JOINING ALSI COATED BORON STEEL WITH BEAM SHAPING OPTICS

A GAME CHANGER FOR THE CAR BODY INDUSTRY

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TRUMPF Laser- und Systemtechnik SE

GREAT DESIGNS IN STEEL™

Agenda

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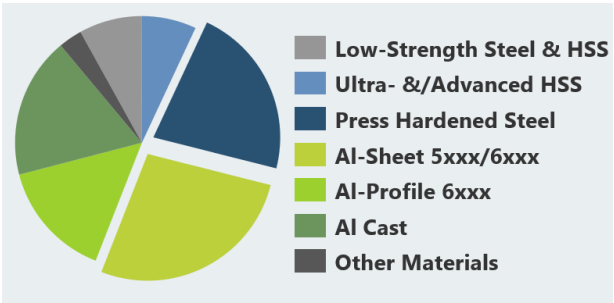
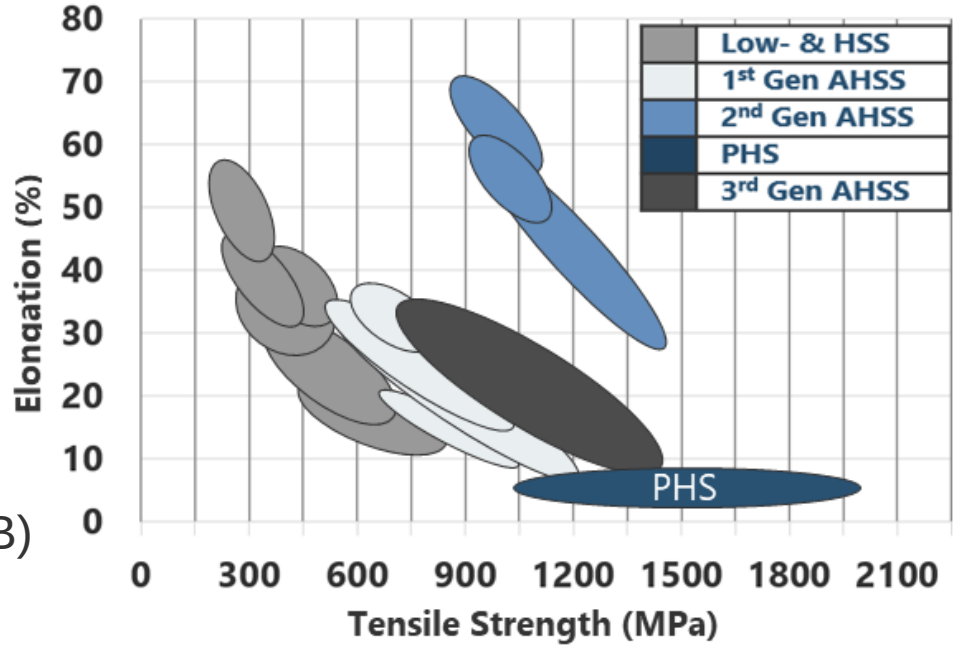
Market Requirements

BIW Material Mix



Trends…

- Higher crash performance requirement
- Trend towards Large Parts
- Increase in application of PHS
- Increase in application of Tailor Welded Blanks (TWB)



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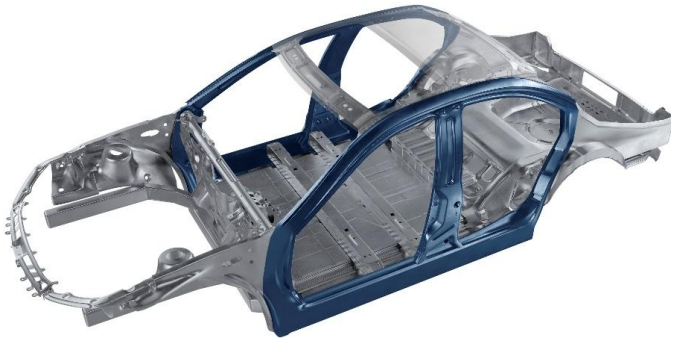
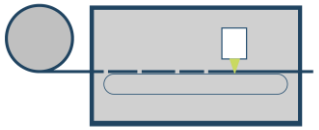
Market Requirements

Benefits of Tailor Welded Blanks:

- Reduce cost, weight and complexity
- Increase crash performance, material utilization

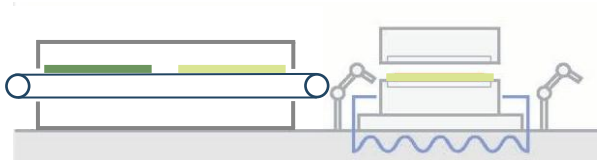




2-D Laserblanking

Laser ablation

TWB & Patchwork welding



3-D Laser trimming

Partial Laser Softening, Surface Engineering

Laser joints

Highly productive, flexible and sustainable manufacturing is key for future vehicle designs

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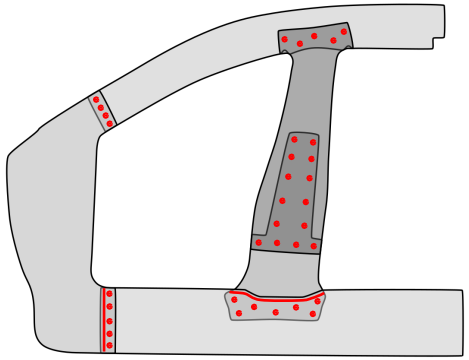
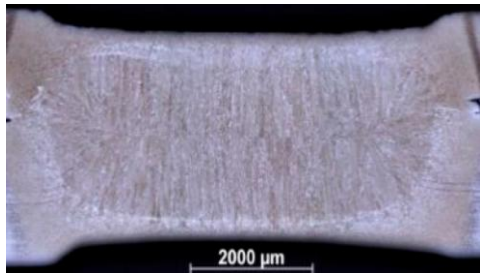
Joining Methods for Car Body Parts

Overlap Welded Blanks (OWB)

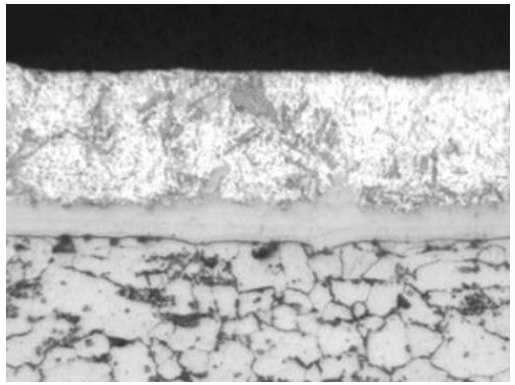


Resistance Spot Weld

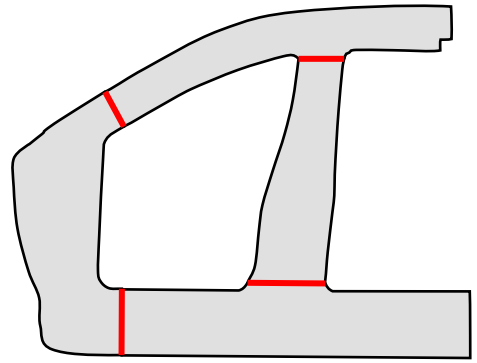


$t_{process}$ = ~2.5 seconds per spot

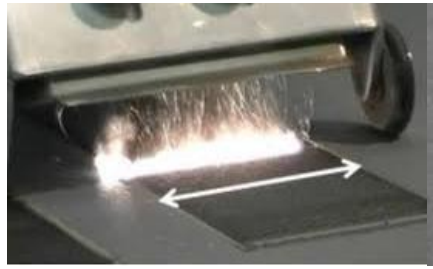
AlSi coating to prevent diffusion of hydrogen into austenite

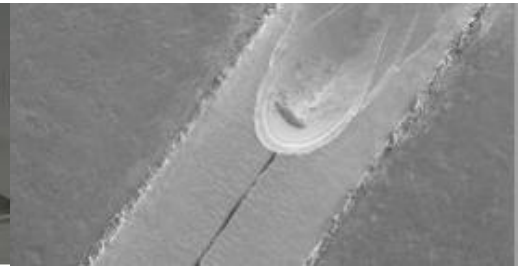


Butt Joint Tailor Welded Blanks (TWB)



Ablation of AlSi Layer Prior to Laser Welding





$t_{process}$ = 1 second per 100-200mm of weld seam

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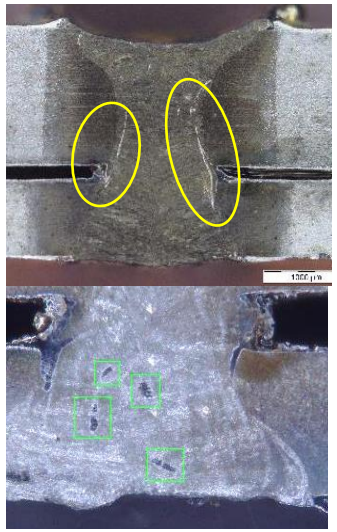
Joining Methods for Car Body Parts

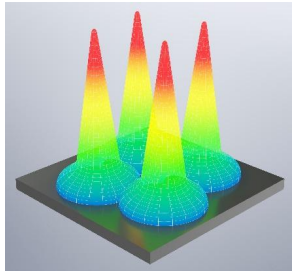
Laser Welding without Ablation of AlSi

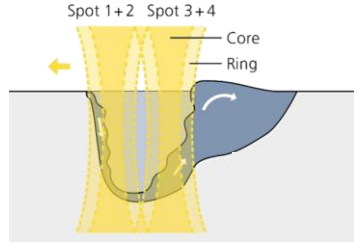
- Standard welding processes with laser investigated for several years already
- Challenge:
  - Ununiform mixture of AlSi in the weld seam
  - Loss of hardenability due to alpha ferrites
  - Embrittlement caused by intermetallic phases
- Mechanical criteria:
  - Hardness
  - Shear Strength
  - Formability



BLW + Multifocus Beam Shape

- Application: Overlap and butt joints of AlSi coated boron steel (22MnB5)
- Goal: homogenous distribution of AlSi inside the molten pool
- New approach: Ring beam shaping + multifocus optic for improved mixing of the molten pool
  - 4 laser spots with core and ring distribution





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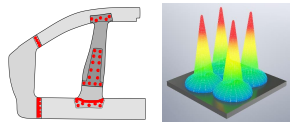
Laser Welding of Overlap Welded Blanks



SCOPE

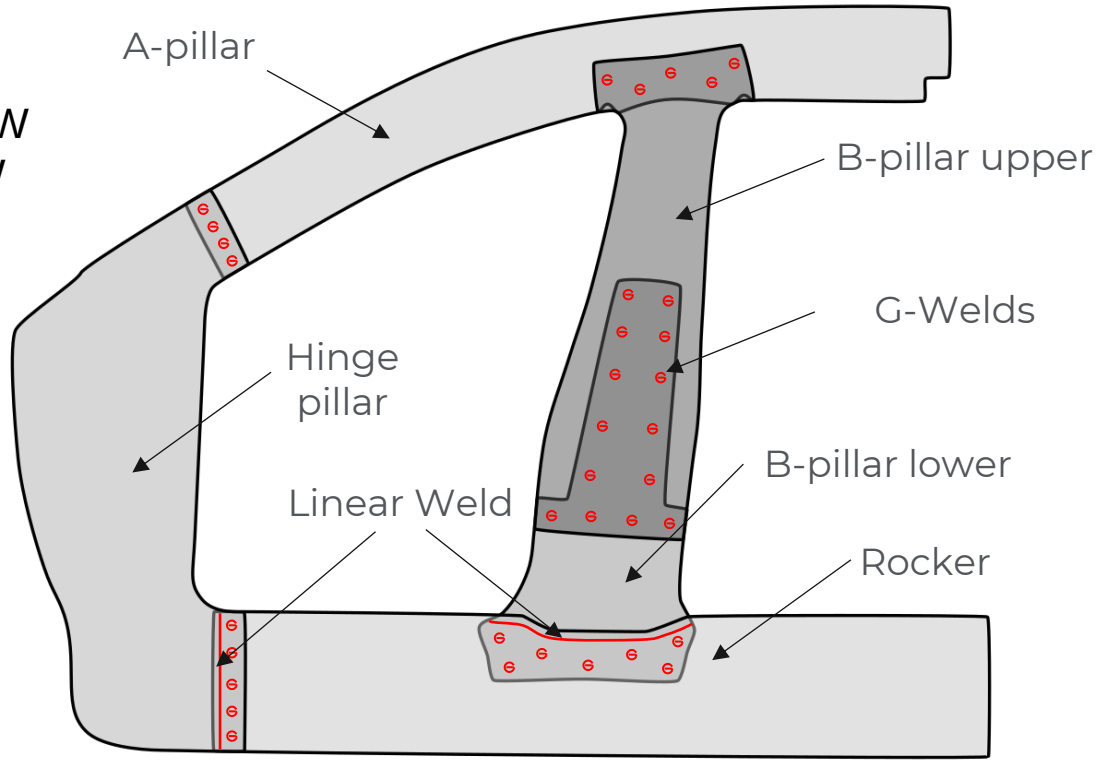
- The project was aimed to study the industrial application of LSW for patches and overlap welded blanks as a substitute for RSW

BENEFITS

- Faster process than RSW (welding and robot air move)
- Optimized Weld Geometries
- Can provide watertight welds within the blanks if needed.
- Reduce equipment cost, footprint and cycle time

CHALLENGES

- Achieve similar mechanical properties to RSW
- Maintain the formability of the part
- Maintain the crash performance



Door ring with LSW overlap patch

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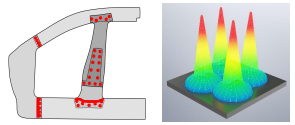
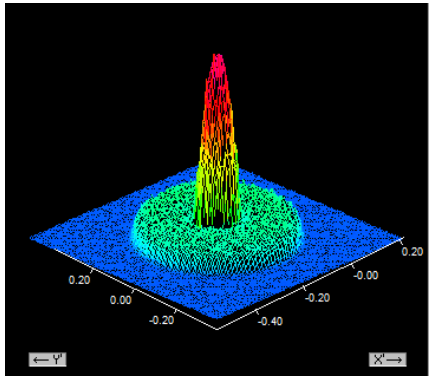
Laser Welding of Overlap Welded Blanks



GDIS

Insufficient Al distribution



Process jointly developed with Gestamp

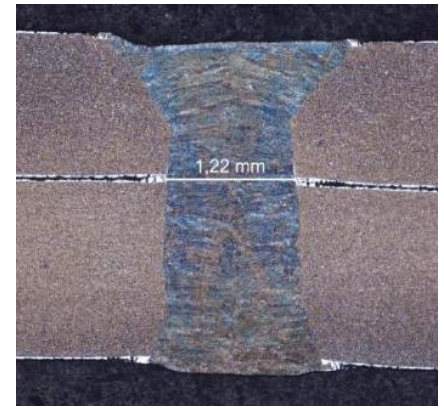
- **Laser power: IP**
- **Beam Shaping: IP**
- **Optics: IP**
- **Welding Speed: IP**

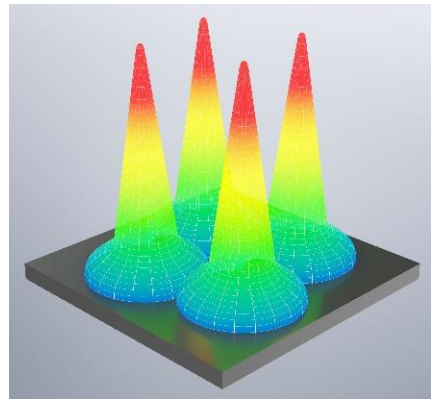
Approved & Tested by Gestamp

TRUMPFs ongoing evaluation

- **Laser power:** up to 7000 W
- **BrightLineWeld:** 200/700 µm fiber
- **Optics:** Ring beam shape + multifocus optics
- **Welding Speed:** up to 10 m/min

Homogeneous Al distribution





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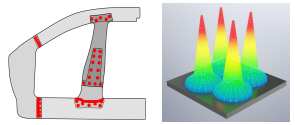
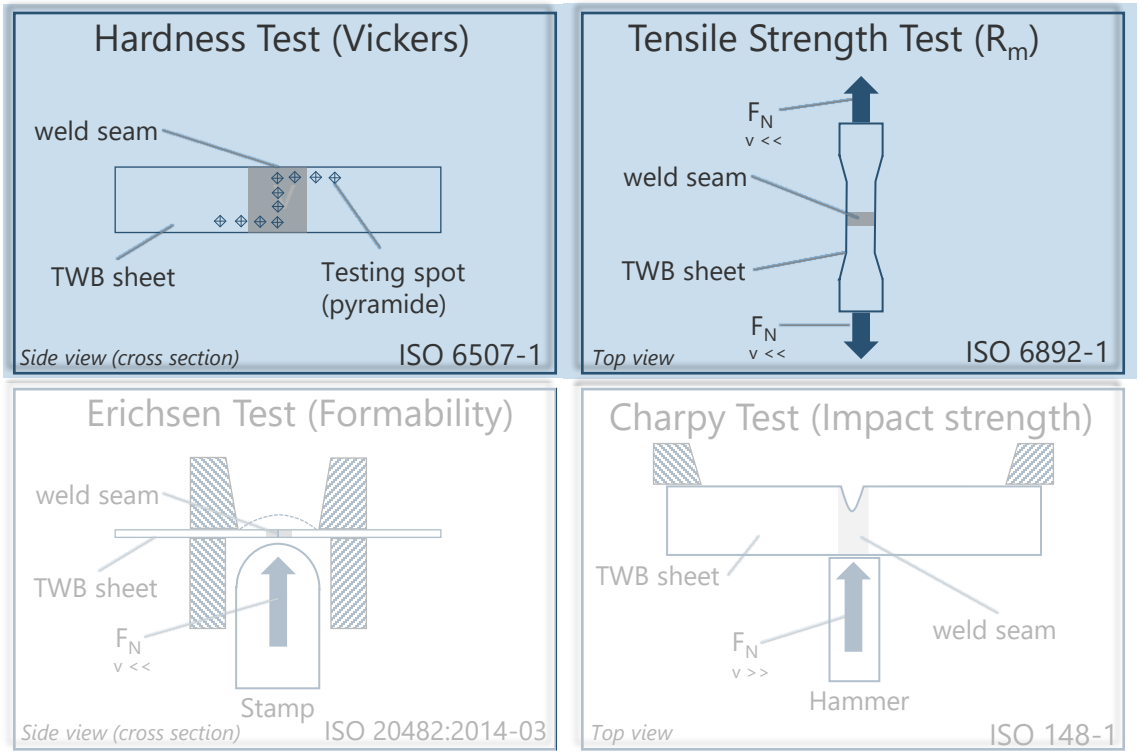
Laser Welding of Overlap Welded Blanks



Common test procedures on coupon level material



Failure modes OWB

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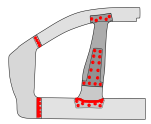
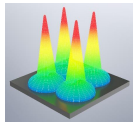
Laser Welding of Overlap Welded Blanks





Shear testing to define the best geometrical design for LSW to meet or exceed RSW properties.

All tested geometries were designed to have a similar welded area as a spotweld (≈ 45mm^2)

STANDARD WELDING GEOMETRIES

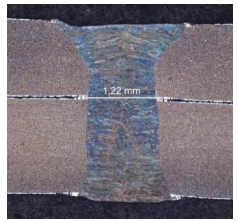
Staple: 

Zig-zag: 

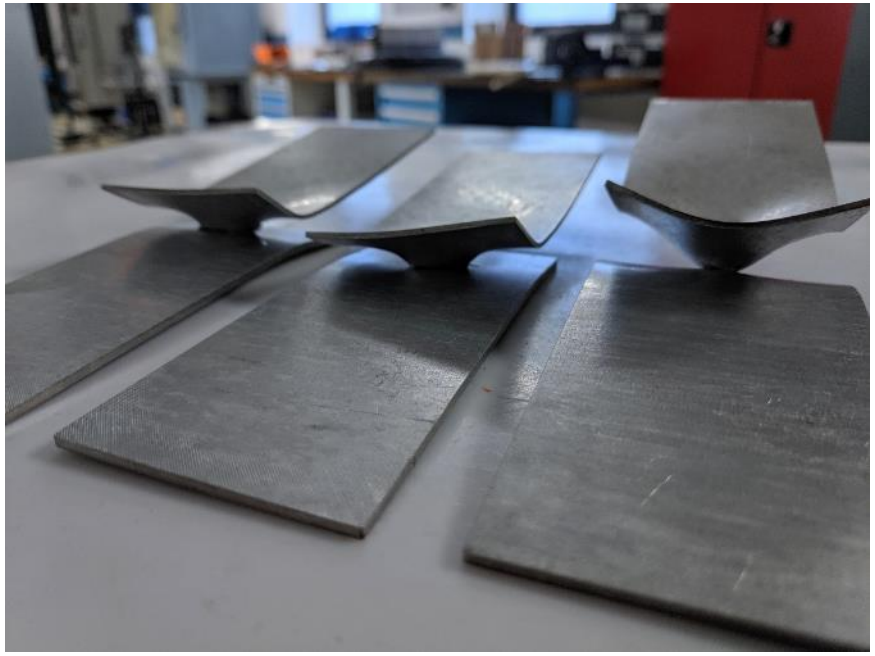
GESTAMP DEVELOPED GEOMETRY

G-Weld:

Patent Pending



$t_{process}$ = 645 ms



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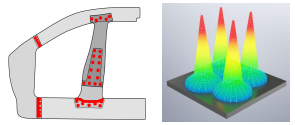
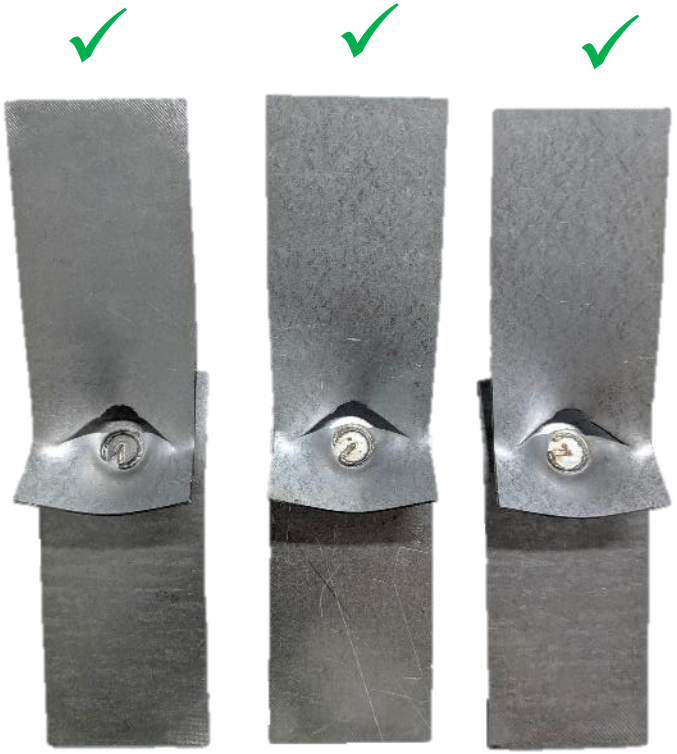
Laser Welding of Overlap Welded Blanks

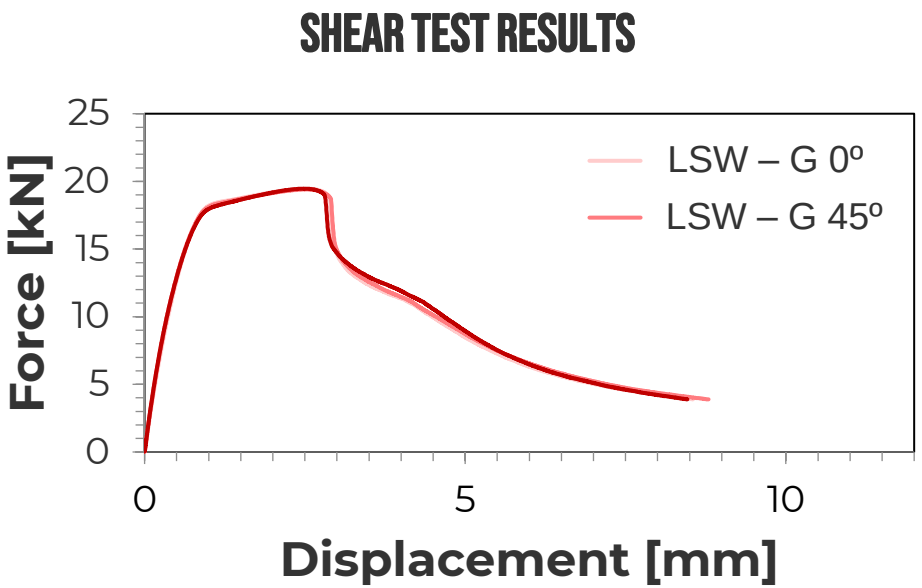


GDIS

"G" welds displayed the most consistent results, regardless of weld orientation



0º 45º 90º



HV1 > 400 for all investigated samples

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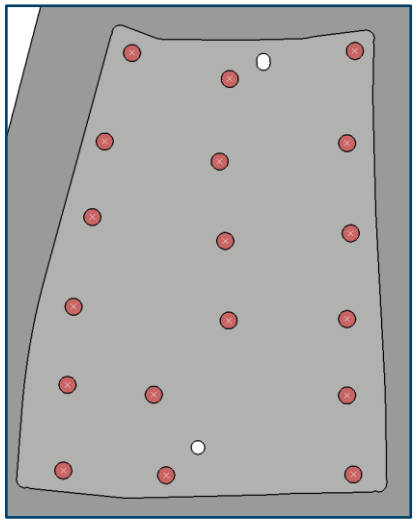
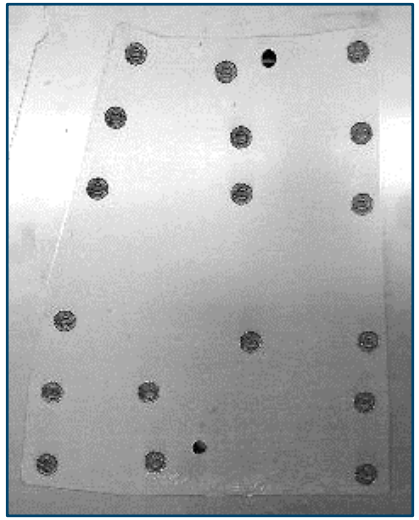
Laser Welding of Overlap Welded Blanks

VALIDATION STUDY ON REAL PARTS

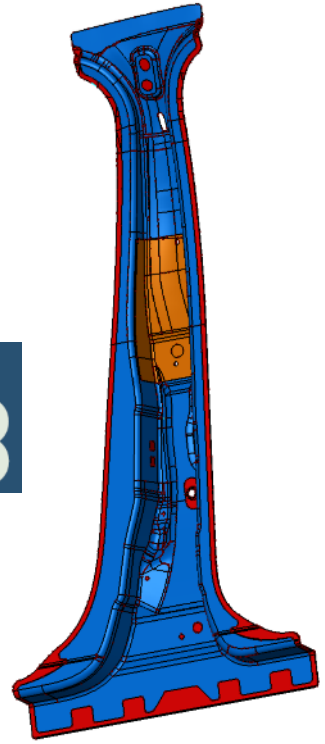
- Part selected from current production.
- Two different configurations were tested and analyzed.
  - RSW & LSW
- Validation of the crash behavior for LSW of a B-Pillar patch.



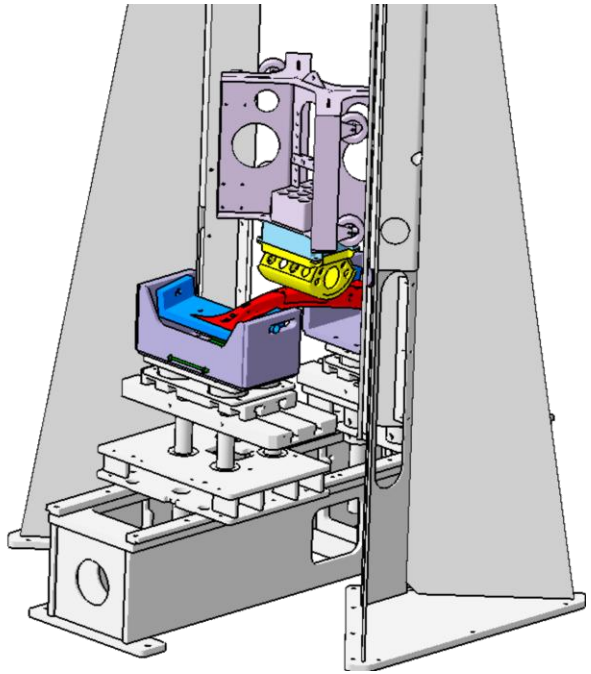
RSW



LSW G-WELDS



B-PILLAR



DROP TOWER SETUP

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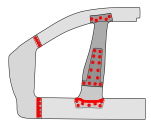
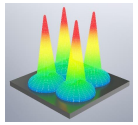
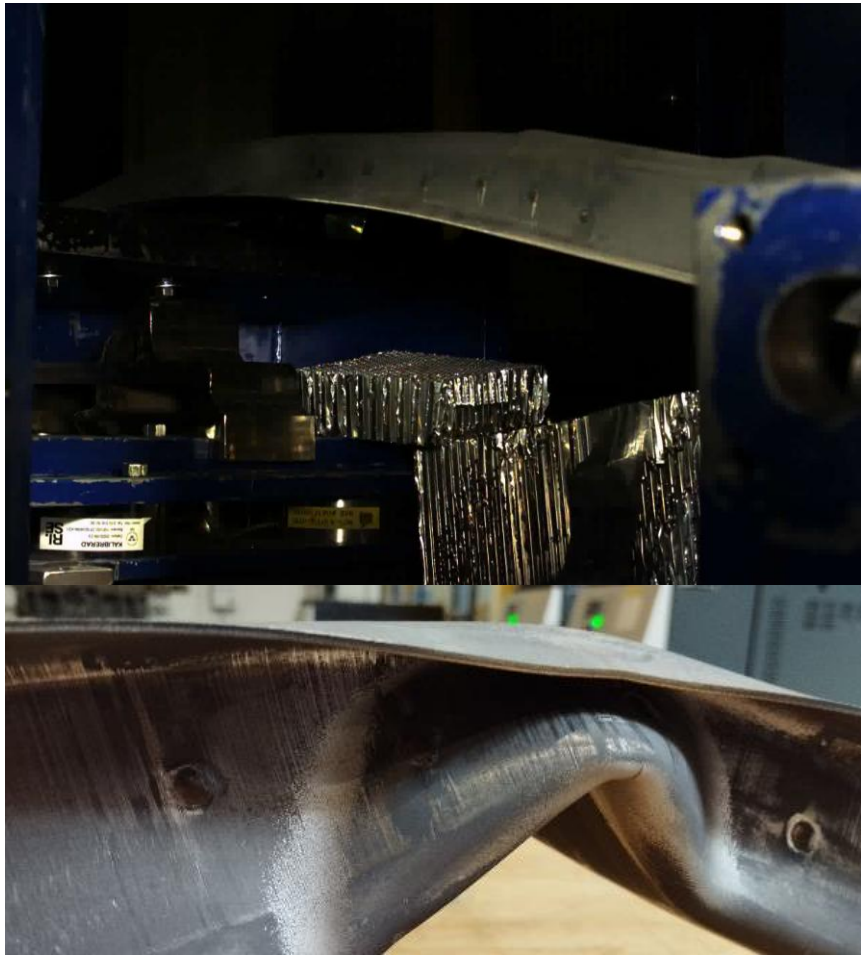
Laser Welding of Overlap Welded Blanks





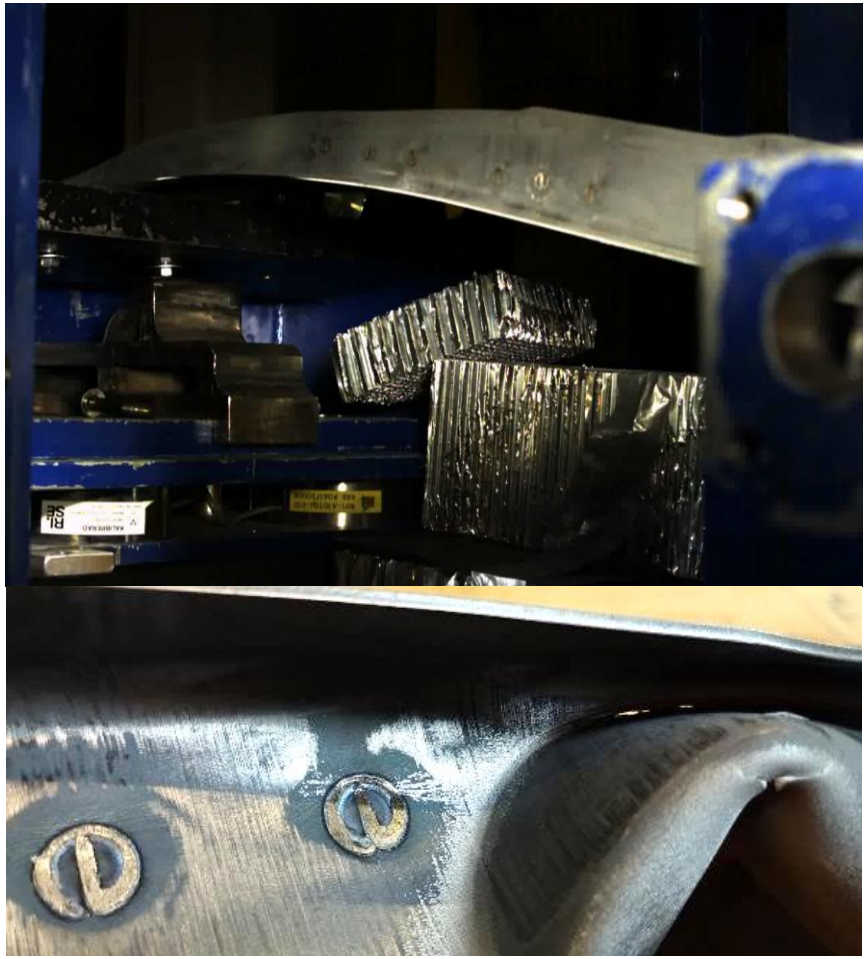
GDIS

RESISTANCE SPOT WELD



Drop Tower Test: No cracks present on the part

LASER SPOT WELD (MULTIFOCUS)



Drop Tower Test: No cracks present on the part

G-Welds

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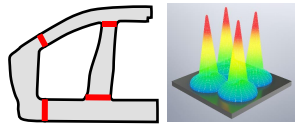
Tailor Welded Blanks

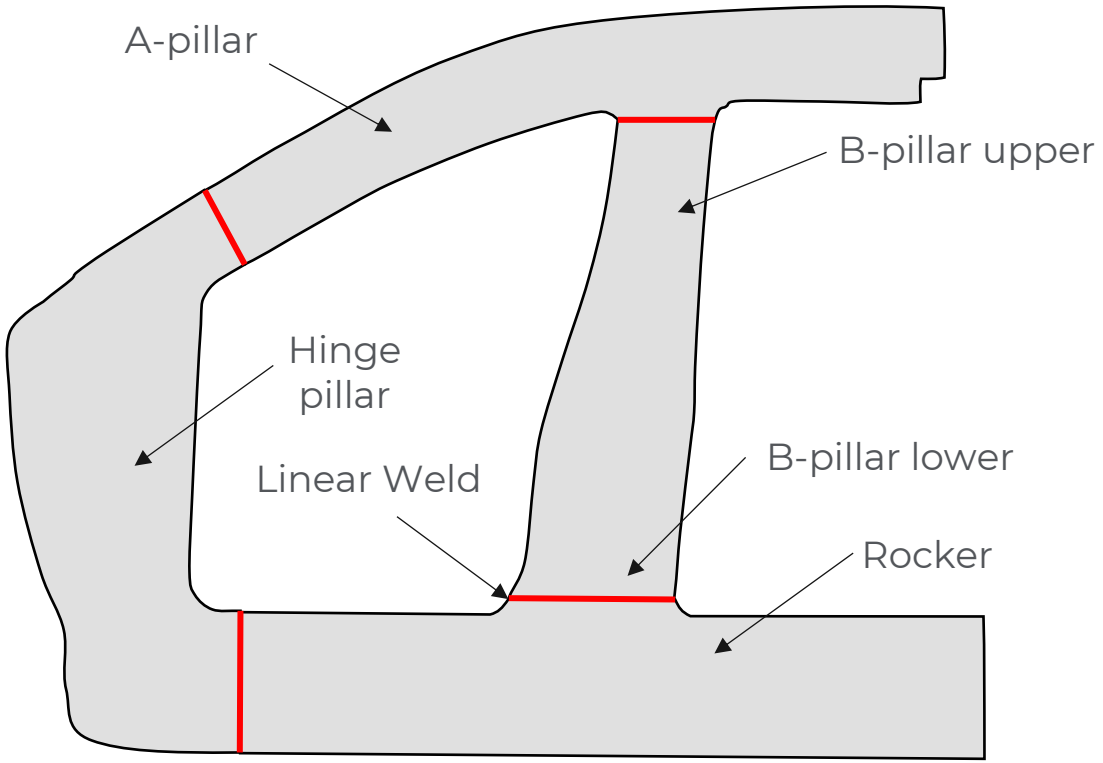


Current Method of Butt Joint TWB

- AlSi coating create intermetallic phases weakening the weld seam
- Current processes to overcome impact of AlSi coating:
  - Ablation - Ultra-short pulsed lasers used to remove layer of coating
  - Filler-wire
- These methods lead to additional capital investment, maintenance and cost.

Development:

- Laser processing without ablation of coating
- Reducing processing effort to a minimum



Door ring with RWL linear welds

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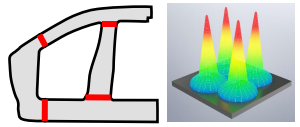
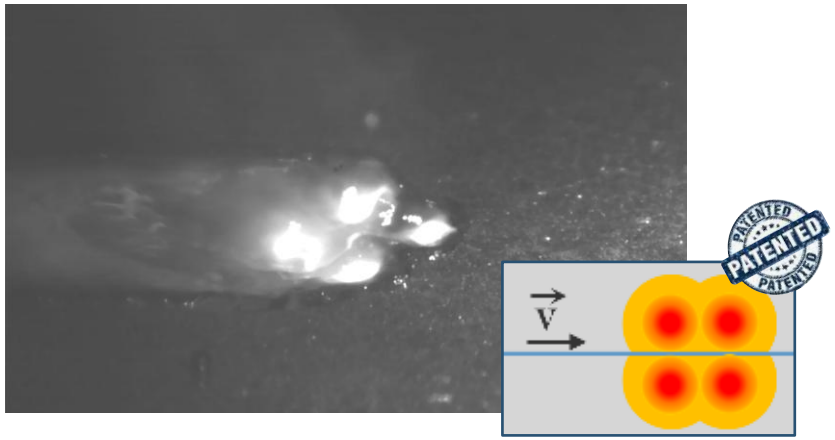
Tailor Welded Blanks



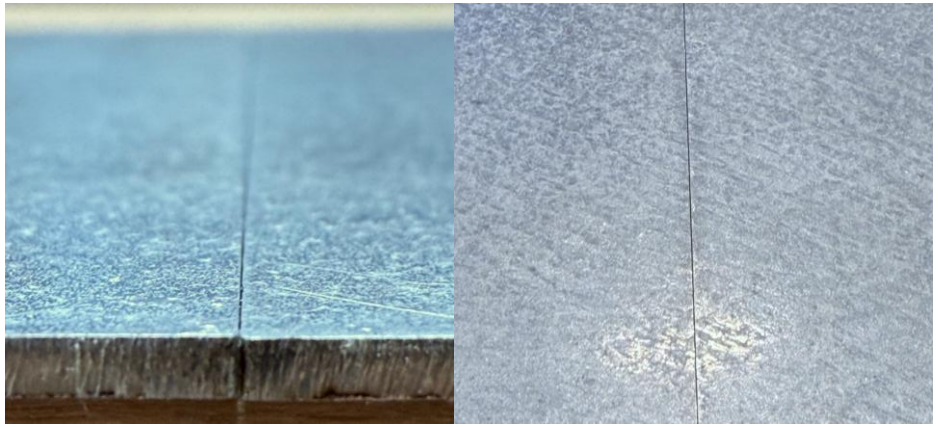
Laser Setup:

- Disk laser: max. 8000 W (200/700 µm fiber)
- Standard fixed optic with BLW + Multifocus (f = 200 mm, f_c = 200 mm)
- v = up to 10 m/min
- Variable: laser power and distribution core/ ring



Material:

- USIBOR 1500 (22MnB5)
- Coating: AS150 (AlSi ~30-35 µm thickness)
- Sheet thickness: 1,6 mm
- Joining configuration: butt joint; ~ zero-gap



$t_{process}$ = 1 second per 200mm of weld seam

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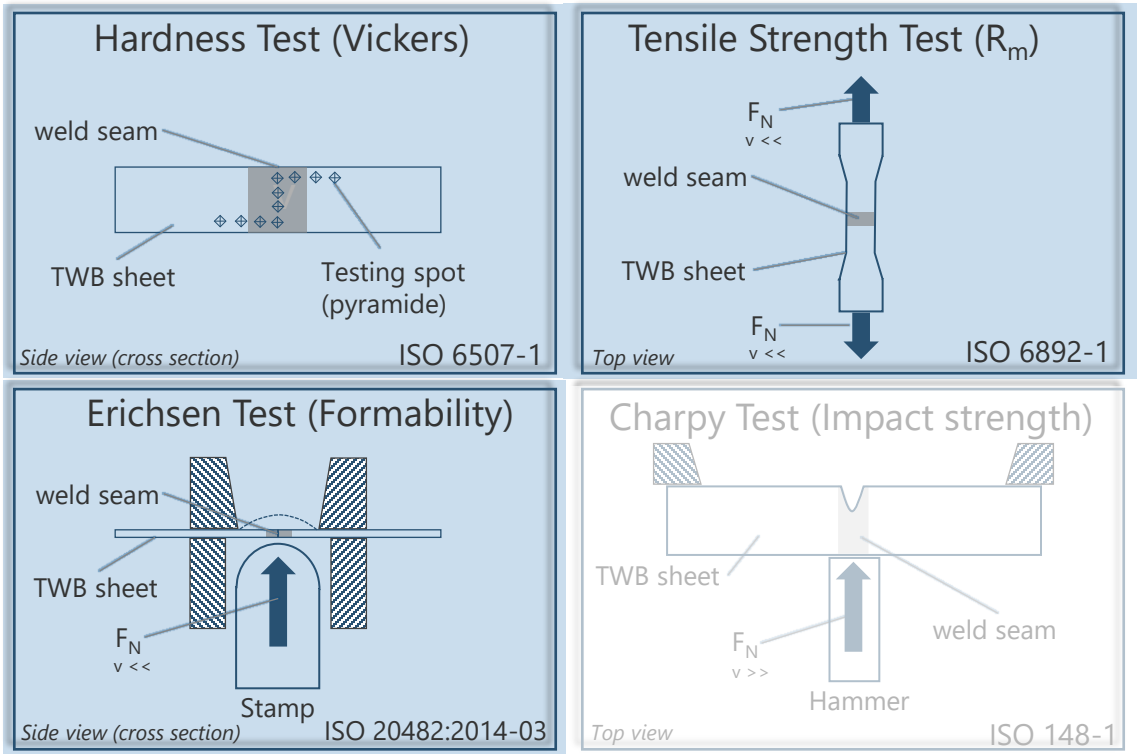
Tailor Welded Blanks

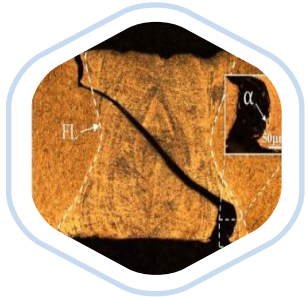
Common test procedures on material coupon level



Failure modes TWB

CRACK failure in HAZ

CRACK failure in weld seam



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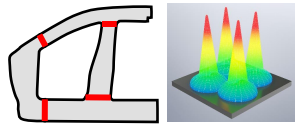
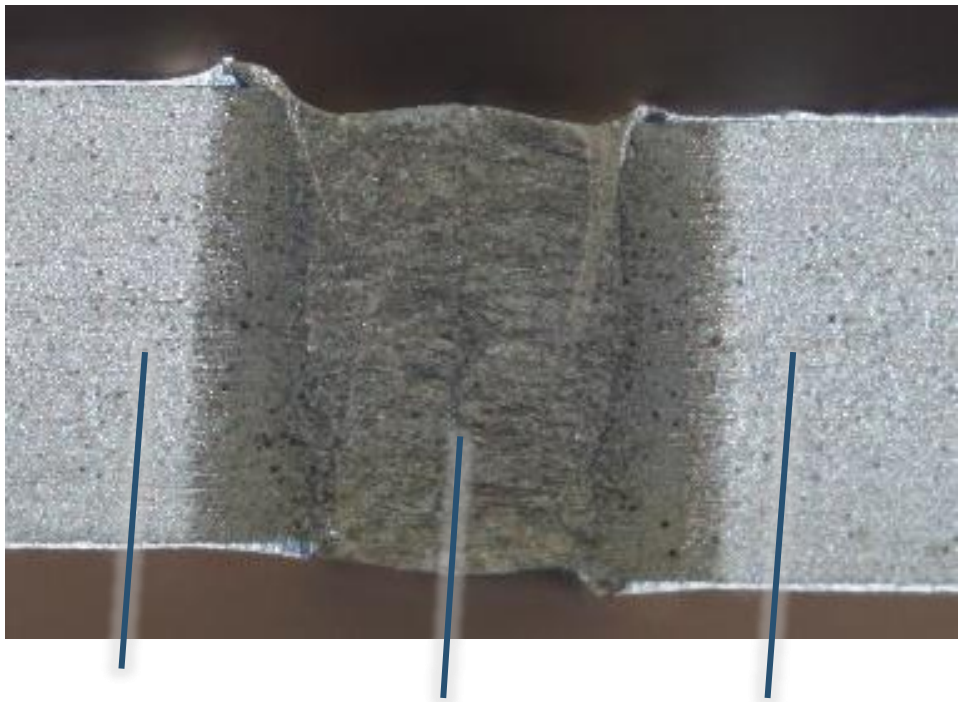
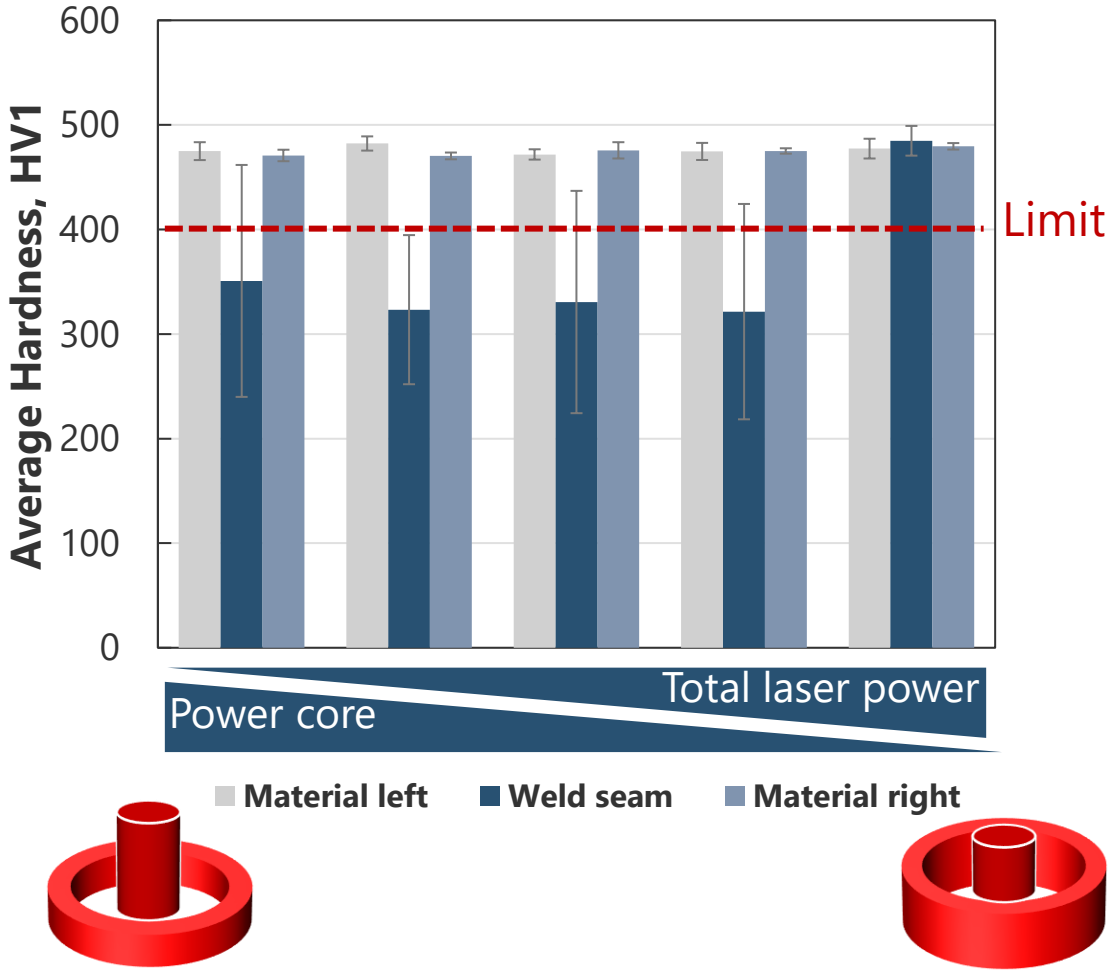
Tailor Welded Blanks



Hardness Test





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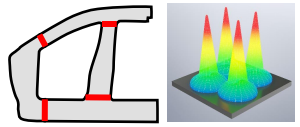
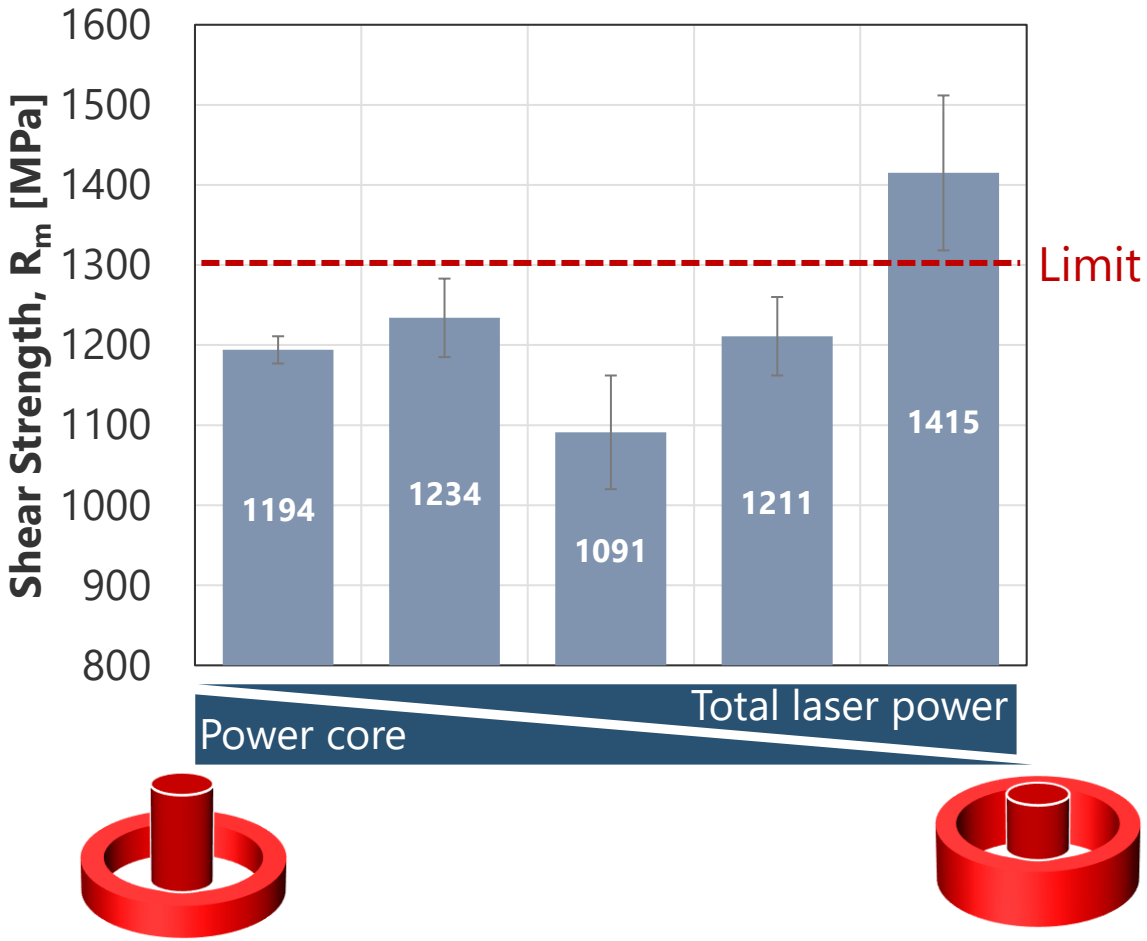
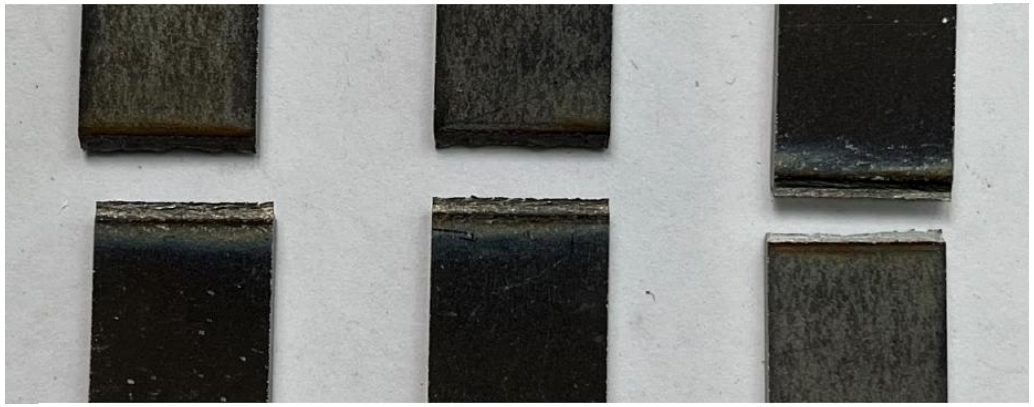
Tailor Welded Blanks





Tensile Test



- Failure mode inside weld seam: Insufficient material (most narrow point)

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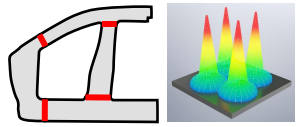
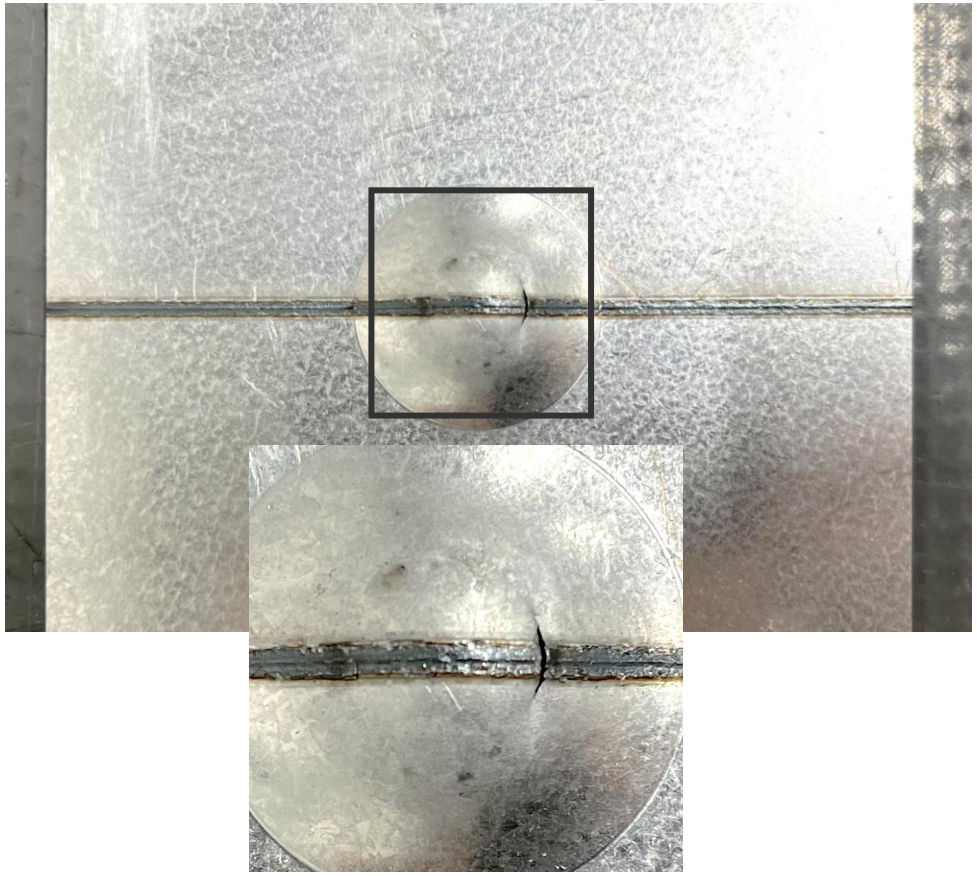
Tailor Welded Blanks



Erichsen Cup Test



Result:

- Erichsen test passed
  - F_{max} = 22 kN
  - v_{deep} = 8 mm/min
- Cracking transversal to the weld seam

Conclusion:

- All 3 testing methods are successfully passed minimum specs
- Zero gap mandatory for sufficient amount of material
- Gap situation in production only manageable with filler wire

→ Dissimilar material thicknesses to be tested soon

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Agenda

01 Market Requirements

02 Joining Methods for Car Body Parts

03 Overlap Welded Blanks

04 Tailor Welded Blanks

05 Results & Next Steps

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Summary of Results & Next Steps

Overlap Welded Blanks (OWB):

- Successfully developed and validated
- Process currently in implementation in automotive manufacturing

Tailor Welded Blanks (TWB):

- Initial development under ideal conditions
- Additional investigation pending
- Real part application and testing planned

Outlook:

- Further improvement of process parameters
- Additional beam shaping (static and dynamic) under investigation

→ **Tailor Made Laser Processes**

Part Design	Hardness	Shear Strength	Erichsen Test	Real Part / Drop Tower
OWB	✓	✓	—	✓
TWB	✓	✓	✓	open

✓ Passed successfully
— Not applied
open Future investigations

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THANK YOU FOR YOUR ATTENTION !

GREAT DESIGNS IN STEEL™

Marc Hummel | Global Business Development

Yama Fedai | North American Business Development

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