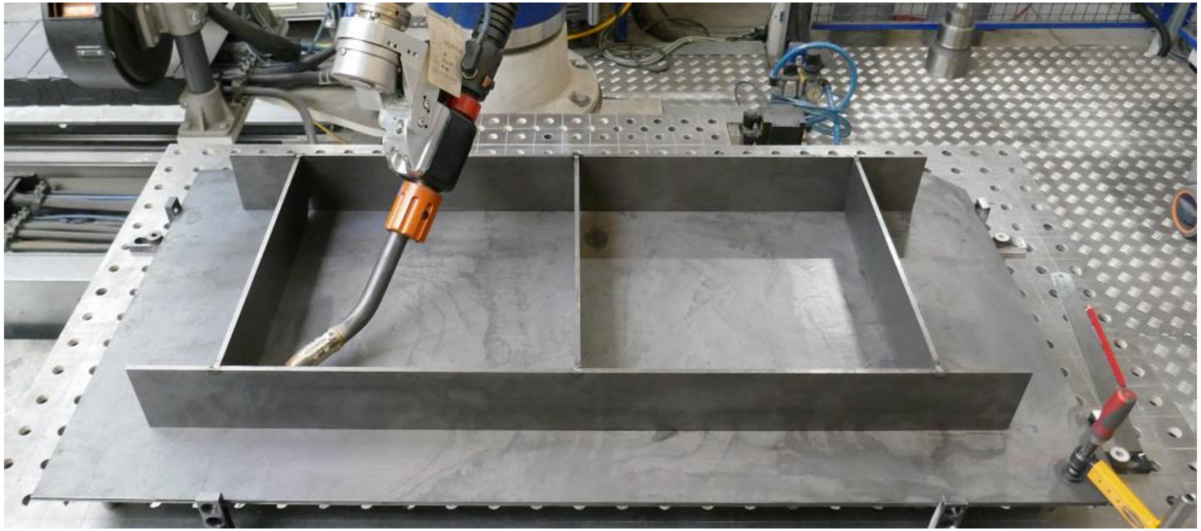
Validation of Welding Structure Simulations

IMAT TU-Graz
The 13th International Seminar "Numerical Analysis of Weldability"
04.09.-07.09.2022 Seggau
Austrira



Tobias Loose, Dr. Loose GmbH, Walzbachtal, Germany
Tobias Girresser, Technologie-Institut für Metall & Engineering GmbH (TIME), Wissen / Sieg, Germany
John Goldak, Goldak Technologies Inc., Ottawa, Kanada

Dr.-Ing. Tobias Loose

Dr.-Ing. Tobias Loose IWE
President and Shareholder
Dr. Loose GmbH

Numerical Analysis for:

Welding

Heat treatment

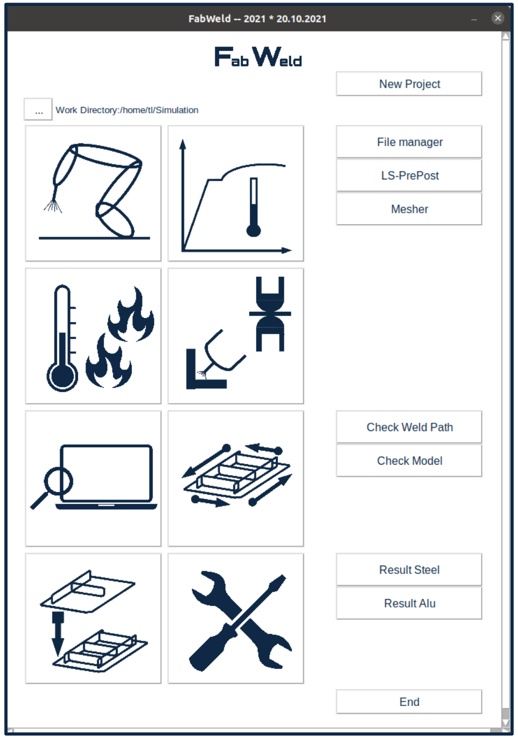
Assembly

Service and Consulting

Software FabWeld

Research

Expert for welding simulation since 2004



Advanced **Fab**rication Engineering for **Weld**ed Structures

- designed for advanced simulation models
- supports all fusion welding processes, brazing and heat treatment.
- assembly, clamping, unclamping and mechanical loading.

Your benefits from FabWeld:

- high precision simulation and result quality
- ensure and optimize your welding and fabrication design in advance
- get the first time right
- save costs and recources and try out loops before fabrication start

Team of Authors

Team of Goldak Technologies,
Ottawa, ON, Canada

Team of Technologie-Institut
für Metall & Engineering GmbH (TIME),
Wissen 7 Sieg Germany

Motivation

Motivation

We want to prove, that our numerical model of simulation matches the physical behavior of the reality.

We have to ensure that the virtual experiment matches the physical experiment and that we compare the same sensor and virtual data:

- Same time
- Same location
- Same state

Previously, the comparison between the virtual and physical experiment was limited to the final result: final distortion, final residual stress and final residual strain.

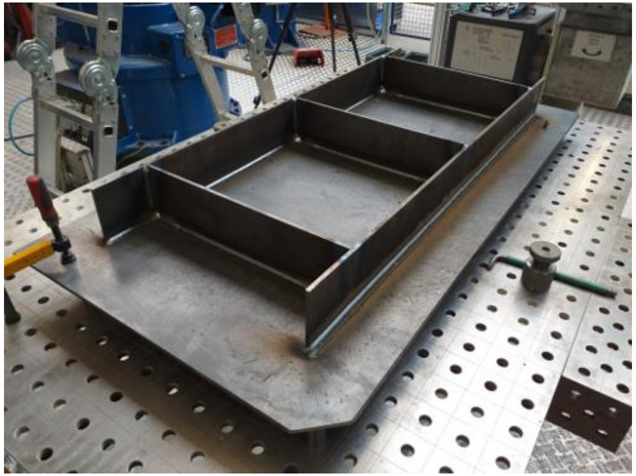
Now also the transient state during the process shall be taken into account: transient measurement of temperature field, strain field or deformation.

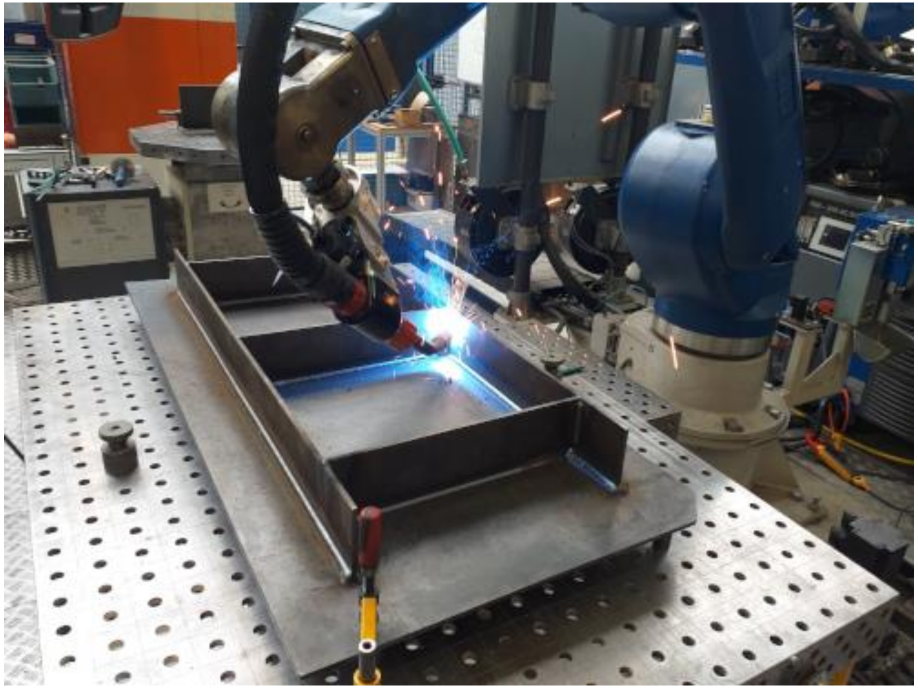
This validates not only the final results but also the computational algorithm that leads to these results

Experiment
real and virtuell

Experiment

Consider all relevant physical effects
Keep close to reality
Get right results



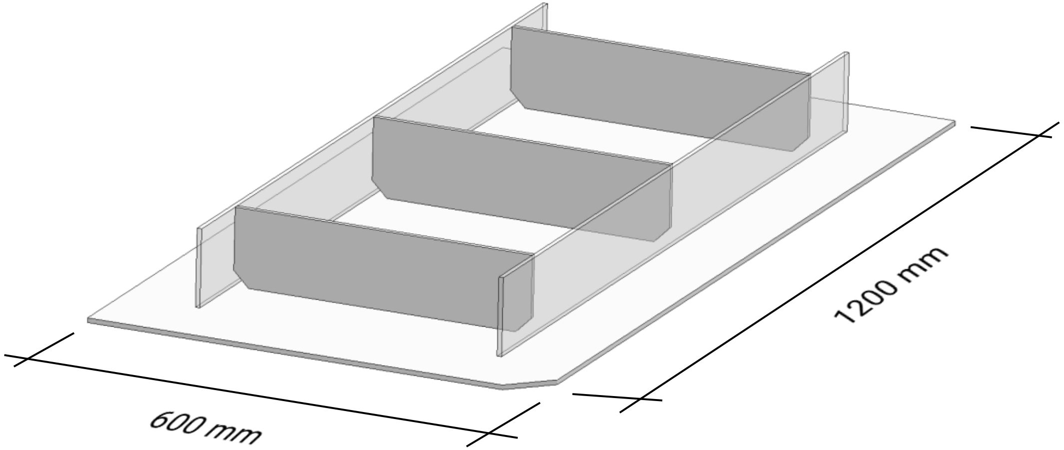


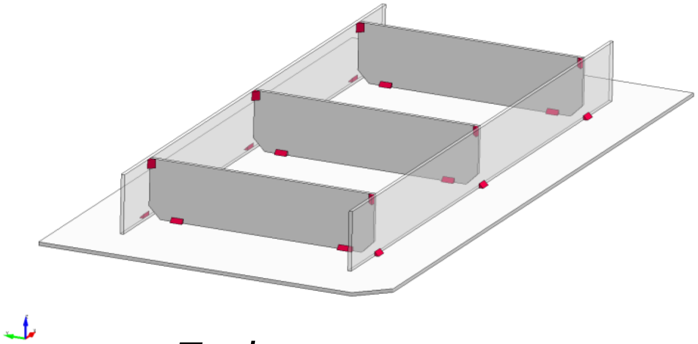
At each state of the welding process

Experiment Details and Simulation Model

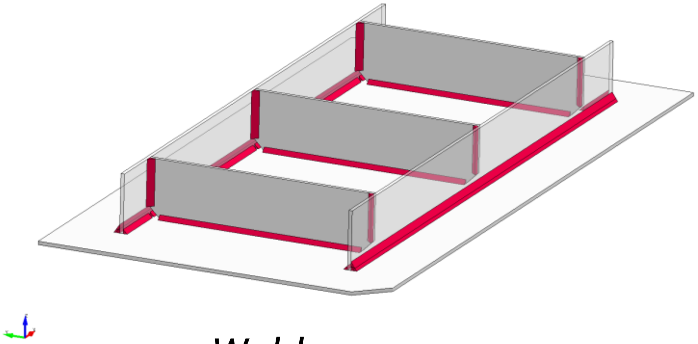
Overview

- 18 tack welds
- 2 supports, removed after tack-welding
- 2 multi pass welds (three-layered)
- 17 single pass welds (fillet weld)





Tacks



Welds

GOLDAK TECHNOLOGIES

Dr. Loose GmbH

TIME TECHNOLOGIE-INSTITUT FÜR METALL & ENGINEERING

The Experimental Setup consisted of

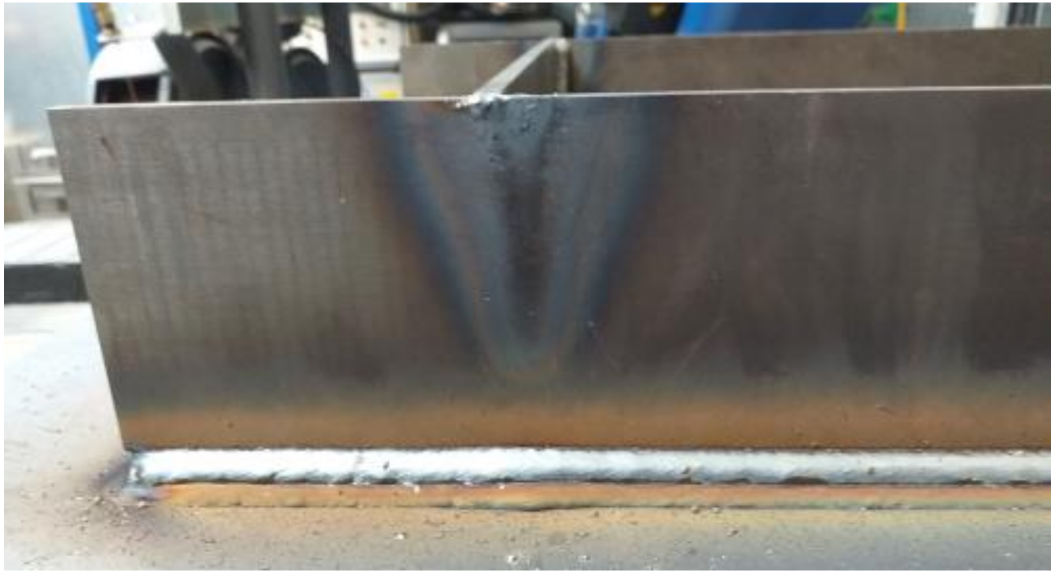
- 1 plate (1200 by 600 by 6 mm),
- 2 plates (1000 by 100 by 6 mm),
- 3 plates (394 by 100 by 6 mm) made of S235 steel
- 1 CAT S60 cell phone with built-in FLIR One Camera
- 5 ASM posiwire Cable extension Sensors
- 1 Cloos Qirox QRC 350 welding robot
- 1 Cloos Qineo Champ 450 welding power source
- 1 Fluke 376 FC True-RMS AC/DC Clamp meter
- MAG welding process
- **12 tack welds**
- **2 three-layered welds**
- **17 single-pass welds**
- All welds are fillet welds

Video on Welding Process
First Longitudinal Pass

Welding Procedure Specification (WPS)

Horizontal welds, tack welds:

- Position PB
- Wire Diameter: 1,2 mm
- Wire feed speed: 8 m/min
- Travel speed: 45 cm/min
- U: 23.5 ± 2 V, I: 258 ± 10 A
- Weave bead
- Weave amplitude: 1 mm
- Weave frequency: 2.78 Hz

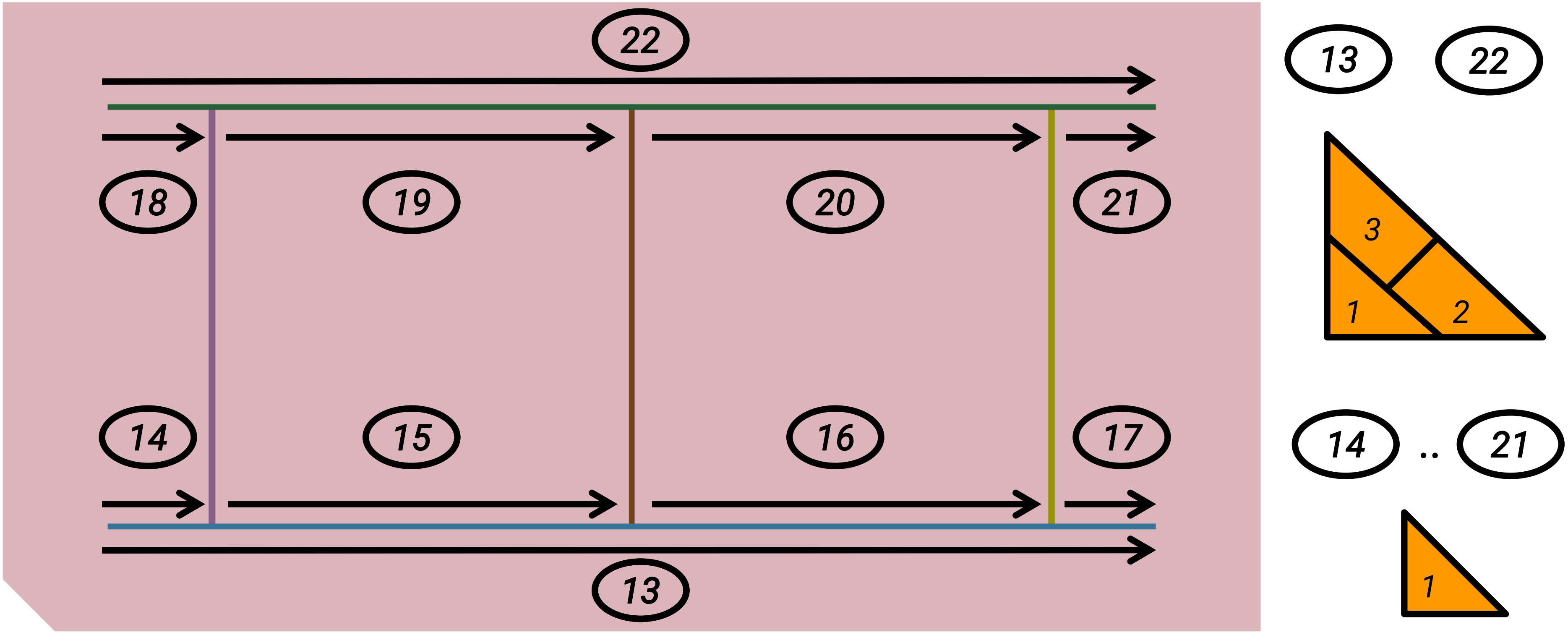


Welding Procedure Specification (WPS)

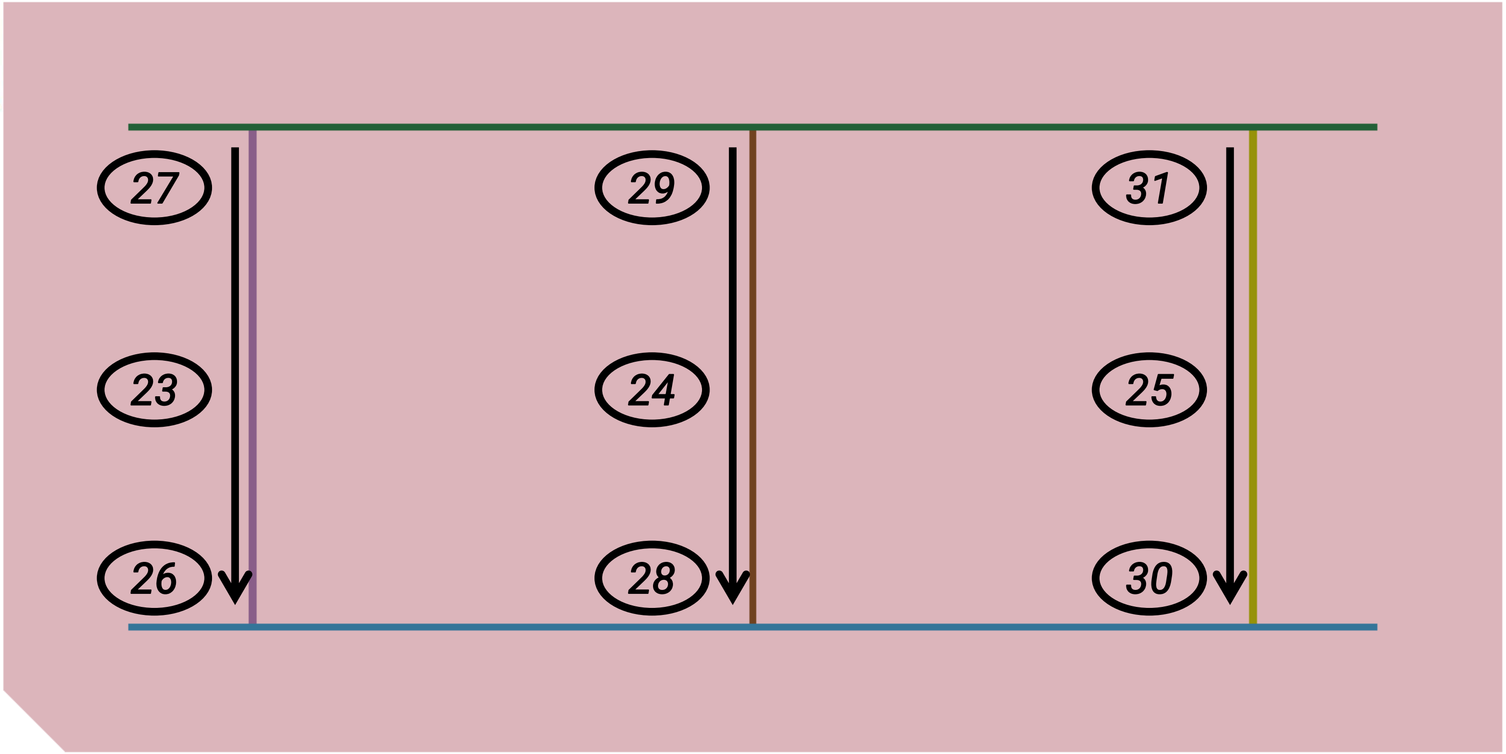
Vertical up-welds:

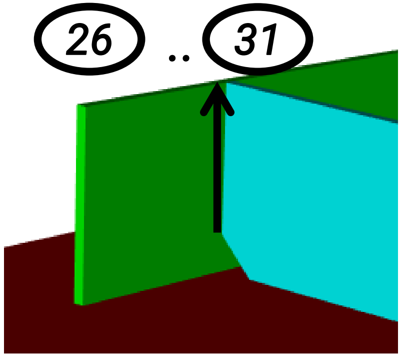
- Position PF
- Wire Diameter: 1,2 mm
- Wire feed speed: 2 m/min
- Vertical travel speed: 4.9 cm/min
- U: 14.9 V, I: 96 A
- Triangle weave bead
- Weave speed: 50 cm/min
- Weave amplitude: 5.5 mm
- Weave frequency: 2 Hz

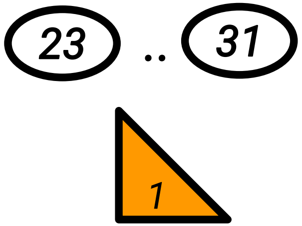
Weld Sequence



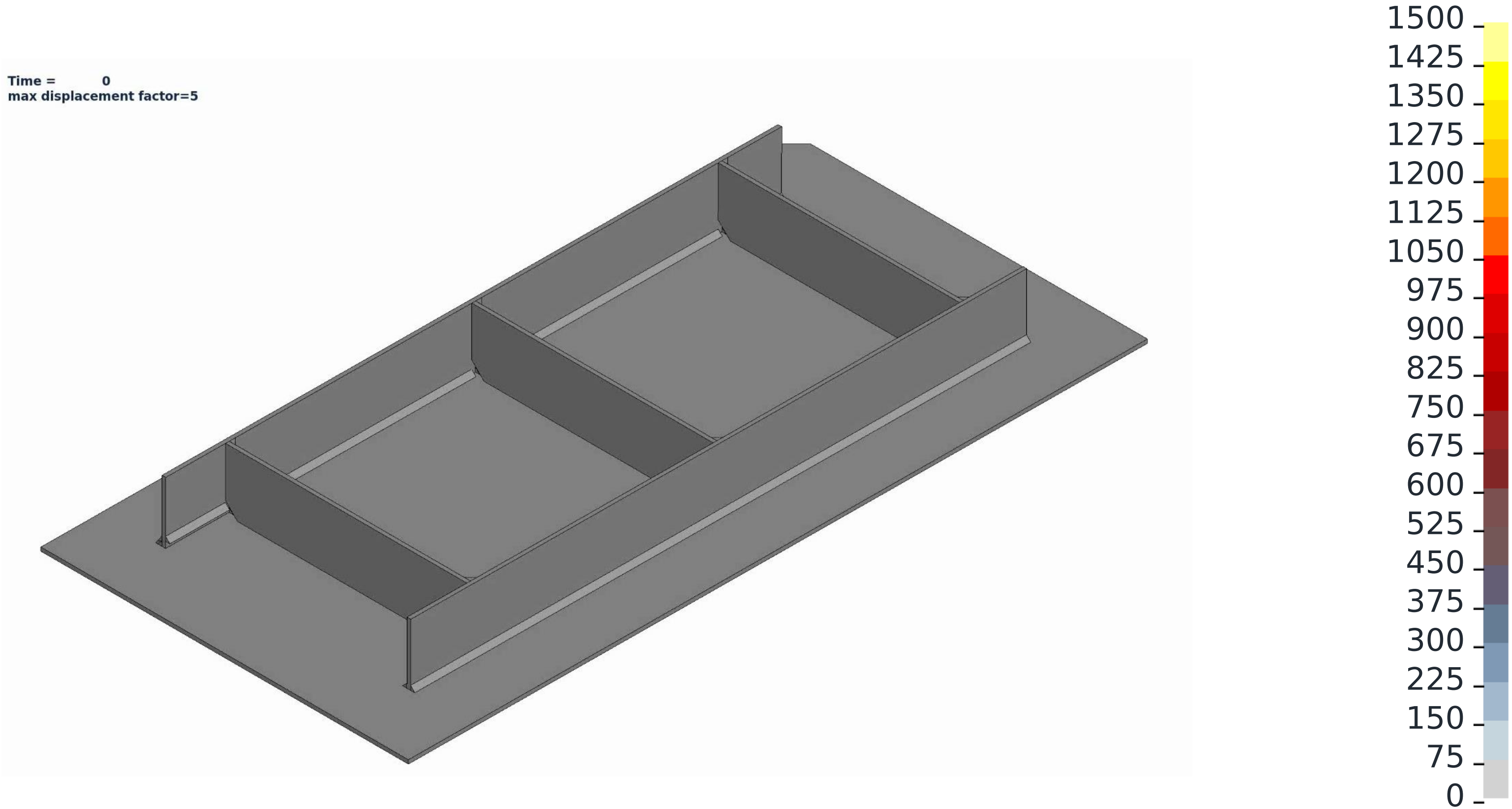
Weld Sequence







Temperature – Fast Animation
Displayed at 5 Times Magnified Distortion



Supports

3-point support:

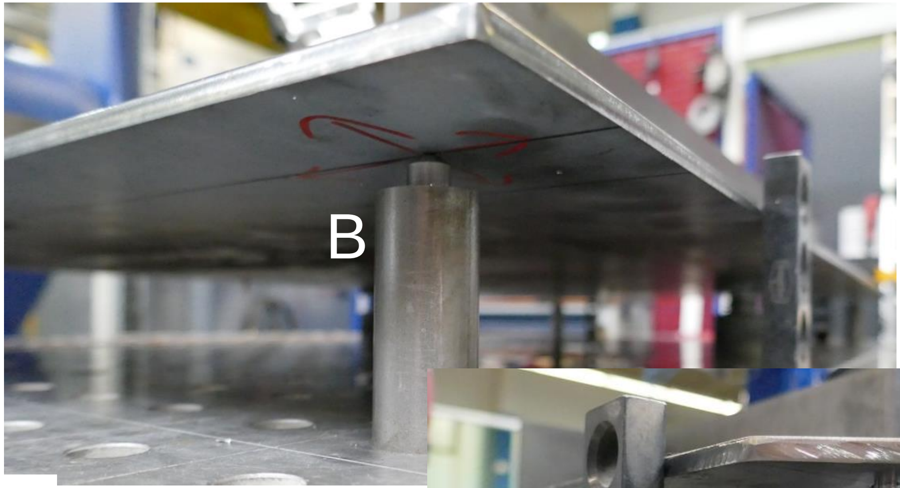
A: cylinder in blind hole

B: cylinder in elongated hole and stop on top side

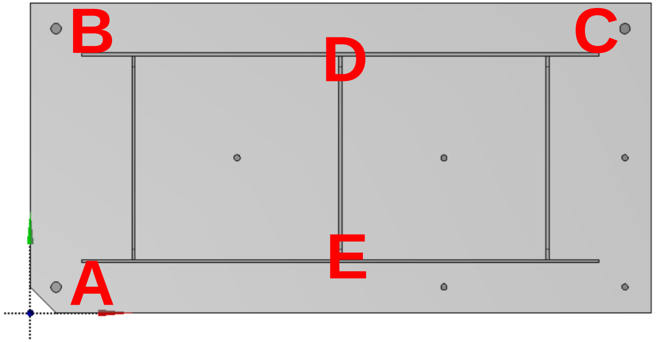
C: cylinder with free-earth support

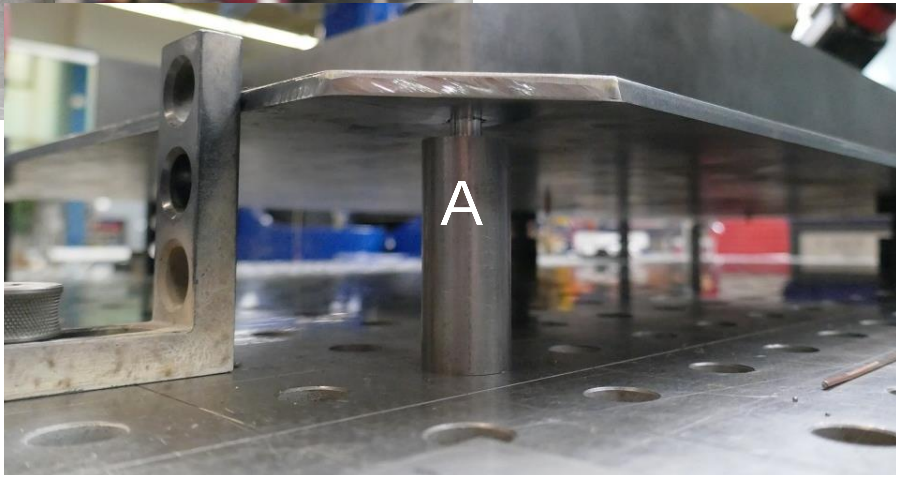
D: support during tack welding

E: support during tack welding

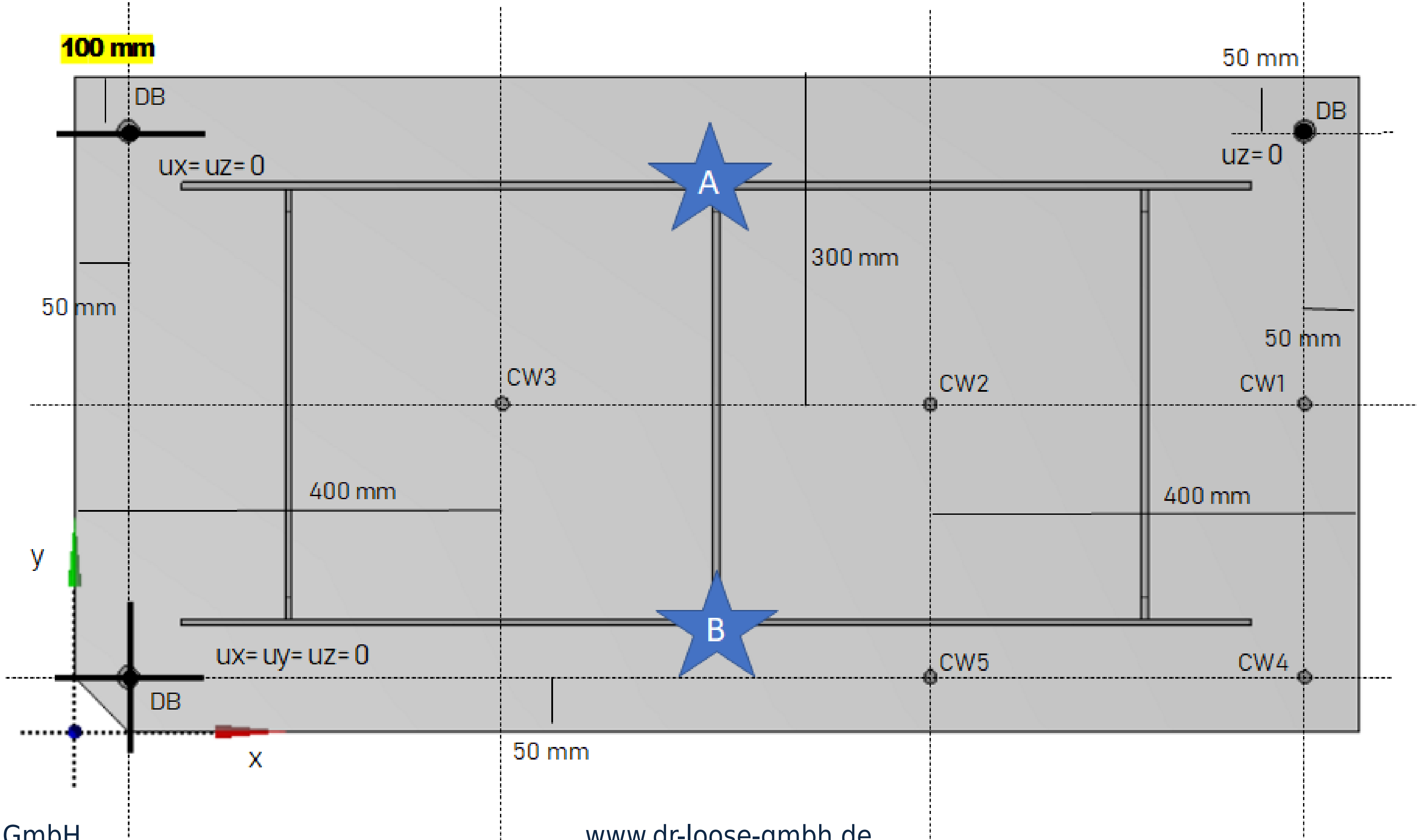


Industrial test case but with desired visible welding deformations

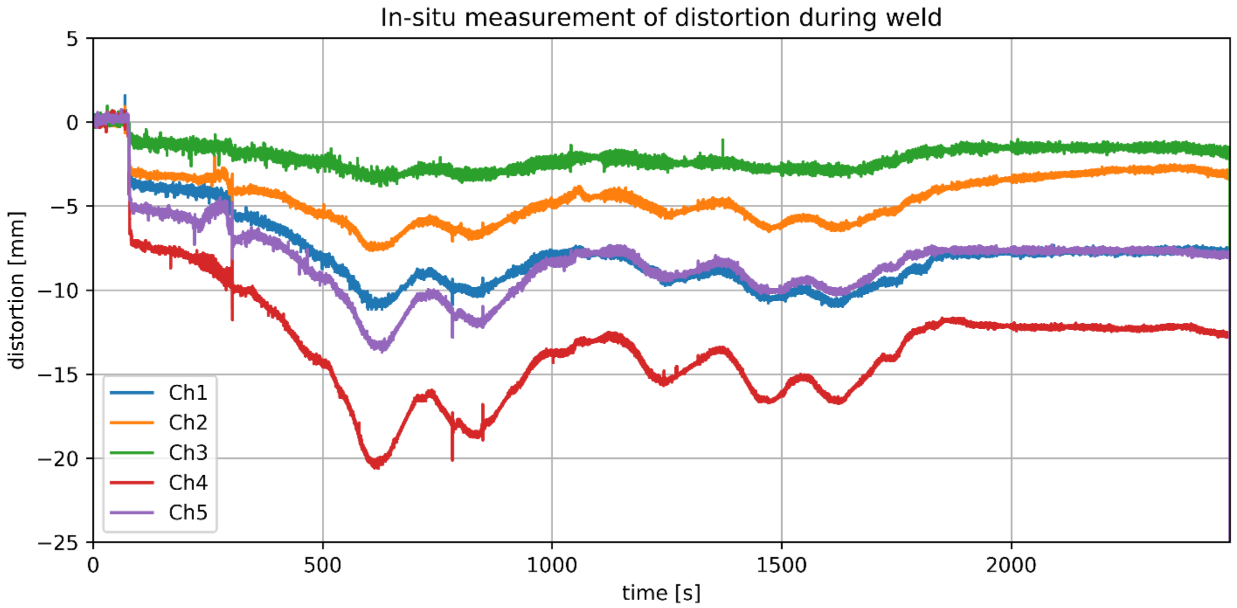


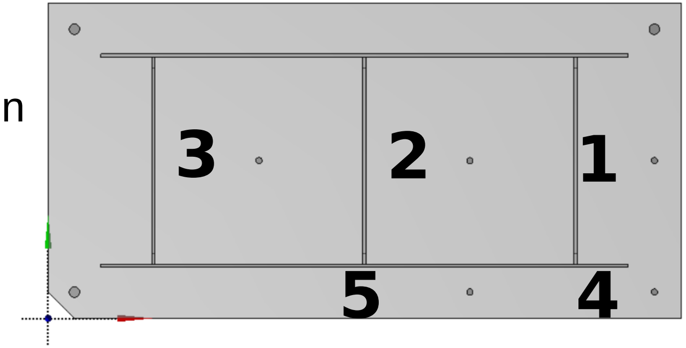


TIME Plate
Supports and Cable Wire Sensors (CW)



Transient Measurement of Deformation with Cable Wire Sensor





Transient, selective measurement of one-directional deformation on 5 points (small dots)

Cable wires are positioned under the plate with welding studs

Negative values equal to downside movement of the plate

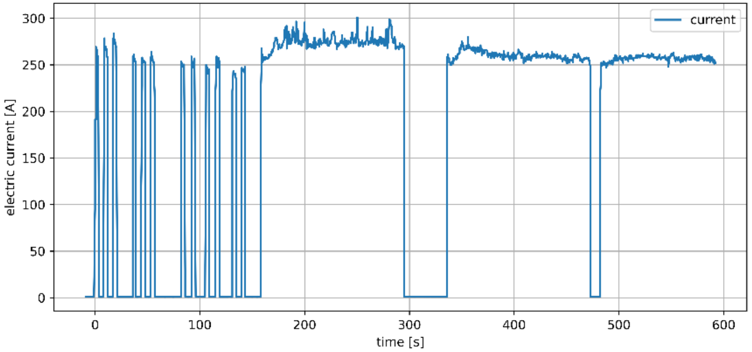
Distance from edges 50 mm due to welding table

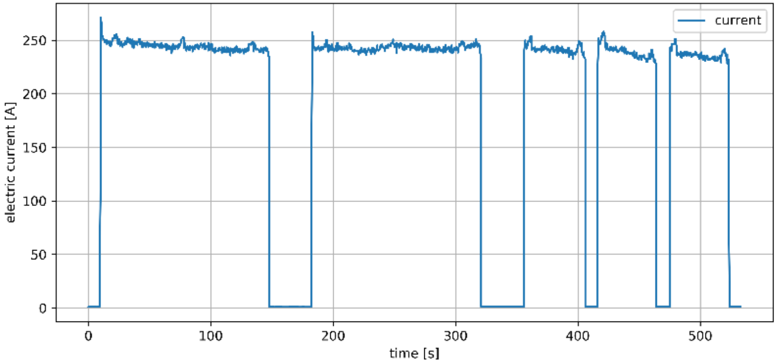
Data Synchronisation

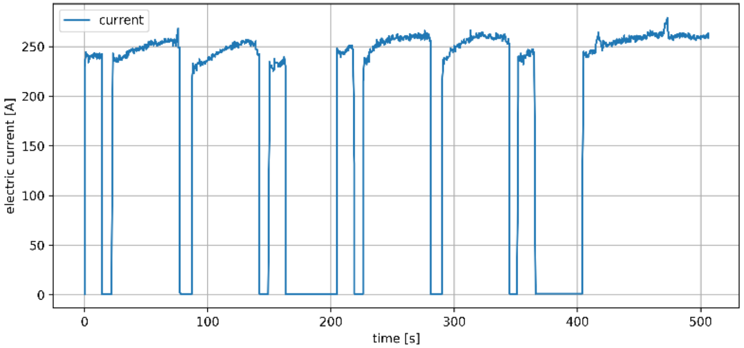
Data Synchronization

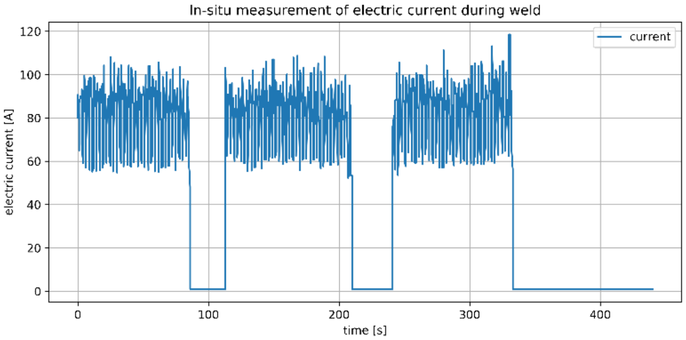
- The Welding time is manually measured for each weld.
- The FLIR camera video additionally offers full welding times in one set for data synchronization.
- TheFluke Clamp meter provides data of electric current during the process.
- The Distortion measurement with cable extension wires during the process in vertical direction.

Measurement of Electric Current



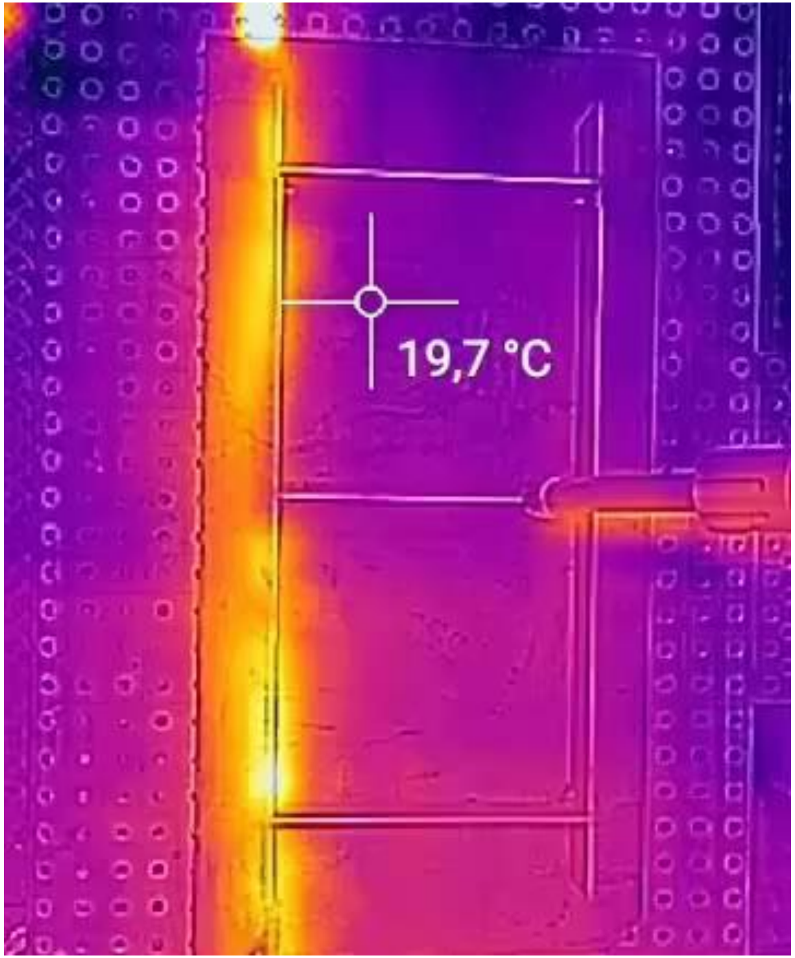






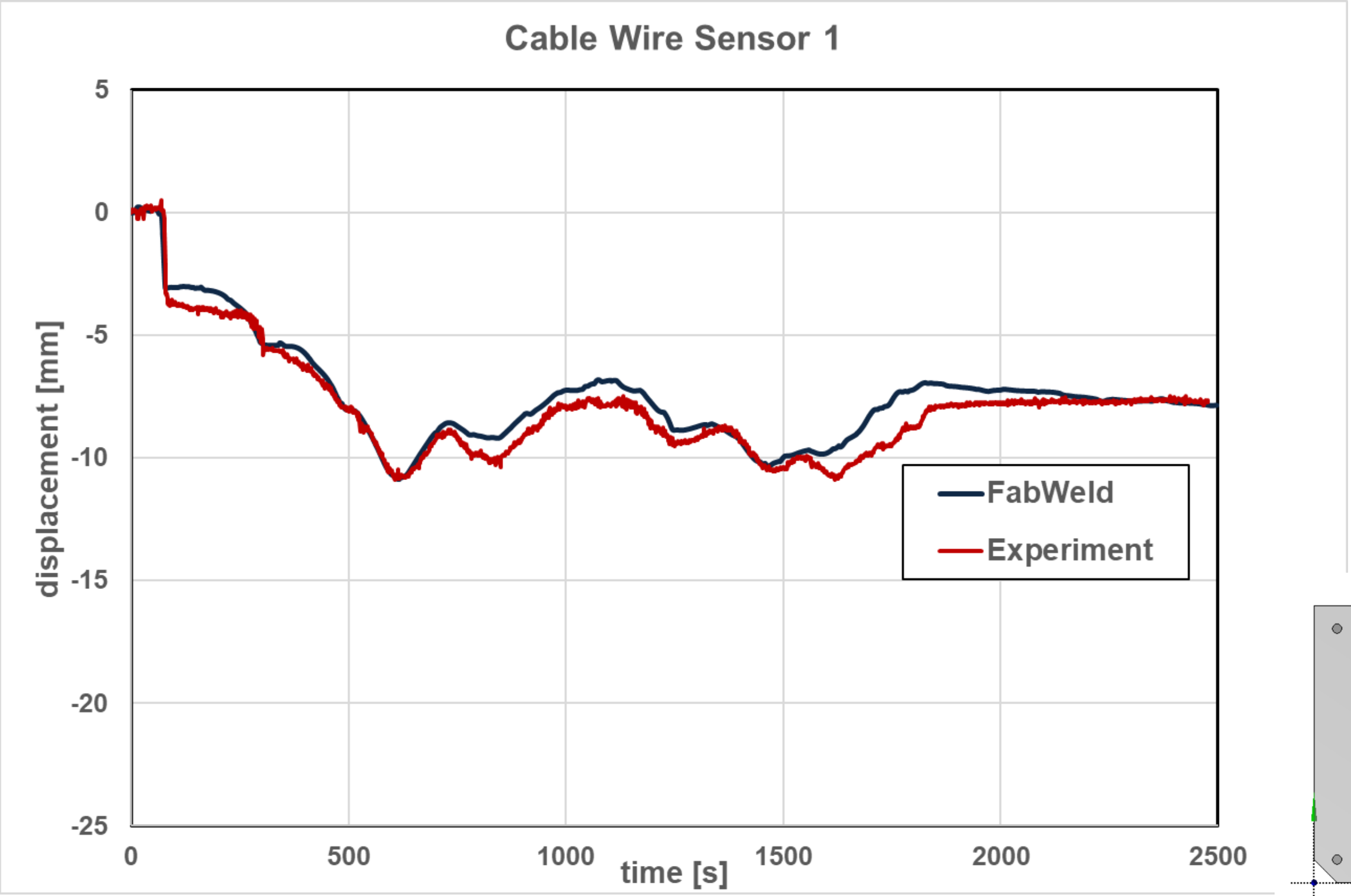
Thermographic Video

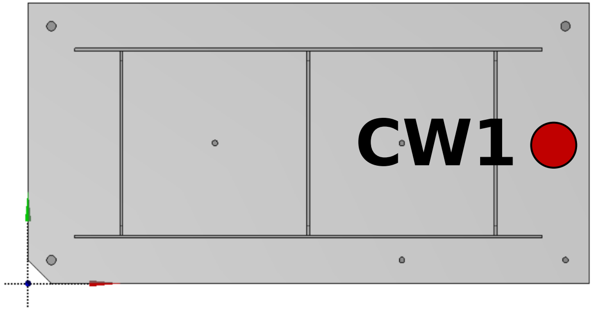
- Thermographic video used for synchronization of weld times and data analysis
- Provides a feeling for thermal material properties, for example in teaching purposes
- FLIR camera with maximum temperature up to 120°C
- Total weld time about 45 min.



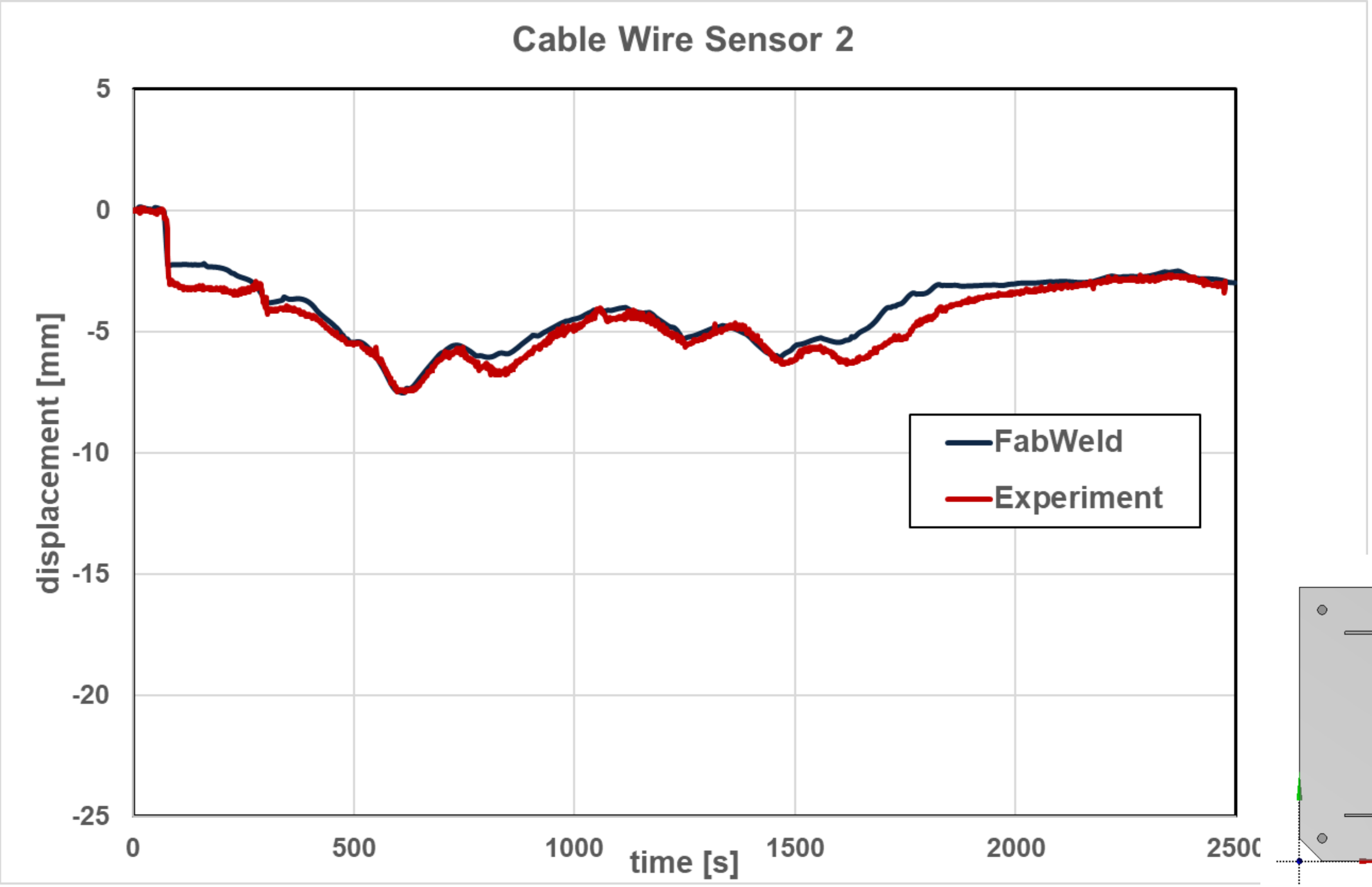
Results

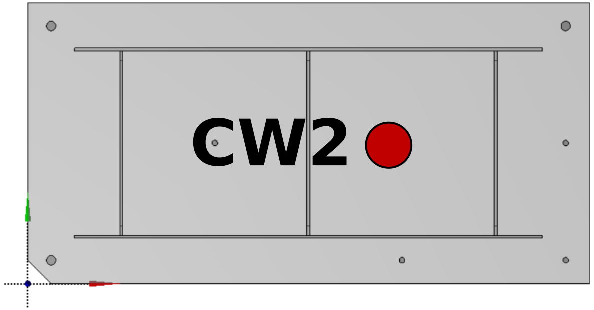
Displacement at Cable Wire Sensor 1



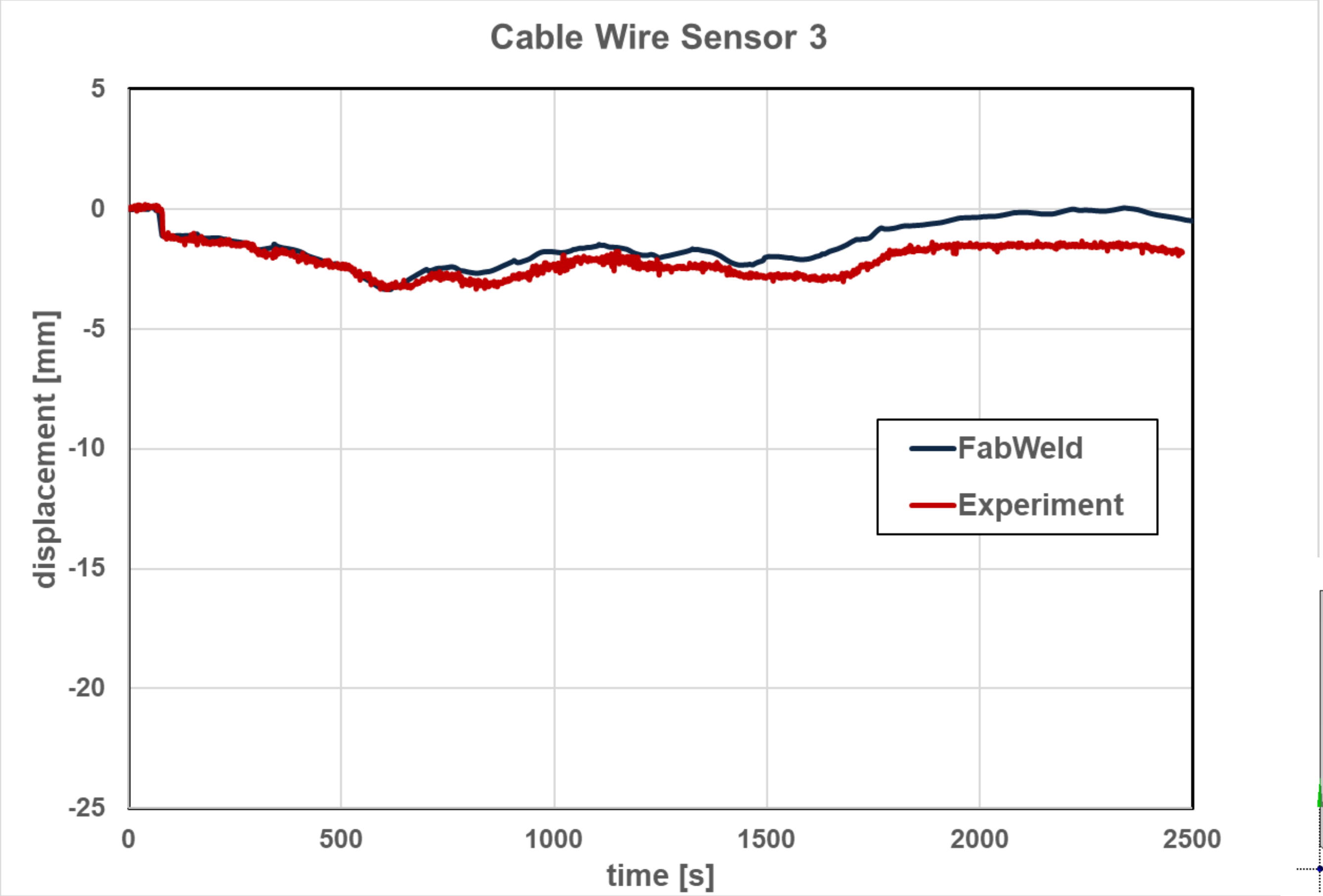


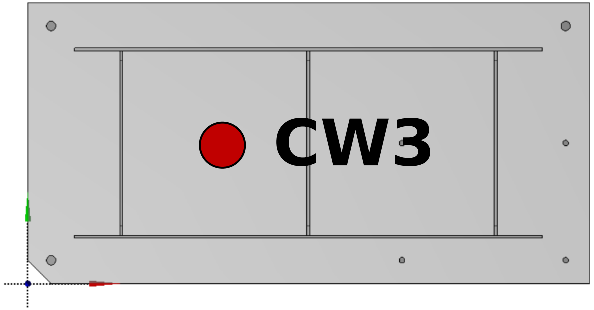
Displacement at Cable Wire Sensor 2



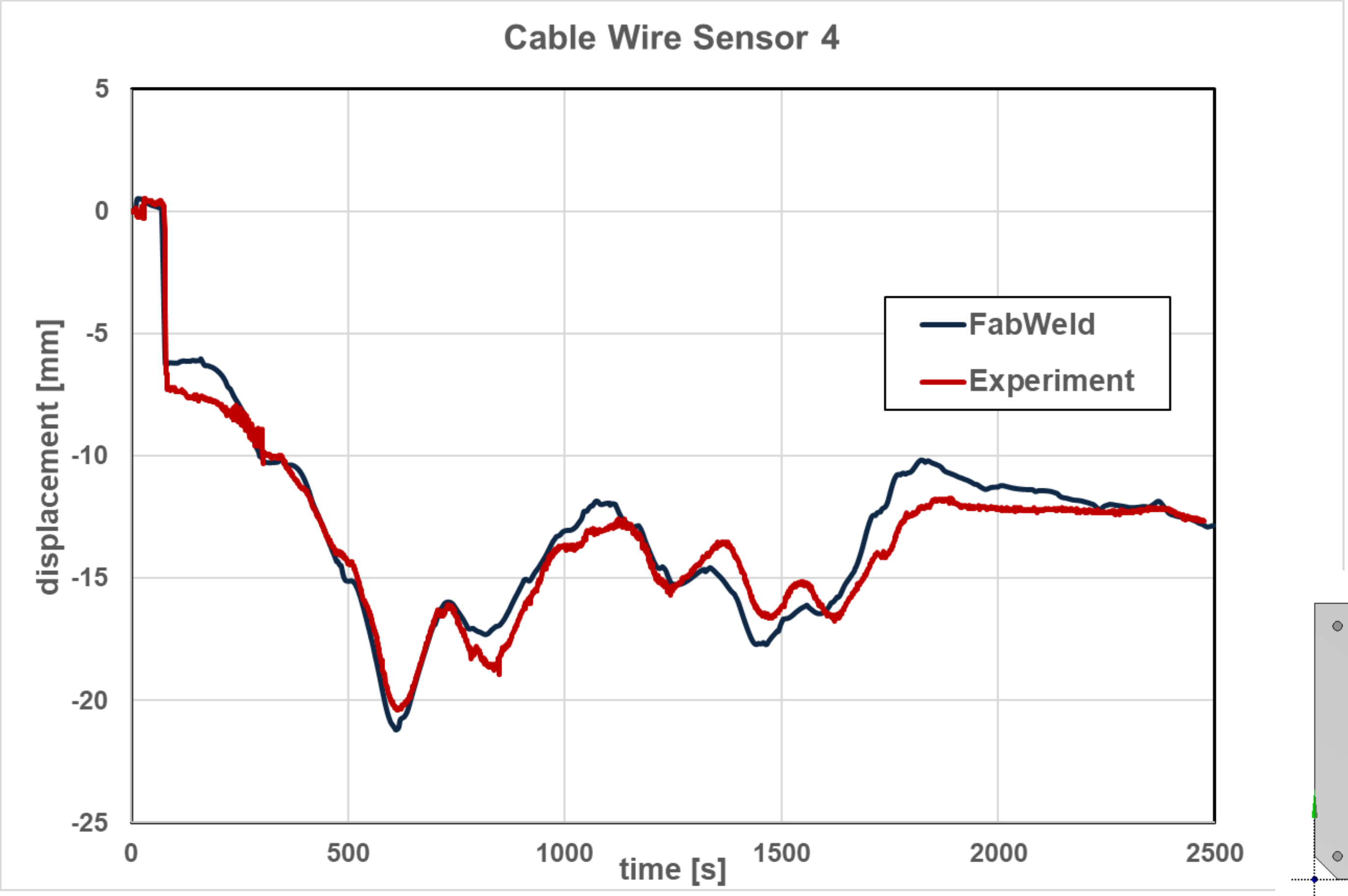


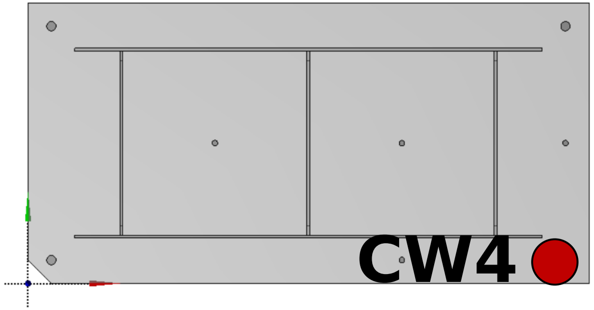
Displacement at Cable Wire Sensor 3



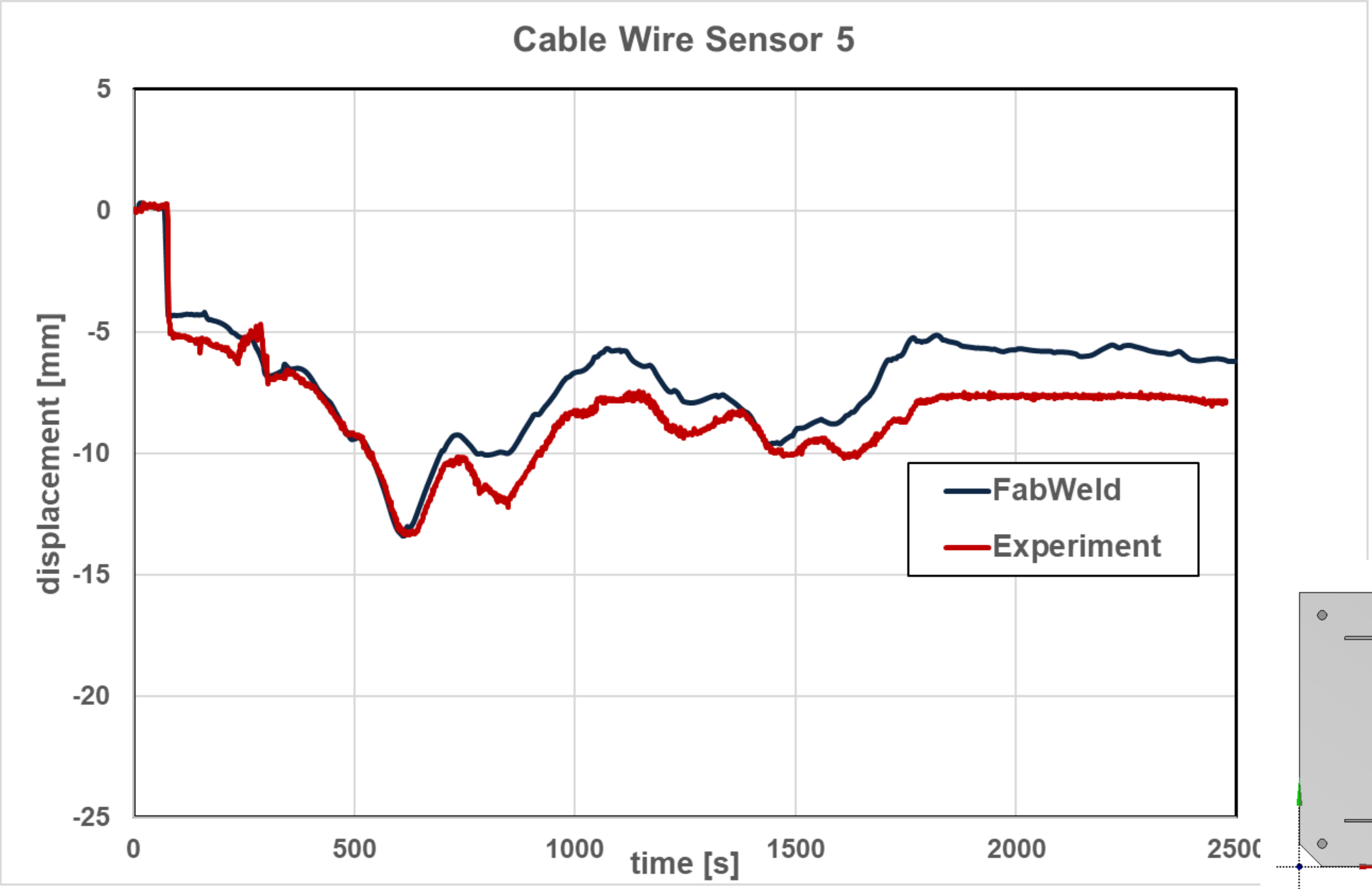


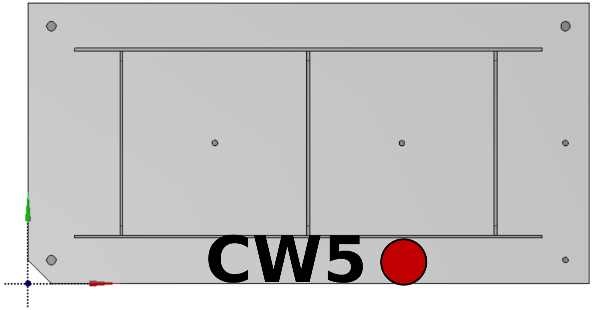
Displacement at Cable Wire Sensor 4



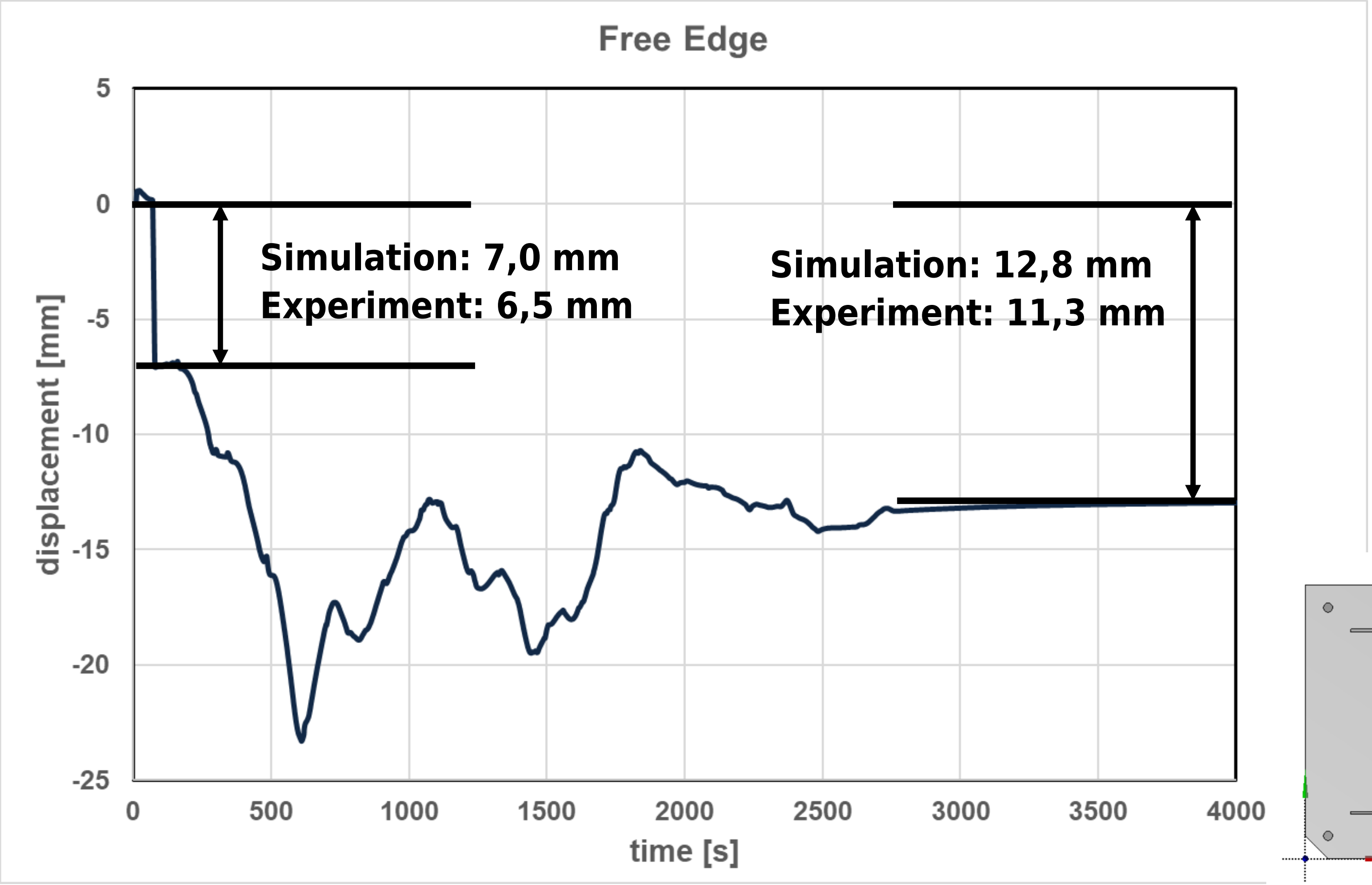


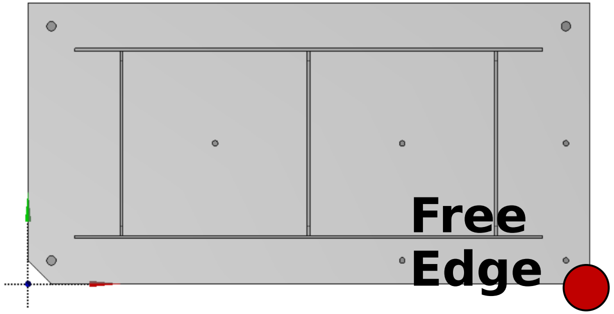
Displacement at Cable Wire Sensor 4





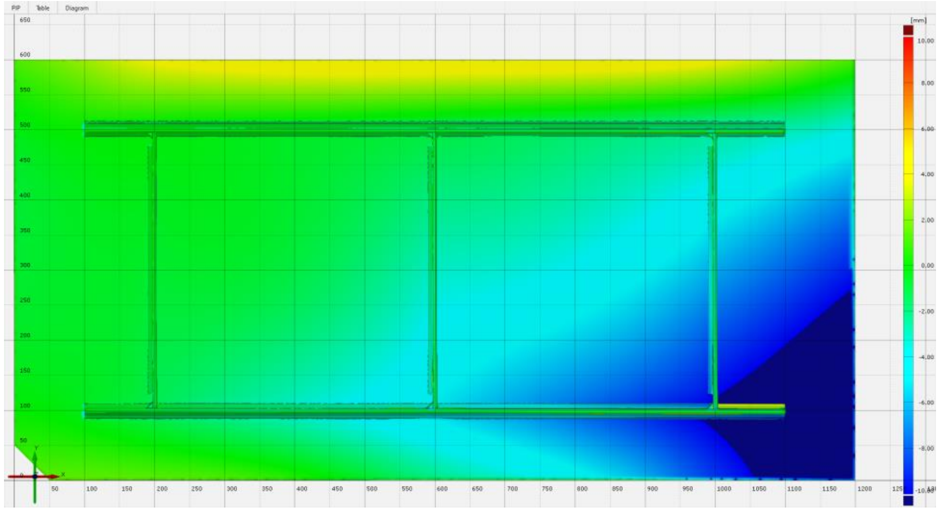
Displacement at Free Edge



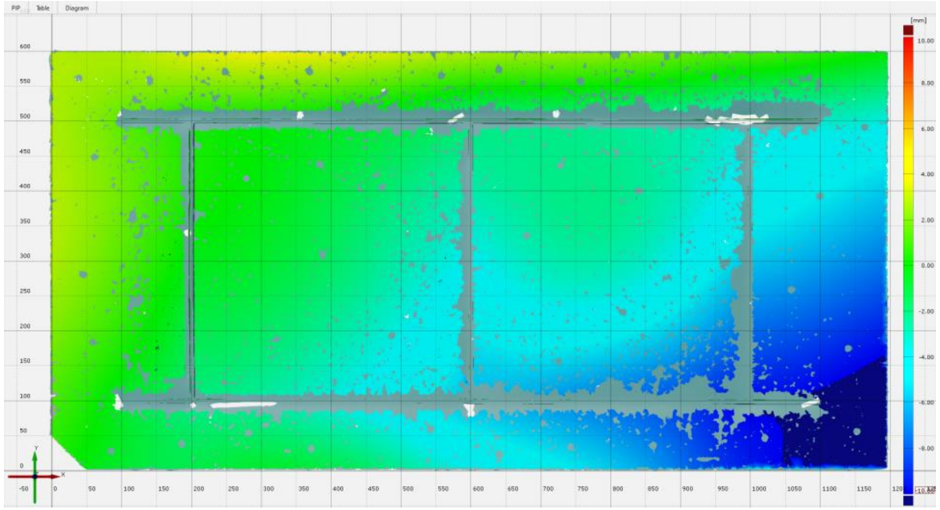


Surface Deviation

Simulation



Experiment

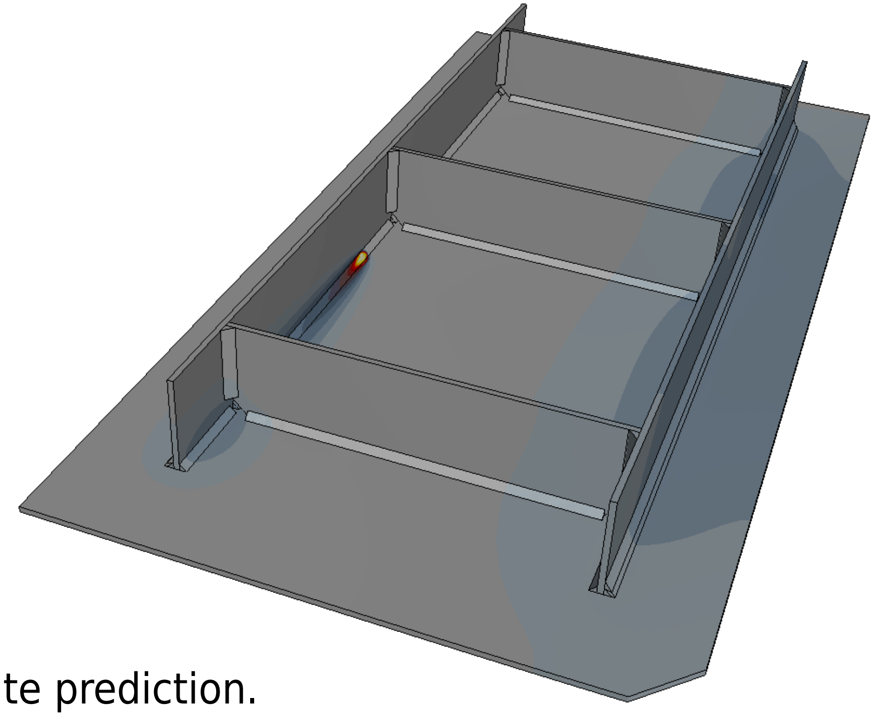


Conclusion

Conclusion

- Consider the material beaviour correctly
- Consider the driving physical effects
- Consider the right boundary condidions
- Consider the process right

- Compare syncronised data
  same location - same time



- Obtain agreement between
  virtual simulation and real experiment.
- Use the weld structure simulation for accurate prediction.
  - understanding of the distortion behavior
  - distortion engineering

Thank You!

Dr. Loose GmbH
Herdweg 13, 75045 Walzbachtal, Germany
E-Mail: loose@Dr-Loose-GmbH.de
Web: www.Dr-Loose-GmbH.de

Goldak Technologies Inc.
3745 Revelstoke Drive, Ottawa, ON, K1V 7C2, Canada
E-Mail: john.goldak@goldaktec.com
Web: www.goldaktec.com

Technologie-Institut für Metall & Engineering GmbH (TIME)
Koblenzer Str. 43, 57537 Wissen/ Sieg
E-Mail: info@time-rlp.de
Web: www.time-rlp.de