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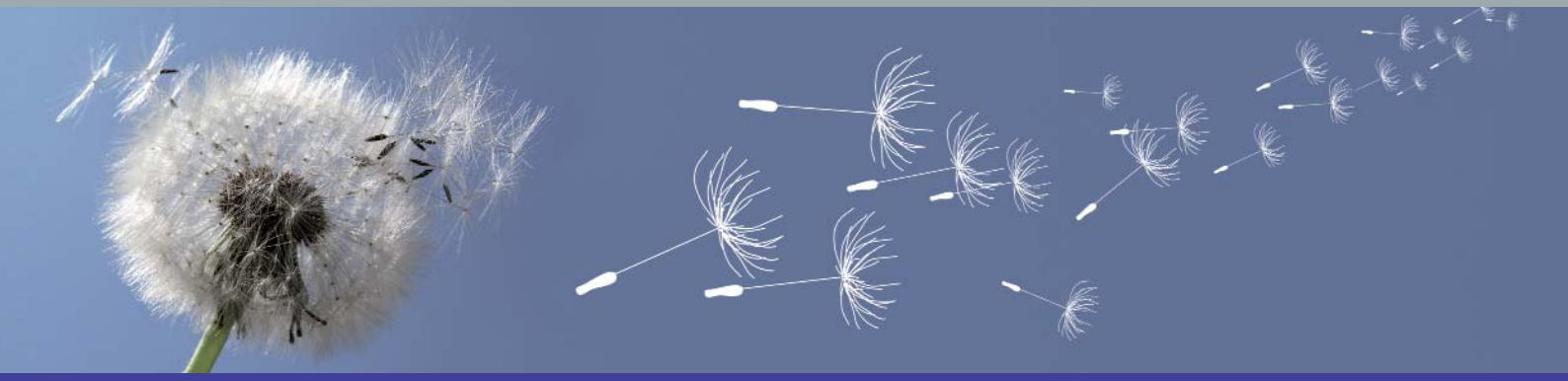
FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS



MOBILITY – EXTRA LIGHT!!!

Laser technological development for innovative lightweight structures

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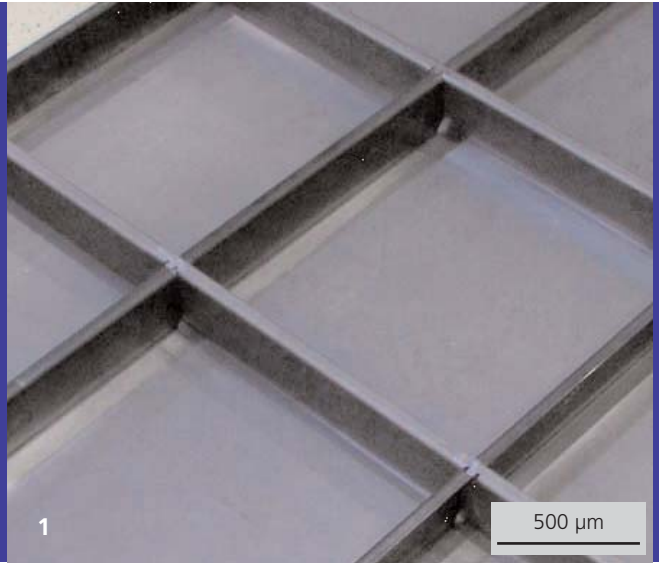
The lighter – the better! This slogan has been the driving force in the automotive industry ever since. Innovative lightweight construction requires a weight reduction without reducing stiffness, cyclic stability and strength. New materials, joining technologies and lightweight structures help to reduce weight. Every gram less means less fuel consumption and less carbon dioxide emissions.

One essential core expertise of the Fraunhofer IWS is the development of manufacturing technologies and concepts to process novel lightweight materials. IWS scientists present selected examples for laser applications to realize lightweight concepts.

1. Laser welding process in gear manufacturing

Transmission elements consist of shafts with mechanically mounted or welded components such as gears, cams, gear parts, cardan shafts and others. These are essential elements in powertrain constructions. They are, however, typically manufactured from hard-to-weld heat treatable steel or case hardening steel.

One of the IWS core competencies is the development of joining processes for heat treatable and case hardening steel. The ability to weld cast-iron differential baskets with gears made of Q&T steel implies a weight saving of 1.2 kg per part. Since there are no clamping or screwing processes necessary, substantial cost-reductions can be achieved.



2. Laser welded integral structures for lightweight constructions

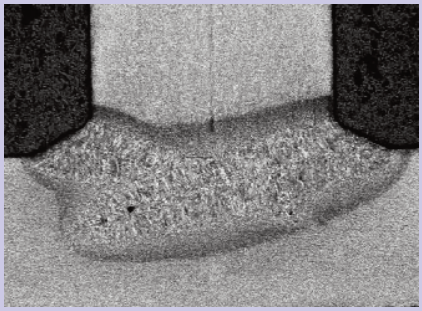
Railroad vehicle assemblies such as side walls of railway cars are currently manufactured in a differential construction. The connection of the outer skin sheet metal to the stiffener is typically welded via point welds in overlapped joints.

Basing on integral construction, the IWS scientists have developed a novel process with a full-depth connection to the stiffener. The basis of this construction is the T-joint. Thus you can avoid overlapping material and achieve a significant reduction in weight.

Furthermore L-shaped stiffeners are still applied and allow a simplified dimensioning of integral nodes. Dual laser beams under low incident angles are applied to simultaneously weld the stiffening elements from both sides.

Sometimes, under certain circumstances, it is also possible to apply single side welding. The key objective for the process design is a full connection of the fin cross section at minimized material heat exposure. A process-integrated mobile clamping jig accomplishes the exact positioning and fixation of the elements to be welded.

Cross section of a double-sided T-joint



Advantages of welded integral structures

- reduced weight of the component
- constantly high seam quality
- high welding velocity of presently more than 4 m/min
- reduced auxiliary process times
- improved structural strength
- low component warpage due to the minimum heat input
- minimum angular distortion
- improved corrosion resistance due to gap avoidance
- minimum damage of the surface quality at the visible side of wall

3. Patchwork structures for lightweight body constructions

Metal sheet parts are required to constantly increase mechanical strength and stiffness and, at the same time, to reduce weight. The patchwork procedure offers a novel answer to locally optimized parts. The principle is to minimize the metal sheet thickness wherever possible and to reinforce the basic blank with additional smaller patch sheets in areas with higher local mechanical loads. The two metal sheets are welded when they are still flat and are formed after the welding process.

The laser remote welding technology is a very efficient method to adapt the patch shape and seam contours to the expected load. The high seam strength guarantees the safe transfer of the forming forces and a flawless function. The advantages of the patchwork technology are a definite material reduction and the possibility to manufacture structures with high load bearing capacity at minimized weight.

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4. Laser welded slot-tab joints

Research developments in the field mobility have two basic requirements of utmost interest: novel, energy-efficient drive concepts and reduction of the total weight of the vehicle. The realization of low-cost and resource-saving lightweight structures is the adequate answer. Economical, flexible, reliable and scalable solutions have to be found because of the huge variety of most different vehicle categories.

Due to the minimized effort for clamping devices and the flexible use of laser procedures, the application of self-centering slot-tab joints is a very cost-saving alternative manufacturing process.

5. Localized laser strengthening to improve crash behavior

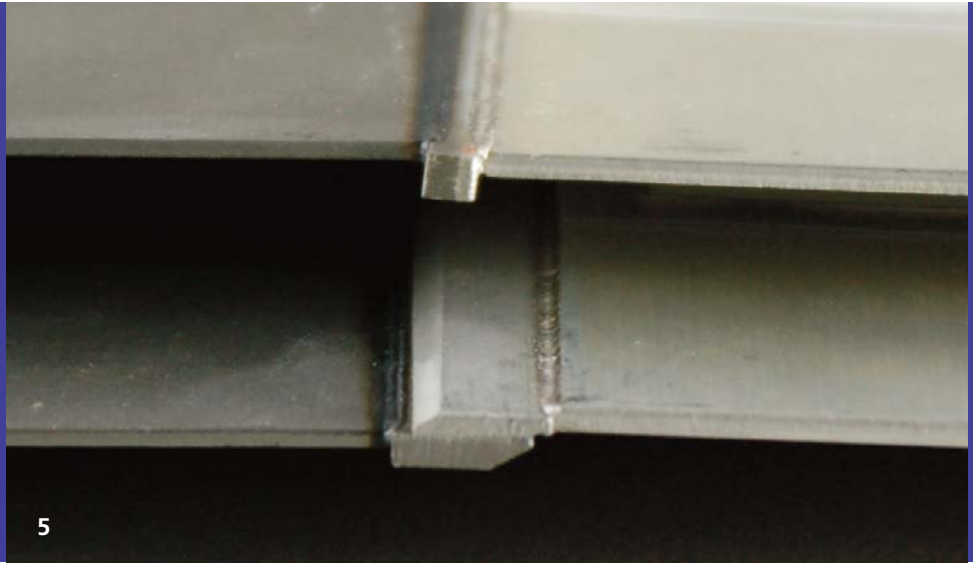
High strength materials such as cold hardened multiphase or press hardned steels increasingly realize lightweight concepts in the modern car body manufacturing industry. However, the processing of such high strength material is very challenging due to the reduced forming capacity. One novel IWS approach is to integrate localized material strengthening in car body components. The goal is to modify the material's microstructure in part areas to high operational loads via laser beam. The increase of the locally tolerable loads and the realization of a controlled part failure imply a significant improvement of the crash behavior.

The application of high power lasers with corresponding beam shaping is a very promising technological approach. It answers the demand to precise heat input and to the modulation capacity of the temperature field.

The manufacturing costs can be significantly reduced due to the parallel utilization of existing laser systems, the fact that you can form in unstrengthened conditions and the possibility to integrate laser strengthening into the process step.

Slotted aluminum cover plate with welded tab made of galvanized steel

1 Laser welded integral structure (1.25 m x 1.25 m for railway vehicles)
2 Demonstrator: engine hood with edge relaxed patch
3 Laser welded slot-tab joints made of galvanized metal
4 Laser penetration welding strengthened pipes show improved failure behavior during compression test



6. Tailored bimetal connectors

The key to resource-efficient lightweight construction solutions in future traffic systems are multi-material systems with tailored material combinations. Since suitable efficient joining procedures for these materials are lakking, these tailored material combinations are hardly applied.

The industrial implementation of a novel joining technology, the so-called inductively assisted laser roll plating, solves this problem. A very short simultaneous high temperature input and a mechanical clamping at the joining surface is the principle of the short time diffusion press joining process. This principle is realized through the simultaneous input of inductive and laser energy onto the metal strips and the roll gap.

The procedure enables to join the most important material combinations steel/aluminum, aluminum/titan and aluminum/magnesium in a very efficient and cost-saving way. It realizes joinings of 5 - 20 mm highly loadable areas with velocities of 30 m/min. These bimetal connections are further treated with forming or joining procedures.

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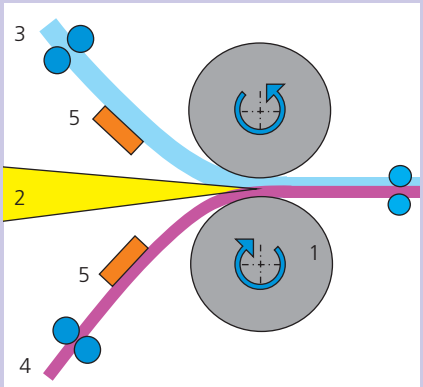
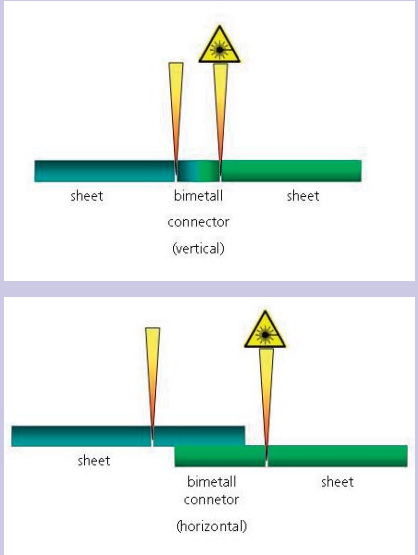
Principle of a laser induction roll plating process



1 roll couple
2 laser
3/4 strip material
5 inductor

Principle of laser welding procedure with bimetal connectors



5 Bimetal connector with laser welded aluminum and steel sheet