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New Modeling Technique for Pre-Strained Heat Treated Aluminium Sheets

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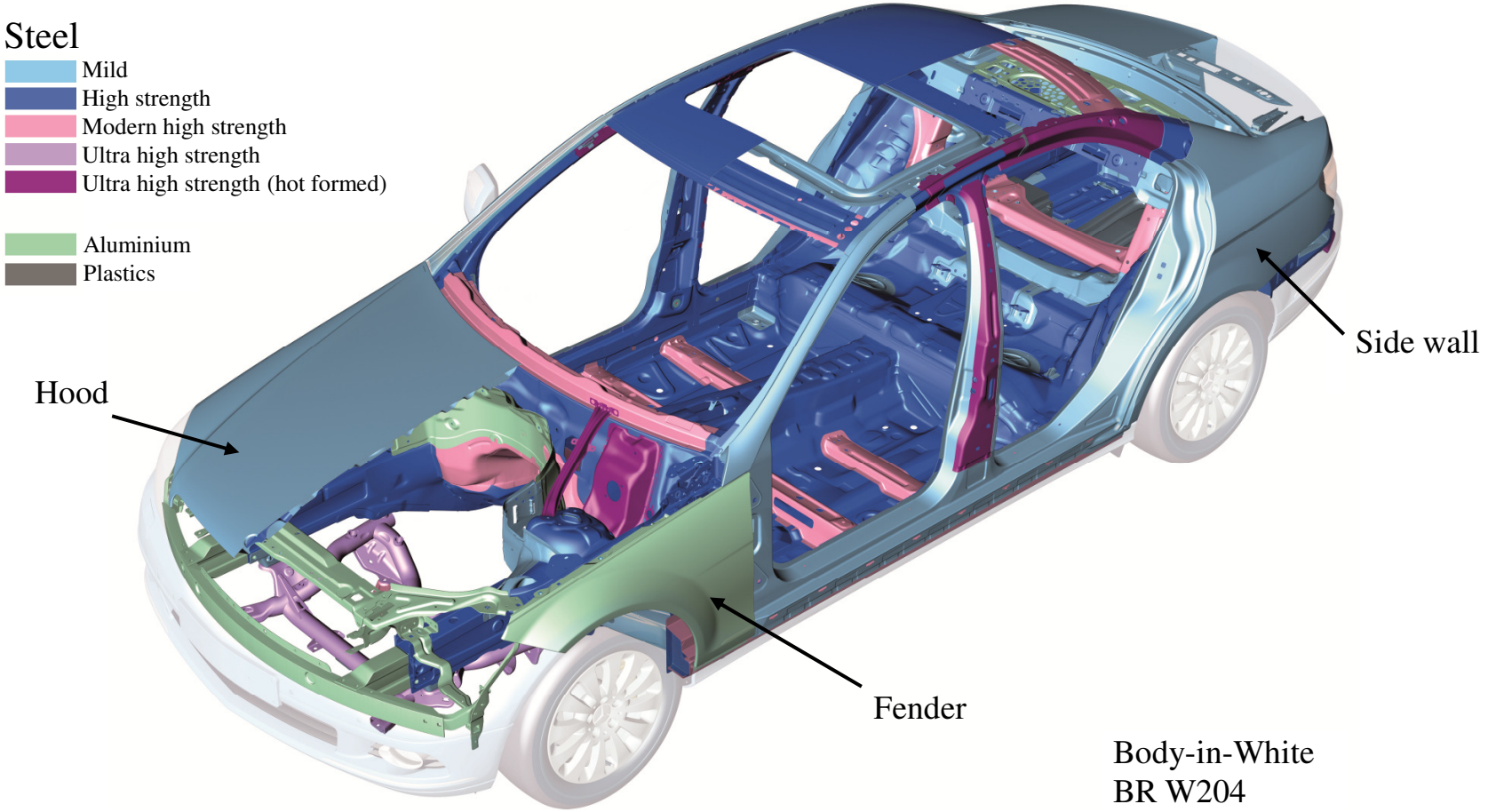
Agenda

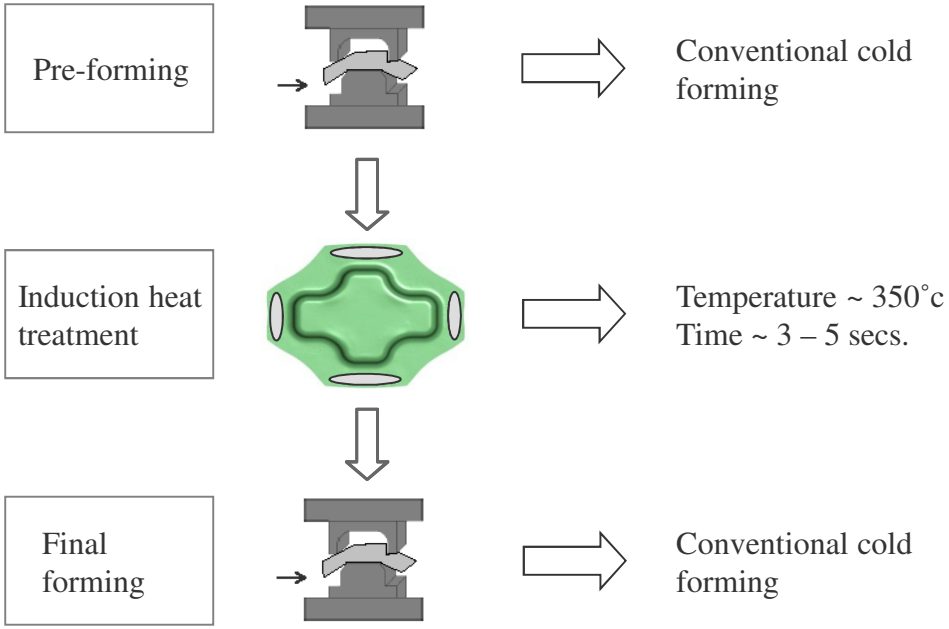
- Introduction
- Intermediate Induction Heat Treatment or Heat assisted forming
- Material behaviour
- New Modelling Technique
- Experiments and validation ⟶ Cross die deep drawn cup
- Conclusion and Discussion

Lightweight construction



Induction heat treatment (IIHT): Process principle

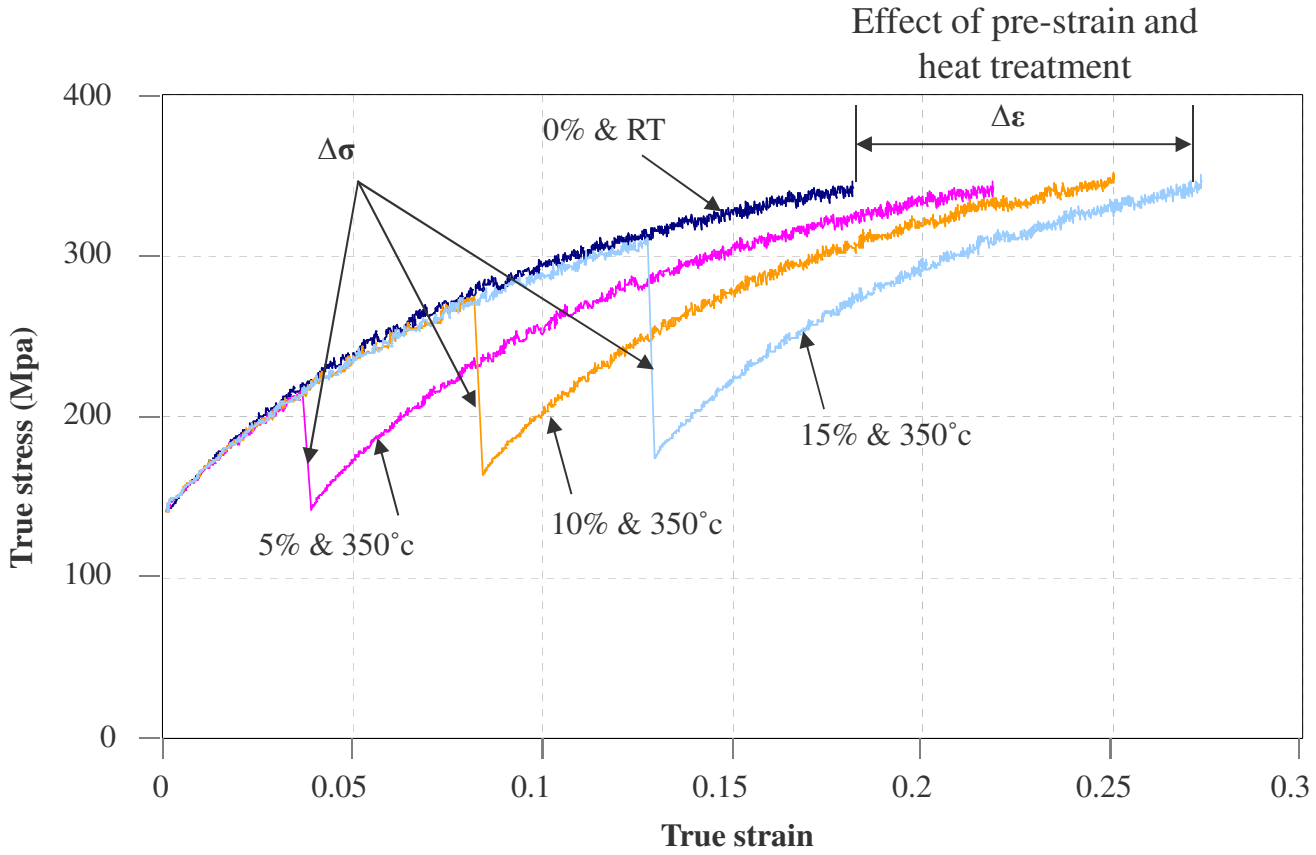
Intermediate Induction Heat Treatment



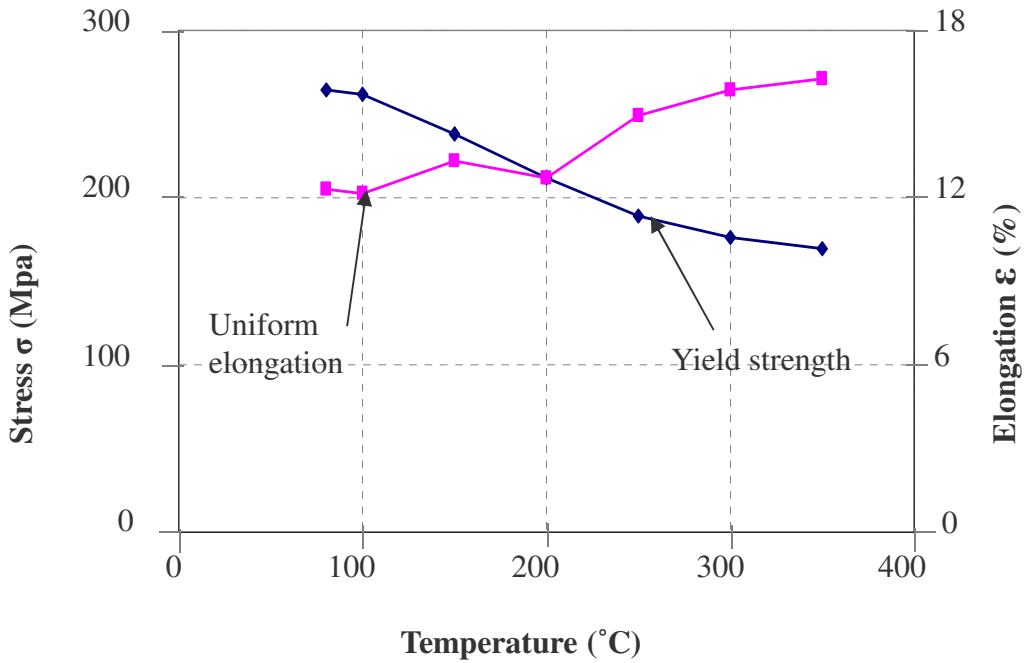
- 1st stage – Part is pre-formed to approx. 90% of its final shape
- 2nd stage – Part is heated up locally with an induction heating tool to approx. 300 - 350˚c for about 3 to secs.
- 3rd stage – Part is cooled down to room temperature and then formed to final shape

Induction heat treatment (IIHT): Material behavior

Material behavior: AA5182, t=1.5mm, Flow curves



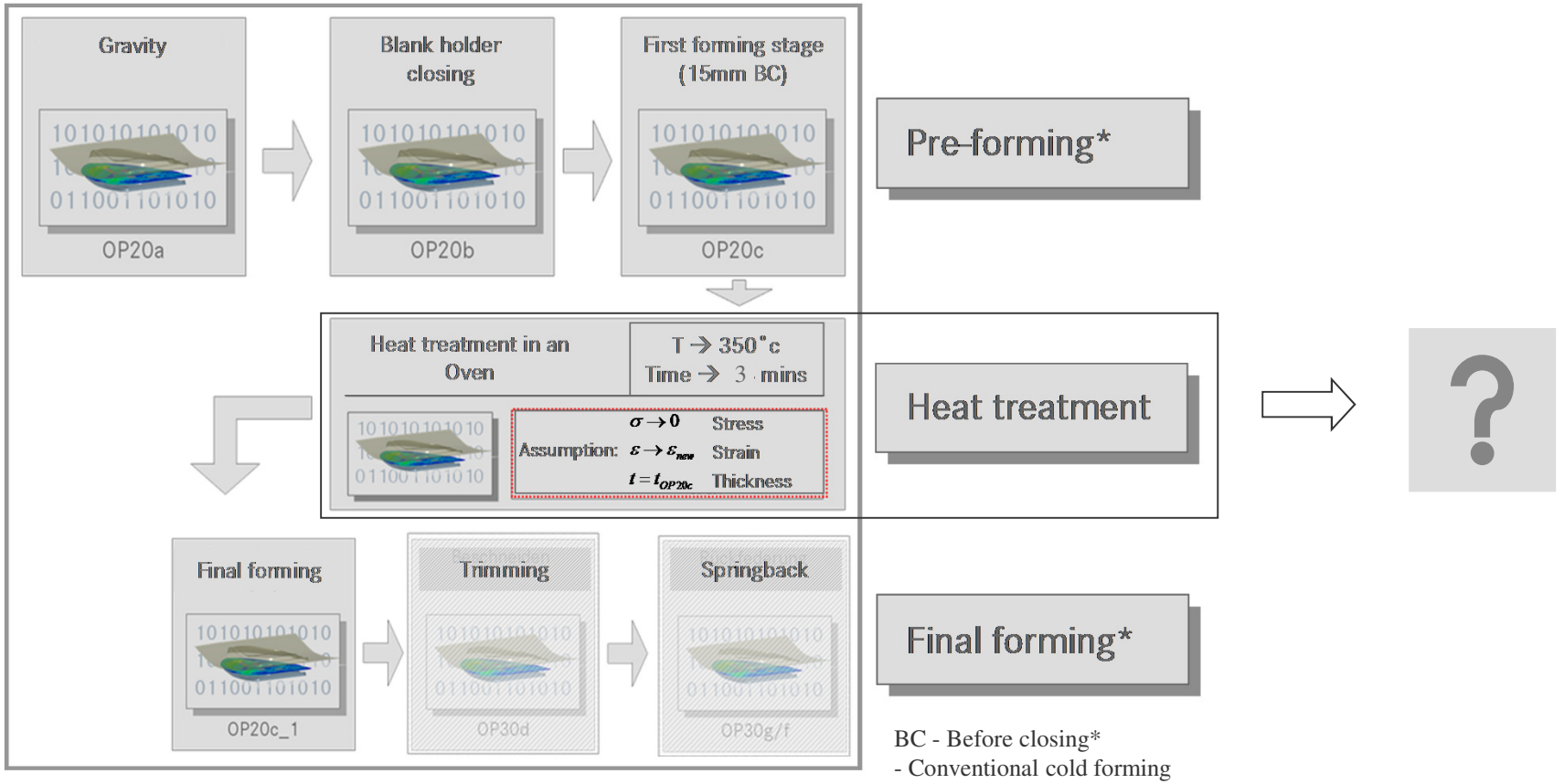
Material behavior: AA5182, t=1.5mm



Pre-strain - 10%

Induction heat treatment (IIHT): Simulation

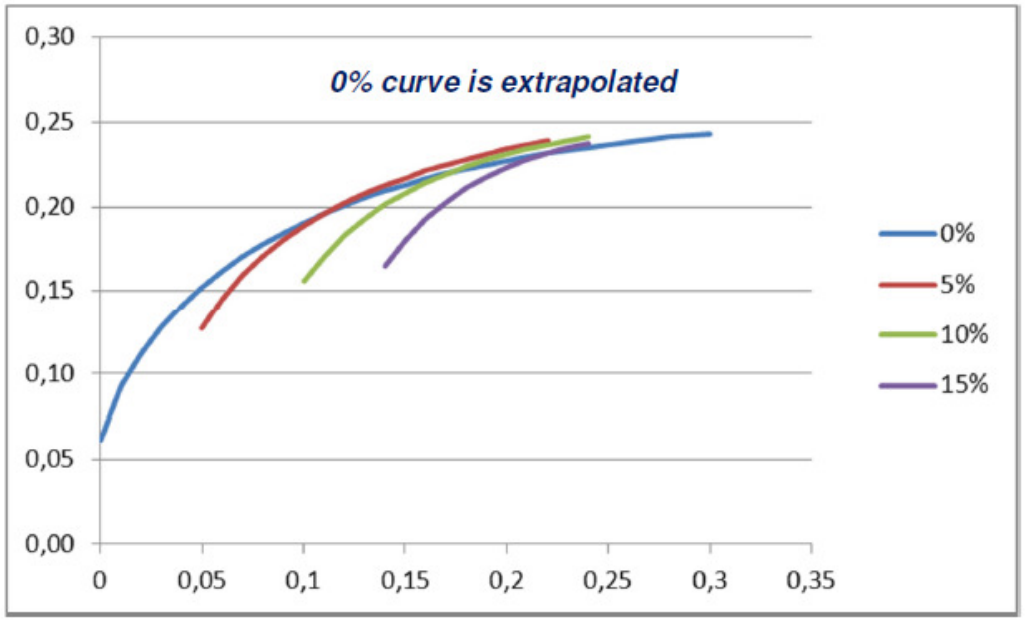
Modeling intermediate heat treatment

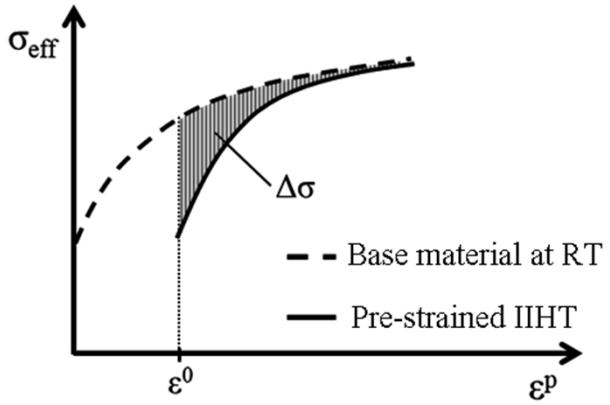


BC - Before closing*
- Conventional cold forming

Modeling intermediate heat treatment

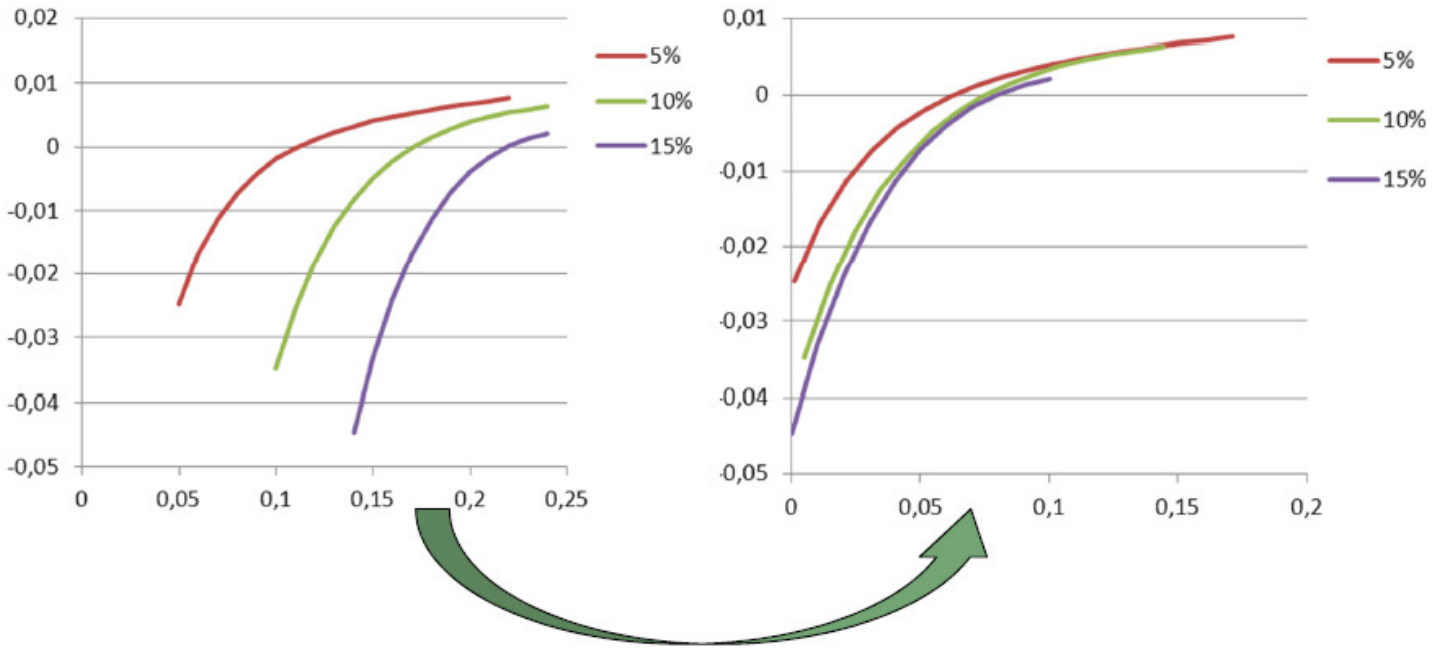
- Tensile test interupted at varying prestrains at room temperature
- Heat treatment of prestrained specimen at specific target temperature
- Tensile test at room temperature after heat treatment
- Heat treatment lowers yield strength
- Heat treatment increases effective hardening modulus → gives more formability





Modeling intermediate heat treatment

$$\Delta\sigma = \sigma_{prestrain} - \sigma_{0\%}$$

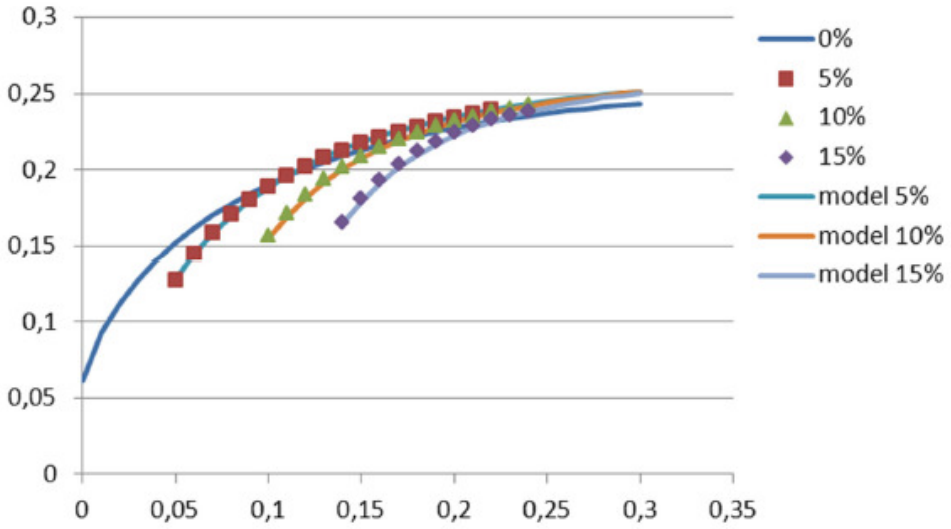


Print $\Delta\sigma$ vs. ε^{p}-ε_{pre}

Modeling intermediate heat treatment

$$\sigma_y\left(\varepsilon_{eff}^p, \varepsilon_0^p\right) = \sigma_y\left(\varepsilon_{eff}^p\right) + \Delta\sigma\left(\varepsilon_{eff}^p, \varepsilon_0^p\right)$$

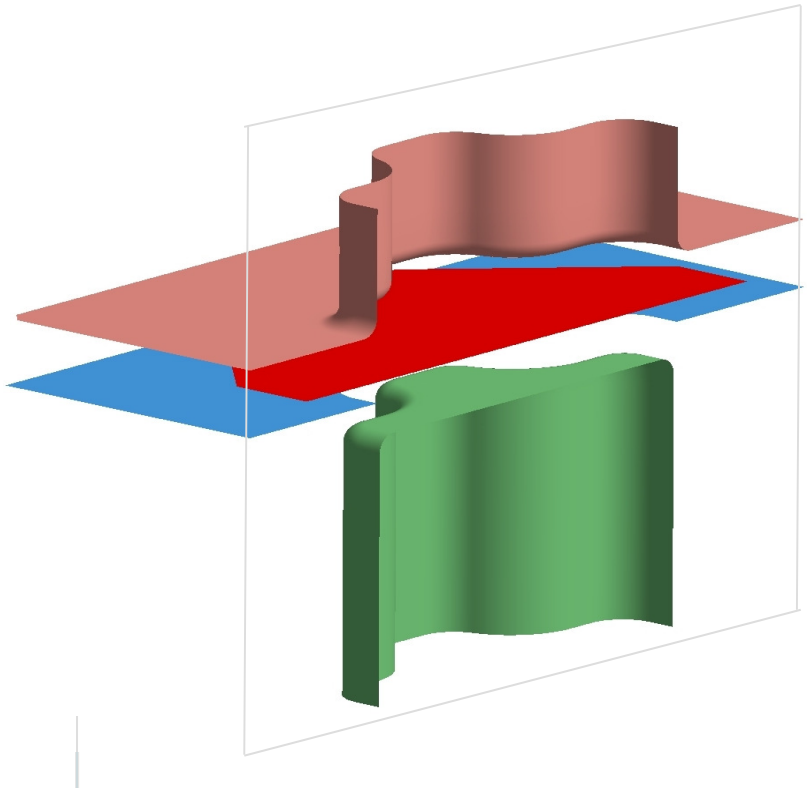
$$\Delta\sigma\left(\varepsilon_{eff}^p, \varepsilon_0^p\right) = b - (b-a)\cdot\exp\left(-c\left[\varepsilon_{eff}^p - \varepsilon_0^p\right]^d\right)$$

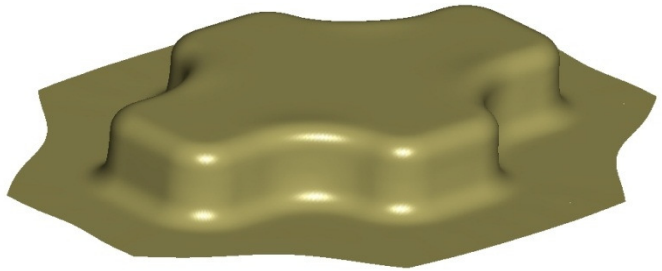


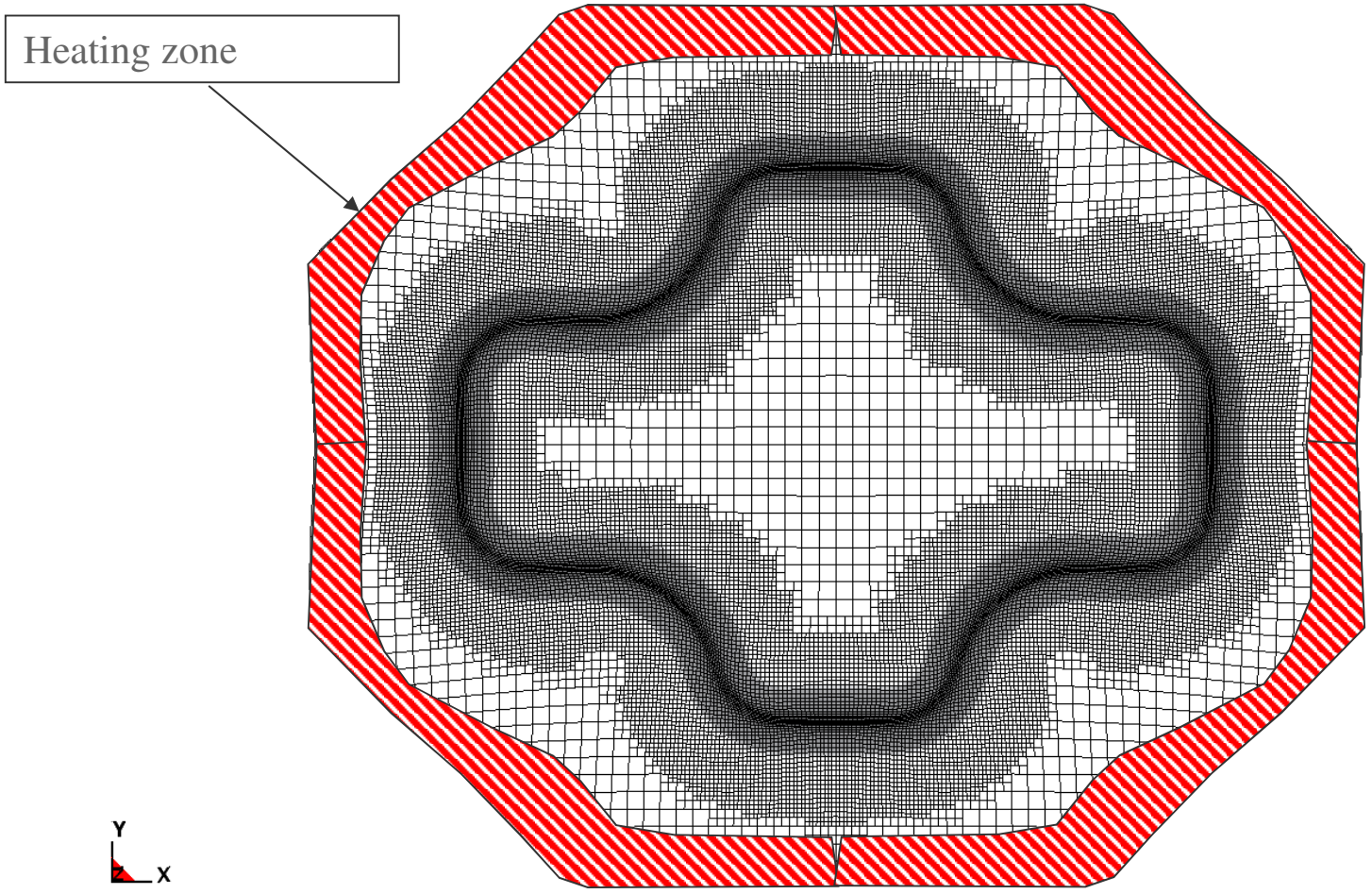
→ very accurate prediction of the measured yieldcurves

Induction heat treatment (IIHT): Validation with Cross die

Cross die – Experiments and Numerical simulations

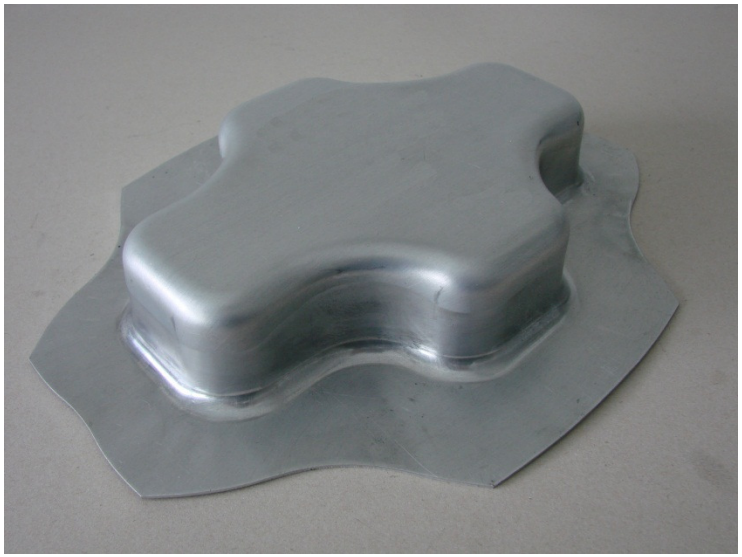




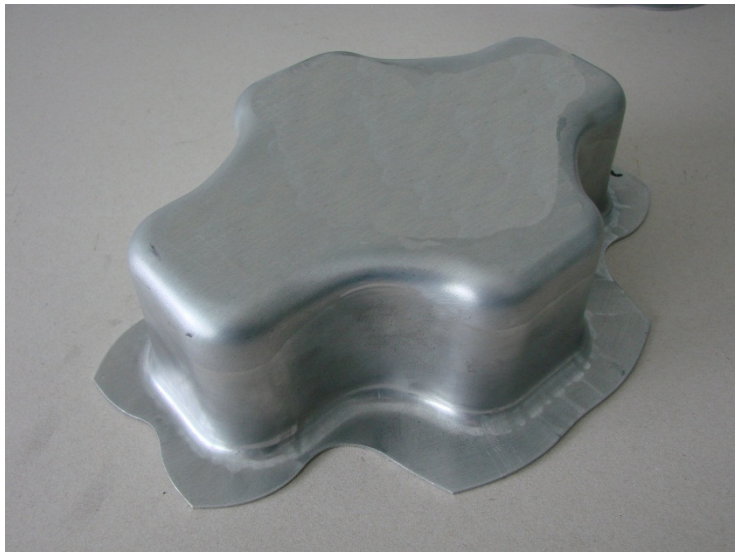


Temperaturen bei der induktiven Erwärmung am vorgezogenen Cross Die lagen zwischen 250°C und maximal 350°C

Cross die - Experiments

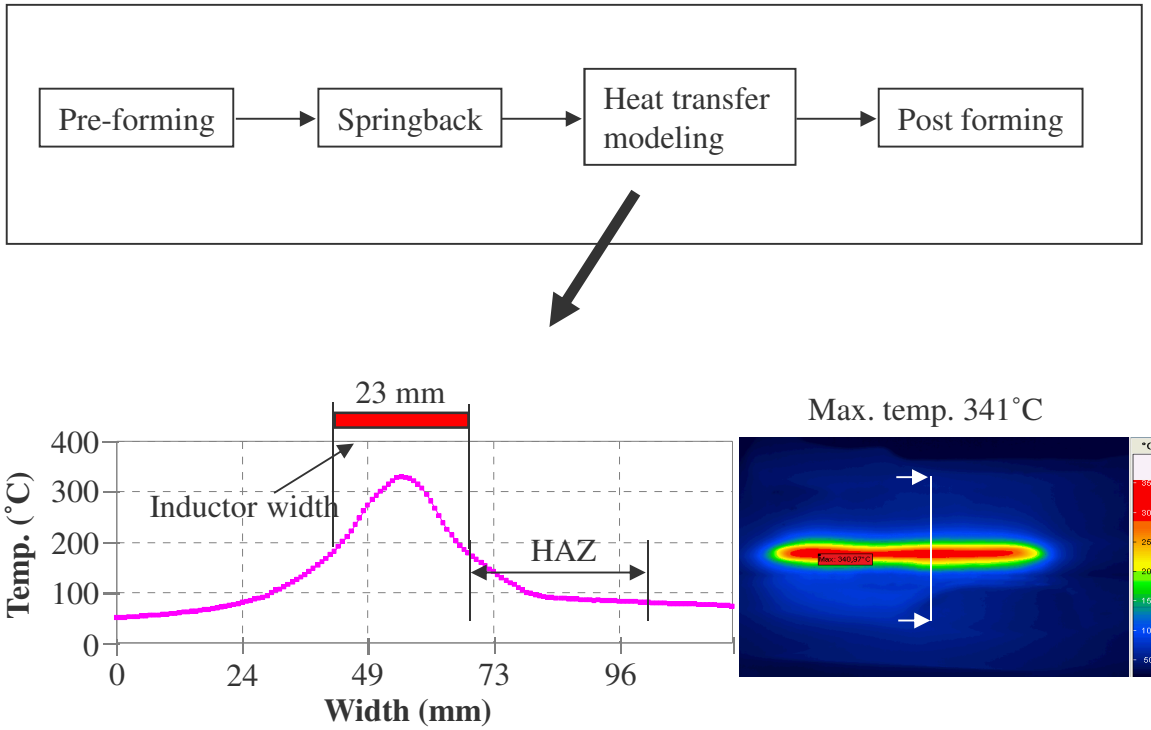


Cold forming
Draw depth - 47mm



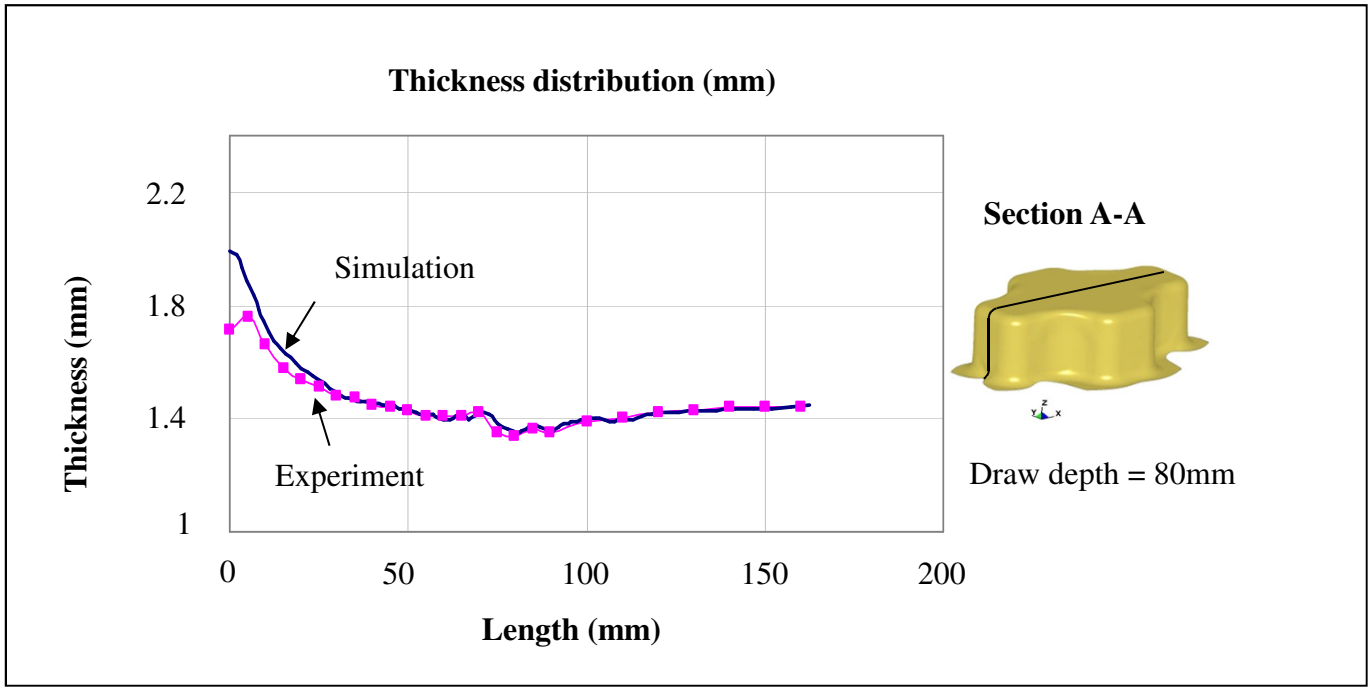
Induction heat treatment
Draw depth - 80mm

Simulation procedure

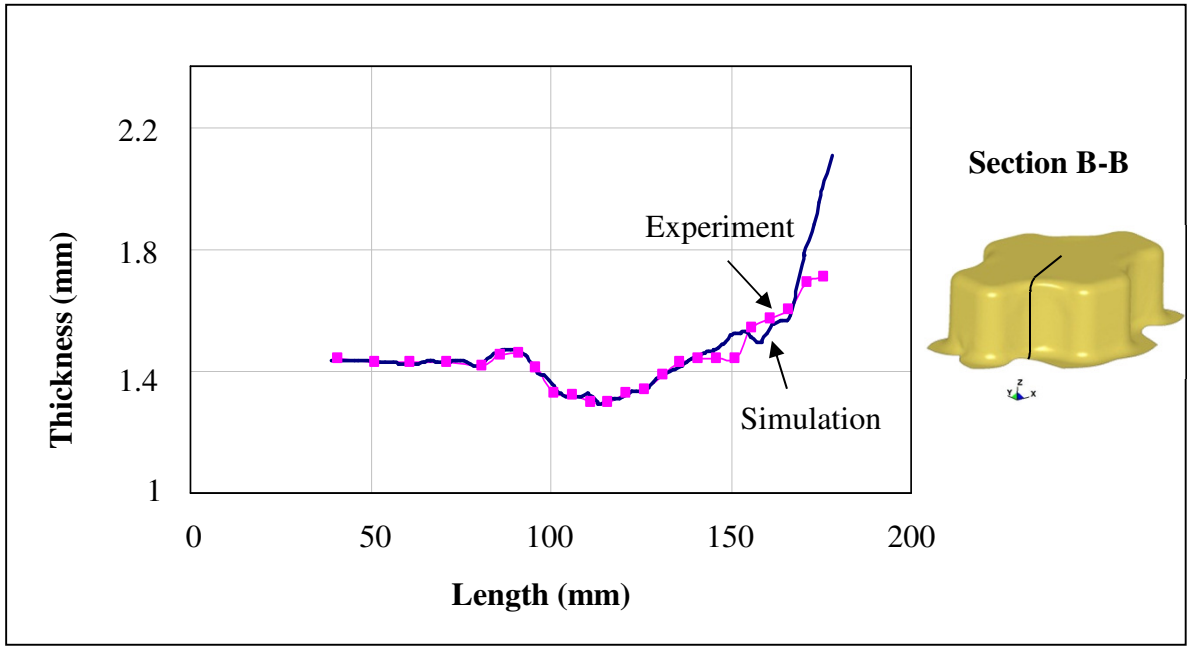


- Calculation of heat affected zone is very important
- Heating simulation is required

Validation


Thickness distribution (mm)
Thickness (mm)
2.2
1.8
1.4
1
0
50
100
150
200
Length (mm)
Simulation
Experiment
Section A-A
Draw depth = 80mm

Validation


2.2
1.8
1.4
1
Thickness (mm)
0
50
100
150
200
Length (mm)
Experiment
Simulation
Section B-B

Conclusion

- Formability of Al-Mg alloy AA5182 has greatly enhanced through Heat assisted forming
- The developed modeling technique is suitable for both Tailor heat treated blanks (THTB) and pre-strained components. It is also suitable for a variety of automotive aluminium alloys.
- Thermal simulation of heat treatment results in proper prediction of heat affected zone.
- Localized heating often results in part distortions due to residual stress gradient. Further research is needed to identify the capability of this technique to capture this effect.

Thank you for your attention!