INNOVATIVE JOINING OF FUNCTIONAL ELEMENTS IN PH-STEEL DURING THE HOT FORMING

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PRESS HARDENED STEELS IN THE AUTOMOTIVE INDUSTRY

Market analysis

- CO₂-Emission
- Range of e-cars
- Occupant safety
- Reduction in vehicle weight
- Use of light materials
- Use of high-strength steels

Need for mounting points in Press hardened, thin-walled parts

- Mild Steel
- High Strength Steel
- Advanced High Strength Steel
- Ultra High Strength Steel
- Press hardened Steel
- Aluminum
CURRENT JOINING TECHNOLOGIES FOR PHS

Welding elements
- Schmeck
- Würth

Disadvantages
- Separate process
- Negative thermal effect on sheet strength (HAZ)
- Not always possible

Mechanical Attached Fasteners (MAF)

Riveting elements
- PROFIL
- PROFIL

Disadvantages
- Separate process
- Pre hole operation needed
- Special solutions (plain hole-perforated sheet etc.)

Self-piercing elements
- PROFIL
- PROFIL

Disadvantages
- High process forces
- Risk of Microcracks
- Limited sheet thickness range
PRINCIPLE

1. Cut Blank
2. Heating in furnace
3. Forming, Application of MAF and hardening
4. Finished component

**T [°C]**

- Ferritic-pearlitic microstructure of the 22MnB5 (Initial condition)
- Martensitic microstructure of quenched 22MnB5

**Heat treatment and austenitization**
- 900°C to 950°C
- 300 s
- 6 s to 8 s
- min. 27 K/s

**Quenching + Application of the MAF**
- 20°C

**Transfer**
- 20°C
EXAMINATION OF THE ELEMENT AND PANEL

Evaluation of the cross-sections

Thread size: M6

- $T_{\text{Joining}} = 800 \, ^\circ\text{C}$
- $F_{\text{Joining}} = 57 \, \text{kN}$

- $T_{\text{Joining}} = 600 \, ^\circ\text{C}$
- $F_{\text{Joining}} = 67 \, \text{kN}$

Thread functionally was tested by a thread gauge.

Thread size: M8

- $F_{\text{Joining}} = 78 \, \text{kN}$

- $F_{\text{Joining}} = 85 \, \text{kN}$

Sheet metal
- 22MnB5 (AlSi coated)

Panel thickness
- 1.5 mm

Joining temperature
- See image

Joining speed
- 60 mm/s
Influence of temperature on the microstructure and the coating of the element

Evaluation of the coating

Evaluation of the microstructure

Zinc-nickel coating shows great temperature resistance.

Zinc-coating isn’t suitable for this application because of its low melting point.

Tempered Martensite - No noticeable changes in the microstructure.
Influence of the process on the panel material

A fully martensitic microstructure can be achieved near the joining zone.

Martensite with needle-like structure in the strongly formed region

EXAMINATION OF THE ELEMENT AND PANEL
EXAMINATION OF THE ELEMENT AND PANEL

Influence of temperature on the strength of the SMA06 element

Negligible influence on element strength class

\[ T_{\text{Joining}} = 800 \, ^\circ\text{C} \]

\[ T_{\text{Joining}} = 600 \, ^\circ\text{C} \]
EXAMINATION OF THE ELEMENT AND PANEL

Mechanical joint properties – Push-out testing

Sheet metal: 22MnB5 (AlSi-coated); t = 1.5 mm

Maximalwert
Minimalwert
Mittelwert

Push-out testing

Typical requirements of OEM

600 °C
800 °C

800 °C
600 °C

8.9
9.6
10.9
11.8

SMA06
SMA08
EXAMINATION OF THE ELEMENT AND PANEL

Mechanical joint properties – Torque testing

Sheet metal: 22MnB5 (AlSi-coated); t = 1.5 mm

Maximum
Average
Minimum
n = 5

Maximalwert
Minimalwert
Mittelwert

Maximum
Average
Minimum

Sheet metal: 22MnB5 (AlSi-coated); t = 1.5 mm

Maximalwert
Minimalwert
Mittelwert

Maximum
Average
Minimum

Sheared off during the torque test.

Deformed sheet metal by ribs of the nut.

Representative failure picture of the nut:

The ribs were sheared off during the torque test.
EXAMINATION OF THE ELEMENT AND PANEL

Mechanical joint properties – Cyclic joint testing

- **Tensile**
  - $f = \text{ca. } 80 \text{ Hz}$

- **Joining partner:**
  - DC04; 1.2 mm

- **Screw:**
  - Class 10.9; $MT = 14.9 \text{ Nm}$
  - plus a washer.

- **Reference**

- **3 mm hole**

- **Only the element**

- **Screwed joint**

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Jointing partner: DC04; 1.2 mm

Screw: Class 10.9; $MT = 14.9 \text{ Nm}$ plus a washer.
Influence of the process on the panel material

No disadvantages detected under cyclic tensile load tests.
TOOLING SYSTEM

Pierce head

Coupling to the feeding system

PROFIL Sorting and Feeding system

Die
TOOLING SYSTEM

Wear of the die

Die button in detail

View on the die button

View on the die button

Cross-section of the die button and hardness measure points

Cross-section of the die button and hardness measure points

Die button in detail

Measure points

HV10

New

Used

(500 strokes)
LEAK TEST

Leakage tests

• Measuring device:
  Mobile helium-leak tester
  INFINICON UL1000

• All tested elements have a leak rate < 10^{-6} mbar·l/s

<table>
<thead>
<tr>
<th>requirement</th>
<th>mbar·l/s</th>
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<tbody>
<tr>
<td>Δp=1bar</td>
<td>10^0</td>
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<tr>
<td></td>
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<td>10^{-2}</td>
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<tr>
<td>IP67</td>
<td>10^{-3}</td>
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<tr>
<td>Oil-tight</td>
<td>10^{-4}</td>
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<tr>
<td>Bacteria proof</td>
<td>10^{-5}</td>
</tr>
<tr>
<td>Gasoline proof</td>
<td>10^{-5}</td>
</tr>
<tr>
<td>Gas tight</td>
<td>10^{-6}</td>
</tr>
</tbody>
</table>
CONCLUSION

- Integration of the application of MAF into direct hot forming process
  - Significant shortening of the process chain for hot formed components
- Successful application of PROFIL functional elements at a sheet temperature of 600 °C up to 800 °C
- Excellent quasi-static and cyclic mechanical joining properties can be achieved
- No negative impact on the strength class, microstructure and coating of the nut caused by temperature
- Possibilities for automated element feeding developed and tested in a near-series production
FOR MORE INFORMATION

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