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)
- 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

Presentation for TOPCON - 2023
Injection molding of thermosetting materials

Chemical curing-/cross-linking process whilst material processing

Bsp. PF, EP

170°C

Bsp. PF, EP

UP 30-40°C

Novolak (Harz, unvernetzt)

Resin, uncured

Hexa (Härter)

Hardener

Presentation for TOPCON - 2023
Injection molding of thermosets

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

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

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

Epoxy molding compound with 50 s curing time

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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
Injection molding of thermosets

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

~10-20mg Probe
Cooperation with sensXPERT® „Turning Data into Quality“ (AI-based process control)

sensXPERT to Optimize Manufacturing

Edge Device as Data Enhancer

sensXPERT is a brand name of Netzsch Process Intelligence GmbH
Material data under processing conditions

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

Presentation for TOPCON - 2023
Our production orientated laboratory

- 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
Material data under processing conditions

- Our cooperation with sensPERT™ „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)
Material data under processing conditions

- **Determination of reaction kinetics: DSC vs. DEA**

![Graph showing Grade of cure vs. time (isothermal)](image)

- **Kinetics via DEA**
- **Kinetics via DSC**

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Determination of reaction kinetics: DSC vs. DEA

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)
Current and future activities

- Tests are running with high performance molding compounds based on:
  - Polyester (BMC = build molding compound)
  - Epoxy (free flowing)
  - Phenolic resin (free flowing)

- Currently provided by:
  - LyondellBasell
  - Menzolit®
  - Lorenz Kunststofftechnik GmbH
  - SBHPP
  - BAKELITE
  - RASCHIG
  - DureSCO

- And from July 2023 we will start testing thermoplastic materials
Why all these efforts?

European Green Deal

- Preserving Europe’s natural capital
- Transition to a Circular Economy
  - A new Circular Economy Action Plan
  - Strategy on the sustainable use of chemicals
  - Clean Air and Water Action Plans
- Sustainable Transport
  - TBD with the commissioner-designate
  - Revising 2030 Climate targets
  - Extending ETS
  - Climate Pact
  - Climate Law
  - Carbon Border Tax
- Achieving Climate Neutrality
  - Review Energy Legislation
  - European Framework for gas
  - Review Energy Taxation directive
- Clean, Reliable and Affordable energy
- Financing the transition
  - European Investment Bank as European Climate Bank
  - Sustainable Europe Investment Plan
  - Green Financing Strategy
  - Mainstreaming climate transition and sustainability in the MFF
- Farm to Fork
  - Farm to Fork Strategy
  - Vision for Inclusive Rural Areas
  - Africa Europe agenda
- Towards a modernised and simplified CAP
- Leave no one behind (Just Transition)
  - Just Transition Instrument, including the Just Transition Fund
  - Mainstreaming the Just Transition in the MFF
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

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 Englich

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)

Presentation for TOPCON - 2023
Consulting – Simulation - Project-support – Education of staff - Material characterisation

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