TOX®- Joining Technology

Presented by
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TOX®- Technology world-wide

TOX views itself as not just another machine builder and manufacturer of products but as partner to all manufacturers in regards to joining processes and the equipment that drives them!
TOX® Mechanical Joining Technologies

- Introduction to:
  - Clinching
  - Clinch Rivet
  - Punch Rivet
  - Special Insertion Fasteners
- Range of material for each process
- Advantages & disadvantages of each process
- Sample Applications
TOX Clinching Technology

Sheet 1
Punch side

Sheet 2
Die side

Ring groove

Punch

Neck area

Die
Phases of TOX®-Clinching

A: Upsetting
B: Lateral spreading of the die side material
C: Filling of the ring groove
D: Lateral spreading of punch side material
E: Finished TOX®-Round Joint

Interlock
X dimension
Performance
What can the TOX Clinching Process Join!

Material:
• metallic and ductile
• same or different materials

Material thickness:
• same or different thicknesses
  (in the ratio of appr. 1:2 up to 2.5:1)
• min. single sheet thickness approx. 0.1mm
• max. total sheet thickness approx. 22.0mm

Component layers:
• two or three layers
• sandwiched layers made of textiles, papers, plastic or adhesive

Material surface:
• uncoated or coated
  (e.g. zinc coated, painted, plastic coated, etc.)
• oily or dry (some lubrication may be required)
When required TOX has developed a spray lube system for lubricating material that is either very dry or very brittle. The lube is contained within the punch or die side strippers. This prevents the lube from being sprayed into the atmosphere.

Also included in this stripper design is our patented TOX Die Check system. This allows us to pneumatically check the punch and die for breakage between joining cycles and send feedback to the PLC.
The life of the TOX® joint is much longer than that of a spot weld...

...because it is a cold forming process that does not create a notch effect and there are no cutting edges in the joint.

The TOX® joint in test:

Results of endurance tests for samples with TOX® joints and spot welds.

The joints were exposed to an initial load of 1 kN and a frequency of approximately 35 Hz. The fatigue life of the joint was measured until failure.
Corrosion
How can I prevent corrosion problems in the joint?

The TOX® joint has a high corrosion resistance, as...

... the TOX®-process requires no cutting edges

... the coating of sheet metal remains mostly intact – even within the TOX® joint!

Many customers from different industries already benefit from this advantage!

- Pre-painted metal in the home appliance industry
- Coated steel in the automobile industry
- Zinc coated metal sheets in plant construction
Environment compatibility
How can I avoid toxic fumes?

**TOX®-Clinching is a cold forming process, therefore...**

- no auxiliary energy needed
- no toxic fumes or gases, even with painted, coated or plastic insulated sheets

**Resulting advantages for your production:**

- daily energy savings
- no need for coolants or expensive inert gases
- no need for washing or surface treatments
- no disposal of chemicals or toxic waste
- no raw edges on the material from piercing
Costs
How can I cut the costs?

The TOX® joint – your cost advantage!

In comparison to welding- or riveting-processes, there are...

→ lower investment costs for machines and equipment
  - TOX® joining is also possible with simple machines and tongs
  - Exhaust systems, coolants or electrode milling not required

→ remarkable cost savings of running production costs
  - no high energy costs for welding operations
  - low tool costs in relation to life time (99%+ uptime)
  - no costs for rivets

→ additional cost saving possible by use of multipoint tools
  - 20 and more joints in one press stroke are possible

Investigations with car manufacturers in Germany, France and Japan showed a cost saving of 15 - 20% per TOX® joint in comparison to spot welding!
Economy of TOX®

Germany: Cost comparison made in collaboration with a German automotive manufacturer in 2006

Base: Steel 0.8 mm / 0.8 mm
depreciation over 6 years

<table>
<thead>
<tr>
<th></th>
<th>Single Point WPS</th>
<th>Single Point Clinching</th>
<th>3-Point Clinching</th>
<th>9-Point Clinching</th>
</tr>
</thead>
<tbody>
<tr>
<td>points per stroke</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>time per point (s)</td>
<td>2.5</td>
<td>2.5</td>
<td>0.83</td>
<td>0.28</td>
</tr>
<tr>
<td>auxiliary process time</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>number of joints per cycle</td>
<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td>cycle time</td>
<td>310</td>
<td>310</td>
<td>117.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Investment costs (EUR)</td>
<td>261,187</td>
<td>213,208</td>
<td>234,192</td>
<td>416,605</td>
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<tr>
<td>variable costs per year</td>
<td>22,572</td>
<td>24,727</td>
<td>44,062</td>
<td>76,815</td>
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<tr>
<td>costing variant</td>
<td>J</td>
<td>G</td>
<td>H</td>
<td>I</td>
</tr>
</tbody>
</table>

| costs per joint (cent) | 1.27 | 1.07 | 0.54 | 0.42 |

18%
Quality assurance
How can I monitor the quality by 100%?

Manual check:
Checking of control dimension „X“ with a scissor gauge.
Process Monitoring of the Clinch Joint

The perfect hardware for your monitoring task

Final force monitoring

Monitoring by means of envelopes

Your benefit:
- Monitoring during series production
- Online archiving of the inspection results
- Monitoring of each individual joint
- Adjustable early warning threshold
- Life time counter for TOX®-Tools
Parameterization of the Clinch Joint

Simple parameterization using our Electric Drive OR our Servo-controlled Powerpackage

TOX Joining process specific HMI for ease of operator understanding
# TOX Joint Validation in Production

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Frequency</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Visual check</td>
<td>Occasionally</td>
<td>Button Shape; control measure - X; no cracks; point symmetry</td>
</tr>
<tr>
<td>B Strength check</td>
<td>Occasionally</td>
<td>Joint strength as per TOX test report; piecepart test; samplings</td>
</tr>
<tr>
<td>C Micrograph (cross section)</td>
<td>Occasionally</td>
<td>Concentricity; neck thickness; interlock; no cracks; control measure - X</td>
</tr>
<tr>
<td>D Continuous process check</td>
<td>100%</td>
<td>Control measure - X; pressforce; tool combination; tool failure; surface condition of sheet (AL); sheet thickness (e.g. TOX monitoring system)</td>
</tr>
</tbody>
</table>

**Number of pieces**

![Graph showing the number of pieces over time]

**Occasional check** such as after crash, tool change, batch change, other changes, company-specific cycle (for example after 50,000 parts each)
Cross Section Analysis

Checking the design parameters of the clinch point:
Projects in the Car Industry
TOX Clinch Applications - Exterior

- 2 A-Pillar
- 1 Antenna hole
- 3 B-Pillar
- 22 Bumper
- 25 Convertible top storage compartment
- Door
- 24 Door jam, Door sealant bracket
- 12 Fender
- 5 Floor panel
- 9 Front bumper
- 11 Hatchback, trunk lid
- 15 Hood
- 17 Hood hinges
- 8 Roof frame
- 7 Roof channel
- 18 Side panels
- 13 Radiator
- 14 Longitudinal chassis beam
- 20 Mirror bracket
- 6 Roof / Roof frame
- 19 Sun roof
- 21 Spoiler / Spoiler bracket
- 21 Spolier / Spoiler bracket
- 19 Tail light board
- Tunnel
- 4 Turn signal hole
- 12 Underbody section / platform
- 8 Window lift actuator track
- 16 Wheel well
- 17 Hood hinges

Clinching
Punching
Punching, Nut insertion
Clinching, Punching, Nut insertion
Clinching, Punching, Fastener-Insertion
Clinching, Punching, Fastener-Insertion
Clinching, Punching, Fastener-Insertion
Clinching, Punching, Fastener-Insertion
Clinching, Punching, Notching
Clinching, Punching, Projection Welding, Stamping
Clinching, Punching, Projection Welding, Stamping
Clinching, Punching, Projection Welding, Stamping
Clinching, Punching, Projection Welding, Stamping
Clinching, Punching, Projection Welding, Stamping
### TOX Clinch Applications - Interior

<table>
<thead>
<tr>
<th>Component</th>
<th>Clinching</th>
<th>Bending</th>
<th>Assembling</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS signal pin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airbag housing</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Aisle bearing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Aisle drive shaft housing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car jack adapter</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Circuit board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Clutch housing</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Grease fitting</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Cylinder head</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Dash panel</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Disc brake dust shield</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Door stop (check-arm)</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Engine shield</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Engine control housing</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine mount</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Exhaust pipe</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Fan clutch</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Filter box</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floorboard</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>Foot pedal</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>+ Fuel filter</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>+ Fuel injection pump</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>+ Fuel tank latch</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>Foot tank opening and fuel tank</td>
<td>Clinching</td>
<td></td>
<td>Punching</td>
</tr>
<tr>
<td>Gas pedal, pedal</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>Gear, gear box</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>Gearbox mounting</td>
<td>Assembling</td>
<td>Clinching</td>
<td></td>
</tr>
<tr>
<td>+ Gear shift housing</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headlight beam panel</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Heat barrier (catalyst)</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Heat shield</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Hose clamp</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Radiator tank</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio housing</td>
<td>Clinching</td>
<td></td>
<td>Pneumatic</td>
</tr>
<tr>
<td>Rear deck</td>
<td>Punching</td>
<td></td>
<td>Bending</td>
</tr>
<tr>
<td>Seat belt eye loop</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat adjuster</td>
<td>Punching</td>
<td></td>
<td>Bending</td>
</tr>
<tr>
<td>Seat shell, seat frame, seat reinforcement, seat side frame</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ski hatch (boot trunk)</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Starter battery housing</td>
<td>Edging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steering column</td>
<td>Clinching</td>
<td></td>
<td>Pneumatic</td>
</tr>
<tr>
<td>+ Suspension mounting</td>
<td>Clinching</td>
<td></td>
<td>Punching</td>
</tr>
<tr>
<td>+ Trunk floor, battery box</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning triangle mount</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>+ Water pump housing</td>
<td>Clinching</td>
<td></td>
<td>Assembling</td>
</tr>
<tr>
<td>Wheel bearing</td>
<td>Punching</td>
<td></td>
<td>Coining</td>
</tr>
<tr>
<td>+ Wheel rim</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window lifter, window track</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Windshield wiper mounting</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Engine and motor housing</td>
<td>Clinching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Engine hood with TOX® joints

125 TOX® joints Ø 8 mm

Al 1.15 - Al 1.25 - Al 2.00 - Al 2.50 mm into
Al 1.15 - Al 1.25 mm

With 9 Robotic Clinch Units
Decklid with TOX®

60 TOX® joints Ø 6 mm

Sheet metal 0.75 mm into Sheet metal 0.75 mm

with 2 Robotic Clinch Units
Sunroof frame with TOX® Dissimilar Materials

12 TOX® joints Ø 8 mm

Anodized Al 2.00 mm into CRS 1.20 mm
Car back wall

Mixed joining of steel with aluminium

- Adhesive + Clinching
- 120 TOX® joints
Other Application - Electrical Conductivity of TOX - Joints

Electrical testing

Energization-test of TOX-joined conductor lines and contacts

Contacts and conductor lines were joined using 3mm TOX-points.

Material contact: CuFe2P, R-470, Sn 1-3μm, 0.8mm thick
Material conductor line: CuETP, R-290, Sn 1-3μm, 1.0mm thick

Energization-tests each 30min with 40, 50 and 60A: resistance at 1A testing current = 0.063mΩ

Measuring device: Microohmometer MGR-10, manufacturer: Sefelec, measuring method: 4-Pol-measurement
Survey of TOX® joining

Simplicity is our strength

with point diameters from 1 mm up to 24 mm

TOX®-Round Joint
TOX®-MICROpoint

TOX®-ClinchRivet

TOX®-SKB

TOX®-Flat Point

TOX®-Vario Joint I

TOX®-Vario Joint II

TOX®-TWINpoint
TOX® Joining Technology

TOX® Clinch Rivet
The TOX® Clinch Rivet
Comparison TOX® Clinch Rivet / SPR Rivet
### Reasons for Clinch Rivet

1. No pre-piercing required
2. Ability to join materials combinations where die side thickness is <0.7mm
3. Flexible joining method in regards to materials, sheet thickness variations and adhesive applications
4. Aluminium rivet for Aluminium materials resolving issues with corrosion
5. Tight sealed joint, which is of interest in high moisture areas
6. Flush surface on the punch side
Example Application for the Clinch Rivet

- 4,000 Filter Cans per day at SHG
  → 40,000 TOX®-ClinchRivet per day with 4 machines
- 1,200 Filter Cans per day at Gesa
  → 12,000 TOX®-ClinchRivet per day with 2 C-frame
  → 6,000 TOX®-ClinchRivet per day per C-frame

TOX®-ClinchRivet used for mounting bracket of automotive filter housing. Advantage: high strength, no cutting, for example like with pierce rivets, thus no damage to surface coating.
Connection TOX®-Clinch Rivet with flat head

Results with CFRP (Carbon fiber) t=2.1mm in AlMg3 t=2.0mm

Rivet material: 16MnCr5

Used matrix: BF8014
Solid Punch Rivet
Solid Punch Rivet Technology: ”the basics“

Hold down device

**$F_N$** Clamping force

**$F_S$** Punching force

**$F_P$** Embossing force

Rivet punch

Solid punch rivet
Solid Punch Rivet: comparison

**Solid Punch Rivet**

- Even surface on punch side
- Multi layers possible
- Tolerates sheet thickness variations
- Joining process monitoring is easy

**Self piercing rivet**

*Rivet is not deformed*

*Bottom edge is opening up*
Typical joining tasks of solid punch riveting
Reasons for Solid Punch Rivet

- No pre-piercing required
- One die and one rivet for a variety of tasks
- Flexible joining method with regards to materials and thickness variations
- Only the die side material must have plastic deformation capability
- Punch side materials may be high strength materials or non-metal materials
- Even surface on the punch side and a minor rivet extension on the die side can easily be achieved
Applications for Solid Punch Rivet

- Door 1
- Body Sidewall 2
- Fender 3
- Trunk Pan 4
TOX Process Development
TOX-Assembly Systems
TOX-Riveting Systems

SPR – System 80kN
Powerpackage Driven
2 Size Rivet selection
Process Monitoring
TOX® Rivet Systems – feeding tube

TOX®- tubes
✓ for 5mm rivet with length 4,0-9,0 mm
✓ for 3mm rivet with length 3,5-5,0 mm
✓ couplings for gunchangers are available

Solutions with 30m of feeding tube length were realized by use of repeater units.

Test area at TOX® PRESSOTECHNIK
✓ realistic tests including robot movements
Special Execution for SPR - Die Driven

- SPR – Setting Head
- Active loading stroke
- Gun equalization
Size Comparison of the Drives

Electric Drive
80kN / 300mm

Powerpackage
80kN with
12mm power &
300mm total strokes

Die driven
mechanism
for SPR
# Overview of Mechanical Joining Processes

## Part 1

<table>
<thead>
<tr>
<th></th>
<th>Punch Rivet</th>
<th>Clinching</th>
<th>Clinch Rivet</th>
<th>SPR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Size 4 rivet -</td>
<td>- Size 6 point -</td>
<td>- Size 5 rivet -</td>
<td>- Size 5 rivet -</td>
</tr>
<tr>
<td>Plate strength</td>
<td>up to 1700 MPa</td>
<td>up to 1200 MPa</td>
<td>&lt;500 MPa</td>
<td>&lt;1000 MPa</td>
</tr>
<tr>
<td>Multi-grip capability</td>
<td>very good</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Compensation for sheet thickness tolerances</td>
<td>very good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Max. number of sheets</td>
<td>3 and more</td>
<td>3 (sometimes 4)</td>
<td>2 (sometimes 3)</td>
<td>2-3</td>
</tr>
<tr>
<td>Flush surfaces</td>
<td>two-sided possible</td>
<td>no</td>
<td>one-sided 2</td>
<td>one-sided 2</td>
</tr>
<tr>
<td>Pressing force utilisation (shear strength/pull strength) 3</td>
<td>40-70 N/kN, 80-100 N/kN</td>
<td>20-40 N/kN, 20-40 N/kN</td>
<td>38-45 N/kN, 60-75 N/kN</td>
<td>ca. 50 N/kN, ca. 100 N/kN 4</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>envelope curves</td>
<td>envelope curves</td>
<td>envelope curves</td>
<td>envelope curves</td>
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<tr>
<td>Tool life</td>
<td>&gt;250,000 5</td>
<td>&gt;200,000 6</td>
<td>&gt;200,000 6</td>
<td>&gt;200,000 6</td>
</tr>
<tr>
<td>Pull strength (Al-Al) 7</td>
<td>1200 N-1500 N</td>
<td>600 N-900 N</td>
<td>1700 N-1900 N</td>
<td>approx. 2000 N 4</td>
</tr>
<tr>
<td>Shear strength (Al-Al) 7</td>
<td>2000 N-2500 N</td>
<td>900 N-1100 N</td>
<td>2700 N-3200 N</td>
<td>approx. 4300 N 4</td>
</tr>
</tbody>
</table>

1. In individual cases, ultra high strength sheets can be joined
2. Slight sheet metal entry around the rivet head
3. Point holding force per kN pressing force, Al 1.5 mm in Al 1.5 mm (à frame size)
4. Small database
5. "Start value" for an Al-Al joint (no reference values so far), level as for clinching
6. For Al in Al in reality sometimes much higher
7. Reference values for a joint mating Al 1.5 mm in Al 1.5 mm
## Overview of Mechanical Joining Processes

### part 2

<table>
<thead>
<tr>
<th></th>
<th>Punch Rivet</th>
<th>Clinching</th>
<th>Clinch Rivet</th>
<th>SPR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Size 4 rivet -</td>
<td>- Size 6 point -</td>
<td>- Size 5 rivet -</td>
<td>- Size 5 rivet -</td>
</tr>
<tr>
<td>Robustness</td>
<td>good 8</td>
<td>very good</td>
<td>very good</td>
<td>very good</td>
</tr>
<tr>
<td>min. flange width 9</td>
<td>12 mm</td>
<td>10 mm</td>
<td>14 mm</td>
<td>18 mm</td>
</tr>
<tr>
<td>Techn. availability</td>
<td>high</td>
<td>very high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Multi-point capability</td>
<td>feasible</td>
<td>very good</td>
<td>feasible</td>
<td>feasible</td>
</tr>
<tr>
<td>Machine complexity</td>
<td>high 10</td>
<td>low</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Cutting of the sheets</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes, upper plate</td>
</tr>
<tr>
<td>Corrosion</td>
<td>yes 11</td>
<td>no</td>
<td>no</td>
<td>yes 11</td>
</tr>
<tr>
<td>Liquid Tightness</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no 12</td>
</tr>
<tr>
<td>Min. lower sheet thickness</td>
<td>1 mm</td>
<td>0.2 mm</td>
<td>0.7 mm</td>
<td>1 mm 13</td>
</tr>
<tr>
<td>Joining component costs</td>
<td>100% 14</td>
<td>none</td>
<td>50% (ca. 2 ct)</td>
<td>50% (ca. 2 ct)</td>
</tr>
<tr>
<td>Slug</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

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8 Due to the low amount of self-centring (rivet centricity) and variation in the degree of groove filling

9 The flange width can possibly be reduced by a die which is optimised for the interference contour

10 Slug disposal in addition to joint component feed

11 Sheets are cut through, no corrosion if joint points are painted

12 Upper sheet layer is punched through

13 Depending on the total sheet thickness

14 A forged rivet is at STR level
Thank You!

Any Questions?