GREAT DESIGNS IN STEEL

TWENTY YEARS

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

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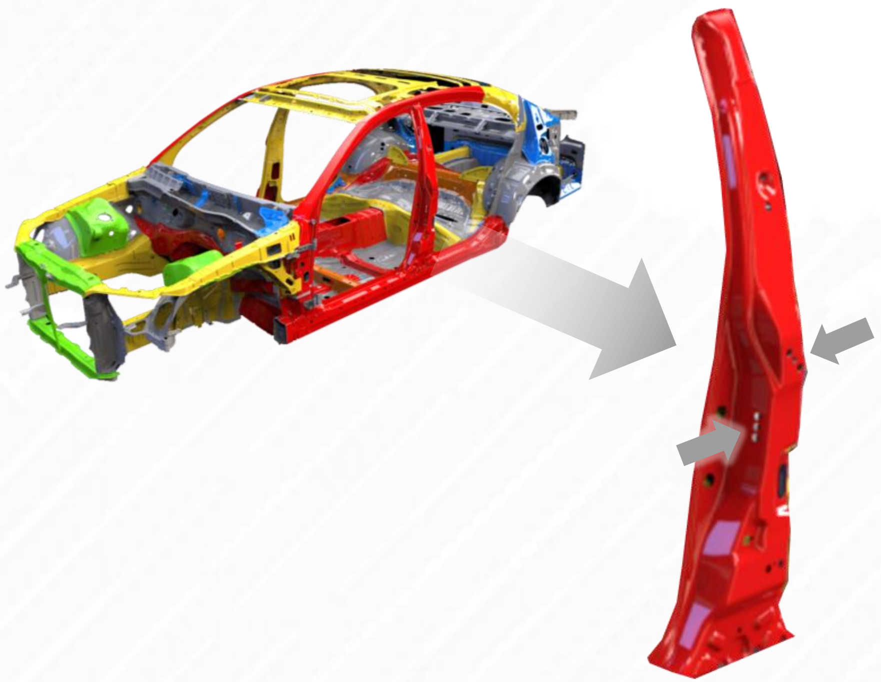
PRESS HARDENED STEELS IN THE AUTOMOTIVE INDUSTRY

Market analysis

- CO_2-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

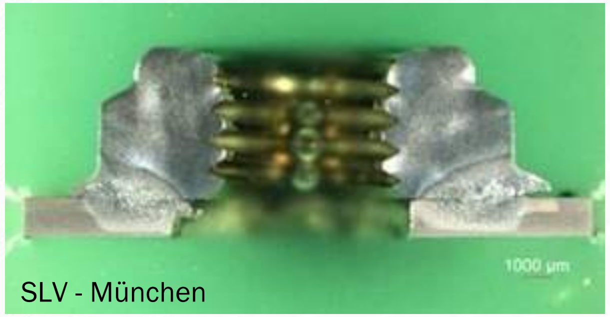
- Mild Steel
- High Strength Steel
- Advanced High Strength Steel
- Ultra High Strength Steel
- Press hardened Steel
- Aluminum

CURRENT JOINING TECHNOLOGIES FOR PHS

Welding elements

Schmeck

Würth



SLV - München

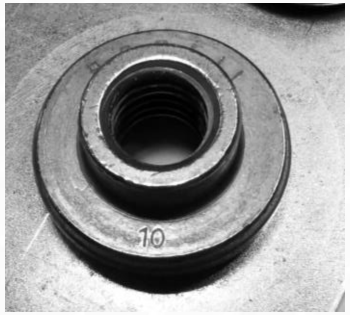
Disadvantages
- Separate process
- Negative thermal effect on sheet strength (HAZ)
- Not always possible

Mechanical Attached Fasteners (MAF)

Riveting elements

PROFIL

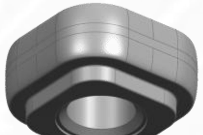
PROFIL



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

Self-piercing elements

PROFIL



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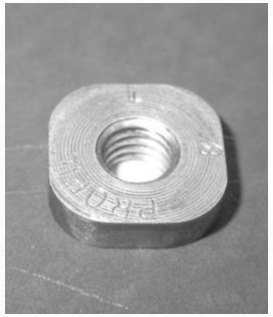
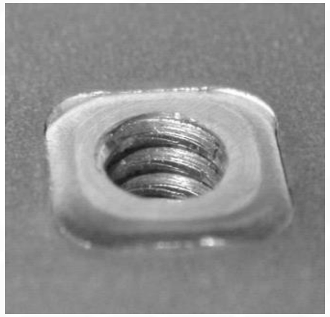
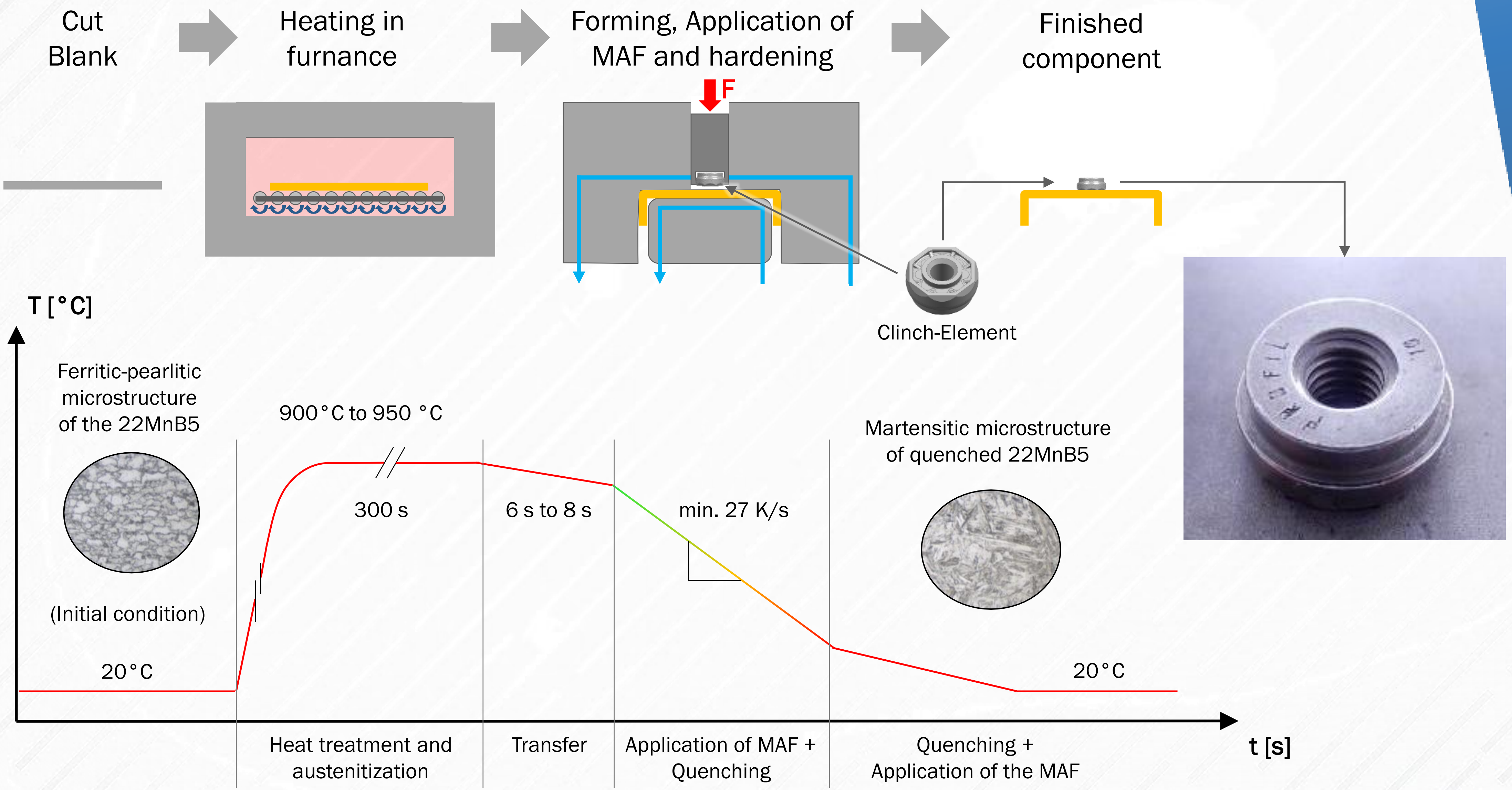




Disadvantages
- High process forces
- Risk of Microcracks
- Limited sheet thickness range

PRINCIPLE



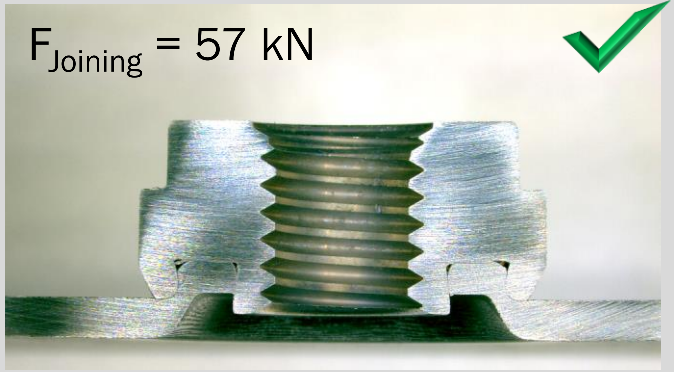
Cut Blank
Heating in furnace
Forming, Application of MAF and hardening
Finished component
F
Clinch-Element
T [°C]
Ferritic-pearlitic microstructure of the 22MnB5
(Initial condition)
20°C
900°C to 950 °C
300 s
6 s to 8 s
min. 27 K/s
Martensitic microstructure of quenched 22MnB5
20°C
t [s]
Heat treatment and austenitization
Transfer
Application of MAF + Quenching
Quenching + Application of the MAF

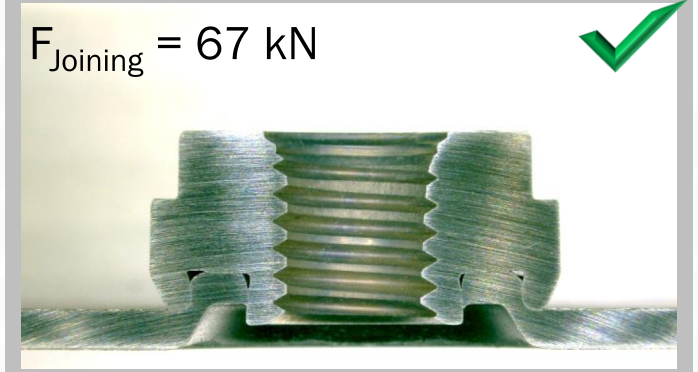
EXAMINATION OF THE ELEMENT AND PANEL

Evaluation of the cross-sections

$T_{Joining}$ = 800 °C | $T_{Joining}$ = 600 °C

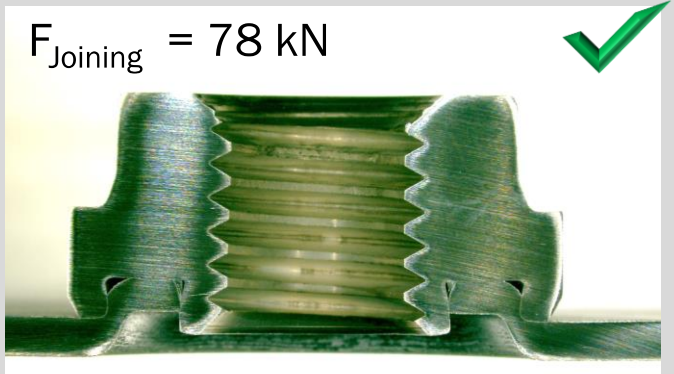
Thread size: M6

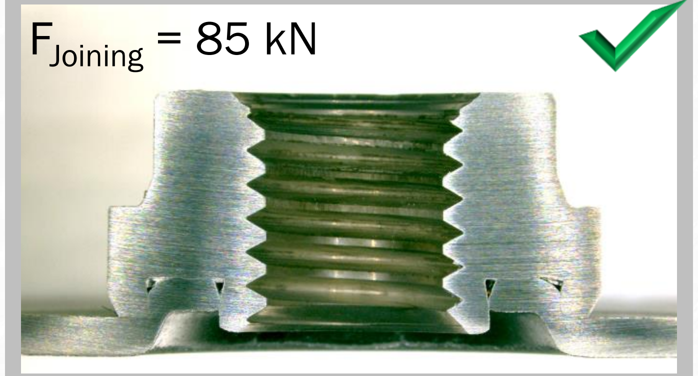




Thread functionality was tested by a thread gauge.

Thread size: M8

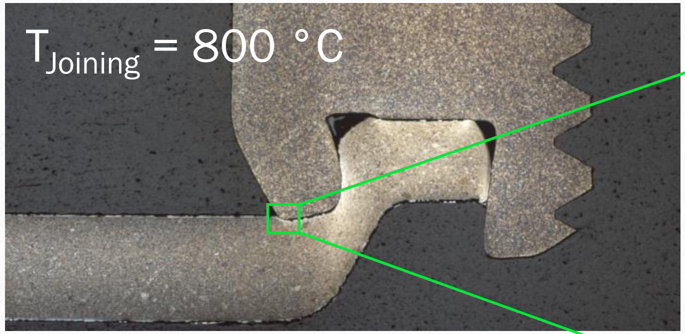


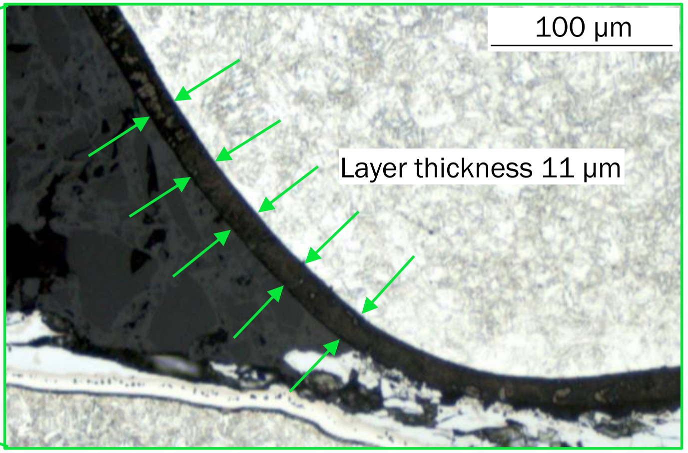


Sheet metal
22MnB5 (AlSi coated)
Panel thickness
1.5 mm
Joining temperature
See image
Joining speed
60 mm/s

EXAMINATION OF THE ELEMENT AND PANEL

Influence of temperature on the microstructure and the coating of the element

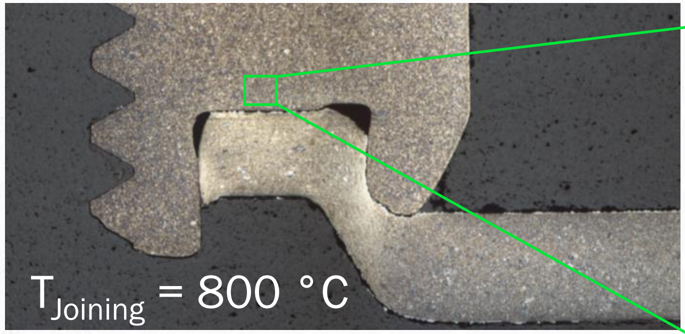


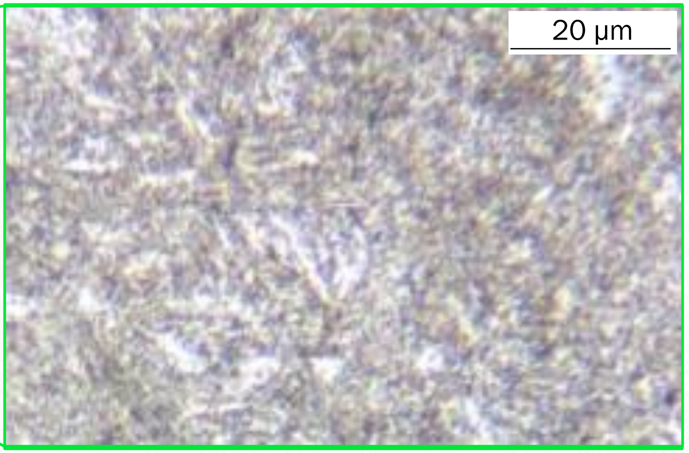


Evaluation of the coating

Zinc-nickel coating shows great temperature resistance.

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



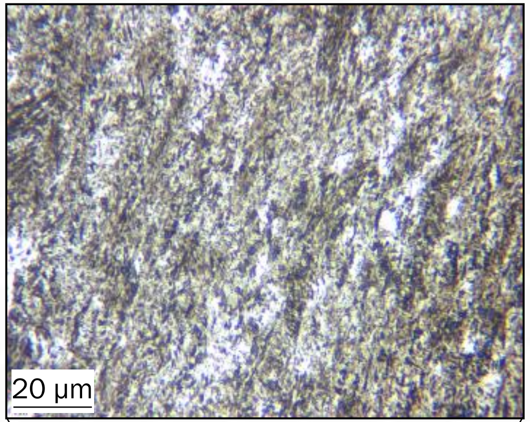


Evaluation of the microstructure

Tempered Martensite – No noticeable changes in the microstructure.

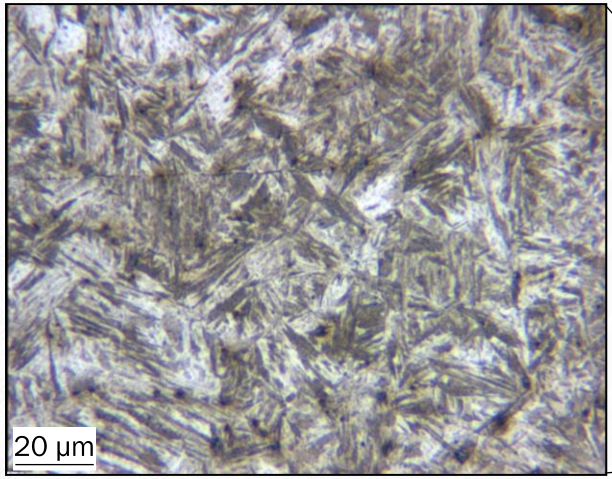
EXAMINATION OF THE ELEMENT AND PANEL

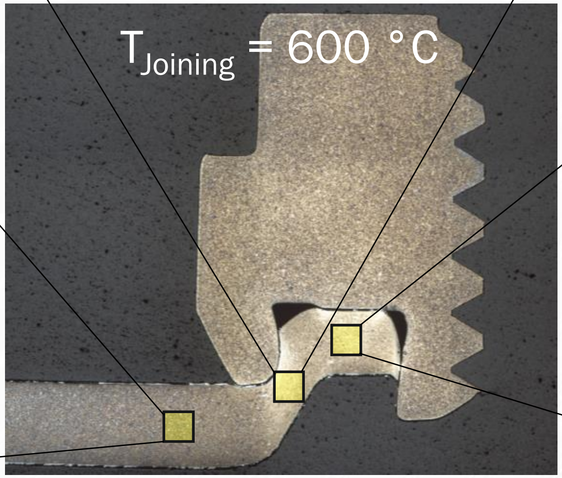
Influence of the process on the panel material

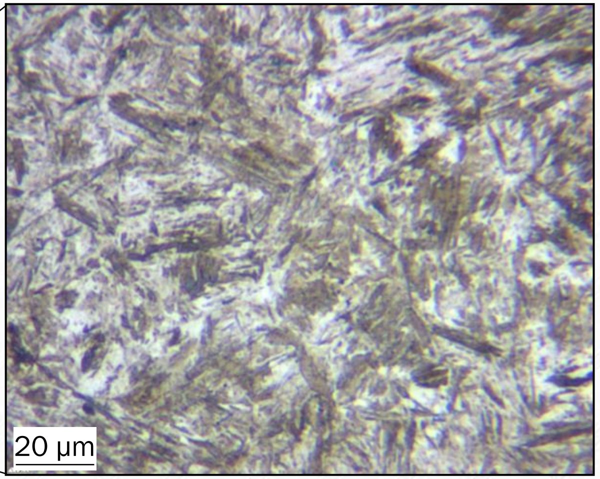


Martensite with
needle-like structure
in the strongly formed region

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

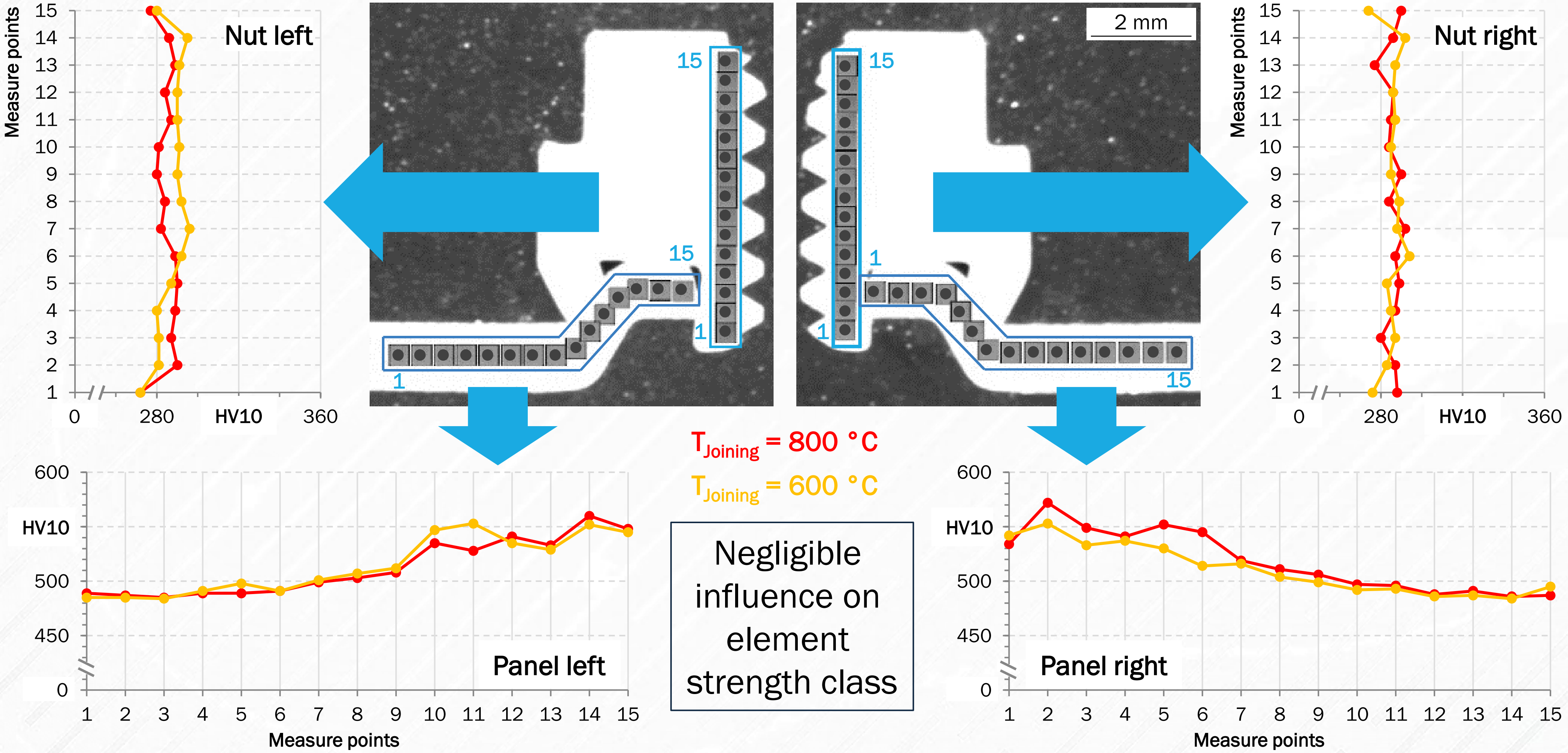






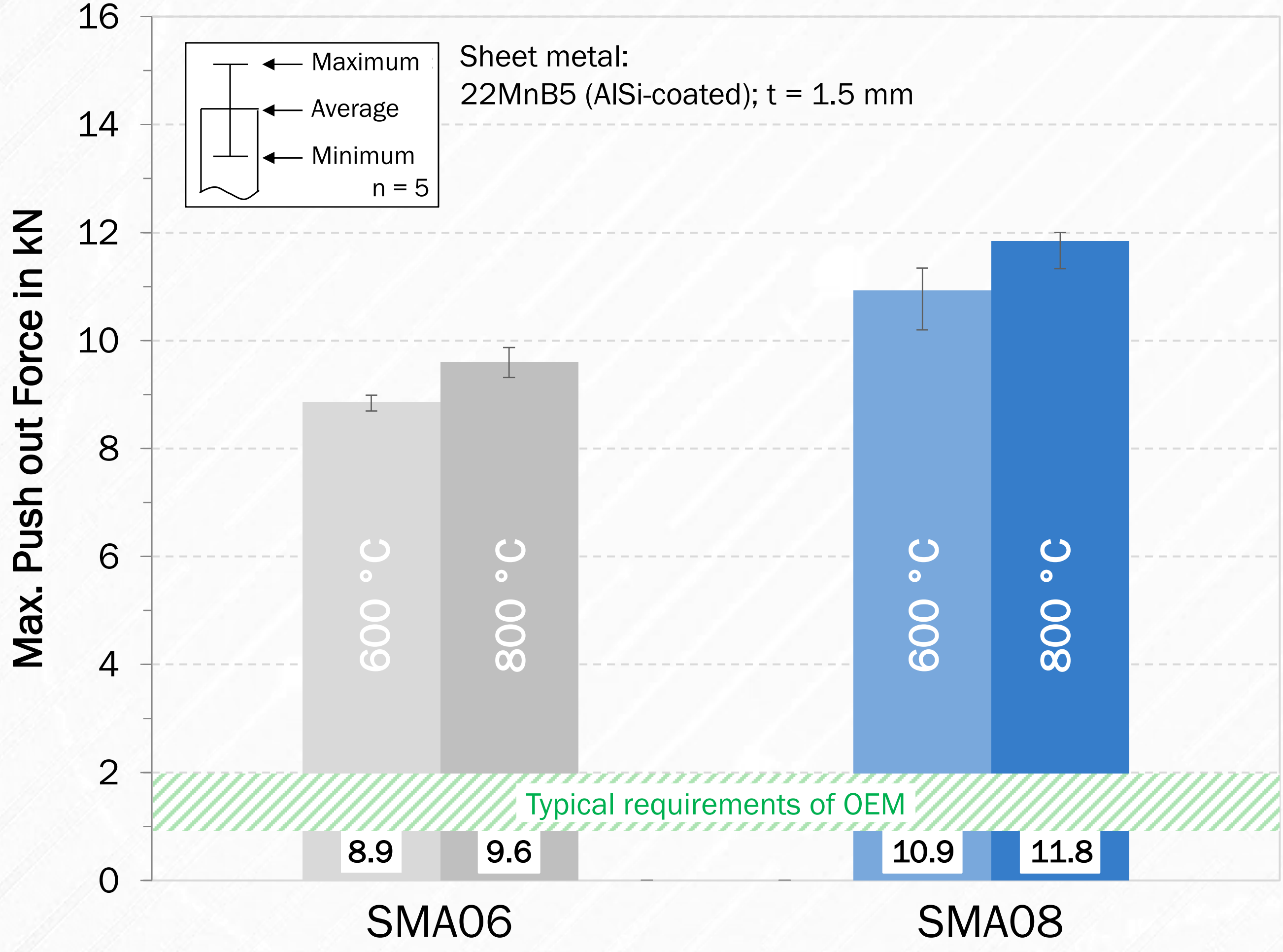
EXAMINATION OF THE ELEMENT AND PANEL

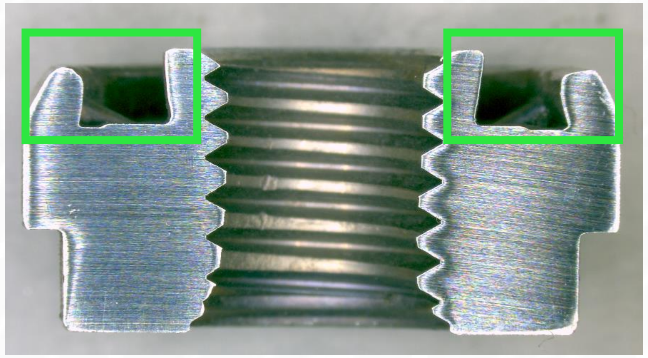
Influence of temperature on the strength of the SMA06 element



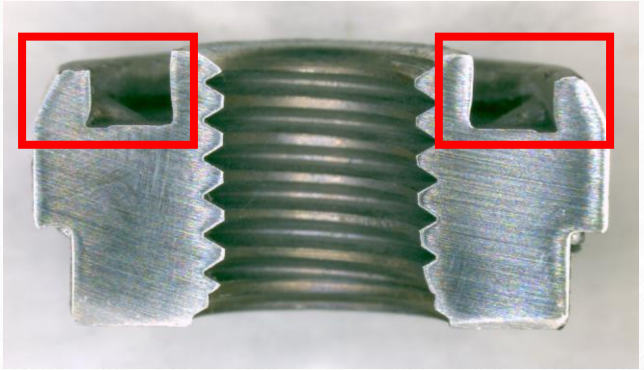
EXAMINATION OF THE ELEMENT AND PANEL

Mechanical joint properties – Push-out testing



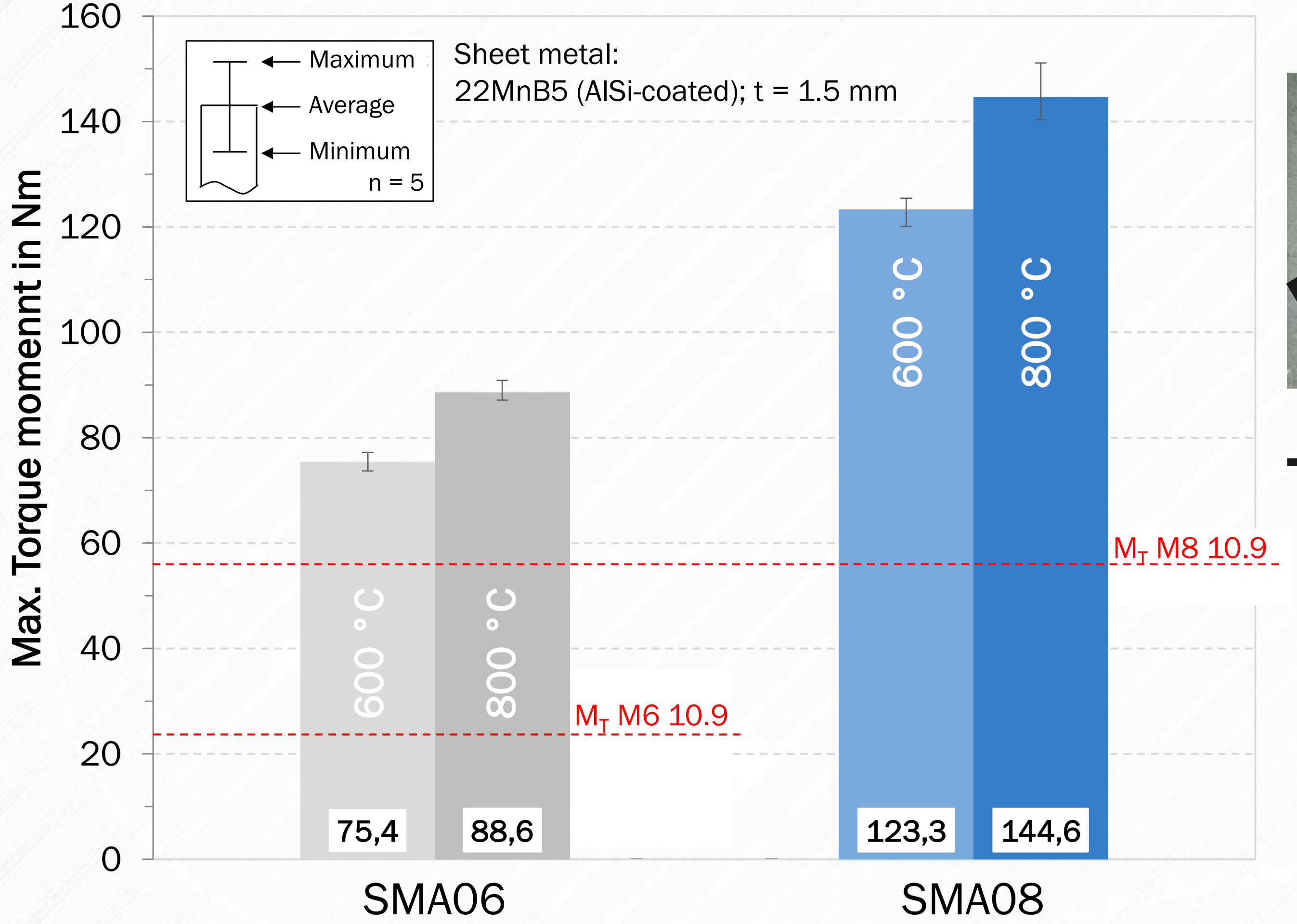


Push-out testing

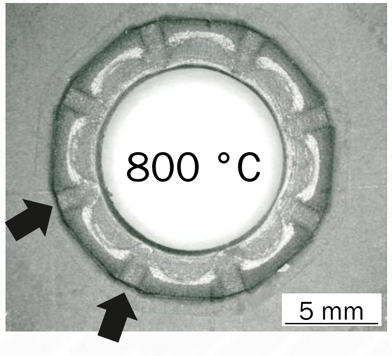


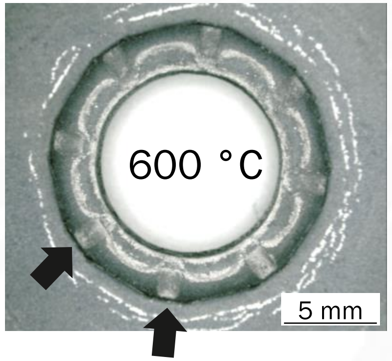
EXAMINATION OF THE ELEMENT AND PANEL

Mechanical joint properties – Torque testing



Deformed sheet metal by ribs of the nut.



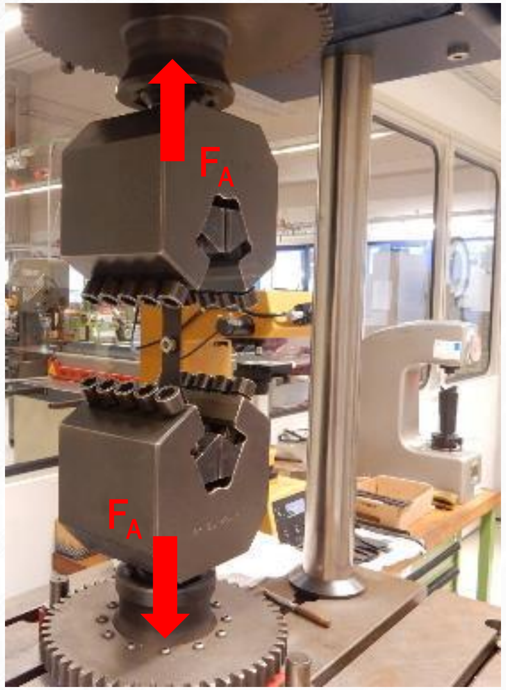


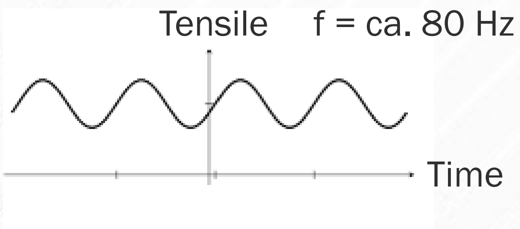
Representative failure picture of the nut:

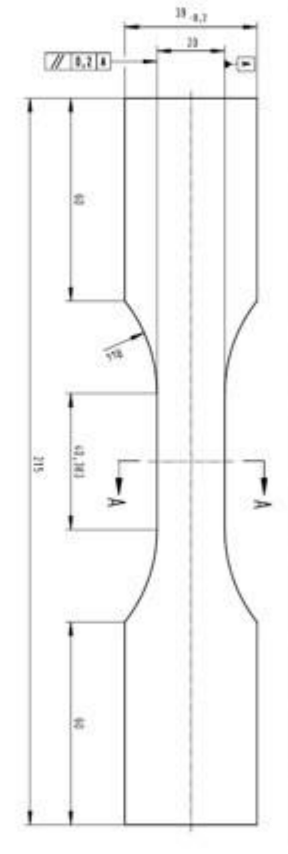
The ribs were sheared off during the torque test.

EXAMINATION OF THE ELEMENT AND PANEL

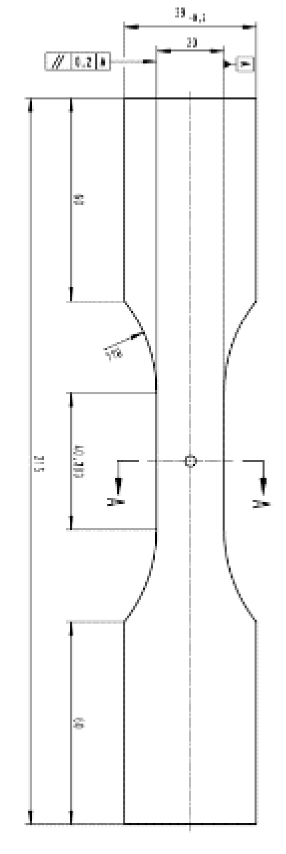
Mechanical joint properties – Cyclic joint testing







Reference

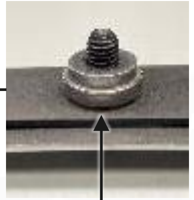


3 mm hole

Only the element

Screwed joint

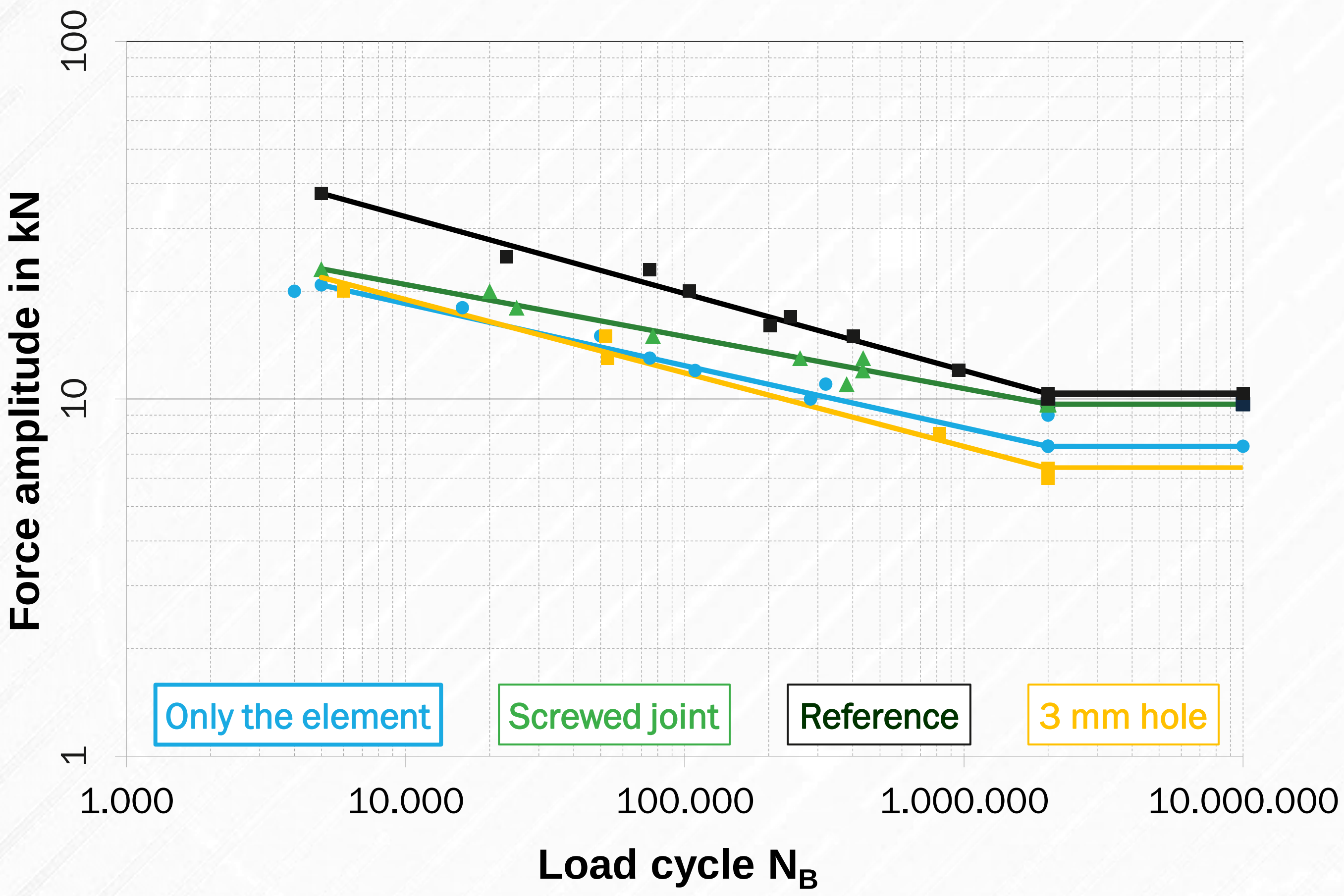
Joining partner:
DC04; 1.2 mm

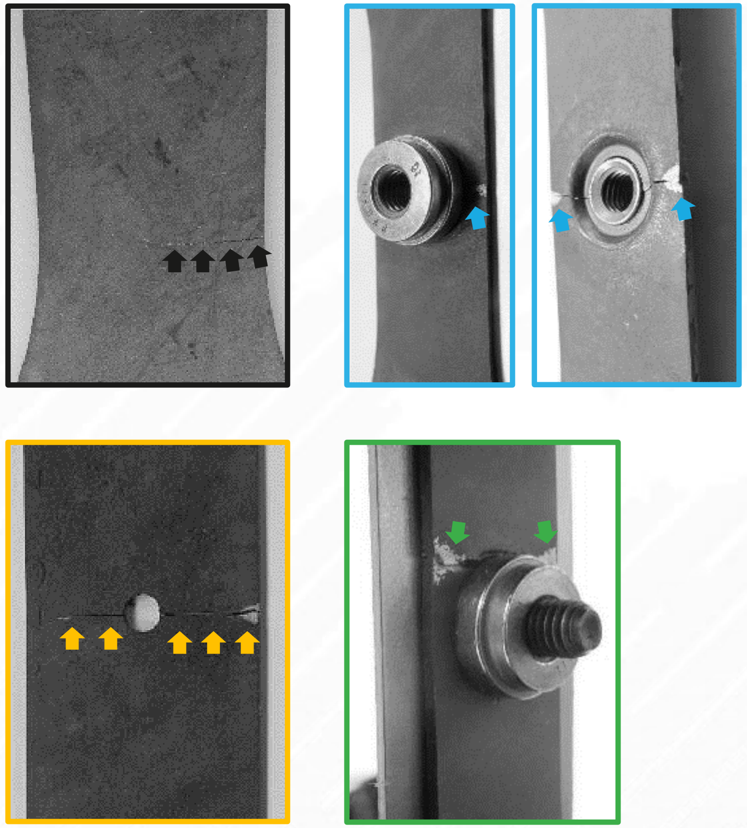


Screw:
Class 10.9;
MT = 14.9 Nm
plus a washer.

EXAMINATION OF THE ELEMENT AND PANEL

Influence of the process on the panel material

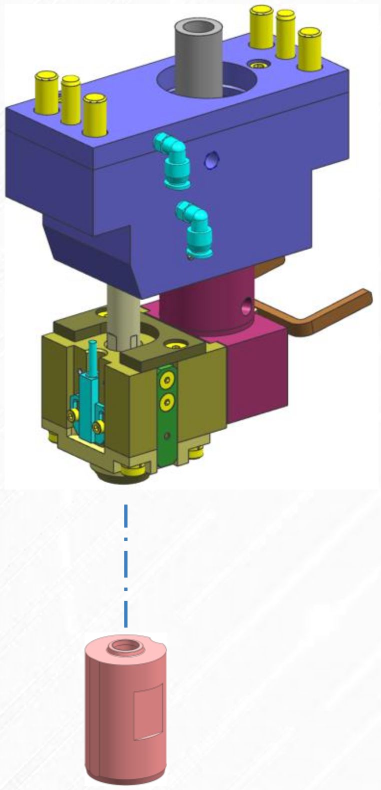




No disadvantages detected under cyclic tensile load tests.

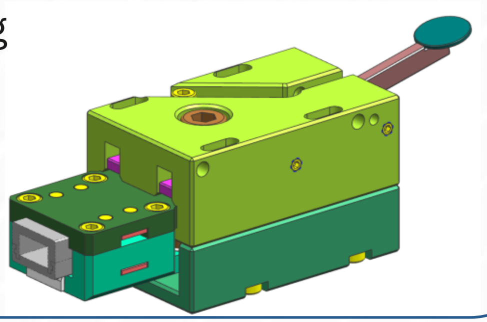
TOOLING SYSTEM

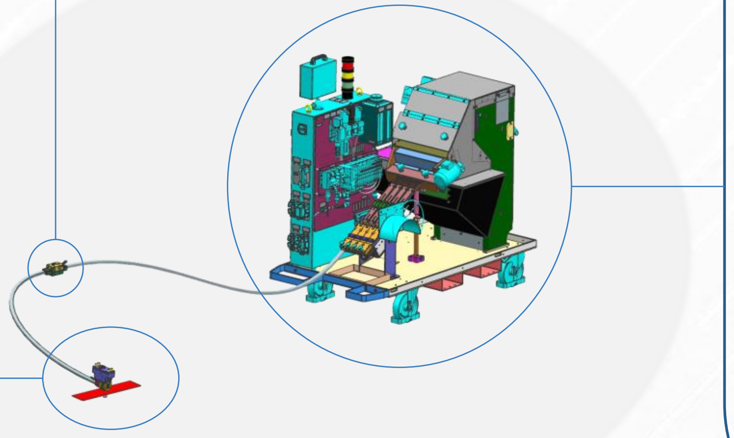
Pierce head



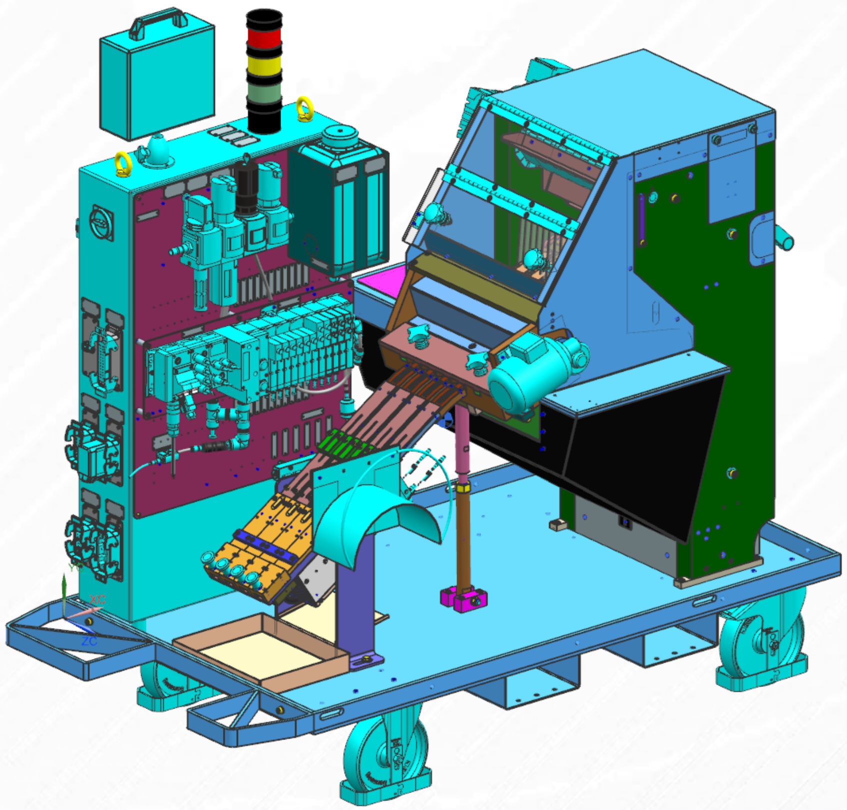
Die

Coupling to the feeding system





PROFIL Sorting and Feeding system

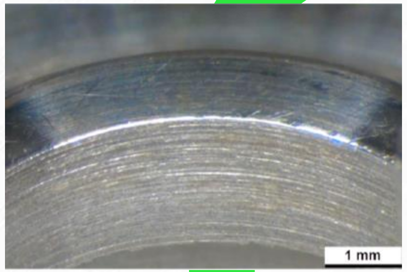


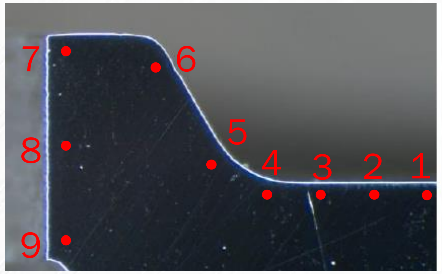
TOOLING SYSTEM

Wear of the die

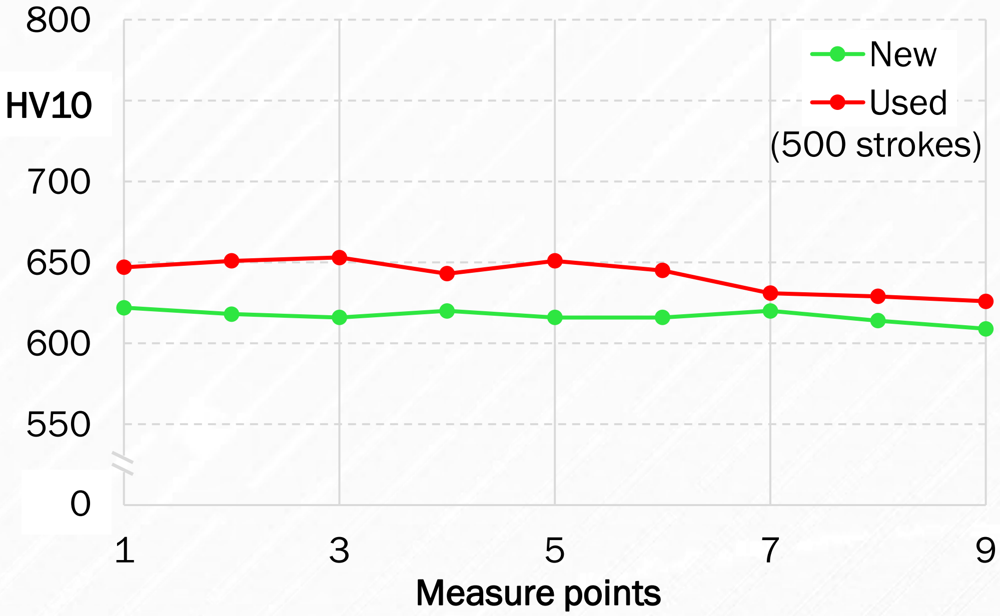
View on the die button

Die button
in detail



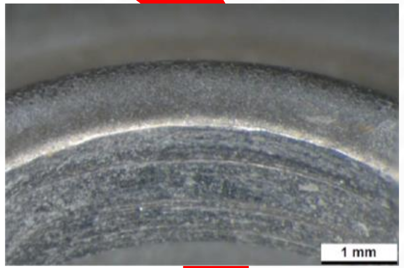


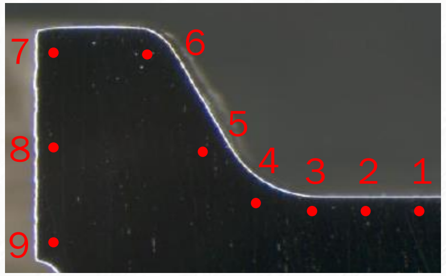
Cross-section of the die button
and hardness measure points



View on the die button

Die button
in detail





Cross-section of the die button
and hardness measure points

LEAK TEST

Leakage tests

- Measuring device:

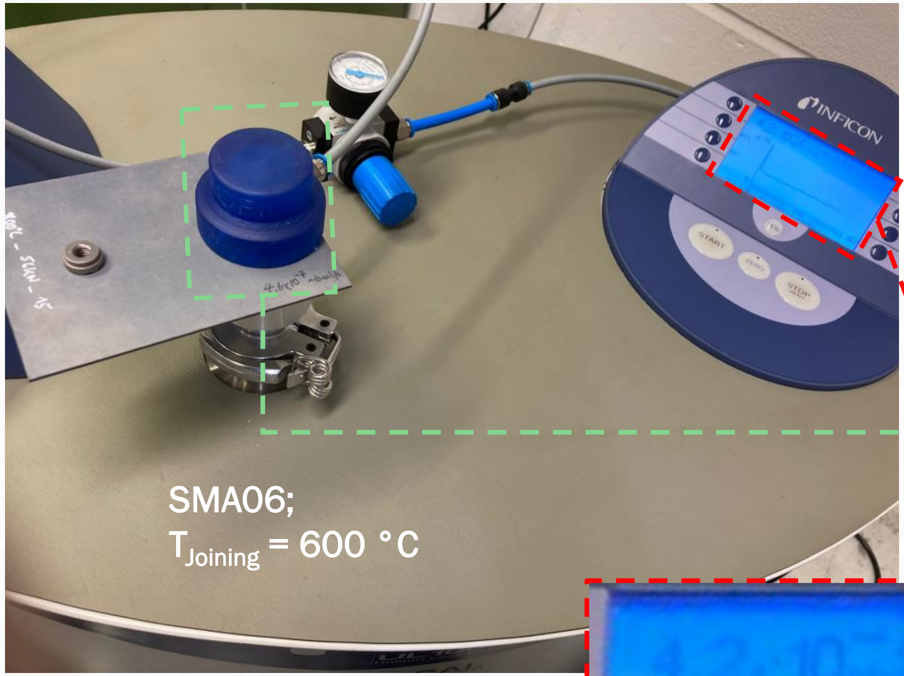
  Mobile helium-leak tester

  INFICON UL1000

- All tested elements have a

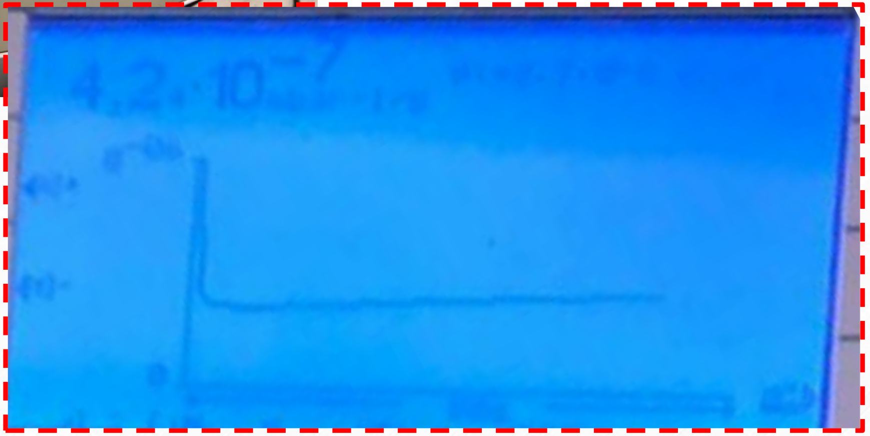
  leak rate < 10^{-6} mbar·l/s

requirement		mbar·l/s
Δp=1bar		10^{0}
		10^{-1}
watertight	IP67	10^{-2}
Oil-tight	IP67	10^{-3}
Bacteria proof		10^{-4}
Gasoline proof		10^{-5}
Gas tight		10^{-6}



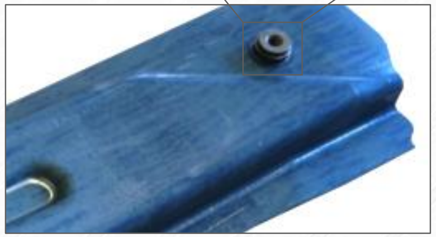
Screwed in and sealed screw

Tested with helium



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



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