TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

New possibilities for process control and higher efficiency at magnetic pulse welding

Joerg Bellmann, Eckhard Beyer, (Institute of Manufacturing Science and Engineering, Technische Universität Dresden and Fraunhofer IWS)

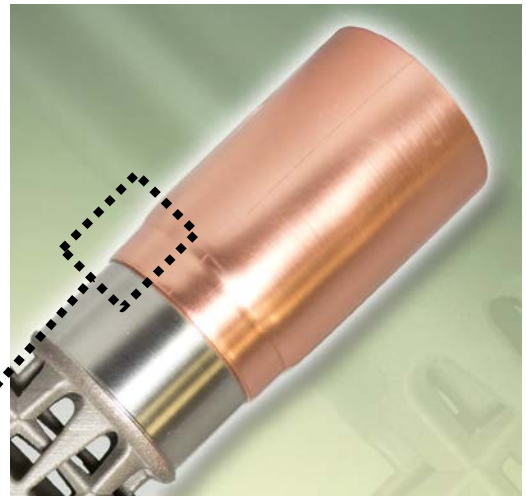
Joern Lueg-Althoff, Soeren Gies, A. Erman Tekkaya (Institute of Forming Technology and Lightweight Components, TU Dortmund)

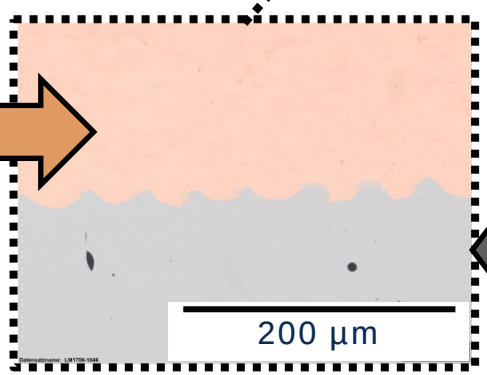
Sebastian Schulze (Fraunhofer IWS)

Steffen Dittrich (Helmholtz-Zentrum Dresden-Rossendorf)

Dresden, 28.02.2018

Welcome to „Tailored Joining“





Copper

Melting point ≈1085°C
Density ≈8.9 g/cm³
Electrical conductivity ≈58 MS/m

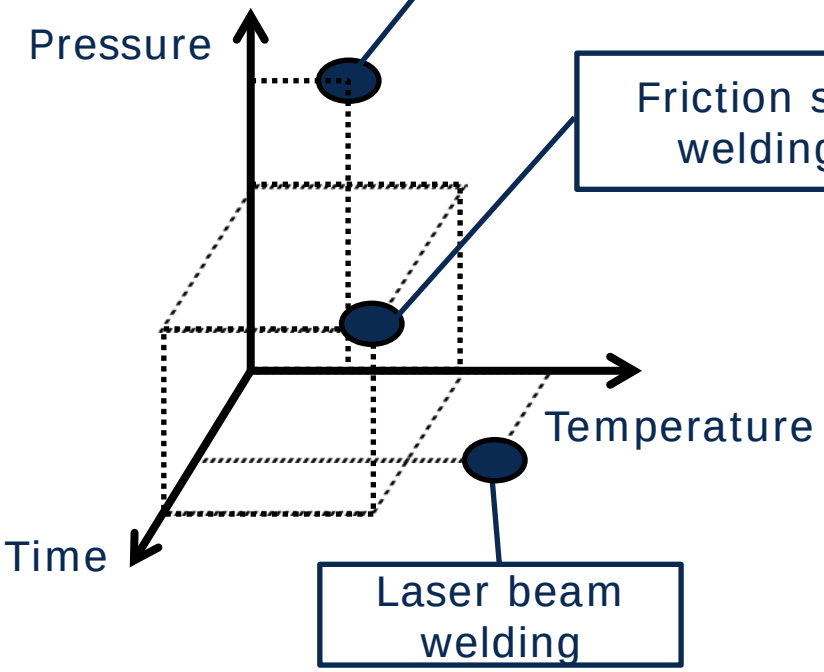
Steel(S235)

Melting point ≈1250-1460°C
Density ≈7.8 g/cm³
Electrical conductivity ≈10 MS/m

MPW: process control & higher efficiency

Classification of welding processes - MPW

Welding by high mechanical energy



Explosion welding

[E. I. du Pont de Nemones & Co.]

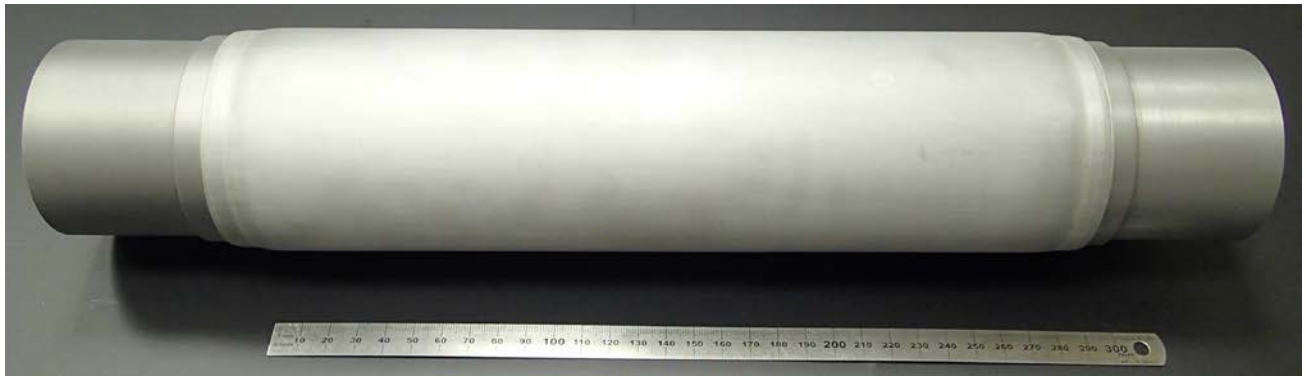
Magnetic pulse welding (MPW)

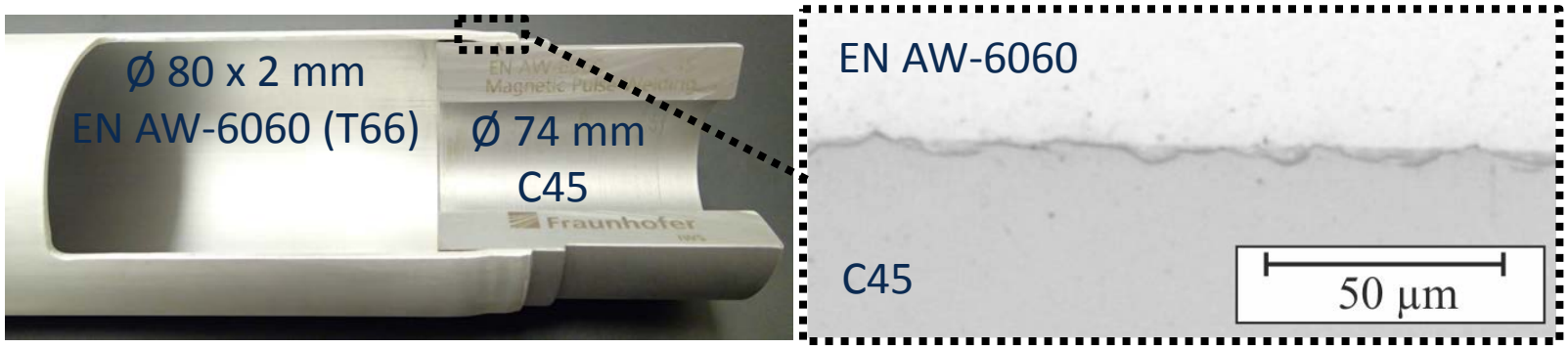
[Fraunhofer IWS]

MPW: process control & higher efficiency

Latest research activities

Magnetic pulse welding of Ø 80 mm aluminium tubes to steel tubes

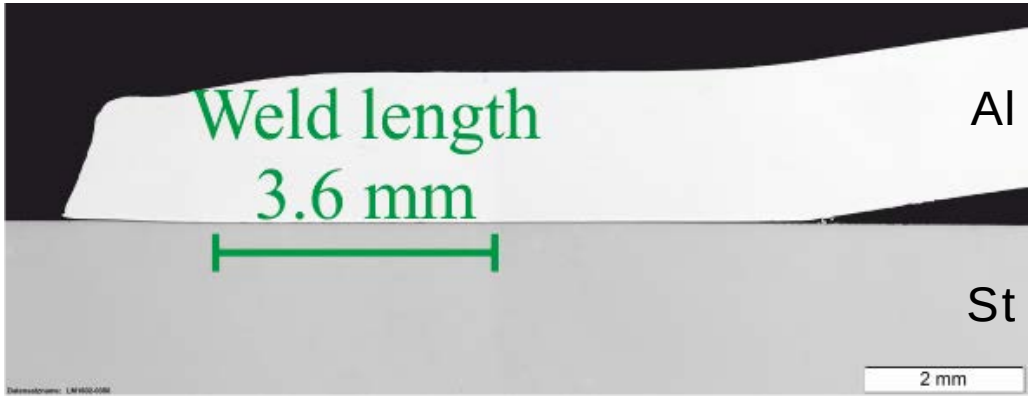




MPW: process control & higher efficiency

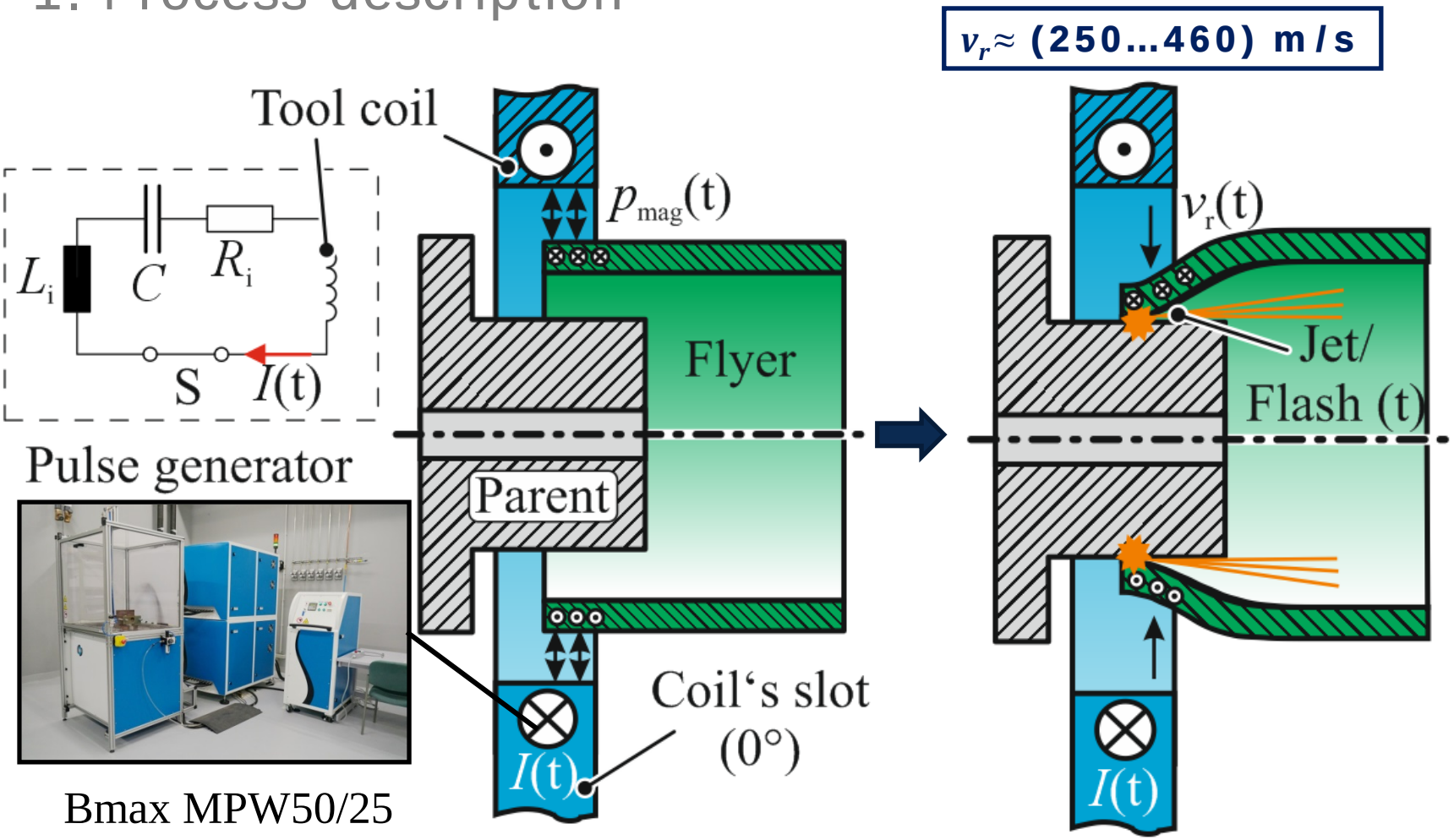
Agenda

1. Process description
2. Challenges
3. Solutions
4. Results
5. Conclusion



MPW: process control & higher efficiency

1. Process description



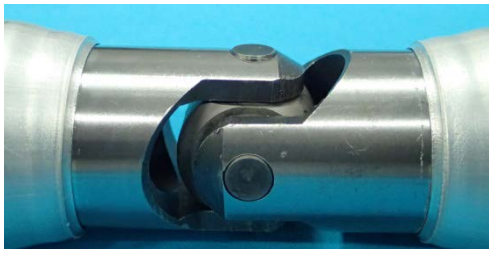
Bmax MPW50/25

MPW: process control & higher efficiency

1. Process description

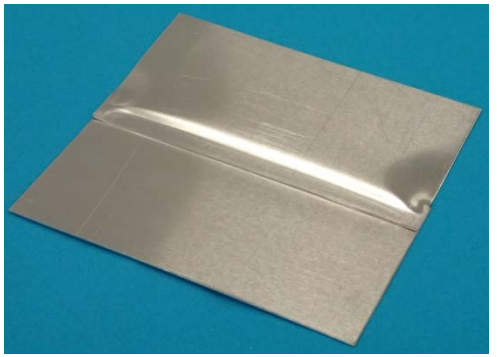
Outstanding:

- Similar and dissimilar metal joining



Versatile:

- Applicable for tubular and flat parts



Side effects:

- No need for filler materials
- Short process times (µs)

2. Challenges

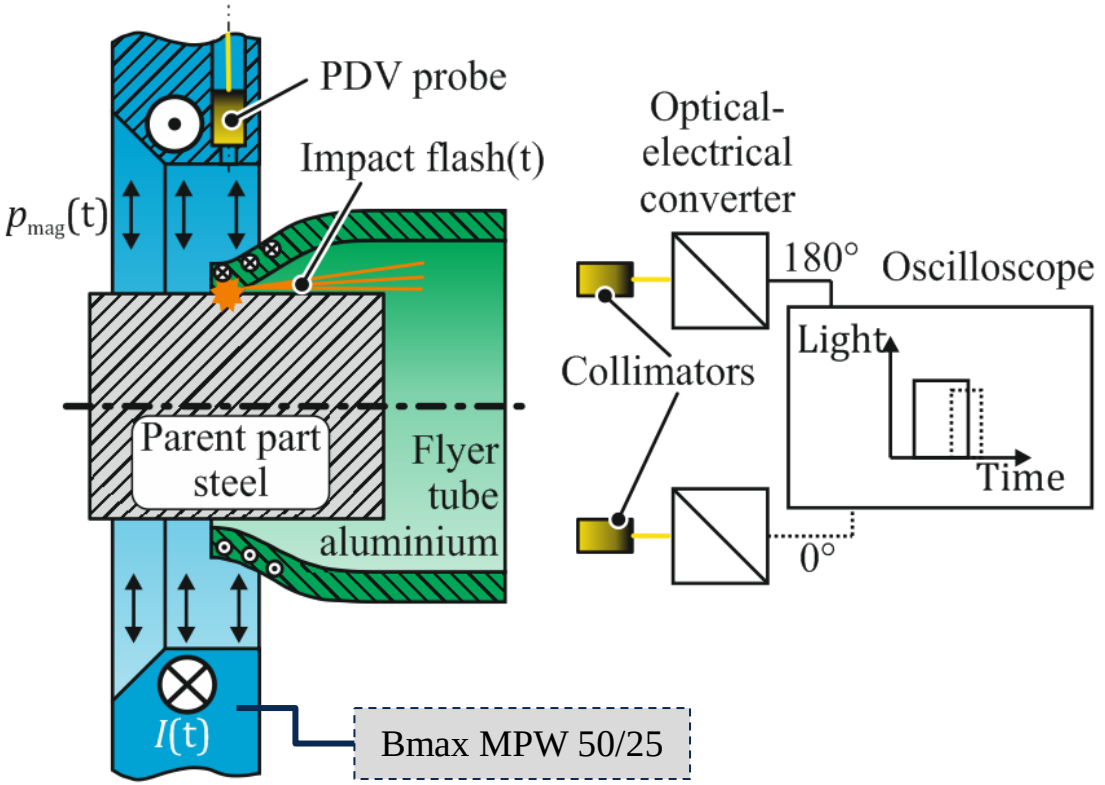
I. Process control

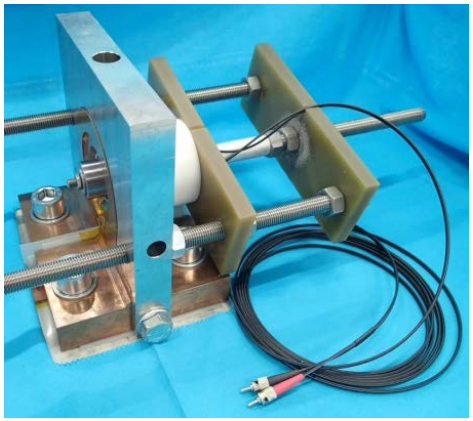
- Short process times (µs)
- Strong magnetic fields
- Intensive process light
- Limited accessibility

II. Lifetime of tool coils

- Joule heating
- Mechanical impact loading

3. Solutions - I. Process control

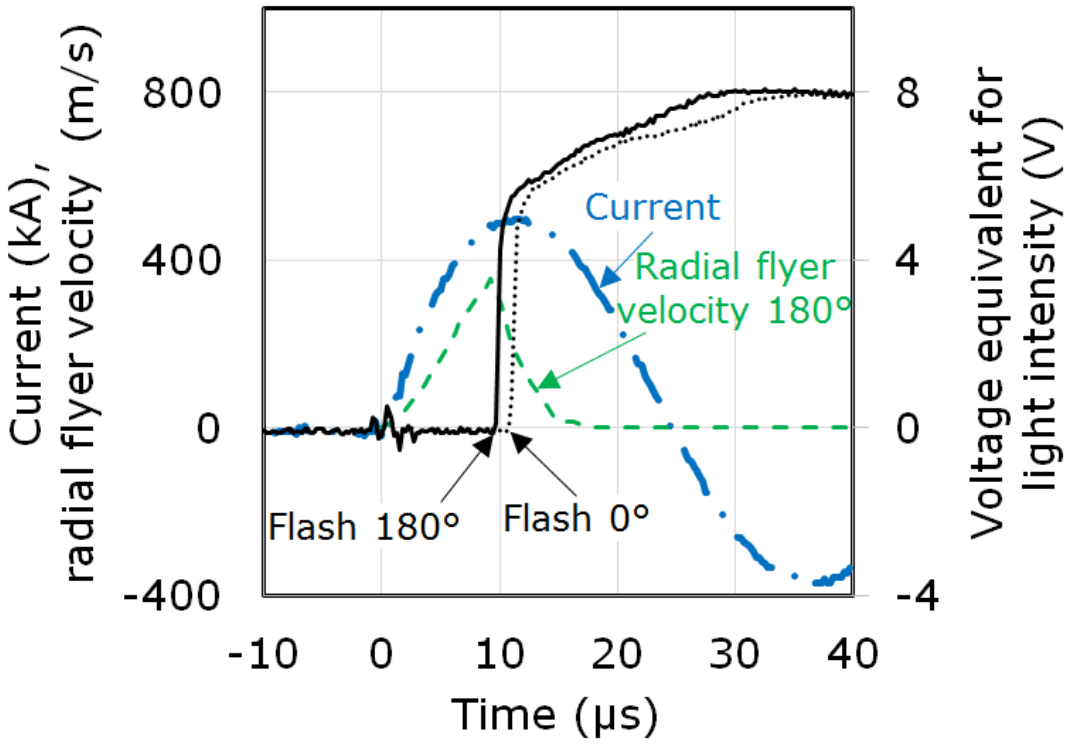


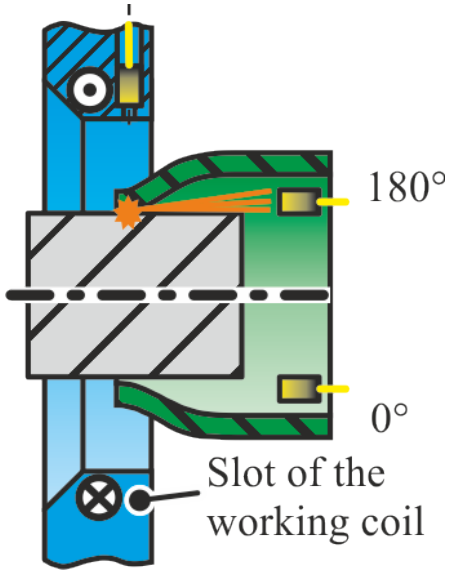


Measurement of the light intensity during welding

MPW: process control & higher efficiency

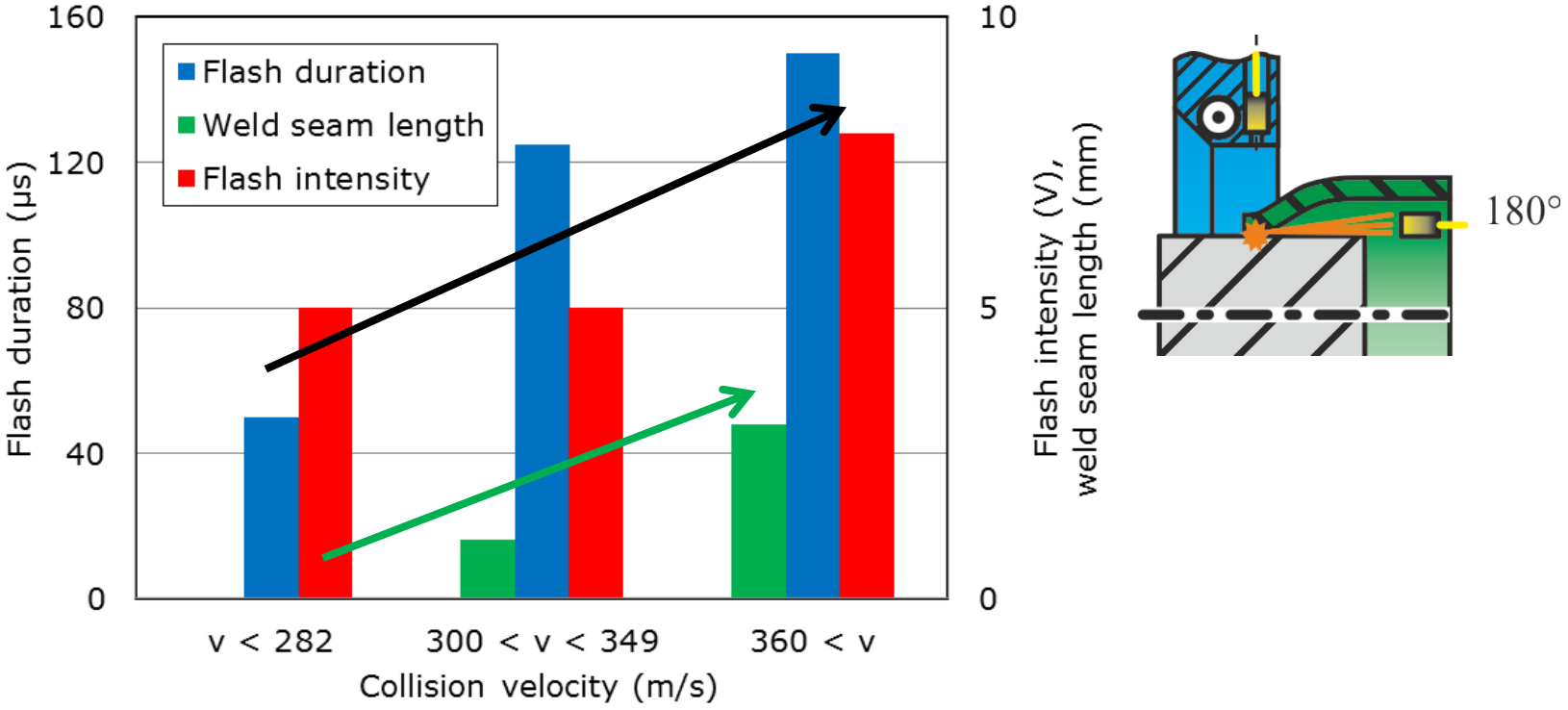
3. Solutions - I. Process control





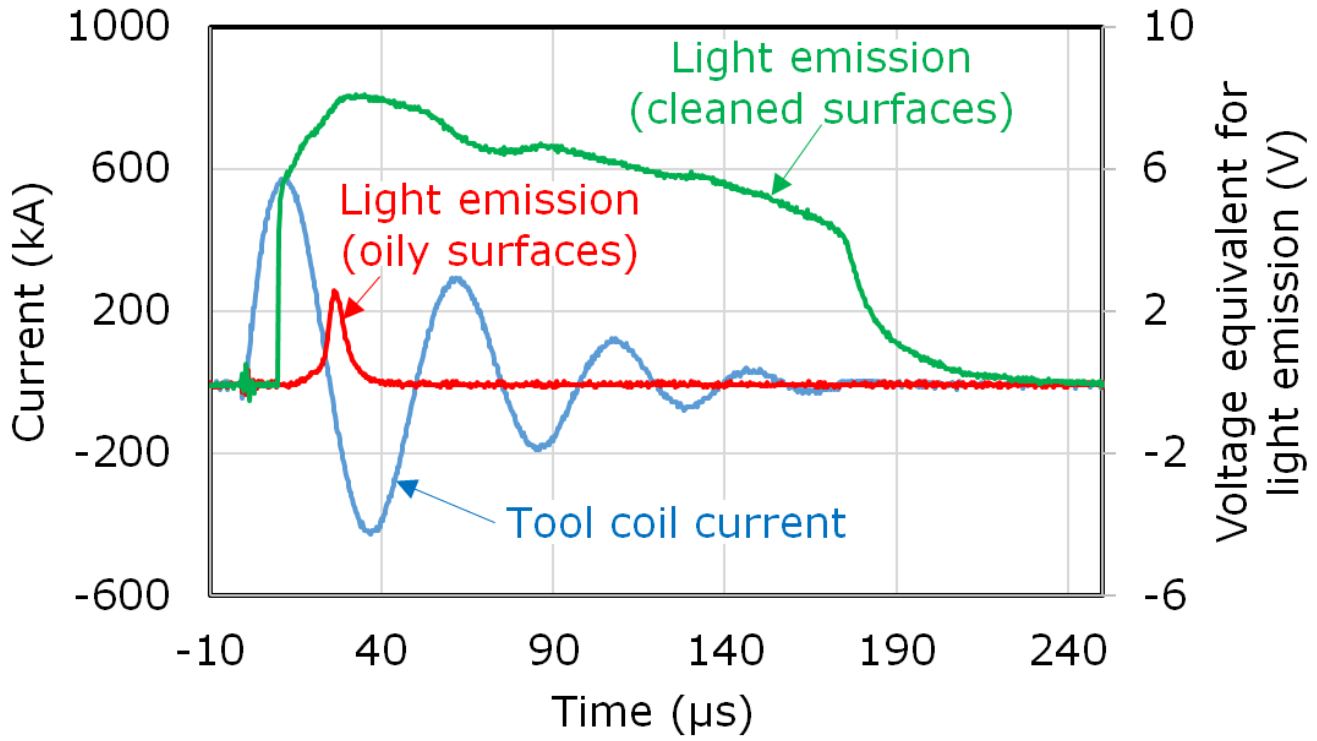
- ✓ Correlation of the flash with the collision time
- ✓ Detection of asymmetries (part related, tool related)
- ✓ Good accessibility

3. Solutions - I. Process control



✓ Correlation of the flash properties with the weld formation

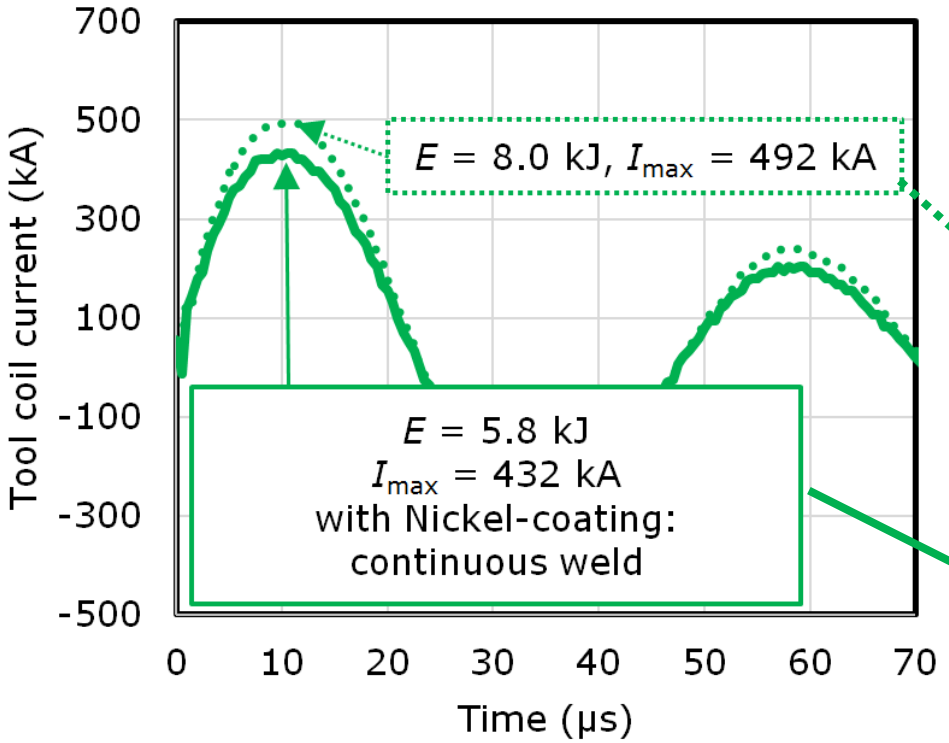
3. Solutions - I. Process control



✓ Suitable for detection of surface disturbances (e.g. oil)

MPW: process control & higher efficiency

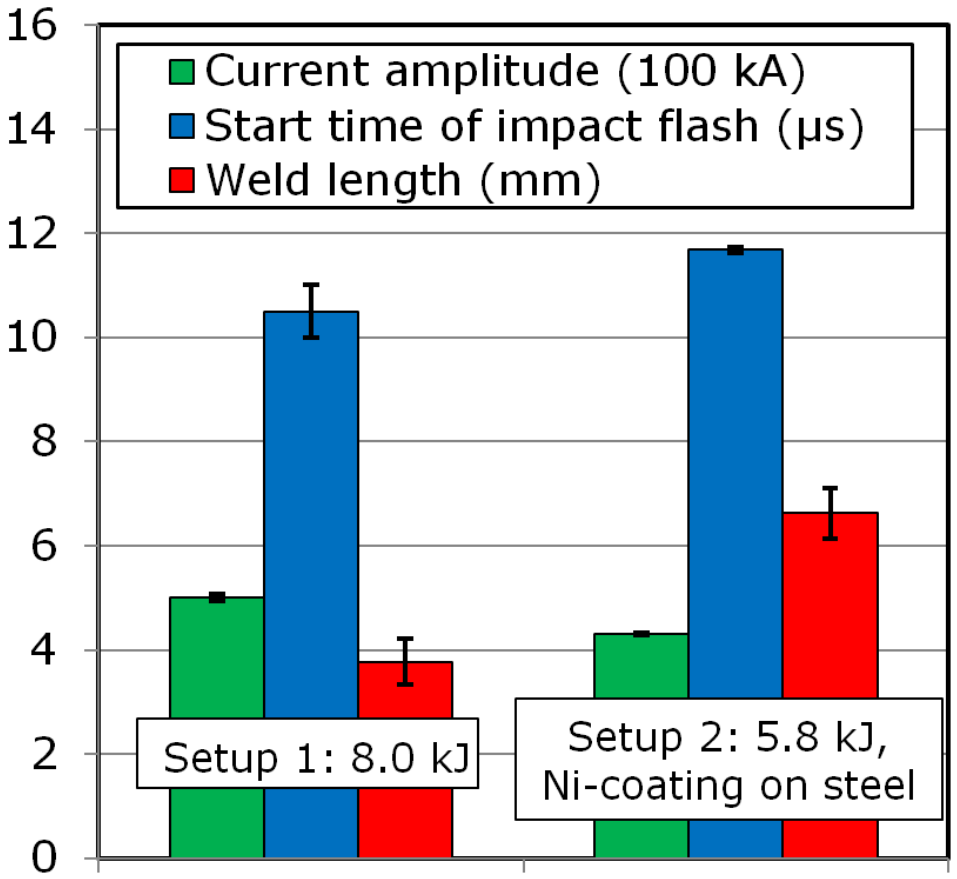
3. Solutions – II. Increase of efficiency



- ✓ Enhanced process boundaries with nickel coating
- ✓ Reduction of maximum current

MPW: process control & higher efficiency

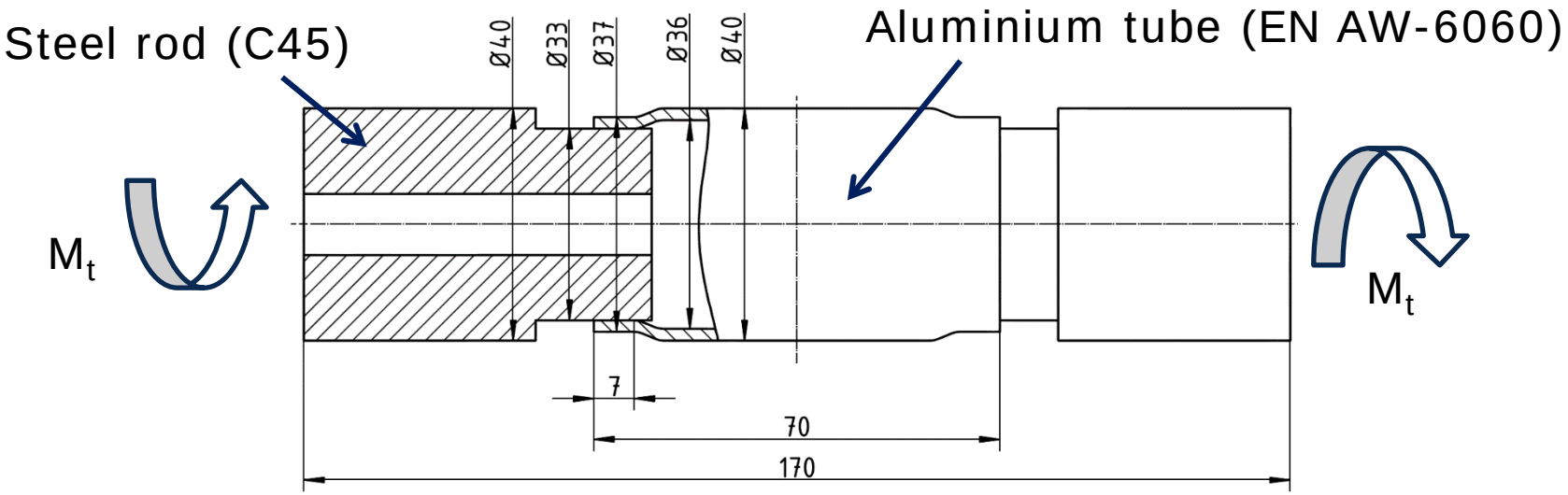
4. Results



For particular example:

- ✓ Reduction of maximum tool coil current by 14%
- ✓ Reduction of minimum impact velocity
- ✓ Increase of weld length by 75%

4. Results – Torsion tests

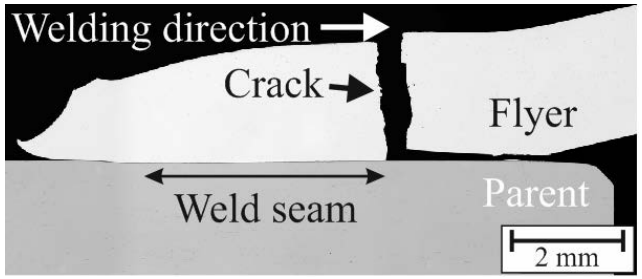


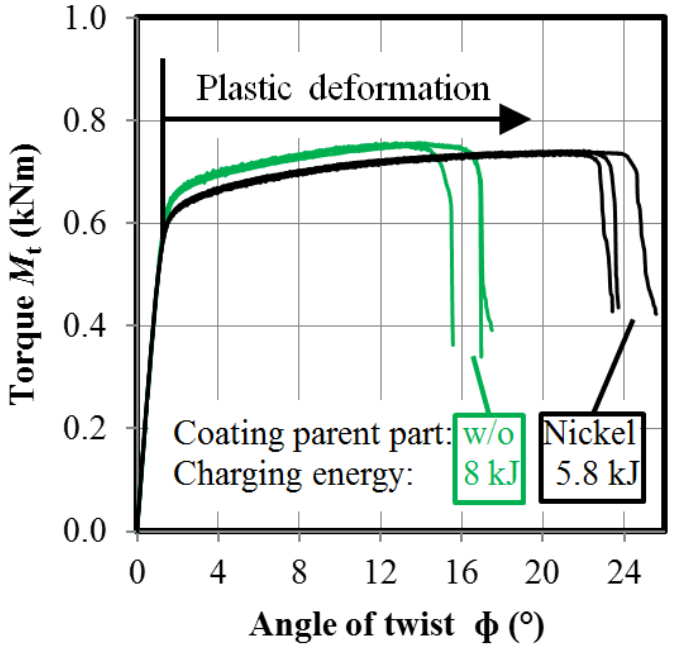
	Static	Cyclic
Number of samples	3	6
Axial force [kN]	0	0

MPW: process control & higher efficiency

4. Results– Quasistatic torsion tests

Angular velocity 10°/min



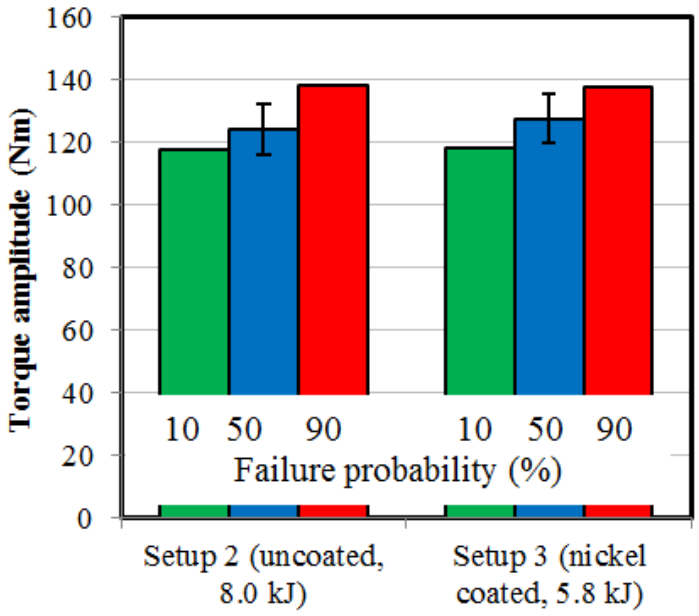


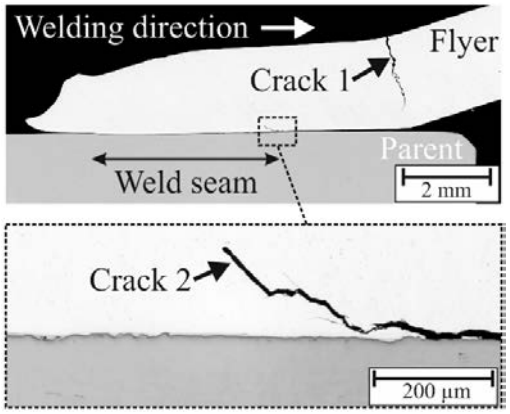
Material failure

- Close to the weld seam,
- At higher torsion angles for samples with nickel interlayer due to favourable stress distribution and reduced hardening

4. Results– Cyclic torsion tests

Staircase test method according to DIN 50100:2016-12	
Loading	Alternating torque (20 Hz)
Torque amplitude (Nm)	119, 131, 143
Maximum number of load cycles	$2*10^6$
Stop criterion	Difference of angle amplitude > 0.01°, macroscopic cracks





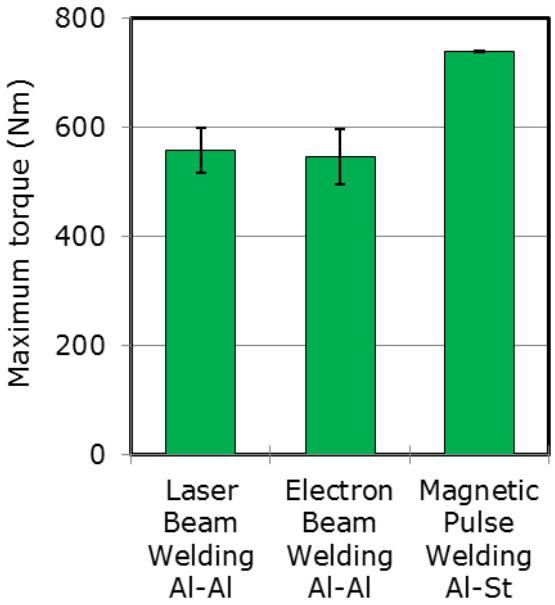
Material failure

- Transition zone (crack 1) and
- Close to the welded zone (crack 2)

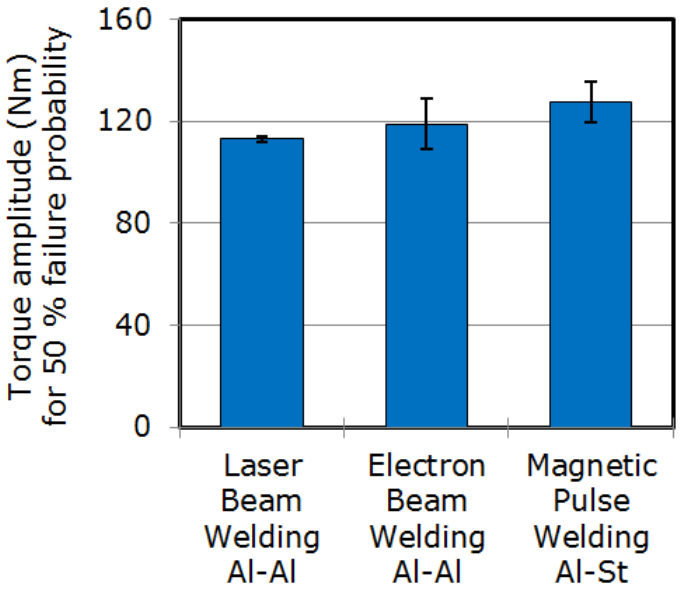
MPW: process control & higher efficiency

4. Results – Loading capacity by comparison

quasistatic



cyclic



✓ Joint made by Magnetic Pulse Welding has improved quasistatic loading capacity

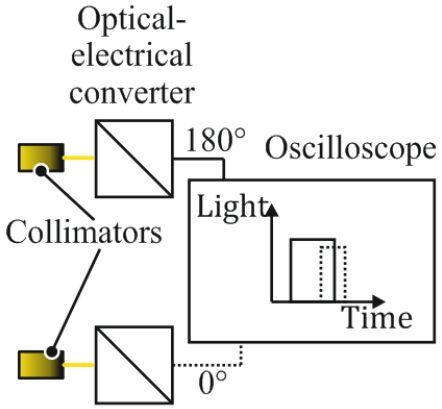
MPW: process control & higher efficiency

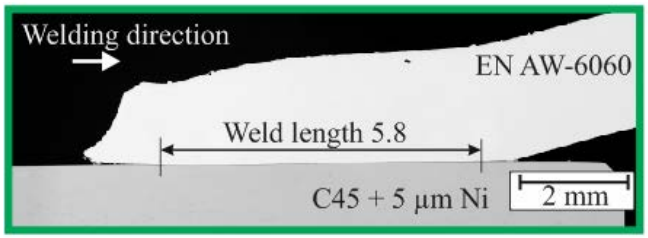
5. Conclusion

I. Process and device for control of the weld establishment during impact welding (Patent DE 10 2016 217 758 B3)

II. Enhanced process boundaries with nickel coating

III. Demonstration of the loading capability in quasistatic and cyclic torsion tests





MPW: process control & higher efficiency

Thanks for...

...your interest in Magnetic Pulse Welding and

...the financial support from the German Research Foundation (DFG)

We also acknowledge the support of the HLD-HZDR, member of the European Magnetic Field Laboratory (EMFL).

SPP 1640

DFG

HZDR

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

MPW: process control & higher efficiency