

Simulation with thermosets

*based on material data
collected in a real molding process*



Our services – provided in

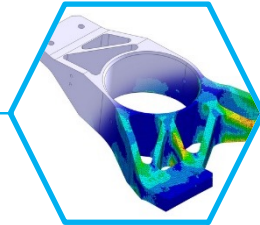


Core area = technology in thermosets

Design optimization

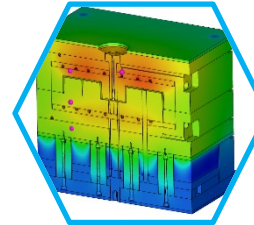
Process simulation

Structural simulation (FEA)



Thermal analysis of molds

Structural analysis of molds



Project support (external)

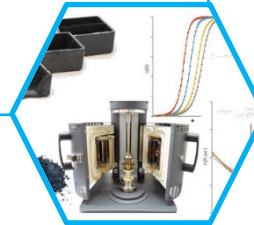


Expert Advice

Material characterization

Rheology

Mech. properties



Inhouse Tech-Coaching

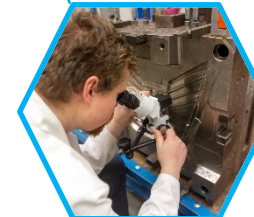
Practical Training @ TTC*



Material trials with customer molds

Initial mold testing

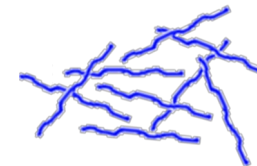
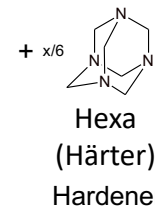
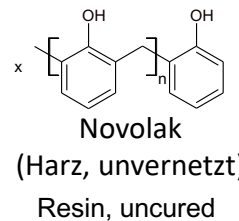
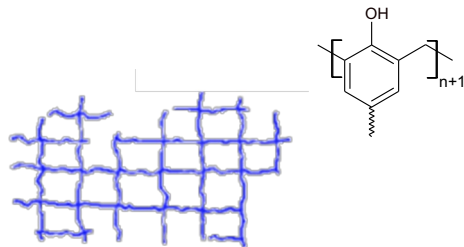
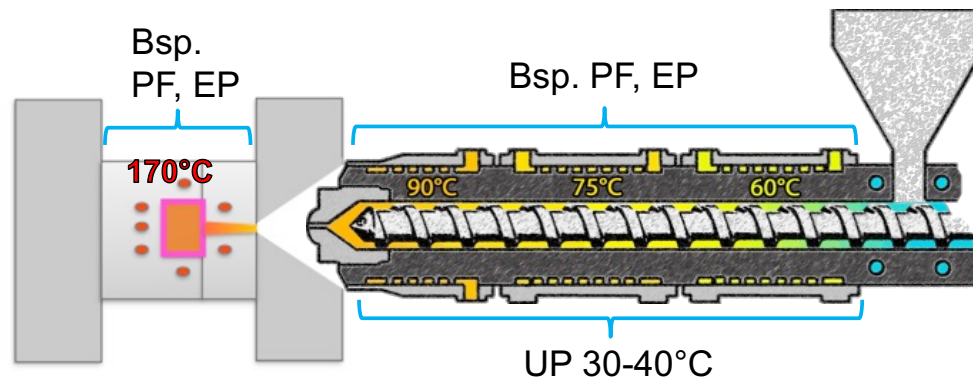
Process optimization @ TTC



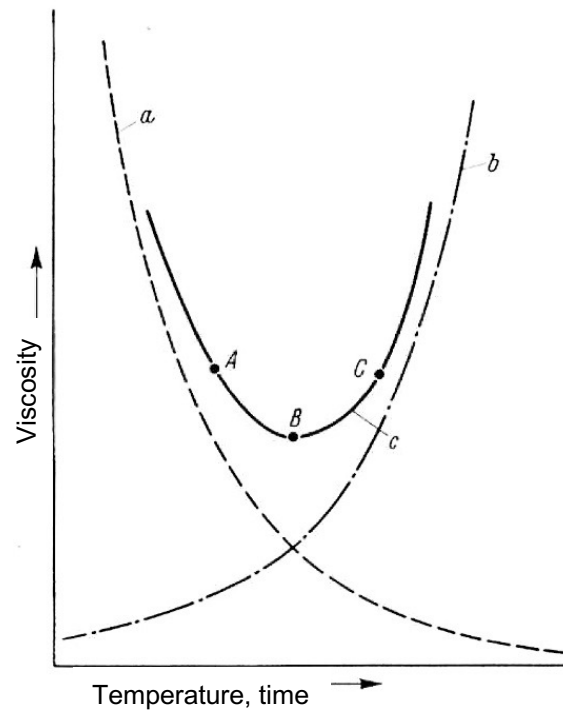
* TTC: Thermosets Technology Center – Gaißach - Germany

Injection molding of thermosetting materials

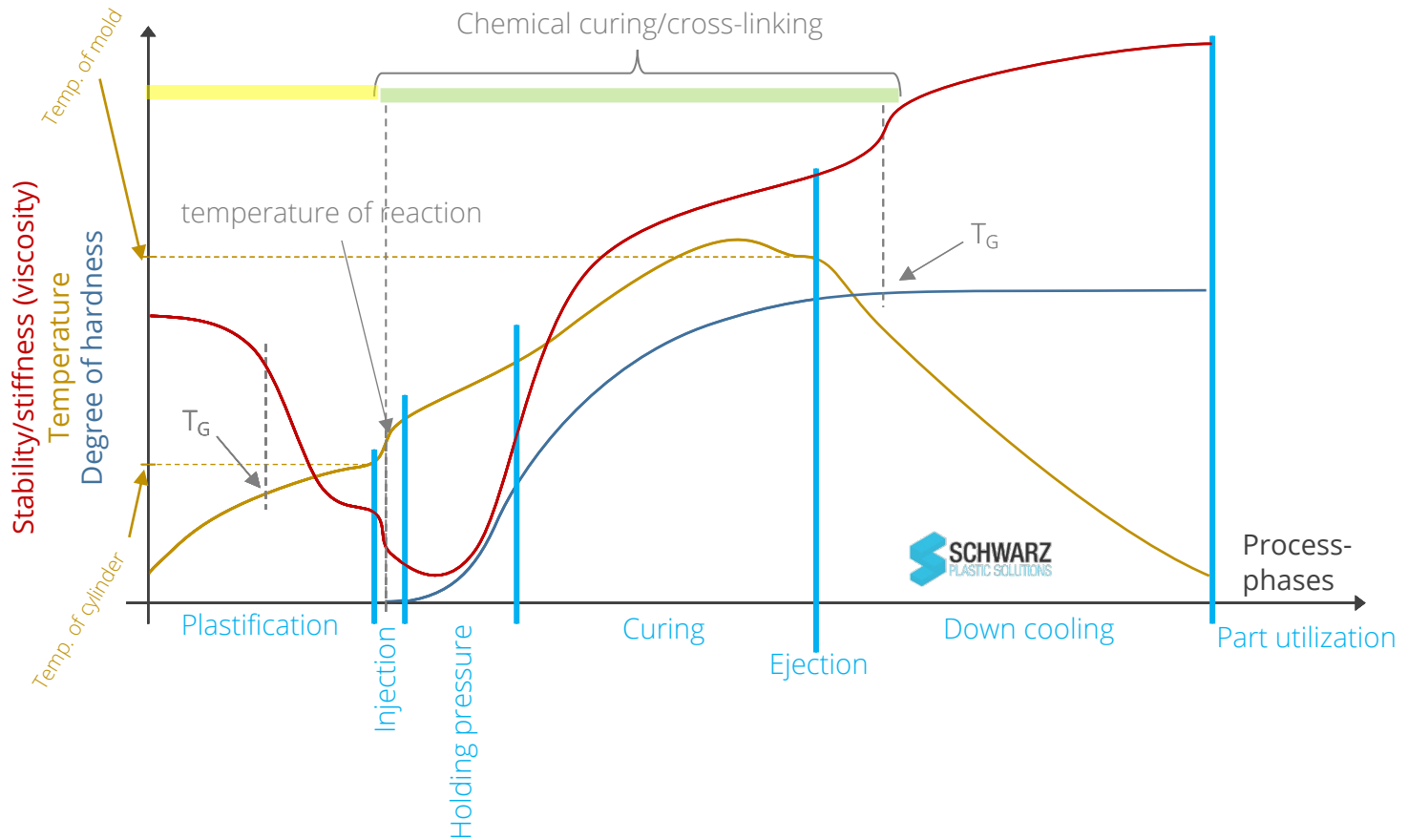
- ⚡ Chemical curing-/cross-linking process whilst material processing



- Chemical curing-/cross-linking process during molding acc. to up to now literature

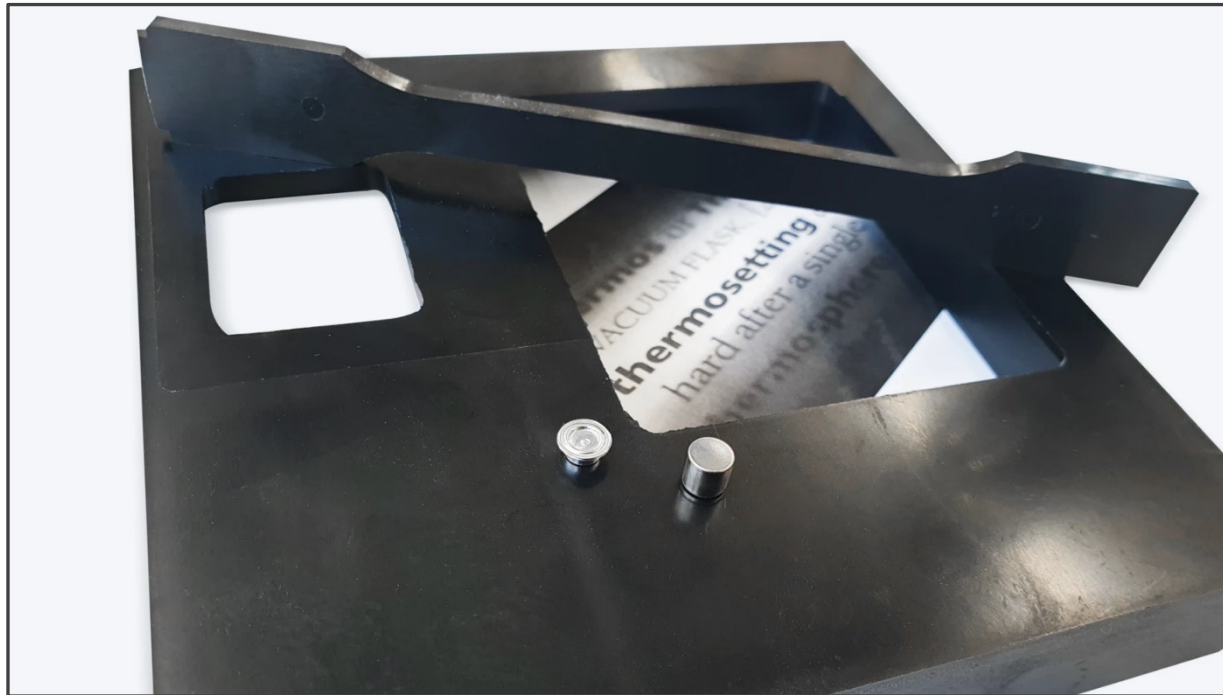


Chemical curing-/cross-linking process during molding in reality

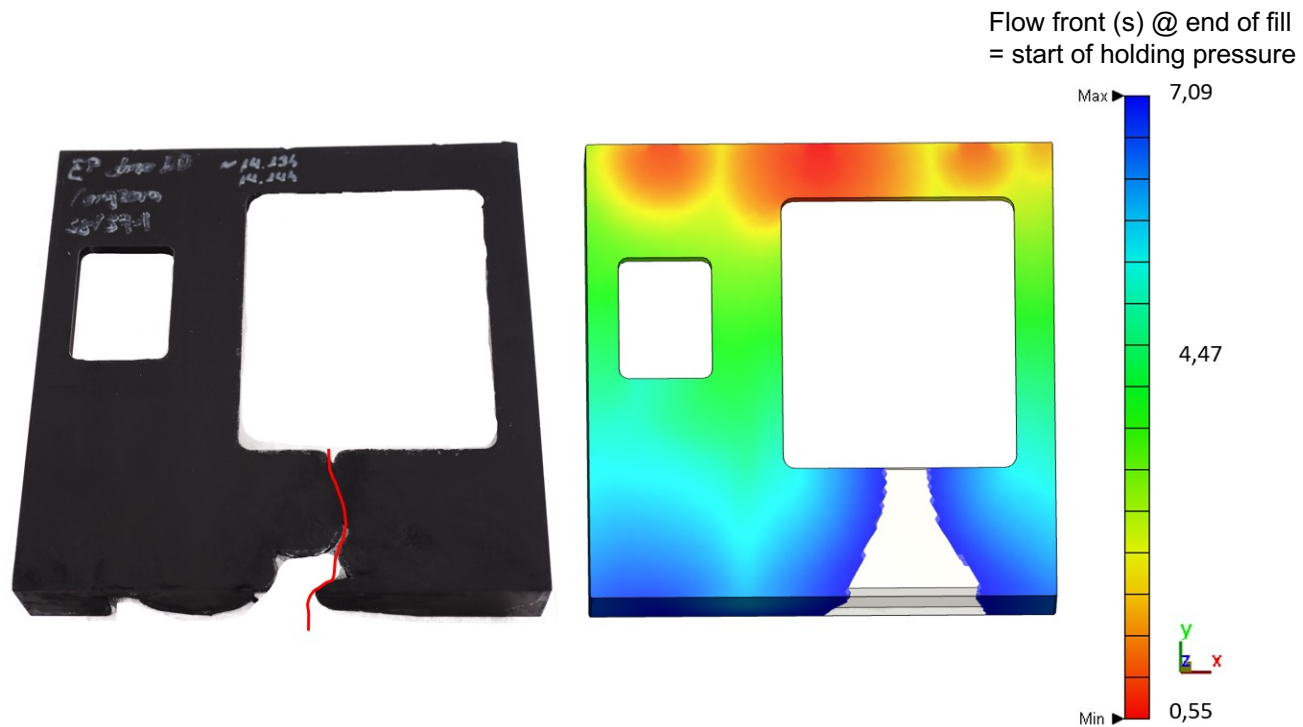


* the axis of process phases may be understood as a principal time-line, however, due better visualization the phase of down cooling has been shortened significantly related to the other phases.

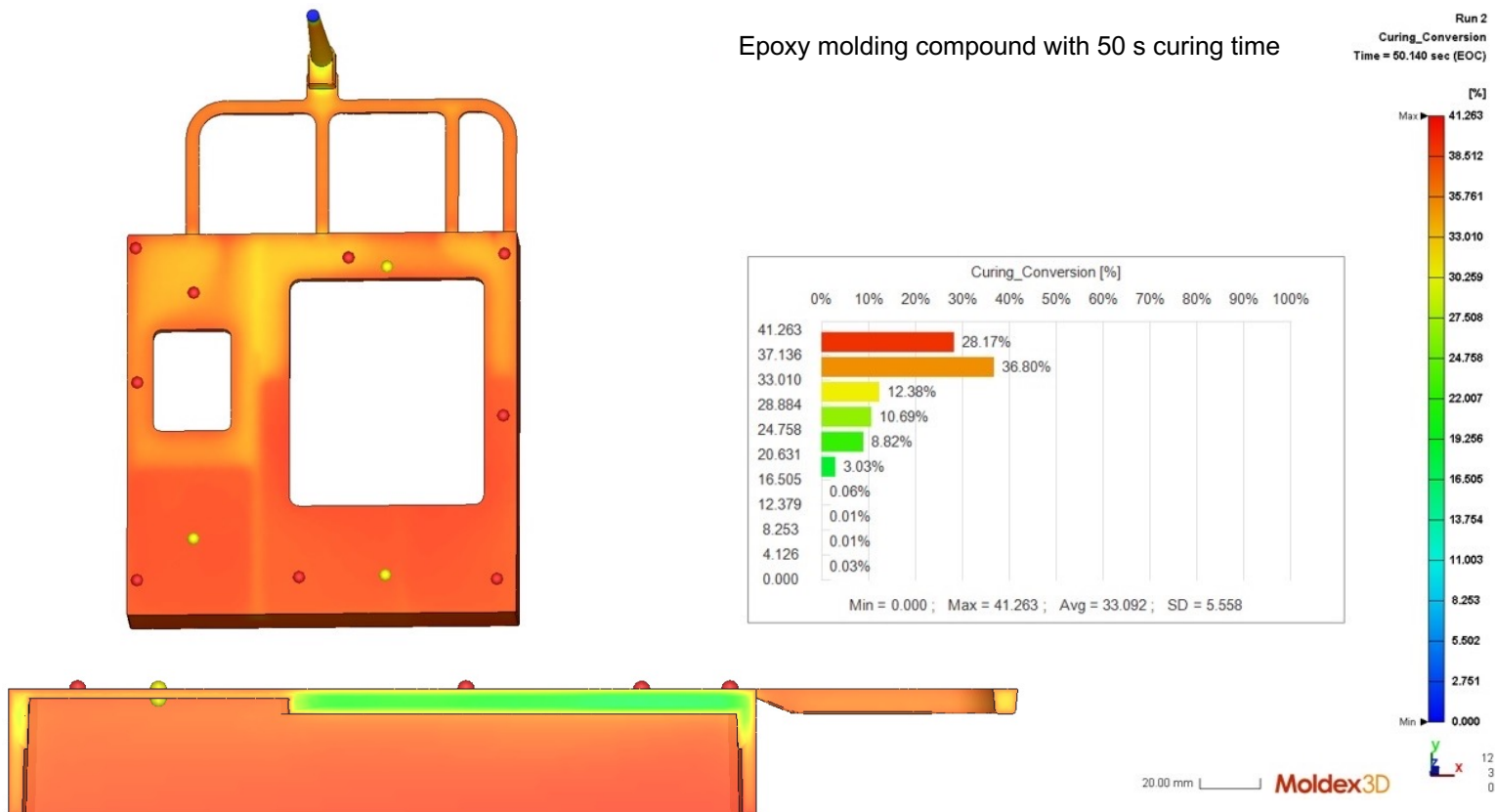
- How precise is simulation with thermosets? Where are deviations to the real process?



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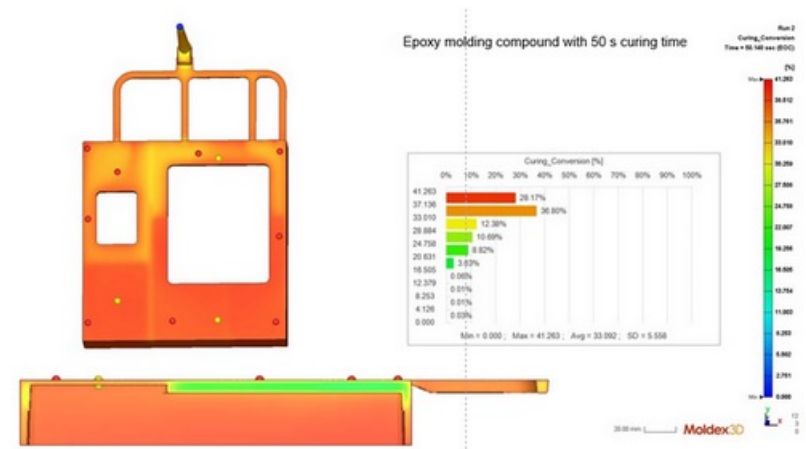


How precise is simulation with thermosets? Where are deviations to the real process?

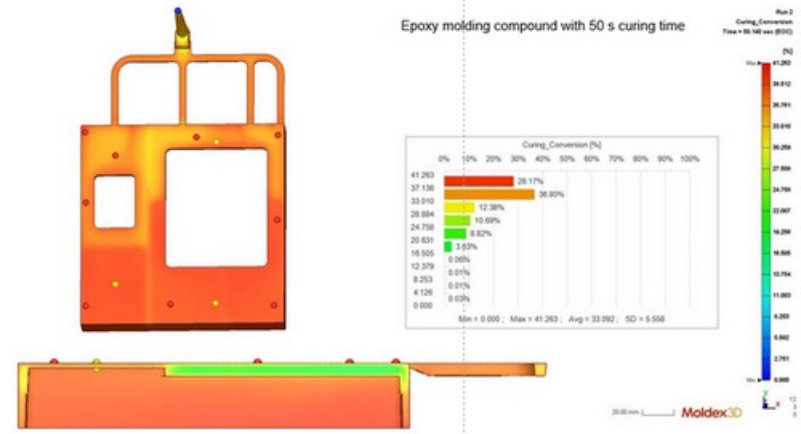
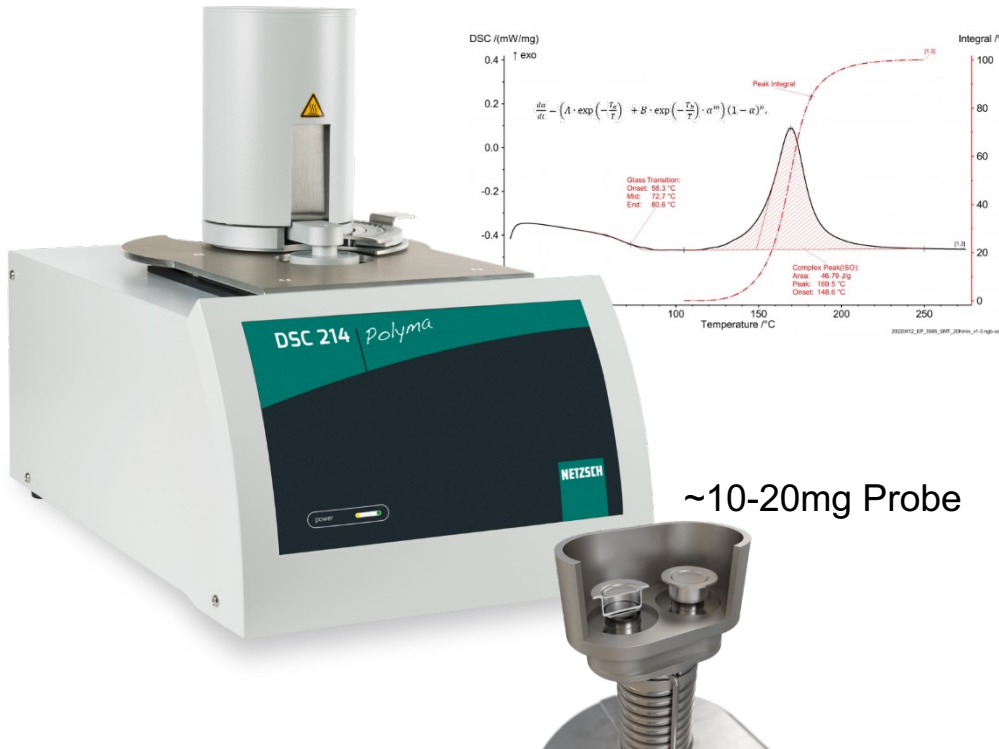
What effect will it have in practical cases?

Uncertainties when calculating parts and processes made of thermosets

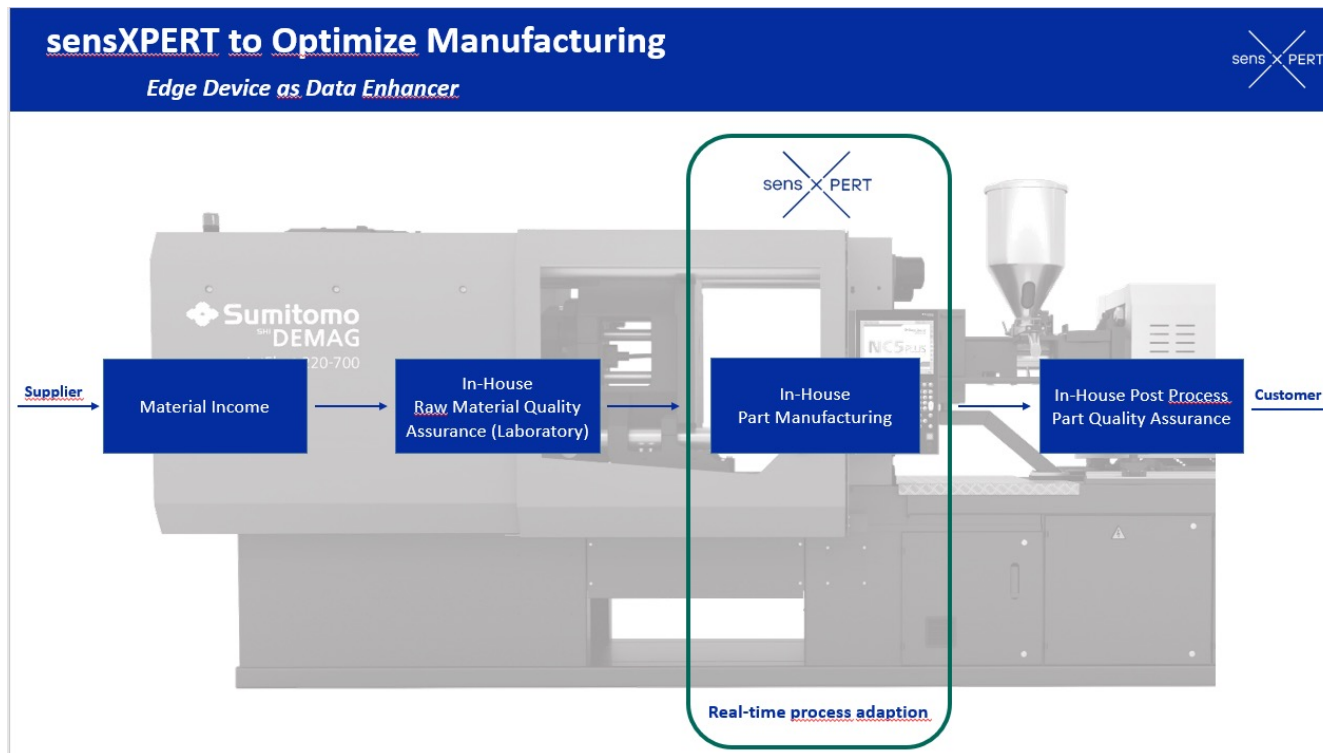
In case of doubt decision against thermosets



- How precise is simulation with thermosets? Where are deviations to the real process?
- How are materials measured and material data generated?



- Cooperation with sensXPERT[®] „Turning Data into Quality“ (AI-based process control)



sensXPERT is a brand name of Netzsch Process Intelligence GmbH


Our cooperation with sens XPERT[®] „Turning Data into Quality“ (AI-based process control)



Substantial investment is building the platform for data collection:

- An injection mold with integrated sensors (DEA; pressure; temperature) for signals to sensXPERT
- Platen 150 x 160 x 4 mm with variable gates
- Test bars (ENISO 527-2 Type 1B) with interchangeable film gates
- Box (housing) with different wall thickness and variable gate positions (1 x – 4 x)
- Capillary-rheometer in new, innovative design
- Cavity for over-molding (encapsulation) of electrical coilformers (testing of wire fixation)
- Injection molding machine with interchangeable plastification units (BMC and free-flowing thermosets from 440 – 1.600 cm³), an innovative core compression unit and access to machine data to feed sensXPERT



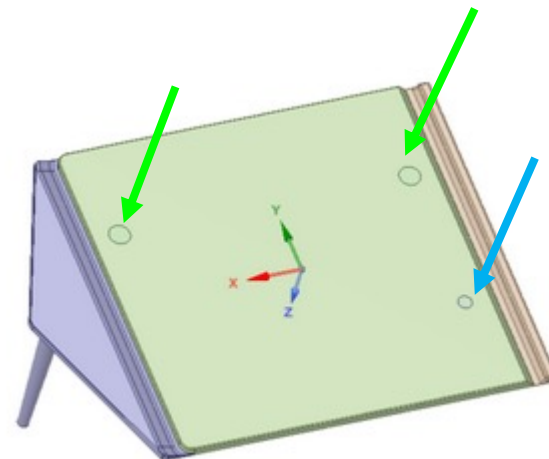
Our cooperation with  „Turning Data into Quality“ (AI-based process control)

DEA-sensor
(Di-electric analysis)

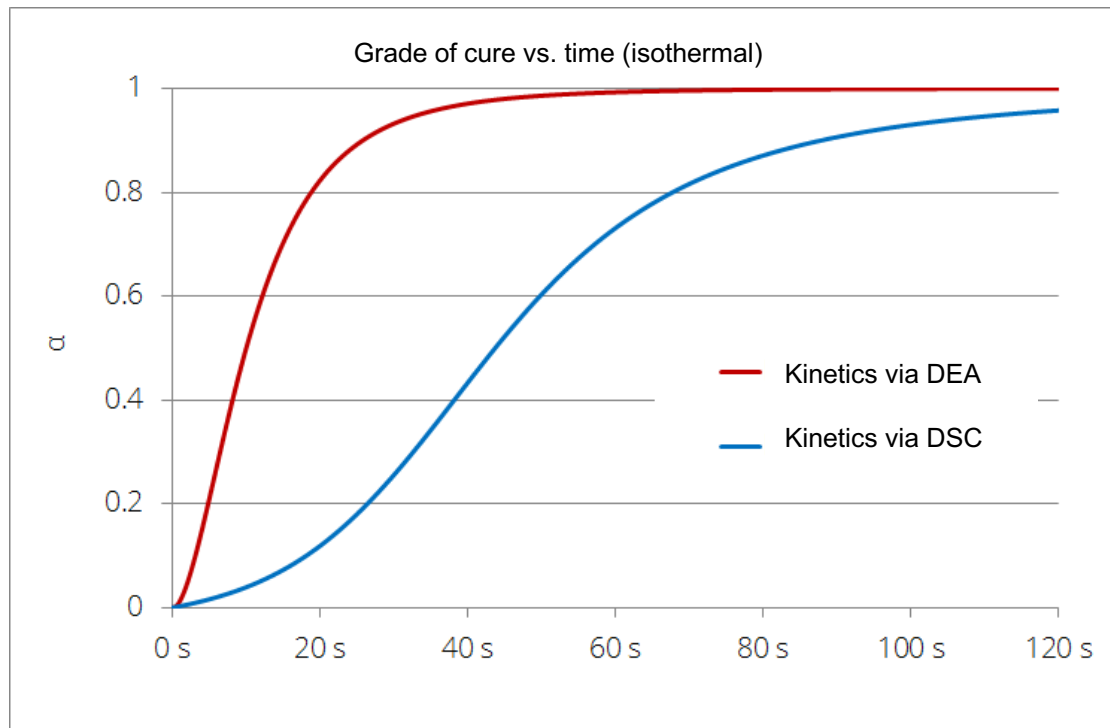
Injection molds



- Cavities:
1 - with integrated cavity pressure sensor (end of flow – blue) and di-electric (DEA) sensor (interchangeable from behind gate to end of flow - green)
- Gate:
Film – three insert with different gates (e.g. thickness 0.8 mm, 1.5 mm, 2.5 mm)



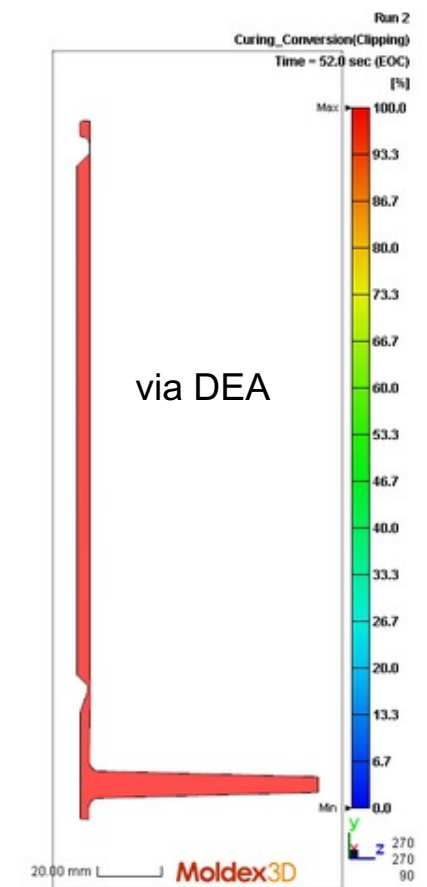
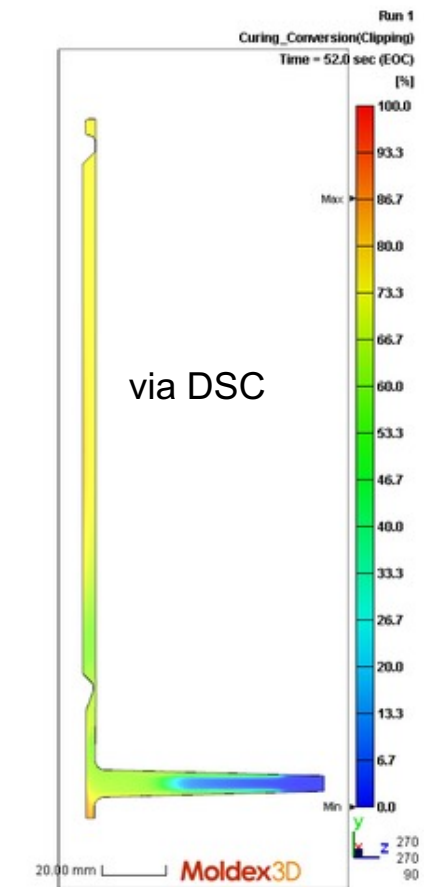
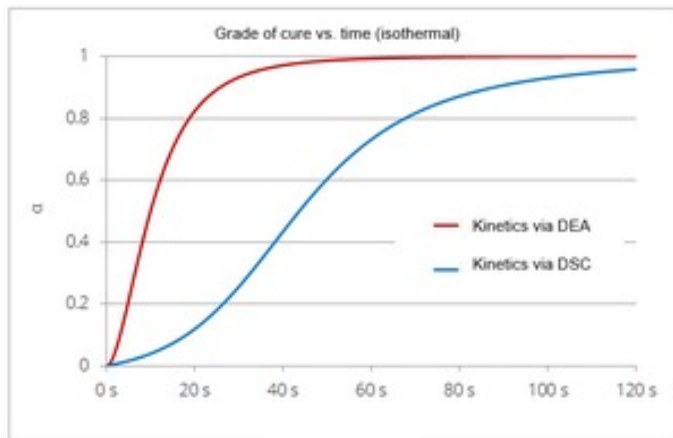
➤ Determination of reaction kinetics: DSC vs. DEA



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➤ After 52 sec the achieved curing:

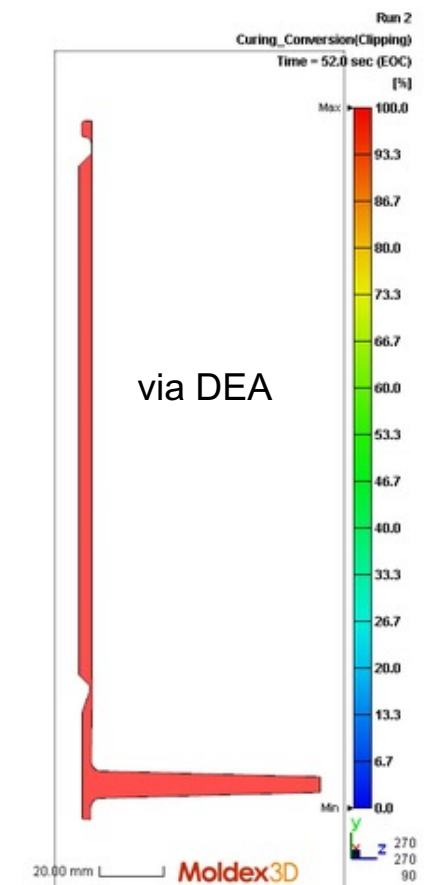
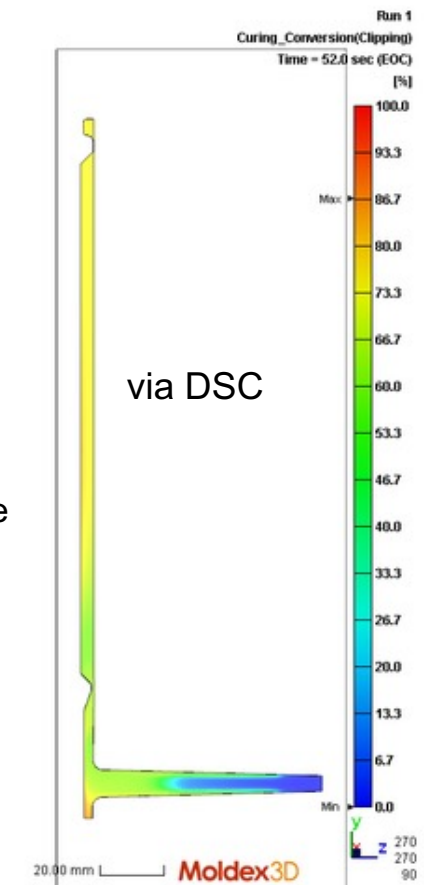
86 % based on DSC
100 % based on DEA



➤ Determination of reaction kinetics: DSC vs. DEA

➤ Application of DEA data shows:

- Curing levels near to practical situation
- about 40% higher injection pressure required
- about 20% reduced cavity pressure effective



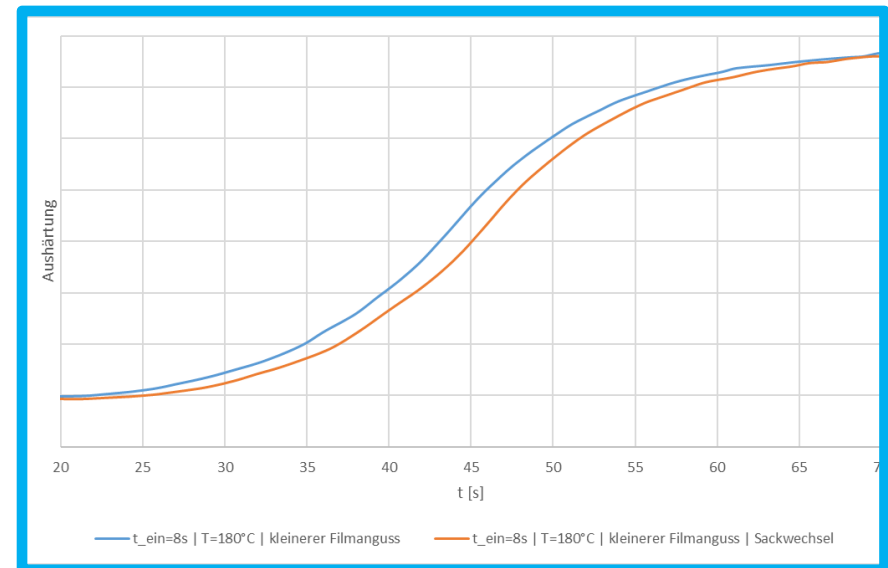
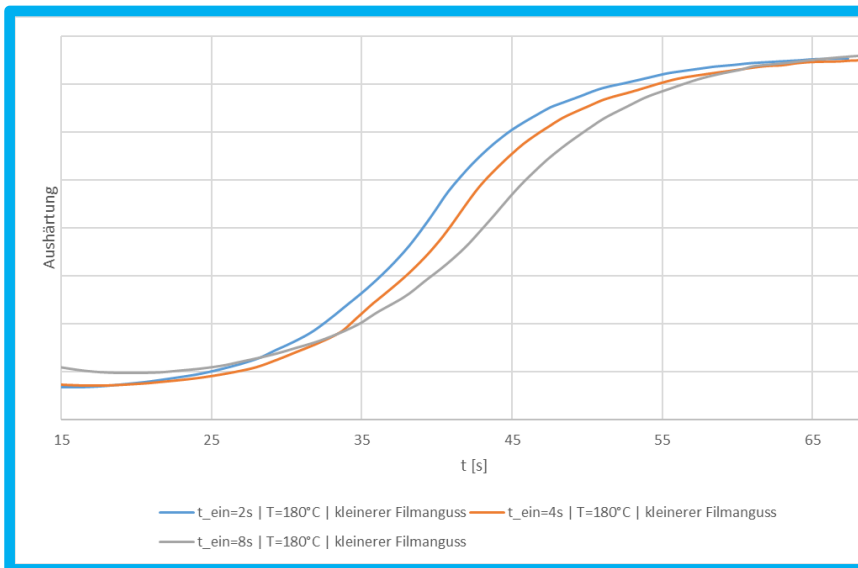
Real-time material characterization and process control



allows recognition of ...

... process variations

... material variations (lot to lot)



Tests are running with high performance molding compounds based on

↳ Polyester (BMC = buld molding compound)

↳ Epoxy (free flowing)

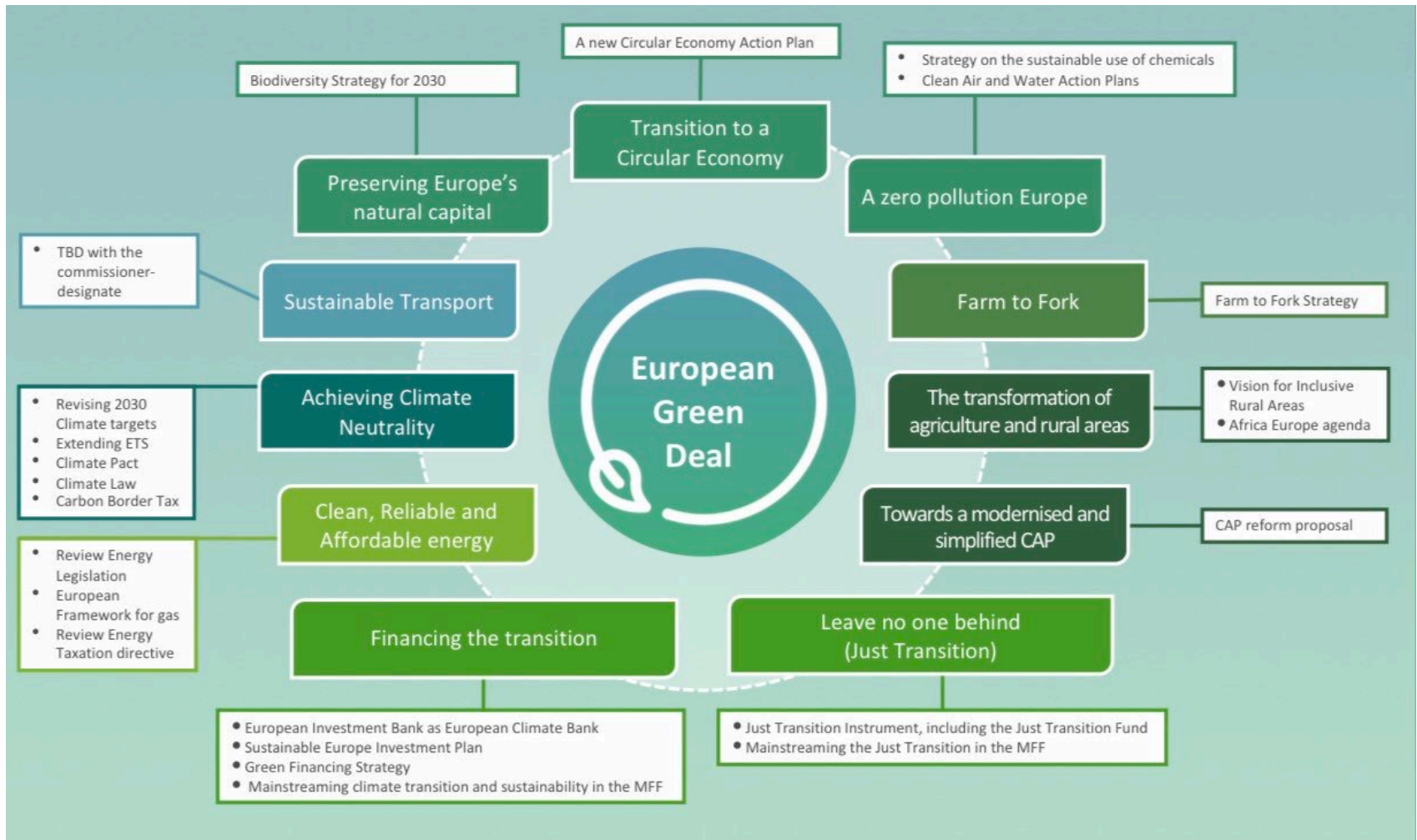
↳ Phenolic resing (free flowing)

↳ currently provided by:



↳ and from July 2023 we will start testing thermoplastic materials

Why all these efforts?

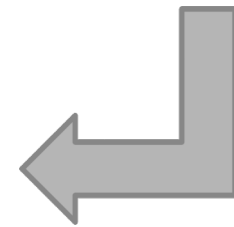
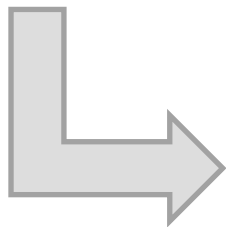


Europe decided to become CO₂ neutral till 2050 (55% reduction → 2030)

- ⚡ **Environmental laws**
- ⚡ **Occupation co-operative regulations**
- ⚡ **Trade supervisory office**
- ⚡ **Certifying bodies**
- ⚡ **Taxonomy**
- ⚡ **SFDR** (Sustainable Finance Disclosure Regulation)
- ⚡ **CSRD** (Corporate Sustainability Reporting Directive)
- ⚡ **MiFID II** (Markets in Financial Instruments Directive)

Effect for industrial entities

- ⚡ **Reporting (in detail) in the annual balance sheet**
- ⚡ **Change of product range**
- ⚡ **Credit allocation restrictive**



The plastic industry will need more data to prove these actions →



We are grateful for the support of our partners

Partners in this project

- Netzsch Process Intelligence GmbH
represented by
Dr. Alexander Chaloupka (CTO)



- Netzsch Gerätebau GmbH
represented by
Dr. Natalie Rudolph



- Steinbeis Technology Group (Dresden, Germany)
member of Steinbeis Hochschule Berlin
represented by
Prof. Dr.-Ing. Sascha English



Partners in thermosetting materials technology



University
of Wisconsin (USA)



University
Erlangen (GER)



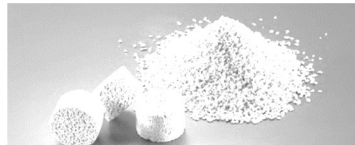
University of Applied Sc.
Rosenheim (GER)



Simulation Software
(TWN – GER)



Mold specialist
(GER)



*Consulting – Simulation - Project-support –
Education of staff - Material characterisation*

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