NEW METHOD FOR MEASURING THE ELECTRICAL CONTACT RESISTANCE DURING RESISTANCE SPOT WELDING

Matthew Galler[1,2], Wolfgang Ernst[1,2], Christof Sommitsch[1]

Institute for Materials Science and Welding

Graz University of Technology[1]

JOIN, Network of Excellence for Joining, Austria[2]

gefördert durch:

Presentation Outline

1. Introduction: resistance spot welding (RSW)
   - *Motivation of work-why study resistance spot welding?*
   - *Importance of electrical contact resistance (Rce)*
2. Definition of new approach
   - *Modified RSW process*
     - *Single sheet welding, one period current application*
3. Simulation procedure
   - SYSWELD used to model welding process
   - *Altered input parameters ➔ Rce and bulk resistance curves*
4. Simulation results
   - Uncoated DP600 steel
5. Comparison to experimental data
6. Conclusions
   - *Rce was successfully measured for the first time during RSW*

gefördert durch:

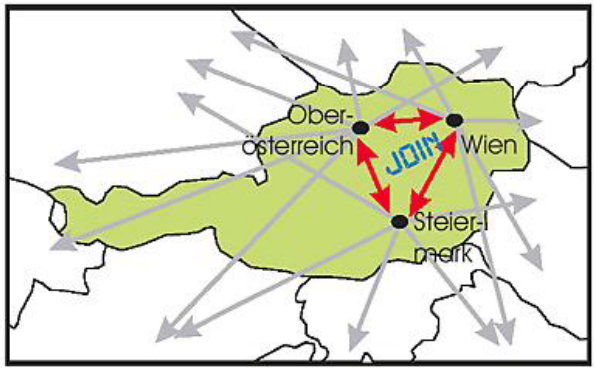
Motivation

Competence Network for Welding and Joining „K-net JOIN“:

Resistance spot welding of coated steel sheets for automobile applications:

Project A.5: Metal – organic sheets (CPP corrosion protection primer)

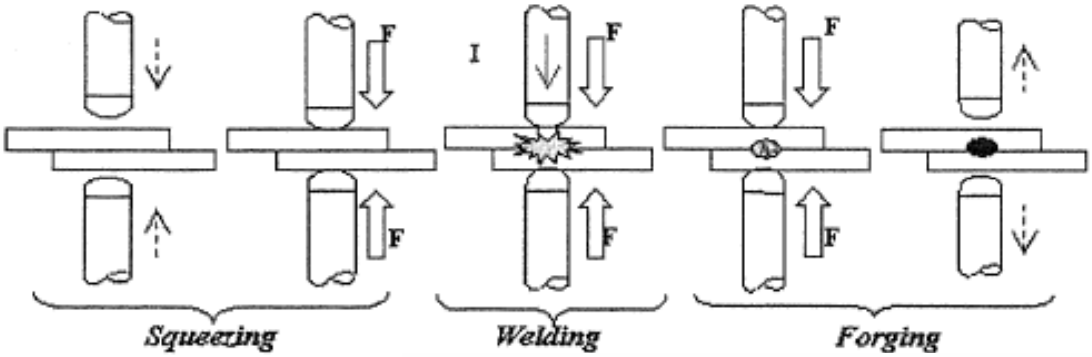
Projekt A.10: Metallic zinc coated sheets (galvanized, galvannealed, electrogalvanized)



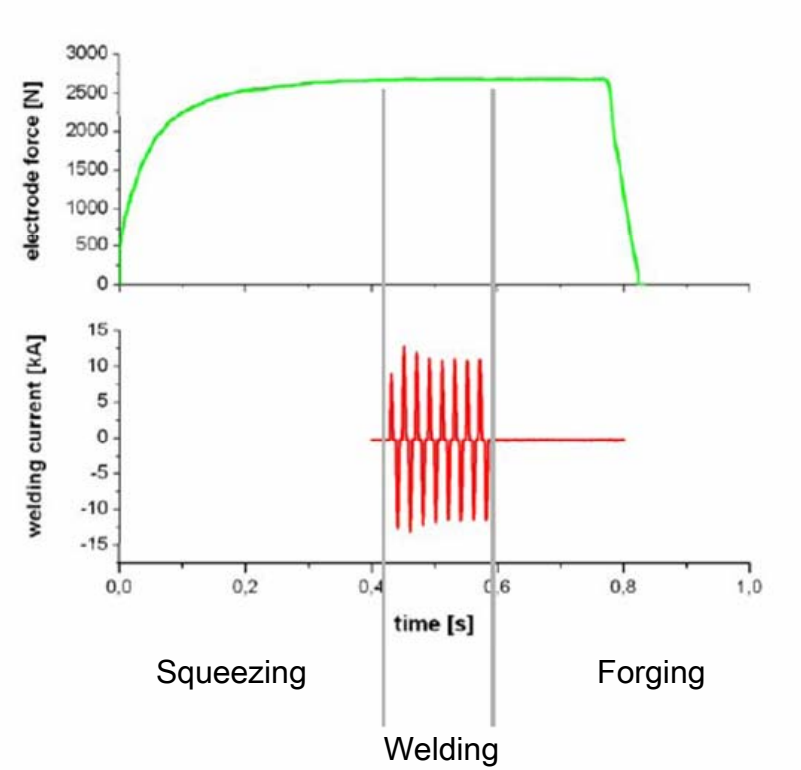
Goal of the projects: Influence of the different surface conditions on the resistance spot weldability with special focus on electrode wear

Main problem: Electrical contact resistance vs temperature for different contact surfaces

Resistance spot welding



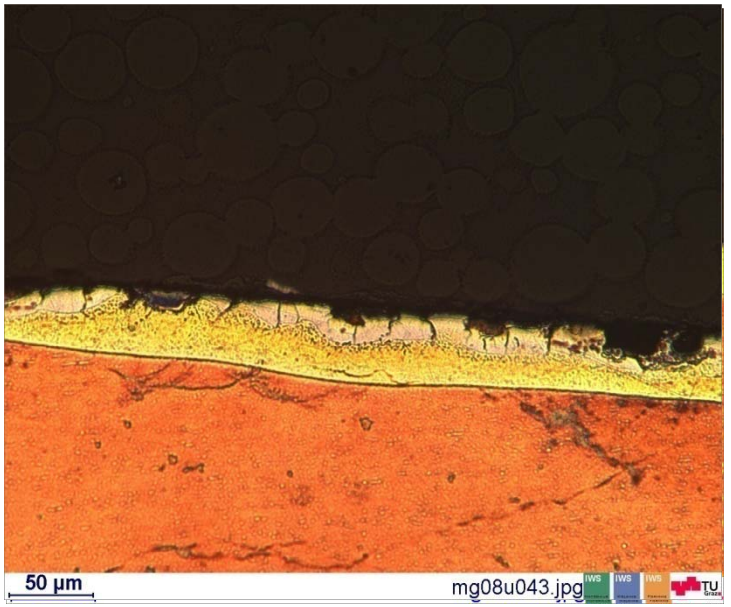
- **Force ~ 3 kN**
- **Current ~ 7-9 kA**
- **Time ~ 0.2 s**



Motivation: Why study resistance spot welding?

- Automobile joining processes: 5000 welds in a car body
- Electrode wear occurs immediately during welding of zinc coatings

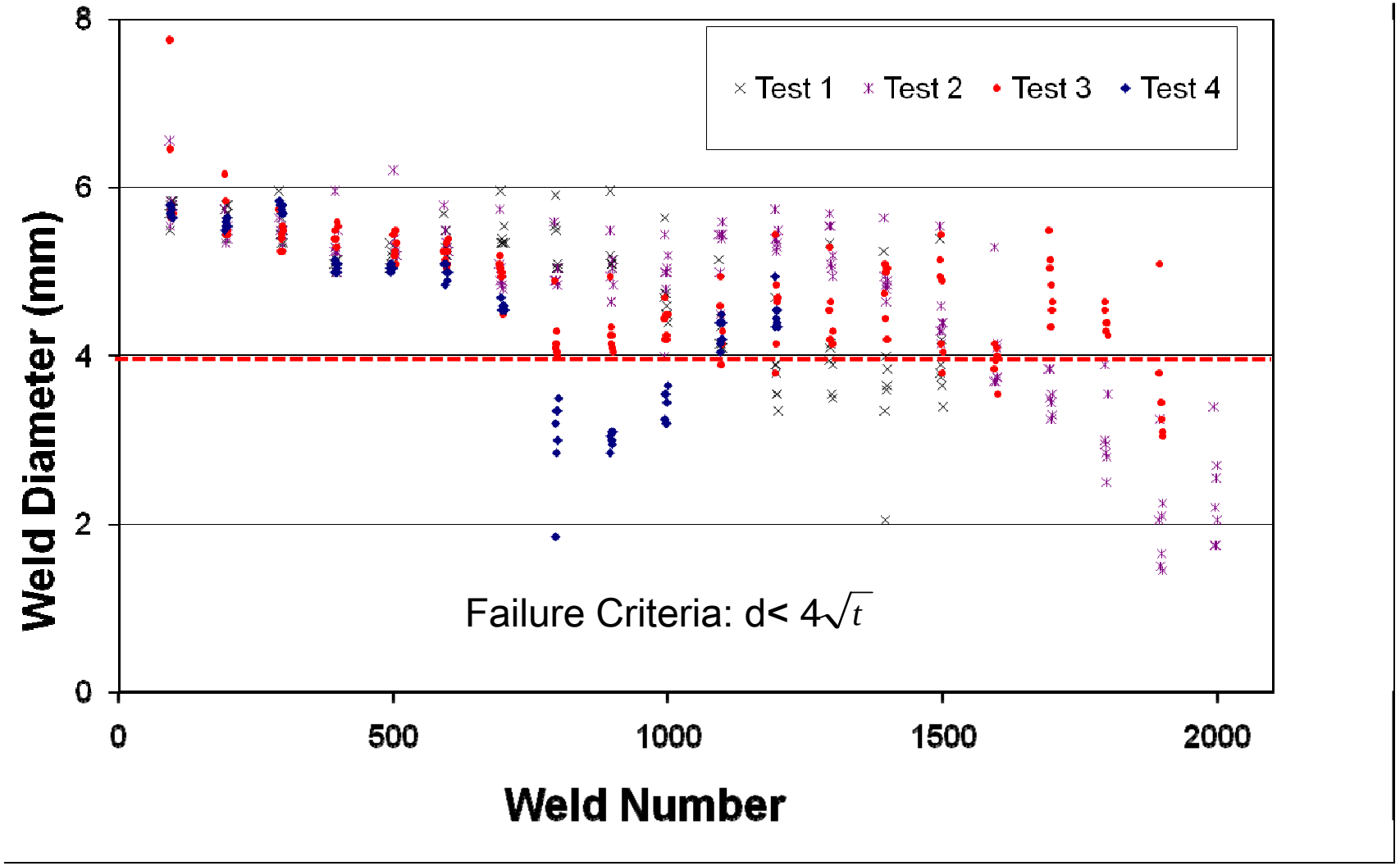
1. Mushrooming
   - Rx, Force
2. Alloying
3. Material loss / pitting



- *All of the wear mechanisms increase electrode face diameter which leads to a decrease in weld size*
- *Want to prevent undersized welds in critical car components*

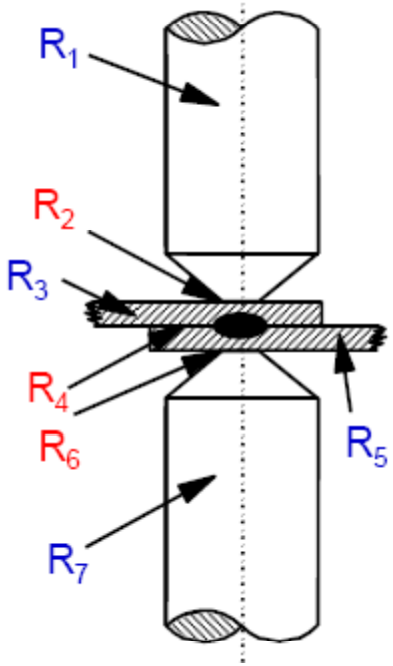
gefördert durch:

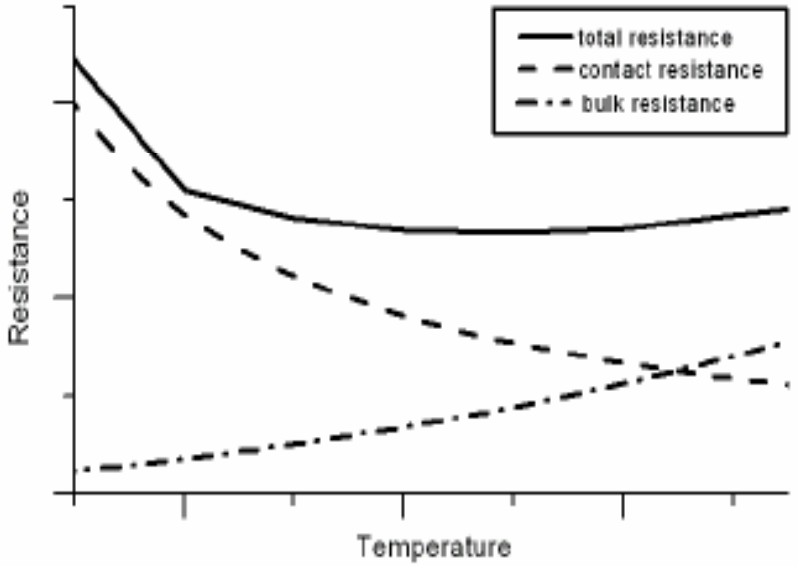
Electrode life test for galvanized materials



Electrical contact resistance

$$H = I^2 R_{total}$$





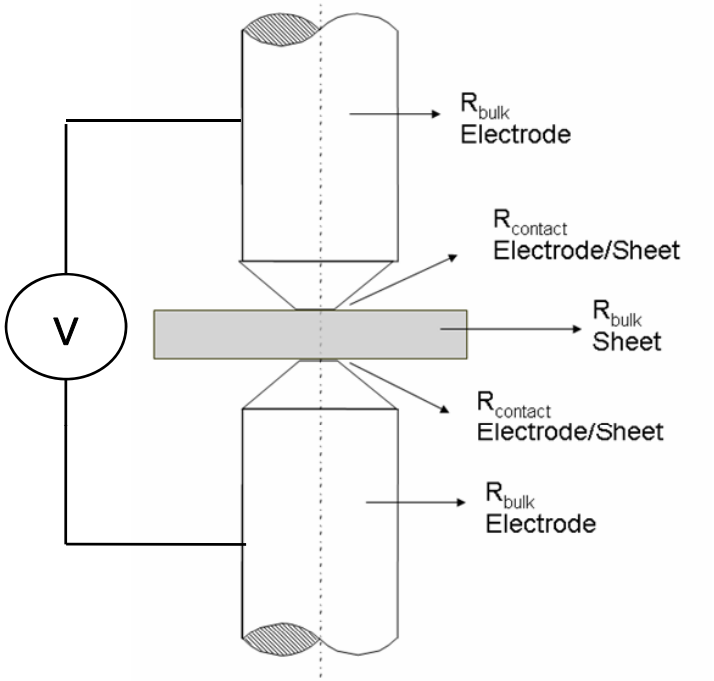
- Importance of Rce curve for simulation
- Never successfully measured during welding ➔ difficulty to separate Rce and bulk material resistance contributions

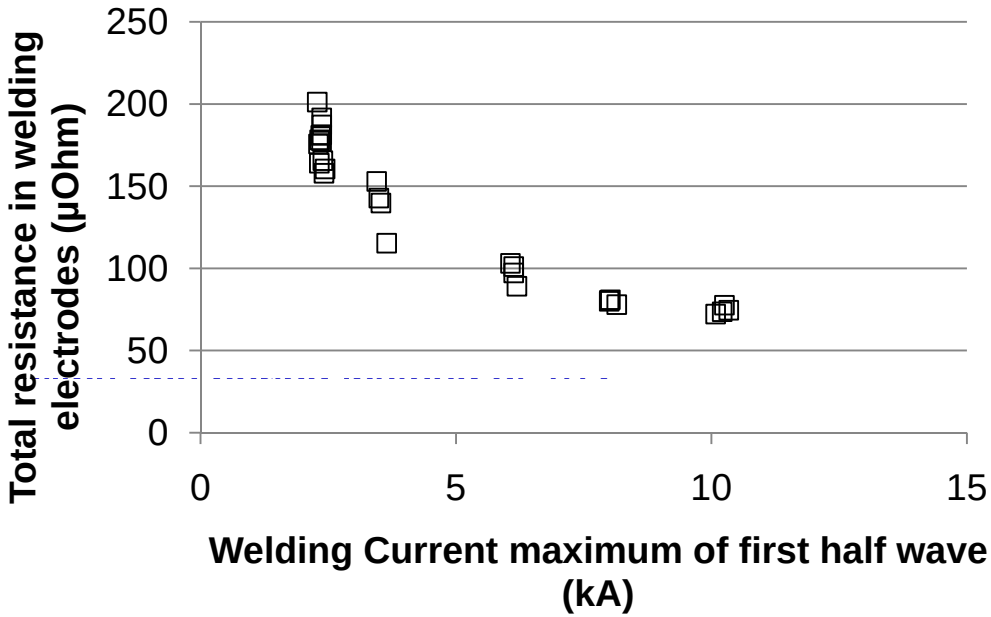
Overall research goal

- *Measure Rce during welding from **total resistance** measurement in the welding electrodes*
- *Problem: very difficult with conventional RSW ➔ New approach must adopted*

gefördert durch:

Definition of New Approach



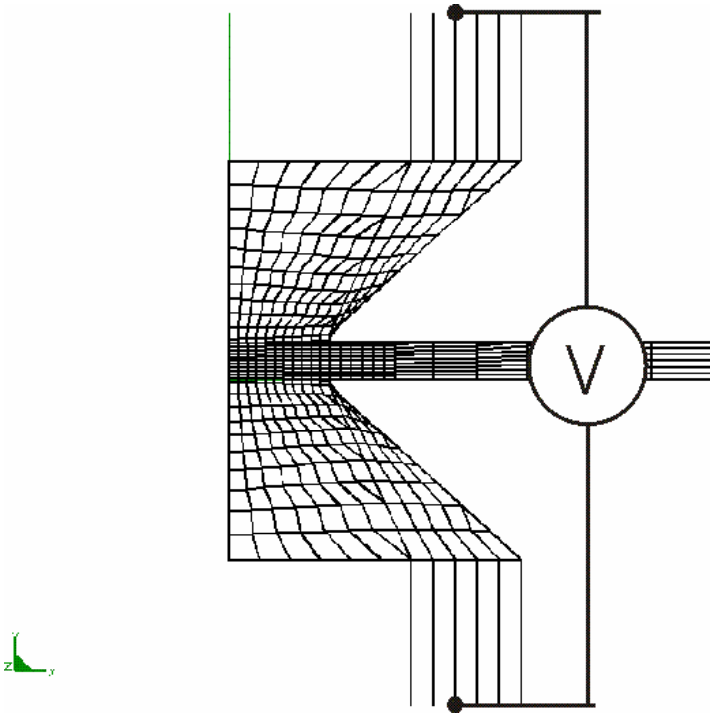


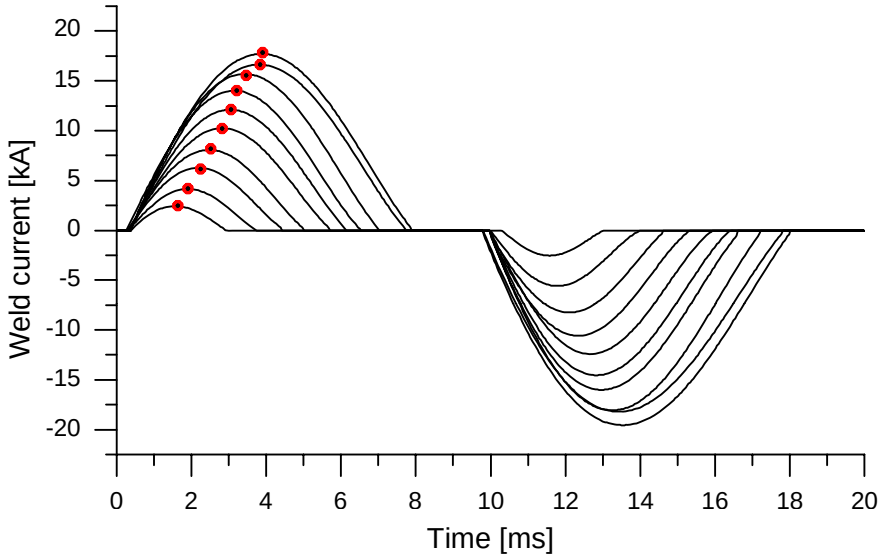
How can simulation help?

- *Goal of the simulation ➔ validate the new approach*
- Find the welding current ranges in which the total resistance measurement in the electrode represents mainly the Rce contribution
- Numerically isolate Rce and Bulk resistance contribution to the total resistance measurement

gefördert durch:

Simulation Procedure

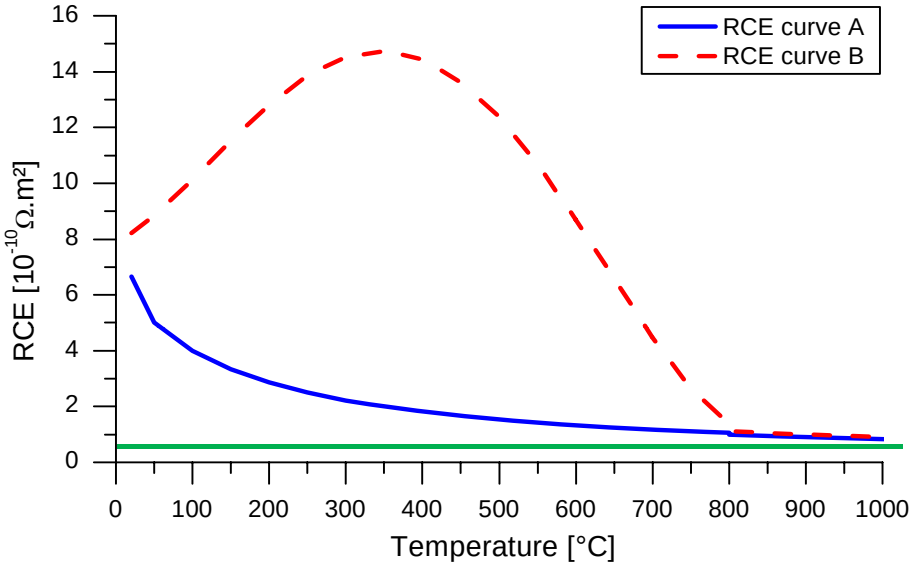


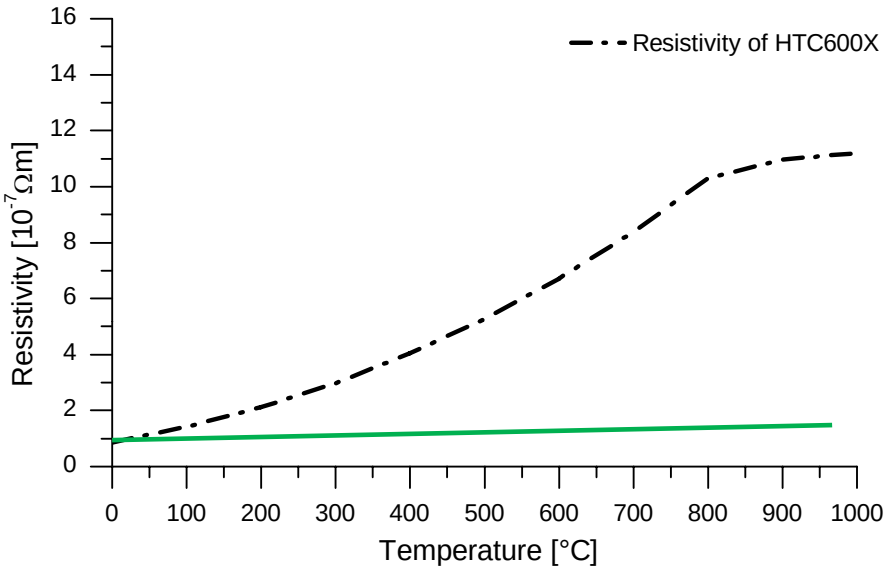


- 1 mm uncoated DP600 steel with 3.5kN welding force
- Real time current inputs ➔ 0.5 - 9.5 kA effective current
- Voltage drop at time of peak of first half wave
- Total resistance calculated from voltage and current

gefördert durch:

Simulation Procedure: Altered Input Parameters



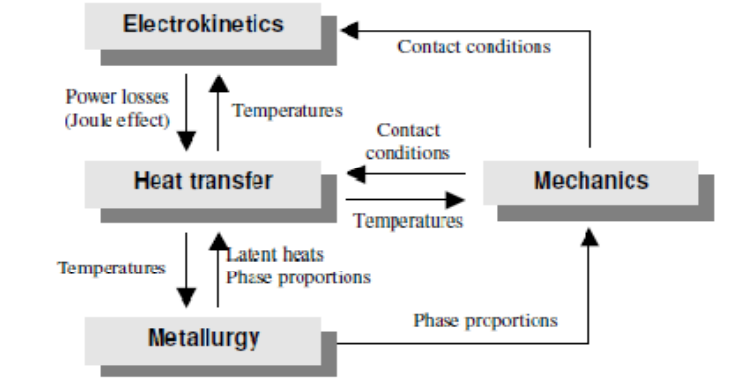


Three Rce curves at electrode/sheet interface were modelled

- Classical Rce curve shape from literature ➔ SYSWELD input for uncoated DP600 steel
- Proposed Rce shape with peak in curve ➔ Model (Babu, Sci. Tech. Weld. Join. 2004)
- Near zero value
- Two material resistivity curves

gefördert durch:

Simulation Results: SYSWELD

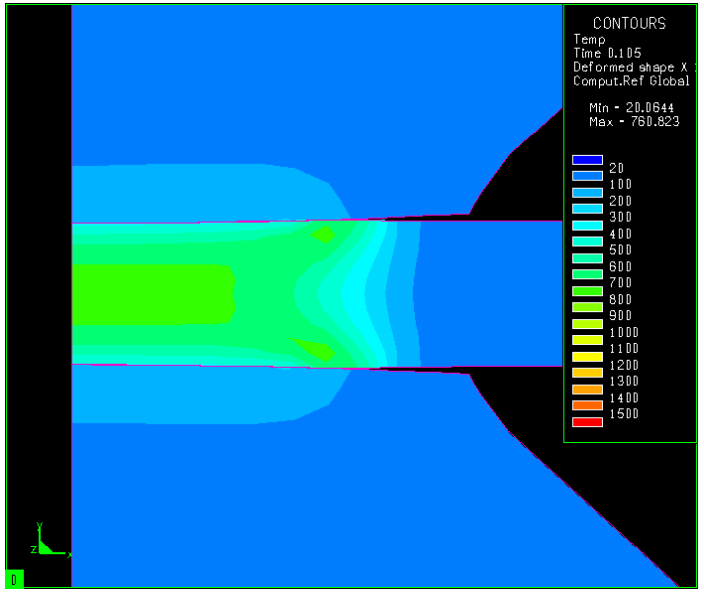


Couplings between electro-kinetics, heat transfer, metallurgy and mechanics

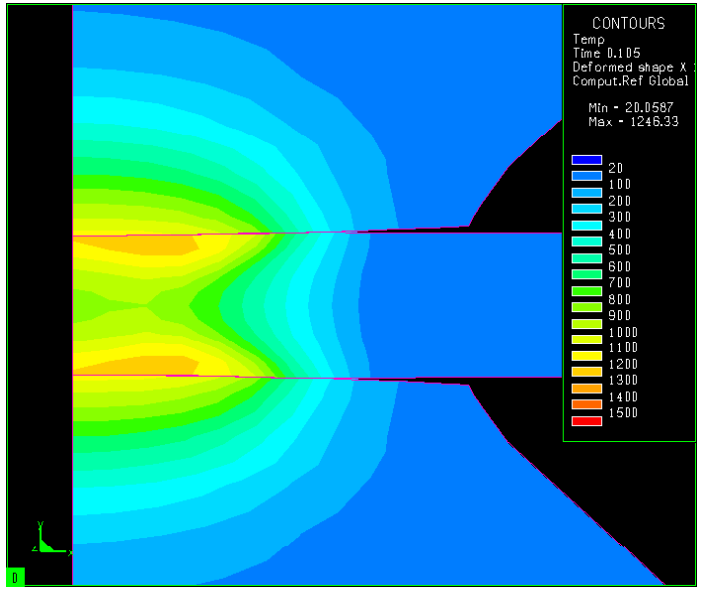
- Strong coupling

  ➔ 2ms iteration time between thermal and mechanical analysis

- Electrode sink-in and evolution of contact radius



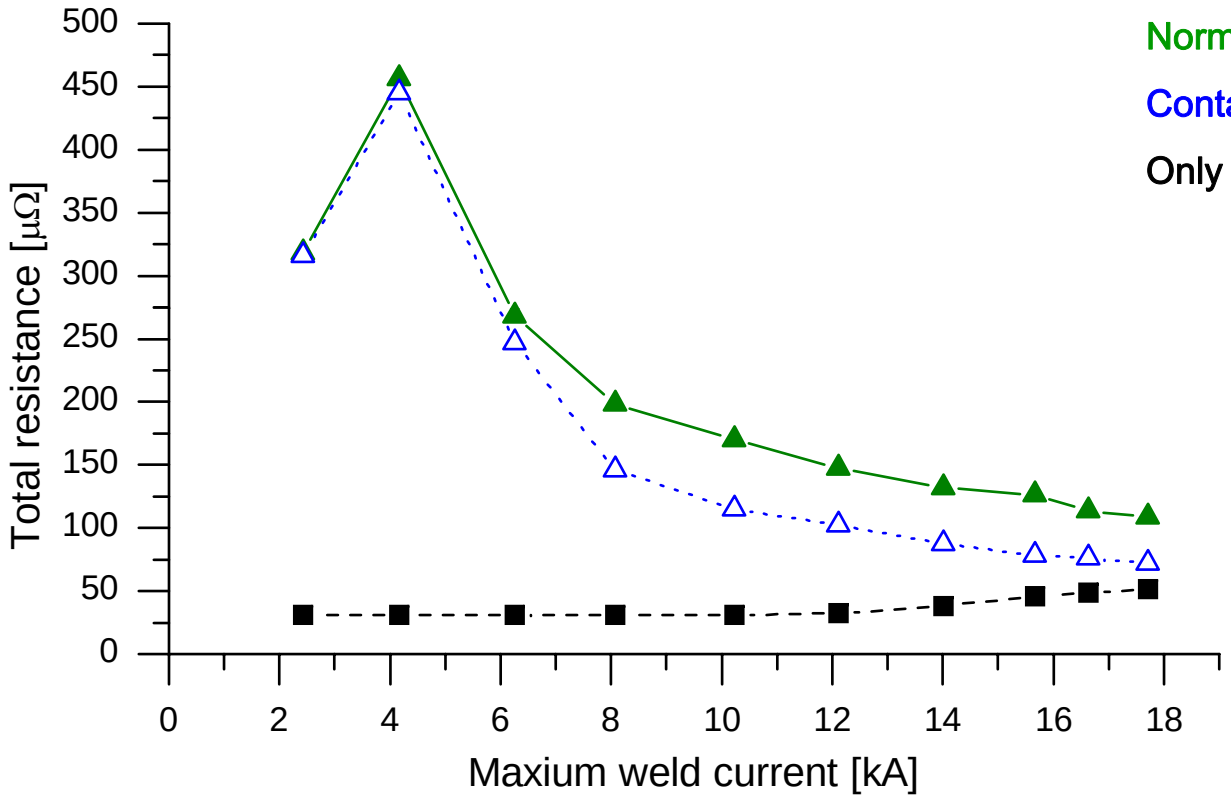
only bulk resistance at 9.5 kA at peak first half wave



only Rce plus RT Bulk at 9.5 kA at peak first half wave

gefördert durch:

Simulation Results: Peak Rce curve



Normal Simulation

Contact Resistance plus RT Bulk R.

Only Bulk Resistance

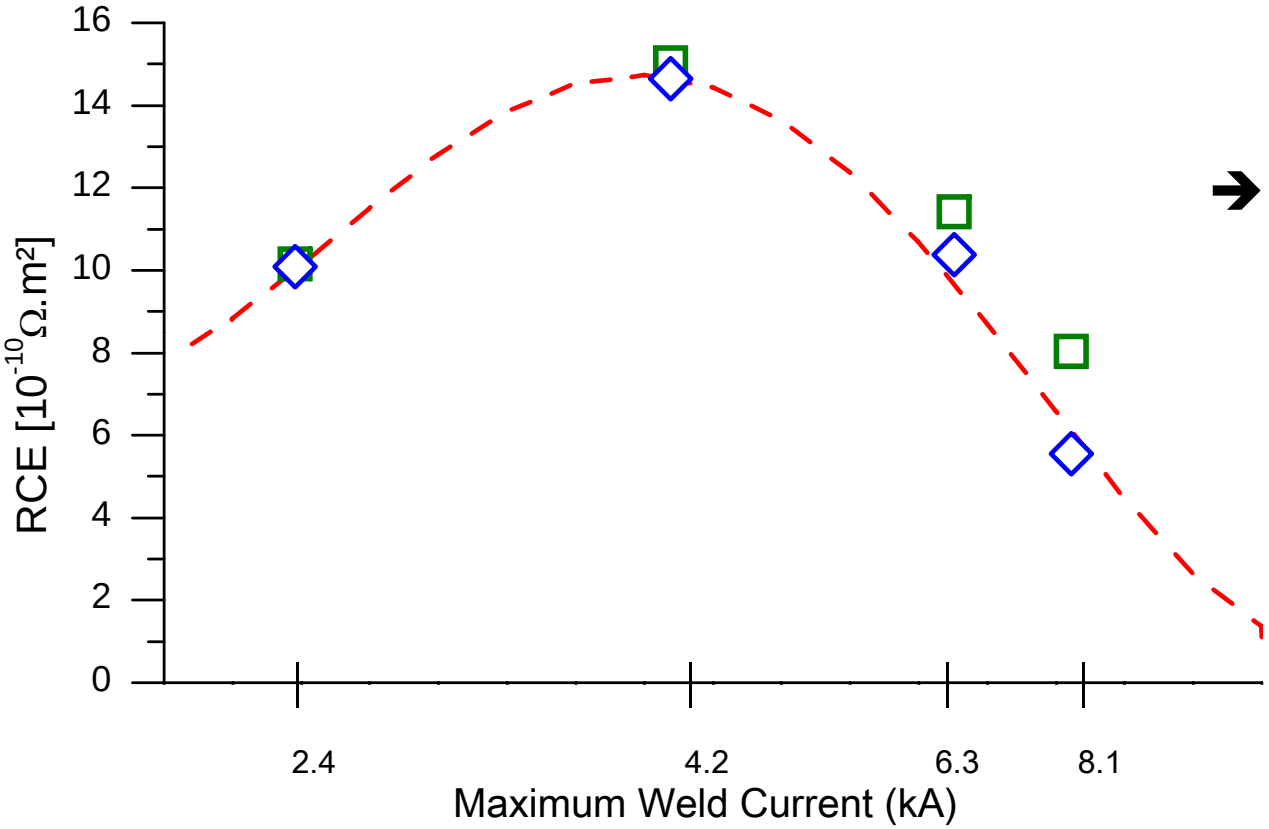
Are these total resistance values the real Rce values?

- *Back calculate Rce from total resistance and compare to input Rce (Ohm*m²)*

gefördert durch:

Simulation Results

Input Rce Curve (Babu) STR4: Normal Simulation STR5: Contact Resistance

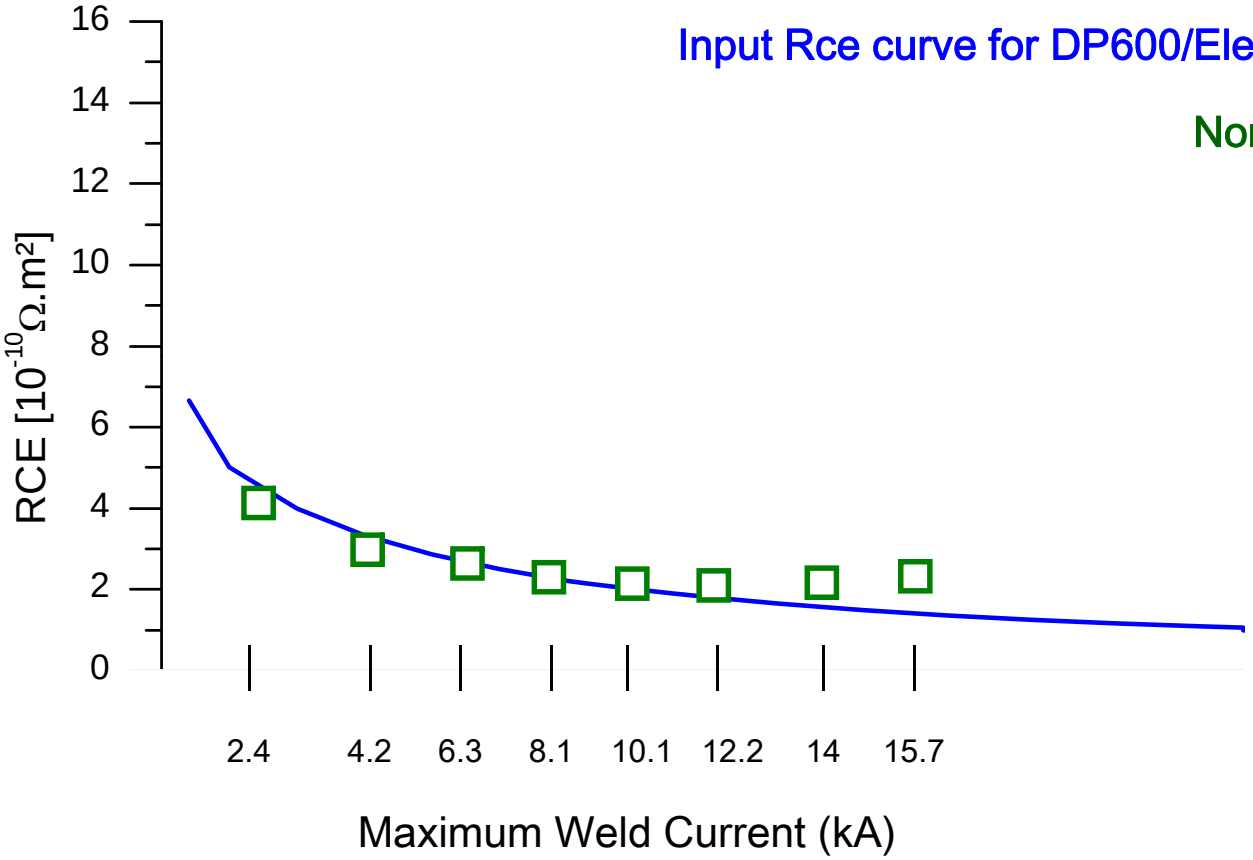


➔ Average interface temperature from electrode contact radius

- Normal simulation deviates at higher interface temperatures, represents the first time in simulation that the bulk contribution is measured
- Current range at which total resistance = Rce is verified from simulation!!

gefördert durch:

Simulation results: DP600 Rce curve

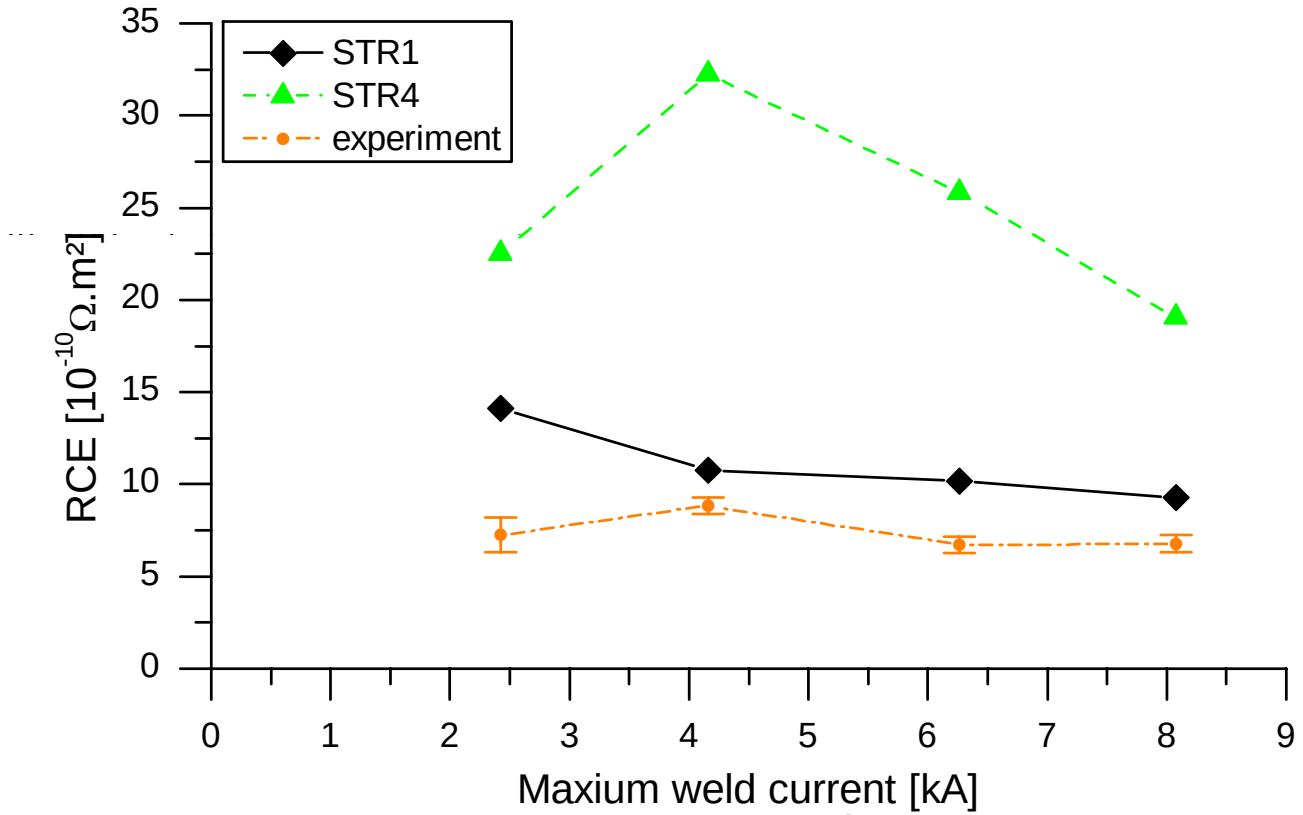


- Valid current range increases for a lower Rce curve!
- Up to max current of 12 kA ➔ the new approach is valid!

gefördert durch:

Comparison of Simulation and Experimental Results

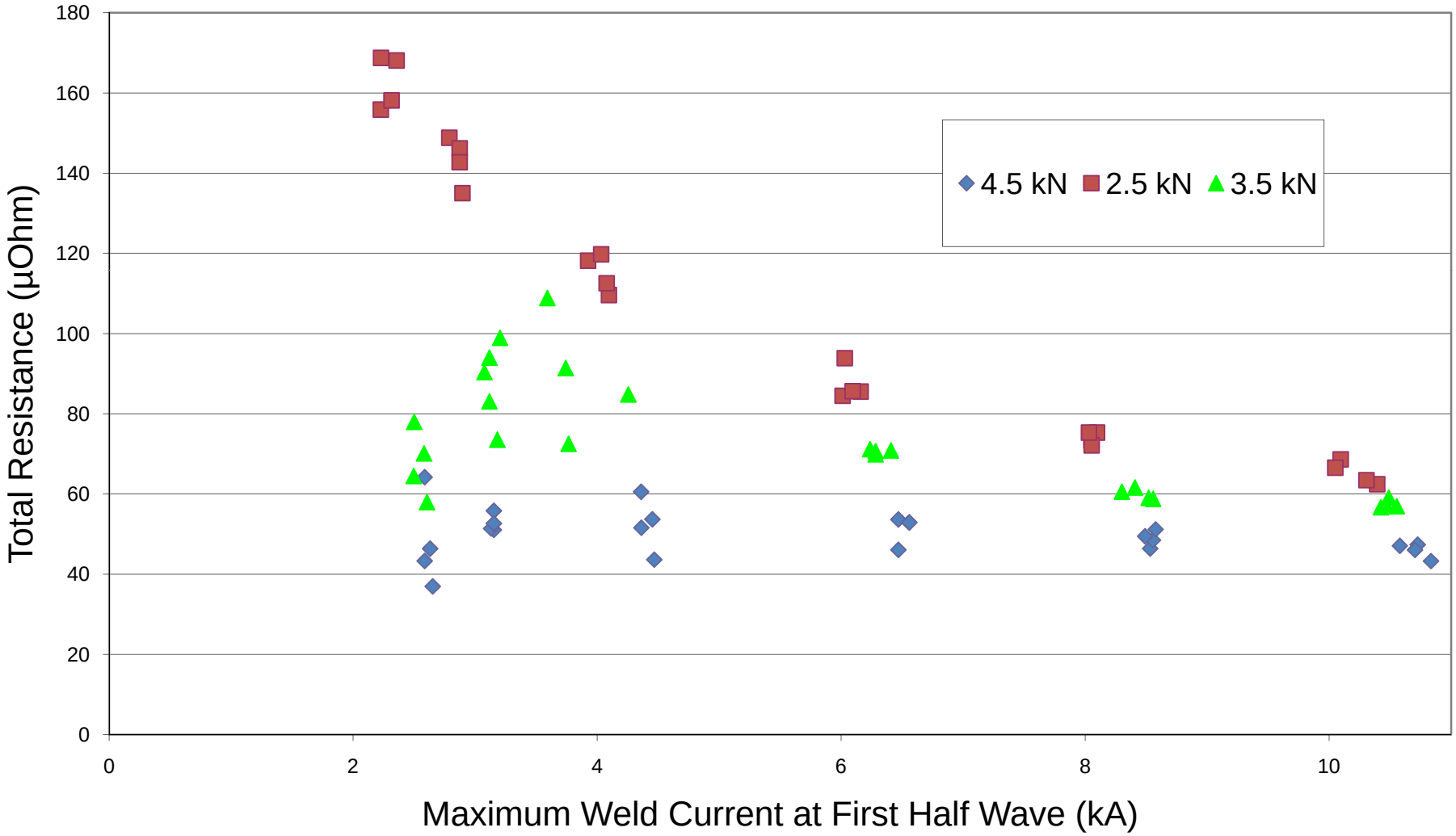
STR1: Normal Simulation Classical Rce shape STR4: Normal simulation Peak Rce Experiment DP600



- Peak in Rce curve measured in experiment for cleaned, uncoated DP600 steel
- Actual values shifted lower compared to input Rce from SYSWELD

gefördert durch:

H180Y Steel Single Sheet Experiments: Influence of welding force on Rce



Conclusions

- *A new method was proposed to measure the electrical contact resistance at the electrode/sheet interface during the welding process*

- *Numerical analysis with SYSWELD verified the accuracy of this method in a defined welding current range ➔ acceptable welding current range depends on value of Rce*

- *The shape of the Rce curve at the electrode/sheet interface for uncoated, cleaned DP600 steel is not the classical exponential decrease, rather there exists a peak in the curve*

gefördert durch:

Outlook

- Rce vs Imax ➔ Rce vs temperature so that it can be used in further RSW simulations

- Influence of zinc coating, organic coating, welding force (interfacial pressure), electrode wear, surface oils, surface oxides can be inexpensively, quickly and easily performed with the new method

- Numerical techniques to find Rce at sheet/sheet interface using 2 sheet welding

gefördert durch:

Thank you for your attention!!!!

gefördert durch: