

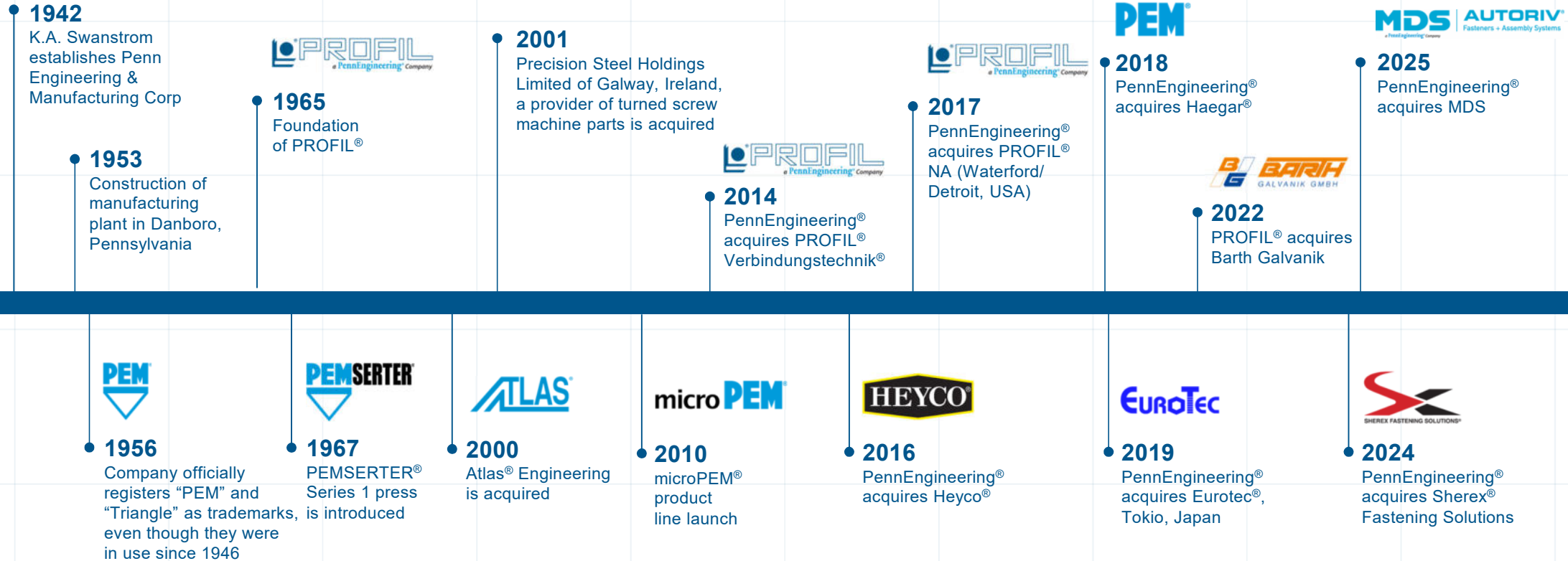


THETA[®] i

Motivation and Process

TOX, PROFIL, Dr. Ewald Nelken

PennEngineering® Group



System Supplier PROFIL – Head Quarter / Manufacturing Sites / Sales & Customer Service

PROFIL Global:

1.8bn

Fasteners p.a.

6.9m

Per day

50+

Years expertise

490

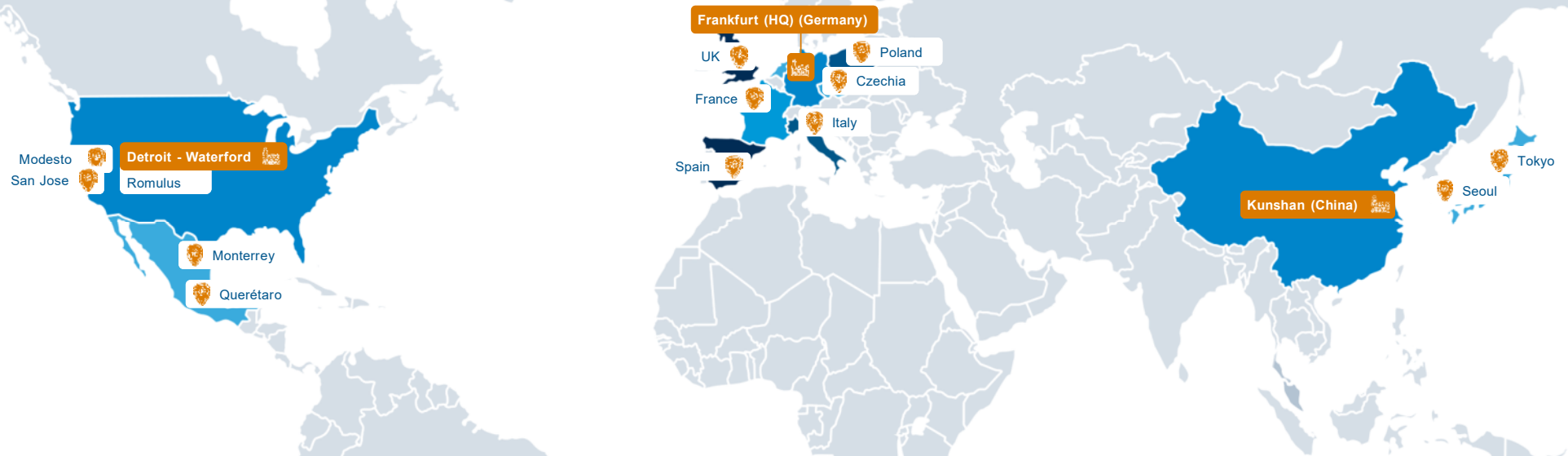
Employees

77

Engineers

3

Production plants: Fulda (GER),
Waterford (US), Kunshan (CN)

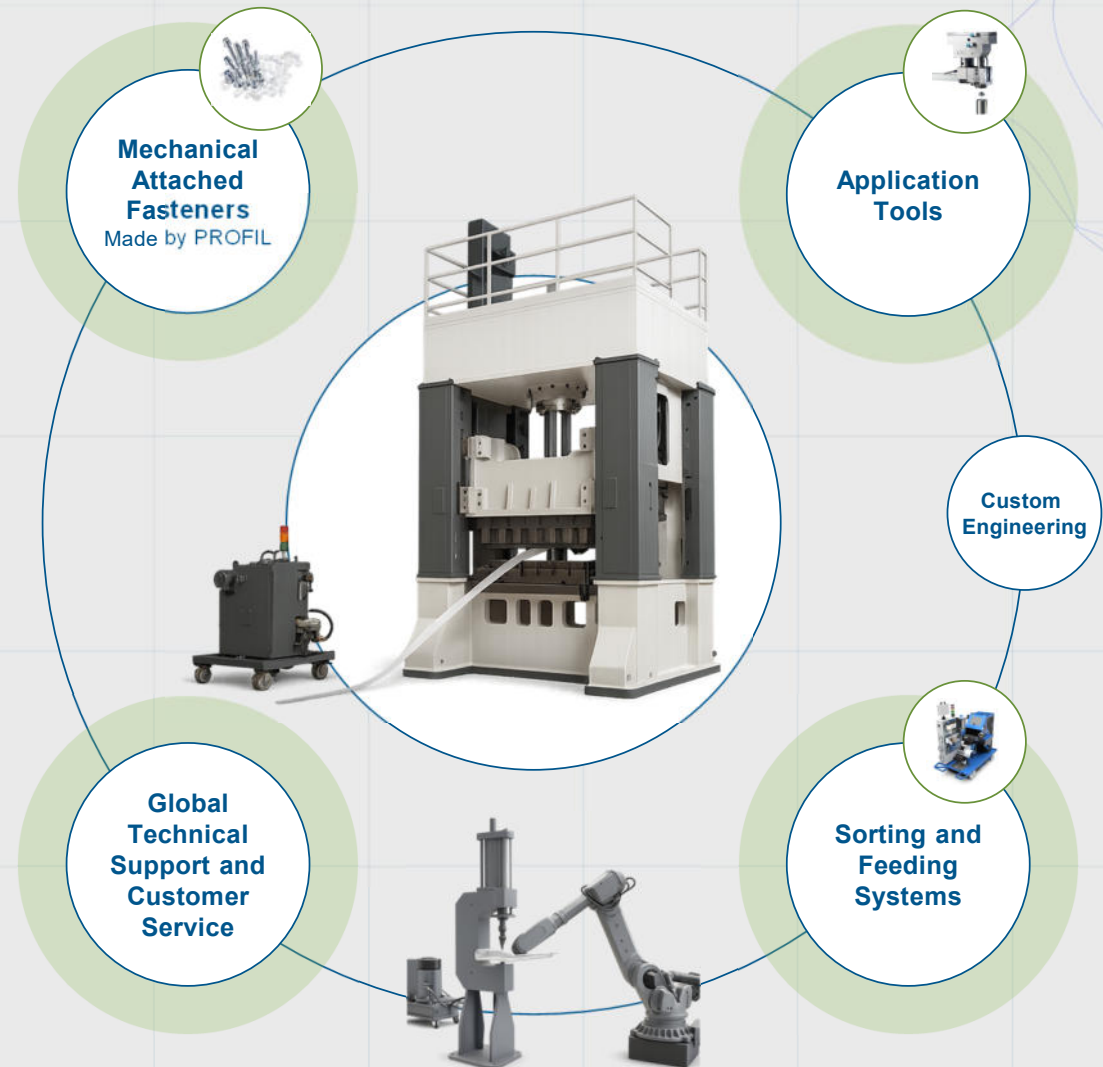


Total Solutions out of One Hand - Closed Loop System

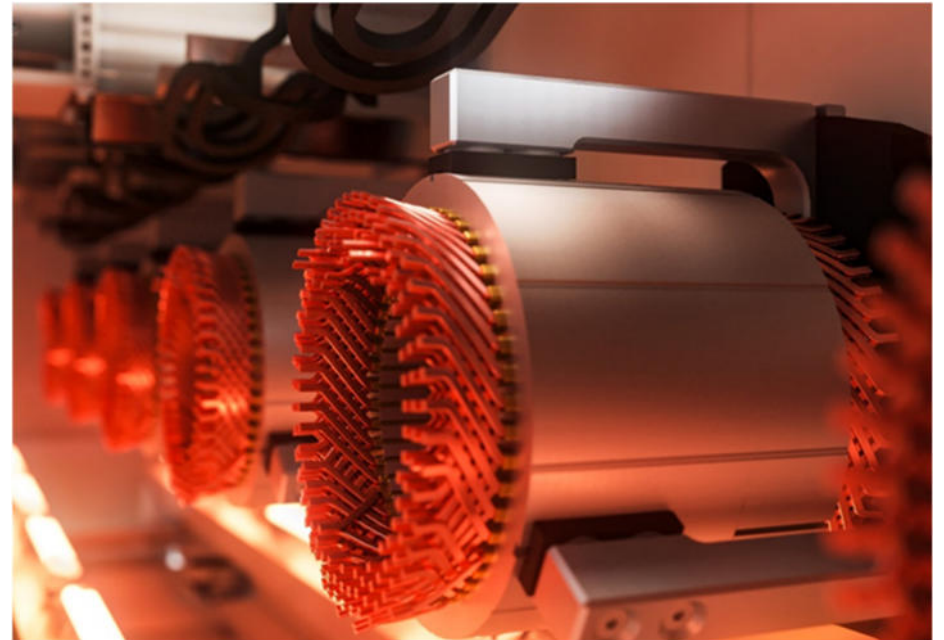


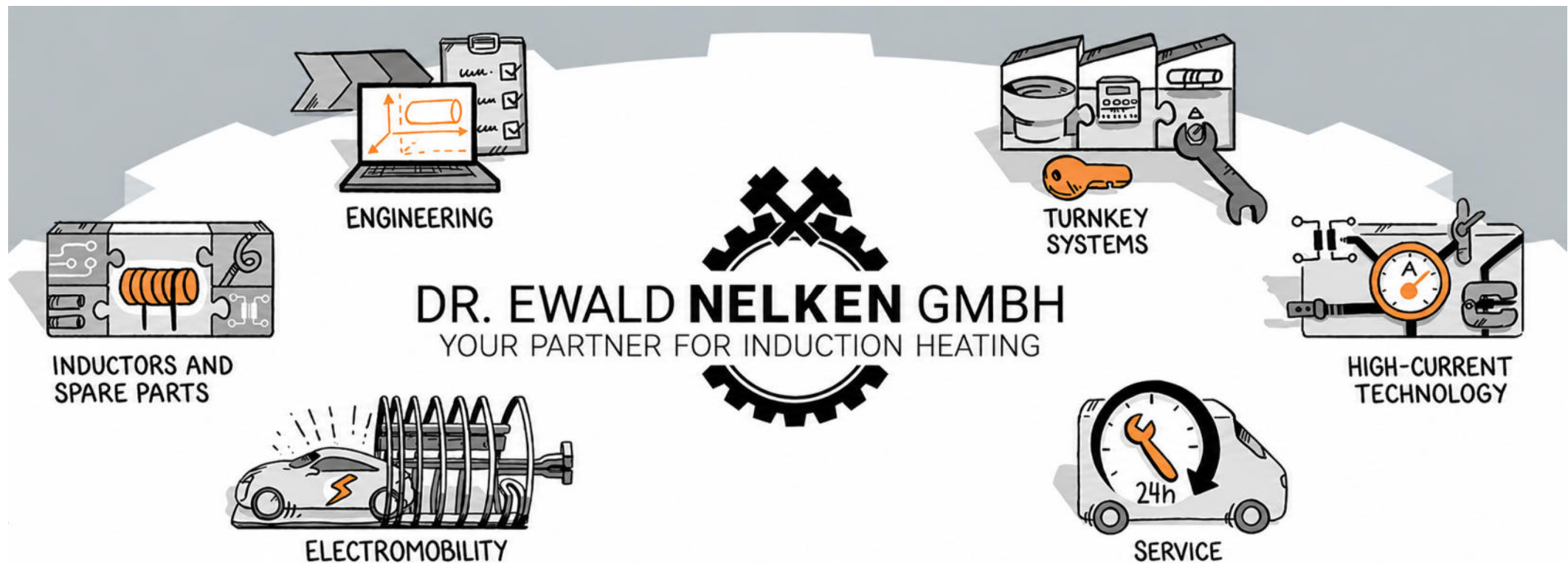
Perfect process knowledge allows only PROFIL to design, deliver and support the fastener and application equipment suited to your needs.

Thus, **PROFIL** takes the complete system responsibility for your in-die or body-shop applications.



- Family business since 1903
- 66 years expertise in induction heating
- 5 Branches
- 4.500 m² Production area
- Flexible capacity adjustment
- Specialising in customized solutions for the automotive sector





- Forging
- Wire production
- Tube production
- Casting
- Automotive industry
- Chain production
- Spring production
- Gear and gearbox manufacturers
- Rolling mills
- Electric motor manufacturers

Dr. Ewald Nelken GmbH – 3D printing of pure copper

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The company and its values at a glance

9



Founding year
1978



Locations/ agencies
36 countries



Employees
1500 worldwide



Turnover
€ 200 million





100% family business

10



As a 100% family-owned company, the shareholders Eugen Rapp, Susanne Eberhardt and Stefanie Reich represent the current generation of TOX® PRESSOTECHNIK.



Susanne Eberhardt
Managing Director &
Chair of the Global Board
TOX® PRESSOTECHNIK
INTERNATIONAL SE & Co. KG



Benjamin Mayer
Managing Director



Jürgen Sollner
Managing Director

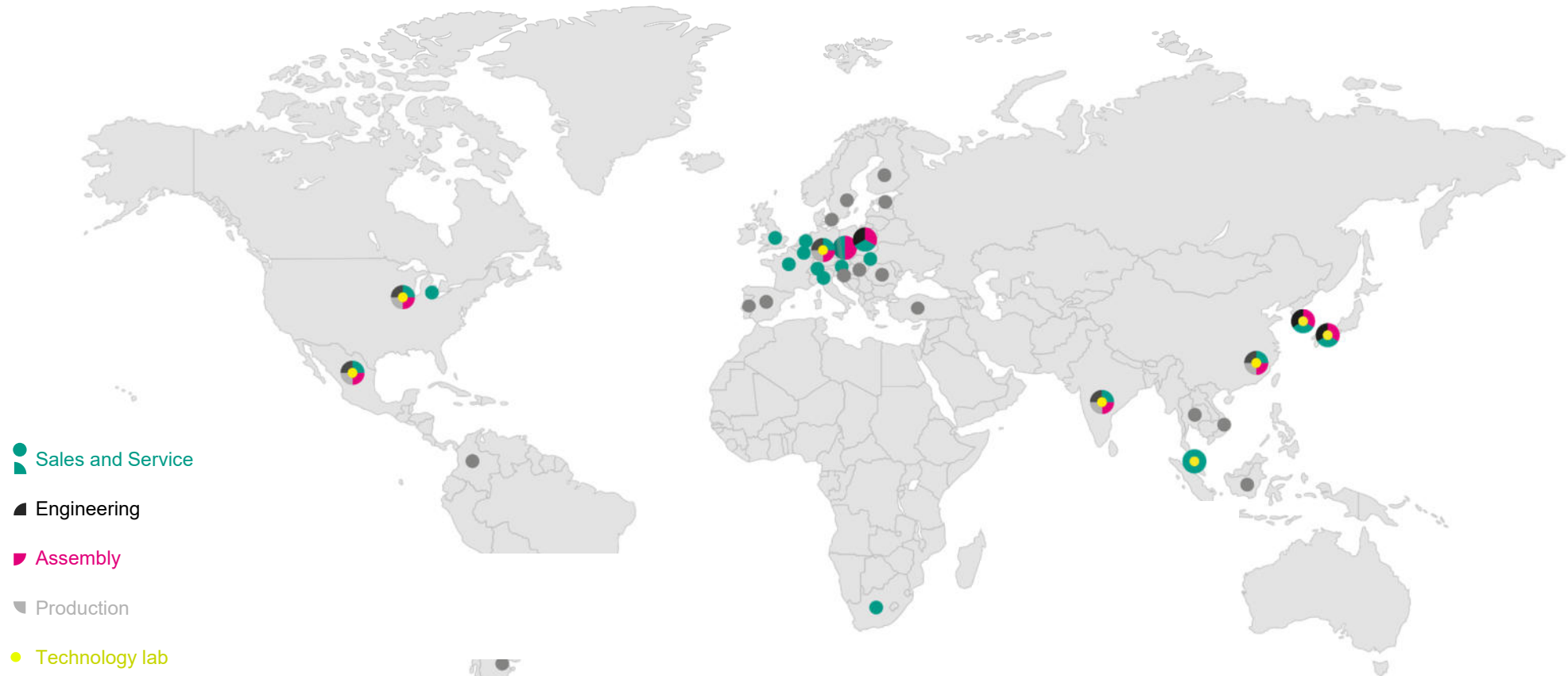


Dietmar Weik
Managing Director

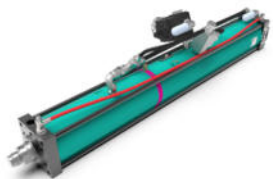


Global locations and expertise

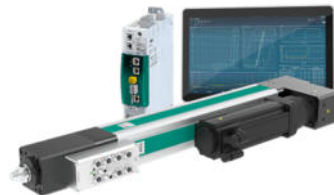
11



Components



Pneumohydraulic actuators
TOX® Powerpackage



Electric servo press
TOX® ElectricDrive



Software & process monitoring



Clinching tools

Technology systems

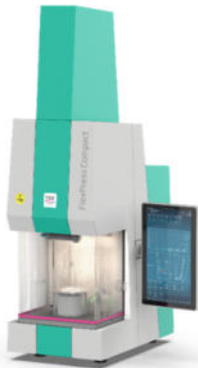


Multi Technology Platform
System solutions for automated joining
technology

Presses & Machines



TOX®
FinePress

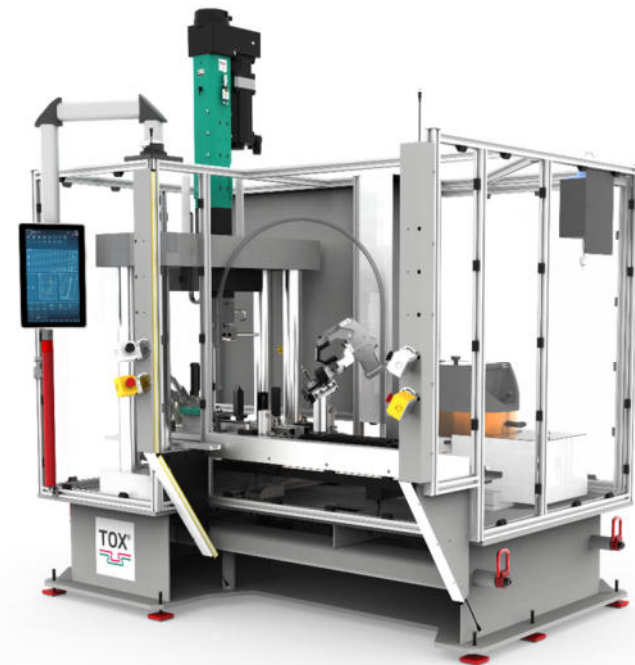


TOX®
FlexPress Compact



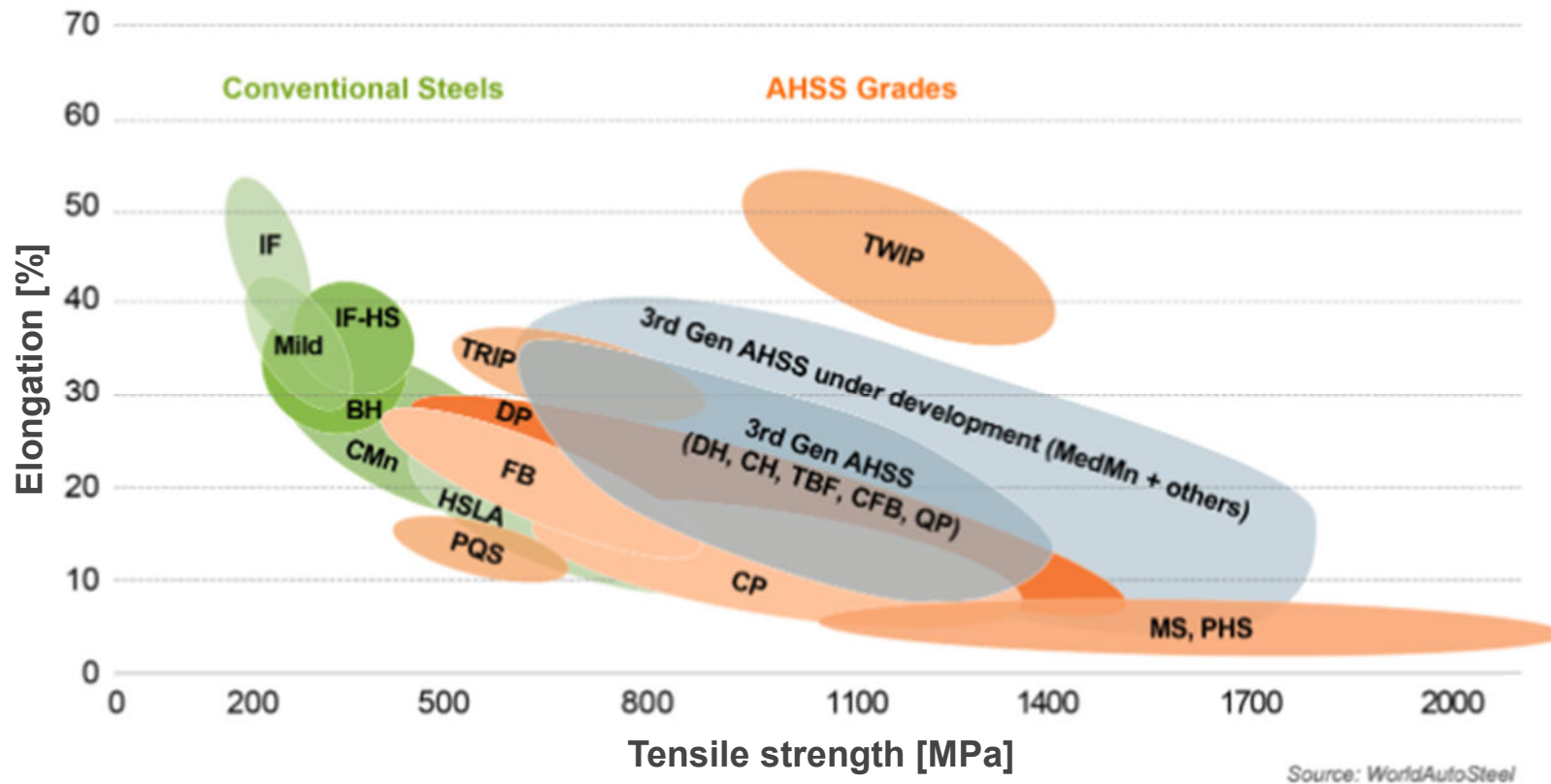
TOX®
FlexPress Station

Special machines



Customised special machines according to customer requirements

Range of Press hardened Steel



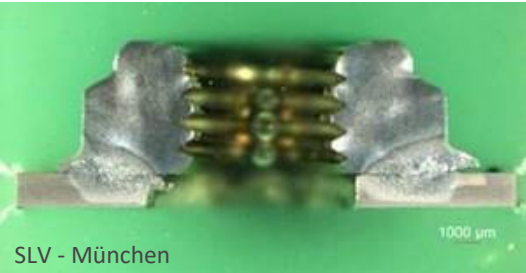
Press Hardened Steel (PHS)

- Most common alloy: 22MnB5
- Others: 20MnB4, 34MnB5
- Trade names:
 - ArcelorMittal (Market leader)
USIBOR (1200 / 1500 / 2000)
 - Thyssenkrupp Steel Europe
MBW (1500 / 1900)
 - Voestalpine (BMW)
PHS ultraform
 - BENTELER
BTR165
 - ...
- Typical surface treatments:
 - Without
 - Coating
 - Aluminium Silicon (AlSi)
 - Zinc (Zn)

Status quo – Fasteners for PHS

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Welding fastener



SLV - München

Disadvantages

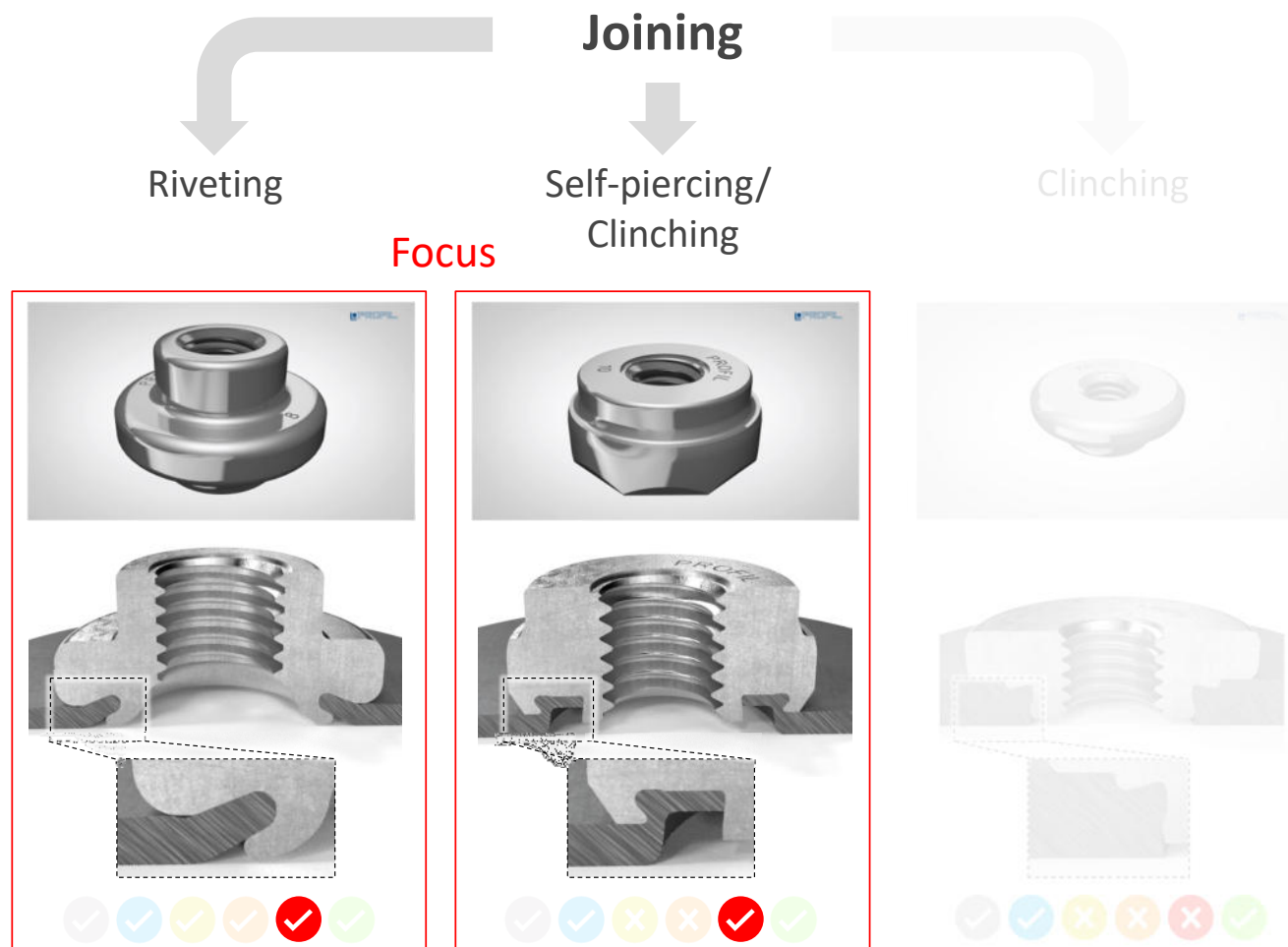
- Separate process
- Negative thermal effect on joint performance (HAZ)
- Not always possible

Representative joint failure



- Mild steel
- High strength mild steel
- Advanced high strength steel
- Ultra high strength steel
- Hot formed and Press Hardened Steel**
- Aluminum / Aluminum die cast

Mechanically Attached Fastener (MAF) for PHS – Joining concepts

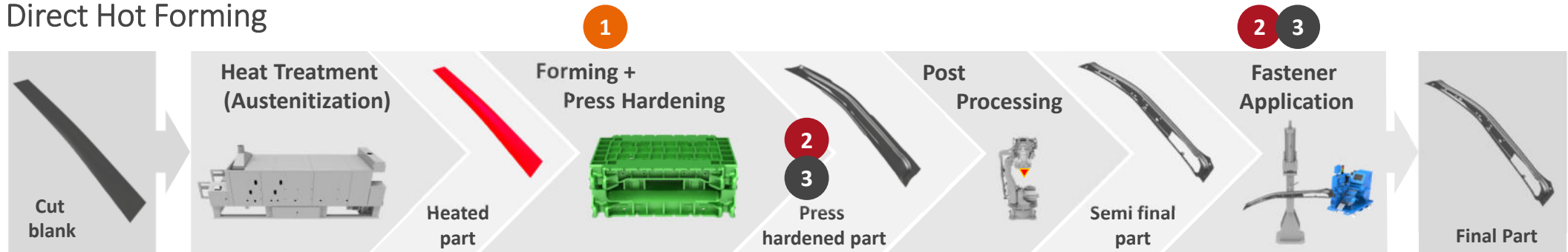


- Mild steel
- High strength mild steel
- Advanced high strength steel
- Ultra high strength steel
- Hot formed and Press Hardened Steel
- Aluminum / Aluminum die cast

PROFIL MAF for PHS – Joining Possibilities

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Direct Hot Forming



1) In-die Hot : *Joining the fastener into PHS inside the forming tool*



2) THETA® i: *Joining the fastener into PHS without a pre-hole*

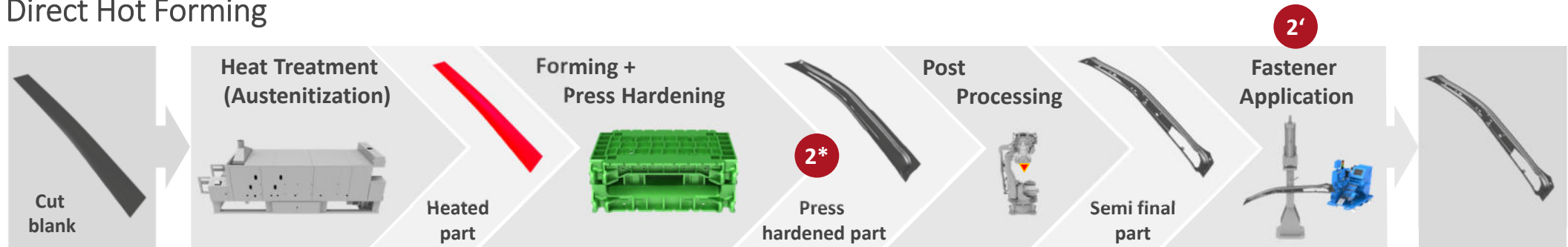


3) Semi In-die Cold: *Joining the fastener into PHS with a pre-hole*

PROFIL MAF for PHS – BIW Installation

18

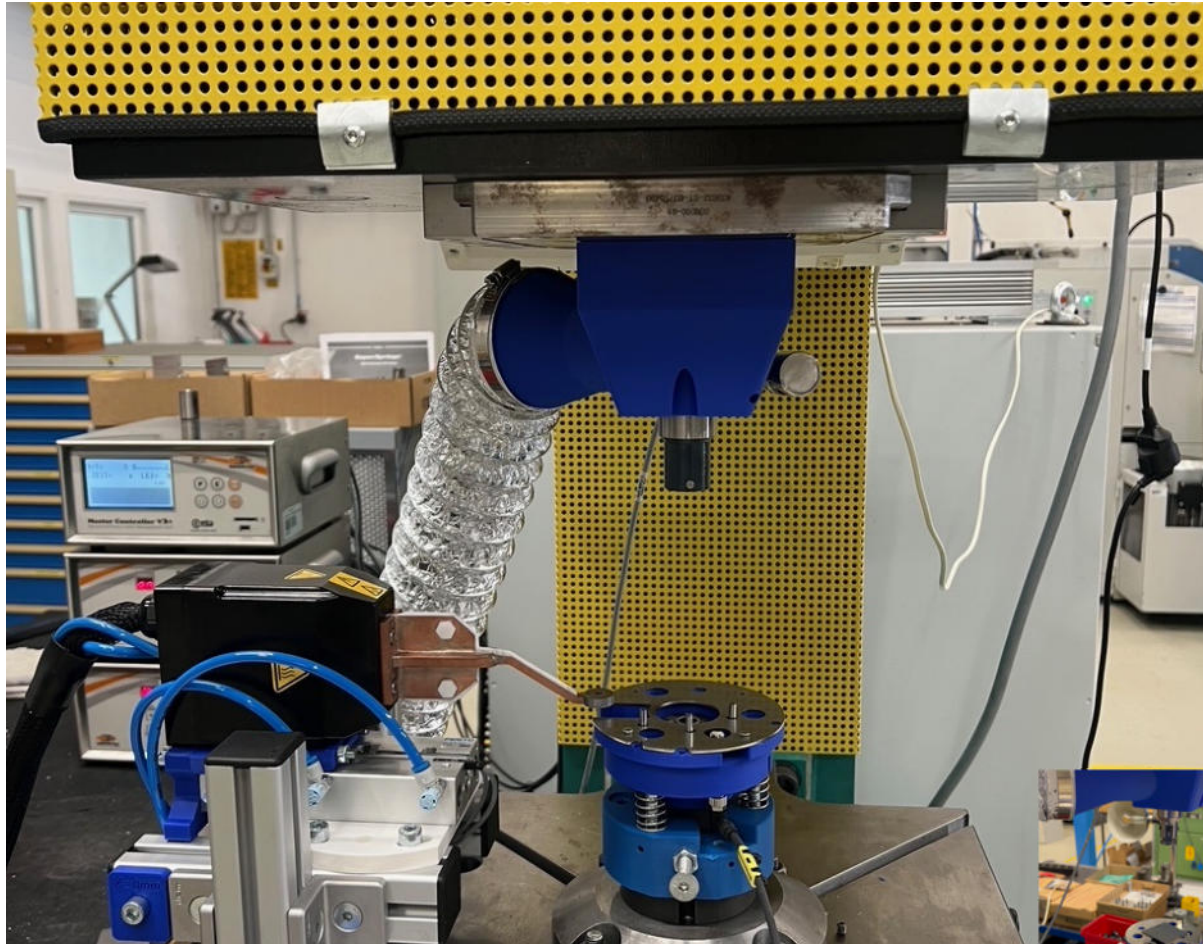
Direct Hot Forming



- Use of robot between the press and the stack (Effective use of waiting time) at 2* | Body-In-White installation at 2'
- Joining PROFIL MAF in PHS without a pre-hole thus avoiding the risk of microcracks
- Thermal mechanical joining the fastener by the use of inductive heating
- Localized reduction in the material strength and increase in the deformability of the PHS
- Residual heat in the part (position 2*) allows shorter heating time

PROFIL Joining Setup and Functional Element for THETA® i

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PROFIL SMA Self-piercing clinch nut

M5 to M8

Panel thickness range

0.6 mm to 2.4 mm



PROFIL MHD Self-piercing clinch nut

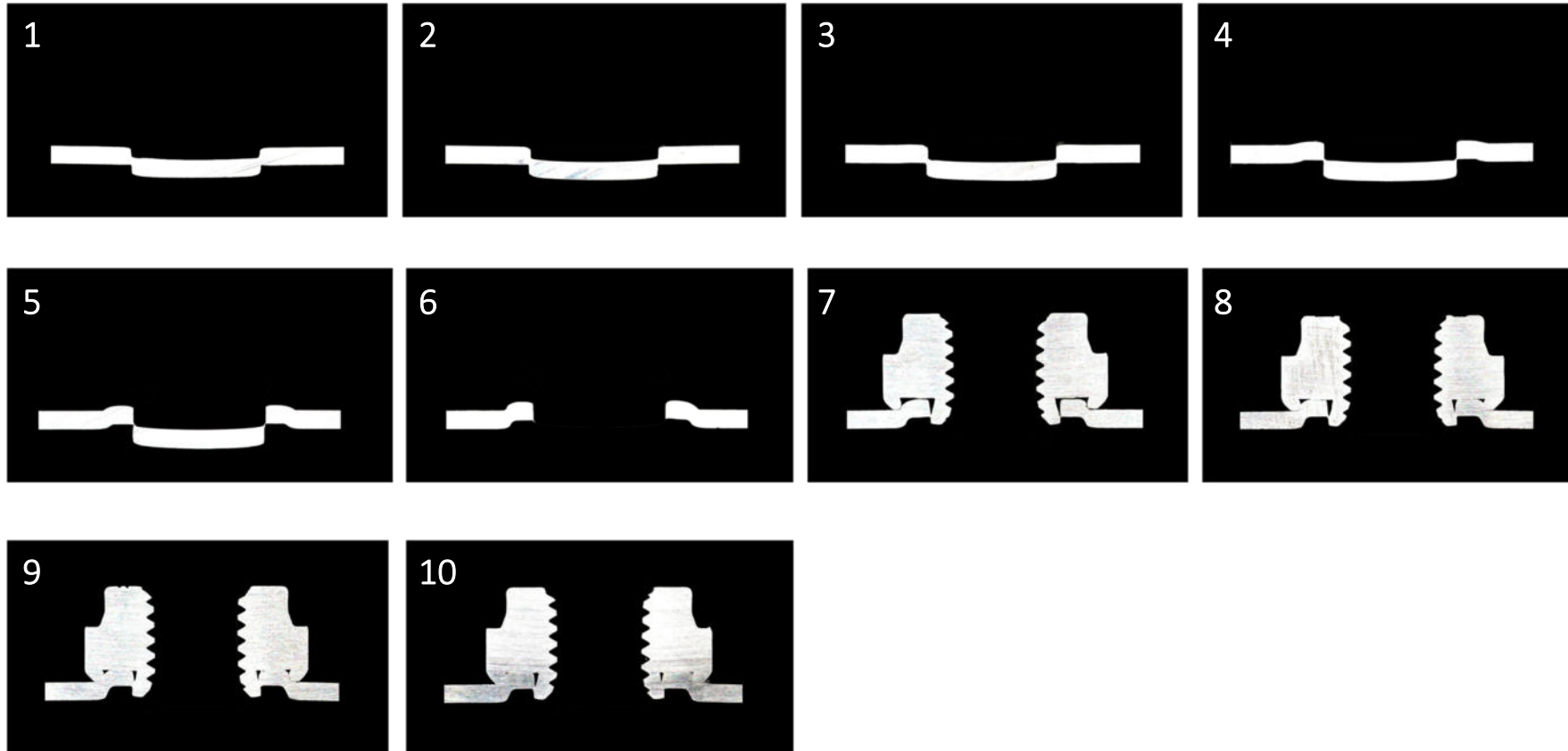
M8 to M10

Panel thickness range

2.0 mm to 3.5 mm



Step by step installation of SMA0824A03A in USIBOR1500; t = 1.5 mm at 750 °C ²⁰



Panel material
USIBOR1500
Panel thickness
1.5 mm
PROFIL element
SMA0824A03A
Die-button
MR131SM0000
Joining temperature
≈ 750 °C
Joining force
70 kN

Cross-Section of installed SMA in USIBOR 2000

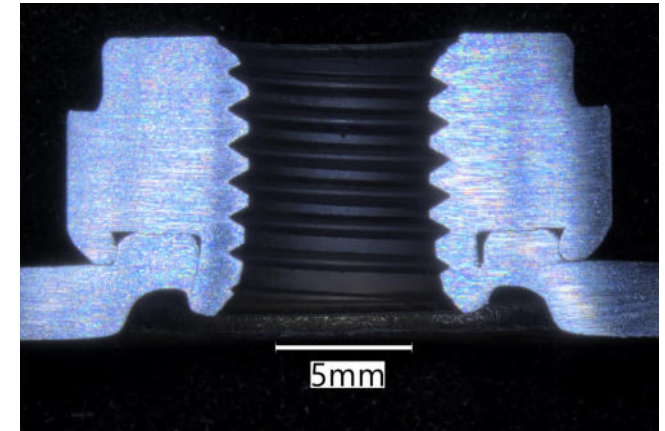
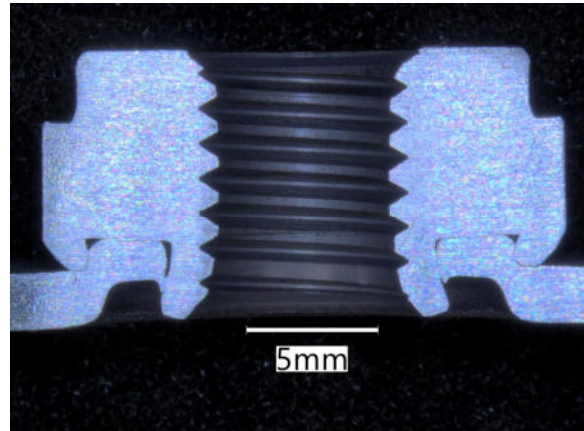
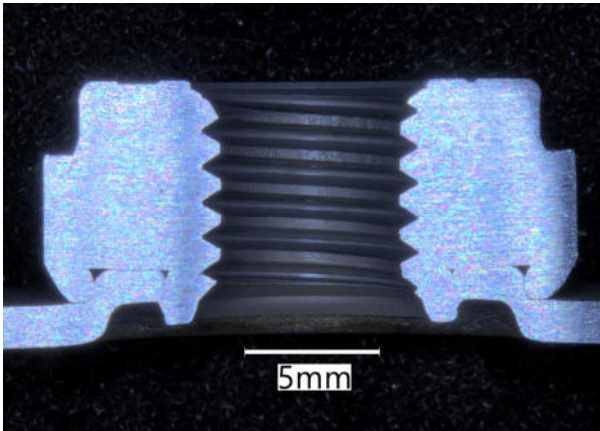
21

t = 1.2 mm

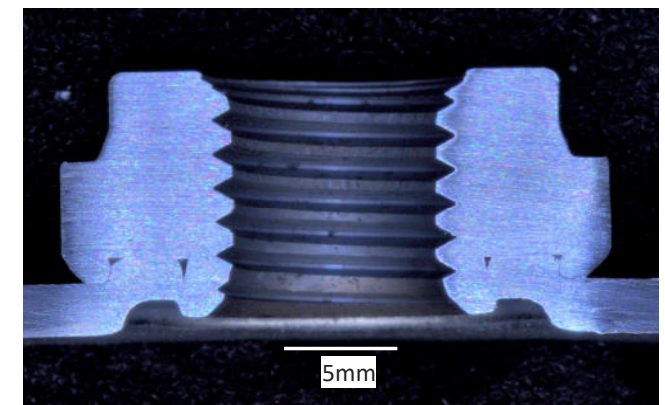
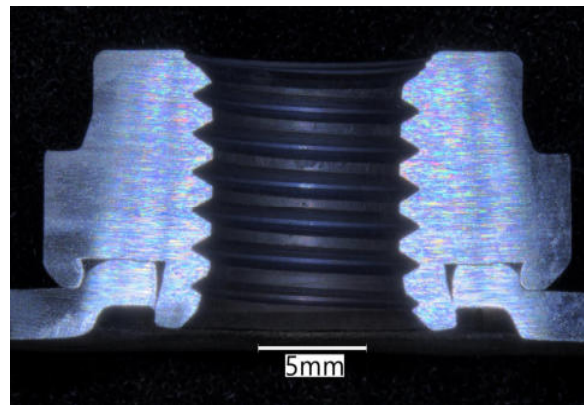
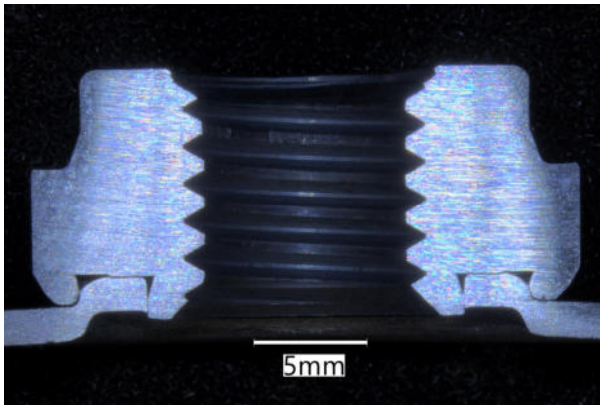
t = 1.6 mm

t = 2.0 mm

SMA06



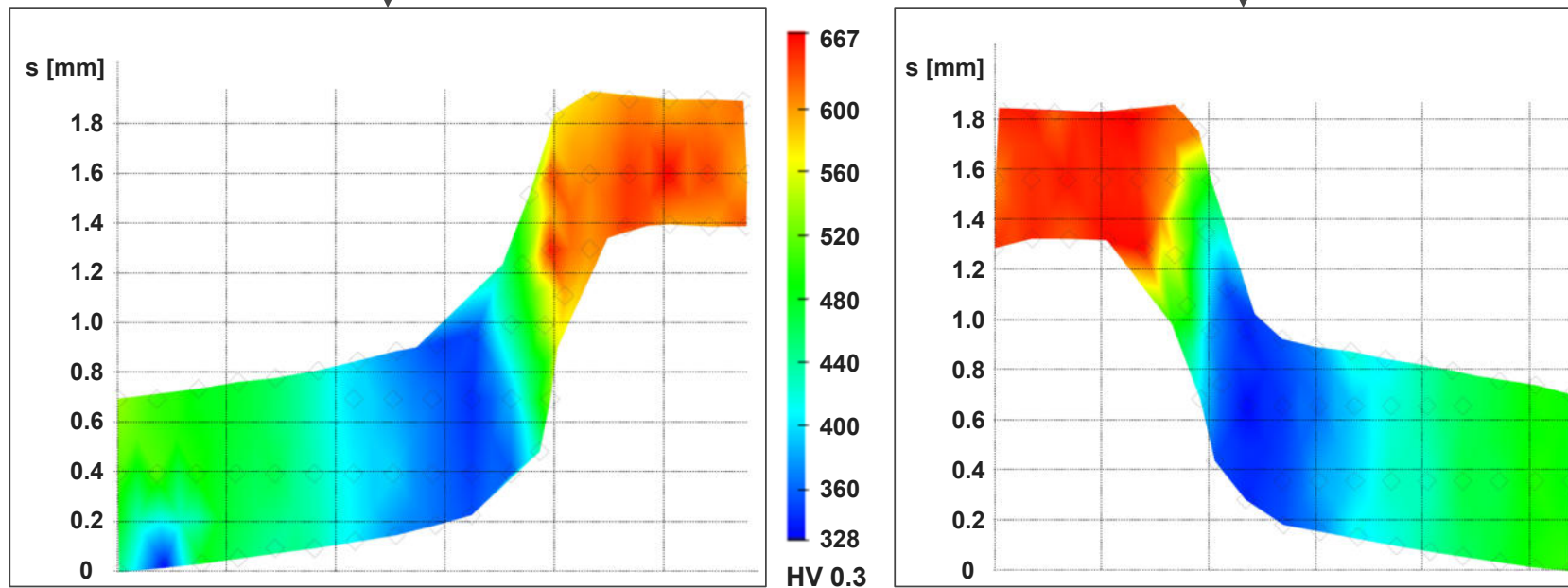
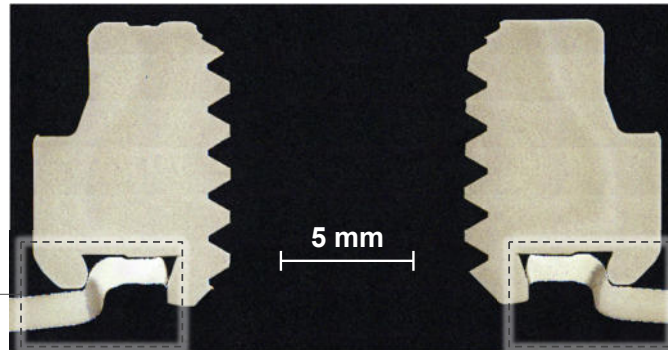
SMA08



THETA[®] i – Joint Analysis

22

Locally reduced hardness due to the altered microstructure



Panel material

22MnB5 (AlSi-coated)

Panel thickness

1.0 mm

Functional element

SMA0816A03A

Joining temperature

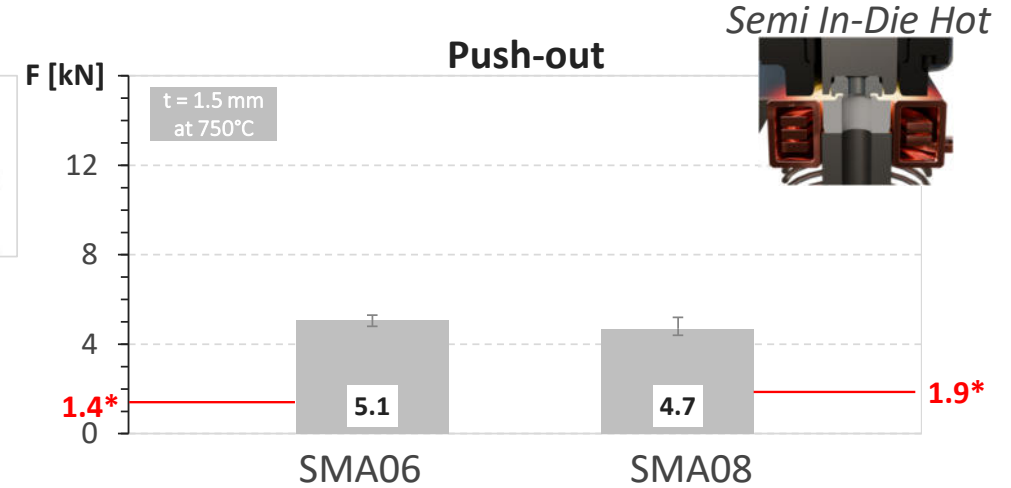
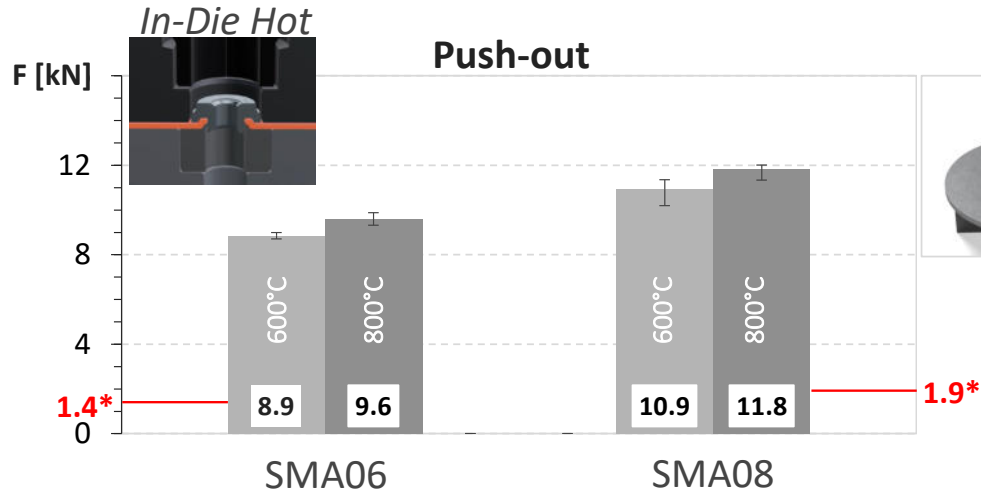
≈ 750 °C

Joining speed

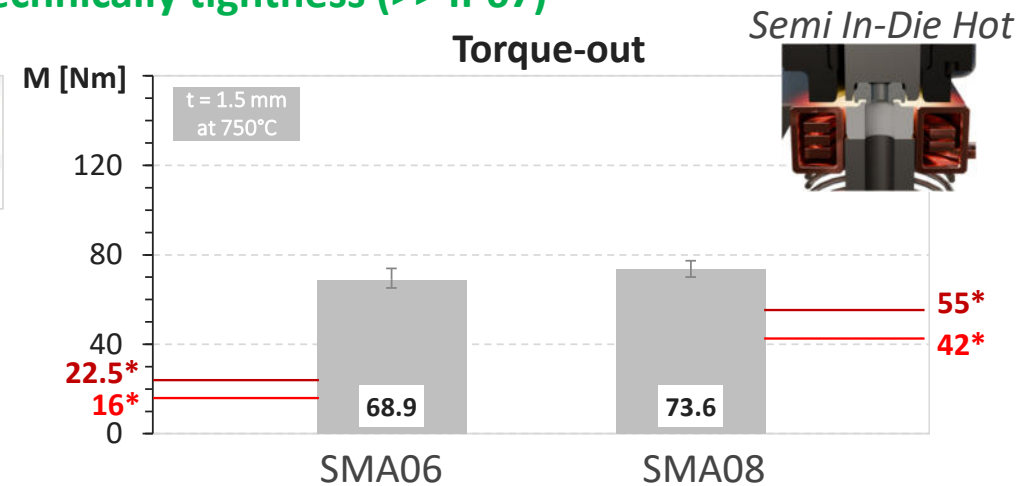
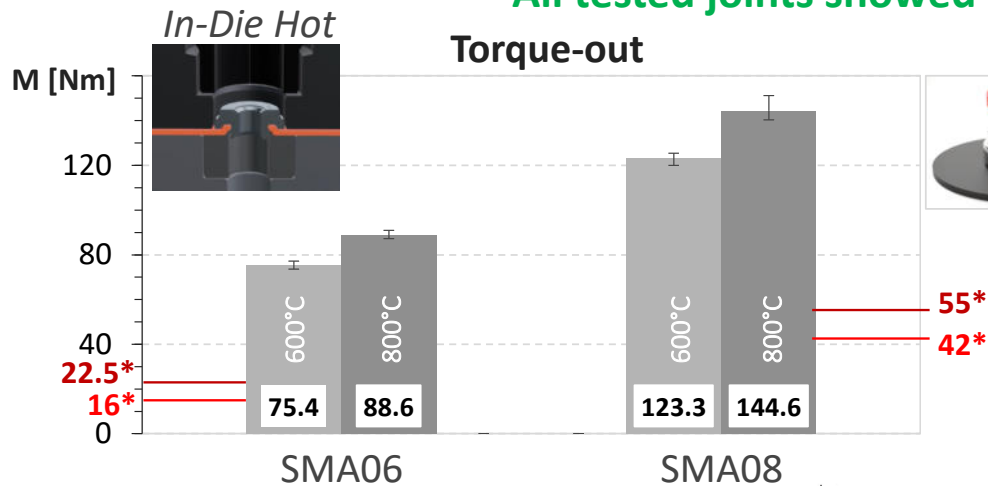
60 mm/s

PROFIL Hot Installation – Performance check under quasi-static loading

23



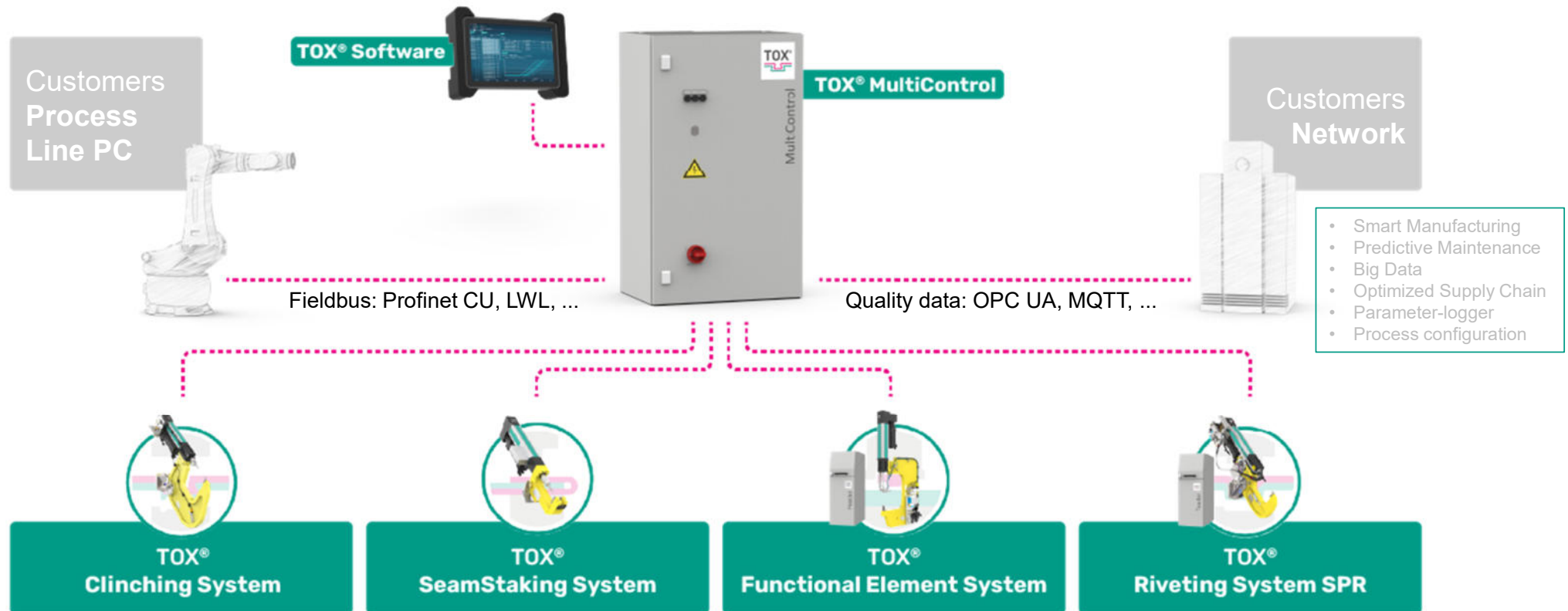
All tested joints showed high technical tightness (>> IP67)



MULTI TECHNOLOGY PLATFORM – One platform – many systems

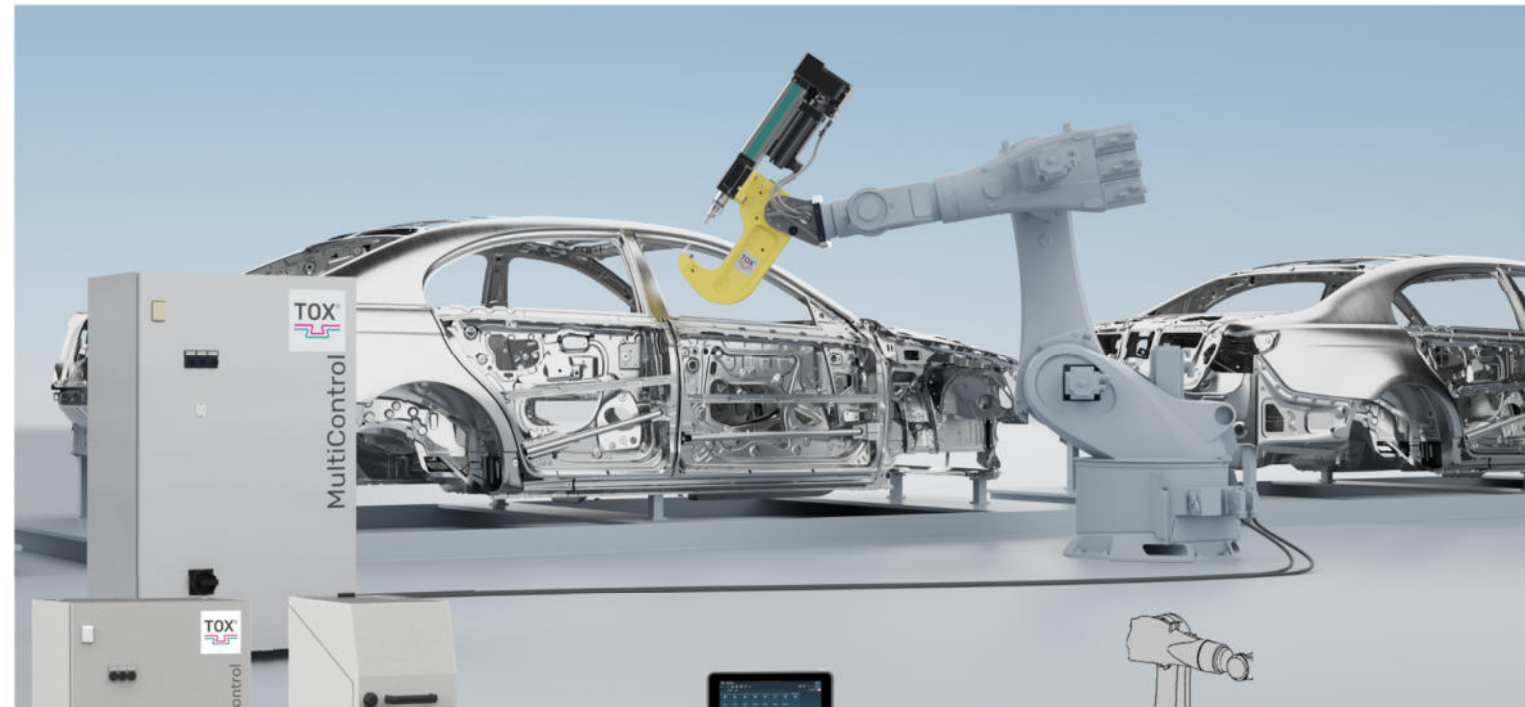
24

A platform for TOX® Technology Systems that are intelligently connected in the production network.



MULTI TECHNOLOGY PLATFORM – Gen 5.0

25



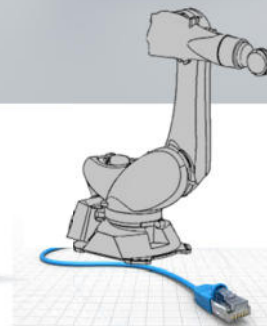
TOX® PLC



TOX® Feeder



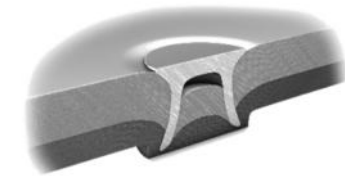
TOX® Monitoring & Control Software



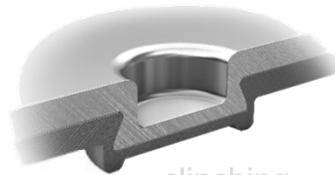
TOX® Robot interface



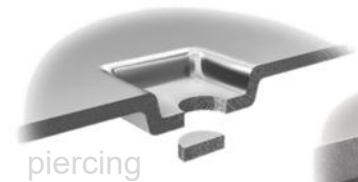
TOX® Data interface



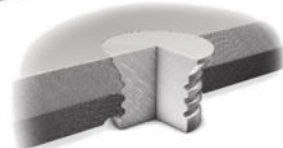
SPR
self pierce rivet



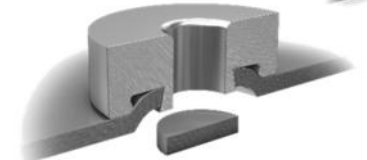
clinching



piercing



FPR
Full pierce rivet

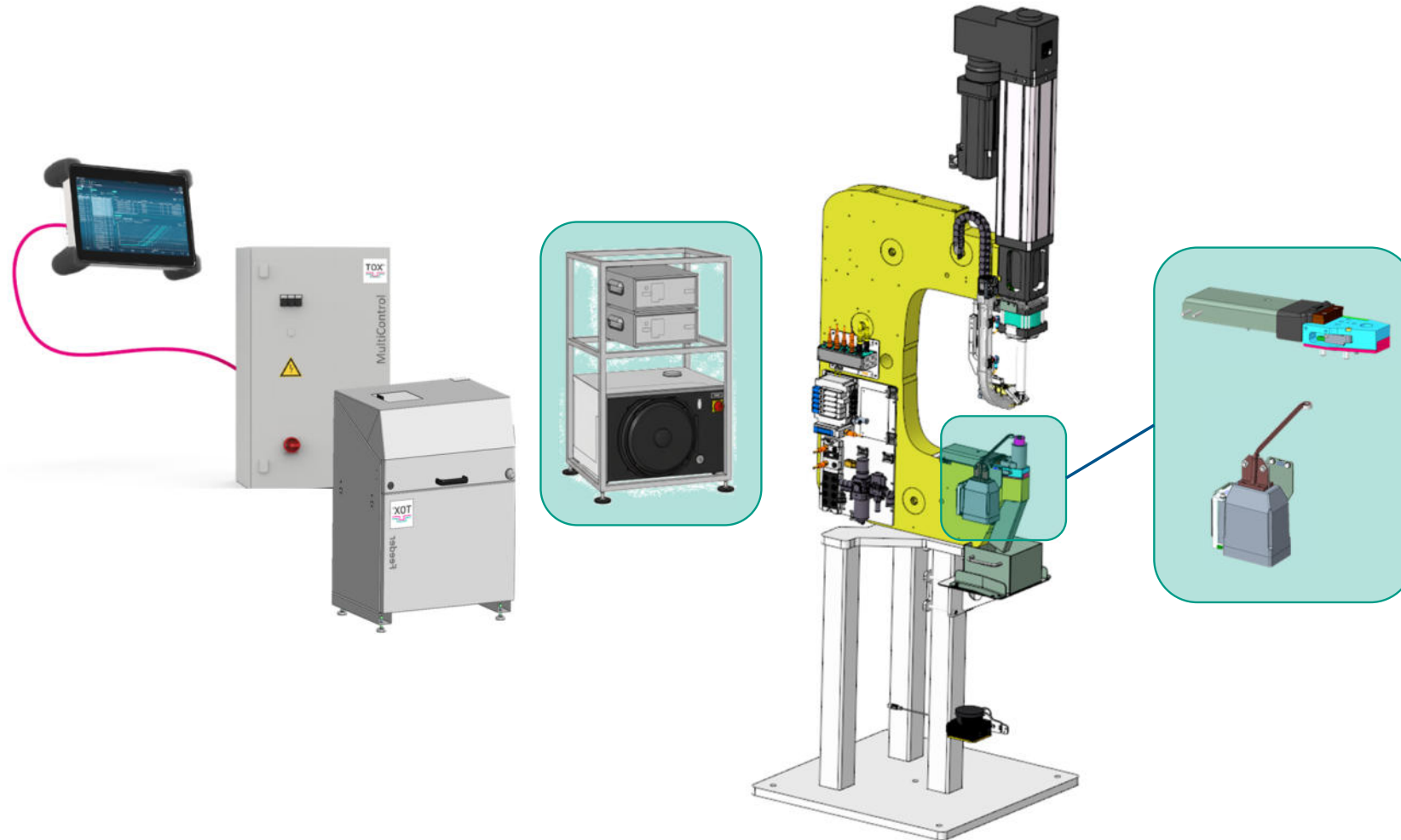


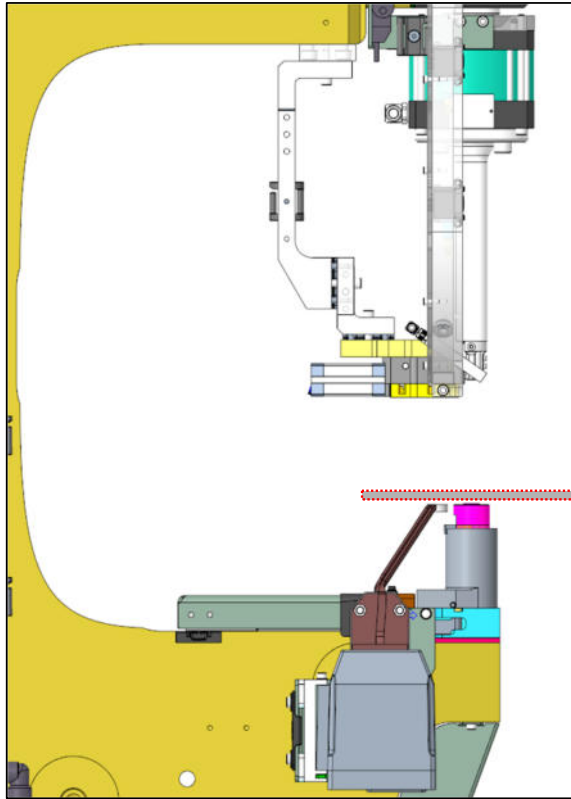
Functional Elements



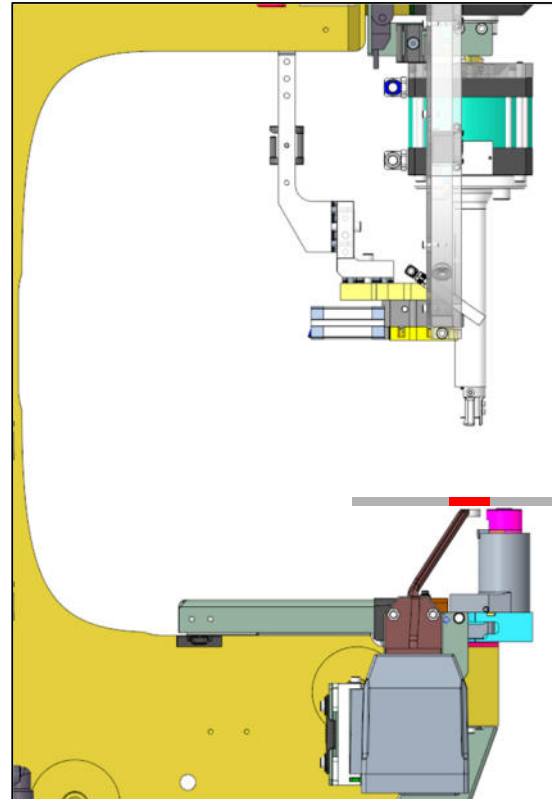
MULTI TECHNOLOGY PLATFORM – TOX® Functional Element System – THETA® i

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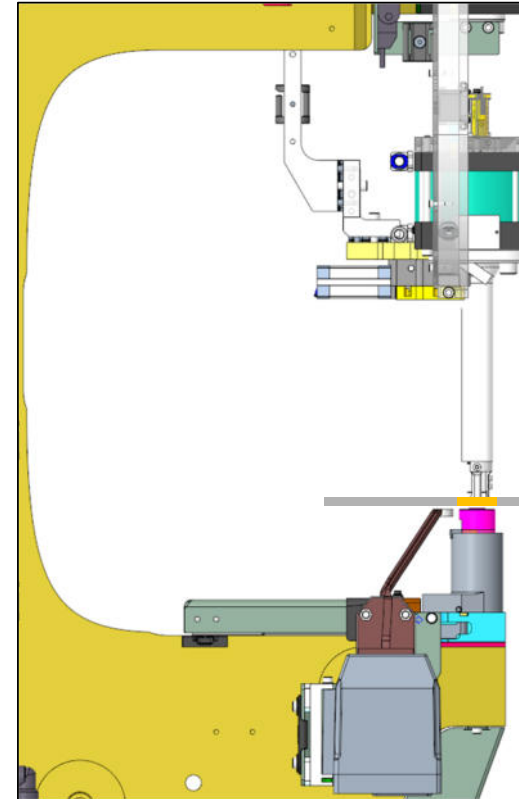




Start position:
Place part



Position 1:
Heating and pre-position of the nut



Position 2:
Joining process / End of process



THETA[®] i – The process

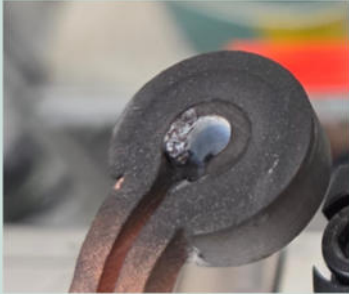
28



Findings from the long-term trial

29

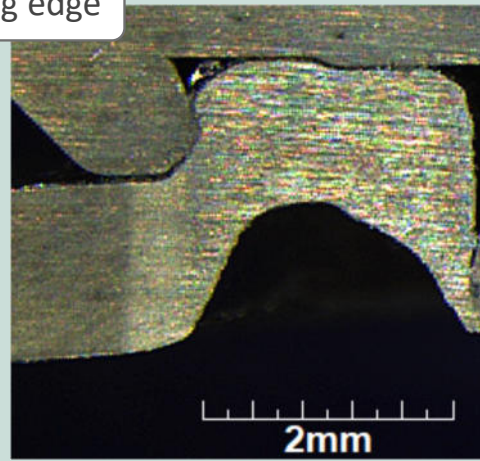
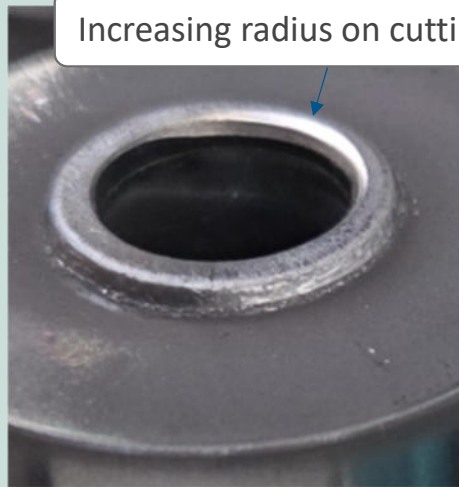
Inductoin coil

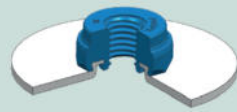


Parts



Die button



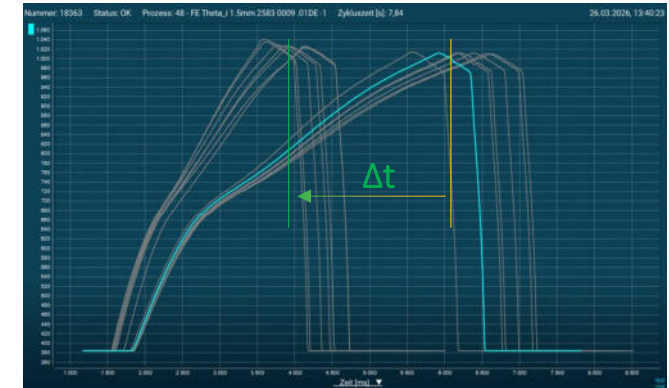
Element	PROFIL SMA0824A03A
	
Panel	1,45 mm Usibor
Force	80 kN
Temperature	820°C

Bewertung

- 10.000 nuts installed
- No equipment failures
- Die buttons cutting edge showed an eccentric fillet
- **Slug cutting ok**
- **Torque-out requir. reached**

Interim summary THETA® i

- Use of THETA® i technology as an alternative to established welding technology
 - Reduction in the influence of material and coating variables
 - Improved joint quality and robustness
 - Elimination of the need for pre-piercing the component
 - THETA® i is suitable for
 - Nuts from M5 to M10
 - Panel thicknesses between 0.6 mm and 3.5 mm
 - PHS strengths up to 2000 MPa (tested)
 - Continuous improvement to optimise process time
 - Endurance test (creation of 10,000 joints at TOX) carried out → No significant problems identified
- Next steps:
- Planning of initial applications, accessibility studies, system design, operational trial – starting immediately



$\Delta t = - 40 \%$

PROFIL MAF vs. Weld for PHS

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Feature	MAF	Weld
Fastener costs	✗	✓
Lowest total joint cost	✓	✗
No effect of surface coating (AlSi) on joint quality	✓	✗
No cold welding	✓	✗
Preload force during assembly is always fully transmitted	✓	✗
Watertightness ($\geq$ IPX7)	✓	✗
Minor influence on the component caused by the joining process	✓	✗
Damage-free corrosion protection achievable (component coating)	✓	✗
Flush joining of reinforcements (P+S joints) achievable (patch)	✓	✗
Better visual appearance (no spatter, no weld bead, ...)	✓	✗
No joining parameter adjustments required in series production	✓	✗
Long joining tool service life (no AlSi adhesion on electrodes, ...)	✓	✗
Significantly improved cyclic load capacity	3x	1x

You contact persons

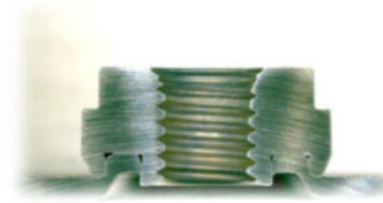
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