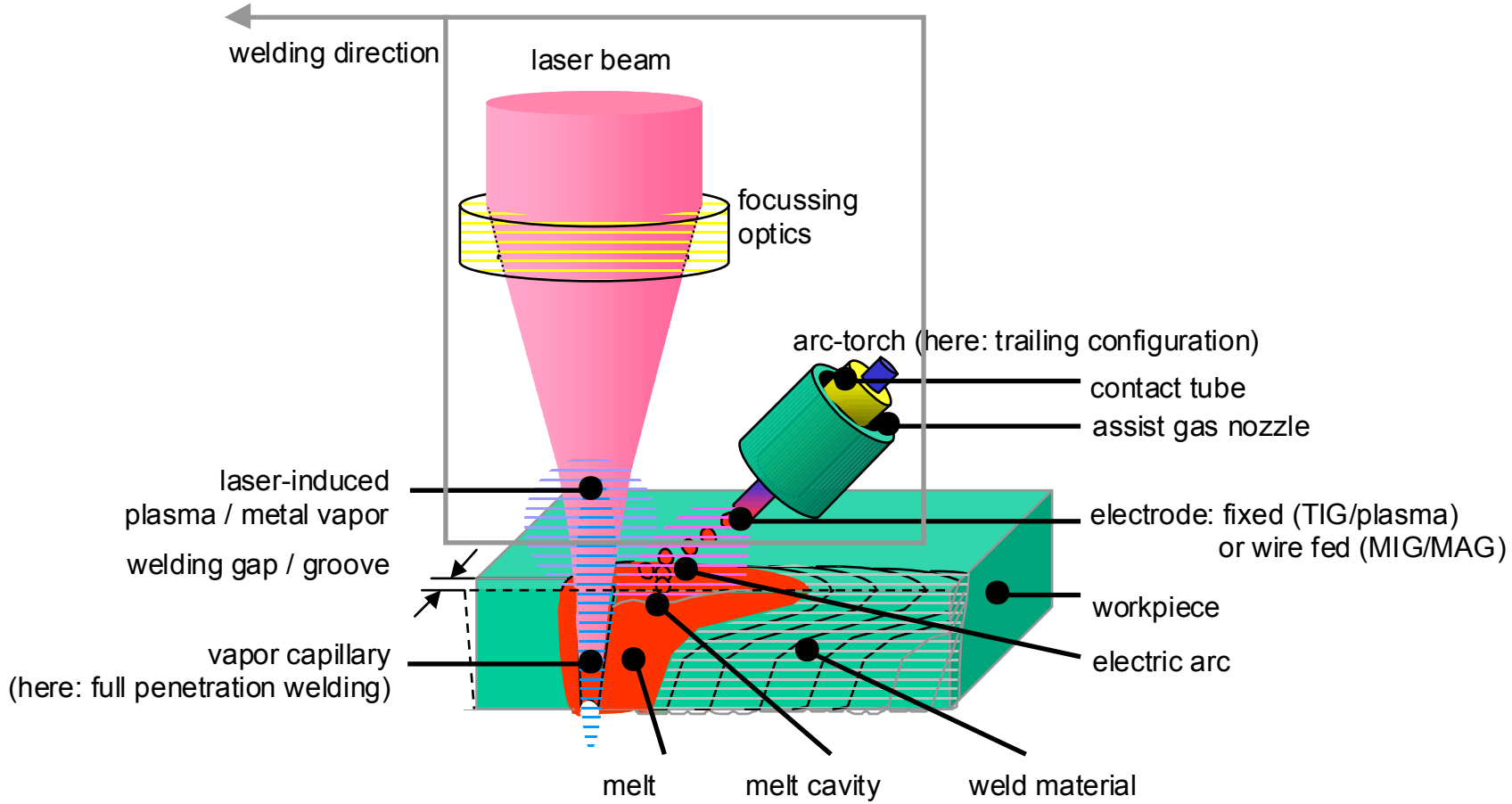
Recent progress and trends in laser hybrid welding

Dirk Petring

Fraunhofer Institut Lasertechnik

Principle of the laser-arc hybrid welding processes



Fraunhofer Institut Lasertechnik

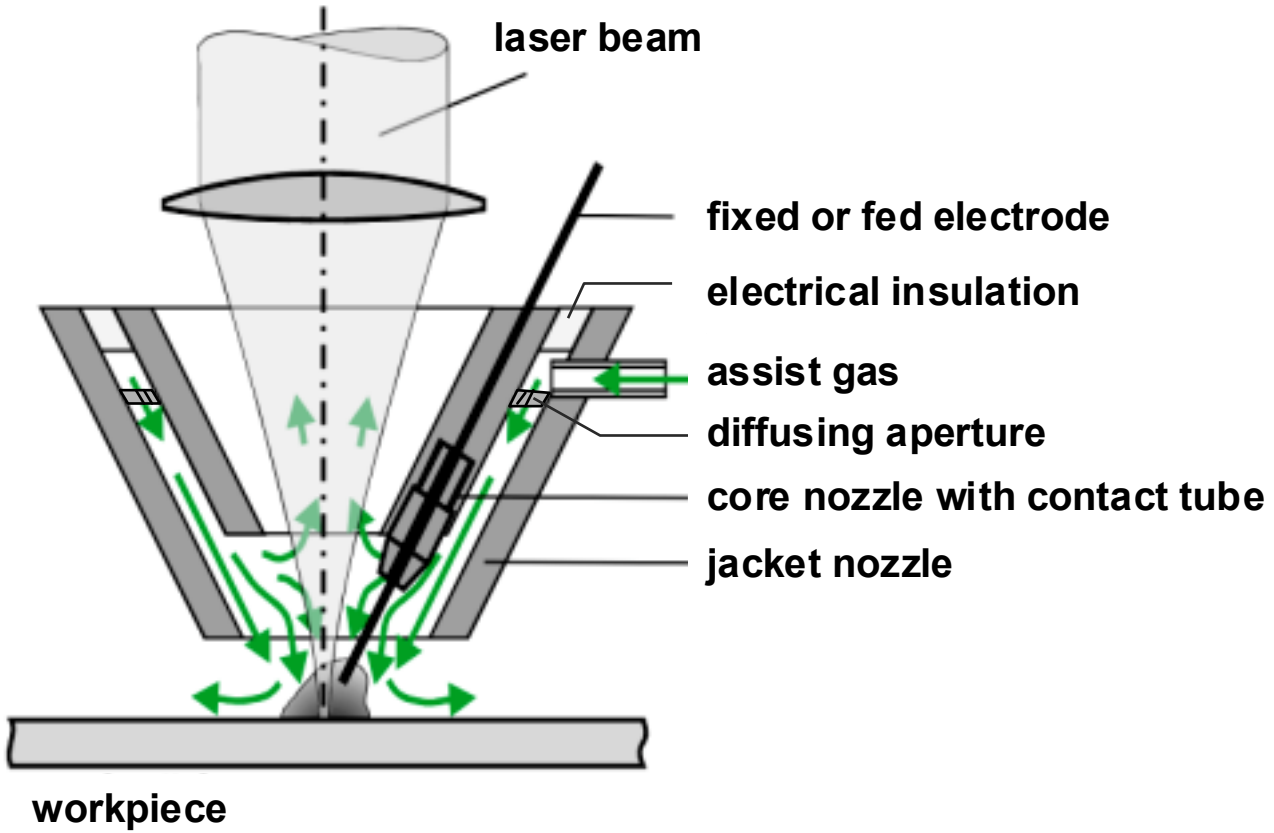
Enhancing and complementing effects by combining laser and arc welding processes

process:	*laser*	TIG/Plasma	**MIG/MAG**	
tool:	*laser beam focus*	arc	**melting electrode**	
phys. transfer:	*energy*	momentum	**mass**	
phys. process:	*vaporization*	*melting*	*heat* conduction	**alloying**
phys. effect:	*vapor capillary*	*melt volume*	*temperature cycle*	*structure*
seam geometry:	*depth*	*root*	width	seam surface
seam preparation:	*zero gap*	*hidden joint*	gap/misalignment	**groove**
manufacturing:	*speed*	*efficiency*	*automation*	*process tolerance*
result:	*productivity*	*profitability*	*flexibility*	*quality*

Fraunhofer ILT Institut Lasertechnik

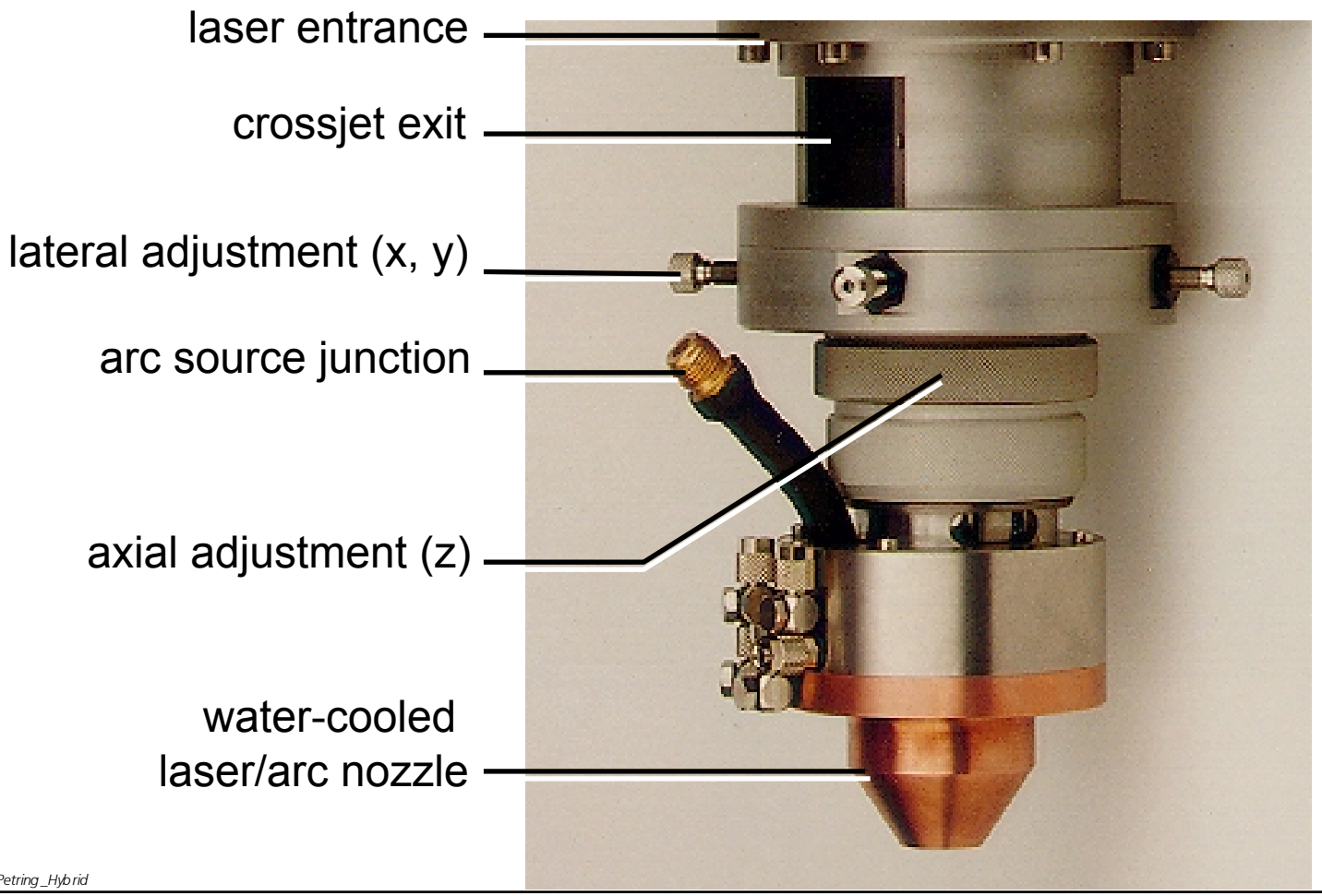
Integrated hybrid-nozzle design (Fraunhofer ILT patent)

- common water-cooled nozzle for laser and arc
- integrated contact tube
- closest laser and arc proximity with steepest arc possible
- annular gas channel with diffusing aperture
- symmetrized, homogeneously distributed assist gas stream
- no contamination by transverse or axial entrainment of air (Venturi effect)
- compatible with various MIG/MAG sources and with CO_2 and Nd:YAG lasers
- in industrial production since 2000



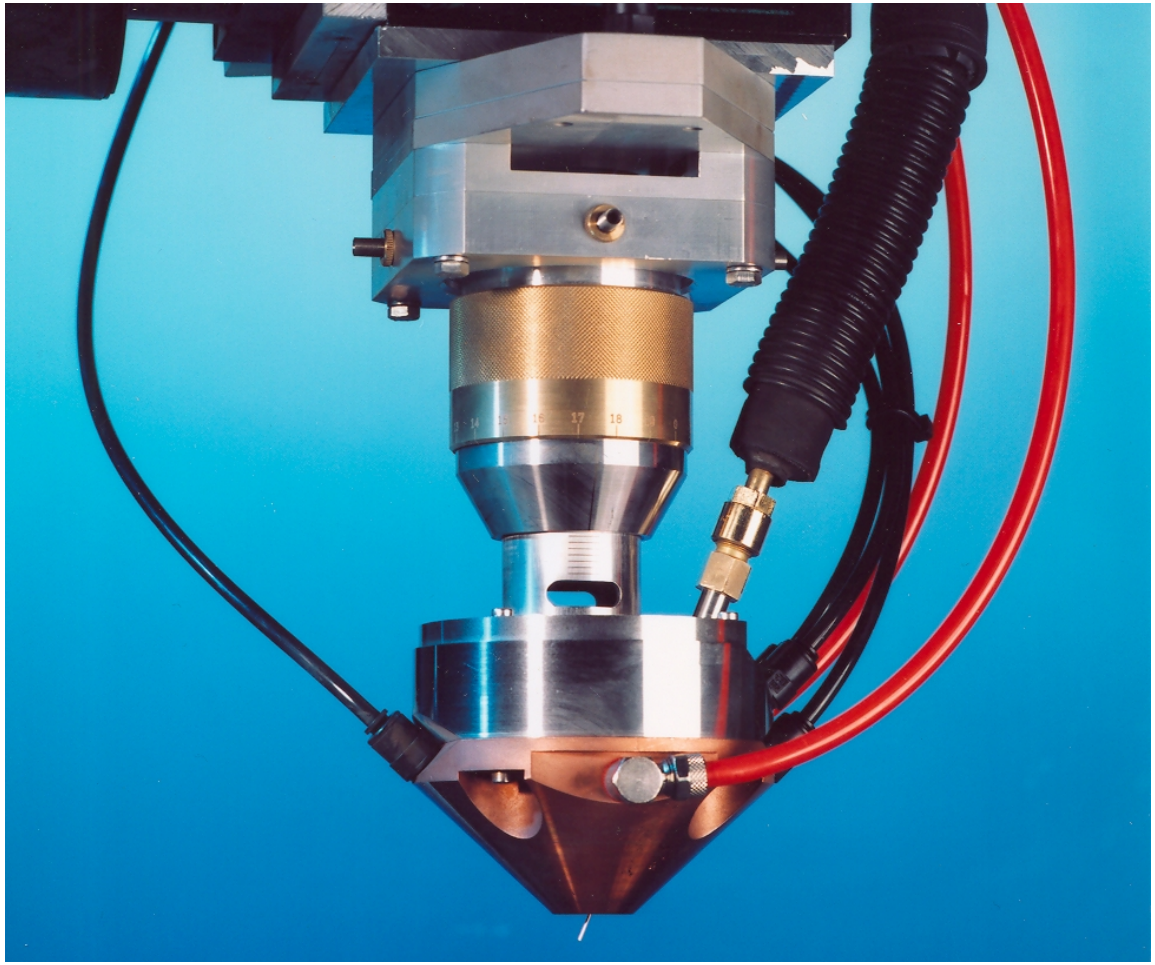
Fraunhofer Institut Lasertechnik

Integrated Hybrid Welding Nozzle (Industrial Standard Version)



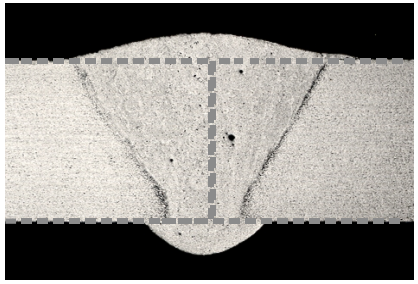
Fraunhofer ILT Institut Lasertechnik

Integrated Hybrid Welding Nozzle (Industrial Heavy-Duty Version)

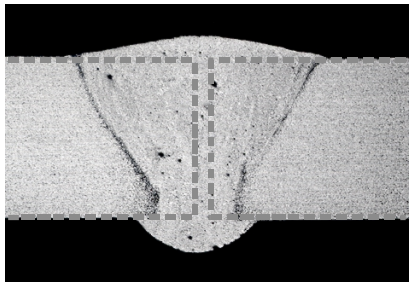


Fraunhofer Institut Lasertechnik

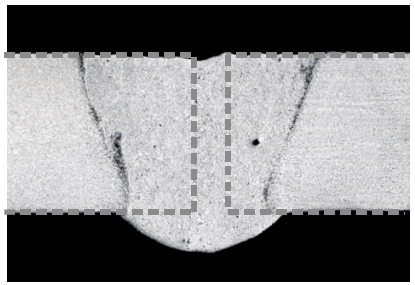
Gap bridging capability during laser-MIG hybrid welding of aluminum (6xxx)



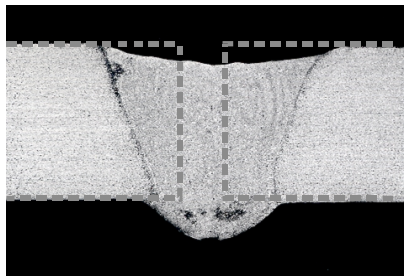
b_s = 0 mm
v_D = 8,3 m/min



b_s = 0,4 mm
v_D = 8,1 m/min



b_s = 0,8 mm
v_D = 7,8 m/min

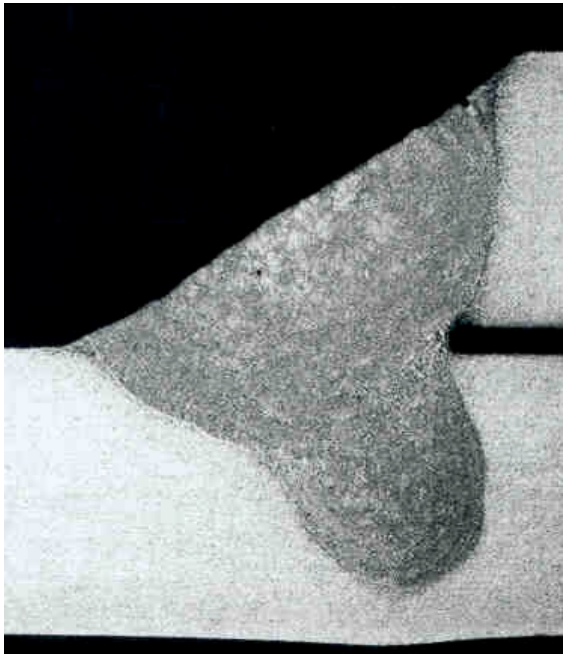


b_s = 1,2 mm
v_D = 7,1 m/min

- sheet thickness 4mm
- square butt weld in flat position without backing bar, gap width b_s
- welding speed 2.5 m/min
- Nd:YAG-Laser 2.7 kW
- MIG impulse arc in trailing configuration
- wire material S-AlSi12, diameter 1.2 mm, wire feed rate v_D
- assist gas argon

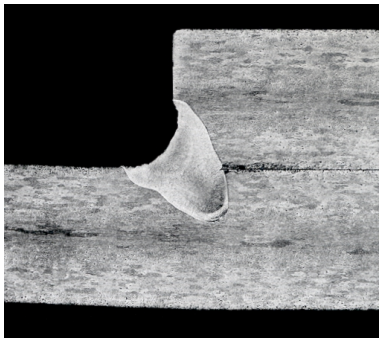
Fraunhofer Institut Lasertechnik
ILT

Behavior of the single processes in comparison to hybrid process

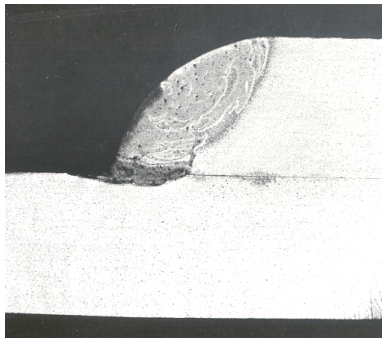


laser-MIG hybrid
v_s = 2 m/min

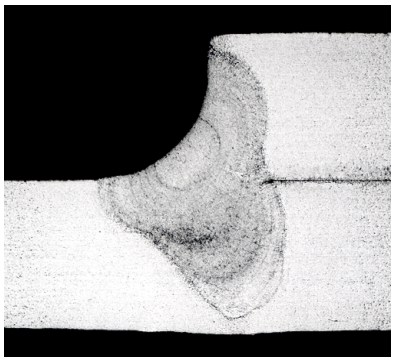
- aluminum profile material
- thickness 4 mm
- Nd:YAG laser 2.7 kW
- MIG impulse arc (trailing)
- wire material S-AlSi12
- diameter 1.2 mm
- assist gas argon



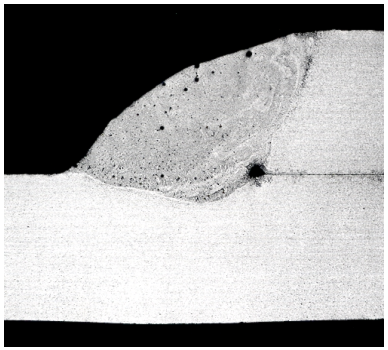
laser only
v_s = 2,0 m/min



MIG only
v_s = 2,0 m/min



laser only
v_s = 0,5 m/min

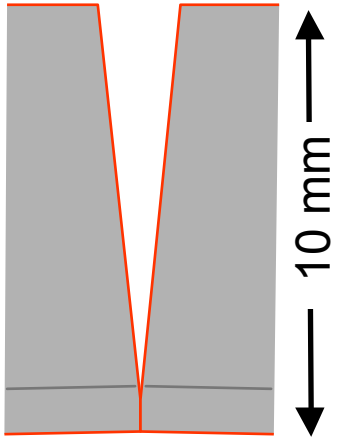


MIG only
v_s = 1,2 m/min

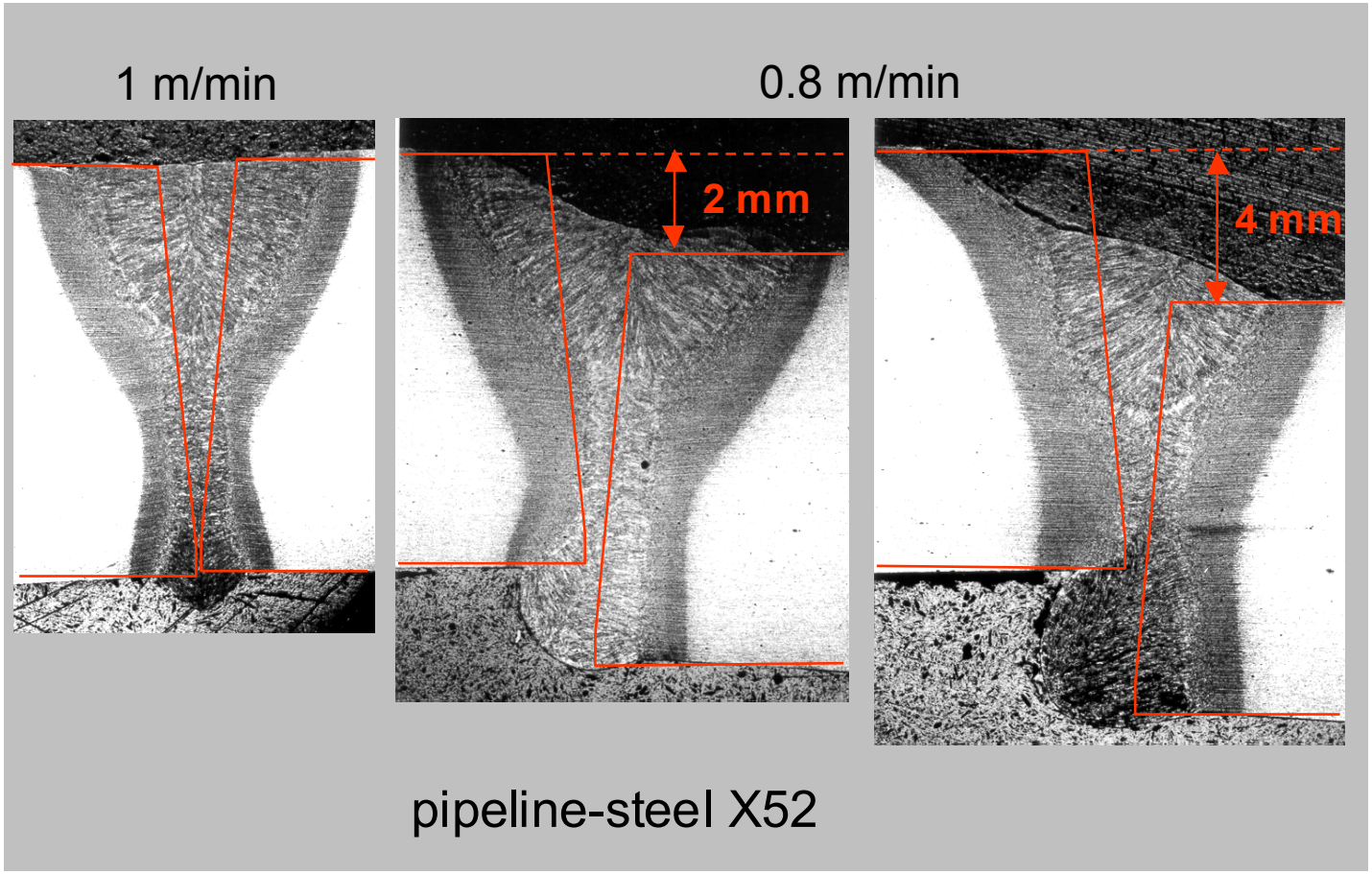
Fraunhofer Institut Lasertechnik
ILT

Laser-MIG hybrid welding of pipeline-material with CO_2 laser (10.5 kW)

10° single-V groove
with 1 mm root face



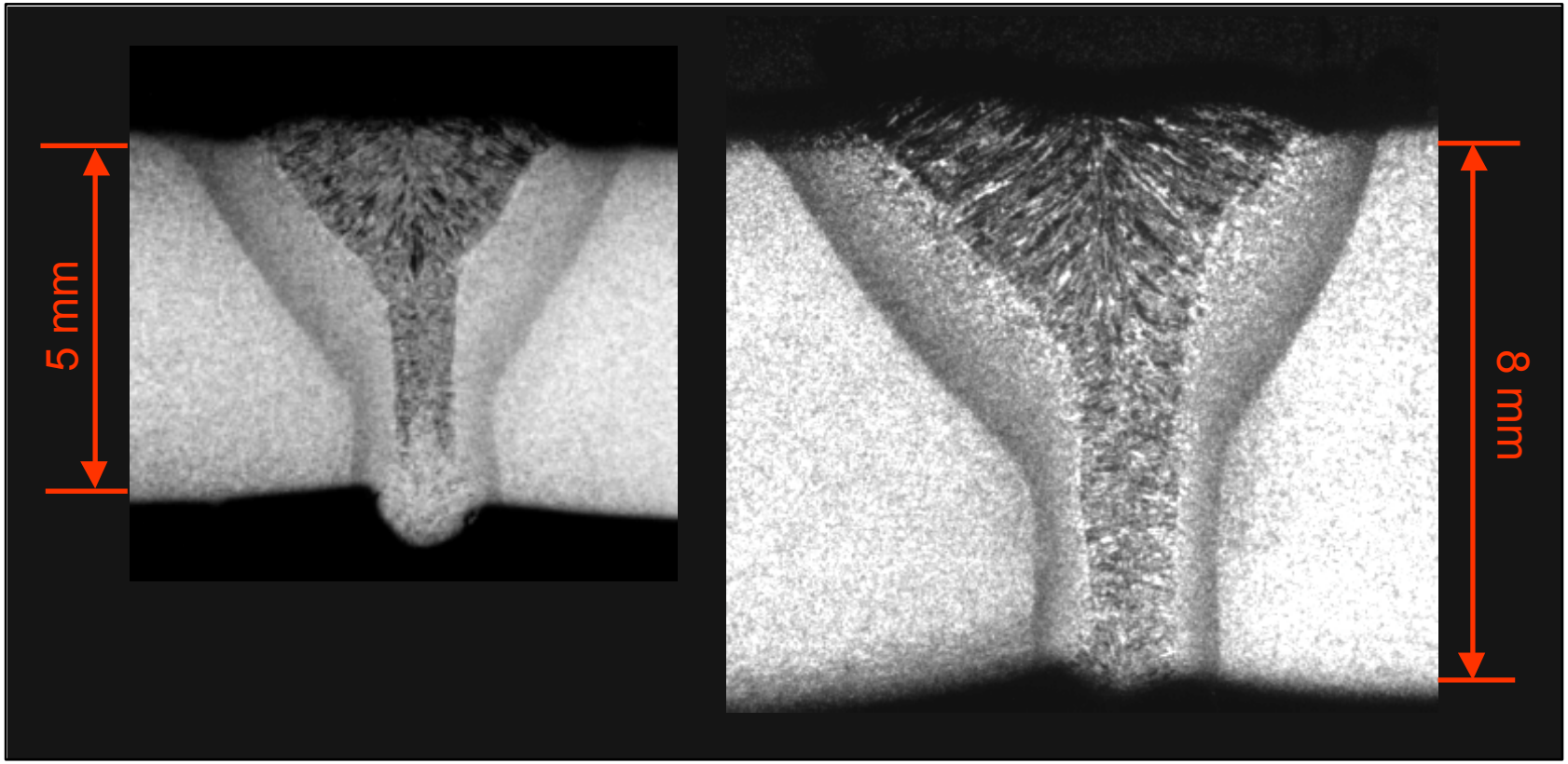
root
shielding gas
Ar/He-mixture



Fraunhofer ILT Institut Lasertechnik

Hybrid welding of oil tanks (S235JR) with CO_2-Laser (5.7 kW)

- Edge preparation by shear cut -



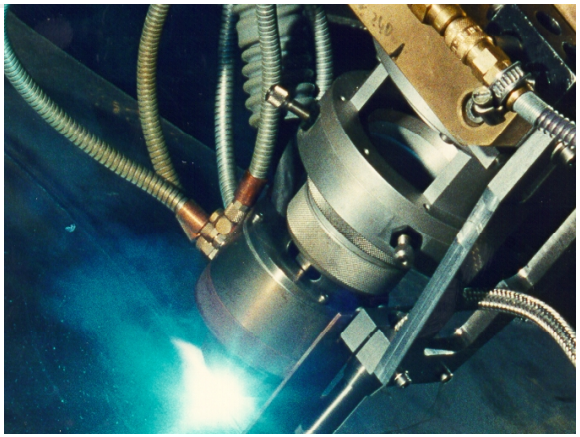
1.5 m/min

0.9 m/min

Fraunhofer Institut Lasertechnik
ILT

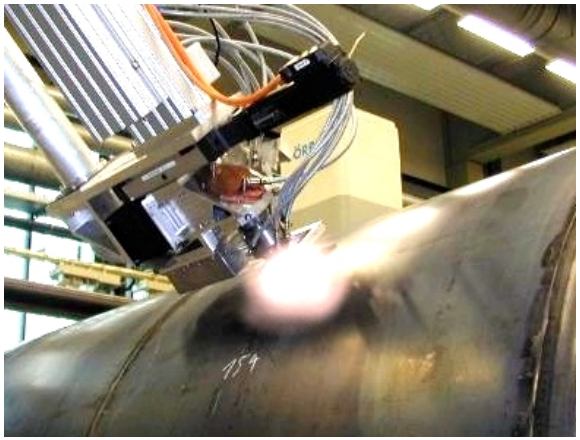
Laser-MIG/MAG hybrid welding of oil tanks: from the development up to industrial production

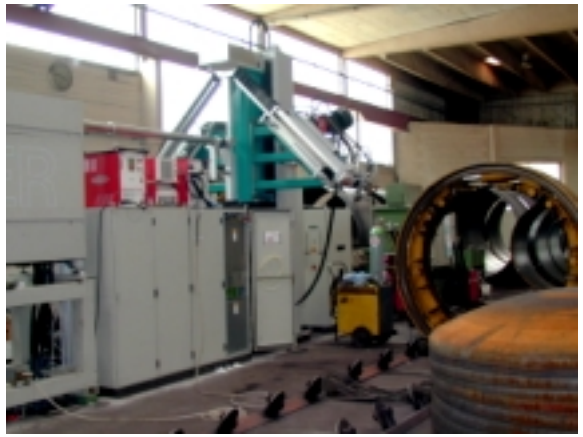
1. Development and qualification of hybrid process



2. Construction, manufacturing and pre-assembly of the hybrid system

3. Test operation and TÜV-acceptance of the process

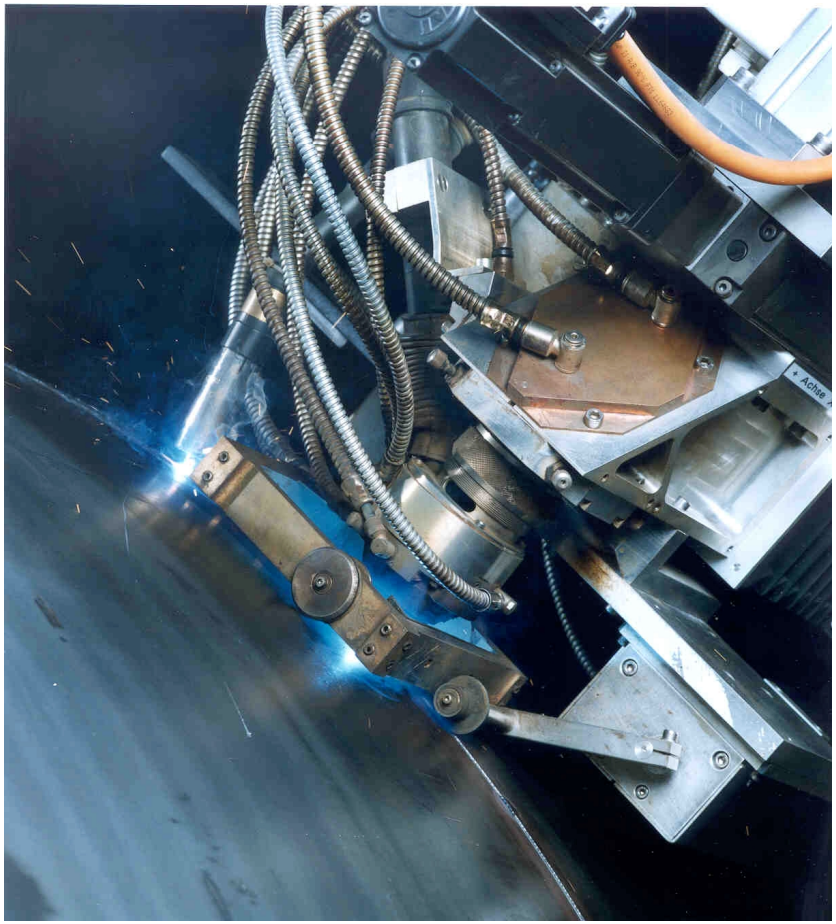




4. Installation and starting up at the tank manufacturer

Fraunhofer Institut Lasertechnik
ILT

Laser-MIG/MAG hybrid welding of oil tanks: Customized solution with the “Integrated Nozzle”

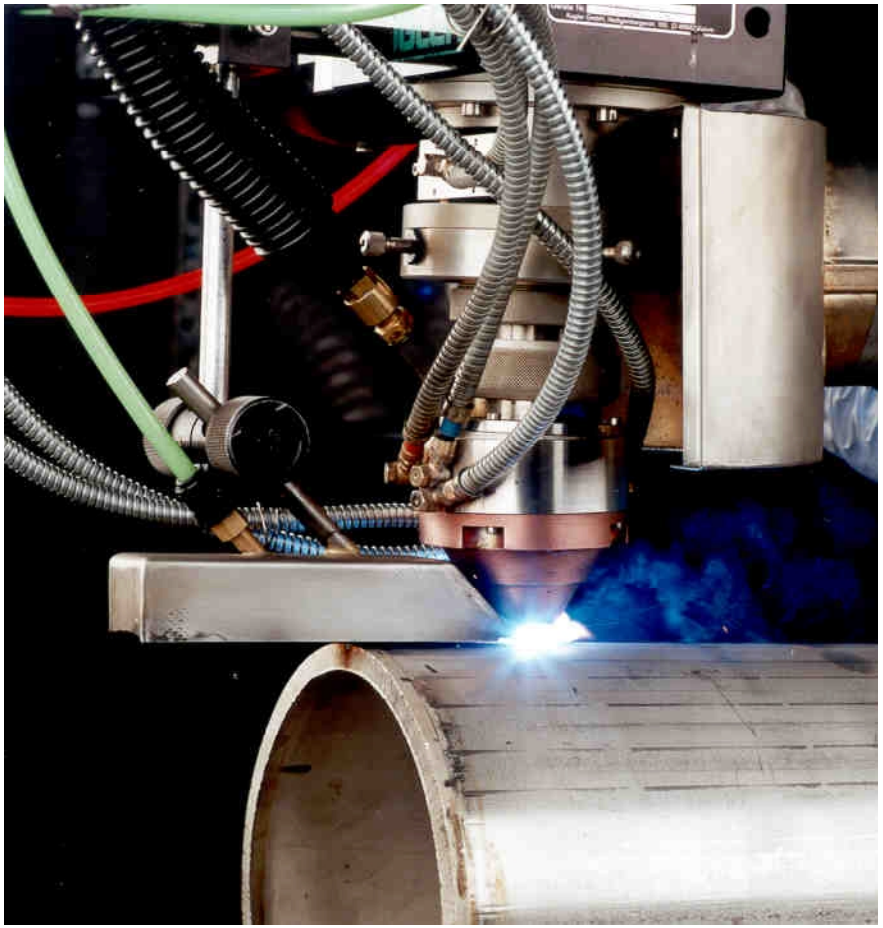


Fraunhofer Institut Lasertechnik

Laser-MIG/MAG Hybrid Welding of Stainless Steel Tubes

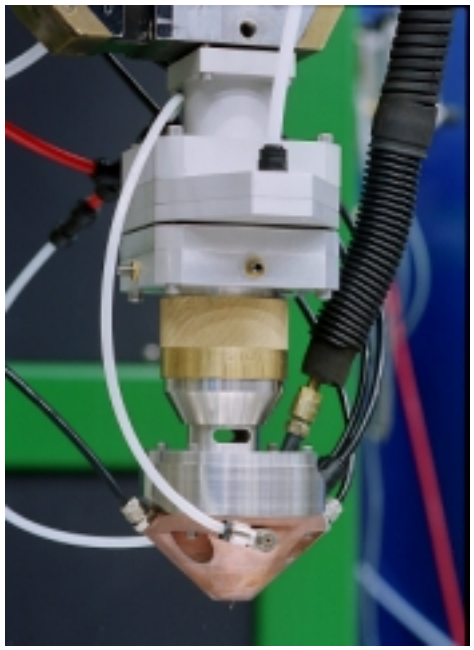
Customer‘s target:

- high-speed
- sound seam and root
- single-pass welding
- no change of conventional edge preparation technique

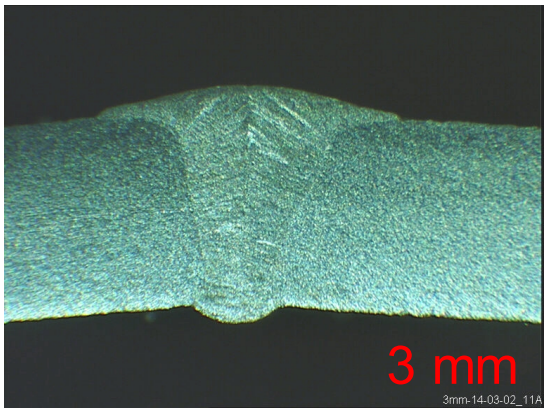


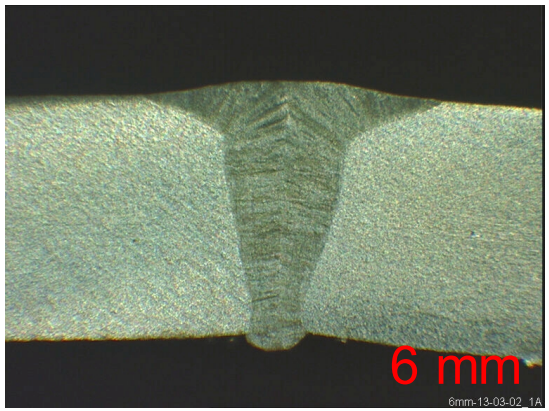
Fraunhofer ILT Institut Lasertechnik

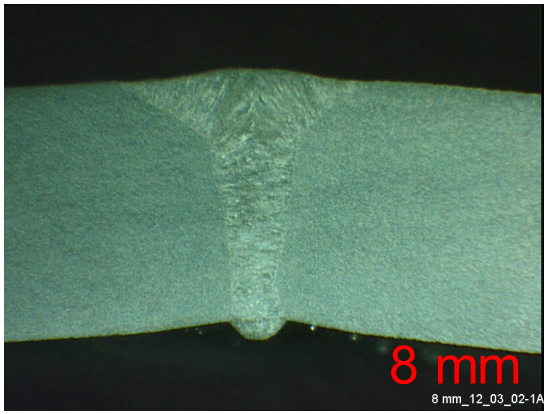
Laser-MIG/MAG Hybrid Welding of Stainless Steel Tubes

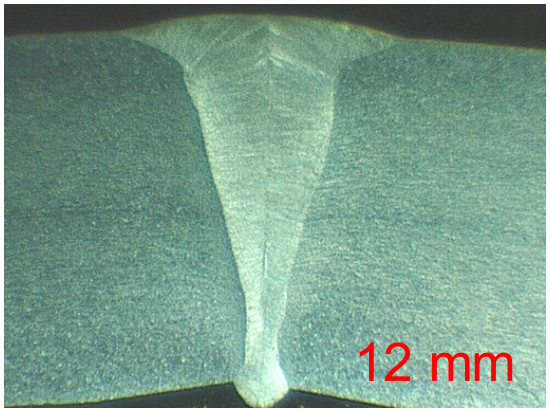


Welding speed 10 times higher compared to the conventional welding process of the customer









Process at Fraunhofer ILT certified by Lloyd's Register

Fraunhofer Institut Lasertechnik

Hybrid Welding at Meyer-Werft, Papenburg

One-sided butt welding of ship panels with dimensions of up to 20m x 20m x 15mm

Fraunhofer Institut Lasertechnik

Hybrid Welding at Meyer-Werft, Papenburg

One-sided fillet welding of up to 15mm thick and 20 m long stiffeners on panels

Fraunhofer Institut Lasertechnik

Implementation-Test of Laser-Arc-Hybrid Welding in Conventional Gantry-Systems of a German Shipyard

Objectives:

- Retrofitting of a conventional MAG-welding gantry with solid-state laser technology
- Application of of laser-GMAW hybrid welding in a real manufacturing environment of a German shipyard
- long linear seams

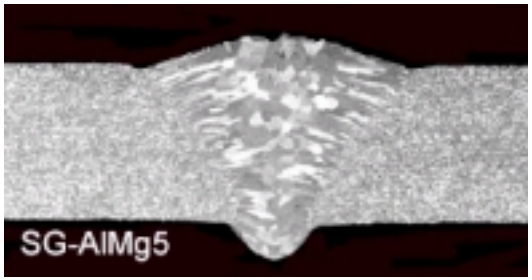
Fraunhofer ILT Institut Lasertechnik

AKER KVÆRNER

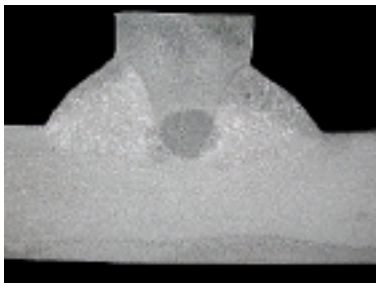
Implementation-Test of Laser-Arc-Hybrid Welding in Conventional Gantry-Systems of a German Shipyard

Result:

- Pilot plant at the Kvaener Warnow shipyard, Rostock
- Practical welding results on seawater-resistant Aluminum confirm capability of retrofitting hybrid technology



Butt joint
EN AW-5083, 5 mm
laser power 4 kW
welding speed 2.8 m/min
wire feed 14 m/min



T-joint
EN AW-5083, 8 mm
laser power 3 kW
welding speed 2 m/min
wire SG-AlMg5

Fraunhofer ILT Institut Lasertechnik

AKER KVÆRNER

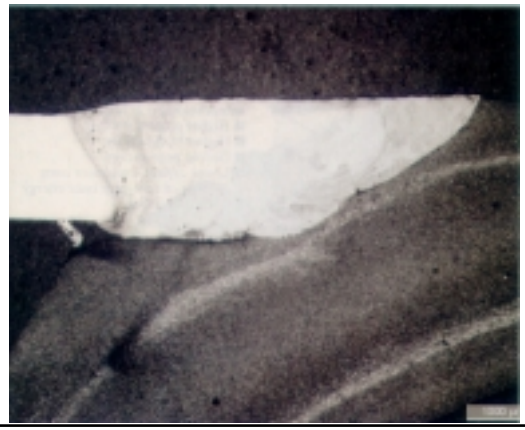
Schweißtechnische Lehr- und Versuchsanstalt Mecklenburg-Vorpommern GmbH SLV

Laser-MIG Hybrid Welding at Volkswagen

Joining techniques used on the Phaeton's front door:

- GMAW process:
  7 joints, 380 mm welded length
- laser beam welding:
  11 joints, 1030 mm welded length
- **laser-MIG hybrid process:**
  48 joints, 3570 mm welded length
- total weld length 4980 mm

Aluminium sheet-to-cast joint:
laser power 2.9 kW
welding speed 4.2 m/min
wire feed rate 6.5 m/min

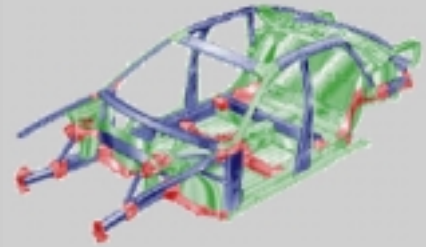


Fraunhofer Institut Lasertechnik
ILT

Laser-MIG Hybrid Welding at AUDI (Rofin DY044)

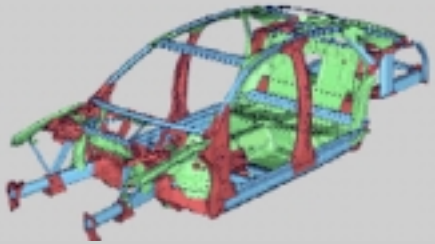
AUDI Space Frame

Audi A8 (D2)
SOP 1994
D-Class
249 kg, 334 parts

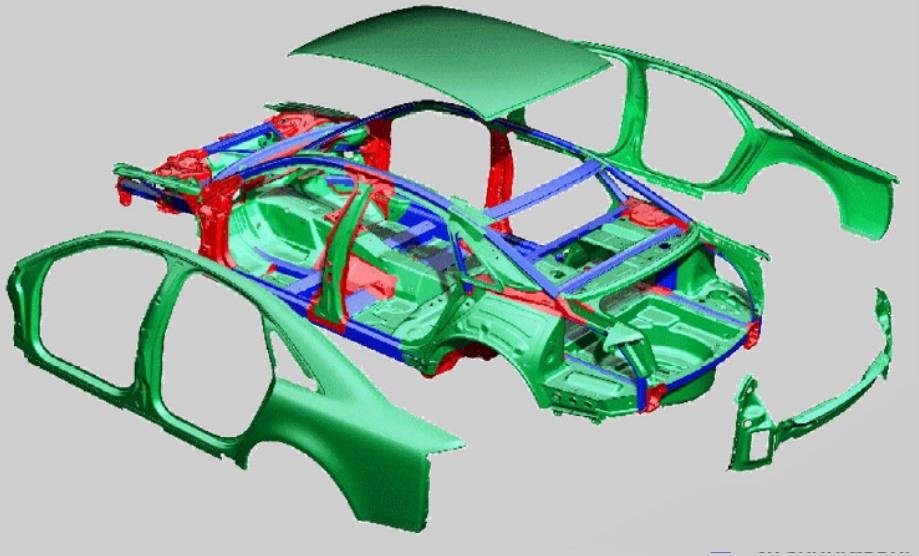


Joining techniques:
1100 rivets
70 m MIG-seam
500 resistant spot welds
178 clinch spots

Audi A8 (D3)
SOP 2002
D-Class
287 kg, 267 parts



Joining techniques:
2400 rivets
64 m MIG-seam
20 m laser seam
5 m hybrid seam

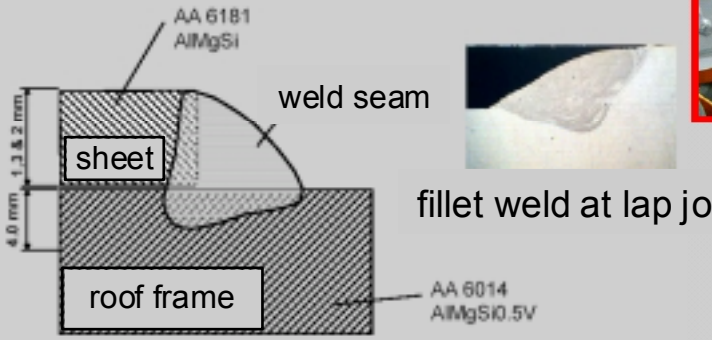


- Sheet
- Extruded profiles
- Cast

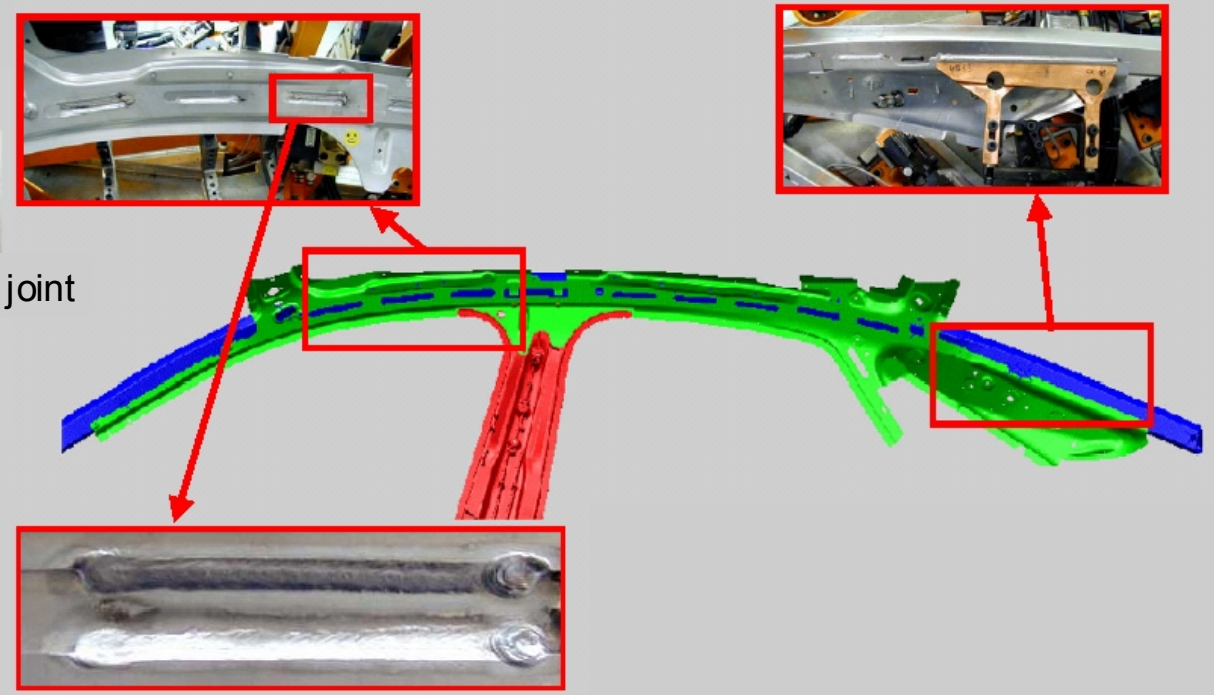
Fraunhofer ILT Institut Lasertechnik

Laser-MIG Hybrid Welding at AUDI (Rofin DY044)

Welding result AUDI A8 side-roof frame



fillet weld at lap joint



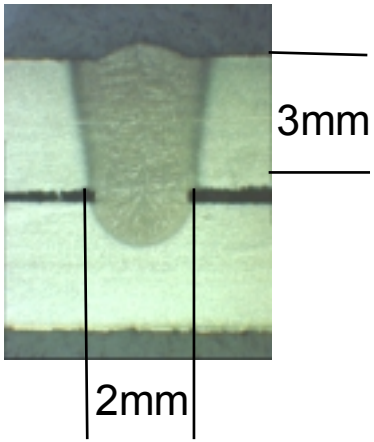
Welding parameters:

laser power	3.8 kW
welding speed	3.6 m/min
wire feed rate	4.5 m/min

Fraunhofer ILT Institut Lasertechnik

Steel Bodies and Frames: Recent Results of Laser-MAG Hybrid Welding at Fraunhofer ILT

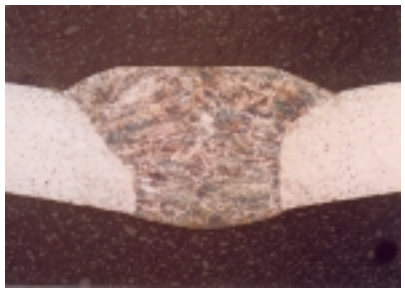
fast lap welds with wide joint interface



3+3 mm mild steel lap joint with

CO_2 laser 7.4 kW
welding speed 4 m/min

stable MIG/MAG metal transfer even at welding speeds above 10 m/min



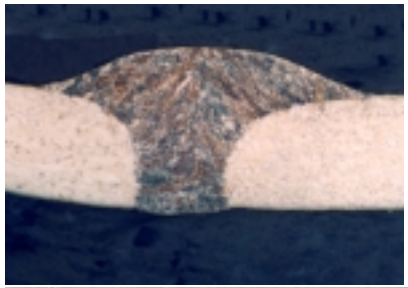
1 mm mild steel bead-on-plate

CO_2 laser 8 kW
welding speed 14.4 m/min

Fraunhofer Institut Lasertechnik

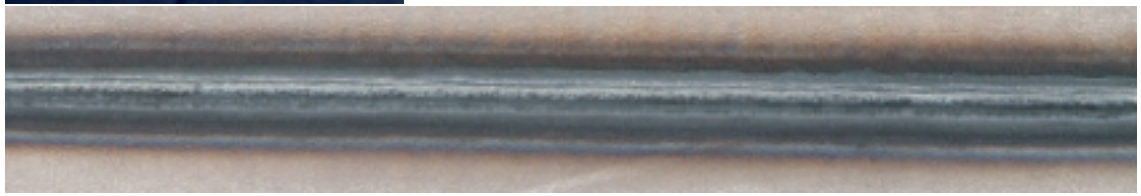
Steel Bodies and Frames: Recent Results of Laser-MAG Hybrid Welding at Fraunhofer ILT

excellent weld reinforcement possible even at high welding speed



1 mm mild steel butt joint with 0.3 mm gap

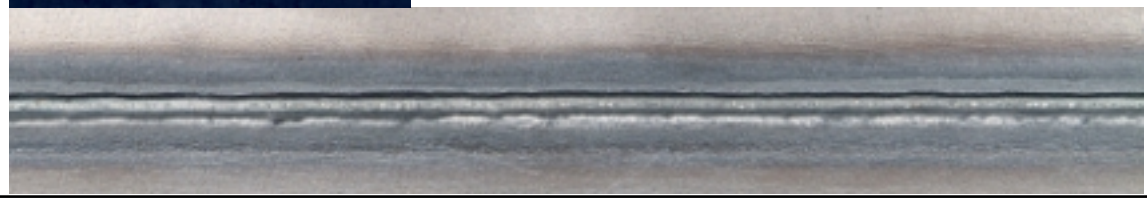
CO_2 laser 4.9 kW
welding speed 10 m/min



excellent bridging of gaps and misalignment even at high speeds

1 mm mild steel butt joint with 0.3 mm gap extreme misalignment

CO_2 laser 4.9 kW
welding speed 10 m/min

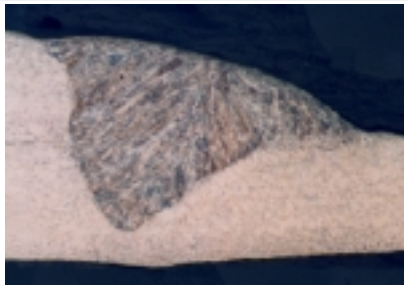


Fraunhofer Institut Lasertechnik

Steel Bodies and Frames: Recent Results of Laser-MAG Hybrid Welding at Fraunhofer ILT

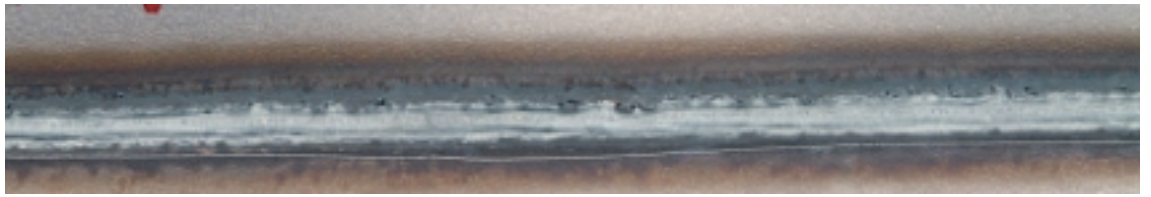
laser power demand significantly reduced...

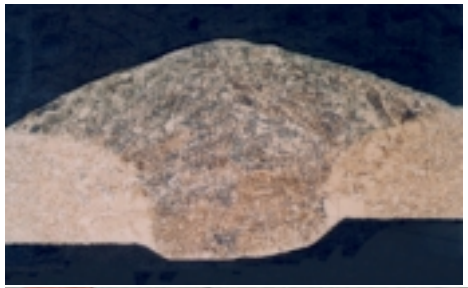
...at strong fillet welds as well as...



1+1 mm mild steel fillet weld at lap joint

CO_2 laser 3.9 kW
welding speed 10 m/min





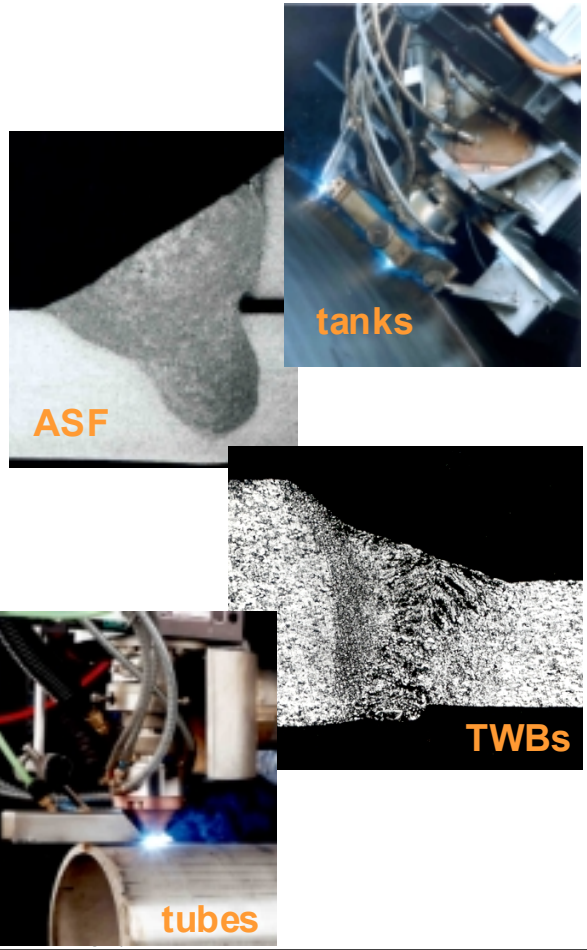
0.8 mm galvanized steel butt joint

CO_2 laser 3.4 kW
welding speed 6 m/min

...with zink coated steel

Fraunhofer Institut Lasertechnik

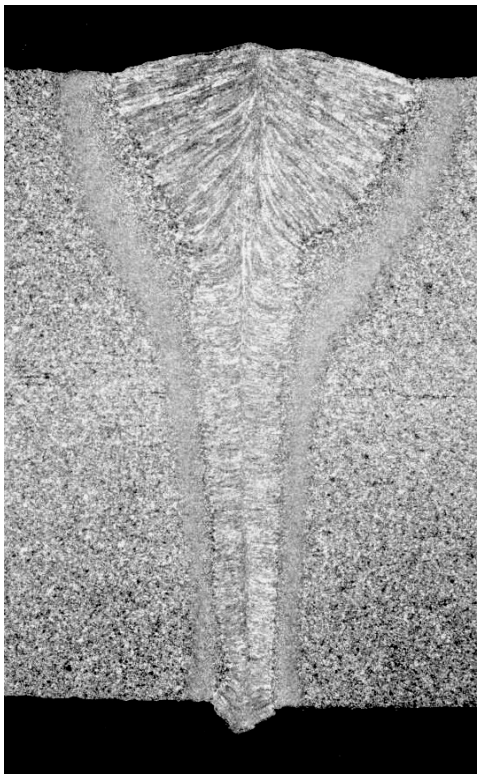
Laser-Arc Hybrid Welding: Trends and existing as well as forthcoming applications



- Higher laser powers (CO_2 and YAG)
- Larger tolerances (gaps, groove shape, misalignment), 3D-capabilities
- Process Monitoring (CPC)
- Heavy section market
- High-strength + light-weight materials
- Dissimilar materials **... ... ...**

Realized and projected applications

- tanks and other (large) vessels
- ship building (panels, stiffeners)
- automotive
  - o nonlinear TWB (laser+TIG)
  - o body, frames
  - o power train (axles, fellies)
- rail wagons (frames)
- tubes and profiles
- on and off shore pipelines (2G, 5G)



15 mm mild steel
6° single-V butt joint
15 kW CO_2 laser+GMAW, 1.2 m/min

Fraunhofer Institut Lasertechnik

More Infos:
www.ilt.fraunhofer.de
petring@ilt.fraunhofer.de