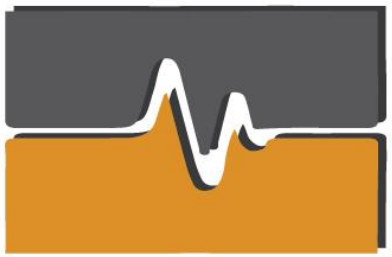
Joining Sub-Platform



JOIN'EM

INDUSTRIAL TECHNOLOGIES FOR ADVANCED JOINING AND ASSEMBLY PROCESSES FOR MULTI-MATERIALS

Verena Psyk

Fraunhofer Institute of Machine Tools and Forming Technology

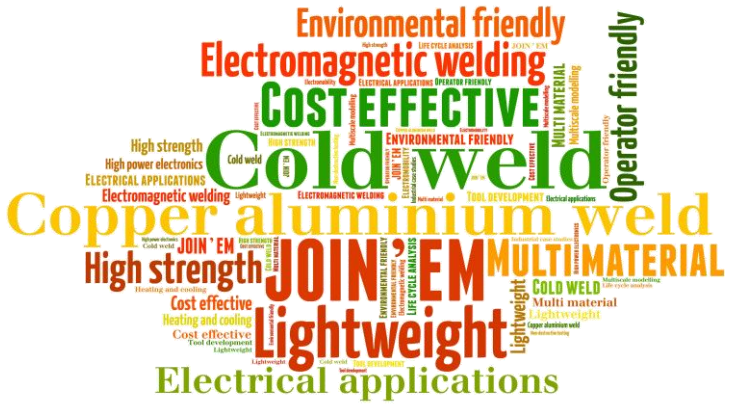
16.11.2017

JOINING

Fraunhofer IWU

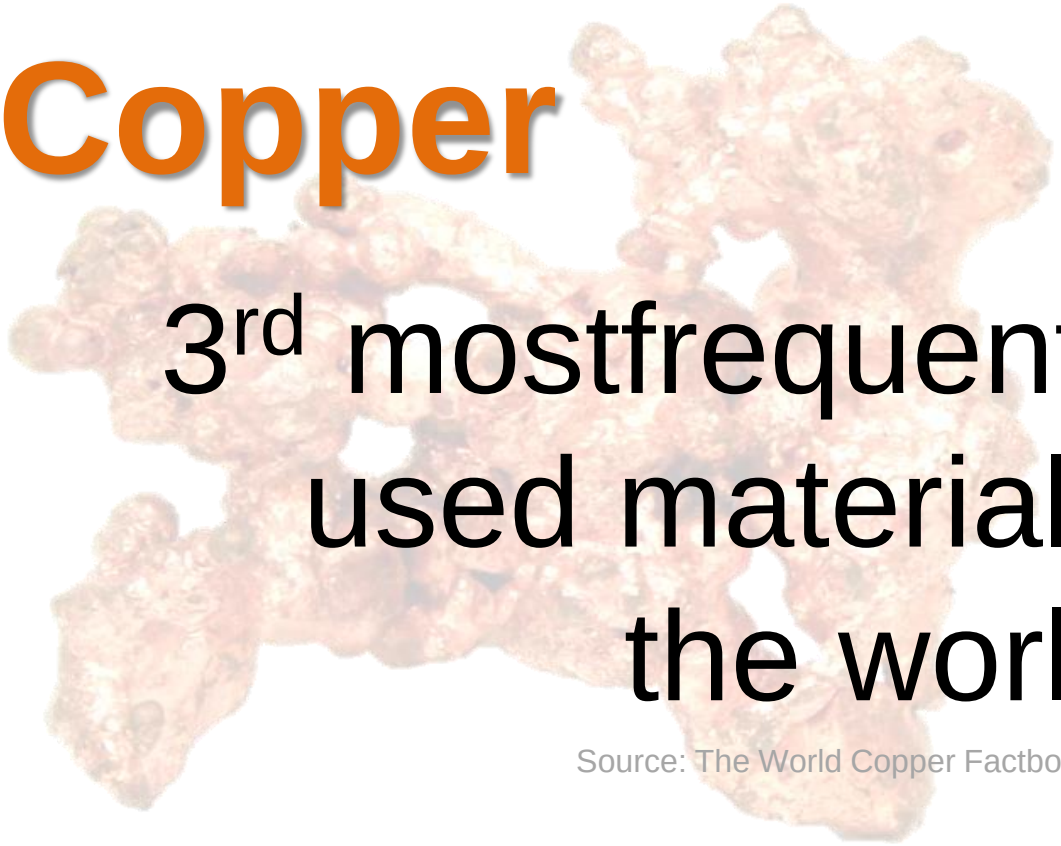
Project data

Titel	JOINing of copper to aluminium by ElectroMagnetic fields
Acronym	JOIN'EM
Duration	01.09.2015 - 31.08.2018
Budget	4.7 Mio. €
Grant	4.1 Mio. €
Coordinator	Fraunhofer IWU (Dr.-Ing. Verena Psyk)
14 Partners	



*Word cloud designed using Tagxedo

Significance of copper



Copper

3rd mostfrequently used material in the world

Source: The World Copper Factbook 2010

Copper characteristics

Advantages

- High electrical conductivity
- High thermal conductivity
- High chemical resistance





Limits

- High cost
- High density



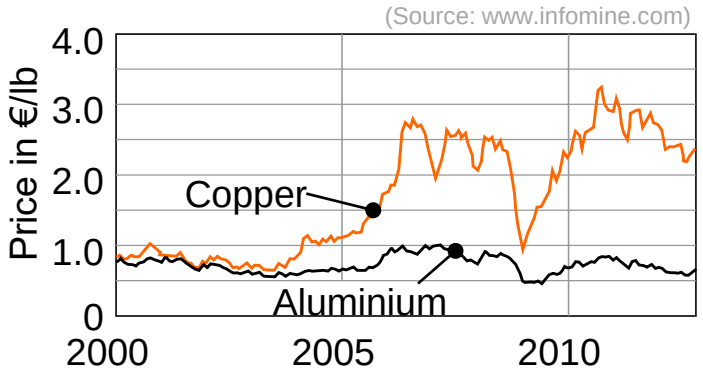


Compromise: Hybrid Components

Substitution of copper-intensive components by hybrid aluminium-copper parts

➔ reduced material costs

➔ reduced product weight



Precondition
Manufacturing technology for efficient production of high quality multi-material joints

➔ **Magnetic pulse welding (MPW)**

	Copper	Aluminium
Electrical conductivity	58 MS/m	36 MS/m
Thermal conductivity	401 W/mK	236 W/mK
Density	8.9 g/cm³	2.7 g/cm³
Price	4,478 €/ton*	1,550 €/ton*

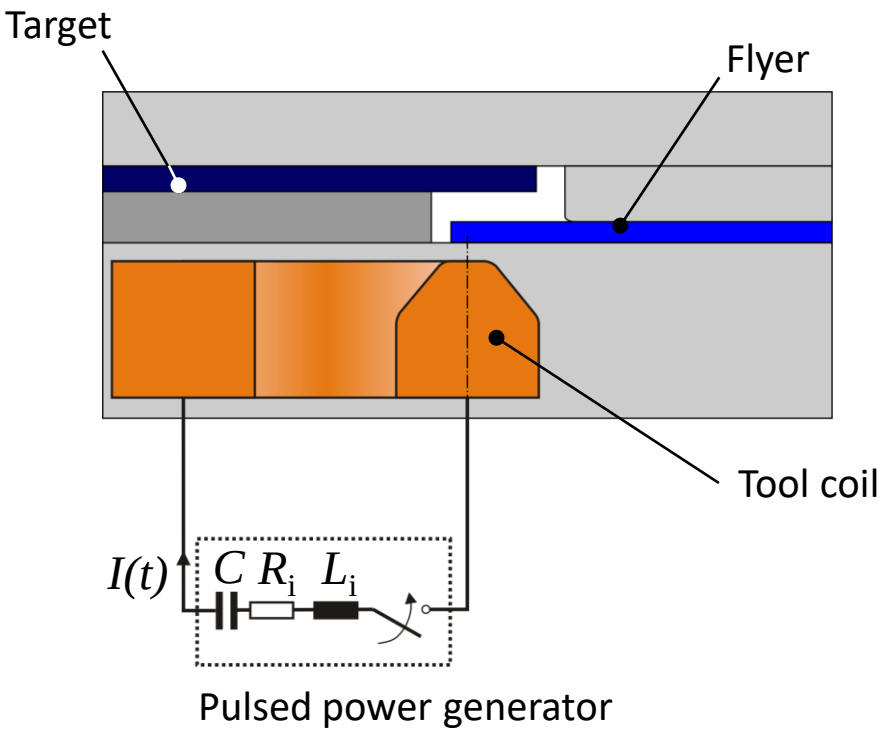
(*Source: http://www.boerse-online.de/rohstoffe;)

JOINING

Fraunhofer IWU

Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

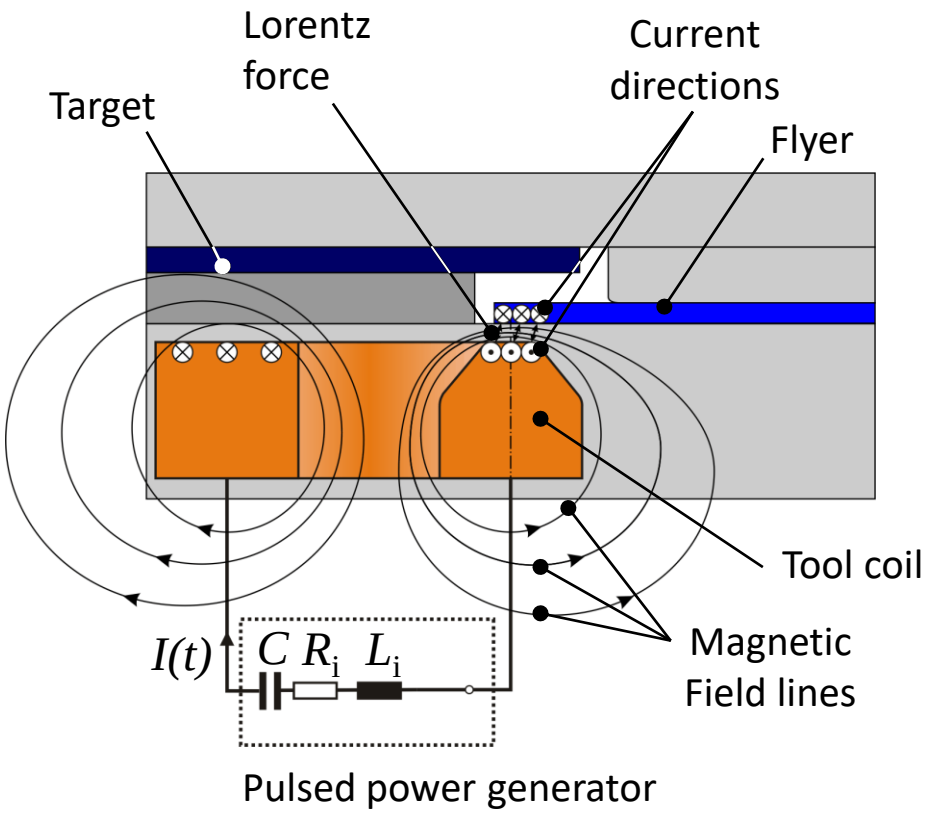


Characteristics of MPW

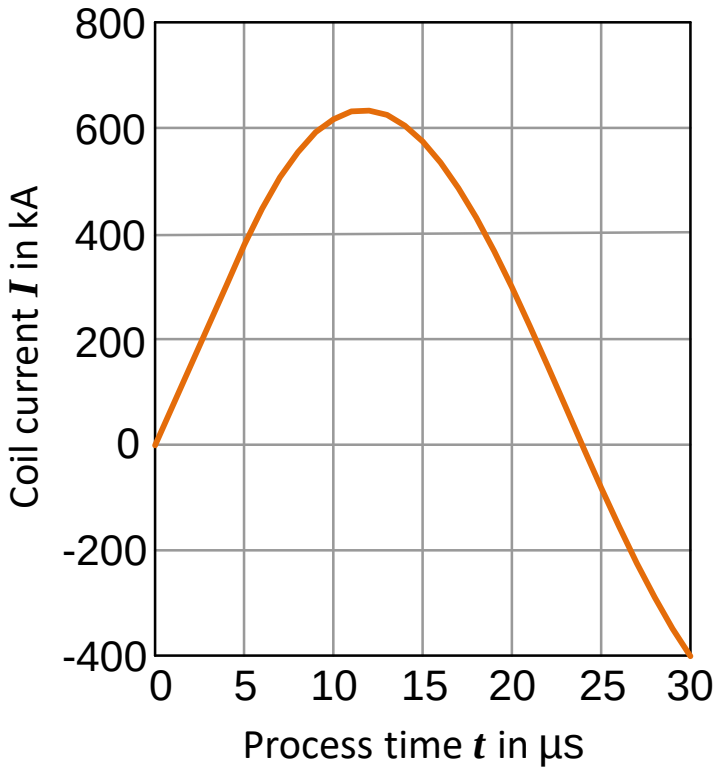
- Joint produced by high speed collision of flyer and target
- No significant heating of the parts
- No temperature induced problems (intermetallics, thermal softening, heat distortion etc.)
- Conventionally non-weldable material combinations possible (e.g. Cu - Al, (stainless) steel - Al)
- High quality joints
  - Mechanical strength
  - Electrical conductivity
- Applicable for tubes and sheets

Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

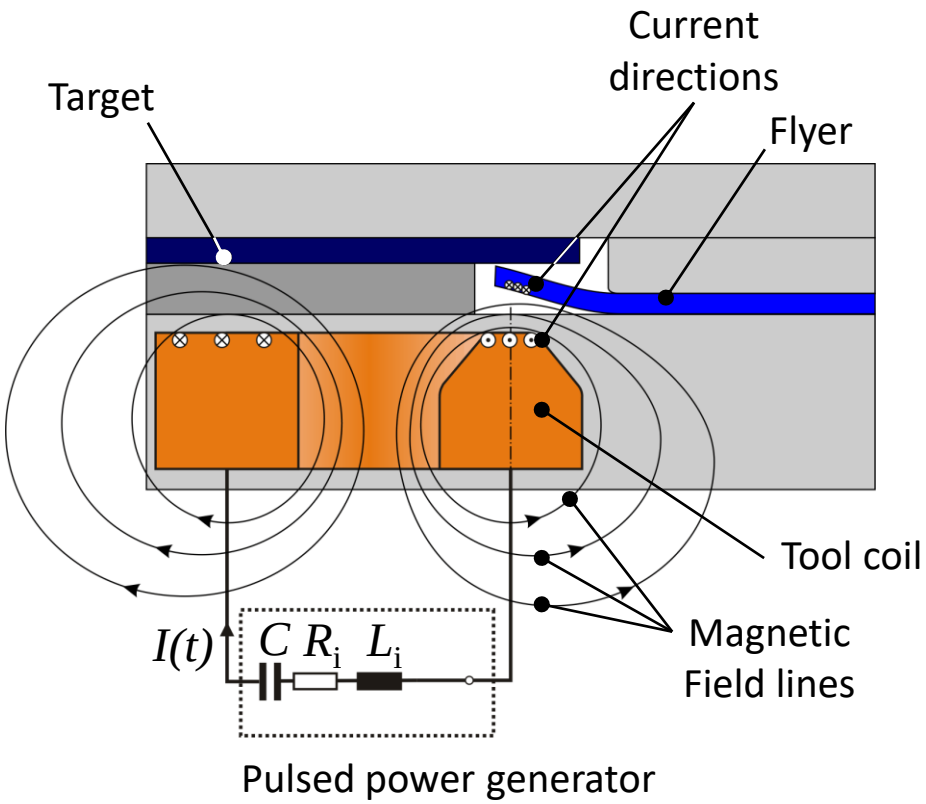


Course of the coil current

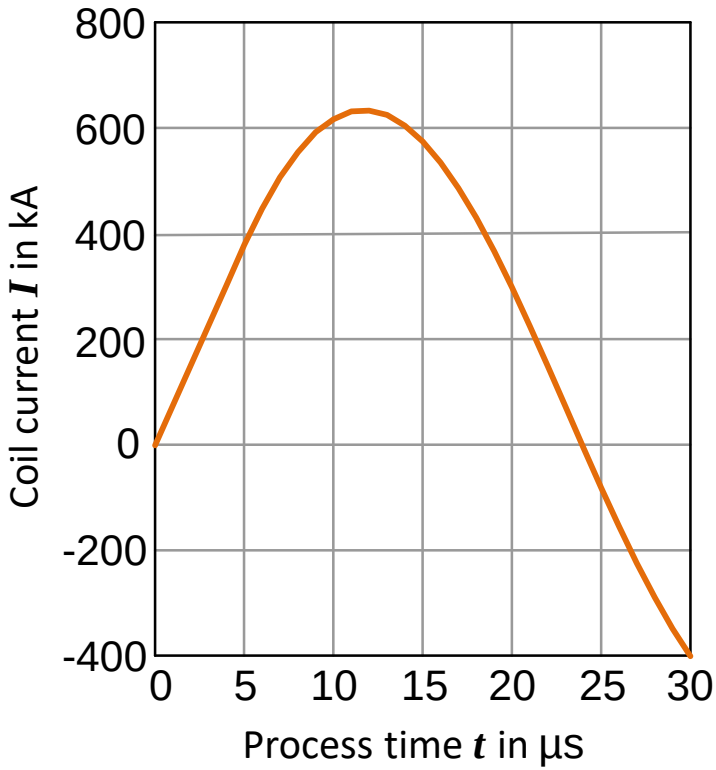


Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

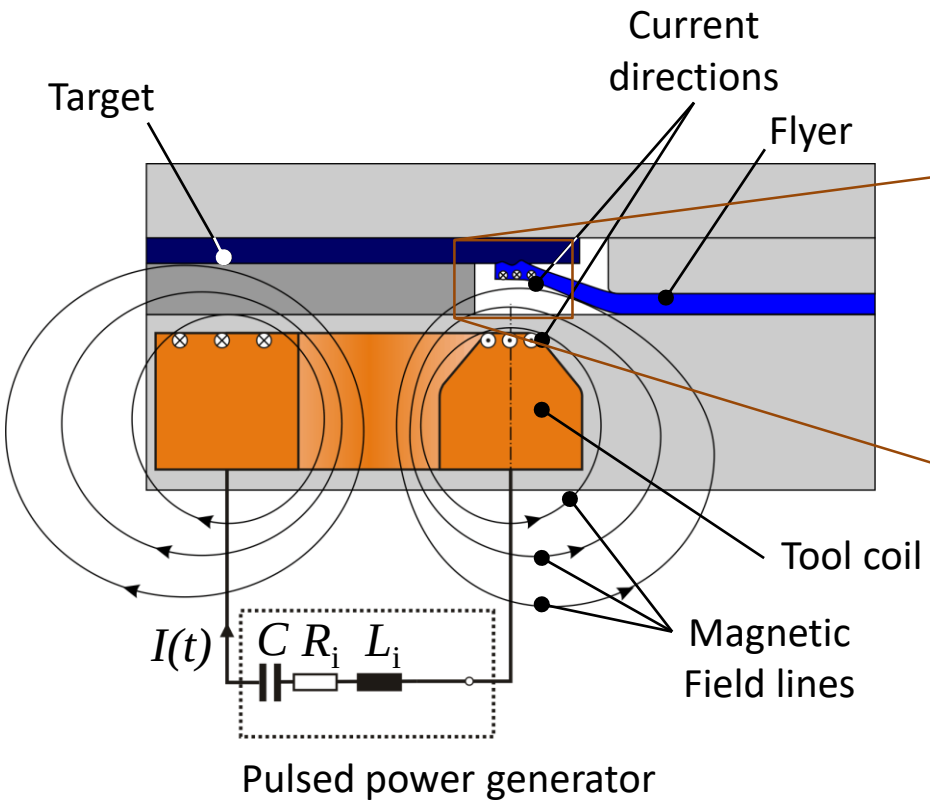


Course of the coil current

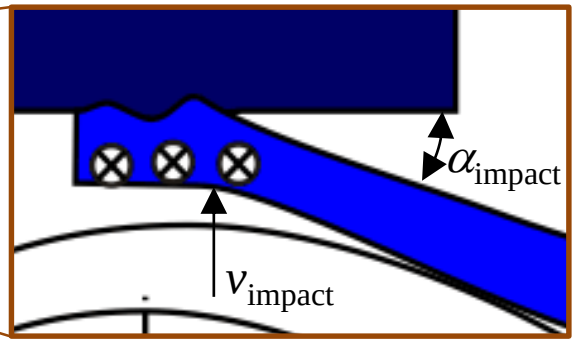


Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process



Collision parameters

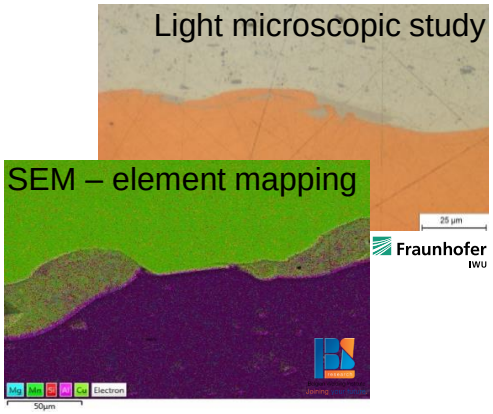


Impact angle α_{impact}
Impact velocity v_{impact}

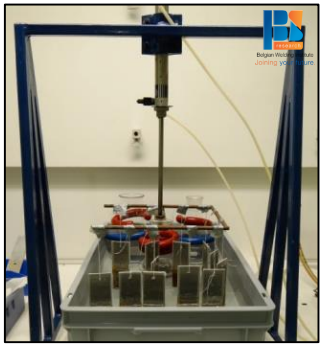
Development of joint characterisation methods

Destructive

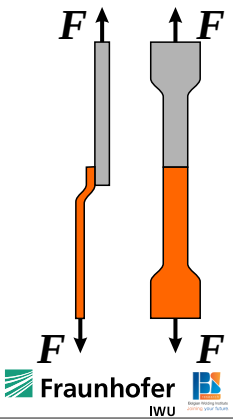
Micrographic investigation



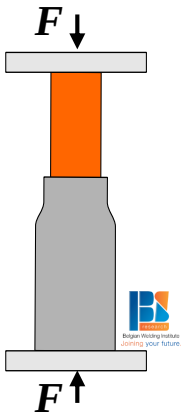
Corrosion test



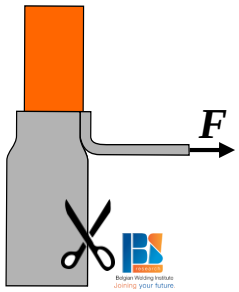
Lap shear test



Compression test

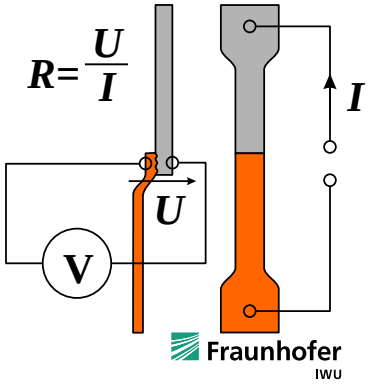


Peel test



Non-destructive

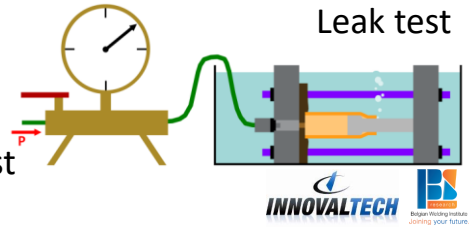
Electrical resistance measurement



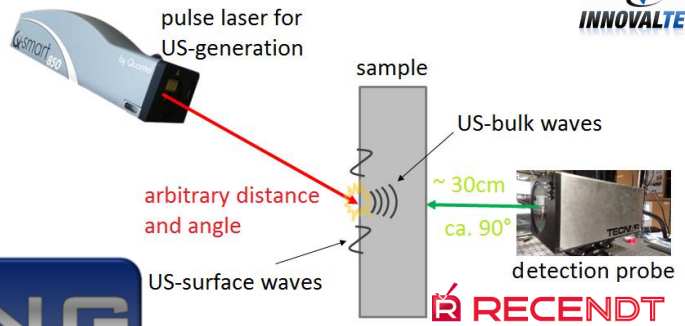
Visual examination



Leak test



Laser ultrasound test



JOINING

Analysis of the joining process

Influencing parameters

Capacitor charging energy

Several geometrical parameters

…

Quality parameters

Joint strength

Leak tightness

Electrical conductivity

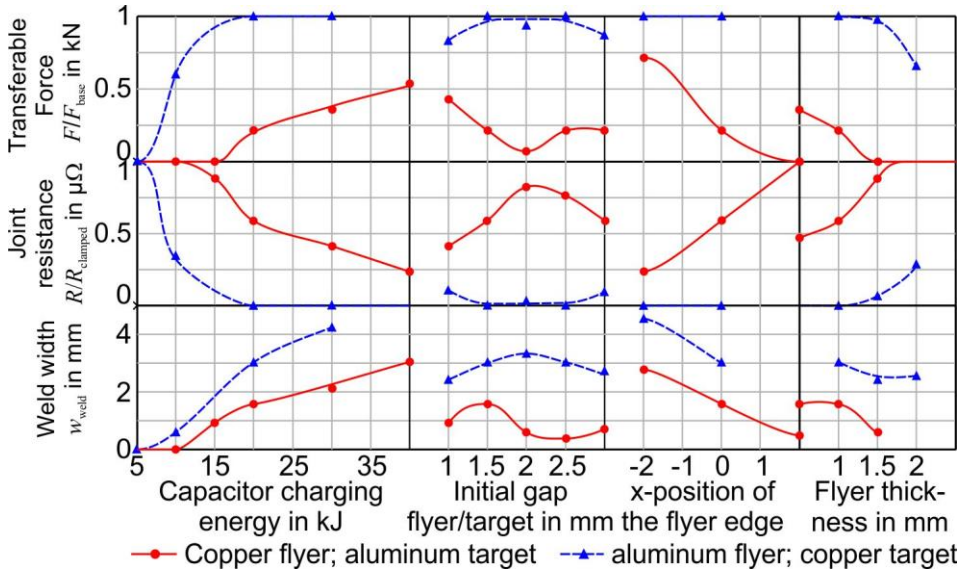
Micrographic investigation

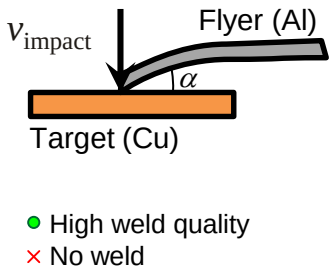
…

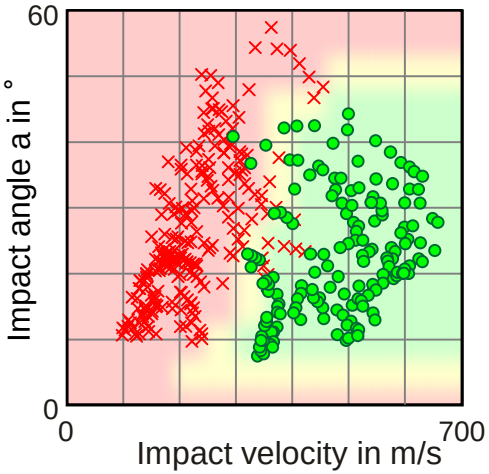
Collision parameters

Impact velocity

Impact angle







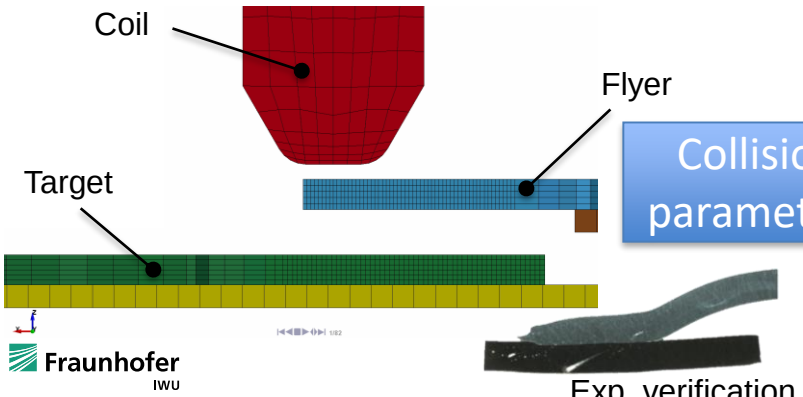
➔ **Identification of Process windows**

Development of multiscale simulation strategies

Macroscale

Coupled electromagnetic and structual mechanical simulation

Workpiece deformation

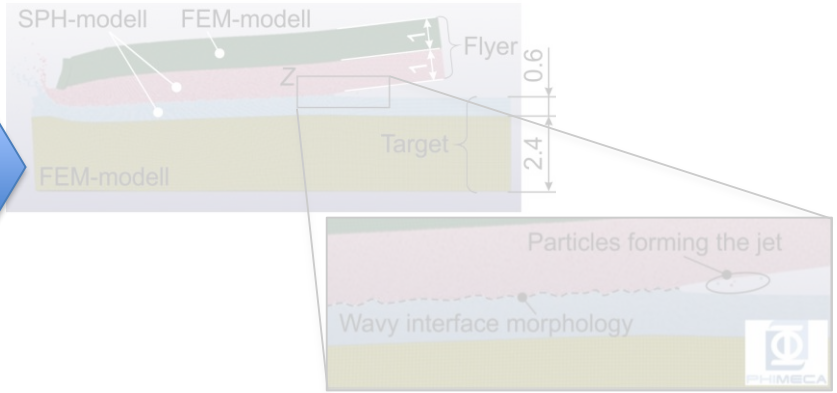


Exp. verification

Collision parameters

Microscale

Mixed smoothed particle hydrodynamics and Lagrange model



Material modelling glass fibre reinforced coil housing

3D stress distribution

Load Conditions

Fatigue analysis

Load Conditions

Tool durability

Interface pressure

Tool development

Investigation of tool materials

Conductor materials

Insulation / housing materials

Design and manufacturing and investigation of tool systems

Tube applications

Sheet metal applications

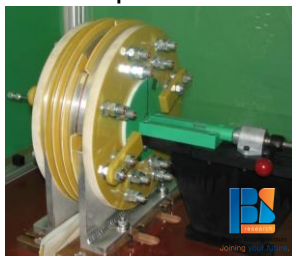
Durability testing of tool systems

Testing of materials and components

Testing of full tool systems

Tube welding coils

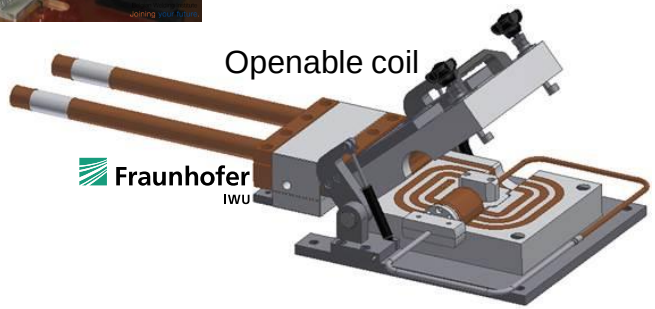
Multi-turn coil including fieldshaper



Single-turn coil



Openable coil

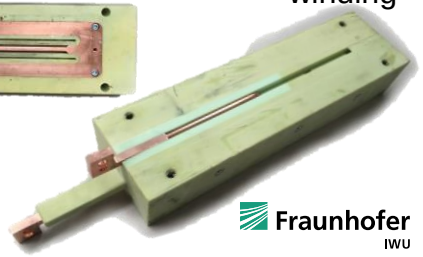


Sheet welding coils

Trident-shaped coil winding



U-shaped coil winding



JOINING

Development of industrial demonstrators and implementation issues

Three full industrial demonstrators

Tube connections for heating and cooling applications

Sheet metal connections for heating and cooling applications

Sheet metal connections for electrical applications

Three partial industrial demonstrators

Tube connections for heating and cooling applications

Sheet metal connections for heating and cooling applications

Sheet metal connections for electrical applications

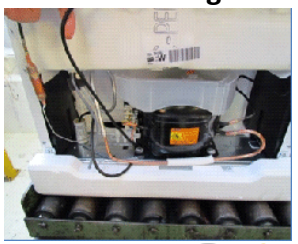
Full demonstrators also serve for studying industrial implementation issues

Concept development for automation and control

Economic efficiency calculation

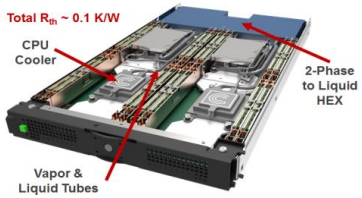
Life cycle analysis

White goods



Whirlpool
SENSING THE DIFFERENCE

High power electronics passive cooling



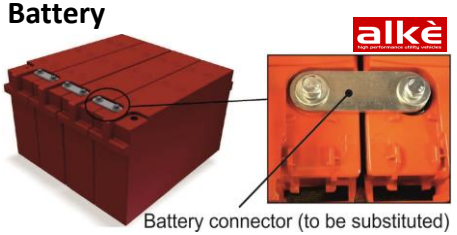
CAL YOS

Battery



CEGASA

Battery



HVAC



refco
THE COPPER REFERENCE

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Further information / Acknowledgement

- Visit our web-page http://www.join-em.eu/
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"JOIN'EM" is funded by the EC within the Horizon 2020 research and innovation program under grant agreement No. 677660.