Laser Welding of AHSS

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TRUMPF

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Advantages of Laser Welding

Advantages of production laser welding

- Minimum heat input and high aspect ratio resulting in …
  > minimal shrinkage & distortion of workpiece (improved dimensional accuracy)
  > small heat affected zone
  > narrow weld with good appearance

- High strength welds often resulting in …
  > improved component stiffness / fatigue strength
  > reduction of component size / weight
  > continuous weld possible

- Ability to weld in areas difficult to reach with other techniques
  > non-contact, narrow access, single sided process

- Easily automated with accurately located welds
  > consistent weld penetration / geometry / quality
  > ability to integrate into existing equipment / production lines

Advantages of Laser Welding

Resistant Spot Welding

Laser welding

Weight Saving
Advantages of production laser welding - continued

- Flexibility …
  - beam manipulation (beam switching and sharing)
  - variety of product geometries and materials
  - ease of back-up (especially YAG)

- Often greater throughput than other techniques …
  - high power density weld process yields high process speed
  - high laser uptime (>98%)

- Cost savings …
  - high productivity yields reduction of equipment, less floor space
  - reduction of component material and weight
  - can eliminate secondary processes

Seam & Joint Types

Seam- and joint types

<table>
<thead>
<tr>
<th>Name</th>
<th>Example</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| I- Seam on joint, butt joint | ![I- Seam on joint, butt joint](image) | + energy transmission  
|                          |         | - positioning tolerance              |
| I-Seam on lap joint      | ![I-Seam on lap joint](image) | + positioning tolerance  
|                          |         | - weld fusion area                   |
| Fillet weld on lap joint | ![Fillet weld on lap joint](image) | + weld fusion area  
|                          |         | - positioning tolerance              |
| Fillet weld on T-joint   | ![Fillet weld on T-joint](image) | + weld fusion area  
|                          |         | - positioning tolerance              |
### Seam & Joint Types

<table>
<thead>
<tr>
<th>Name</th>
<th>Examples</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>I- seam on T-joint, border joint</td>
<td><img src="image1" alt="image" /></td>
<td>+ positioning tolerance</td>
</tr>
<tr>
<td>(hidden T-joint, border joint)</td>
<td></td>
<td>- weld fusion area</td>
</tr>
<tr>
<td>I-seam on flange</td>
<td><img src="image2" alt="image" /></td>
<td>+ weld fusion area</td>
</tr>
<tr>
<td>Edge weld on flange</td>
<td></td>
<td>- positioning tolerance</td>
</tr>
<tr>
<td>Edge-formed seam</td>
<td><img src="image3" alt="image" /></td>
<td>+ positioning tolerance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- weld fusion area</td>
</tr>
</tbody>
</table>

### Seam Tolerances

**Butt joint configuration:**
- Gap: 3-10% thickness of thinnest sheet
- Offset: 5-12% thickness of thinnest sheet

**Overlap joint configuration:**
- Gap: 5-10% thickness of thinnest sheet

**Why is this general guideline not absolute?**
(What influences the amount of gap that can be bridged?)
**Keys to Success**

- Design components for laser welding (flange widths, gauge thicknesses, single sided access)
- Maximize laser “beam on” time (i.e. time sharing of beam to multiple stations)
- Good part fit-up req’d via part tolerances & fixturing
  - Butt weld: edge preparation, gap <10% of \( t_{\text{min}} \), seam location
  - Overlap weld: gap < 10% of \( t_{\text{min}} \)
- Parts must be clean & dry for optimum results (no dirt, rust, grease, heavy oils, sand residue)
- Zn coated steels in overlap configuration requires special considerations
- Assign laser welding champion (engineer, attitude/aptitude, teachable, can teach others)
- Early involvement of production personnel (ownership, design for service & maintenance)
- Partner with suppliers that have proven expertise, longevity & reputation

**The Motivation for the use of AHSS**

Golf 1

Safe cars with the help of AHSS

Golf 5
Customer Requirements

- Process Stability \(\uparrow\)
- Weight \(\downarrow\)
- Stiffness \(\uparrow\)
- Cost \(\downarrow\)
- Quality \(\uparrow\)
- Body designed for manufacturing

Customer Requirements

- Weight
  - ≤ 140 MPa
  - 180 - 240 MPa
  - 260 - 420 MPa
  - ≥1000 MPa

Material Trends – wide mix

Tensile Strength

- Example 2003 (Golf)
  - % of Body Weight:
    - 29%
    - 34%

- Example 2005 (Passat)
  - % of Body Weight:
    - 30%
    - 18%

www.autosteel.org
Different Materials - where & why

- ≤ 140 MPa
  - Outer Panels
  - Components with difficult forming operations
- 160 - 240 MPa
  - Parts with complex geometries used in areas with increased strength requirements
- 260 - 300 MPa
  - High strength steels
  - Structural parts with high strength requirements.
- 300 - 420 MPa
  - Crash area with high energy absorption
- ≥1000 MPa
  - Hot stamped
  - Structural parts with highest resistance against deformation

Applications for AHSS

- Part 1: ZSte260 (1.5 mm)
- Part 2: ZSte260 (1.5 mm)
  - CRPW800 (2.25 mm)
  - TRIP700 (1.75 mm)
- Part 2: 22 MnB5 hot stamped (2.00 mm)

Achieving the crash performance even with reduced weight and reduced number of parts.
New Automotive Materials

![Tensile Strength vs. Elongation Diagram](image1)

Example: VW Passat

![Example Image](image2)
Boundary conditions:

1. The strength of the weld nugget is lower than the strength of the parent material.
2. Thicknesses of up to 2 mm are utilized.

- Load bearing (force flow) should be done via joint design
- A larger weld width can be achieved by static or dynamic optical means (attached a micrograph of a twin-spot welded 3-layer joint)
Laser Processing of AHSS

- Shearing, trimming, punching => *Laser cutting*
- Engraving, ID stamp => *Laser marking*
- Tool wear and repair => *Laser cladding*

Hot Stamping at VW
How to label hot stamped parts?
Traditional engraving & stamps can not be used (wear).
Laser marking: No wear
Not weakening the part
Cost effective

Laser Marking

Laser Cladding

Automotive Industry
Trim Insert for cutting AHSS

SUPERALLOY

Trim Steel upgraded Superalloy

Existing Trim Steel

Hard surface applied with Laser Cladding allows:
1. Longer life
2. Repair
**Hard facing of nodular cast iron**

- No pre-heating
- Seamless transition from welded areas to parent material
- Welding on used tool surfaces

**Cast Iron with embedded cooling circuits**

**Summary**

- The steel industry offers new high performance steel grades => *Weight savings, Improved fuel efficiency, Improved crash performance, Potential for reduced manufacturing cost*
- The new steel grades require optimized car designs (*design for laser welding & laser welding principles for AHHS*)
- The new steel grades require the further development of joining methods, new tools, NDT-systems, etc.
- The laser is an established, flexible, industrial tool that addresses many of the challenges that arise from the use of AHHS (*welding, cutting, marking, hard facing*)
Thank you for your attention!

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