# Modelling Pulse Magnetic Welding Processes– an Empirical Approach

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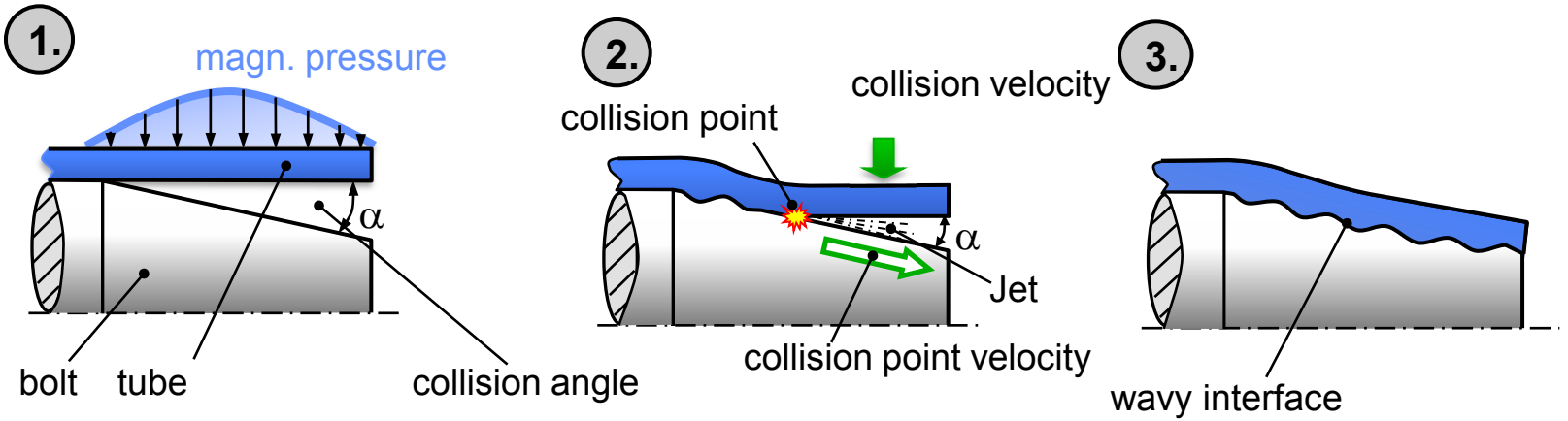
# The Process

1. • Due to magnetical pressure, the tube is accelerated to the center

2. • High pressures at the collision point are developing
   • A materialjet is created at the collision point.

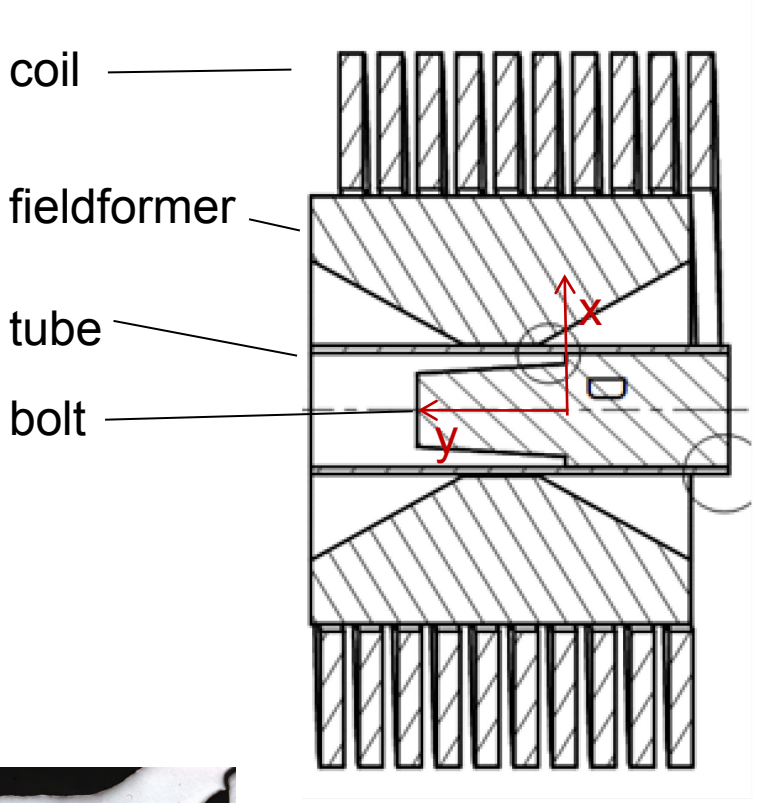
3. • Material within the contact zone changes to a highly viscous state
   • Formation of a wavy interface



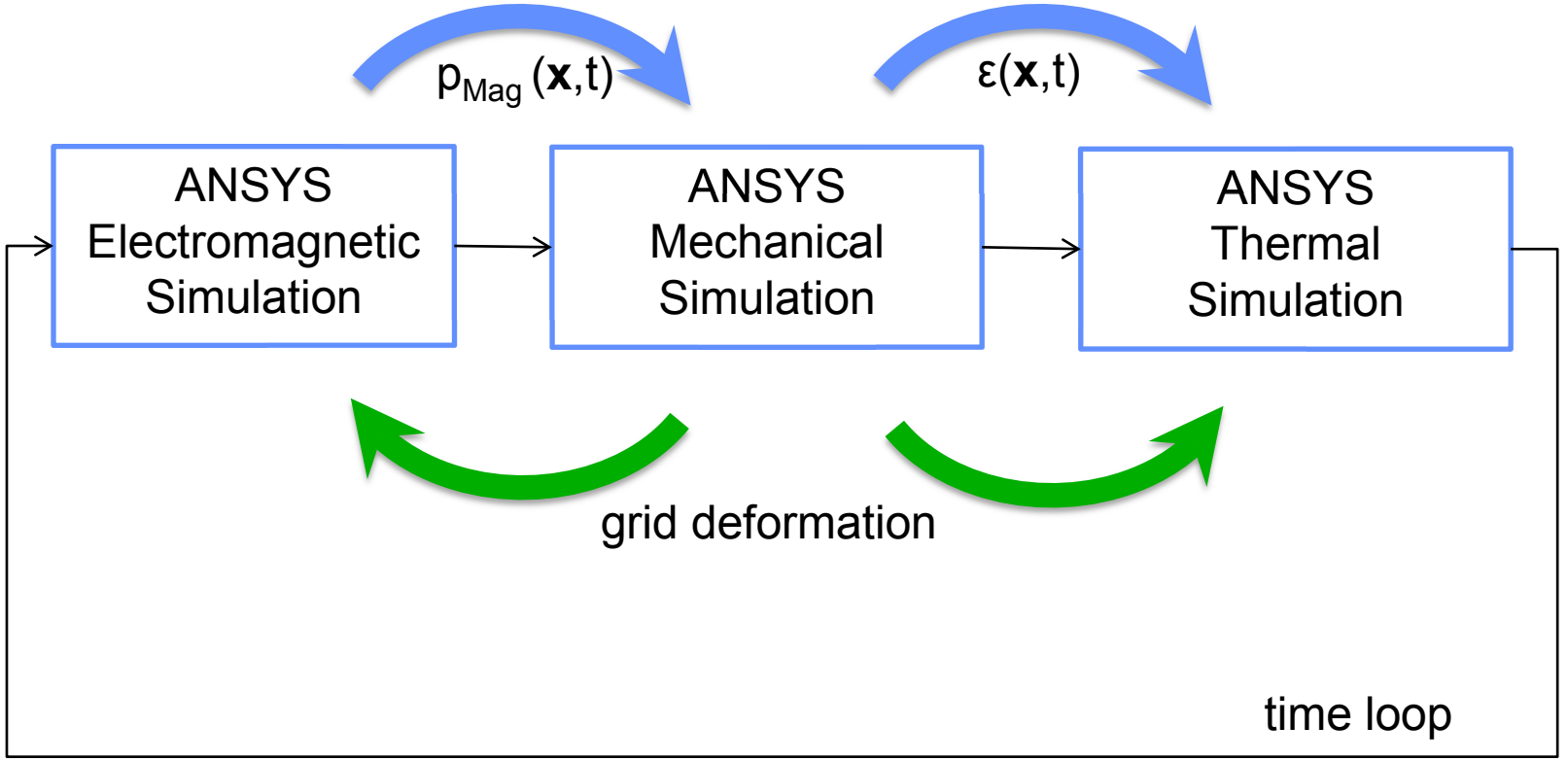
# Experiments

| Properties EN AL6063 | Value |
|---|---|
| Specific Resistance | 3,3 $10^{-8}$ Ω m |
| thermal conductivity | 201 W $m^{-1}K^{-1}$ |
| specific heat capacity | 898 J $kg^{-1}$ $K^{-1}$ |
| thermal expansion coefficient | 23,5 $10^{-6}$ $K^{-1}$ |
| permeability μ | 1 $\mu_0$ = 1,2566 $10^{-6}$ H $m^{-1}$ |

| Parameter | Value |
|---|---|
| Capacity | 240 μF |
| Inductivity | 1,966 μH |
| Charging Energy | 7, 8 and 9kJ |
| Frequency | 7,3 kHz |
| skindepth | 1,07 mm |




# Simulations – Sequential Coupling of Electrodynamic and Mechanical FEA



# Simulations – Empirical Model

Possible influences to weldability:

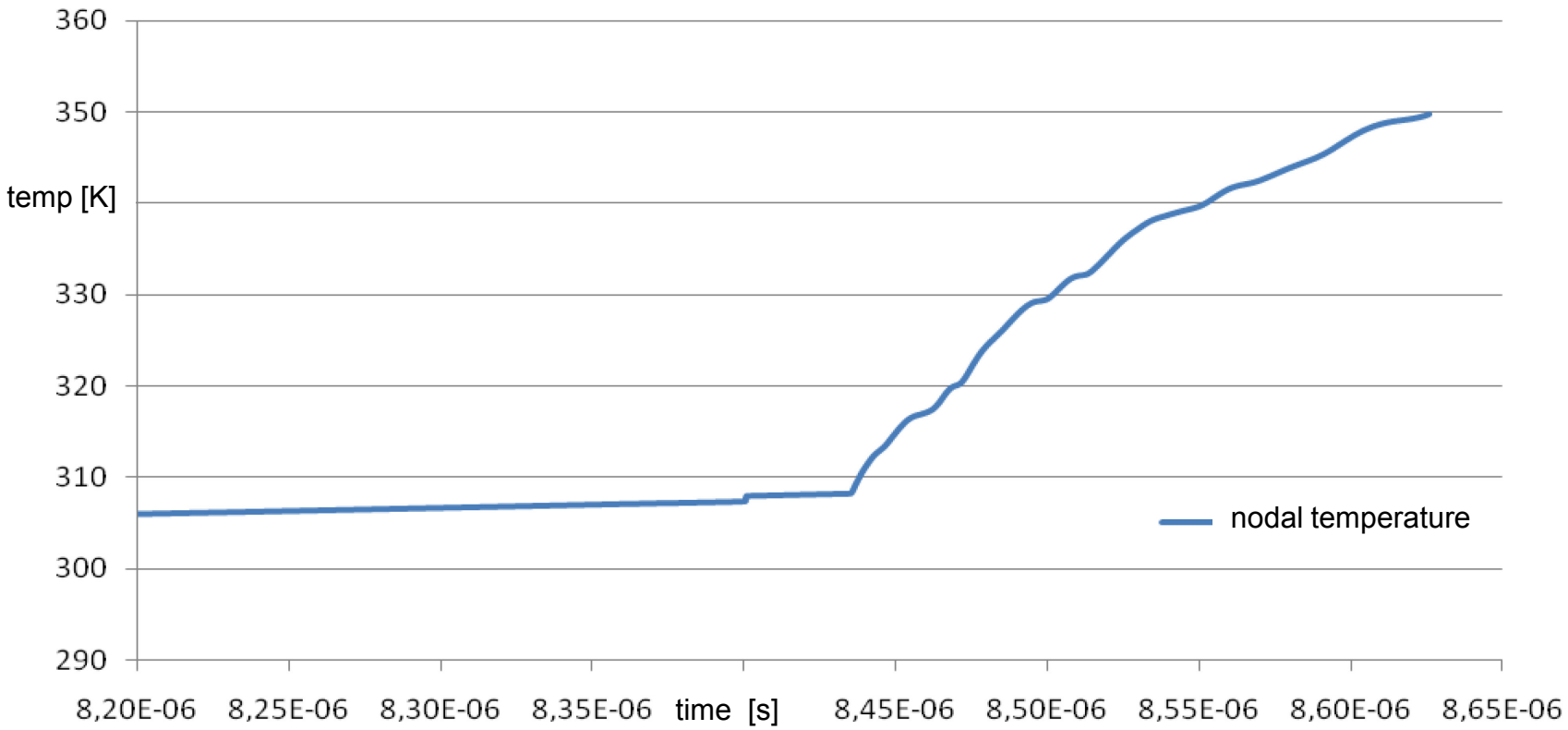
- $\alpha$ inclination-angle,
- $v_{\perp}$ collision point velocity,
- $V_{cp}$ collision point velocity,
- $P_{PL}$ plastic work,
- $\varepsilon$ deformation.

$$B = f(\alpha, v_{\perp}, v_{cp}, P_{PL}, \varepsilon)$$

bondage

no bondage

# Simulations – Influence of the Temperature



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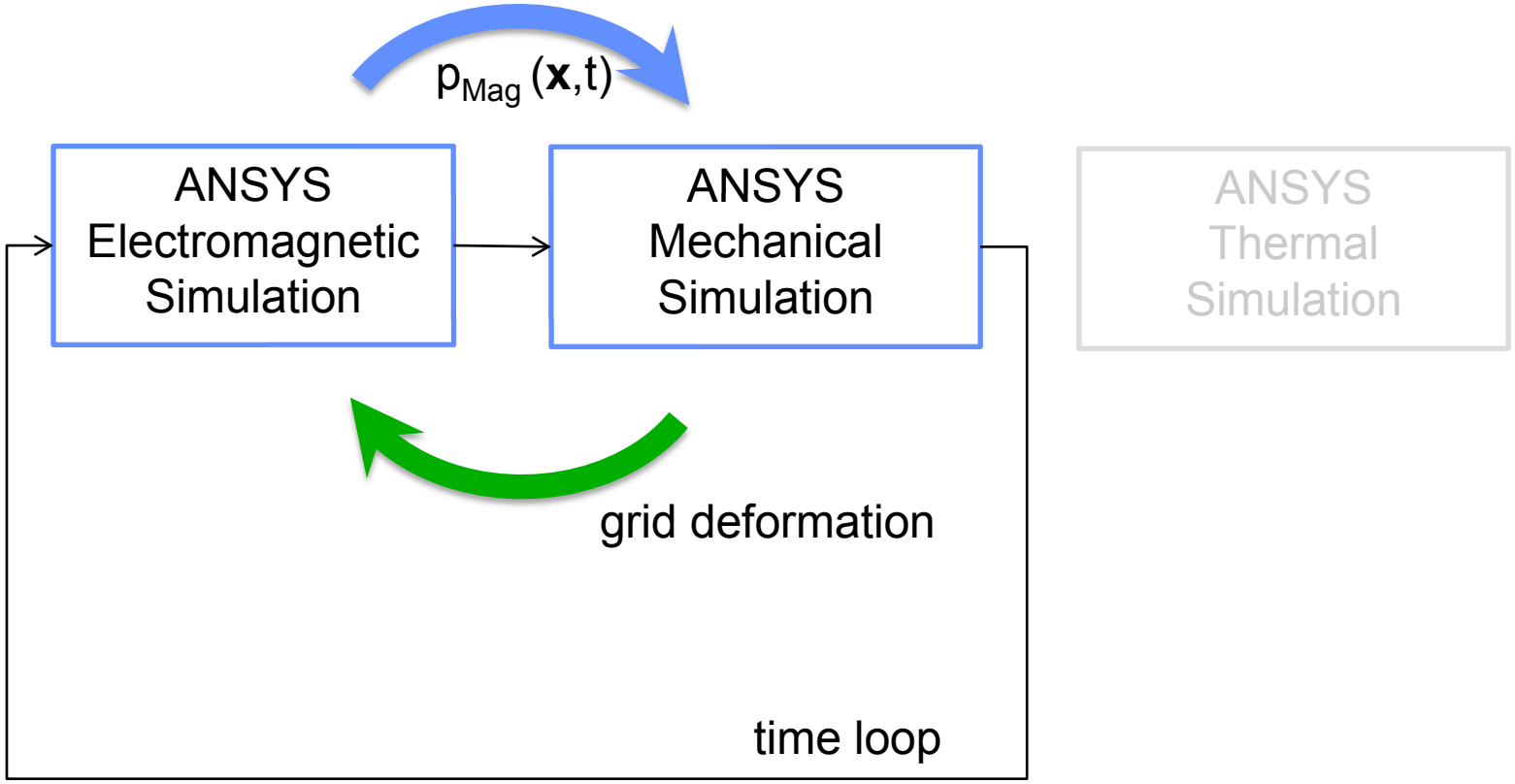
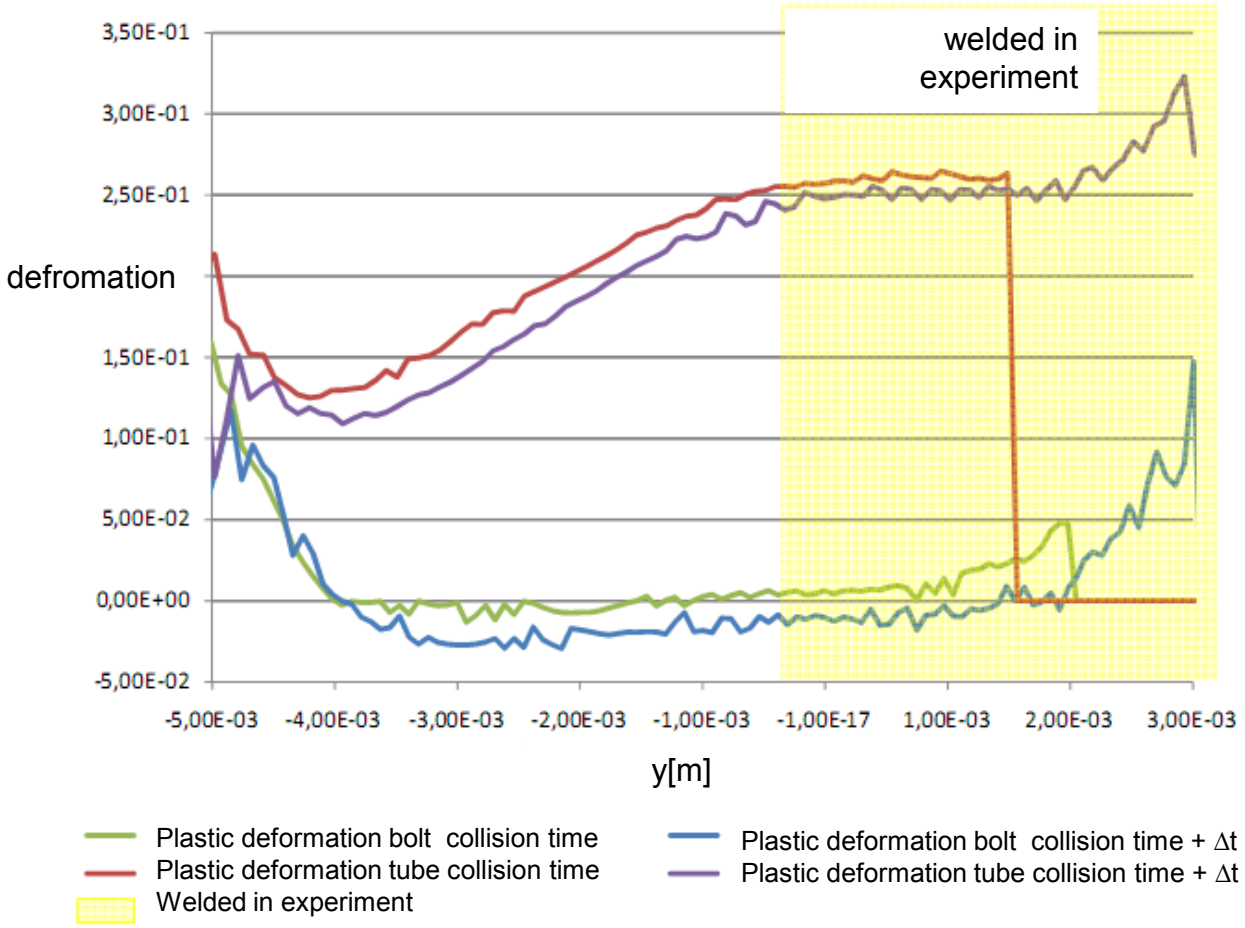
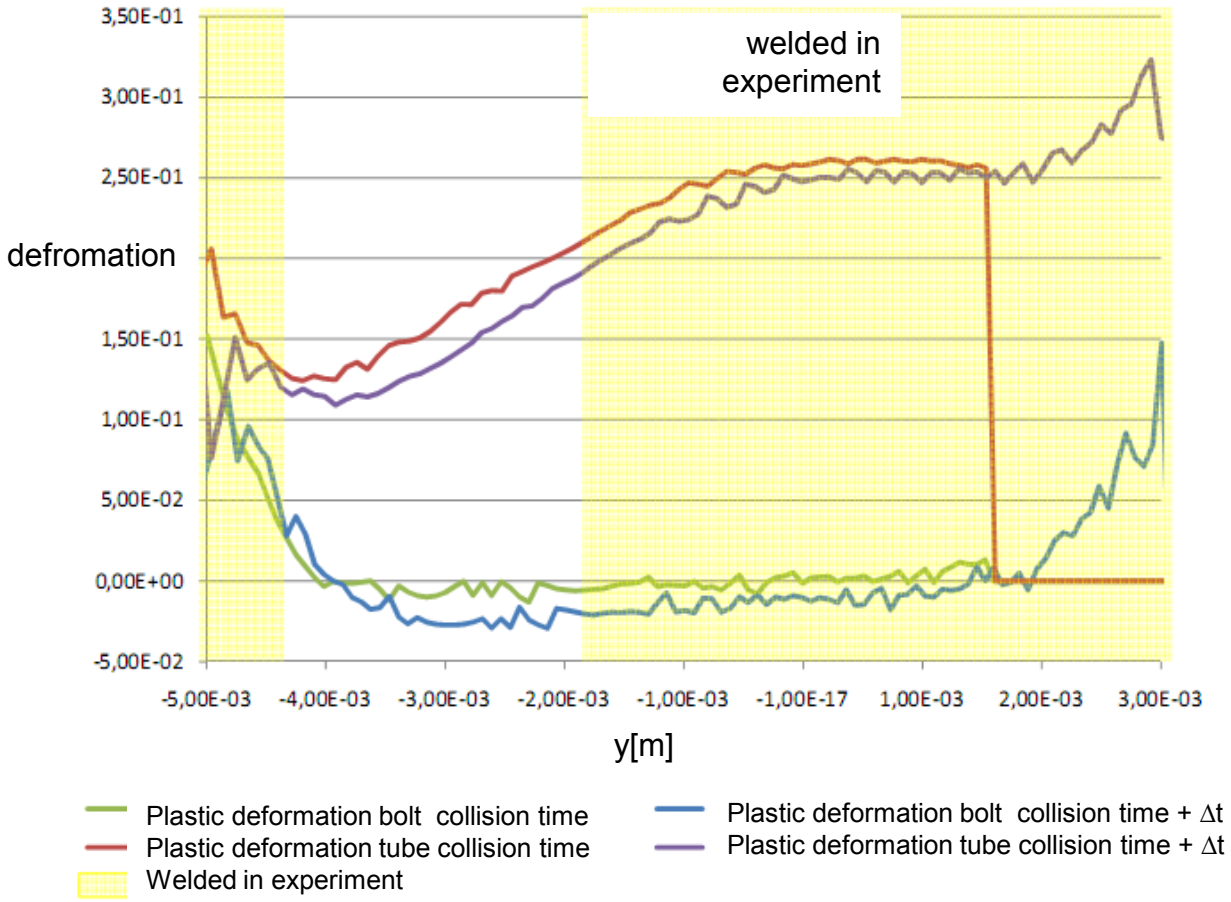


# Model Setup




Energy: 7kJ

# Model Setup



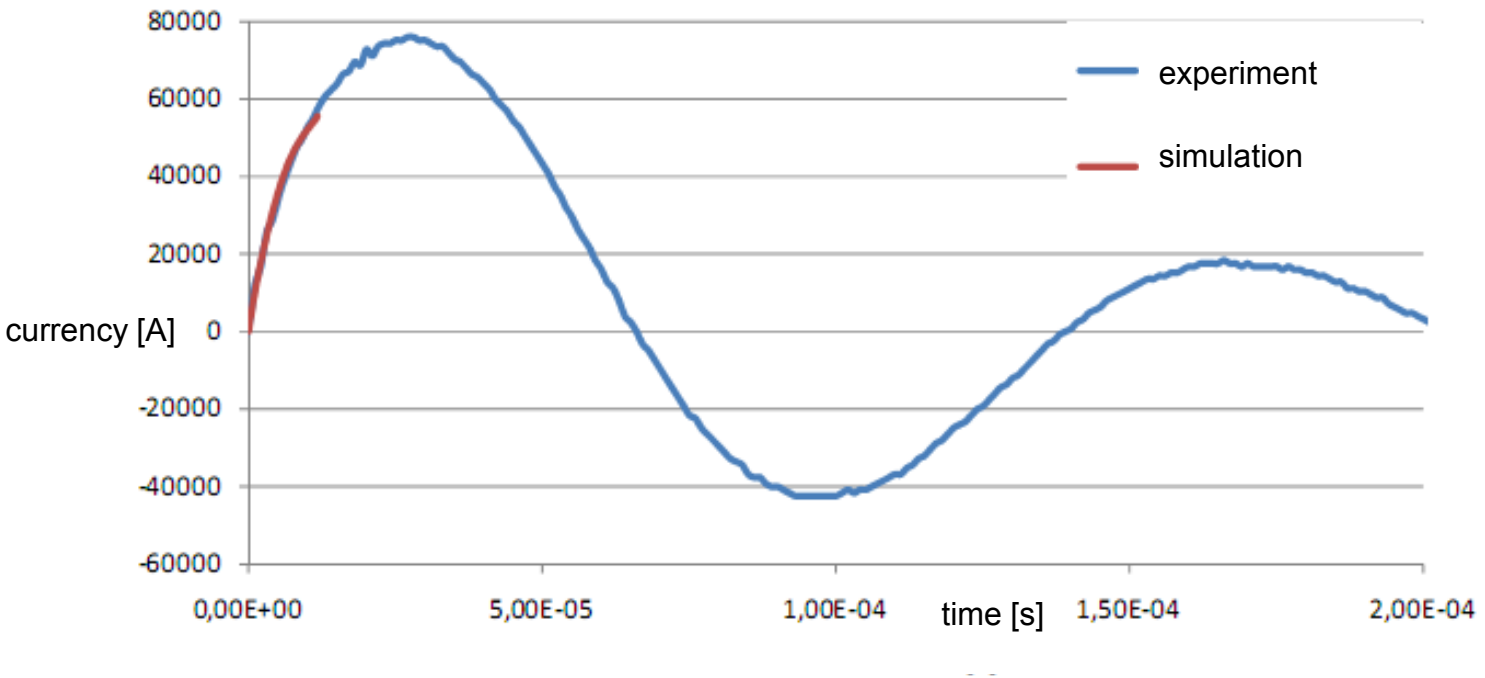

Energy: 9kJ

# Model Setup


Energy: 9kJ

# Results

## Currency distribution of the electromagnetical simulation and measurement



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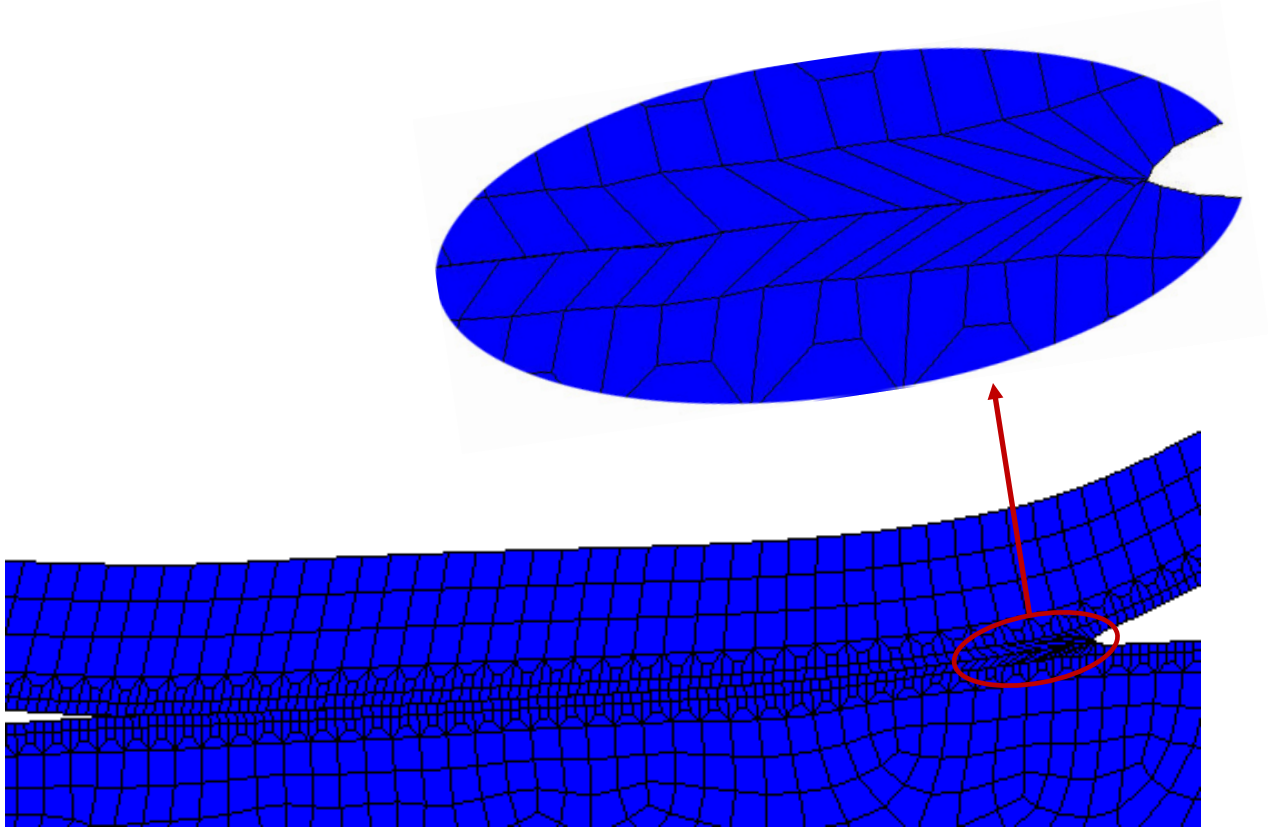
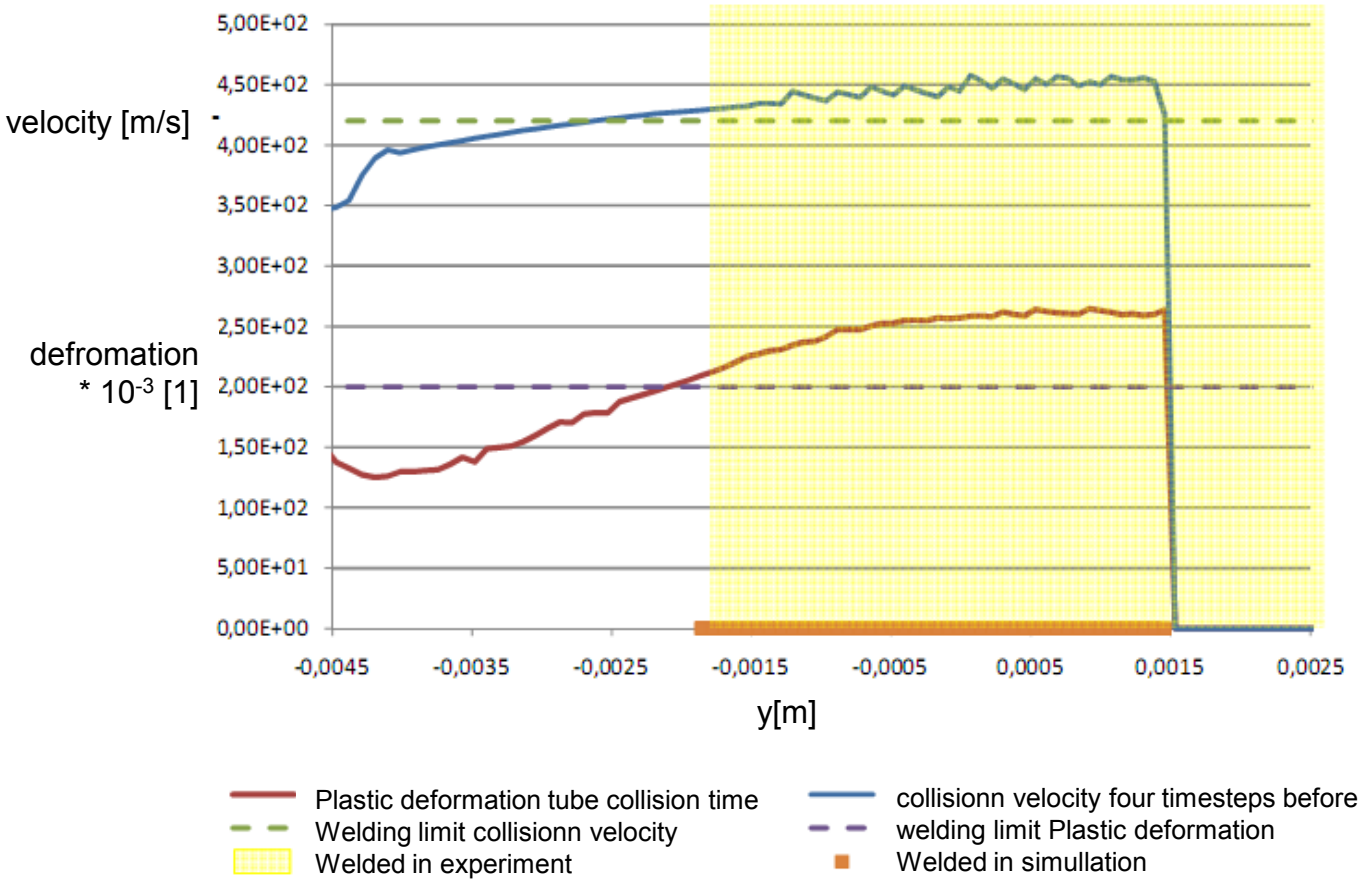


# Results




Energy: 8kJ

## Conclusions

- The used FEA – Model was a complete sequential-coupled thermal-electromagnetical-mechanical Simulation.
- Simulations show, that the heat generation due to plastic deformation does not account for the welding process.
- Set up and calibration of a bonding-model for accurate material bonding at the welding-interface
- Reduction of the set of necessary parameters, leaving the normal collision velocity and plastic deformation.

## Outlook

- Further validation is necessary in order to expand the extent of validity as well as the use for additional Materials.
- An open question is the welding behaviour with mixed materials.
- The implicit FEA - software was not designed to calculate big deformations
  → Making use of explicit FEA – software such as AUTODYN
- Loosening and cracking were not part of the model as well.

# Thank you!

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