Reliable simulation requires excellence in material data

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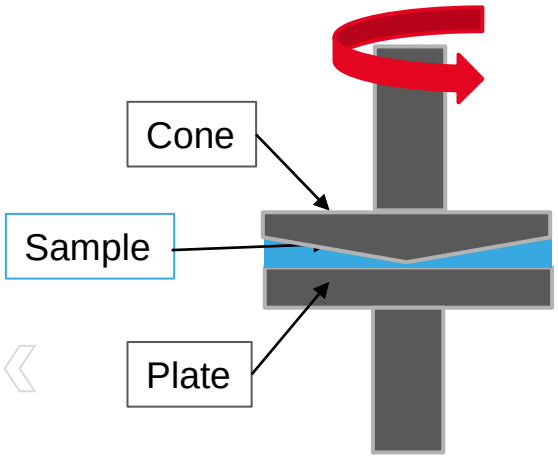
Aachen, 17.04.2024

Initial situation

- New material type (HCR silicone) to be used for simulation
- Material type up to now neither simulated nor measured
- HCR silicone processing: very high viscosities compared to LSR

- General approach: simply measure material & use in production
- **BUT** possibly slightly wrong predictions by simulation

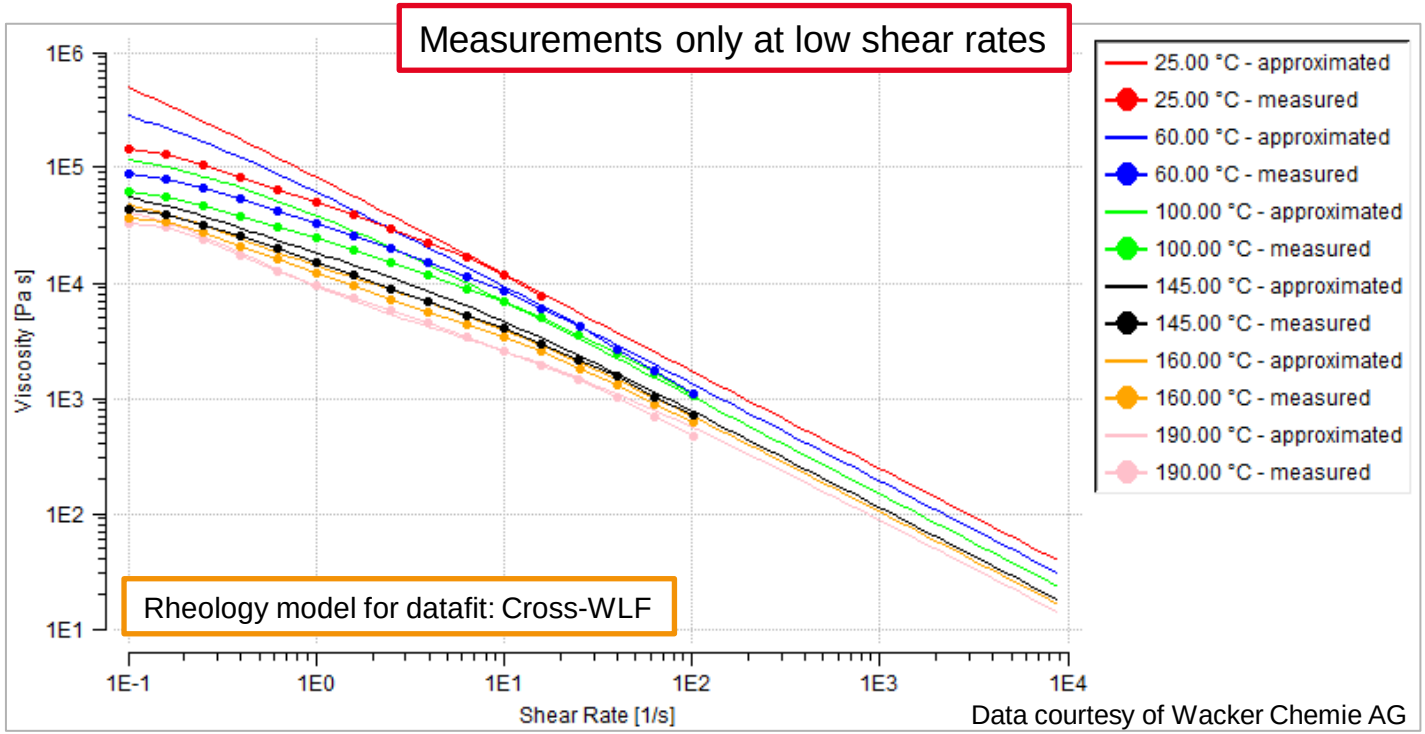
Rotational viscometer (RR)



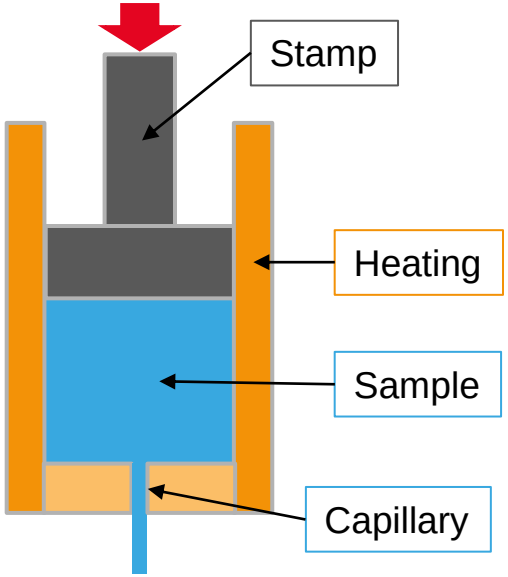
- Measurements only at low shear rates
- Inhomogeneous shearing rates inside sample
- Sample has to be heated

Viscosity: Rotational viscometer (RR)

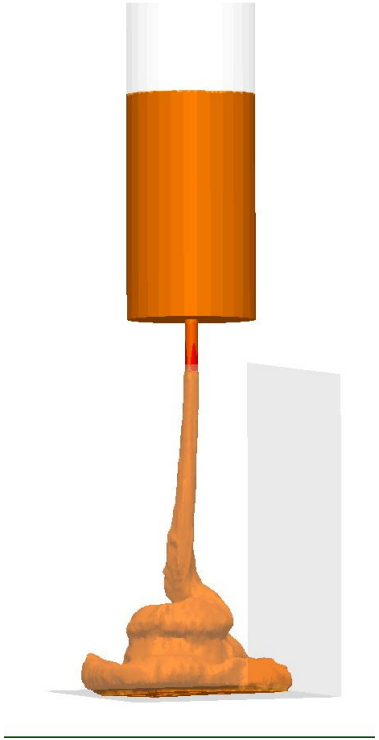
WACKER HCR material ShA 40



High-pressure capillary viscometer (HKV)

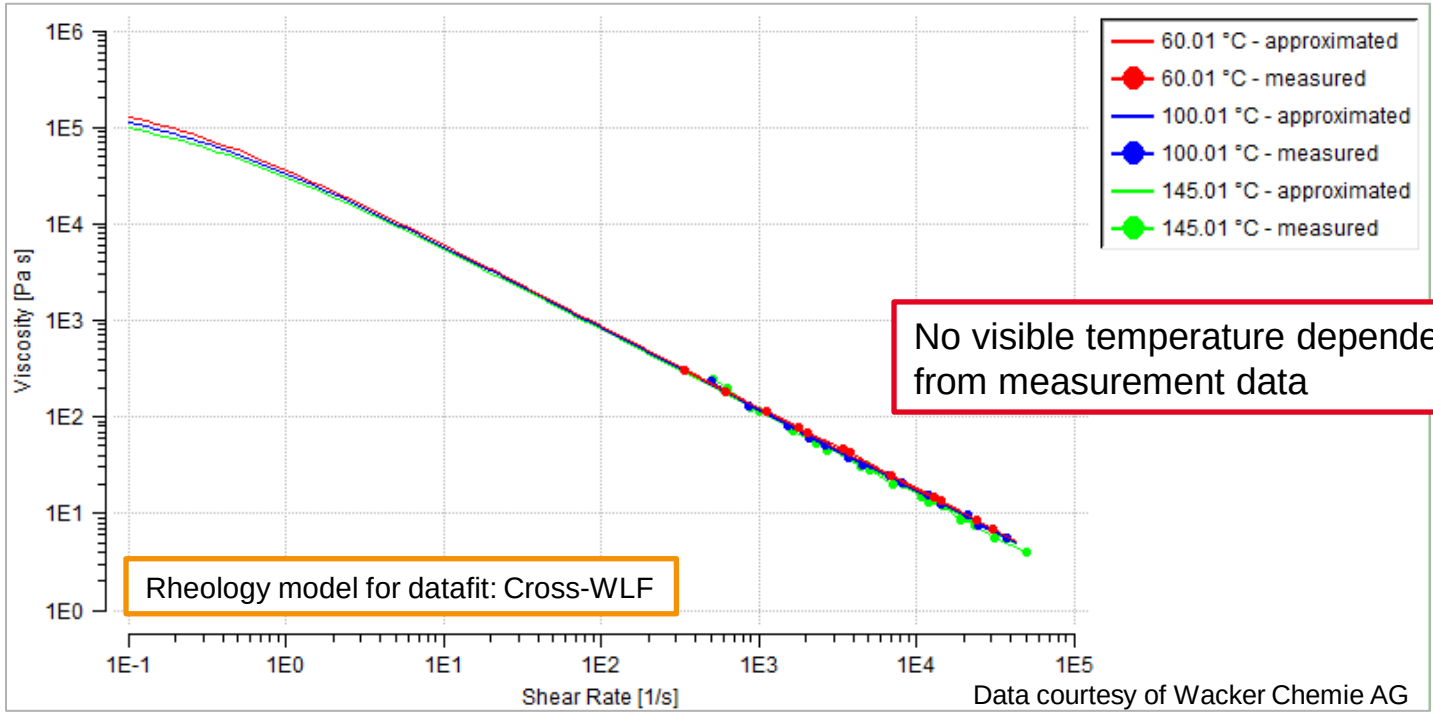


- Long measuring times
- Homogenity of temperatures questionable
- Test method close to injection molding process



Viscosity: High-pressure capillary viscometer (HKV)

WACKER HCR material ShA 40

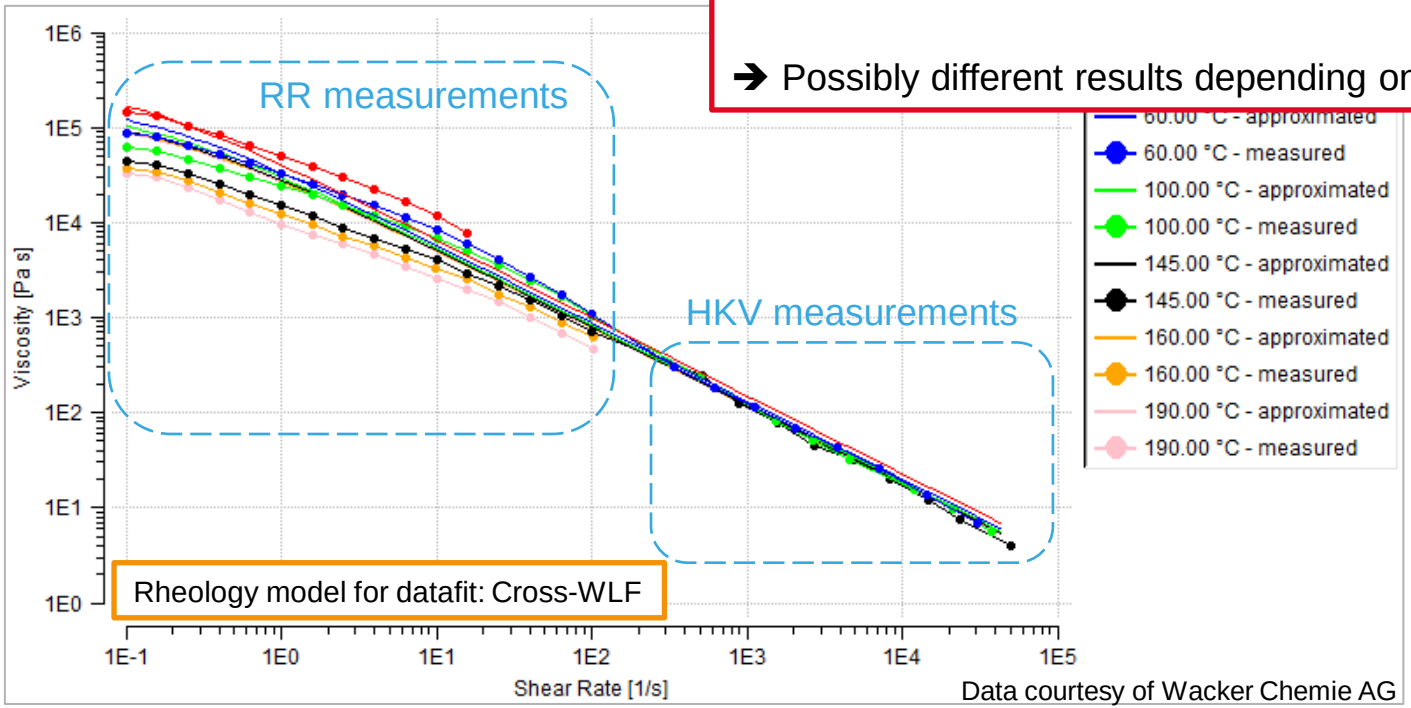


Viscosity comparison of RR + HKV measurements

- Similar slope for the fitted curves
- Difference in temperature dependency

➔ Possibly different results depending on dataset

WACKER HCR material ShA 40



Data courtesy of Wacker Chemie AG

SIGMA approach to new material types

Validate datasets before usage in simulation in close cooperation with the material supplier

Procedure:

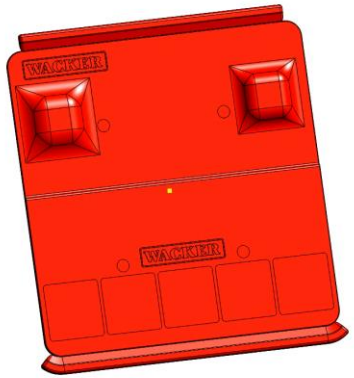
- ¬ Material measurements
- ¬ Production of test geometry with detailed monitoring of process as well as short shot production
- ¬ Run test geometry in simulation & comparison with findings from production
- ¬ If necessary adjust dataset & run follow-up simulation

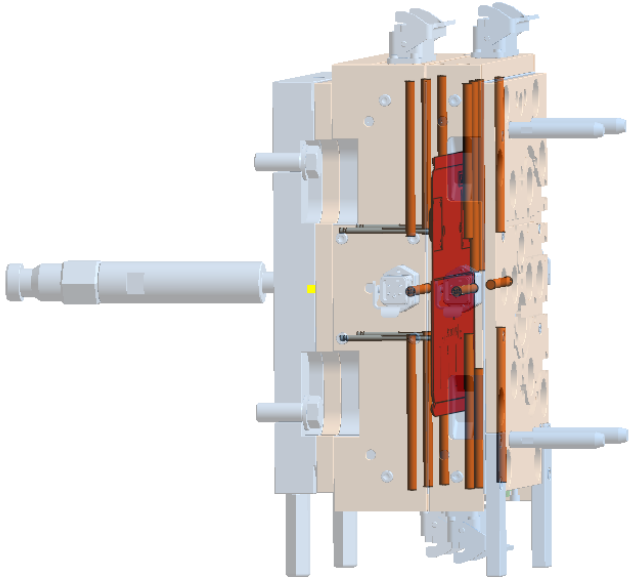
Match of simulation & reality ➔ dataset ready for other projects

SIGMASOFT® Virtual Molding

First dataset validation – testing plate

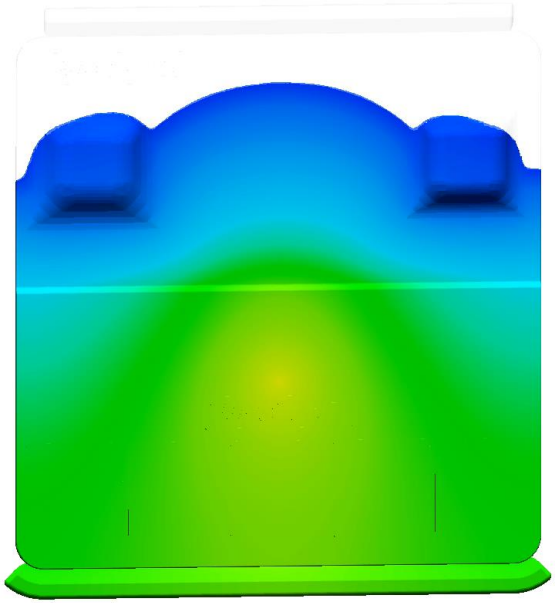
- Testing plate with varying thickness (very thin areas)
- Goal: comparing simulation results with short shots for validation

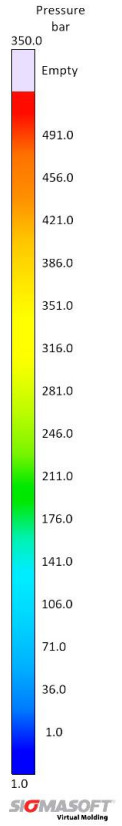


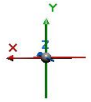


Data courtesy of Wacker Chemie AG

Exemplary part filling (170 °C, 20 cm³/s)





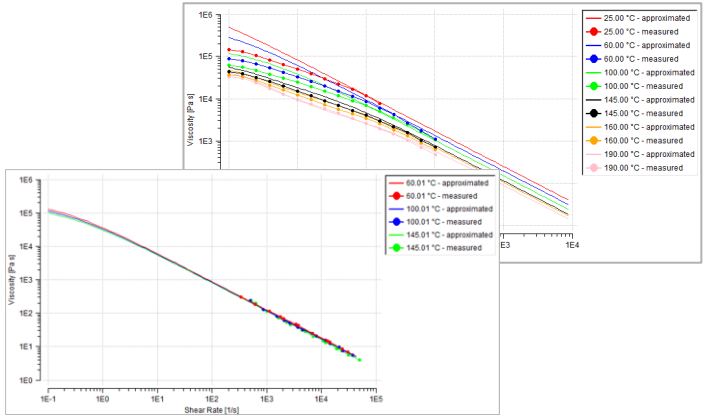


v10_d2
Cycle 11, Filling, Pressure
30.476s, 88.06 %
X-Ray: on

Plan for virtual DoE

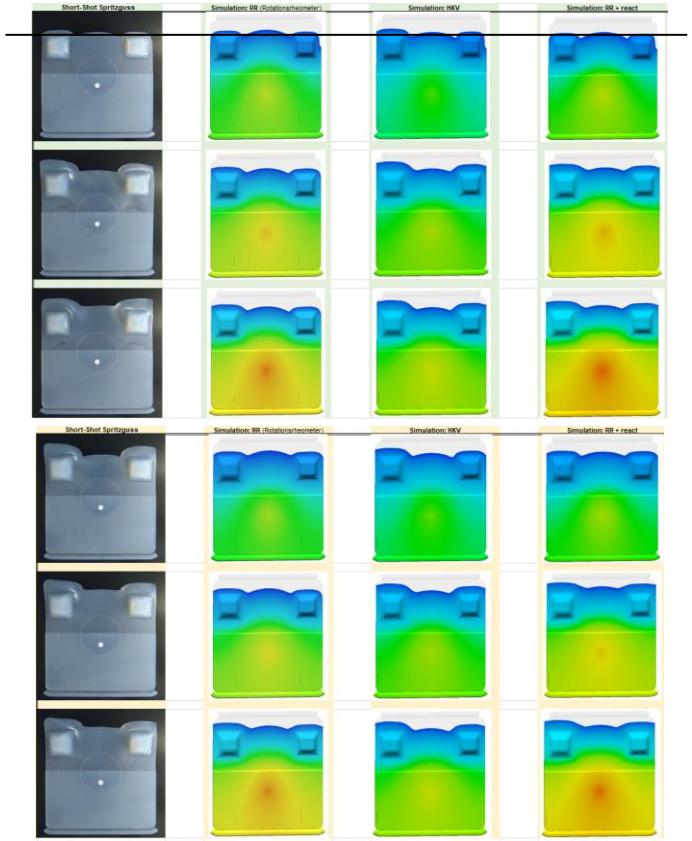
- Mold temperatures (Control points):
  - 130 °C - 170 °C - 180 °C
- Flow rates:
  - 10 cm³/s - 20 cm³/s - 40 cm³/s

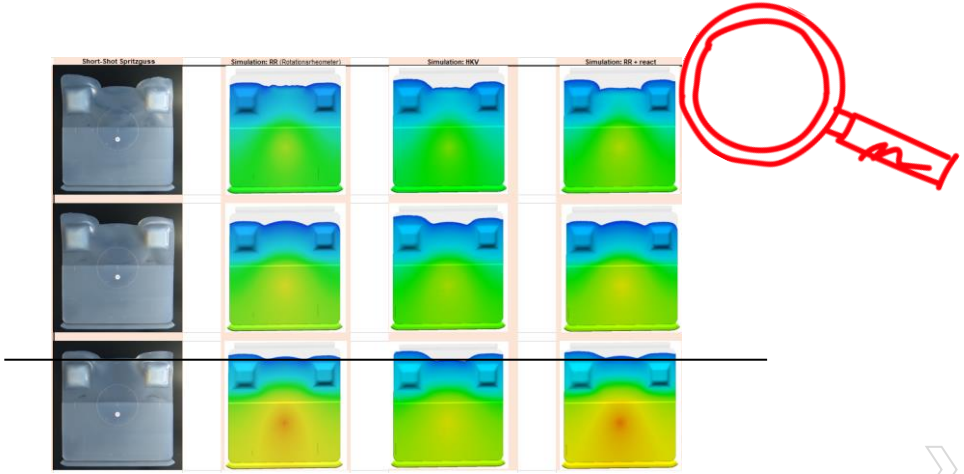
➔ 3 x 3 = 9 possible setups (designs)



This type of DoE is calculated for the datasets with different viscosity measurements.

Comparison of Short shots and simulation data kindly provided by Wacker Chemie AG

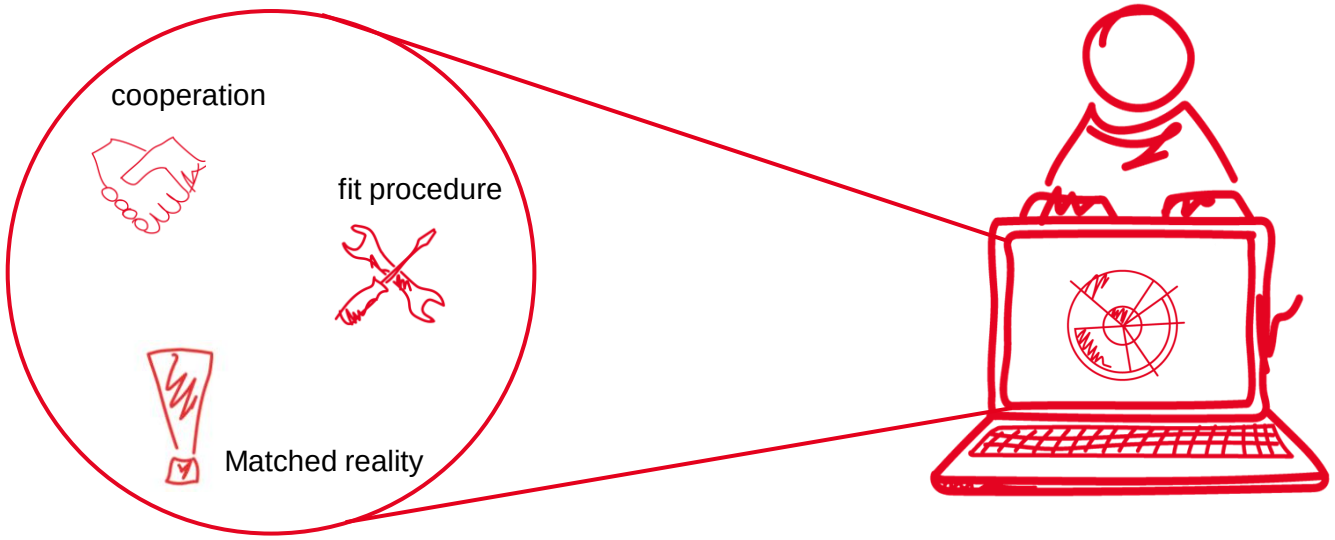




Sometimes measured data has to be supported by generic data

➔ After validation dataset can be used for complex shapes as well

Virtual Molding based on SIGMA approved material

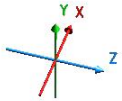


Lemon squeezer

- Food grade HCR material (SILMIX® eco R *plus* TS 40002)
- Filling needs close evaluation due to wall thicknesses
- Curing degree important for stable ejection of part

https://www.WACKER.com/cms/en-gb/insights/k2022-livedemo-htvsilicon.html

Geometry



Process & simulation

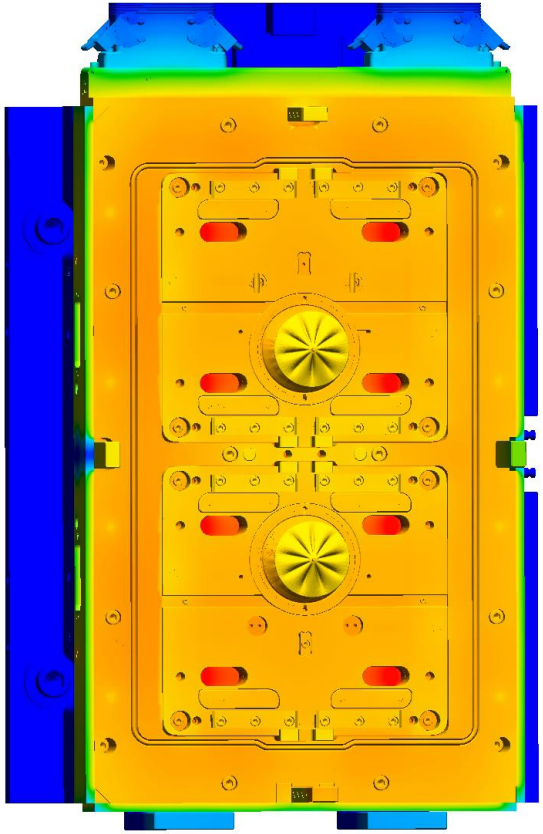
What is simulated?

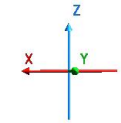
- Mold heating for 30 minutes
- Total of 11 cycles

Injection temperature	20 °C
Mold temperature (control points)	190 °C
Filling time	3.5 s
Cycle time	92 s

Heating up of moveable mold

Temperature distribution during 30 minutes of heating & 11 cycles

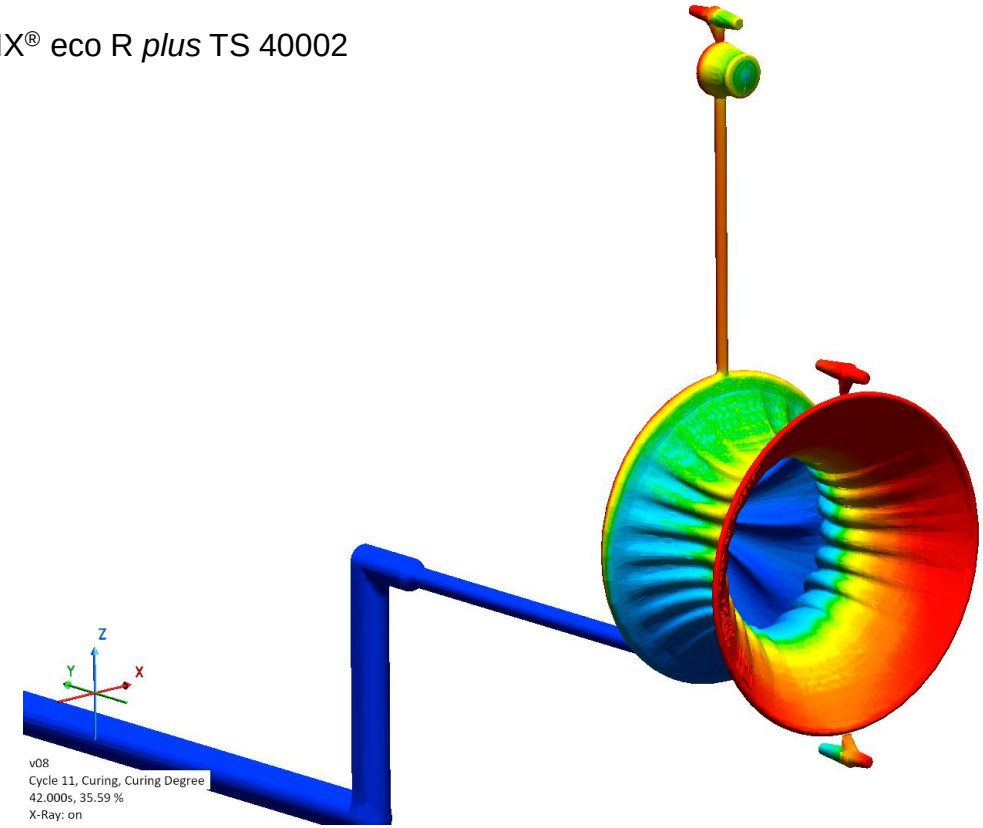


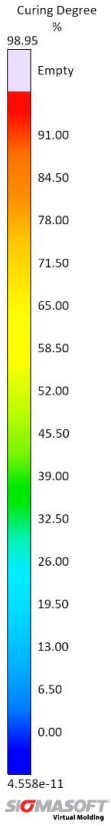


v08
Heating-Up, Temperature
25min 0.0s, 0.00 %
X-Ray: on

Filling & Curing degree – upper cavity

SILMIX® eco R *plus* TS 40002

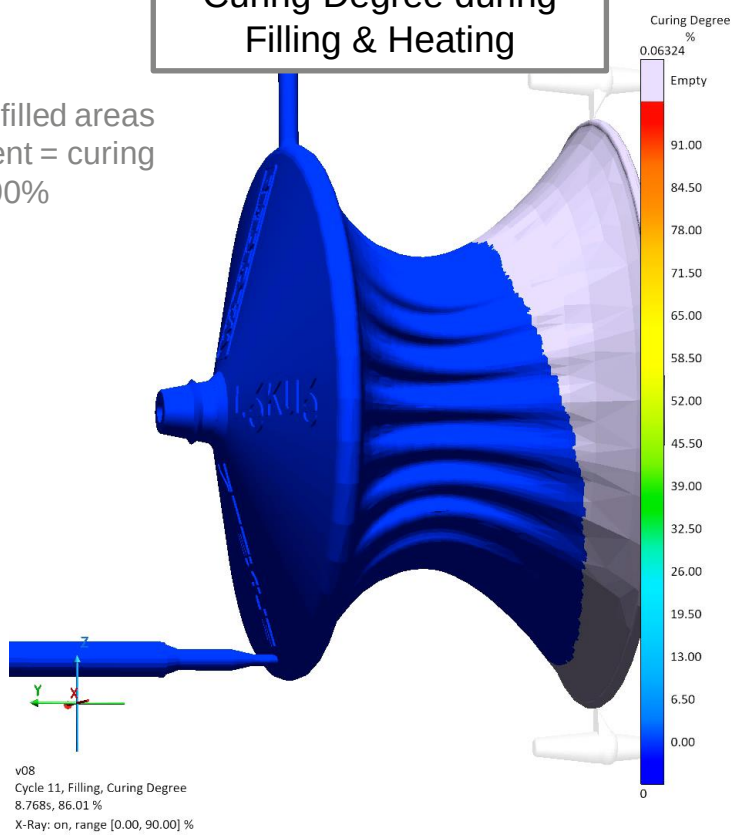




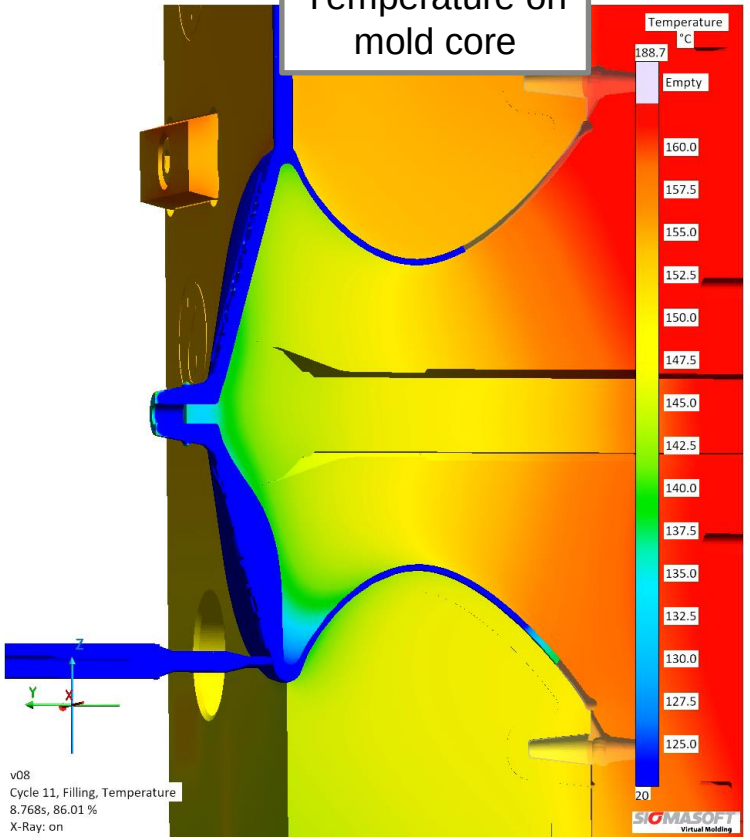
Correlation of mold core temperature & curing degree

Grey = unfilled areas
Transparent = curing degree >90%

Curing Degree during Filling & Heating

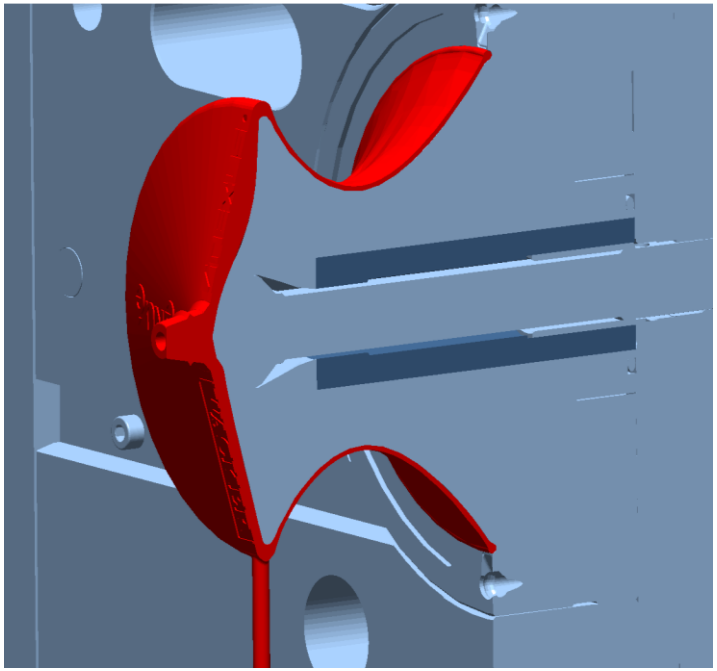


Temperature on mold core

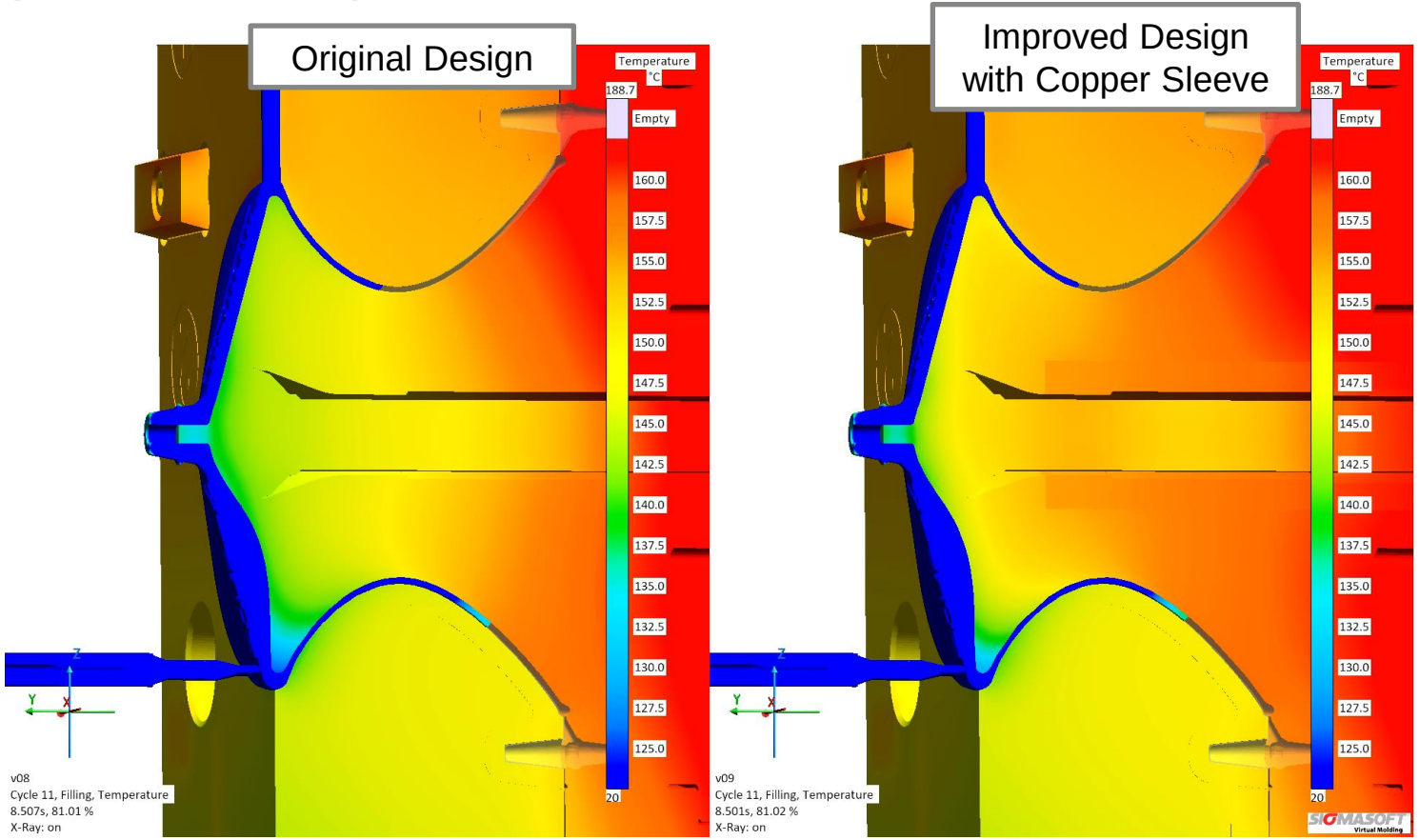


Possible optimization

- Cores cool down too much because of cold HCR injected
- Copper sleeve inside cores of movable half to improve temperature distribution

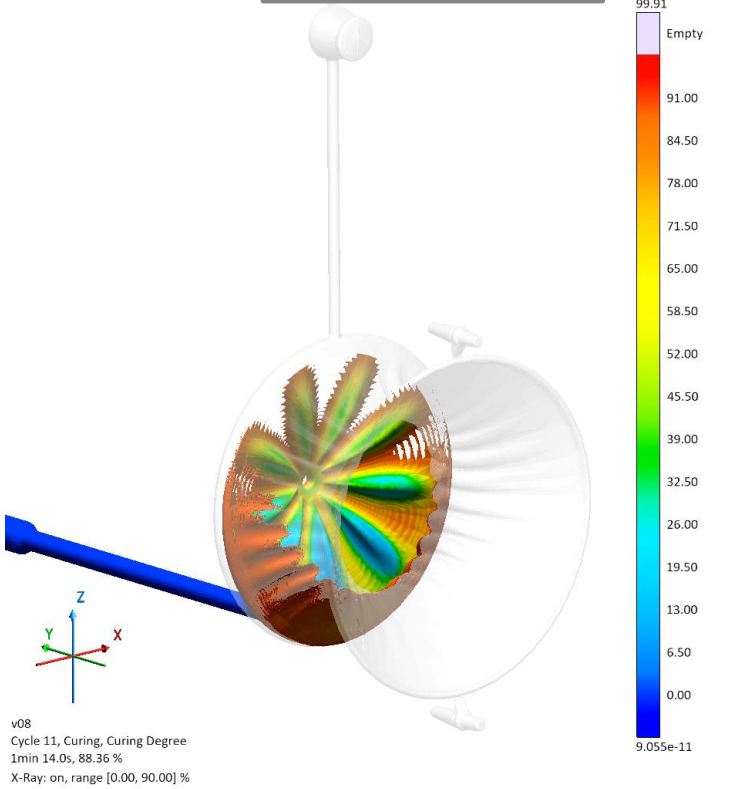


Comparison – temperature distribution

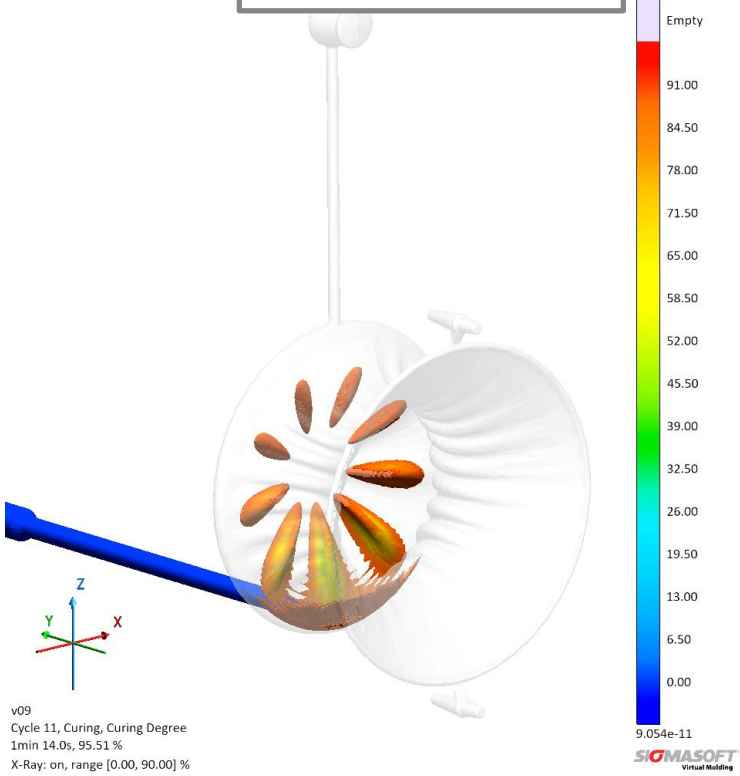


Comparison – curing degree below 90

Original Design



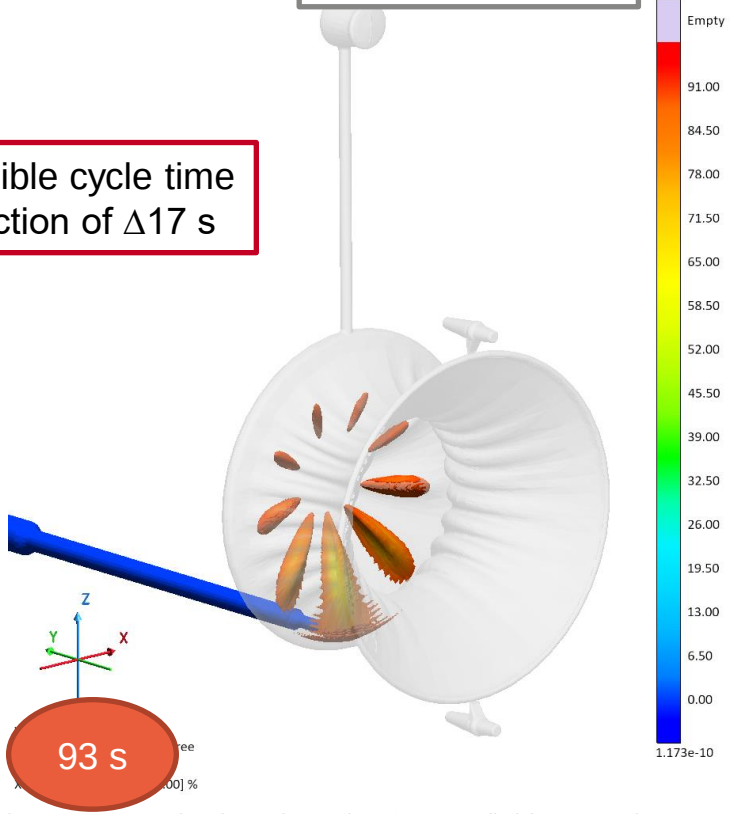
Improved Design
with Copper Sleeve



Comparison – curing degree below 90

Original Design

Possible cycle time reduction of Δ17 s



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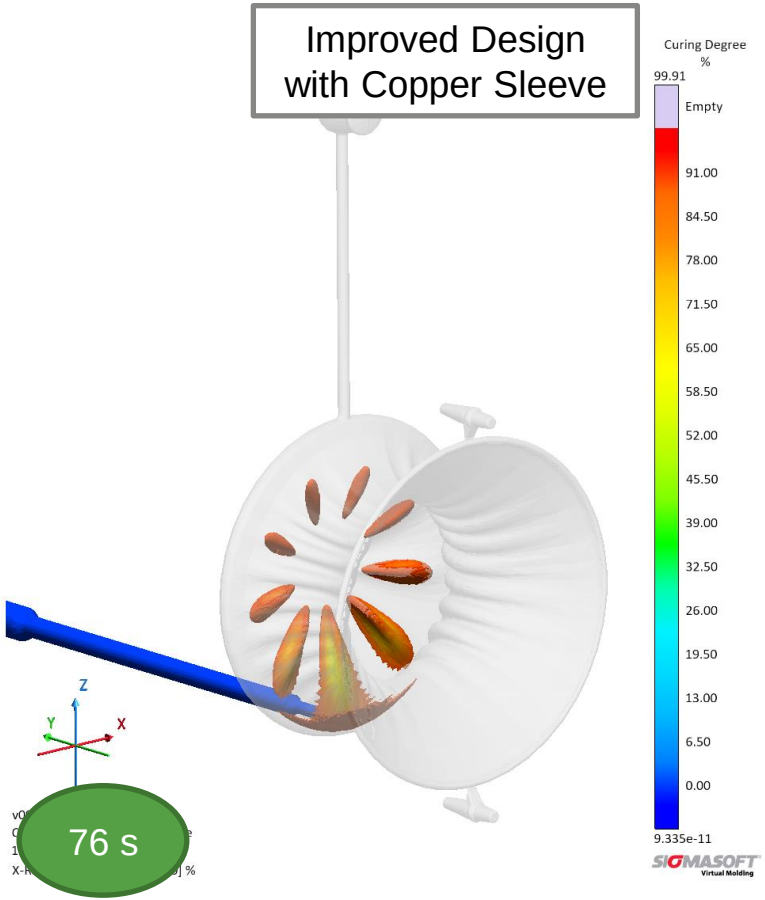

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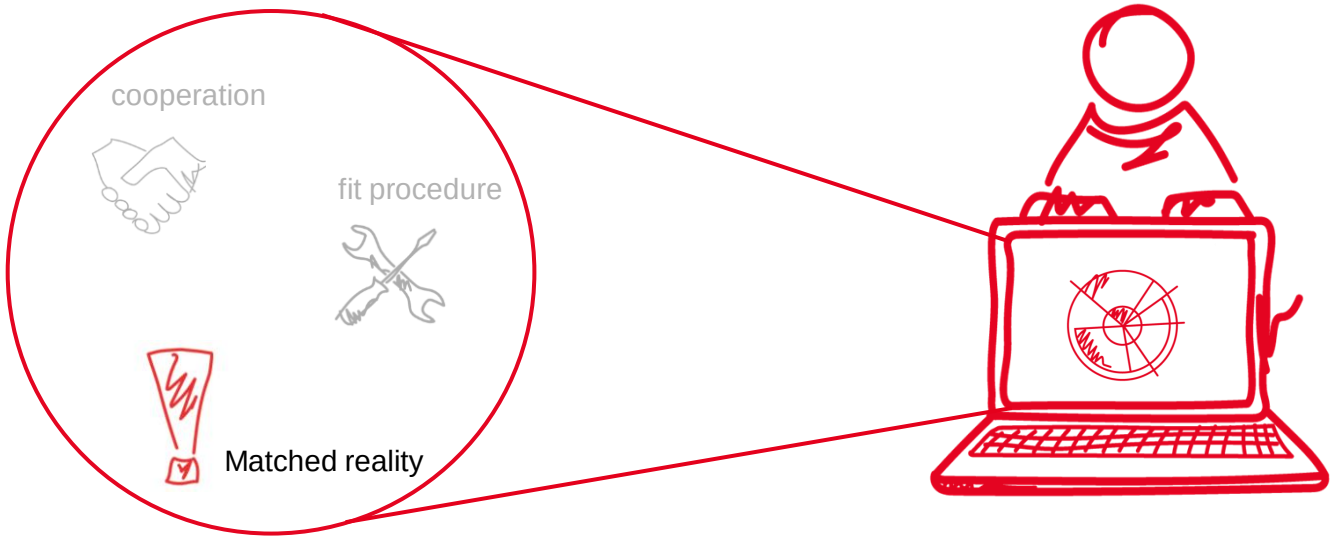

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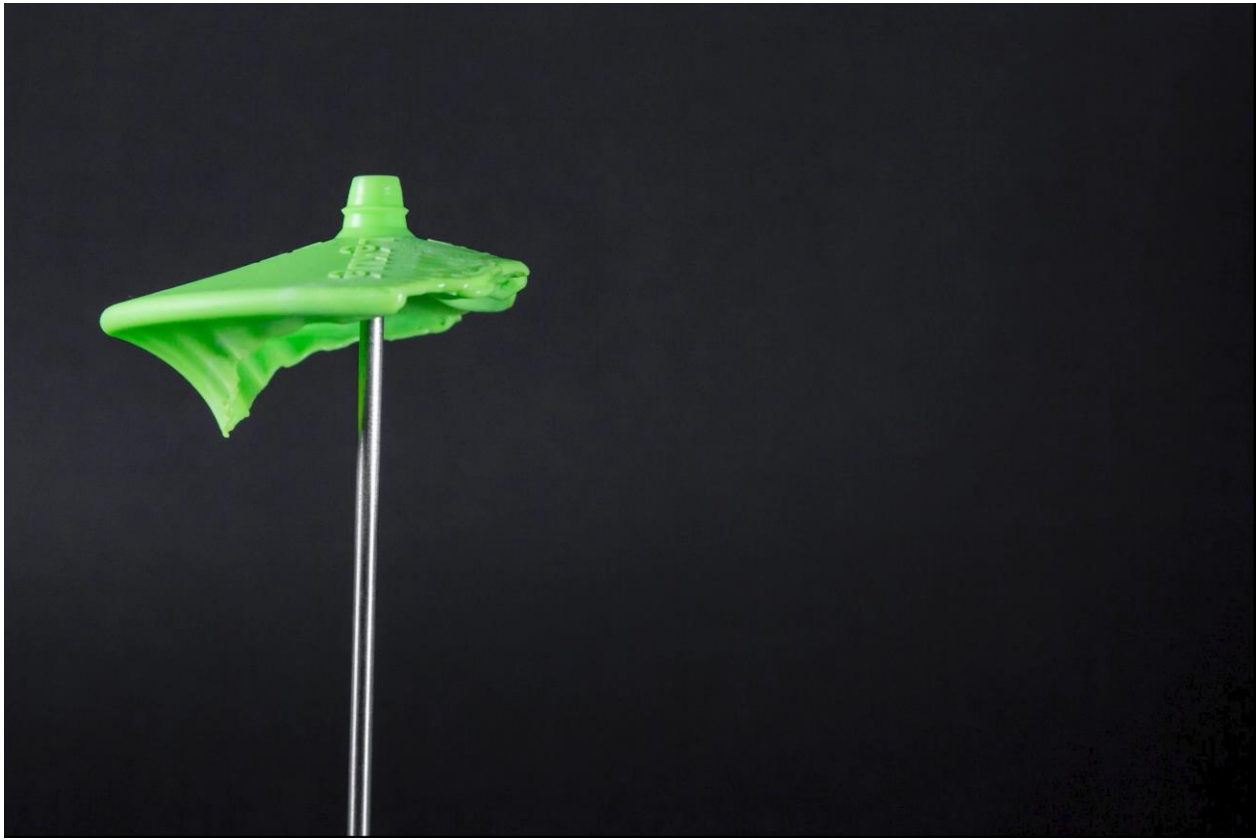

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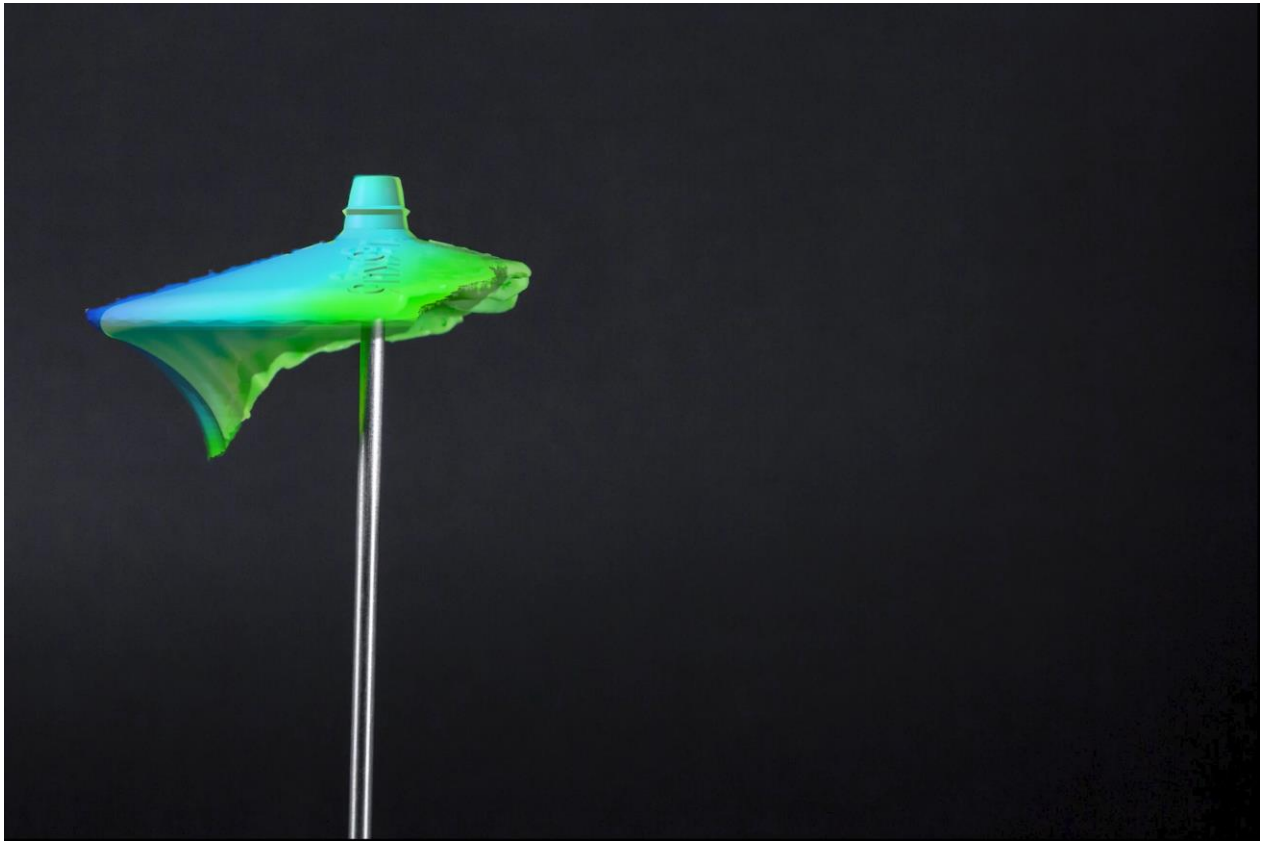

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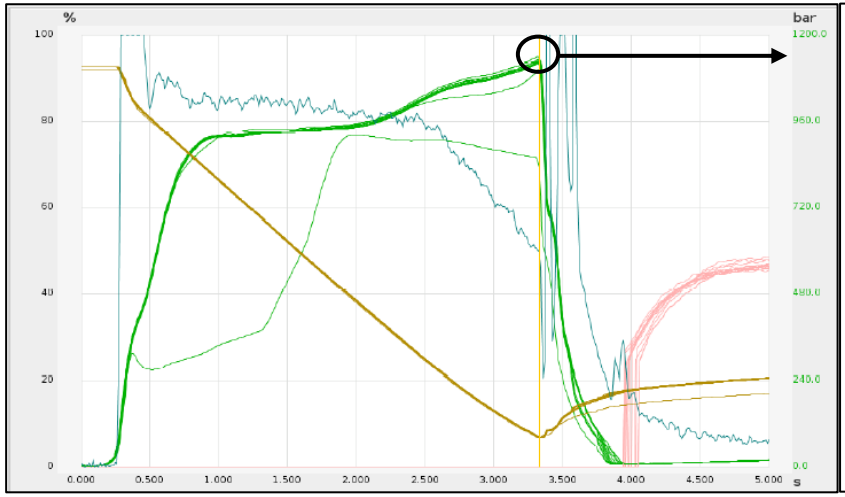
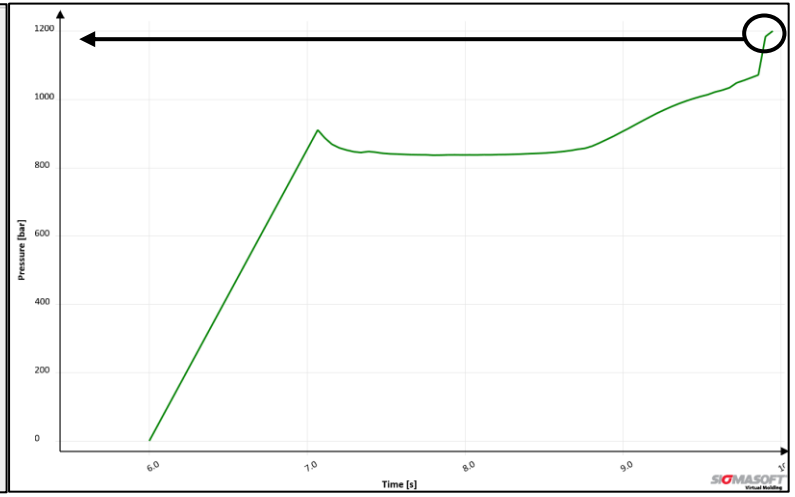
Comparison: Fill pressure

Machine Pressure Curve



SIGMASOFT® Curve



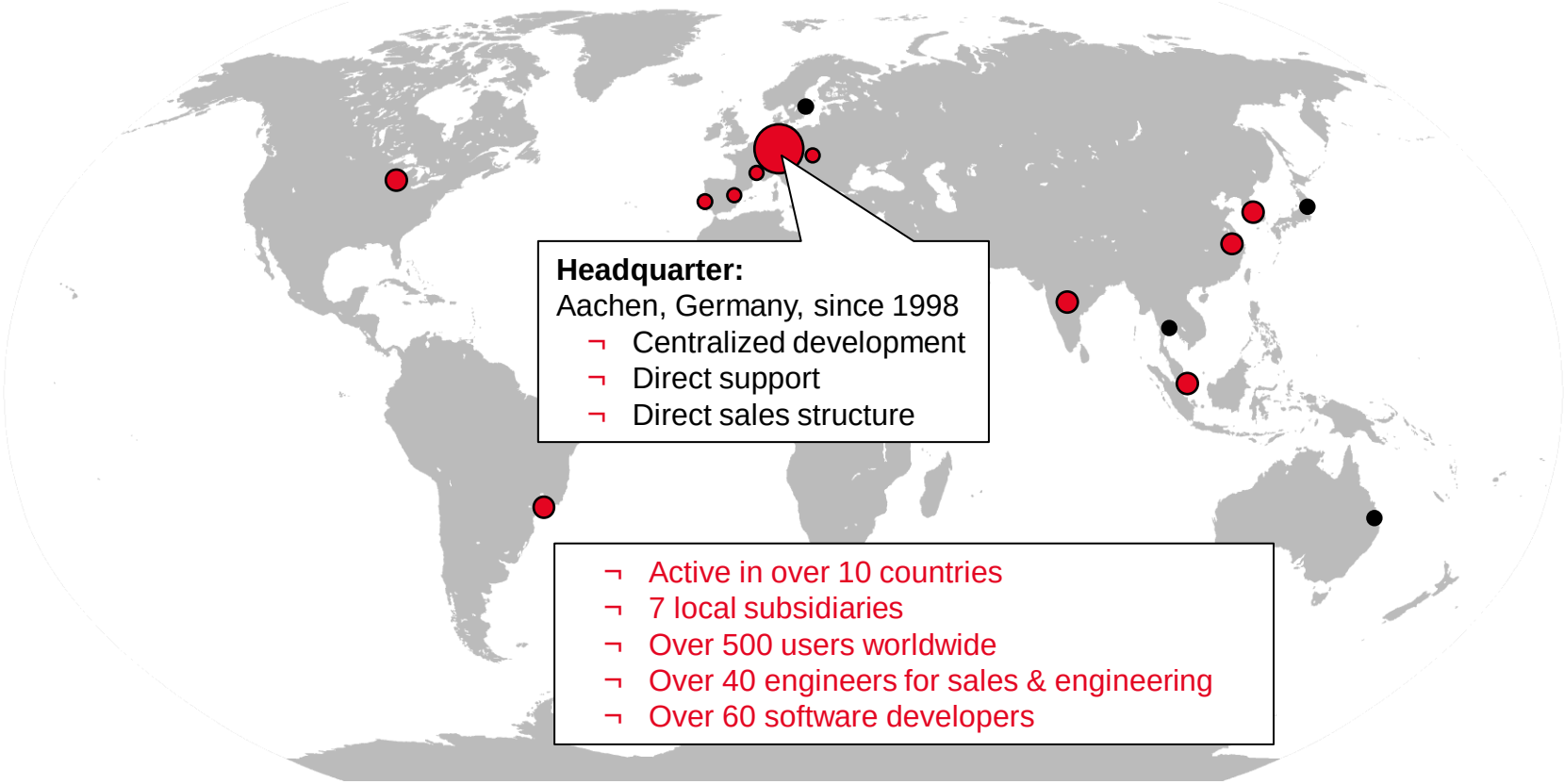
Conclusion

- Challenging material types require know-how to correctly combine material characteristics with observations from the production

- This validation process in close cooperation with the material supplier is a sound basis for reliable simulation results

➔ Strong results based on know-how and excellent cooperation

About SIGMA



Headquarter:
Aachen, Germany, since 1998
- Centralized development
- Direct support
- Direct sales structure

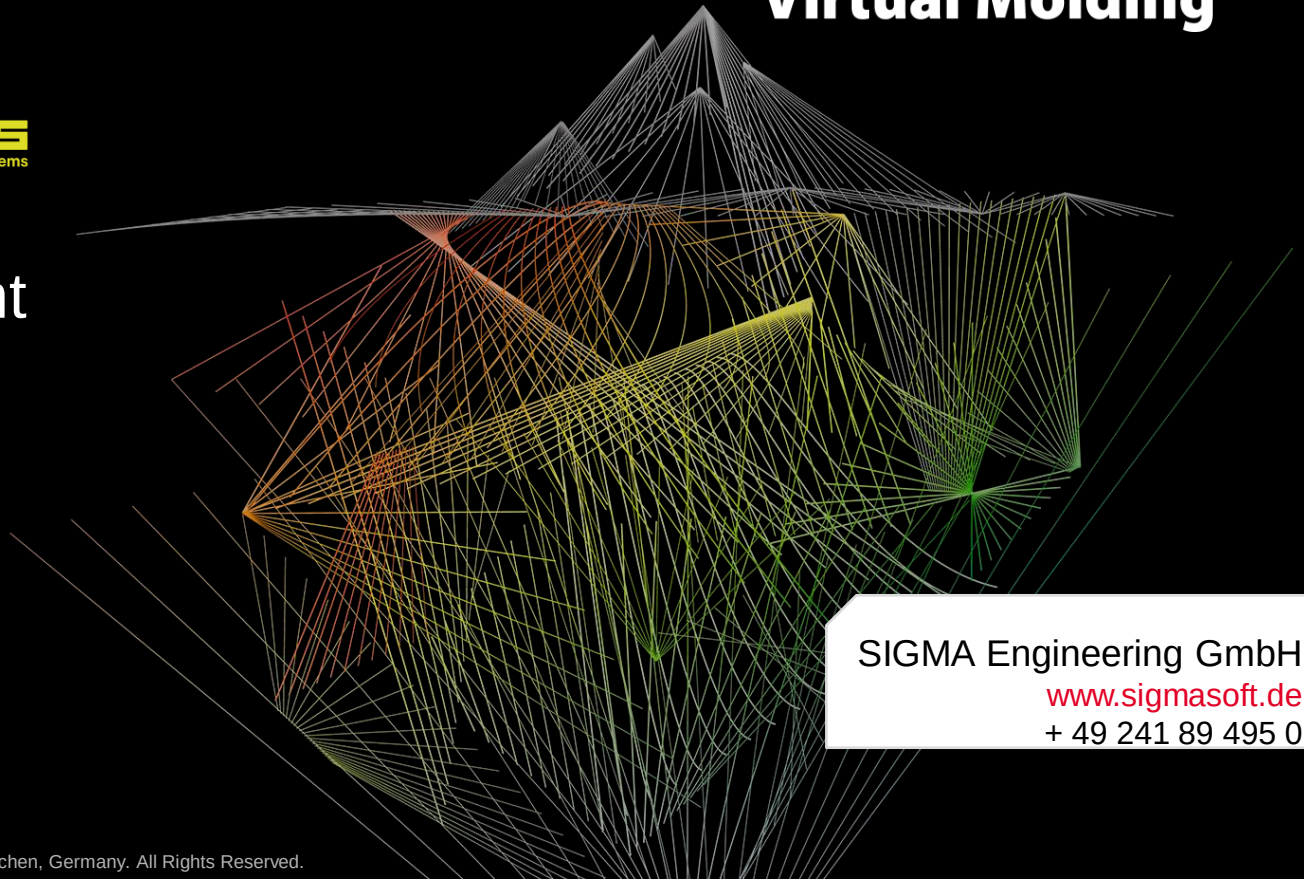
- Active in over 10 countries
- 7 local subsidiaries
- Over 500 users worldwide
- Over 40 engineers for sales & engineering
- Over 60 software developers

SIGMASOFT®
Virtual Molding

We thank

LéKUé
WACKER
NEXUS elastomer systems
ENGEL

for the excellent co-operation



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