Brazing with Diode Lasers
June 2005

Laserline GmbH • Mülheim-Kärlich • Germany
www.laserline.de
Brazing and Welding with Filler Wire

Advantages of Diode Lasers
- High welding / brazing speed
- Excellent surface finish
- Continuous, evenly distributed energy input
- Good process control and high stability
- Economically advantageous compared to other laser sources
- Very compact, mobile laser systems
- Easy integration of filler wire and seam-following systems into laser head

Applications
- Steel sheets and galvanized sheet metal with high requirements on seam quality: Automotive industry, consumer goods
Brazing: Typical Data

- **Laser**
  Direct and fiber-coupled diode lasers

- **Power**
  1.000 W to 3.000 W

- **Beam quality**
  100 - 150 mm mrad

- **Spot dimensions**
  1 to 2.5 mm, 1.5 x 1.5 or 2 x 6 mm²

- **Filler wire**
  1 to 1.6 mm, hotwire by current of 50 to 150 A, material CuSi3

- **Material**
  - Steel sheets, galvanized steel with high requirements on seam quality

Trunk number plate connection
Diode Laser Types for Brazing

Fiber-coupled diode laser

Direct diode laser on robot

Direct diode laser with brazing head (Scansonic)

Photo: Reis Robotics
Diode Laser Types for Brazing

Direct diode laser with brazing head on robot

Direct diode laser on robot

Direct diode laser with brazing head on robot

Photo: Reis Robotics

Photo: Japan
Brazing: Options

- Commercial brazing optics, different manufacturers (Scansonic, Highyag and others)
- Beam switch for fiber-coupled diode laser
- Controlled wire feeding with integrated gas feed
- Weld seam tracking
- Cross jet
- Cover slide monitor
- CCD camera
- Tactile or camera-based seam tracking
- Crash sensor
- Interfaces: Profibus-DP, Interbus, Ethernet, PC-based control
Brazing: Principle

Cold or heated wire is fed into the laser beam

Localized heat input: Laser beam melts only brazing wire

Low heat input into base material: low deformation, no damage to Zn coating

Process speed: 2 to 6 m/min

Sketch: Scansonic

<table>
<thead>
<tr>
<th>L</th>
<th>Laserstrahl</th>
<th>Laser Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Naht</td>
<td>Seam</td>
</tr>
<tr>
<td>s</td>
<td>Spalt</td>
<td>Gap</td>
</tr>
<tr>
<td>V</td>
<td>Vorschub</td>
<td>Feeding Tool</td>
</tr>
<tr>
<td>WD</td>
<td>Drahtvorschub</td>
<td>Wire Feeding</td>
</tr>
<tr>
<td>W</td>
<td>Werkstück</td>
<td>Workpiece</td>
</tr>
</tbody>
</table>
Suitable joining geometries for laser brazing

- Fillet welds on flare joint
  - Trunk lid, roof to side panel

- Fillet welds on lap joint
  - Add-on parts, hemmings e.g. doors and hoods
<table>
<thead>
<tr>
<th>YAG</th>
<th>Fiber-coupled Diode Laser</th>
<th>Direct Diode Laser</th>
</tr>
</thead>
</table>
| + fiber delivered  
  + established process | + fiber delivered  
  + direct transfer of YAG laser brazing results to diode laser brazing  
  + plug and play interfaces  
  (brazing head – fiber – beam source) | + direct diode laser  
  + optimized spot geometry  
  + higher joining speed  
  + smoother surface |
| + multi beam switch  
  - high investment  
  - high running costs | + multi beam switch  
  + lower investment costs  
  + low running costs | + much lower investment costs  
  + low running costs |
Influence of Spot Geometry

Spot size: 2 – 3 mm
- Limited speed
- Not optimized interaction time

Spot size: 1,5 x 6 mm
- Adapted spot geometry
- Optimized diffusion process
## Requirements for Brazing Applications

<table>
<thead>
<tr>
<th></th>
<th>Solid state Laser</th>
<th>Diode Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical power</td>
<td>2 - 4 kW</td>
<td>2 - 4 kW</td>
</tr>
<tr>
<td>Spot diameter</td>
<td>1,5 -3 mm, defocused</td>
<td>1,5 -3 mm, focused</td>
</tr>
<tr>
<td>Working distance</td>
<td>approx. 150-200 mm</td>
<td>approx. 150-200 mm</td>
</tr>
<tr>
<td>Beam switch</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Redundancy concept</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Service intervals</td>
<td>1.000 h</td>
<td>20.000 h</td>
</tr>
<tr>
<td>Efficiency</td>
<td>3%</td>
<td>30%</td>
</tr>
<tr>
<td>Space requirements</td>
<td>100%</td>
<td>20%</td>
</tr>
<tr>
<td>Beam fluctuation and stability in time</td>
<td>acceptable</td>
<td>very good</td>
</tr>
</tbody>
</table>
Laser brazing requires diligent process control

- Precise laser beam and wire guidance along the seam
  - Seam tracking in order to compensate for tolerances of parts and robot
  - Dimensional process window perpendicular to seam approx. +/- 0.2 mm
- Variation of filler wire speed to process speed while reorienting the robot

Seam tracking

- Offline
- Online
Possible Brazing Application

- Power range: 2 – 6 KW
- Spot: 1,5 to 2,3 mm
- Spot geometry: round to elliptical

Laserline GmbH, Germany
Advantages of Diode Laser Brazing

- Better quality of weld seam
- Higher brazing speed
- Higher flexibility in spot geometry
- Moderate beam quality
- Wavelength slightly better for brazing
- Low down time and maintenance periods
- Low investment costs
- Low cost of ownership

Example: 4 kW laser
Possible Laser Brazing Configuration

Fiber-coupled diode laser

- Beam switch
- Brazing head (HIGHYAG)

- 3000 to 4000 Watt
- Fiber cable Ø 1 mm
- Focus Ø 2 – 3 mm
- Working distance 200 – 250 mm
- Stack management
- Teleservice

Communication
- Interbus or Profibus
- Teleservice

Drawing: HIGHYAG
Integration of Brazing Heads

Fiber-coupled diode laser

Direct diode laser

Tactile Systems
- ScanSonic
- HIGHYAG

Sensor guided Systems
- HIGHYAG
- Erlas
Brazing Head for Diode Laser

- Working optics with cover slide cassette
- Crossjet and gas feeder
- Camera monitoring
- Wire feeder with adaption
- Crash sensor
- Exchange tool

Drawing: HIGHYAG
Tactile Diode Laser Brazing Head

- Tactile sensor (feeding wire) guides focus
- Modular optical system
  - beam transformer (different spots & twin spot)
  - camera system
- Crossjet
- Cover slide monitoring
- Crash sensor

Drawing: HIGHYAG
Adaptive laser processing heads (ALO)

- Integrated seamtracking and filler wire feeding devices
- Laser welding and brazing, power up to 4000 W
- Autofocus, crossjet, cover gas feeder
- Cover slide crack monitor
- Camera monitor for setup
- Crash protection

Source: Scansonic
Brazing with Direct Diode Laser

- Feed rate approx. 1 m/min per kW laser power
- Smooth surface
- Good adhesion
- Small heat affected zone
- Advantages due to rectangular spot

Photo: IPT
Brazing with Diode Laser: Results

- Optical Power: 4000 W
- Material: DC04 zinc coated
- Brazing wire: CuSi3
- Brazing speed: 4.0 m/min
- Wire feed rate: 4.0 m/min

<table>
<thead>
<tr>
<th>Optical Power</th>
<th>Material</th>
<th>Brazing wire</th>
<th>Max. brazing speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000 W</td>
<td>DC04 + zinc</td>
<td>CuSi3</td>
<td>5 m/min</td>
</tr>
<tr>
<td>1500 W</td>
<td>DC04 + zinc</td>
<td>CuSi3, L-Ag55Sn</td>
<td>1.5 m/min</td>
</tr>
<tr>
<td>4000 W</td>
<td>DC04</td>
<td>CuSi3</td>
<td>1.5 m/min</td>
</tr>
<tr>
<td>3000 W</td>
<td>DC04 + zinc, AC120ZnAl2</td>
<td>CuSi3</td>
<td>2 m/min</td>
</tr>
</tbody>
</table>
Brazing with Diode Laser

Optical Power: 1500 W

<table>
<thead>
<tr>
<th>Brazing speed</th>
<th>Wire feed rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 m/min</td>
<td>1.5 m/min</td>
</tr>
<tr>
<td>1.0 m/min</td>
<td>2.0 m/min</td>
</tr>
<tr>
<td>1.0 m/min</td>
<td>1.7 m/min</td>
</tr>
</tbody>
</table>
Diode Laser Brazing Head on Robot

- Seamtracking and filler wire feeding
- Crossjet and shield gas
- Camera monitoring for setup
- Crash protection

Photo: Scanssonic
Features of Laser Processing Head (PDT)

Complete processing head assembly
- Focus head with integrated seam tracking
- Cctv camera with illumination
- Crash sensor with robot adaption
- Interface to wire feeding system (suitable for hot wire)
- Cable management system
- Electric pneumatic installation system with PLC interface

Modular optical and mechanical setup
- Different spot diameters (imaging ratios) for welding/brazing

Tactile sensor with servo motor support
- Tactile sensor with or without filler wire
- Sensor system using absolute non incremental encoders
- Built in „intelligence“
  (start of programs depending on movement of tactile sensor)
- Individual and process optimized control by PC program

Source: HIGHYAG

Photo: Yasukawa
Brazing with Direct Diode Laser

- Up to 4 kW optical power
- Compact wire feeding
- High working distance: 150 mm
- CCD camera integrated
Brazing in Automotive Industry

- Fiber-coupled diode laser
- Trunk number plate weld
- 3-shift production
- Solid state laser replaced by diode laser