New trends of laser processing within the process chain of hotforming

TRUMPF Laser- und Systemtechnik GmbH
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Industry Management Automotive
Introduction

We are a high-tech company for laser and machine tool technology. With approximately 10,000 employees we are represented in all world markets, close to our customers with 58 subsidiaries.

We are the world leader in laser technology
Introduction

Our lasers are used in the Automotive Sector for the following laser applications:

- Cutting (2-D and 3-D)
- Welding
- Remote Welding
- Brazing
- Ablation
- Hardening
- Softening
- Marking
- Engraving
- Cleaning
- Metal Deposition
- Drilling
Motivation for Hotforming

Reduce fuel consumption

Increase safety
Process Chain Hotforming & Laser Applications

1. Cutting blanks with laser
2. Ablation with TruMicro
3. TWB with TruDisk
4. Tool properties
5. Laser cutting
6. Partial Softening
7. Laser Metal Deposition / LMD
8. 3-D Cutting TruLaser Cell
9. Flange softening with induction or laser
10. Laser marking and welding
Trend: Tailored properties

→ Tailor Welded blanks for different material thickness
→ Tailor welded blanks for different material properties
  (e.g. hard top, ductile bottom)

Challenge:
AlSi coating and subsequently aluminum in the weld seam cause failure of weld

Solution: Removal of the AlSi coating along the seam before welding

R. Vierstraete, „Laser ablation for hardening laser welded steel blanks,” Industrial Laser Solutions, 26 01 2010
Process requirements

- Removal of 10-20 µm AlSi along the welding edge of blank
- Adjustable remaining Al content (down to 0%)
- Preserve properties of base material
- Removal width of 1 mm – 2 mm
- Simultaneous removal of two sides of blank
- Typical welding speed is 6 m/min, resulting linear removal speed of >12 m/min necessary
- Removal rate of more than 5 cm²/s
Optical arrangements: Fiber, Focusing and Laser

- Round
- Square
- Rectangular
- Line focus

Ratio 1:10
Laser equipment: ns-laser TruMicro 7050

Features

- Highest productivity
  - Big spots @ short pulses
  - Highest pulse energy and power @ high repetition rates
- True scalability through constant pulse duration
- Flat top spot due to fiber guidance
Heat conduction in the ablation process

Square

1:1

25% of heat conduction in direction of ablation

Rectangle

1:2

33% of heat conduction in direction of ablation

Line

1:10

45% of heat conduction in direction of ablation

+ 32%  

+ 80%
Summary and facts of the process

- Thermal Process
- For good process quality and efficient process speed a high energy density and a laser with high frequency level needed
- Ablation rate, quality, speed and residue of Al can be adjusted with optical setup and process parameters
Process Chain Hotforming & Laser Applications

Blanking
Edge ablation
TWB & Patchwork
Ablation with TruMicro
TWB with TruDisk
Tool properties
Laser cutting
Partial Softening

Cutting blanks with laser
Laser Metal deposition / LMD
3-D Cutting TruLaser Cell
Flange softening with induction or laser
Laser marking and welding

Johannes Bührle  – 2013-04-11
Werkstoff Forum Uni Hannover - TRUMPF
Trend: Large and complex parts

- Complete door rings out of one part
- Body sides
  - More laser cutting content due to complexity
  - Longer cycle times
  - Larger machine envelope
Trend: Large and complex parts – Y2000

Advantage
- 3D work envelope is nearly entirely used.
- Rotation time <5 seconds
- Identical dynamik as TruLaser Cell 7000 with Y=1500mm
- Precise processing
- Short installation time

Characteristics
- Diameter 5200 mm
- Maximum load: 700 kg per side
- Optimized alignment from laser to machine.
- Minimal influence of ambient conditions like temperature or vibrations compared to portal machines
Trend: Pre-developed parts

- Typically parts with low complexity of geometry
  - pre-cut contours
  - shorter cycle times

T > 1,0mm = Prestamped
T ~ 0,5mm = Laser cut
Why laser cutting?

- Material hardness does not allow conventional trimming process
  - extremely high wear of tools (cost, consistency of quality)
  - high forces required (cost of equipment, local part deformation)
  - Possibility for micro cracking on mechanical cutting edges
- Laser cutting:
  - no wear
  - no deformation
  - access in complex contours /angles

A-pillar

N2, clean edge

Compressed air cut, slightly darker colored edge but no loose particles or scale
Why cutting with 5-axis machines

- Highest real machine dynamics in combination with highest positioning/path accuracy independent from position and speed
- Machine follows programmed path accurately, no axis compensation for NC-path needed
- Easy and logic adjustments of geometries
- Integrated laser light cable
- Large working envelope
- Robust and industrial proven (installed base)

→ Highest output/footprint
→ Lowest cost per part/total cost of ownership
Laser Cutting in Hotforming - TruLaser Cell 8030
Optimized walking distance and part logistics
FastLine

„Normal“ piercing

FastLine (piercing on the fly)

<table>
<thead>
<tr>
<th>Part tolerance smaller</th>
<th>Bigger part tolerance (±2,5 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ For greater piercing height it is a safe process, but slower</td>
<td></td>
</tr>
<tr>
<td>→ For shorter piercing height it is app. as fast as FastLine, but it is not a safe process</td>
<td></td>
</tr>
<tr>
<td>The part can have bigger part tolerances without increasing the cycle time due to an optimized and longer piercing distance.</td>
<td></td>
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</tbody>
</table>
ObserveLine – Slug detection

Laser emits a short pulse after a geometry is cut

In case the slug doesn’t fall, some of the light goes back through the fiber into the laser

A sensor in the laser unit detects the reflected light and gives a signal to the control.

Advantages of optical detection in comparison to capacitive measurement with height regulation (standard function at TruLaser Cell 8030)

2x faster
Smaller (all) diameter can be checked → no limitation
100% process safety
High productive and high accurate rotary changer

<table>
<thead>
<tr>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation time only:</td>
<td>2,3s</td>
</tr>
<tr>
<td>Total part change time:</td>
<td>5,0s</td>
</tr>
<tr>
<td>- Beam off</td>
<td></td>
</tr>
<tr>
<td>- Moving to safety position</td>
<td></td>
</tr>
<tr>
<td>- Turning</td>
<td></td>
</tr>
<tr>
<td>- Moving to part</td>
<td></td>
</tr>
<tr>
<td>- Beam on</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cutting time [s]</th>
<th>60</th>
<th>50</th>
<th>40</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased productivity</td>
<td>3,70%</td>
<td>4,35%</td>
<td>5,26%</td>
<td>6,67%</td>
</tr>
</tbody>
</table>

Increased productivity compared to a standard rotary table with 7,5s change over time.
Productivity improvements and technical trends
Impact on the machine concept

+ Trend: Pre-developed parts
(= decrease of cycle times)

Operator is bottle-neck of operation!

Distribution of Cycle times

- Machine
- Operator

- 30-50 s
- >50 s
- <30 s
Loading strategies for TruLaser Cell 8030

Manual loading

Automated loading cycle
Sequence of automated loading cycle

- Box or bundle
- Positioning of part in rack
- Detect part location with sensor
- Load machine

Tolerance
- ± 1 mm
- ± 50 mm
- < 1 mm

Undefined part location
Part position sensor system in production

- Measuring part position via laser light sensors
- 3 positions define the position in space
- Correction of the gripper position
TruLaser Cell 8030 + LiftMaster Robot
LiftMaster Robot – overview of advantages

- Less operators → lowering hourly rate for machine, saving cost for operator
- Steady output and better continuity of production → more produced parts per shift
- Accurate loading of part compared to manual loading → less wear on fixture
- Automatic detection and discharge of bad parts (ObserveLine)

Resulting in reduction of cost per part, strengthening competitiveness
Better quality due to higher accuracy in loading and less wear of fixture
Laser-cutting-fixture
Example for a B-Pillar-fixture
## TRUMPF fixture pros

<table>
<thead>
<tr>
<th>Feature</th>
<th>TRUMPF</th>
<th>Fixture Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special know-how in building cutting fixtures for hotforming parts. &gt;150 fixtures built in 2012.</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Turn-Key-Solution (Laser+Maschine+Fixture)</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>Use of mostly standard components with world-wide spare parts and service coverage</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>TruTopsCell simulation: Secured accessibility for laser cutting head</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>TruTopsCell simulation: Best cycle time by optimized arrangement of clamping devices</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>TruTopsCell simulation: Optimized part orientation for best cutting quality and cycle time</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>Guaranteed functionality of all mechanical, electrical and pneumatic interfaces between machine and fixture.</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Fixture adjustment according to the CAD-part-model with measurement report</td>
<td>+++</td>
<td>-</td>
</tr>
</tbody>
</table>
Thank you for your attention!

“Oh, I saw the sign, officer, but my car can go a lot faster than that!”

Johannes Bührle
Industry Management Automotive