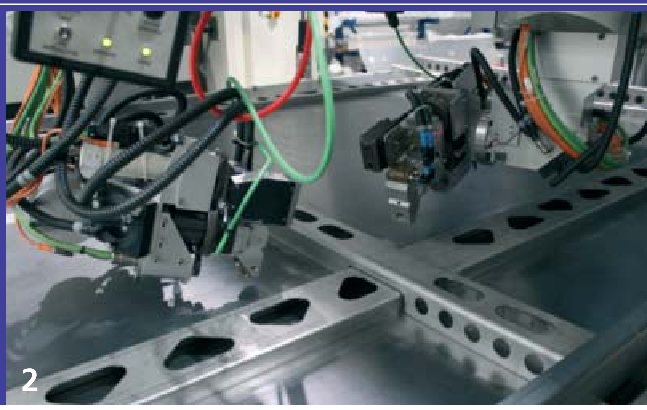
1



2

LASER BEAM WELDED LIGHTWEIGHT SIDEWALLS FOR RAILROAD VEHICLES

THE TASK

Railroad vehicles would greatly benefit from inexpensive and lighter sidewalls. The manufacturing of such sidewalls requires new designs and new manufacturing concepts. A promising lightweight manufacturing concept is the fabrication of welded and fully connected integral structures. This approach requires a highly efficient welding process with low heat impact such as offered by laser beam welding using modern brilliant beam sources. The process in combination with new sidewall designs reduces the number of individual parts, weight and manufacturing times.

Developing such a sidewall was the objective of a publicly funded project. The project partners primarily aimed at a strategy to weld the U-shaped longitudinal and horizontal stiffeners to the thin and curved outer skin panels. An actual welding experiment had to demonstrate the feasibility of this novel sidewall concept.

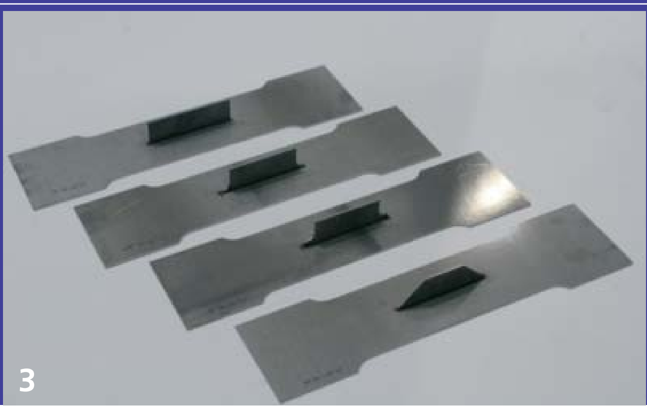
OUR SOLUTION

The first step was to mathematically estimate the strain that the welded joints would have to withstand under realistic conditions. The required input data were obtained from cyclic force tensile fatigue testing. The goal was to find suitable geometries for the start- and endpoints of the seams. These have to be insensitive to cyclic loading, which is a permanent condition during operation of railroad vehicles.

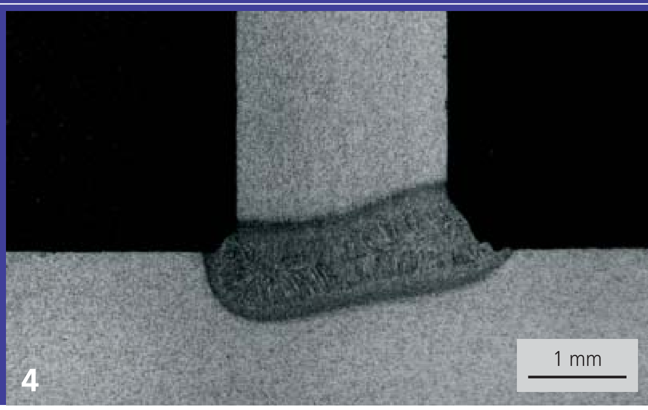
The efficiency of laser welding increases with seam lengths since handling and positioning times become less relevant. Therefore the sidewalls were designed to maximize seam lengths.

The actual manufacturing process consists of two steps. First the continuous longitudinal stiffeners are welded followed by welding the interrupted horizontal stiffeners. Prior to welding the stiffeners, they are tacked to the panel with high accuracy applying low laser power. The Fraunhofer IWS welding system is equipped with two DC045 CO_2 lasers. Tacking and welding can be simultaneously performed from both sides of the wall (Fig. 1 and 2). This approach reduces the risk of tilting the sections, as could occur if the welding is performed one side at a time.

Optical sensors monitor the position of the seam during the laser welding process. The welding of the longitudinal stiffeners is monitored online. The sensor runs ahead of the laser and detects intersections of stiffener section and skin panel. Geometric data analysis reveals the desired seam location to position the welding optics. Online monitoring does not work for the interrupted cross stiffener sections. Here the optical sensors detect the welding position offline. The data are first stored and then processed via NC software.



3



4

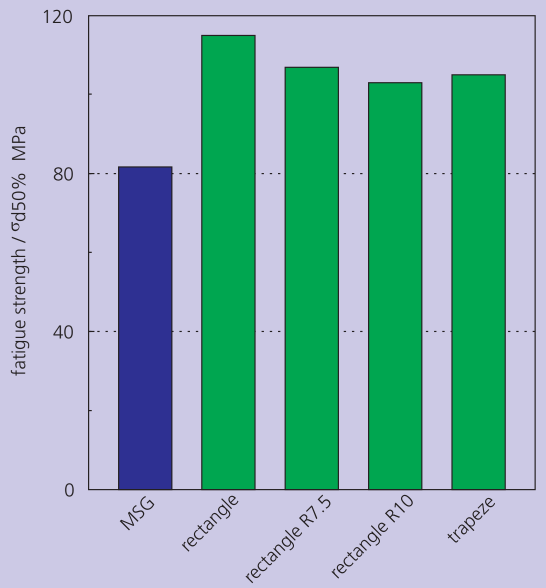
RESULTS

Samples were prepared using the welding process for longitudinal stiffeners and then subjected to fatigue testing. Steel S355 served as the reference material. Stiffener sheets were welded to flat samples aligned along the direction of fatigue strain. The stiffener panels were rectangular and trapezoidal sheets of identical overall length and height. The test sample batch with rectangular stiffeners had two additional variations with different transition radii (Fig. 3). Metal inert gas welded reference samples with rectangular stiffeners were also tested.

An important result of the fatigue test was that all laser-welded stiffeners yielded substantially higher fatigue strengths than the metal inert gas welded samples (Fig. 5).

The project also demonstrated the feasibility of building the complete sidewall structures using laser welding. The optimized design, the precision of the fabrication of the individual parts and the use of flexible fixtures allow for an almost gap-free welding of the stiffeners to the outer skin panels. Since high quality laser beam sources were used, it was not necessary to apply filler wire to close gaps during the welding process.

Comparision of fatigue strength



5

Based on redesigning the overall fabrication process of such sidewall structures it was possible to produce them with little distortions. The number of individual parts, the weight and the manufacturing times were reduced. Manual post-treatment is usually very expensive and time consuming. The developed process drastically reduces post-treatment requirements in series production of railroad vehicles.

The project “Segmented trams in ultra lightweight construction and structurally integrated design” was funded by Saechsische Aufbaubank (project number: 100508762).

1 *Laser beam welded sidewall*

2 *Section of the sidewall with welding optics for cross stiffeners*

3 *Test specimen for fatigue testing*

4 *Polished cross sections of single-side welded T-joint*

CONTACT

Dipl.-Ing. (FH) Jens Liebscher

phone: +49 351 83391-3288

jens.liebscher@iws.fraunhofer.de