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DRESDEN concept

Measurement techniques for magnetic pulse welding*

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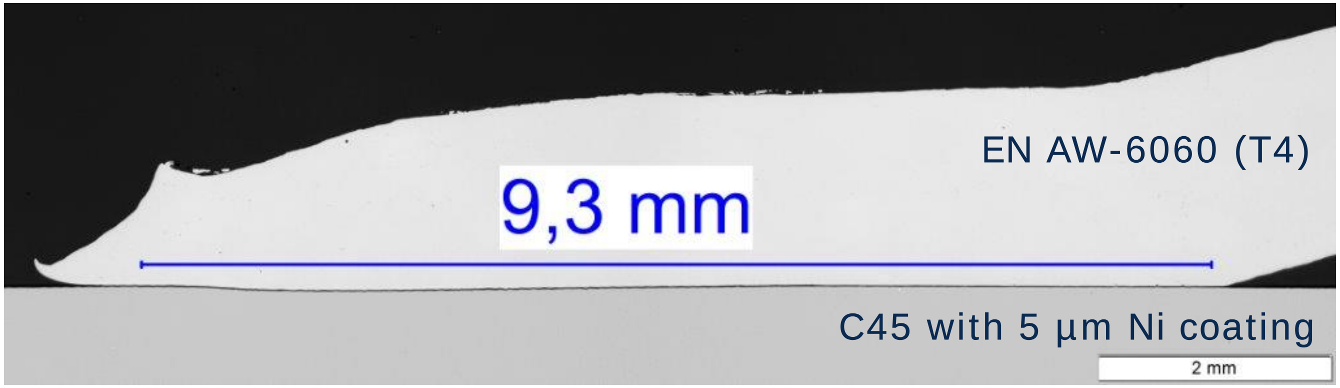
*The full-text on „Measurement and analysis technologies for magnetic pulse welding - established methods and new strategies" is available in Advances in Manufacturing, 2016, DOI 10.1007/s40436-016-0162-5 (http://link.springer.com)

Nantes, 1st December 2016

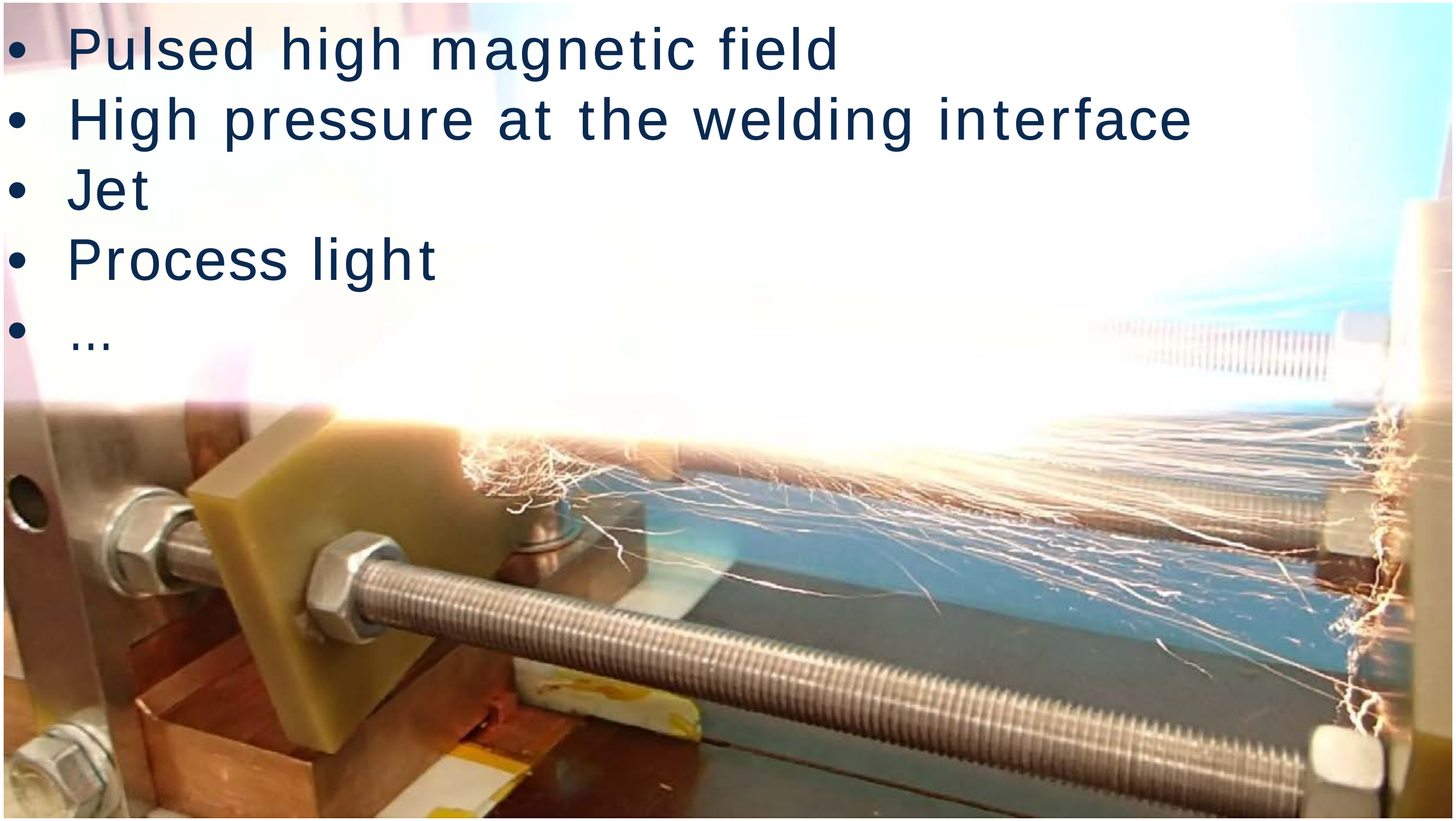
Motivation for measurements during MPW

	Process development	Quality assurance
Aim	Elaborate optimal welding parameters	In situ detection of non-welded parts
Typical methods	Photon Doppler velocimetry, current measurements, high speed imaging	



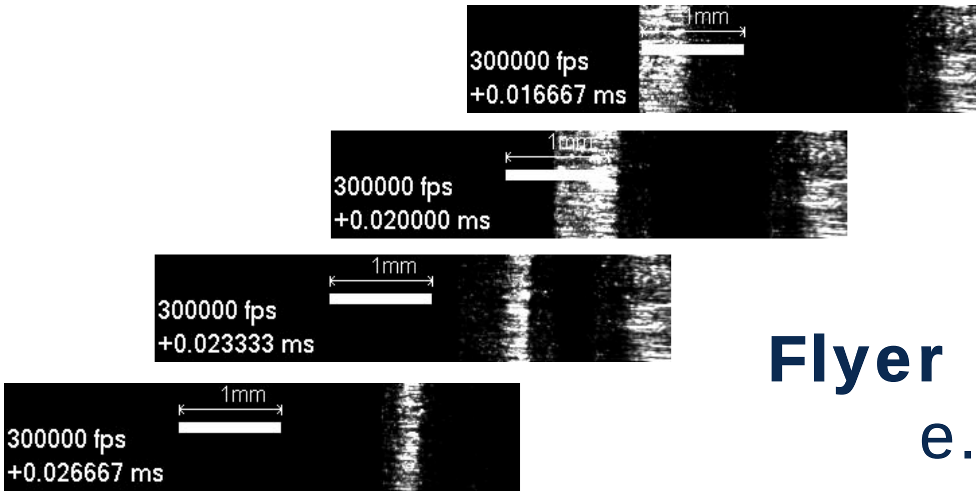
Bellmann et al., "Effects of surface coatings on the joint formation during magnetic pulse welding in tube-to-cylinder configuration," 7th Int. Conference on High Speed Forming, 2016

Challenges for measurements during MPW



- Pulsed high magnetic field
- High pressure at the welding interface
- Jet
- Process light
- ...

Established measurement methods



Collision behaviour
e.g. High speed camera

Flyer movement
e.g. PDV

Magnetic field
e.g. Hall sensors

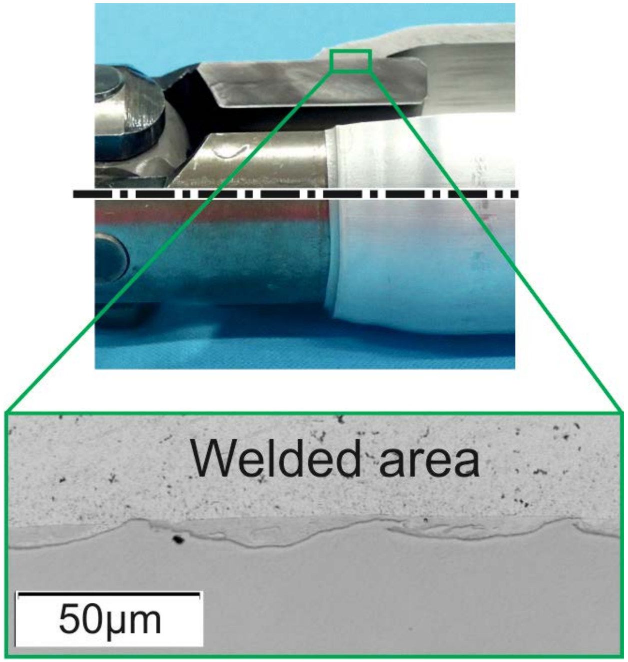
Current
e.g. Rogowski pick-up coil

Increasing prediction capabilities of a sound weld

New ideas for the measurement of the collision behavior

Aim: Consolidation of process insights

1. PDV
2. Indentation test
3. Flash detection



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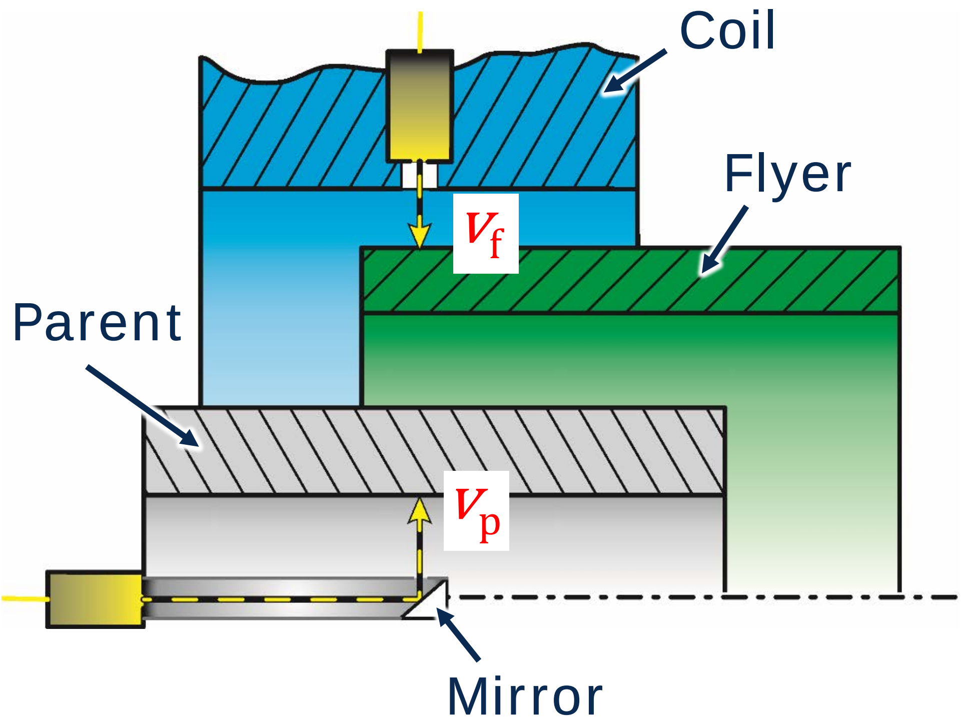
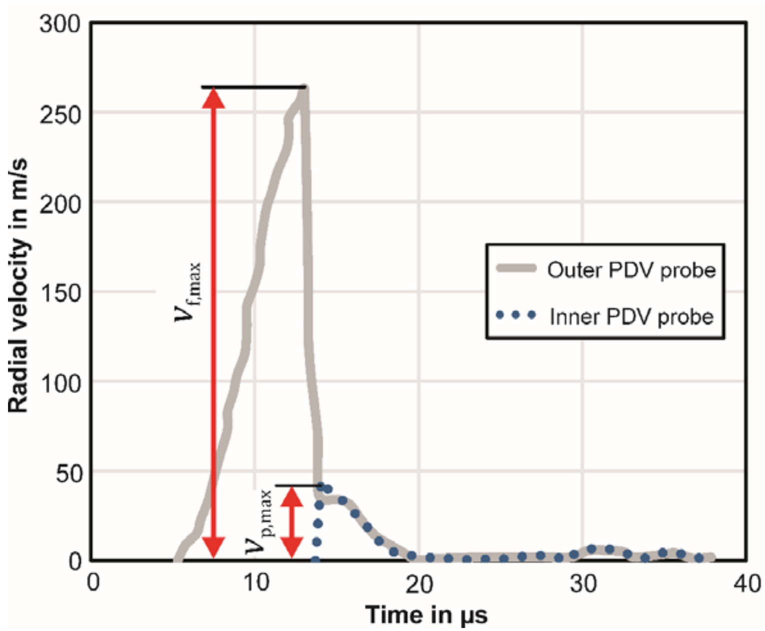
1. PDV – tube to tube configuration

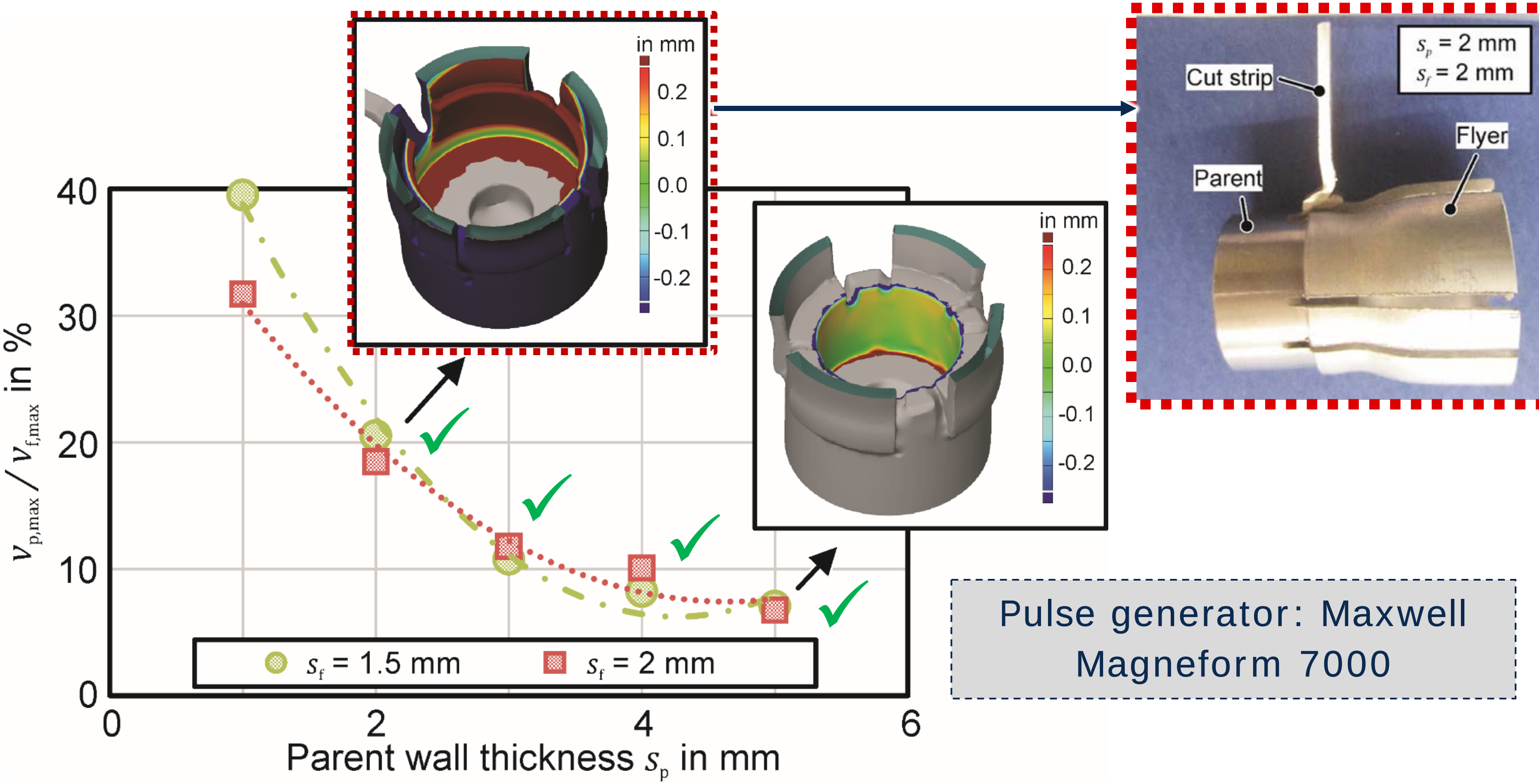
Concept: In situ velocity measurement





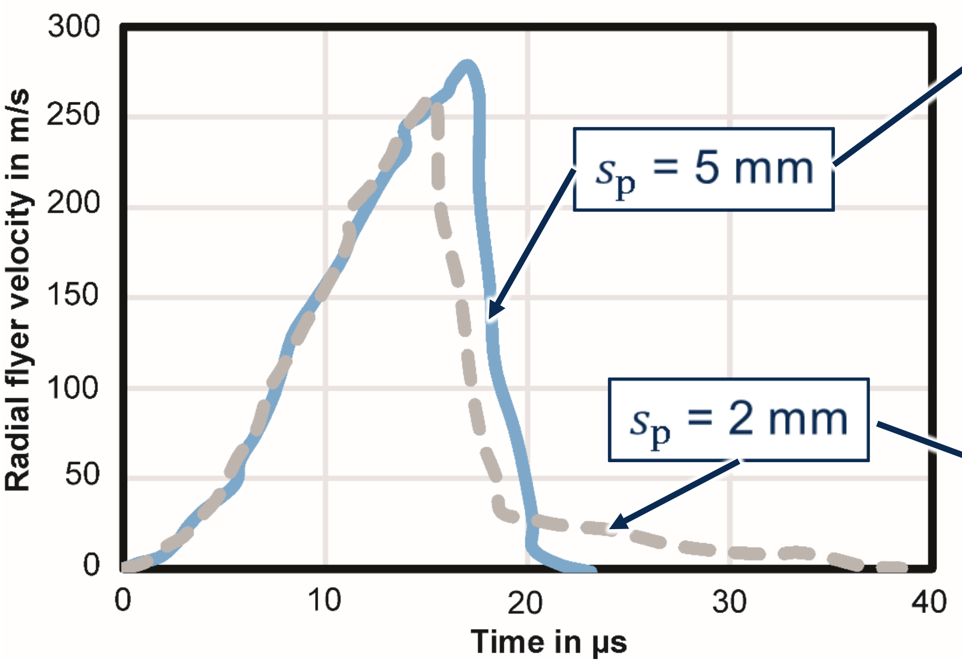
Key figure: $v_{p,max}$ / $v_{f,max}$ in %

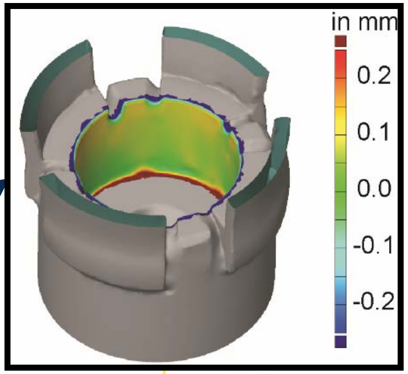
Result: MPW possible despite parent deformation

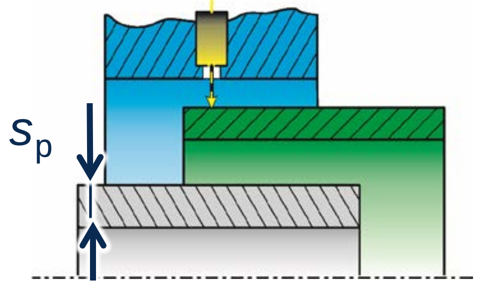


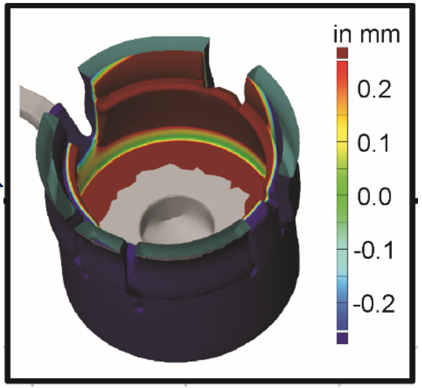
Pulse generator: Maxwell Magneform 7000

Timeshift between collision and parent deformation → weld strength established within 20 µs

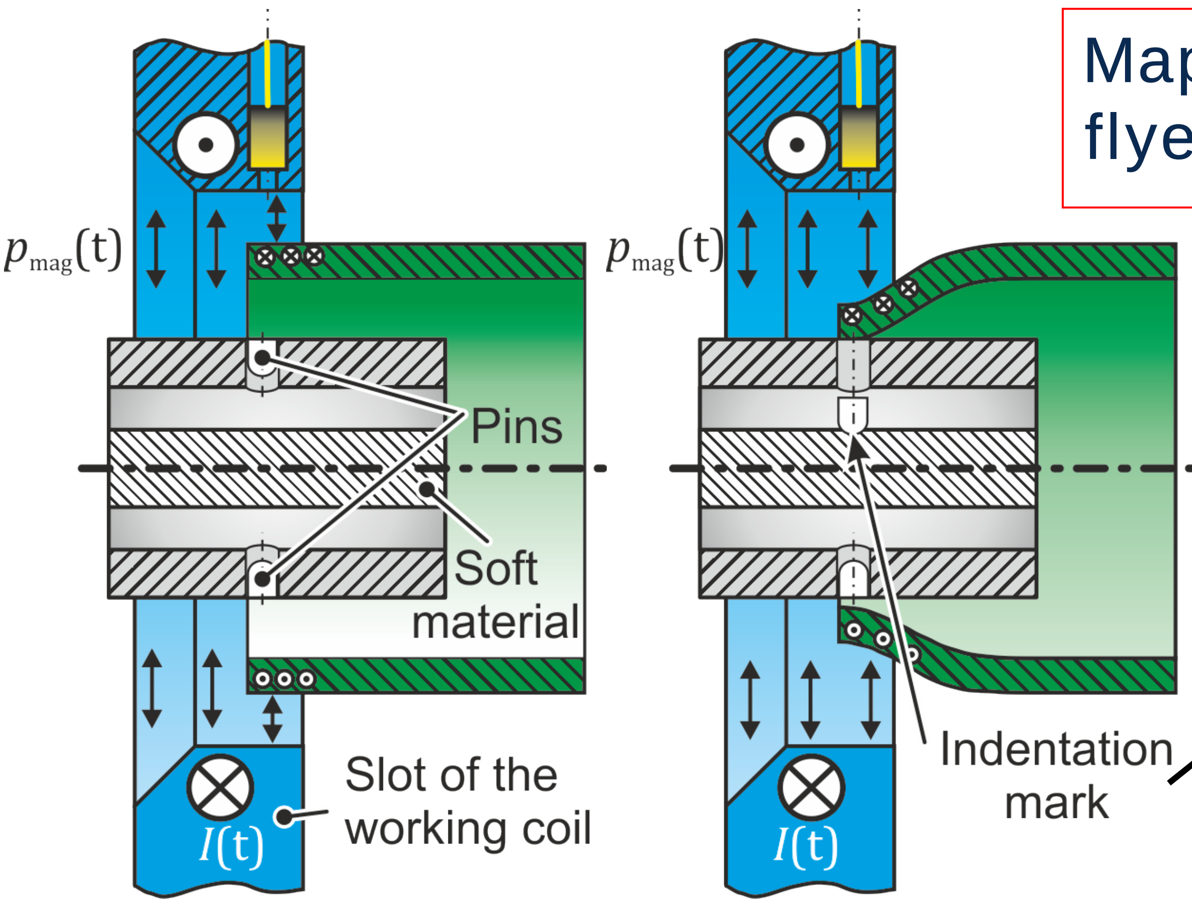




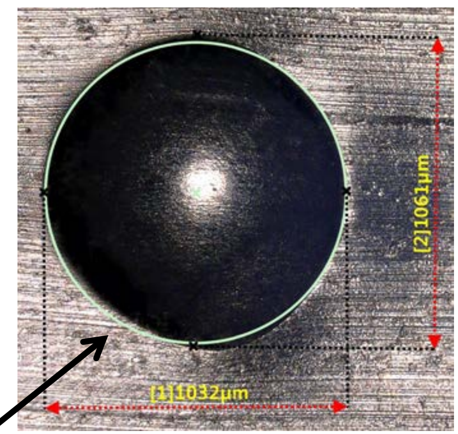




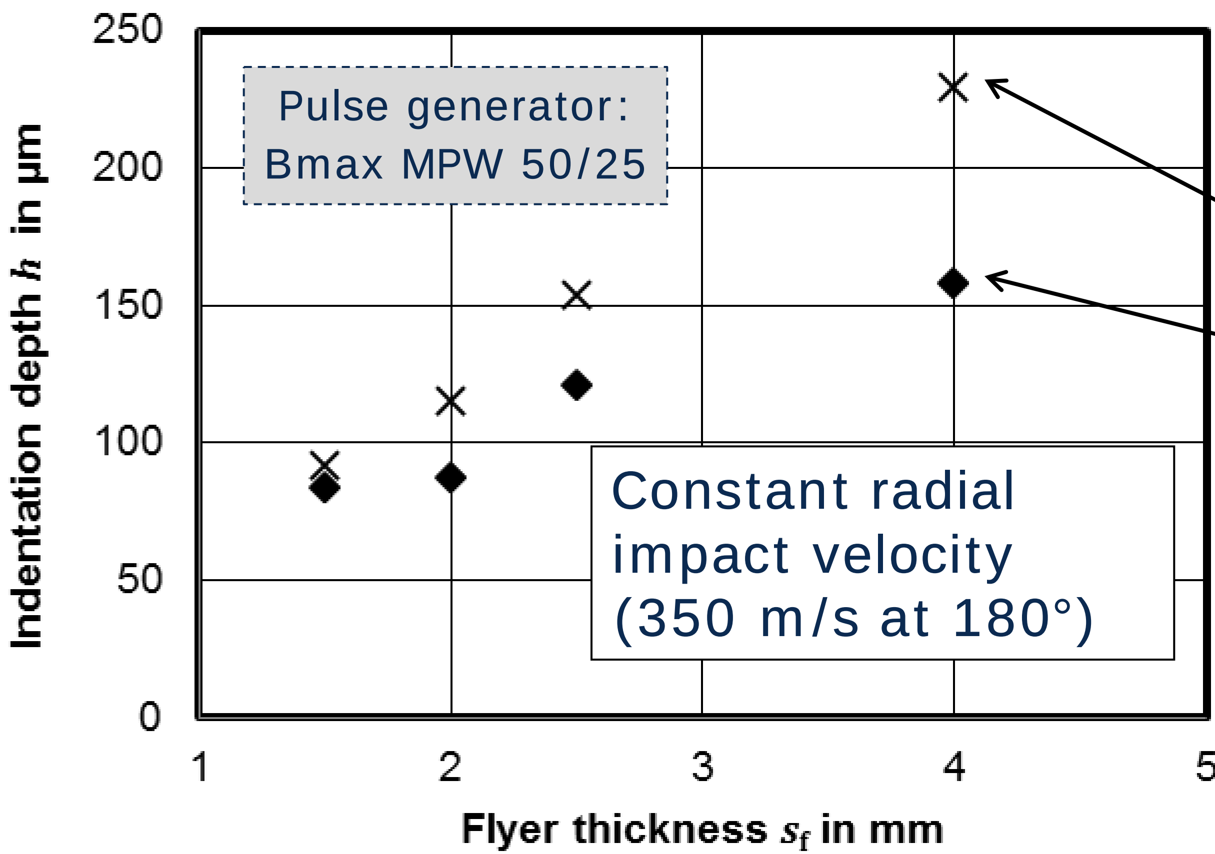
2. New indentation test

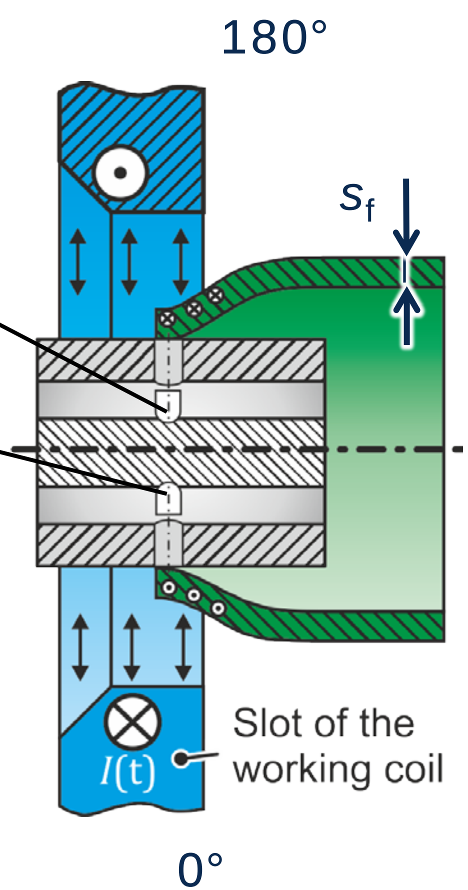


Mapping of the flyer‘s kinetic energy

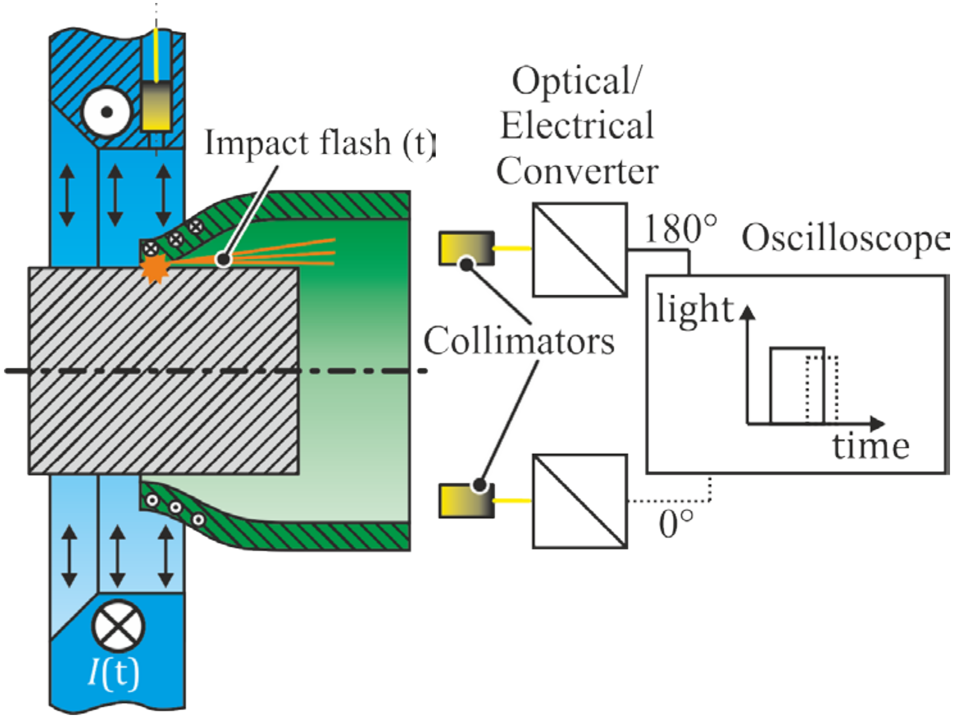


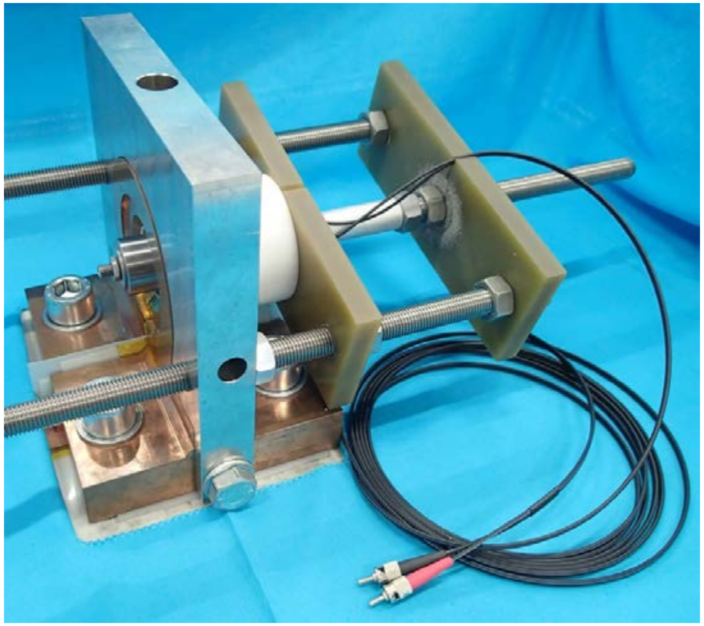
Result: Influence of the slot and flyer thickness



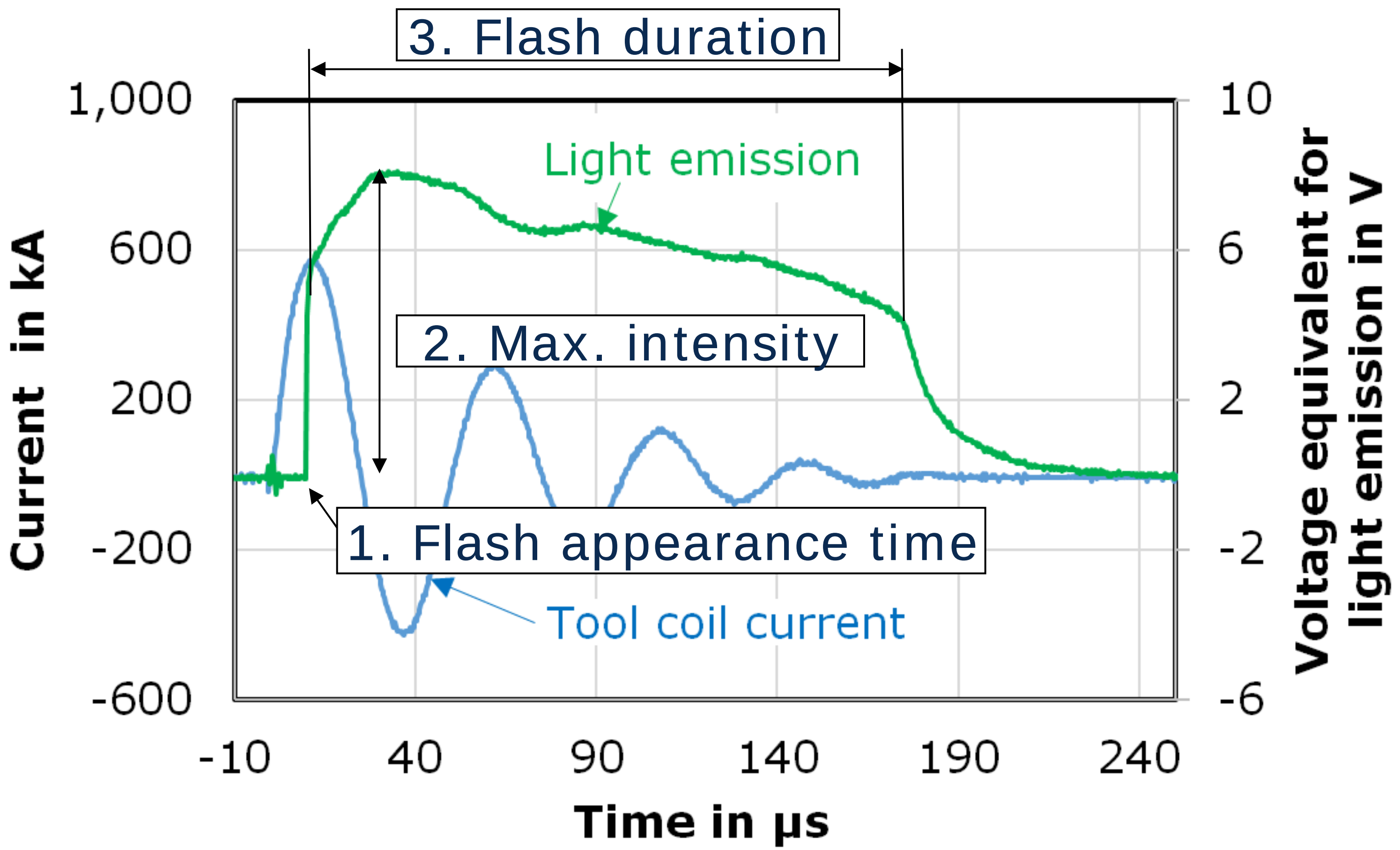


3. Flash detection – new possiblities



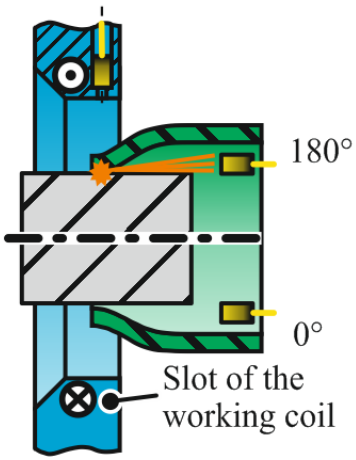


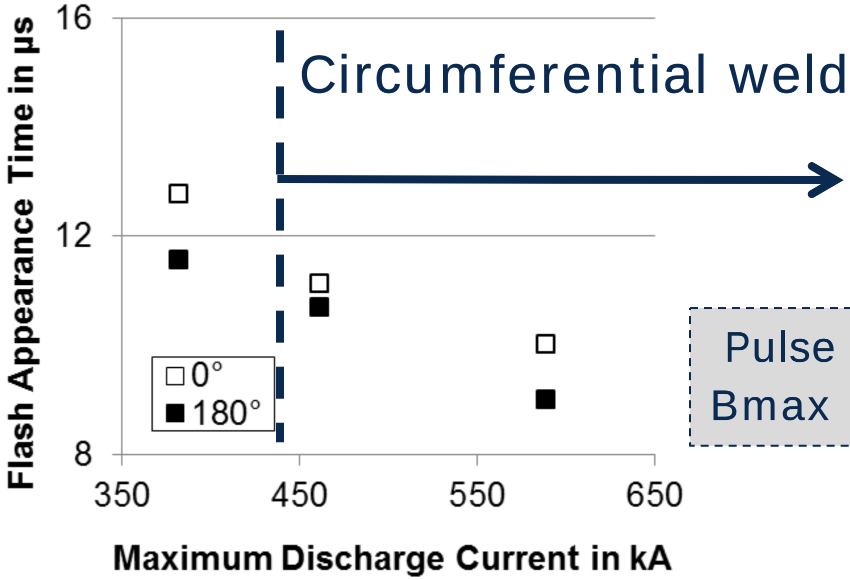
Characteristic values of the flash



- ✓ Detection of failures during acceleration
- ✓ Detection of asymmetries (part / tool related)
- ✓ Good accessibility

	Flash Appearance Time (µs)		Flash Duration (µs)		Maximum Light Intensity (V)	
	180°	0°	180°	0°	180°	0°
Average (n=4)	10.59	10.91	145	125	6.5	6.8
Variation coefficient	1.7%	4.2%	4.2%	9.1%	5.4%	3.2%





Pulse generator:
Bmax MPW 50/25

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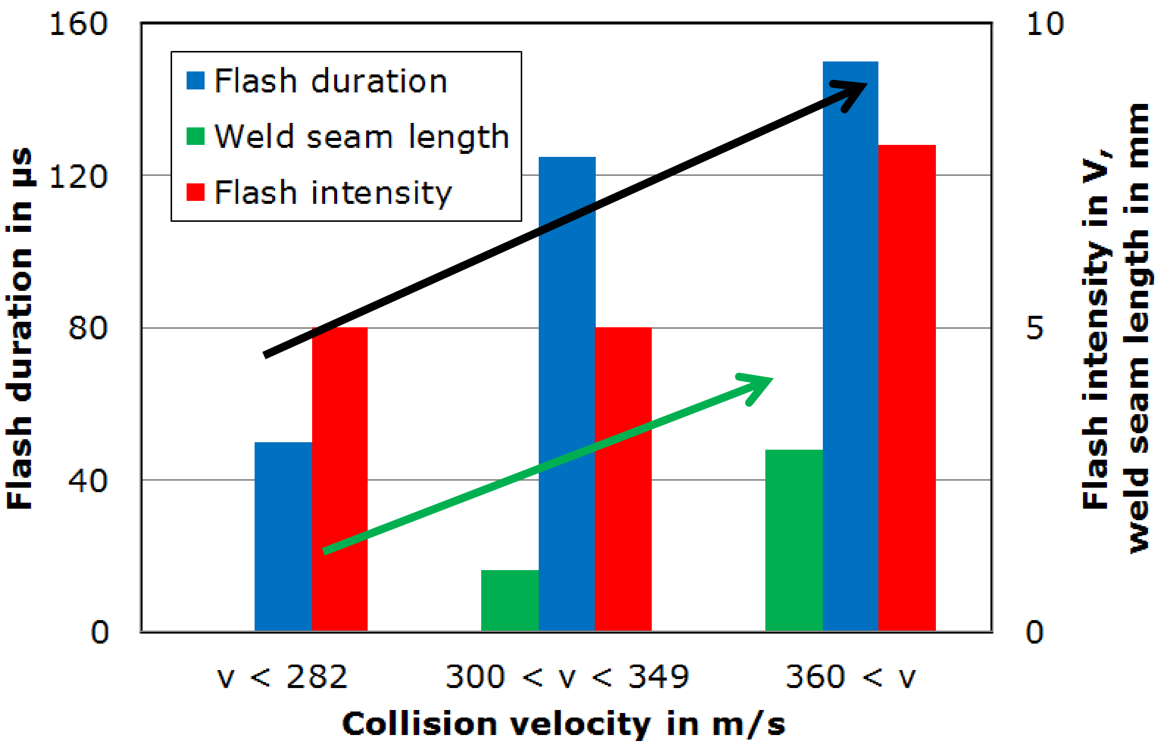
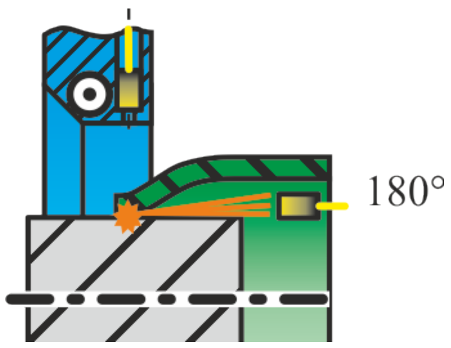
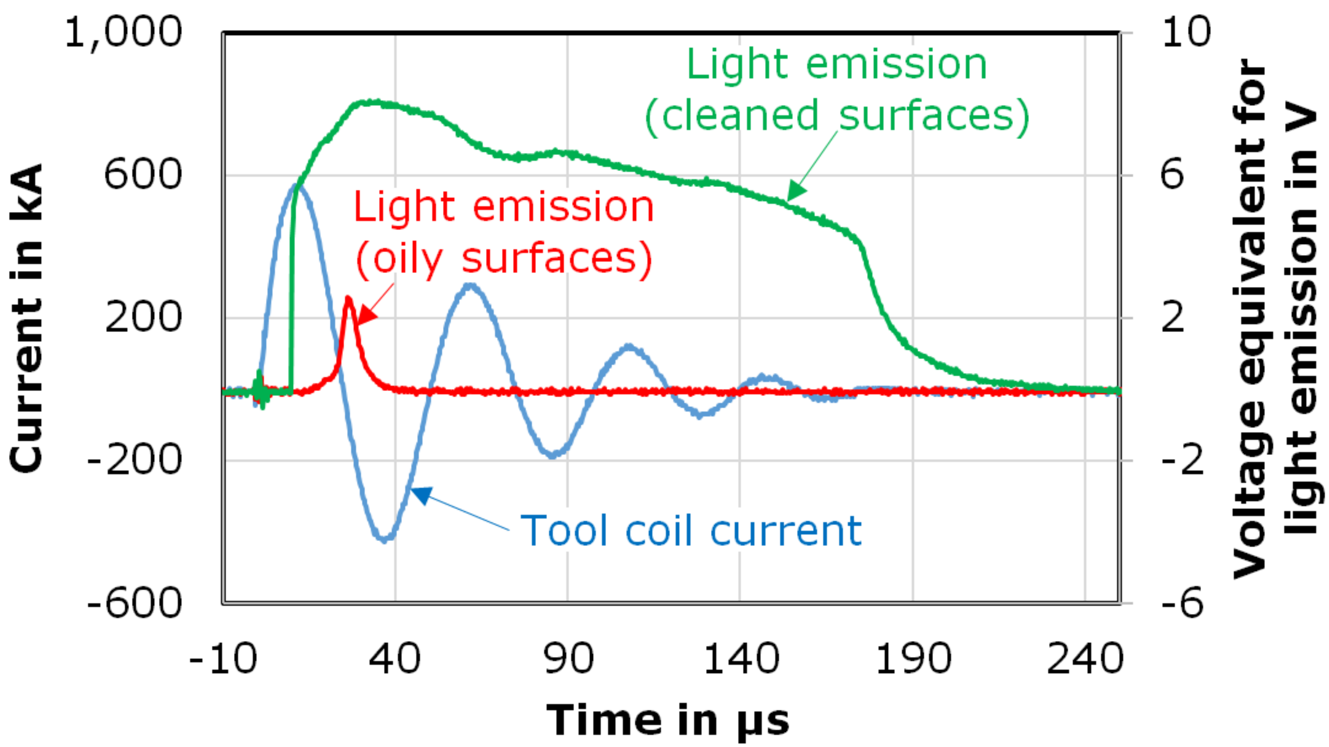
Correlation of the flash with the weld seam formation



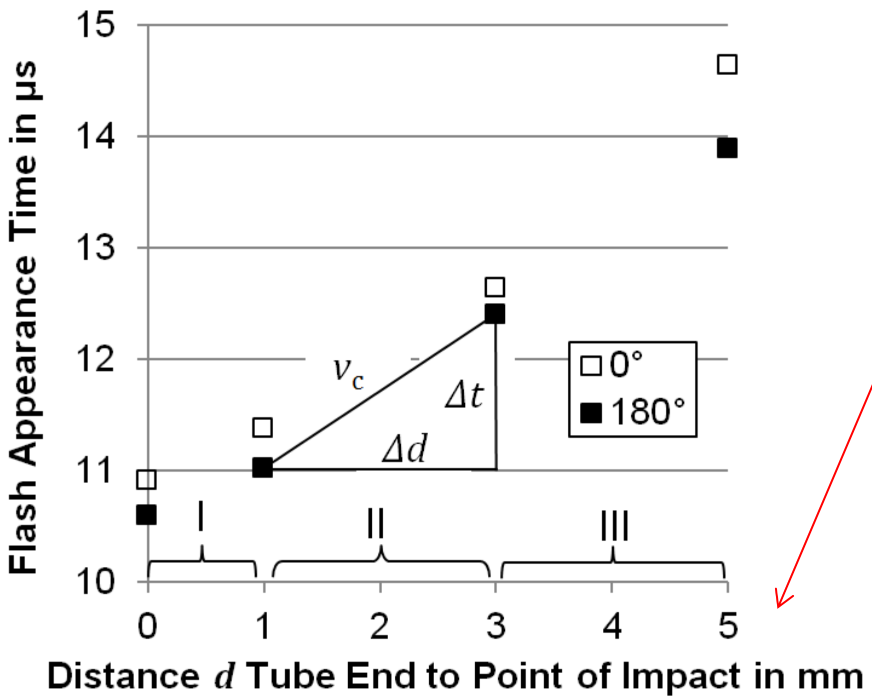


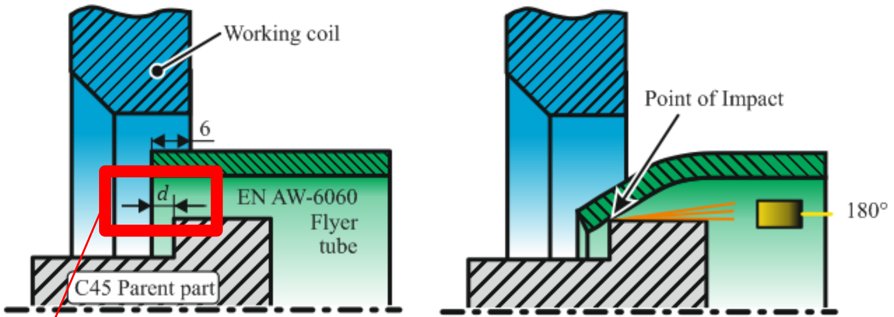
Pulse generator:
Bmax MPW 50/25

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



Measurement of the weld front propagation

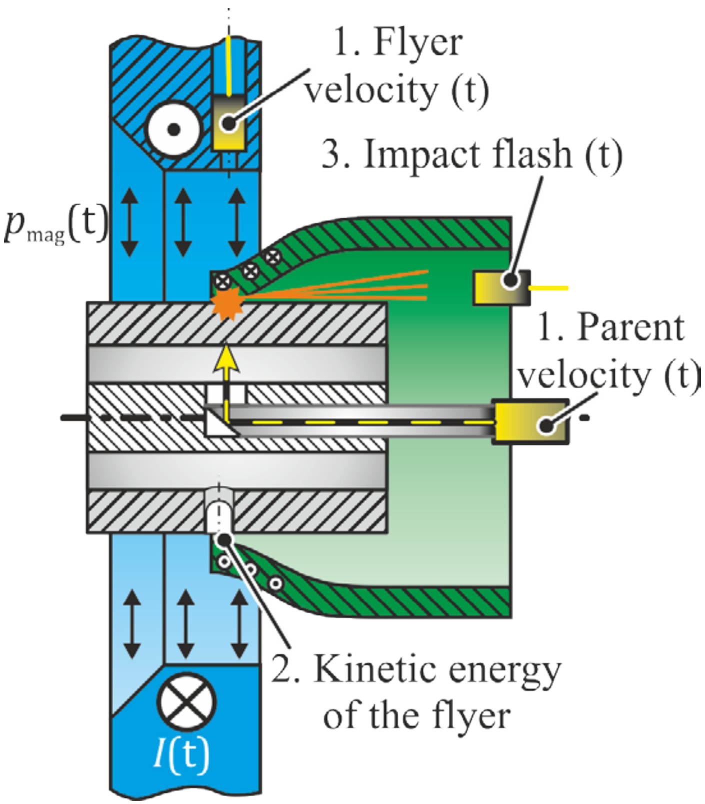




Pulse generator:
Bmax MPW 50/25

Location	Weld front propagation velocity v_c (m / s)	
	180°	**0°**
I	2326	2105
II	1449	1587
III	1351	1000

Summary



Insights into MPW:

1. Weld strength is established before parent deformation is completed (tubes)
2. Impact energy of the flyer varies over the circumference
3. Hypervelocity impact flash is a suiteable tool for the measurement of collision parameters, detection of asymmetries,...*

*DE102016217758.3 (patents pending)

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Acknowledgements

DRESDEN concept

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technische universität dortmund

DFG

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