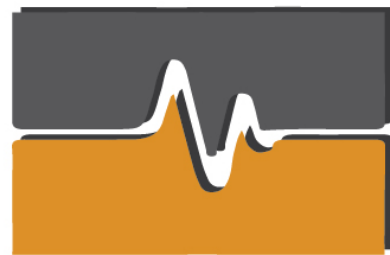


Joining Sub-Platform



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



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  **Fraunhofer**
IWU



*Word cloud designed using Tagxedo

Significance of copper

Copper

3rd most frequently
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

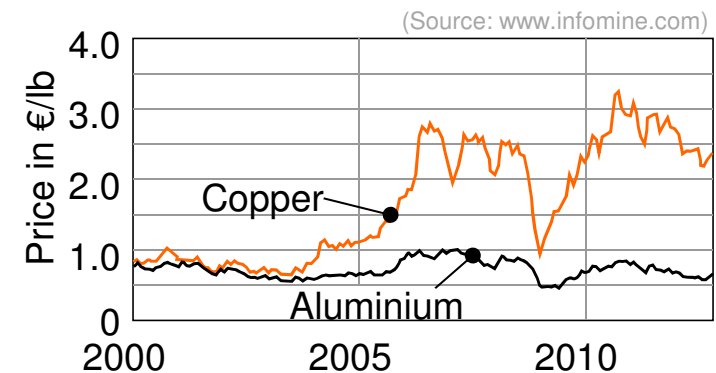
Substitution of copper-intensive components by hybrid aluminium-copper parts

- ➔ reduced material costs
- ➔ reduced product weight

Precondition

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

➔ **Magnetic pulse welding (MPW)**

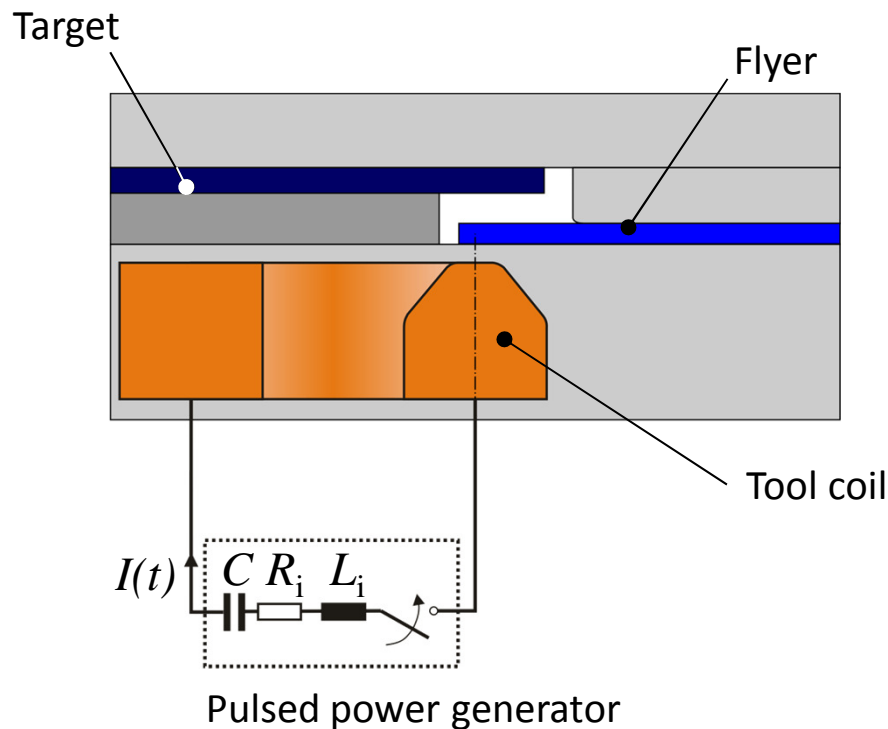


	Copper	Aluminium
Elektrical conductivity	58 MS/m	36 MS/m
Thermal concuctivity	401 W/mK	236 W/mK
Density	8.9 g/cm ³	2.7 g/cm ³
Price	4,478 €/ton*	1,550 €/ton*

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

Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

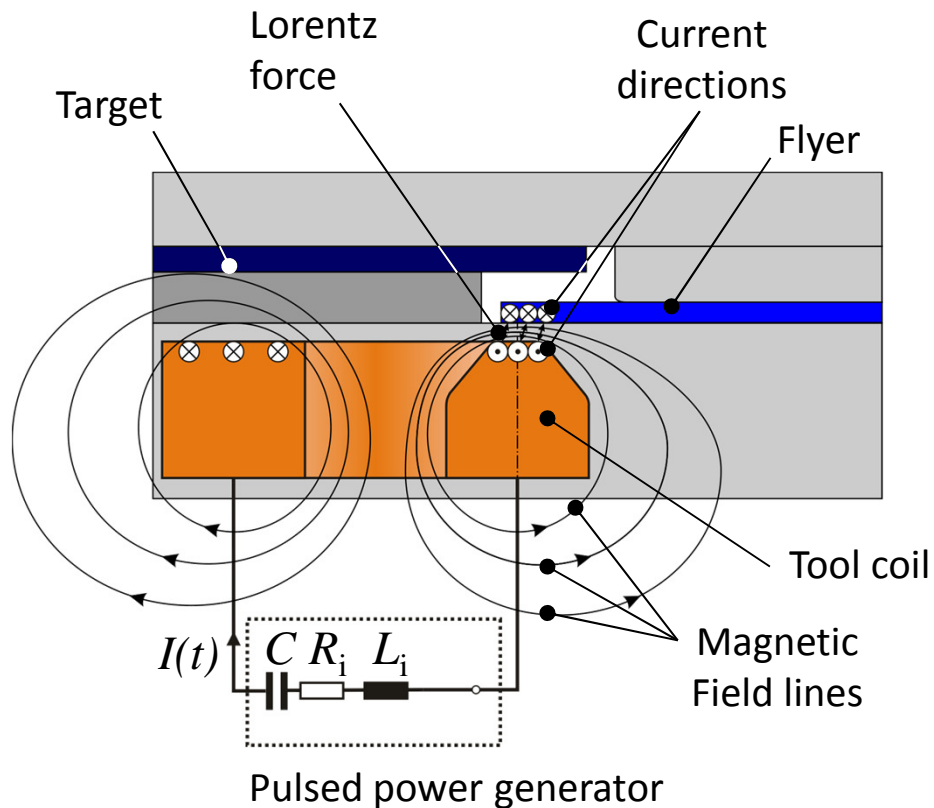


Characteristics of MPW

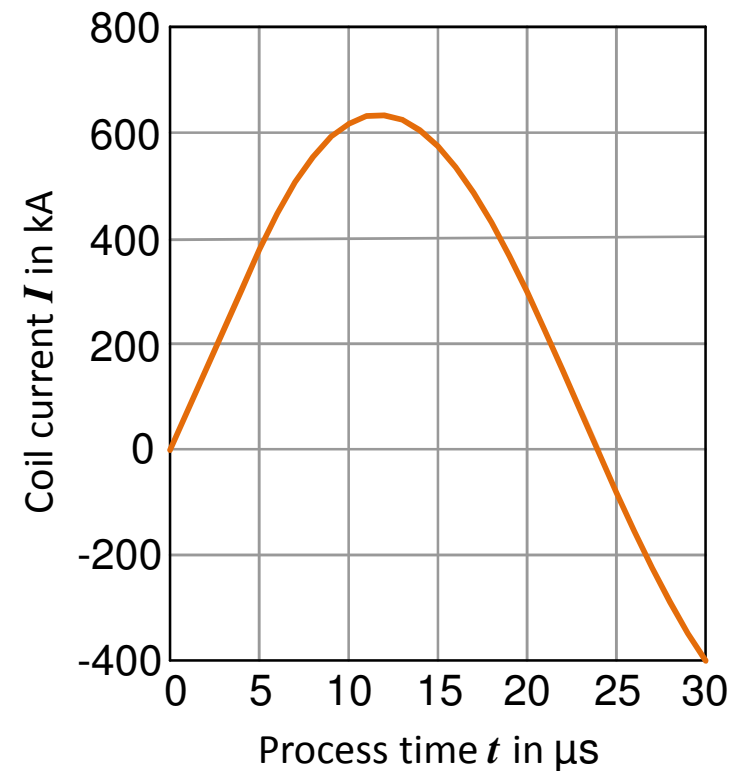
- Joint produced by high speed collision of flyer and target
- No significant heating of the parts
- No temperature induced problems (intermetallics, thermal softening, heat distortion etc.)
- Conventionally non-weldable material combinations possible (e.g. Cu - Al, (stainless) steel - Al)
- High quality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

Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

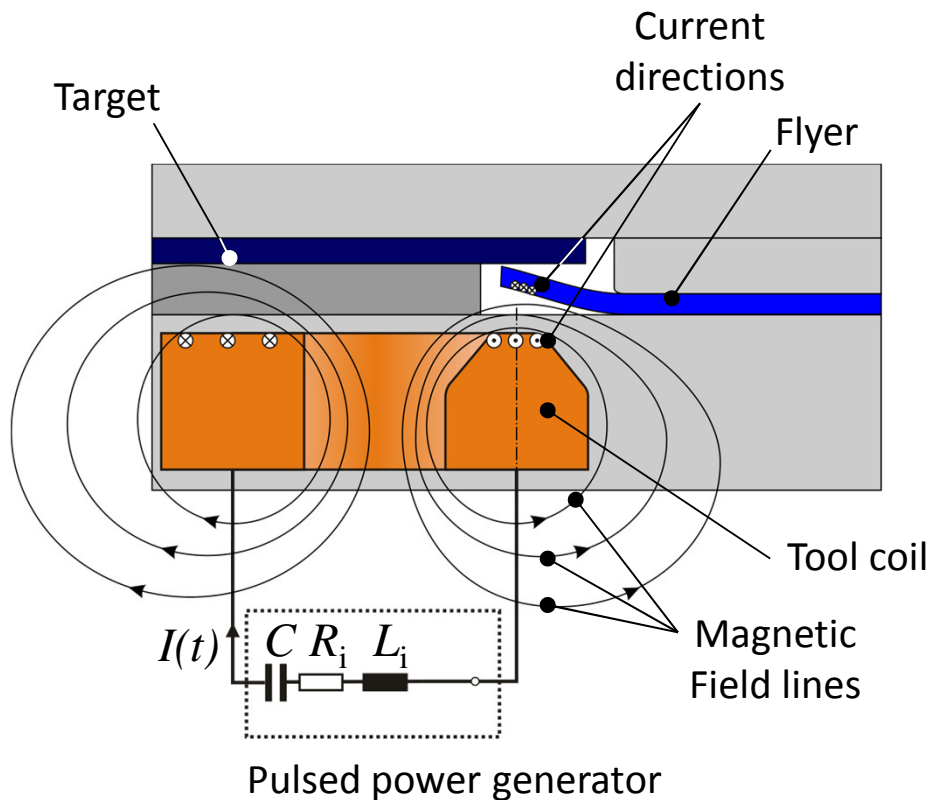


Course of the coil current

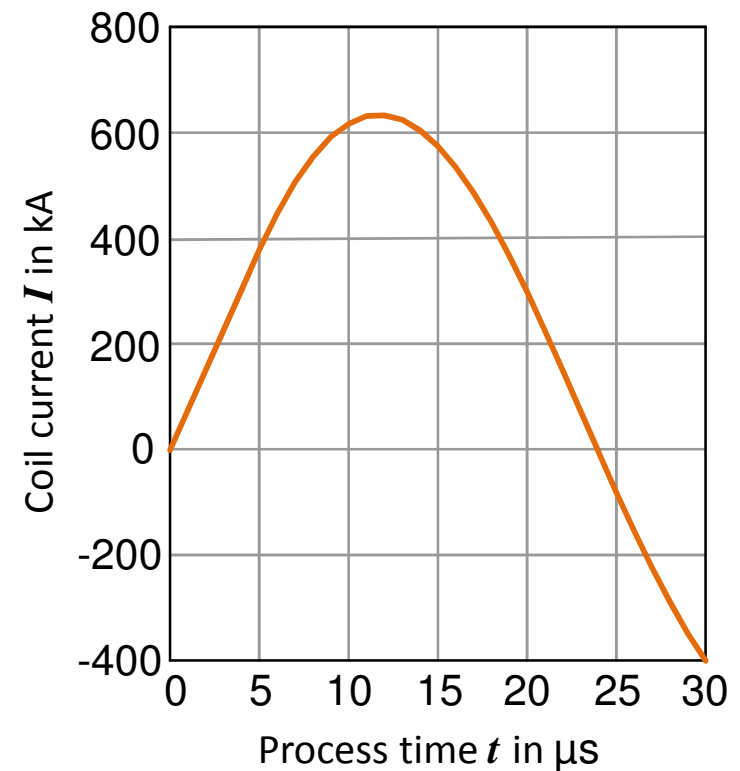


Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process

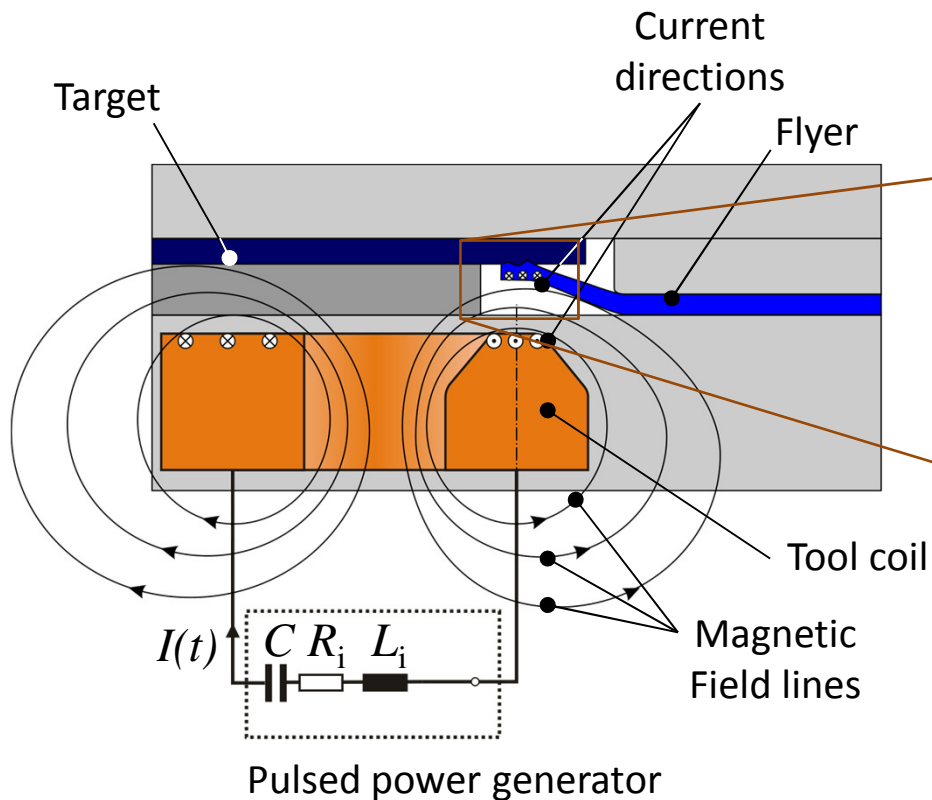


Course of the coil current

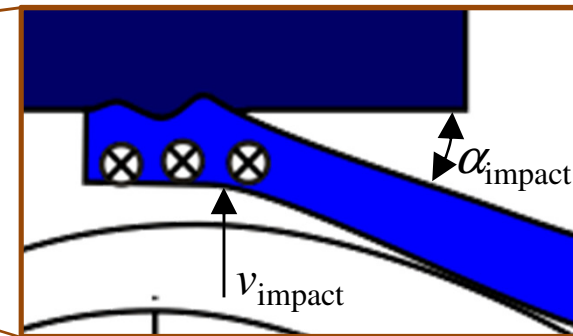


Magnetic pulse welding - process principle and characteristics

Exemplary setup of a sheet welding process



Collision parameters

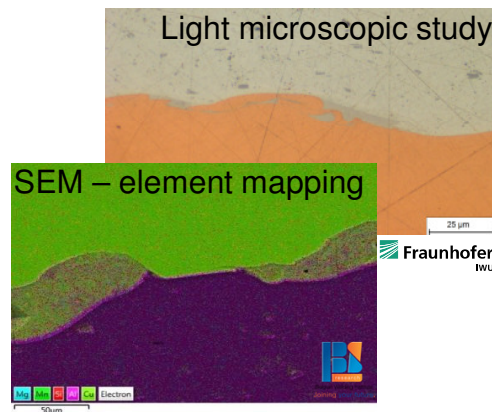


Impact angle α_{impact}
Impact velocity v_{impact}

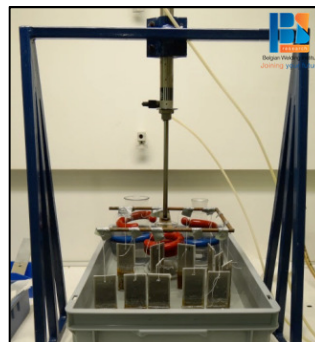
Development of joint characterisation methods

Destructive

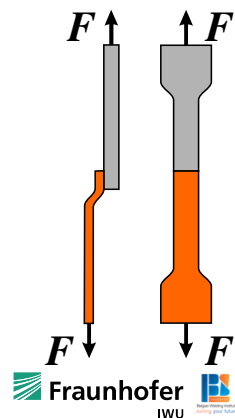
Micrographic investigation



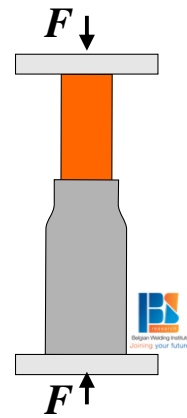
Corrosion test



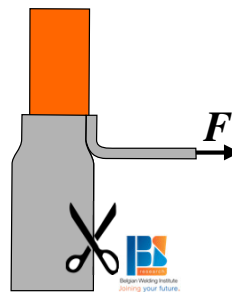
Lap shear test



Compression test

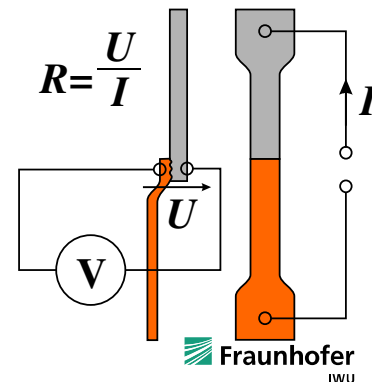


Peel test

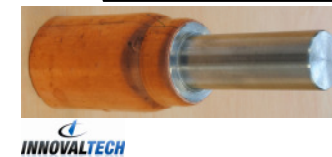
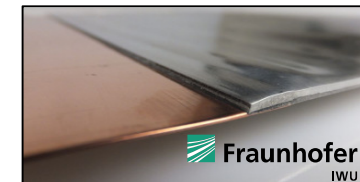


Non-destructive

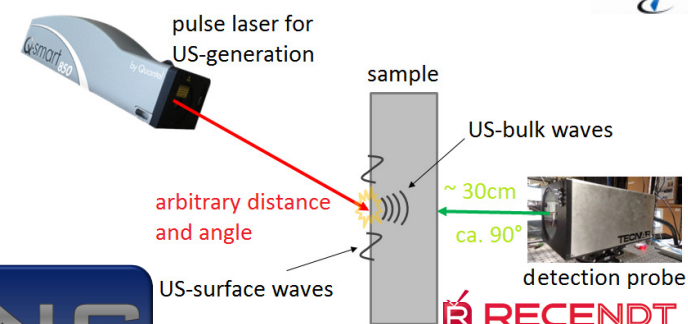
Electrical resistance measurement



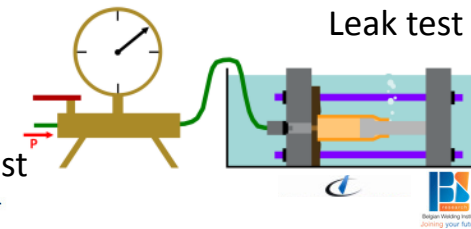
Visual examination



Laser ultrasound test



Leak test



Analysis of the joining process

Influencing parameters

Capacitor charging energy
Several geometrical parameters
...

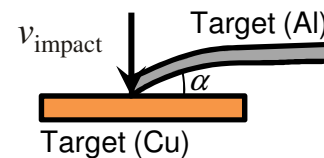
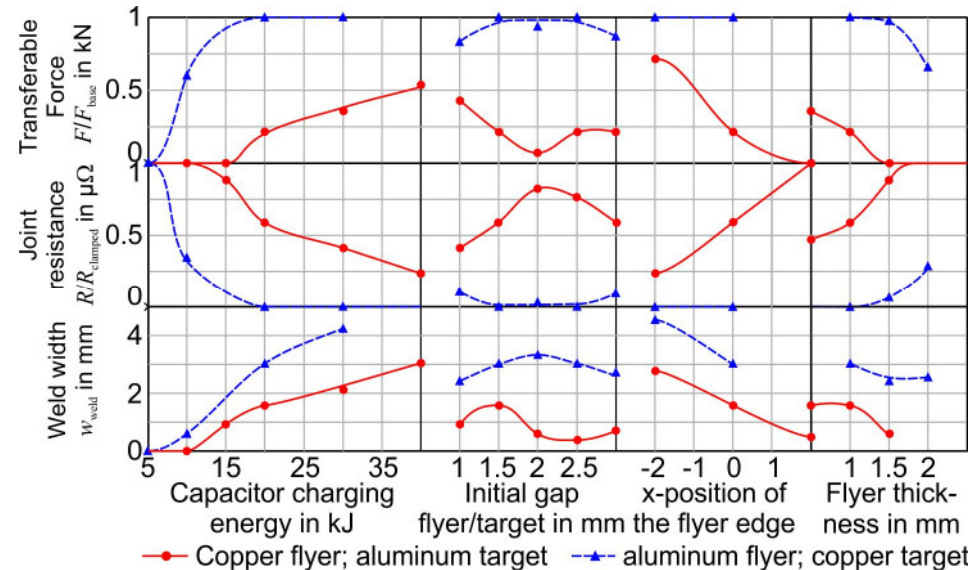
Quality parameters

Joint strength
Leak tightness
Electrical conductivity
Micrographic investigation
...

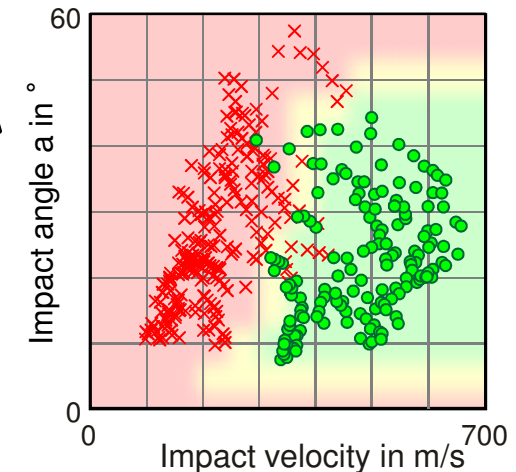
Collision parameters

Impact velocity
Impact angle

➔ Identification of Process windows



● High weld quality
✕ No weld

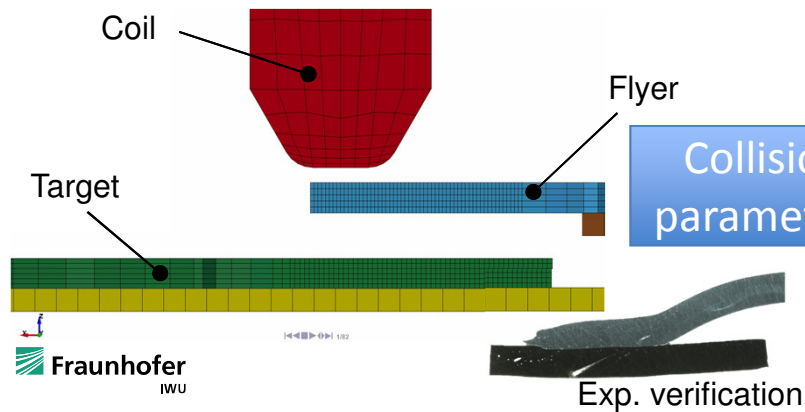


Development of multiscale simulation strategies

Workpiece deformation

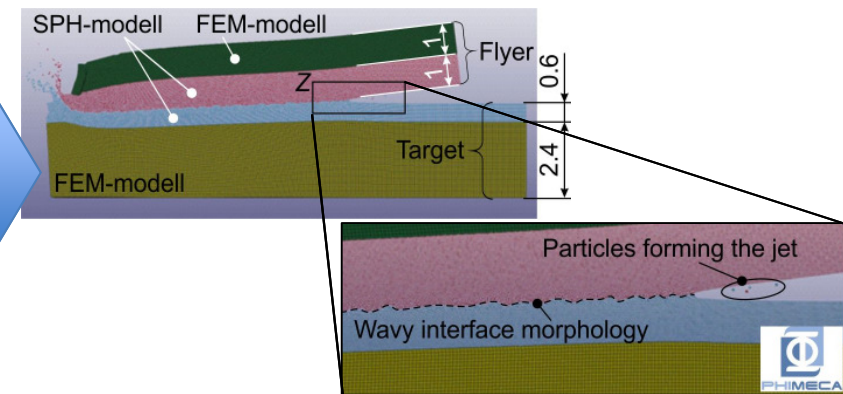
Macroscale

Coupled electromagnetic and structural mechanical simulation

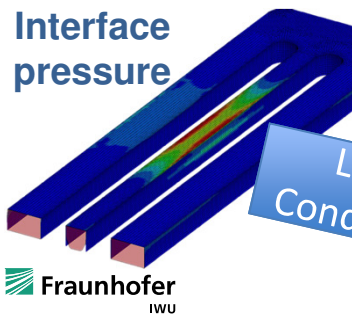


Microscale

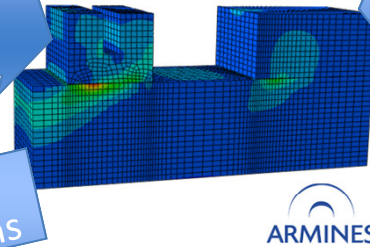
Mixed smoothed particle hydrodynamics and Lagrange model



Tool durability



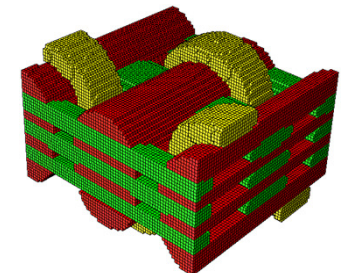
3D stress distribution



Fatigue analysis



Material modelling glass fibre reinforced coil housing



JOINING

Tool development

Investigation of tool materials

Conductor materials

Insulation / housing materials

Design and manufacturing and investigation of tool systems

Tube applications

Sheet metal applications

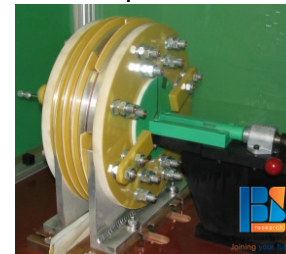
Durability testing of tool systems

Testing of materials and components

Testing of full tool systems

Tube welding coils

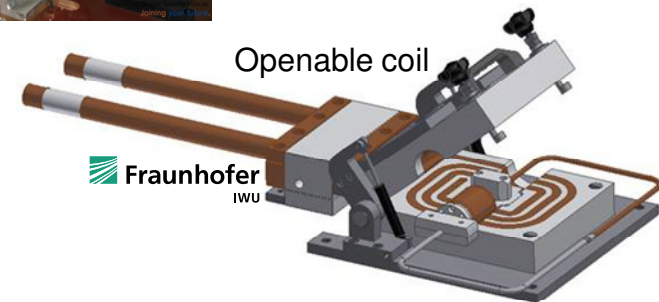
Multi-turn coil including fieldshaper



Single-turn coil



Openable coil

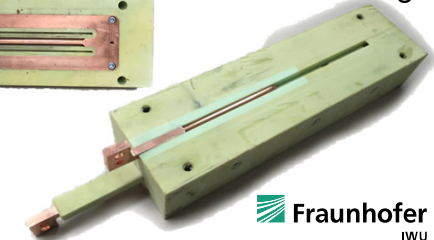


Sheet welding coils

Trident-shaped coil winding



U-shaped coil winding



Fraunhofer
IWW

Fraunhofer
IWW

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

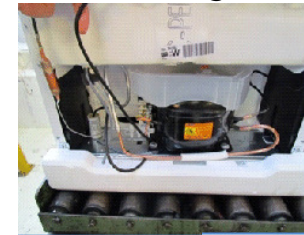
Full demonstrators also serve for studying industrial implementation issues

Concept development for automation and control

Economic efficiency calculation

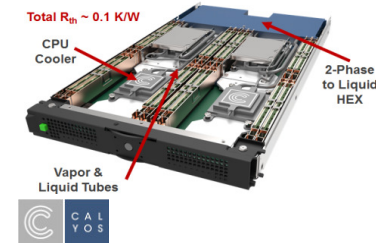
Life cycle analysis

White goods

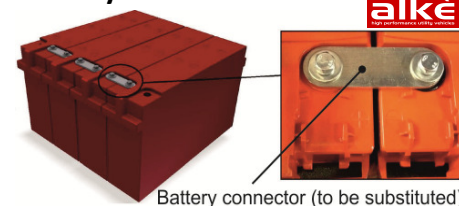


Whirlpool
SENSING THE DIFFERENCE

High power electronics passive cooling



Battery



Battery



ceGASA

HVAC



refco
THE COPPER REFERENCE



Further information / Acknowledgement

- Visit our web-page <http://www.join-em.eu/>
- Follow us on Twitter [#JOINEMproject](https://twitter.com/JOINEMproject)



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