LASER WELDED LIGHTWEIGHT PROFILES OF INTEGRAL MIXED DESIGN

THE TASK

The lightweight construction of car bodies is critical to meet future targets for reduced CO_2 emissions. Crash relevant parts of the body are made from high strength steel. These can absorb large amounts of energy. Alternatively lightweight alloys are used with low specific weights. The currently used mono material designs offer very limited opportunities for further weight reduction while maintaining mechanical strength.

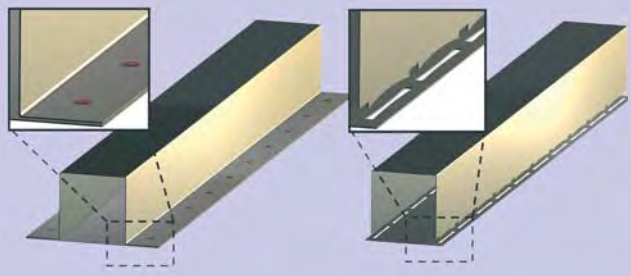
Innovative laser welding technologies enable the implementation of new construction principles. These lead to significant weight reduction without compromising mechanical strength. In addition this construction technology is also very cost efficient. The starting point was the development of a new hybrid construction method for strength engineered crash profiles. This was accomplished by laser suitable integral construction and mixed metal construction. To effectively exploit lightweight construction principles the components and joining geometries are designed using FE crash simulations.

The development work pursued the following goals:
- reduction of the component weight if compared to conventionally welded structures
- maintaining or increasing the crash strength
- optimization of crash component designs using FE crash simulations

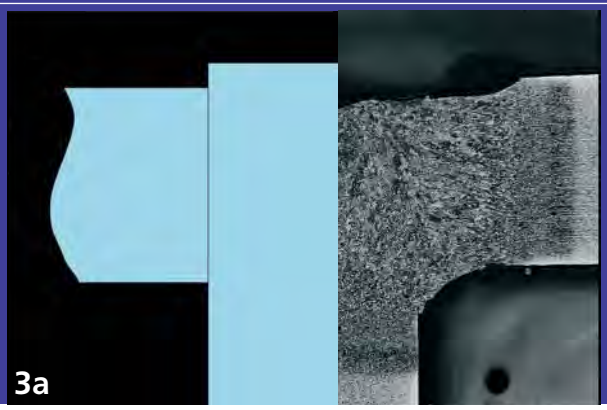
OUR SOLUTION

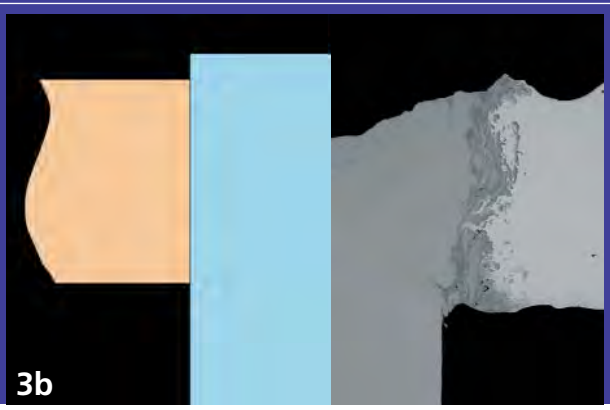
Conventional differential construction with resistance spot welding requires relatively wide flanges for lap joints. In some cases these account for up to 20 % of the total component mass. Laser beam welding is suitable to perform a novel integral plug-in construction method (Fig. 2). FE simulations help to select appropriate materials for the individual components depending on the part loading. These methods are also applied to select the geometries of the semi-finished parts and of the joint.

Construction principles during joining (left: spot welding, right: plug-slot joint)



Laser remote welding processes perform the welding of the plug-slot joints. The lateral width of the melting zone is adjusted by beam scanning. In coordination with the remaining parameters this process can make a complete connection in mono material design (e.g. steel-steel) and it can also selectively melt the plug material for mixed material joints (steel-aluminum, Fig. 3b).



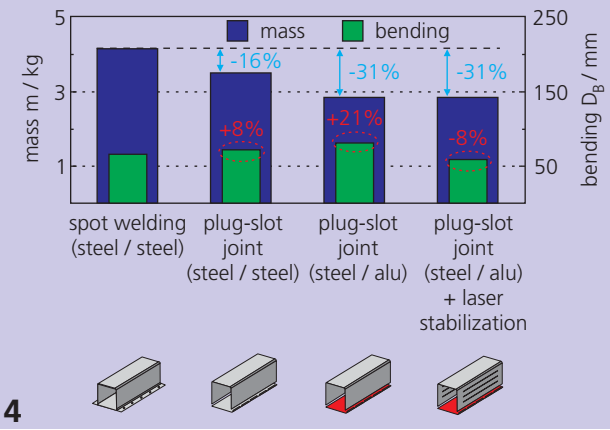


RESULTS

FE crash simulations (PAM CRASH, Shell model) were used to optimize a demonstrator part (Fig. 1 and 2) for minimum weight and maximum strength. The integral plug-in design eliminates the welding flanges leading to a weight reduction of 16 % compared to a spot welded reference part. If the steel cover sheet would be replaced by aluminum the total weight reduction could be 31 %.

Fig. 4 shows the results of the crash simulation of a 3-point bending load for various designs. The plug-slot profiles in steel-steel configuration have comparable structure deformation as the spot-welded reference profile. The steel-aluminum (plug-slot / steel-alu) design has reduced stiffness, which can be compensated by adding local stabilizing structures placed in the plates of the steel U profile (plug-slot/steel-alu + laser stabilization).

Simulation results for component weights and crash deformations in a 3-point bending test



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The addition of the stabilizing structure is accomplished using laser hardening. The material strength in the plastic deformation zone is locally increased (see annual report 2009, pages 38/39).

Laser welded integral mixed designs open manifold opportunities for savings. The elimination of welding flanges does not only reduce weight but also saves space. Due to the implementation of linear joints the specific strength increases compared to spot-welded designs. Accessibility limitation to only one side of the part is sufficient for laser beam welding. Part designs can be very compact and thus cost effective manufactured.

1 Laser welded lightweight profile of integral mixed design

3 Cross section image and principle sketch of plug-slot joints,
a) steel-steel,
b) aluminum-steel

CONTACT

Dr. Axel Jahn
phone +49 351 83391-3237
axel.jahn@iws.fraunhofer.de