Friedrich-Alexander-Universität
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Welding of Thermoplastic Polymers

Motivation

The joining of polymers often represents a main task within the manufacturing process chain. By connecting several components, it is possible to circumvent existing restrictions of the primary shaping process by polymer assemblies. Furthermore, multi-material design enable more efficient use of material-specific properties by combining different types of polymers and their specific material characteristics. Hereby, a sustainable and resource-saving production can be achieved.

Application

Welding is exceptional in its possibility to produce parts with high joint strengths without the use of additives. Industrial applications can be found especially in the automotive and medical industry, in household appliances as well as in pipeline and tank construction (Fig. 1). The heat input during the joining process can be introduced in various ways, such as friction (e.g. vibration or ultrasonic), infrared radiation or heat conduction. In addition, combined heating mechanisms are possible (e.g. infrared preheating for vibration welding). The novel multi-function welding machine of the Institute of Polymer Technology (LKT) combines three heating mechanisms - vibration, ultrasonic and infrared (area or spot) - and can be used individually or in any combination for joining multi-material joints (Fig. 2).

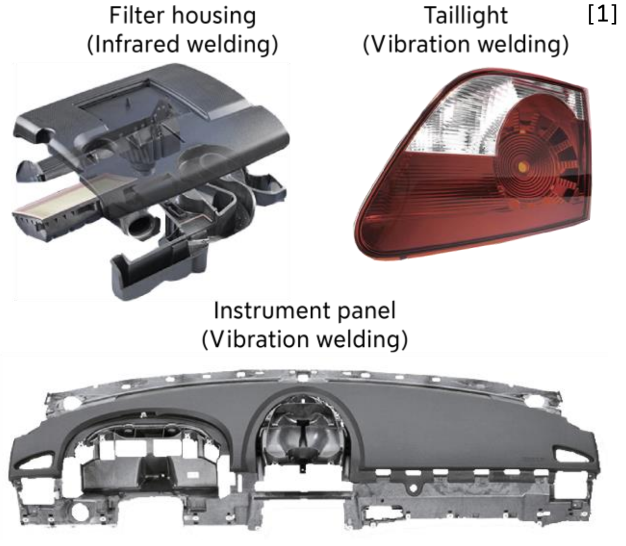
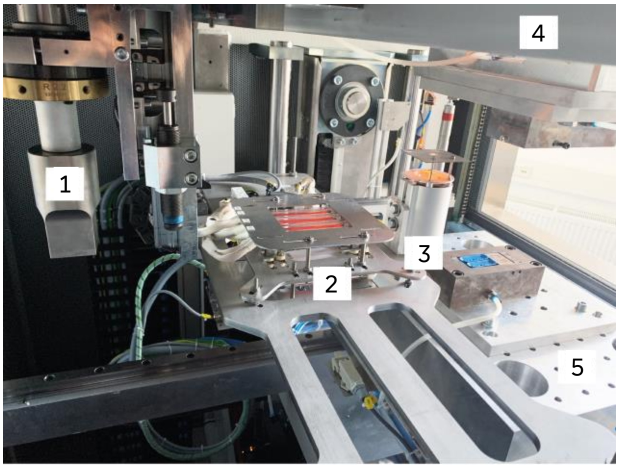


Fig. 1: Applications of welding



1: ultrasonic horn 2: IR-area emitter 3: IR-spot emitter
4: vibration-head 5: maschine table

Fig. 2: Multi-functional welding machine

[1]: bielomatik GmbH

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Research focus

In terms of sustainable and resource-saving production, the trend is moving towards intelligent multi-material solutions and locally resolved part properties. The complex material-process interactions lead to a limited spectrum of possible material combinations in welding. Activities of the LKT focus on the development of new processes for multi-material joints. Further, welding is transferred to new manufacturing processes like selective laser sintering (LS) (Fig. 3). Such processes offer the possibility to individualize serial components by customized LS parts. LS-specific influences (e.g. change in porosity and morphology, deviating surface roughness and absorption properties) significantly affect the welding process.

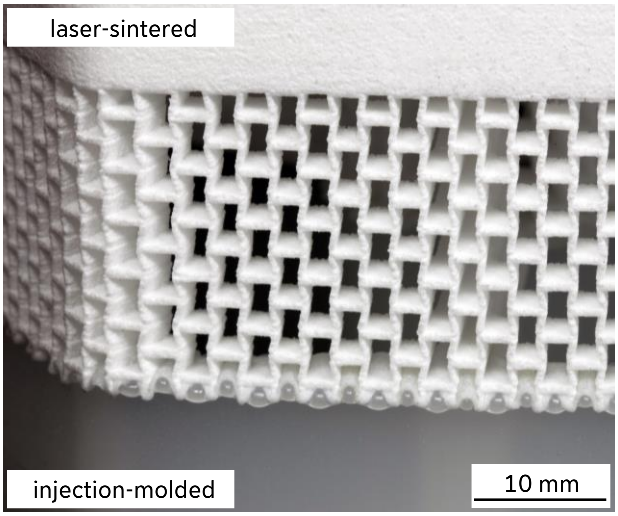

Fig. 3: Weld joint between injection-molded component and individualized laser-sintered part

Main research results

High bond strengths for joints between LS parts as well as between LS and injection-molded parts are achieved. Striking is the deviating seam structure for welded LS components, which has been attributed to material- and LS-process related influences. Infrared-welded LS parts, for example, exhibit a clearly increased residual melt layer thickness and have no multilayer structure (Fig. 4). LS-specific effects on the welding process are especially noticeable in the build-up direction. Complex or thin structures can be welded by IR in particular due to the lower stress and contactless heating.

Apart from functionalization, local property variations can be achieved by cross-linked materials. Here, radiation cross-linked polymers reach high short-term strengths by welding. Long-term properties depend in particular on internal stresses in the weld seam. However, long lifetimes are achieved by vibration welding. This opens up a wide field of new applications for cross-linked polymers, especially in the building sector.

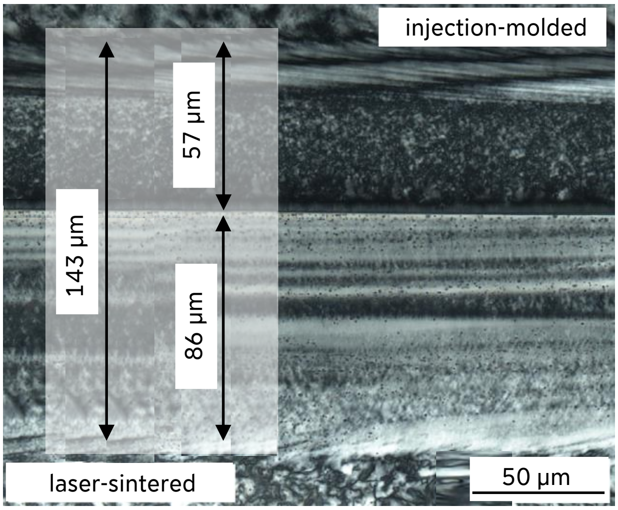

Fig. 4: Morphological weld seam structure of infrared-welded joint between laser-sintered and injection-molded part

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