for this is the filling of the micro structures with polymer during the injection molding process.

Injection Molding of Thermosets

In several scenarios, even technical or high-temperature thermoplastic materials cannot reliably fulfil the diverse requirements of parts in actual usage, especially in technical applications. Here, when high-temperatures and the presence of electrical circuits or different chemicals heavily impair the material properties of most plastics, thermosets can be a possible alternative solution. A reliable way to manufacture thermoset parts is injection molding, however, in contrast to thermoplastic injection molding, the special case of highly reactive polymers leads to a process, which is still not fully understood and researched at the LKT. In the same way as thermoplastic polymers, thermosets can additionally be used in polymer-metal hybrid structures or in combination with continuous fiber reinforced pre-pregs, leading to a high spectrum of possible part properties, which are suitable for the most demanding applications and yield the highest possible weight specific properties (Fig. 5). Due to the general usage of the injection molding technology, complex geometries can be manufactured and enhance the usually limited geometrical freedom of continuous fiber reinforced thermosets, allowing for a thorough funcationalization.

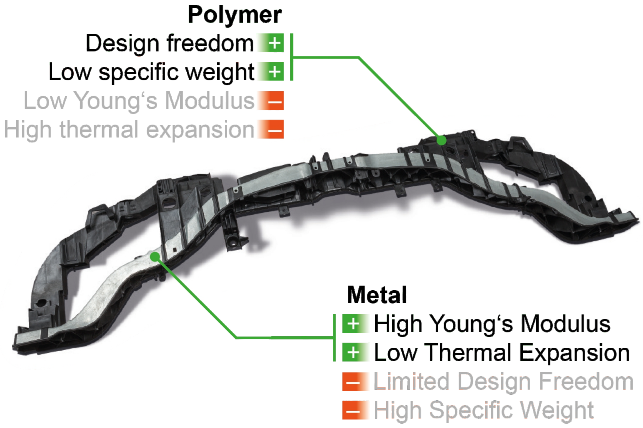

Fig. 3: *Synergetic utilization of the characteristic material advantages for polymer-metal hybrid structures in the Ford C-MAX front-end carrier with an adhesive promoter to increase the performance*

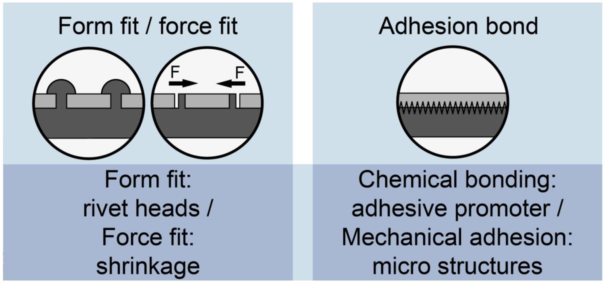

Fig. 4: *Joining mechanisms of polymer-metal hybrid structures*

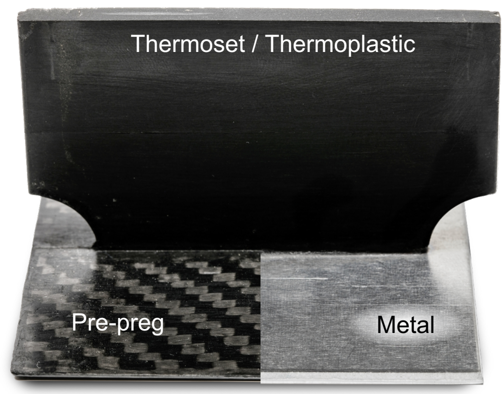

Fig. 5: Exemplary depiction of possible material combinations for thermoplastics and thermosets shown for a rib sample manufactured by injection molding

Research Objects and Service for Industry

- Thermoplastic and thermoset injection molding
- Development of thermoset compounds
- Processing characterization of fiber-reinforced polymers
- Processing simulation of fiber-reinforced polymers
- Joining of polymers and metals
- Testing and failure analysis of polymer-metal hybrid structures

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