VMAP

VMAP – *Virtual material modelling in manufacturing*

Physical foaming in Injection Moulding

F. Pühringer, P. Pazour (Wittmann Battenfeld); M. Mades (Simcon)
P. Reithofer, B. Jilka, B. Hirschmann (4a engineering)

17th 4a technology day – Plastics on the test rig

3-4th March 2020, Werfenweng

AGENDA

Foam Injection Molding

Introduction – What is VMAP

Process Simulation

Structural Simulation

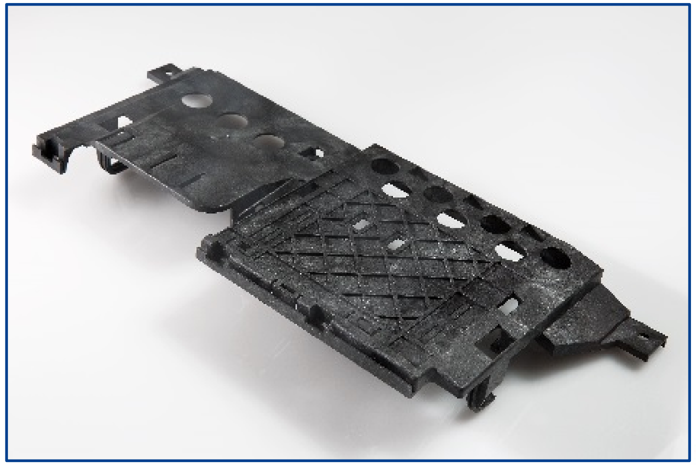
CELLMOULD®

F. Pühringer, P. Pazour;
Wittmann Battenfeld, Kottingbrunn Austria

CELLMOULD® - Lightweight Technology

Part 1: Foam Injection Molding

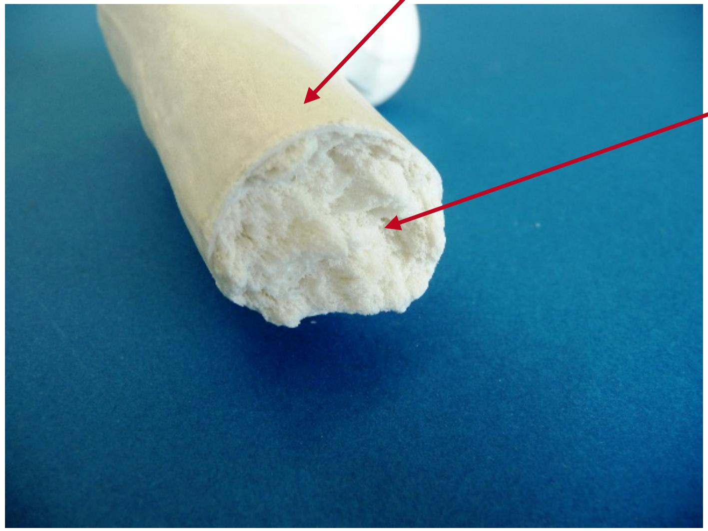
- Why structural foam?
- Process technology
- Blowing agent
- Process Components
- Product examples



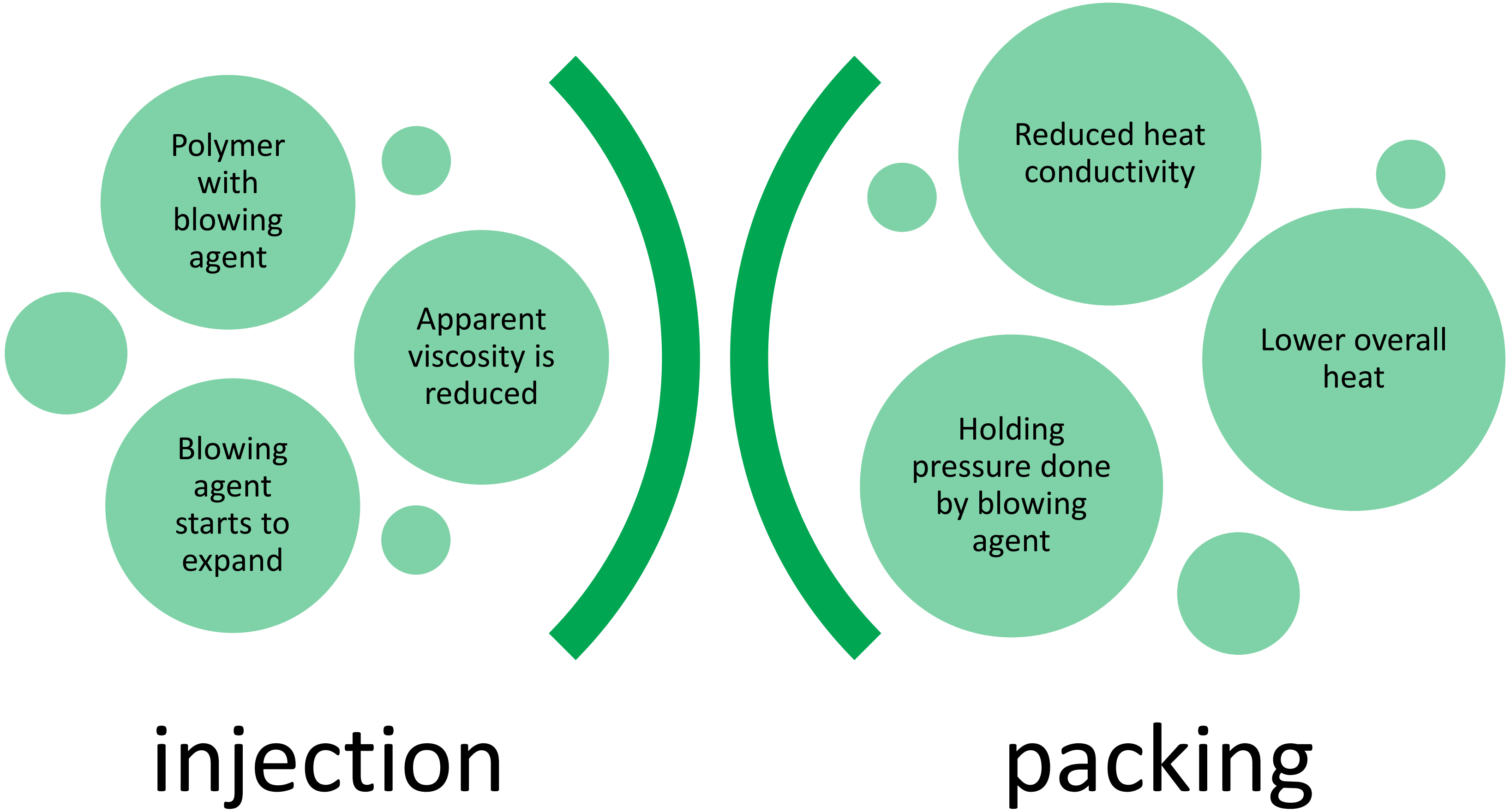
Design of mixing elements

Why structural foam?

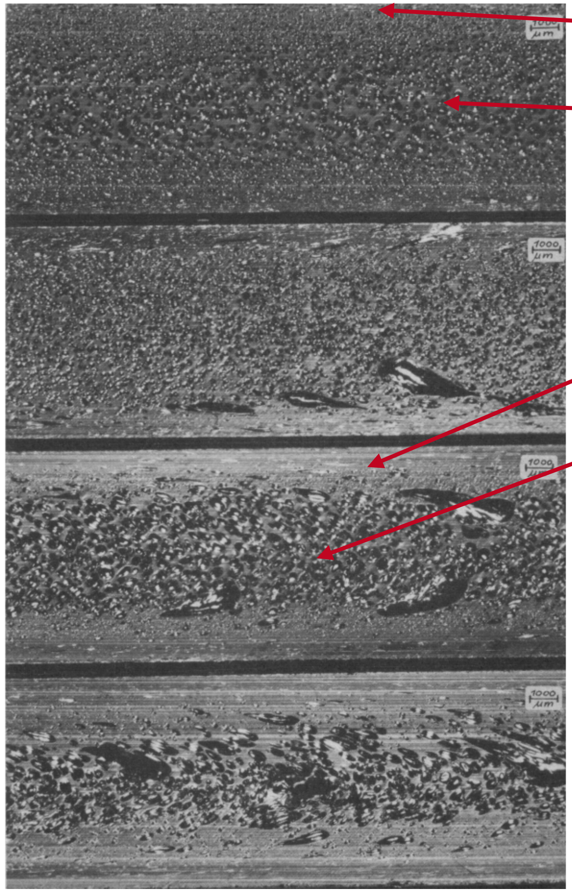
- *Elimination / reduction of sink marks (gas has function of holding pressure)*
- *No or low orientations / warpage*
- *Lower injection and cavity pressure*
- *Clamping force reduction (smaller IMM)*
- *Reduced flashing*
- *Reduced cooling times / cycle times*
- *Improvement of weight specific mechanical properties*
- *Longer max. flow paths through reduced viscosity*
- *Reduced weight (material savings)*



Process Technology



Process Technology



a)
b)
c)
d)

Thin skin

Very fine cells

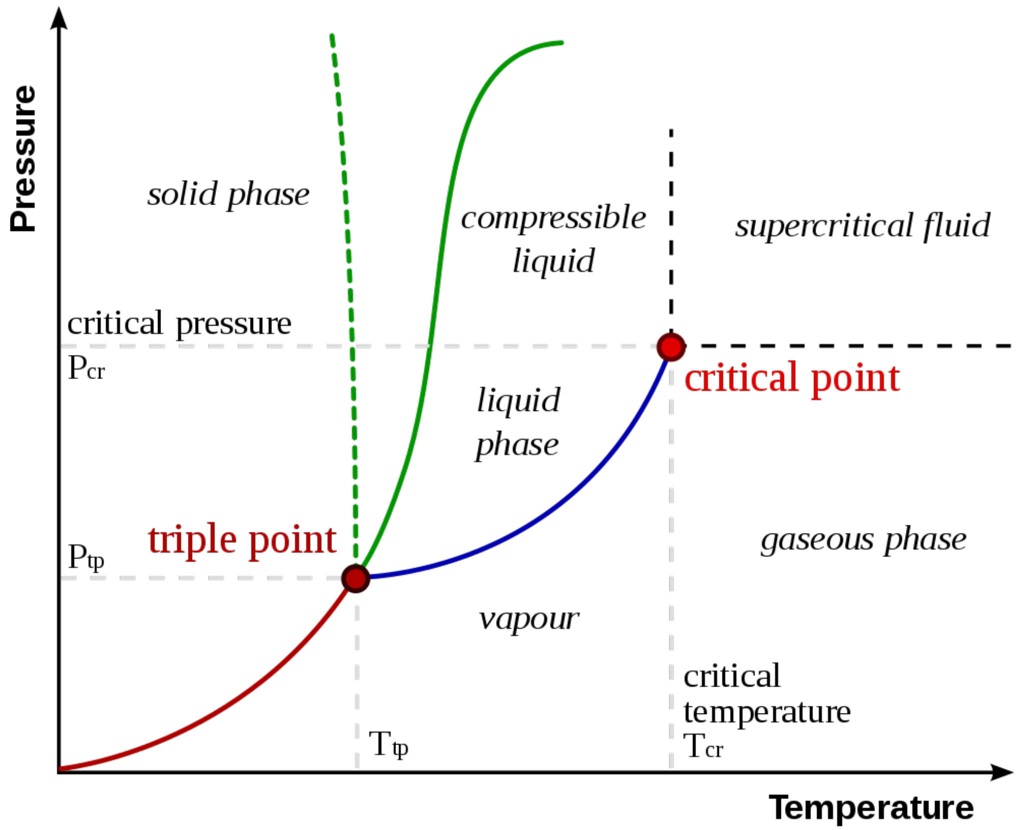
Thick skin

Larger cells

Influence of fill time on foam structure for PC mouldings

Fill times: a) = 0.3 s; b) = 0.6 s; c) = 1.2 s; d) = 1.5 s

Blowing agent



https://en.wikipedia.org/wiki/Critical_point_(thermodynamics)

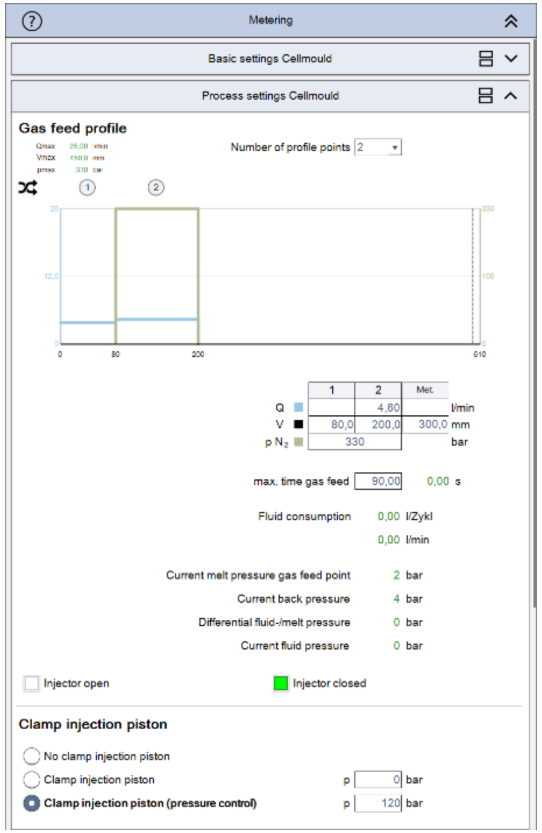
	Density [g cm^{-3}]	Diffusion coefficient 10^{-9} [m^2 s^{-1}]	Viscosity [µPa s]
Gaseous phase	0,001	1000	10
Liquid phase	1	1	1000
Supercritical	0,2-0,9	10-100	10-50

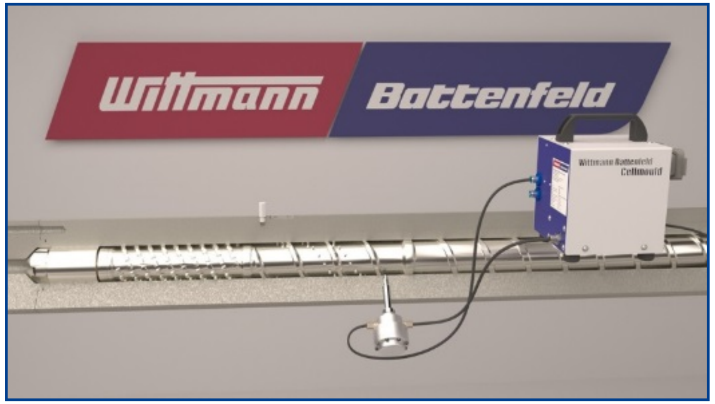
N. Dahmen, V. Piotter, F. Hierl, und M. Roelse, „Überkritische Fluide zur Behandlung und Herstellung komplexer Werkstoffe und Oberflächenstrukturen“, Forschungszentrum Karlsruhe GmbH, Karlsruhe, Abschlussbericht FZKA 6585, 2001.

Nitrogen: -147°C and 34 bar

Process components

- *CELLMOULD® unit*
- *Nitrogen supply*
- *Pressure generation*
- *Gas flow regulator*
- *Gas injector*
- *Process control*





Product examples

Cable drum:
(PP recycylate, D = 700 mm)

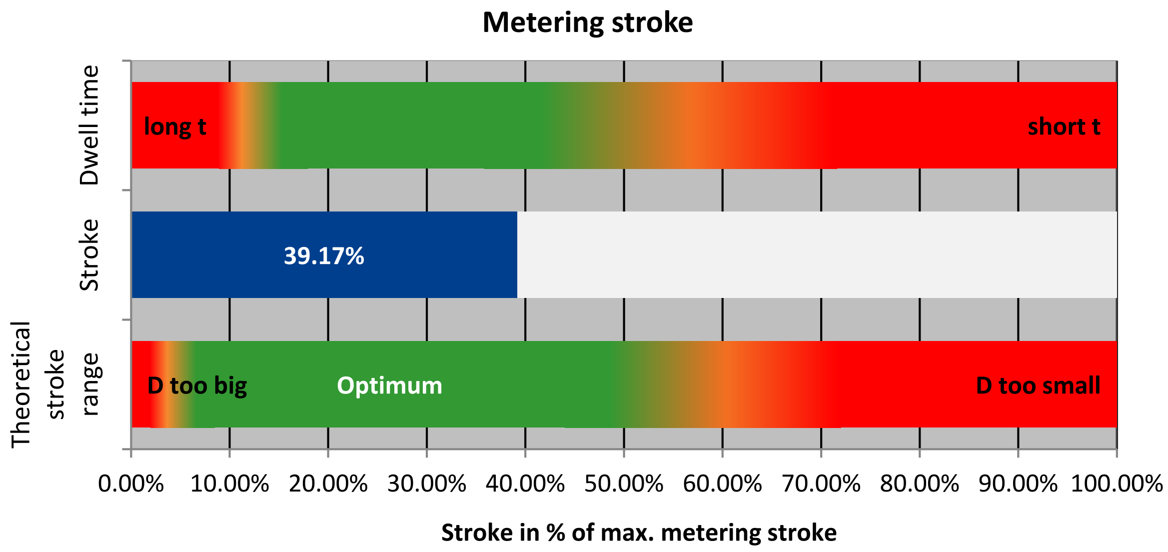
Weight: -25%
Compact: 5080 g
CELLMOULD®: 3800 g

Clamping force: -60% (500 t → 200 t)

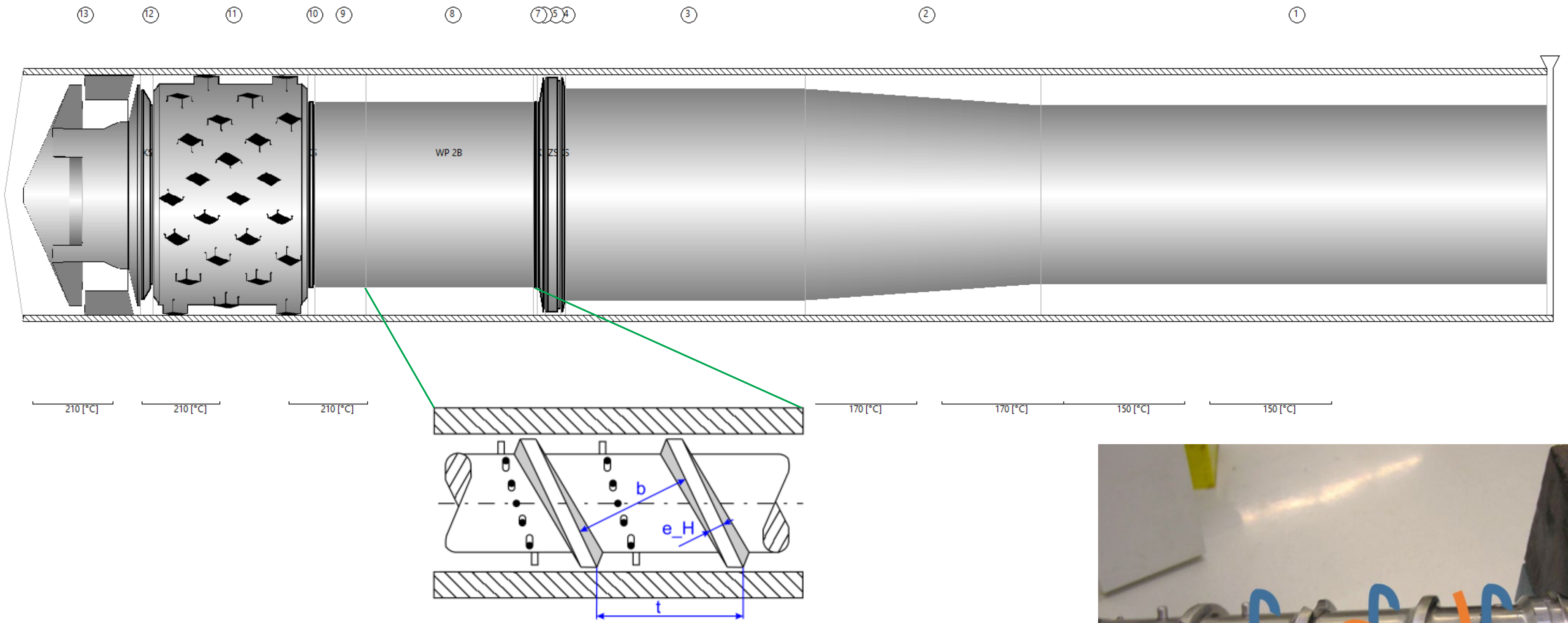
Design of mixing elements

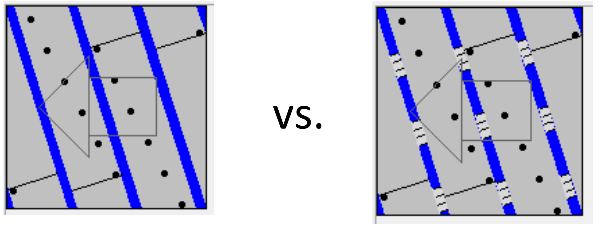
Introduction

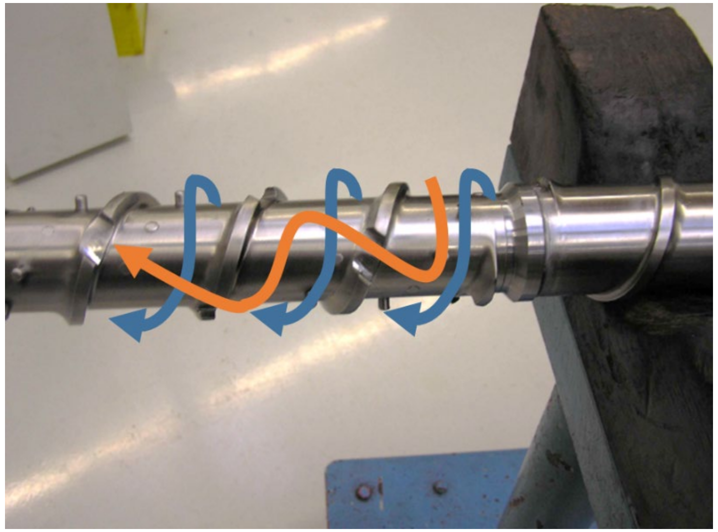
- *Design of plasticizing unit*
  - Shot volume
  - Dwell time
  - Maximum screw torque
  - Maximum injection pressure
- *Special features for CELLMOULD*
  - Retaining ring
  - **Mixing elements**
- *PSI/Rex*



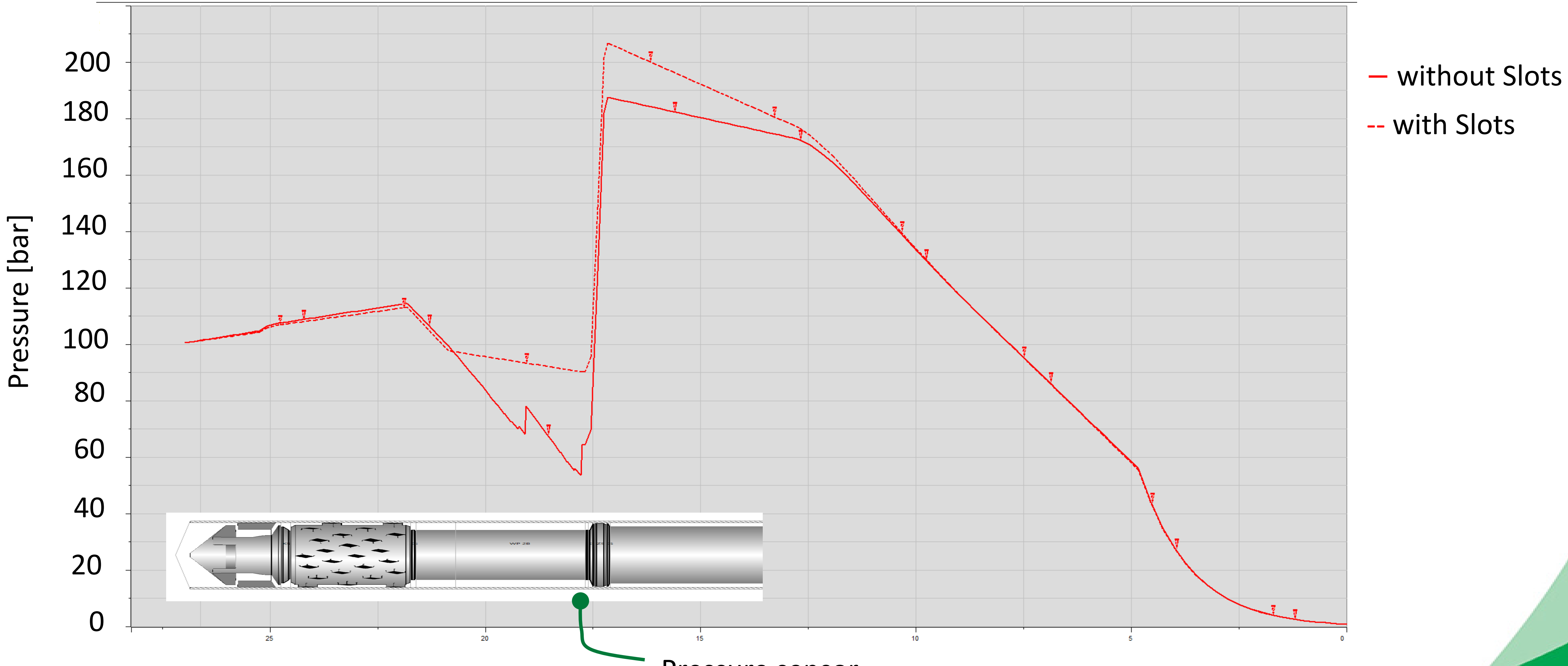
Screw design of CELLMOULD test rig



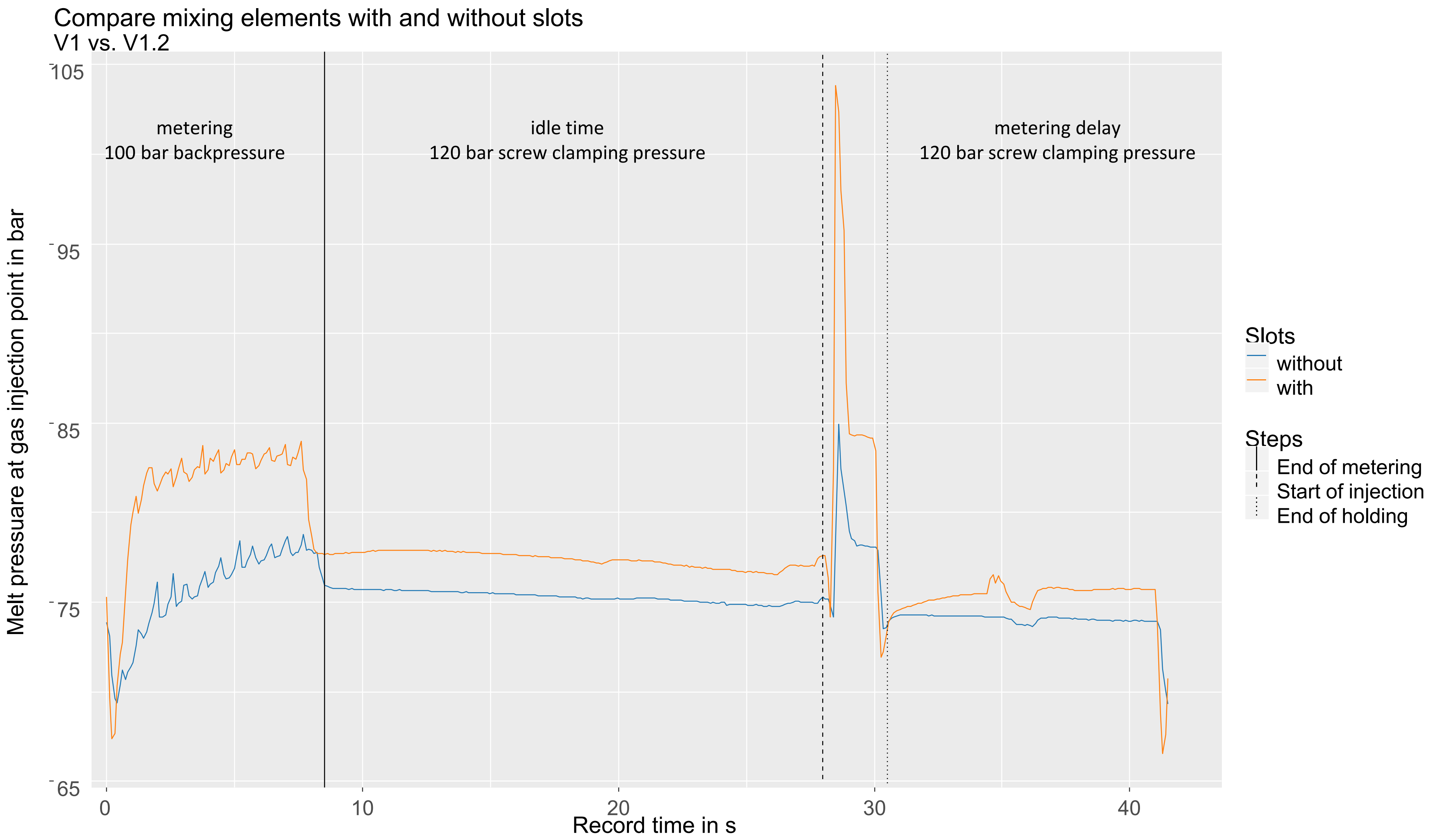




Simulation results



Practical results



Conclusio

- *Target values for screw design diverge*
- *Universal 3-zone screw is not a specialist*
- *Many input parameters for a CELLMOULD screw*
- *Desirable simulated output of CELLMOULD screw*
  - Smooth pressure curve
  - Low pressure buildup/loss
- *Good correlation between simulated and measured pressure values*

Introduction – What is VMAP

Motivation - a general problem in many industries

Process 1 – Vendor A

Process 1 – Vendor B

Process 1 – Vendor C

??

→

File format definitions
notation for discretisation
(Shell) element definitions
results
distributed material props
manufacturing history
….

Process 2 – Vendor B

Process 2 – Vendor C

Process 2 – Vendor D

??

→

Process 3 – Vendor A

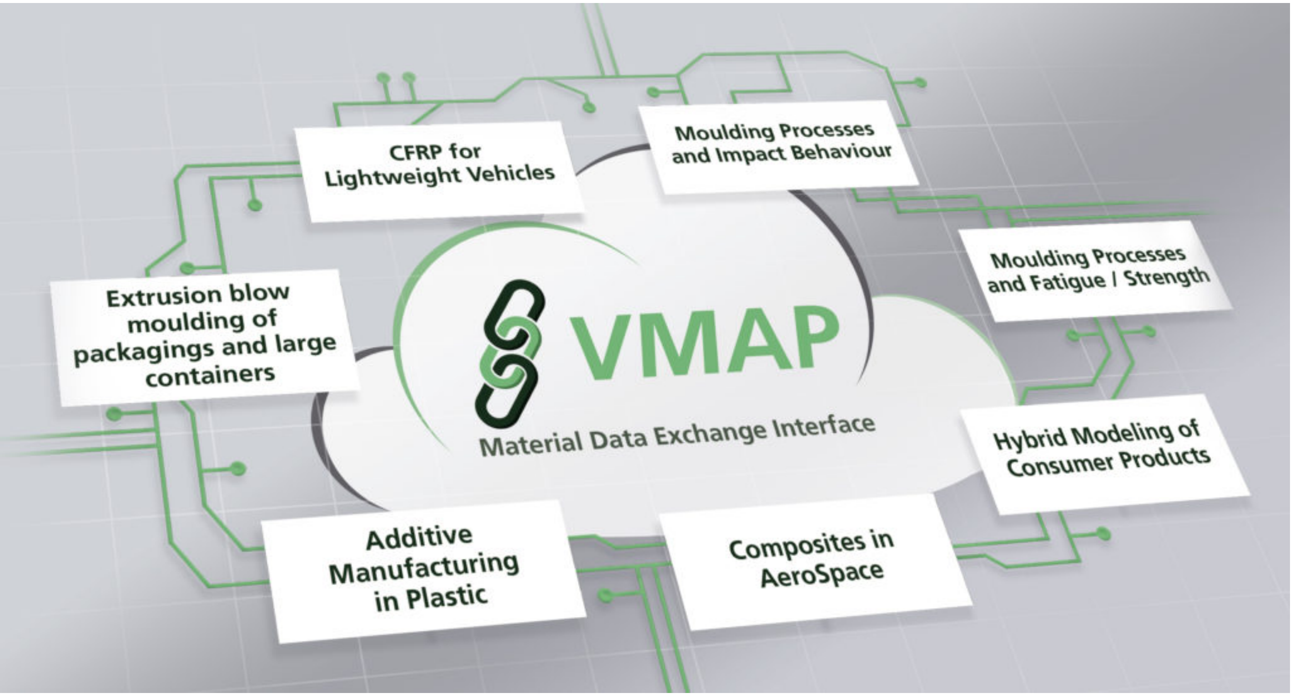
Process 3 – Vendor D

Source: Gino Duffett, Klaus Wolf; A new Interface Standard for Integrated Virtual Material Modelling in Manufacturing Industry
more: http://vmap.eu.com/

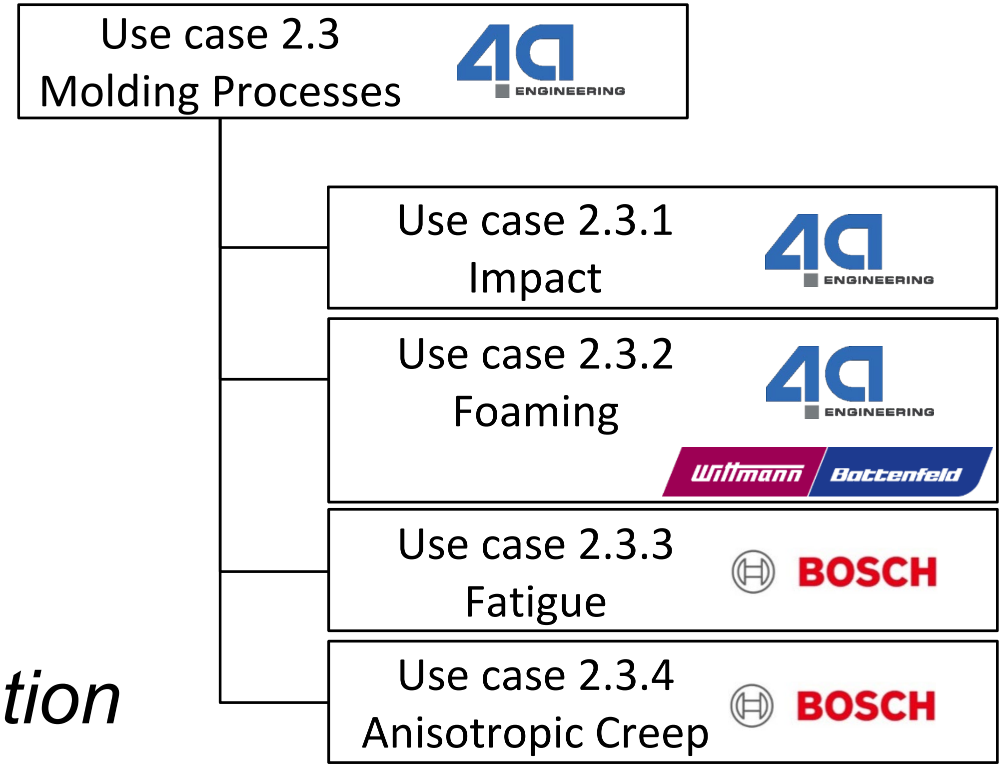
A new Interface Standard for Integrated Virtual Material Modelling in Manufacturing Industry

- *ITEA 3 – standardizing project*
- *working on a new CAE industry standard*
- *29 partners*
  - CAE end users
  - application end users
  - R&D engineers
  - software vendors
- *use cases in the field*
  - metal forming
  - composites manufacturing
  - injection moulding of plastics
  - 3D printing

A new Interface Standard for Integrated Virtual Material Modelling in Manufacturing Industry



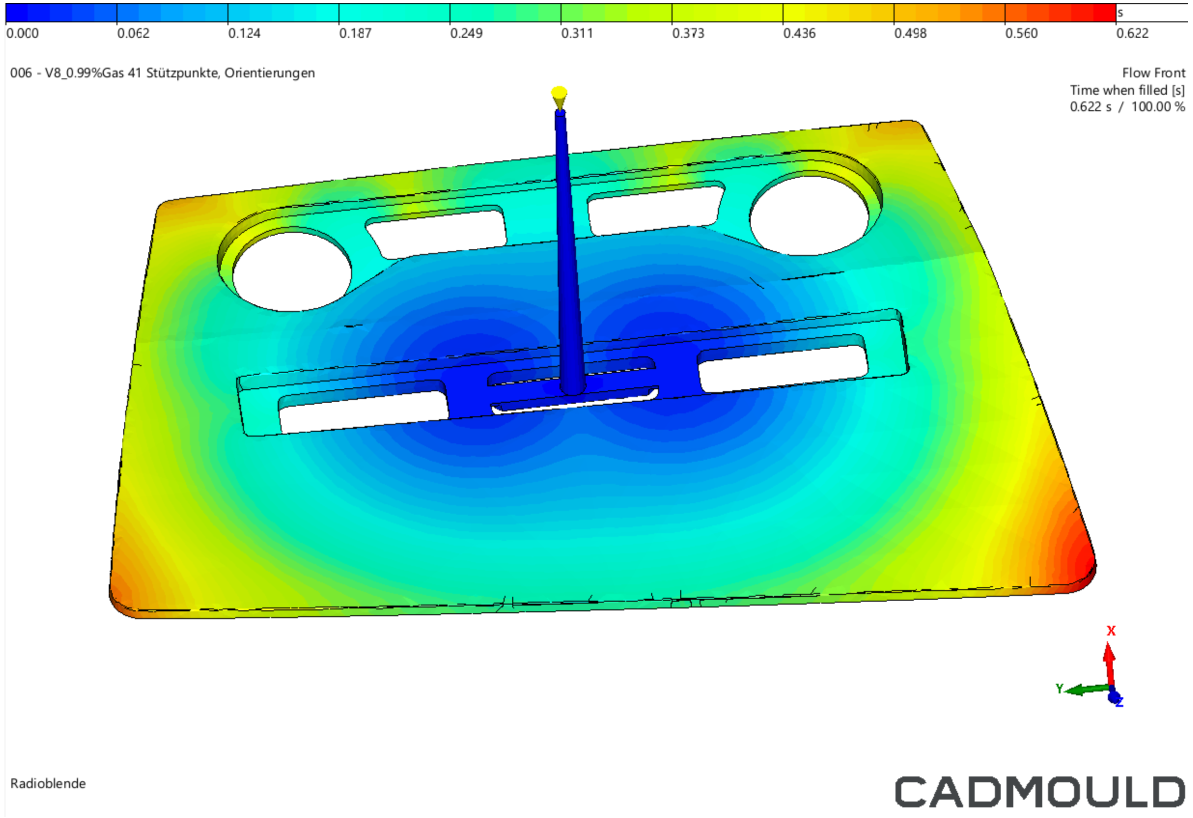
- *Use Cases → to get input for specification*



Process Simulation

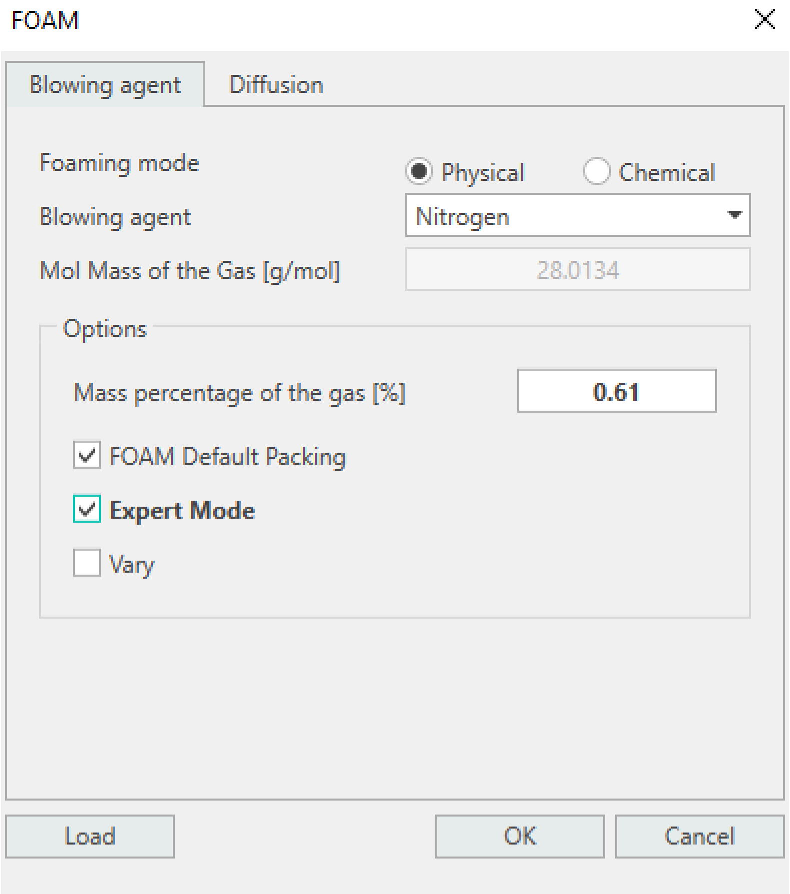
4a Technology Days, 03. -04. March 2020
Max Mades
Simcon kunststofftechnische Software GmbH, Würselen

Filling Simulation
Simulation is State of the Art in the Development Stage

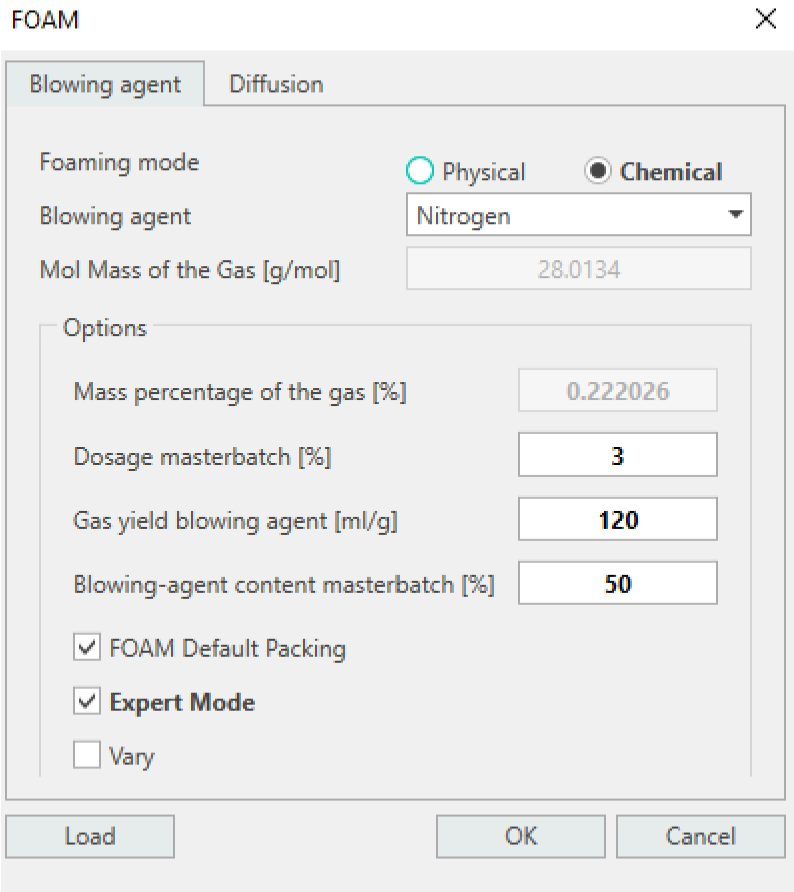


- Part and Mold Geometry available as 3D-Model
- Filling Simulation is Standard
- Virtual Optimization Of Part, Mold and Process in early stadiums of the Developing Process
- Useful results for Users in Injection Molding, Mold Design or from Developers from every kind of Industry

CADMOULD® 3D-F Foam
Input of Foaming Parameters

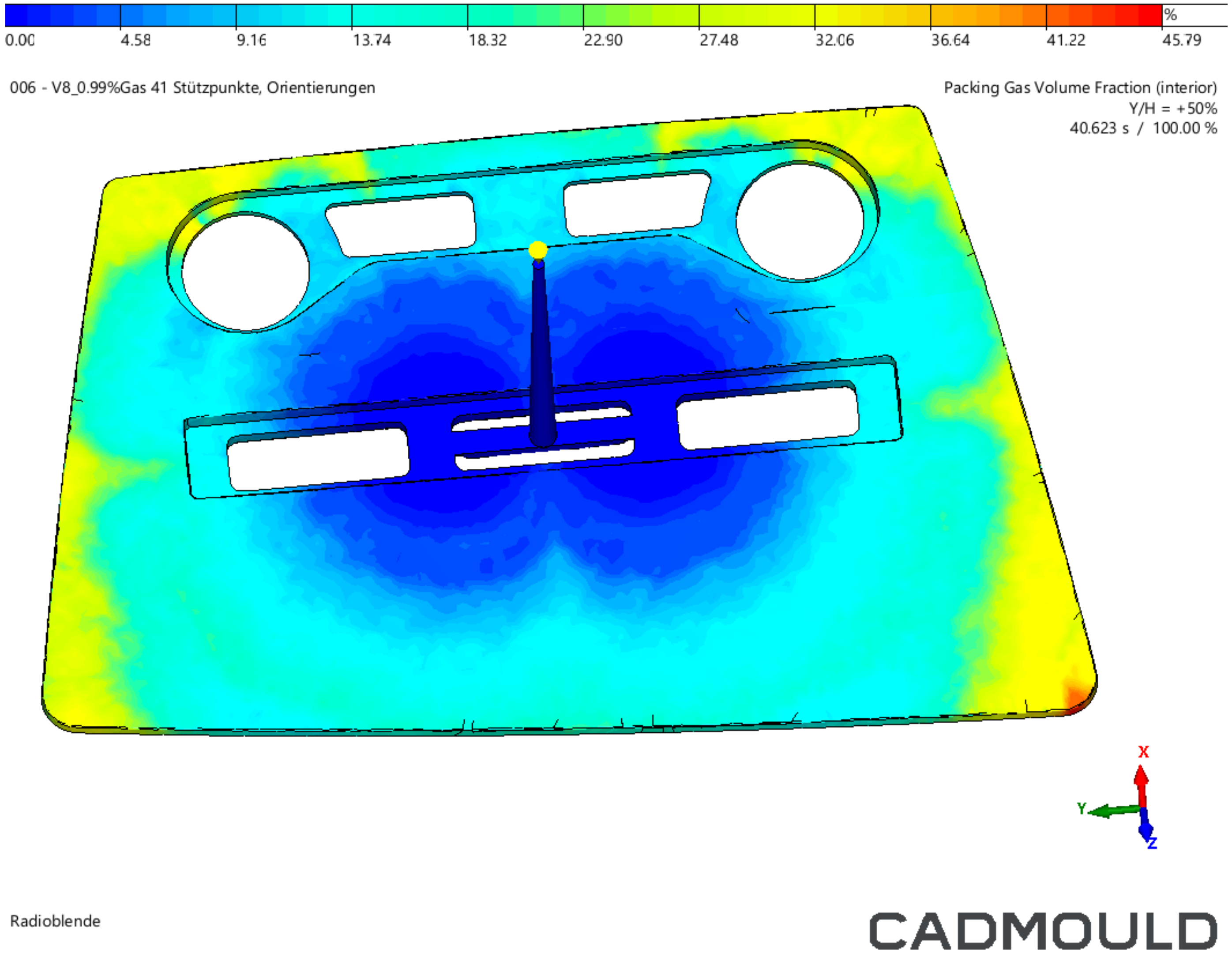


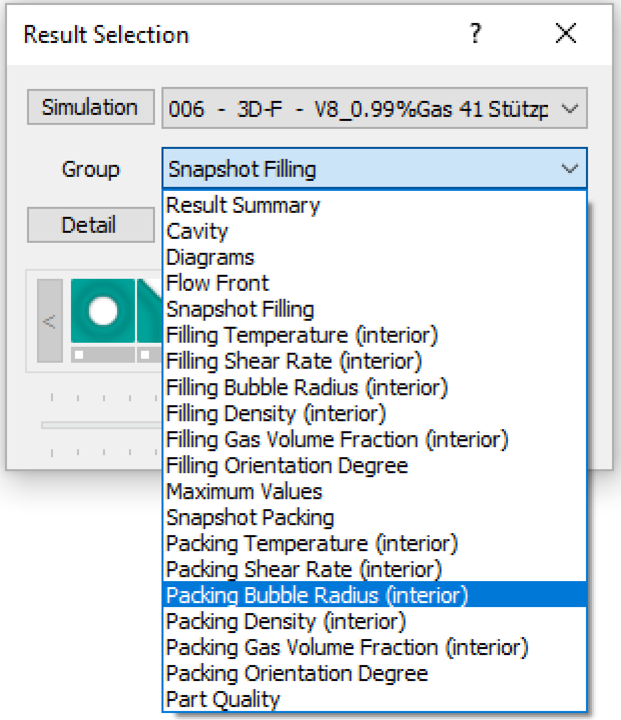
Physical Foaming



Chemical Foaming

CADMOULD® 3D-F Foam
Available Results in FOAM





- Bubble Radius (interior)
- Density (interior)
- Gas Volume Fraction (interior)
- Temperature (interior)

All Available for Packing + Filling

CADMOULD 3D-F FOAM FILLING - ANIMATED

VMAP

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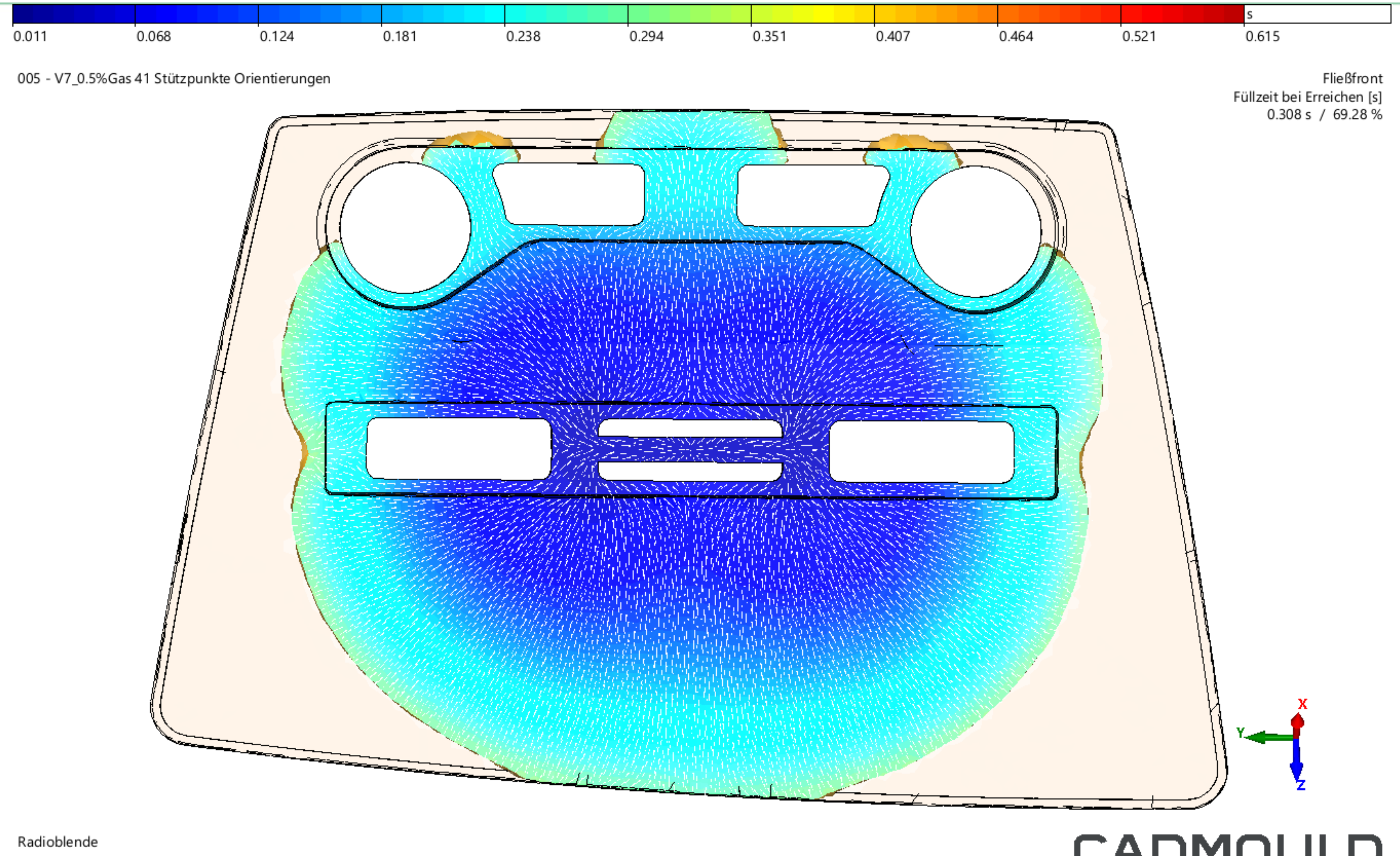

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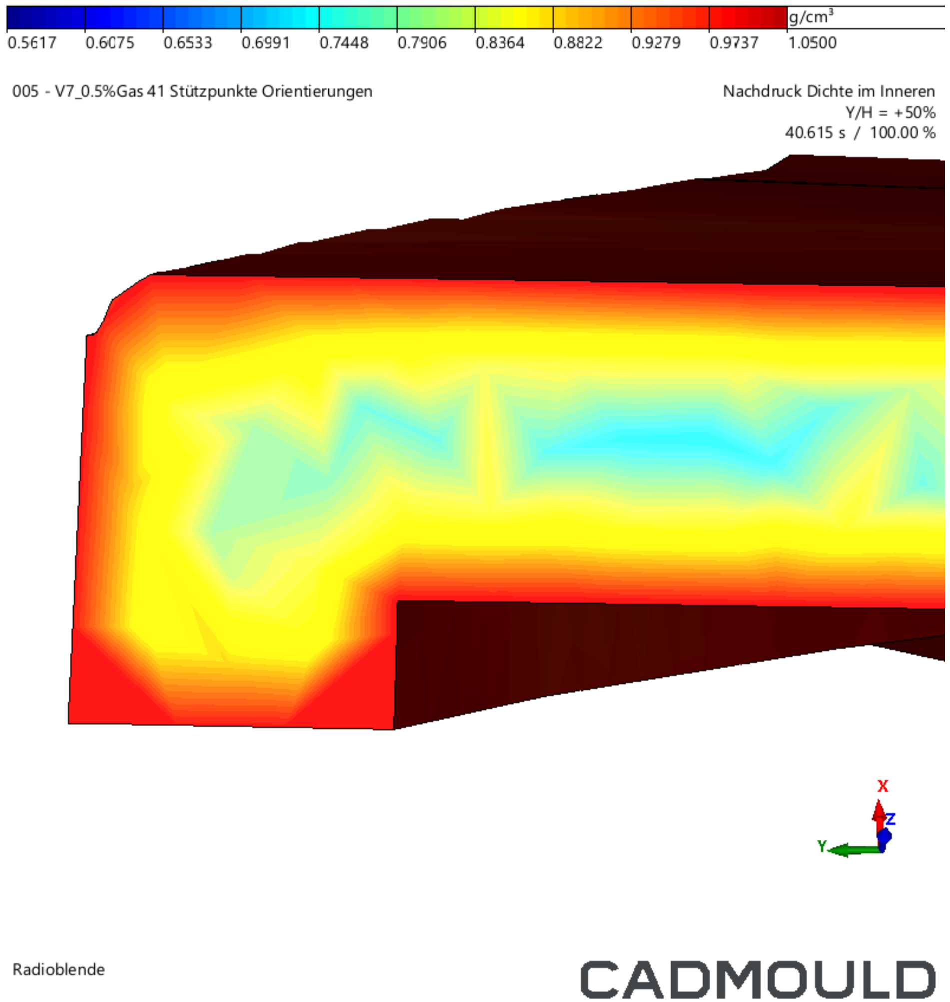
ITEA 3

COMPARISON SIMULATION & REALITY
PACKING DENSITY

VMAP

SIMCON



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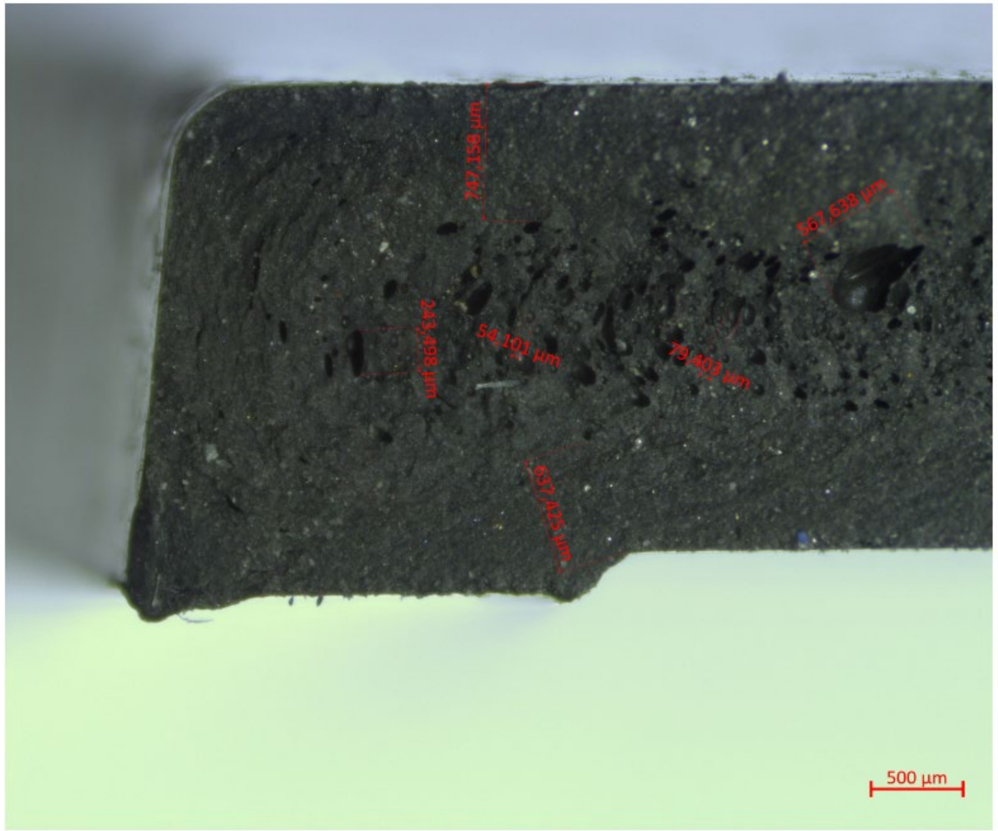

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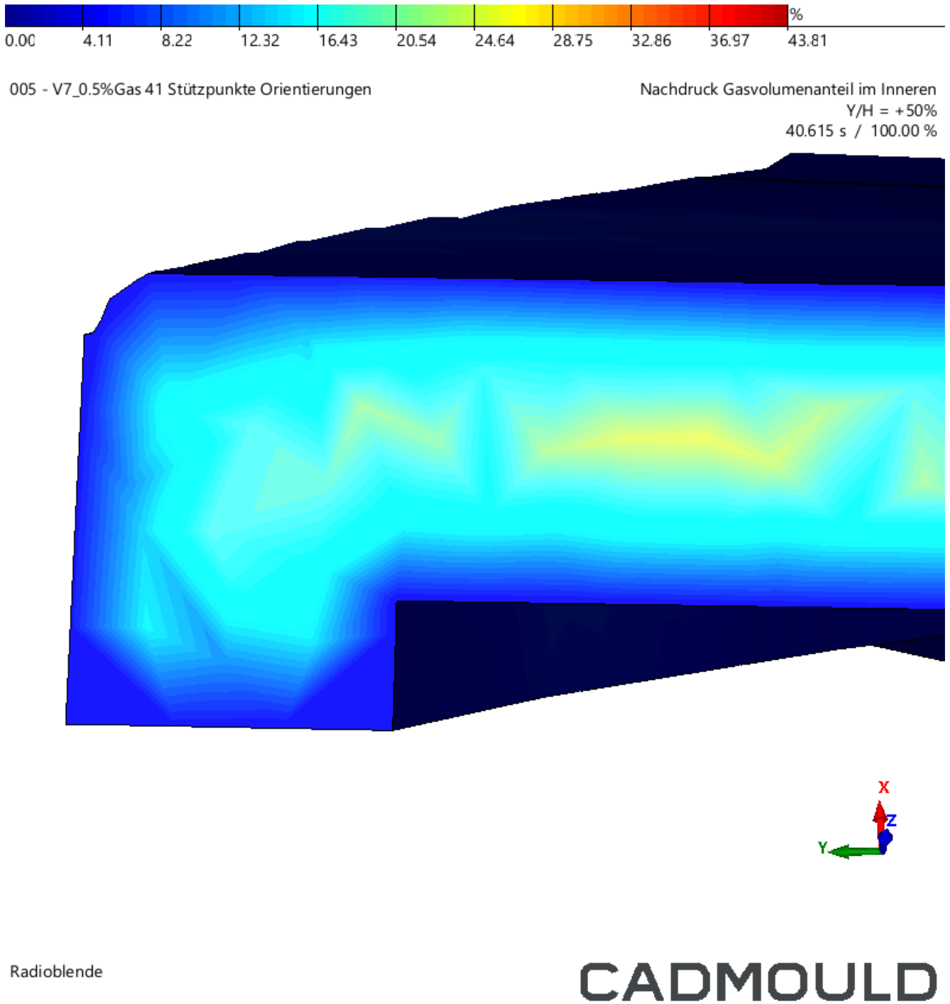
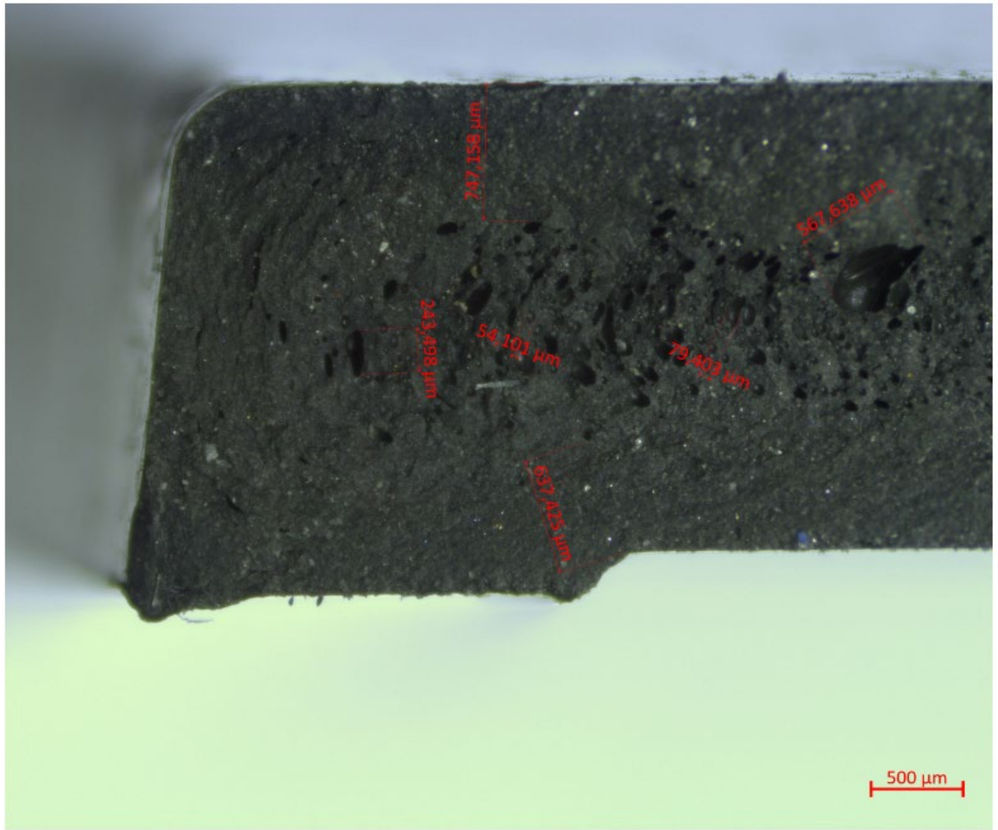
COMPARISON SIMULATION & REALITY
GAS VOLUME FRACTION

SIMCON





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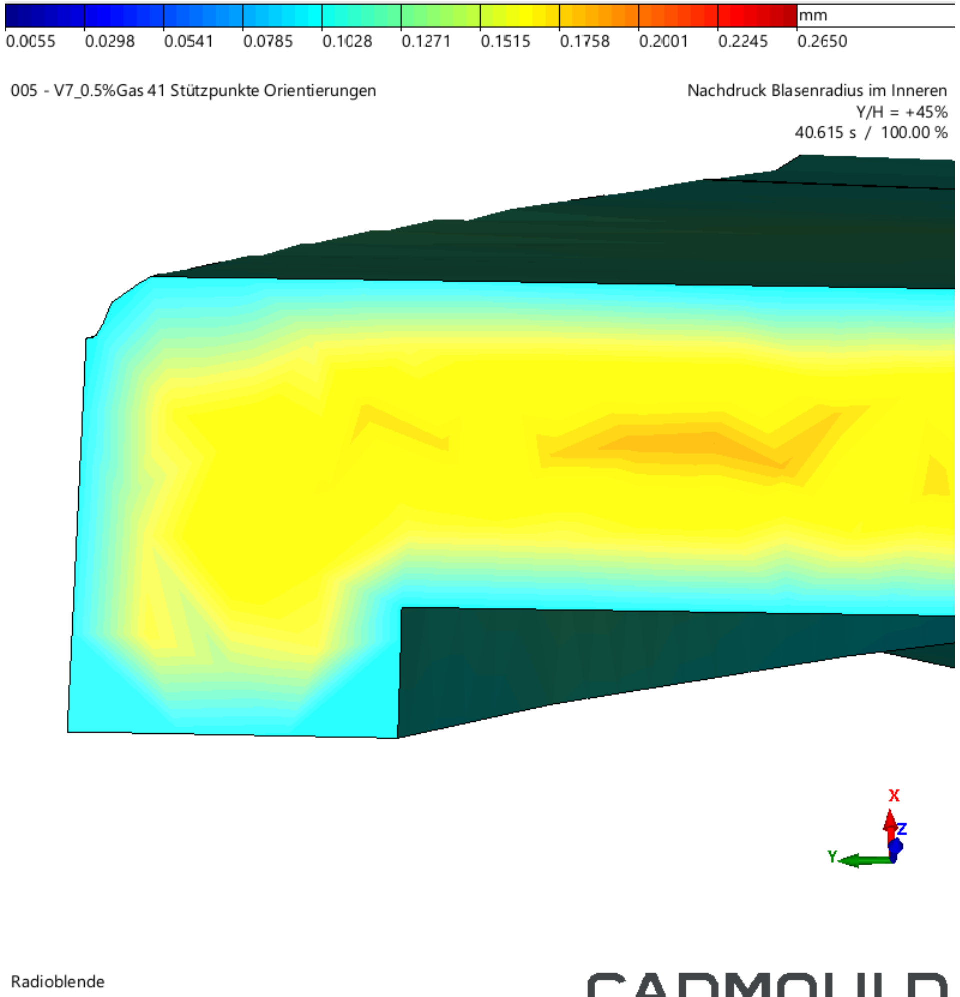
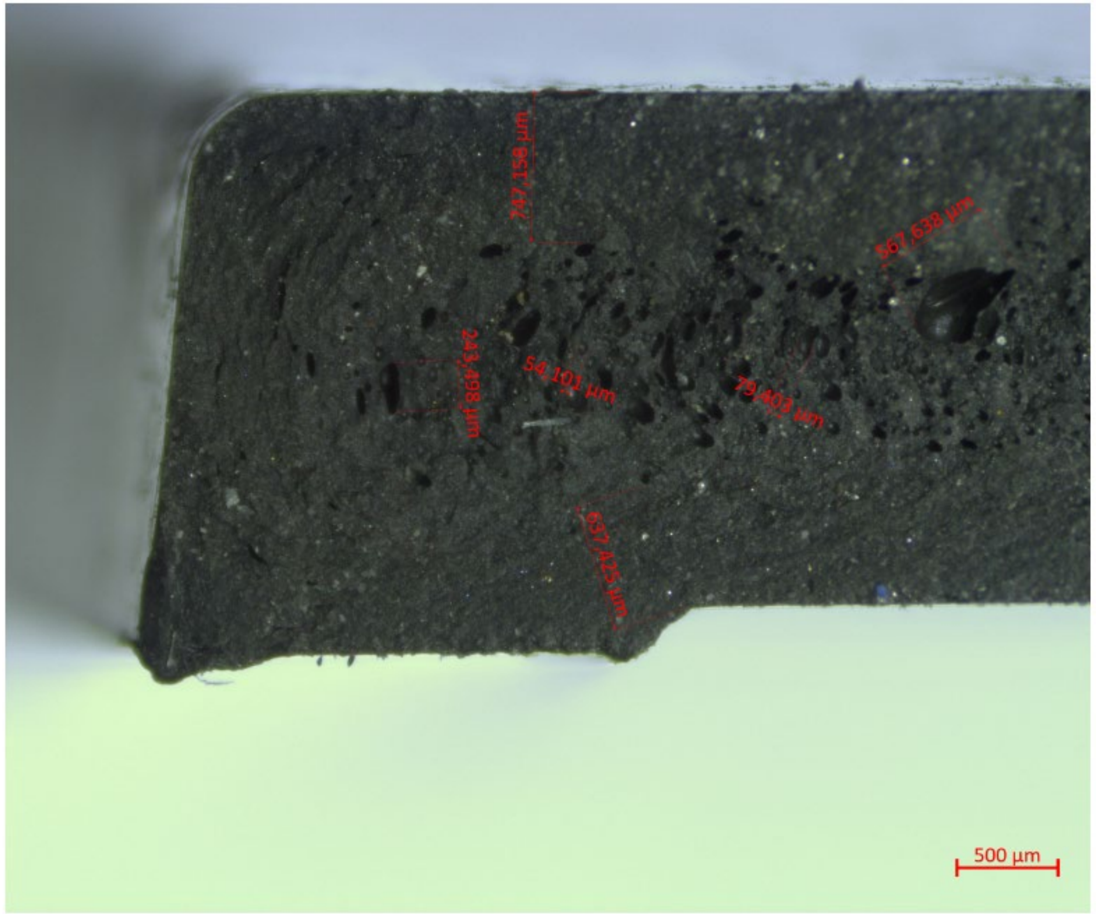
COMPARISON SIMULATION & REALITY
PACKING BUBBLE RADIUS

VMAP

SIMCON





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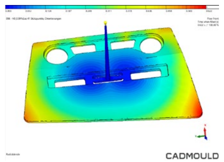
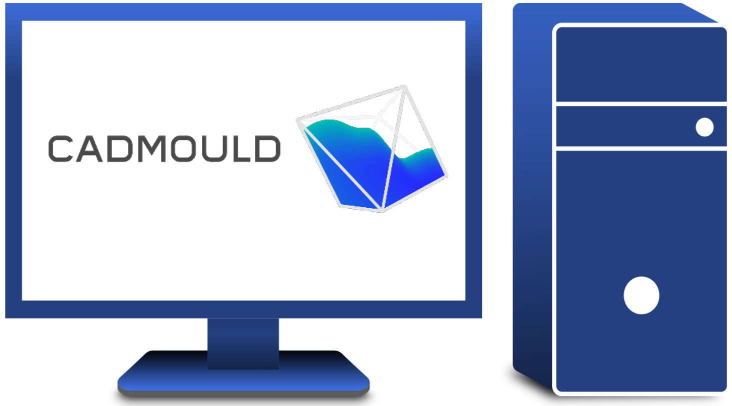
ITEA 3

CADMOULD® 3D-F Foam
VMAP Format as Connection to next Simulation Step

VMAP

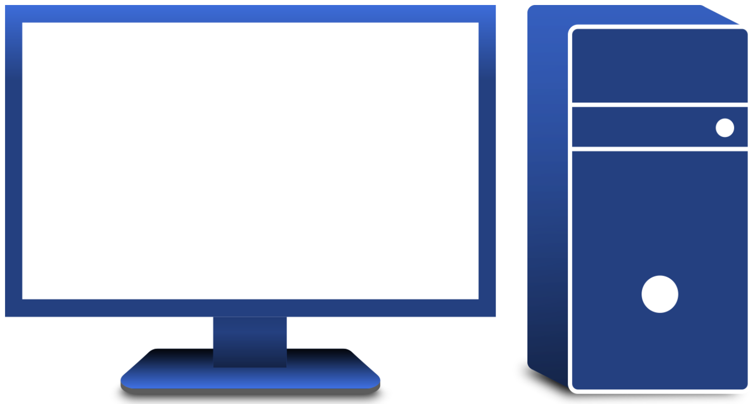


Virtual Performance Solution



VMAP

Using VMAP as easy Connection between multiple Simulation-Tools



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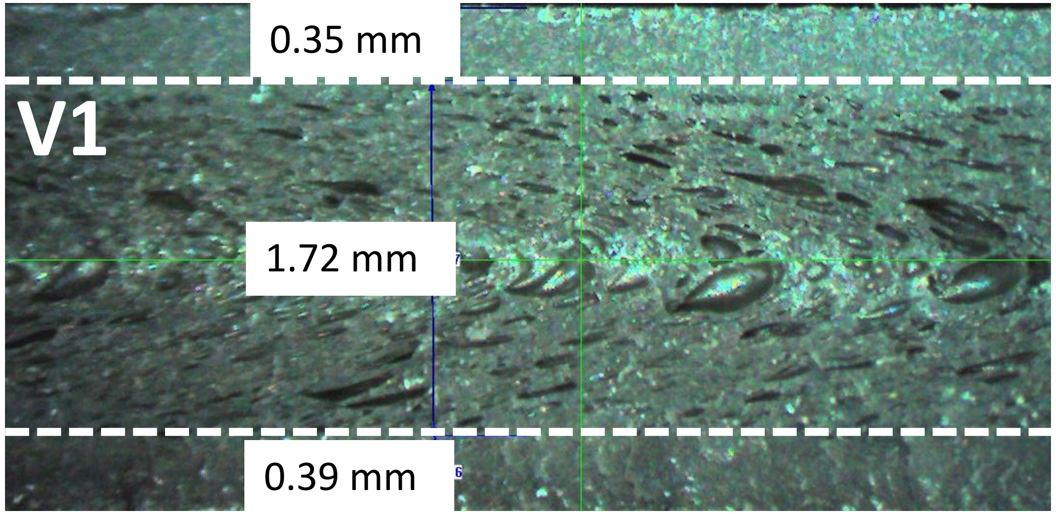
Structural behavior

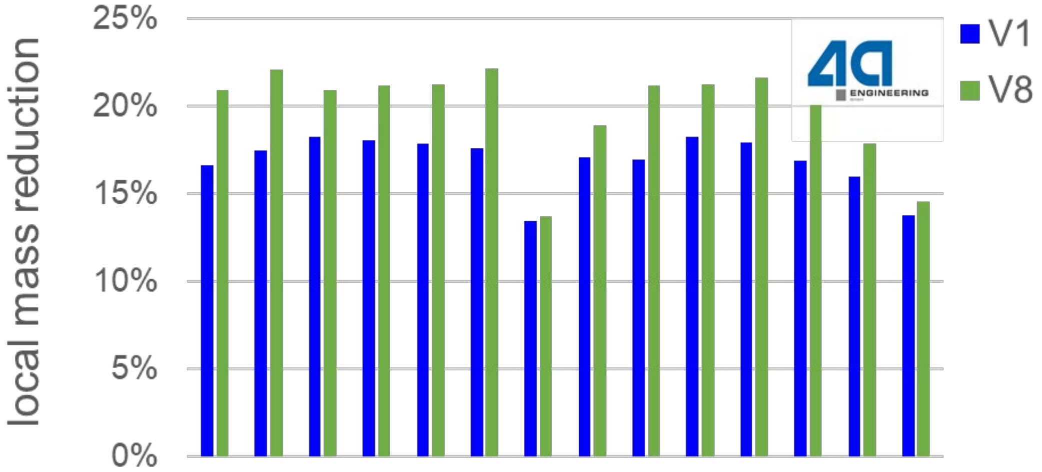
4a Technology Days, 03. -04. March 2020

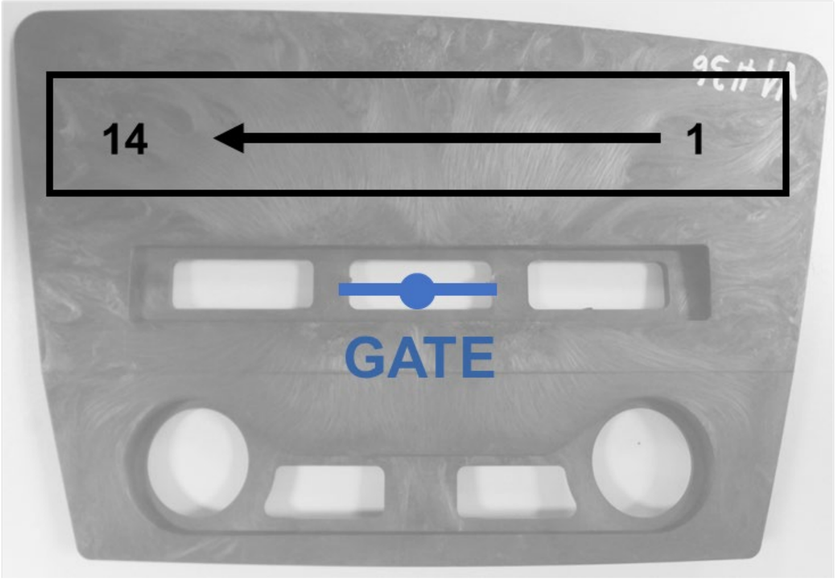
Bernhard Jilka
4a engineering GmbH, Traboch (Austria)

USE CASE - radio mask structural foaming

- ***investigations***
  - different processing
    - ***compact***
    - ***foamed*** ***V1: -12% mass***
    - ***foamed*** ***V8: -14% mass***
  - foam distribution

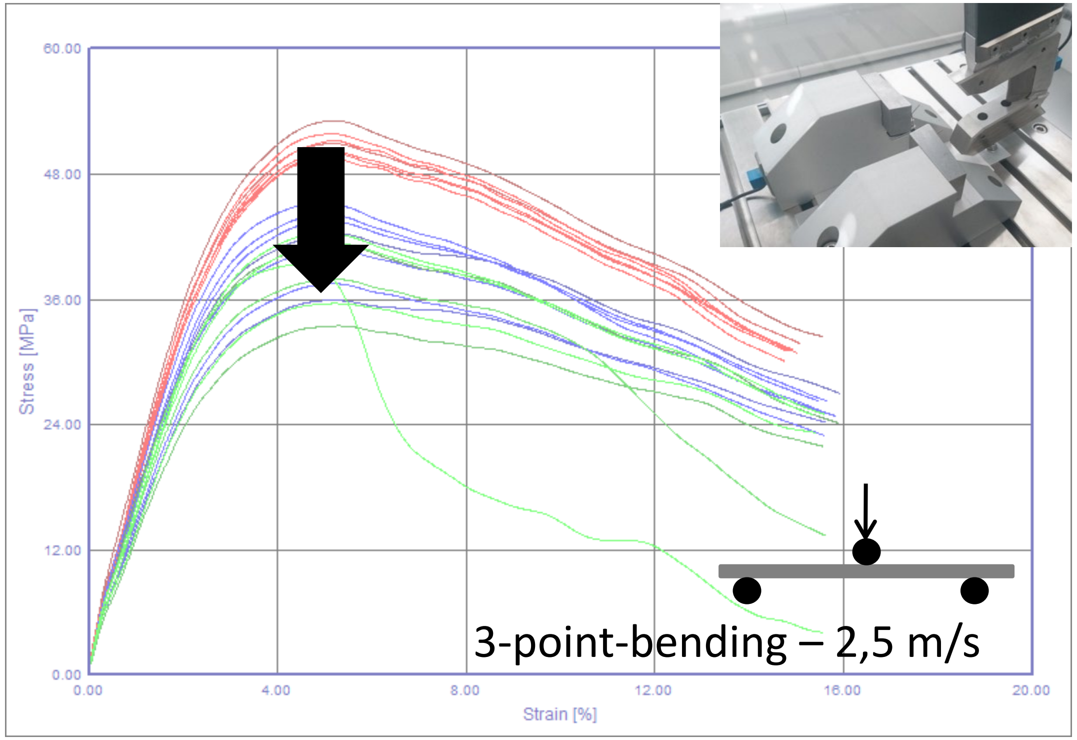


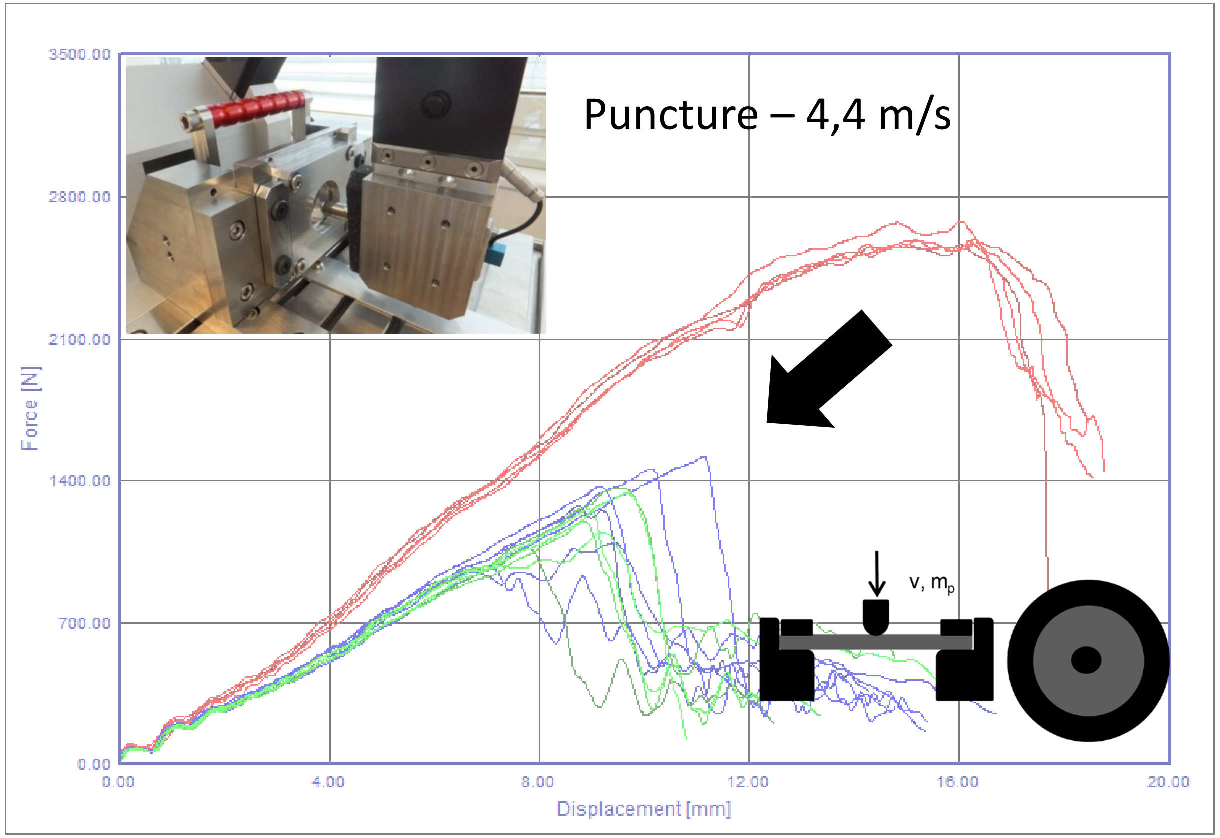




USE CASE - radio mask structural foaming

- *investigations* ***mechanical behavior***
  - static tensile tests
  - static & **dynamic bending tests**
  - **dynamic puncture tests**

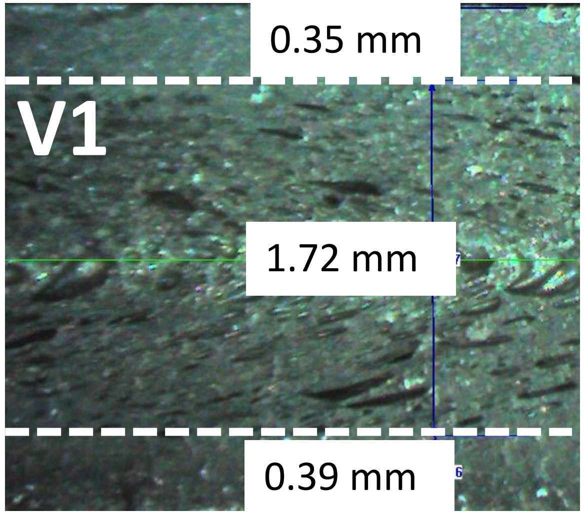




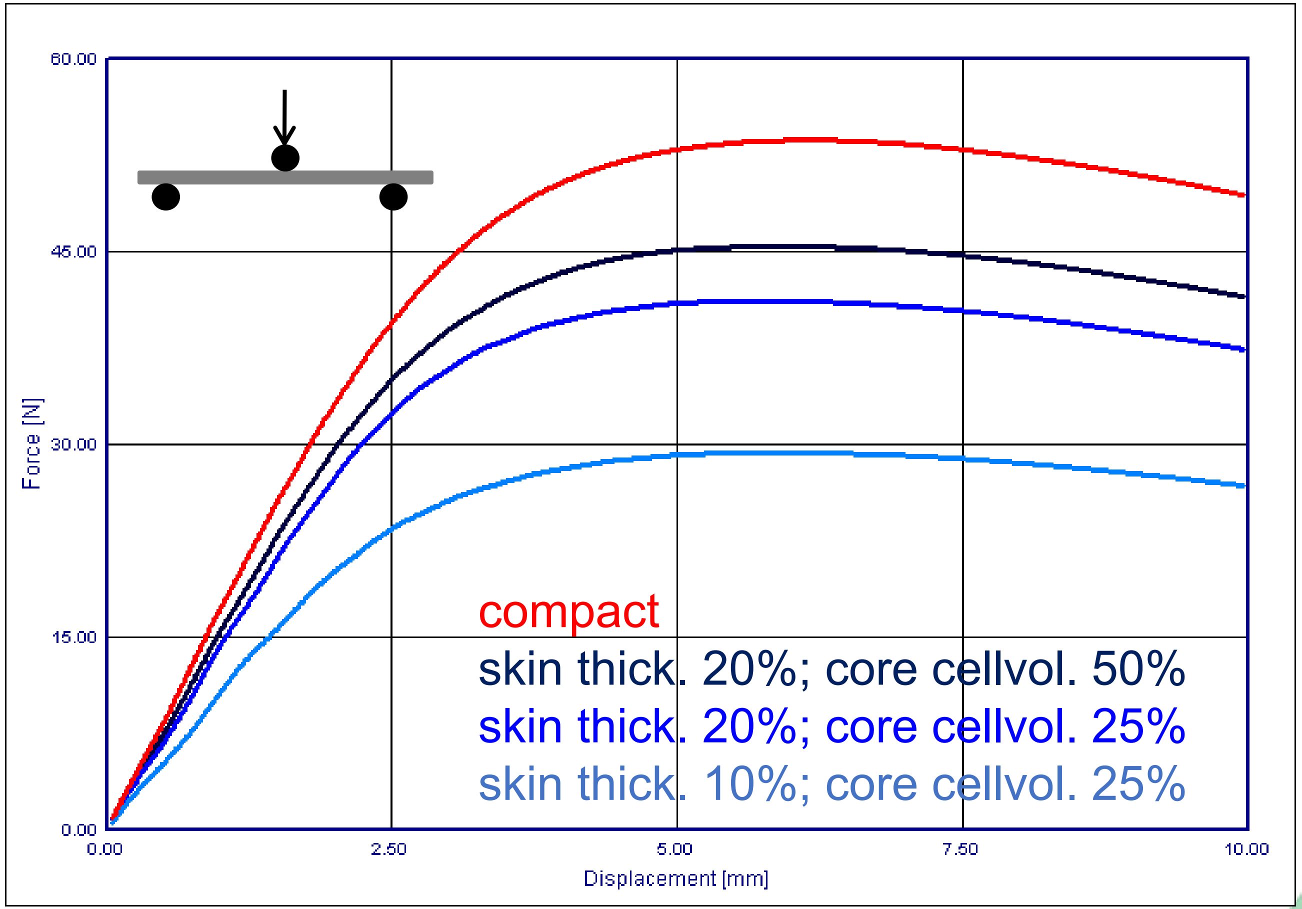
compact
V1: -12% mass
V8: -14% mass

USE CASE - radio mask structural foaming

- *correlation simulation*
  - virtual material modeling
  - structural prediction
    - **variation skin thickness**
    - **variation of cell volume**

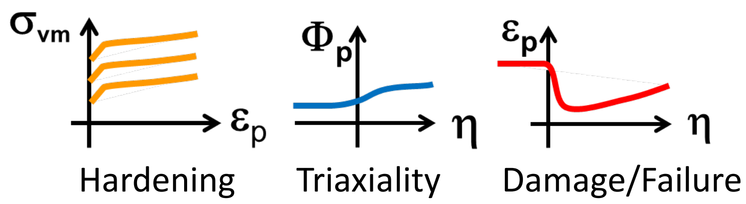


SIMULATION with SKIN-CORE-SKIN



USE CASE - radio mask structural foaming

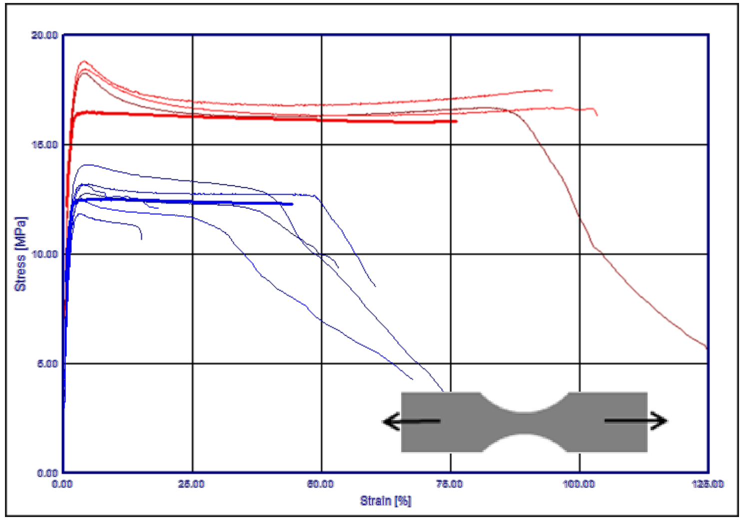
- ***virtual material modeling***
  1. compact material – PP T10 determine ***MAT_SAMP-1** by reverse engineering
  2. **foamed material scaled by 0.8**



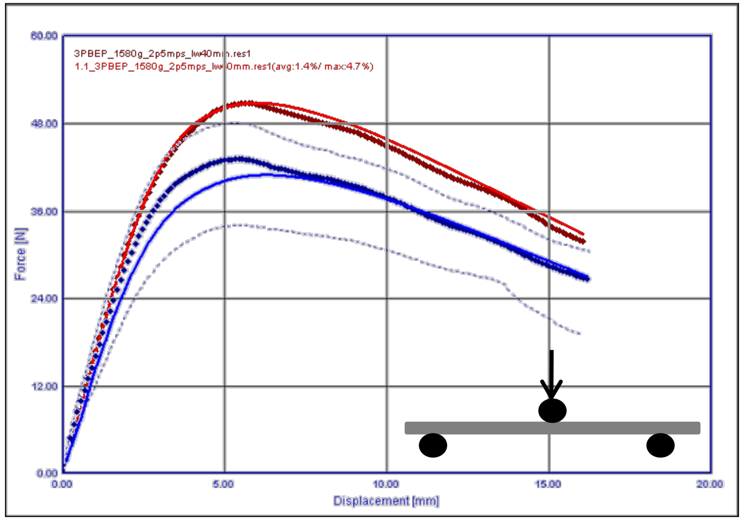
compact

foamed V1

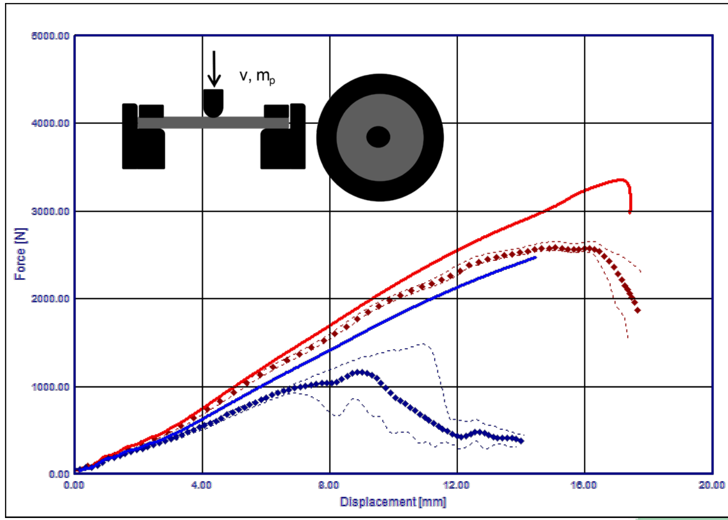
static tensile



dynamic bending



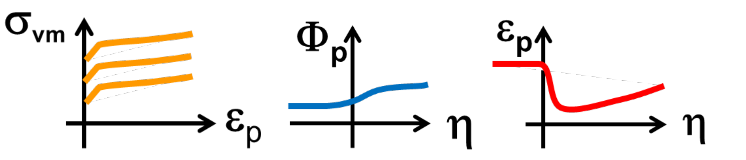
dynamic puncture test



USE CASE - radio mask structural foaming

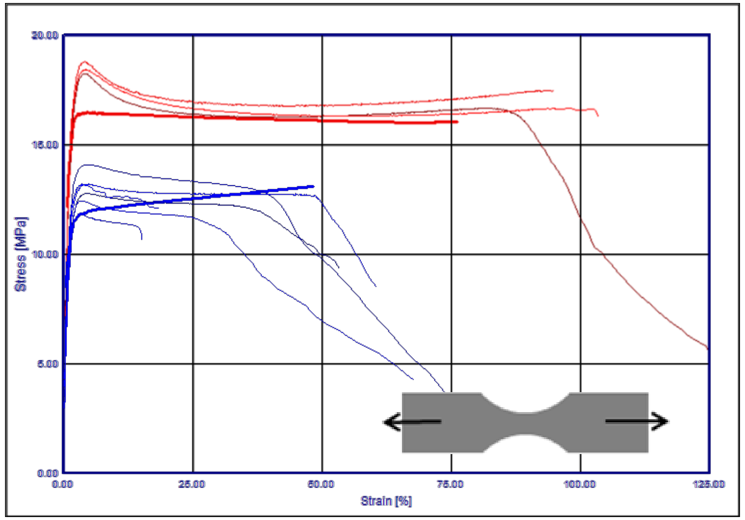
- ***virtual material modeling***
  1. compact material – PP T10
     determine ***MAT_SAMP-1**
     by reverse engineering
  2. **foamed material PCOMP**

VALIMAT

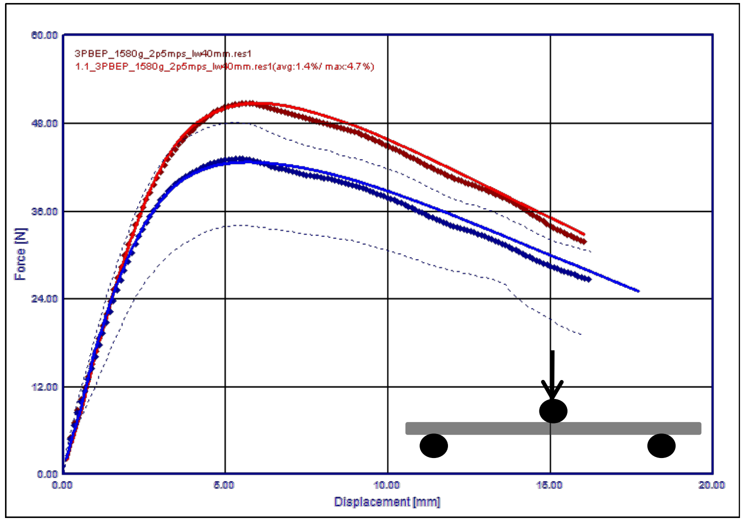


compact
foamed V1

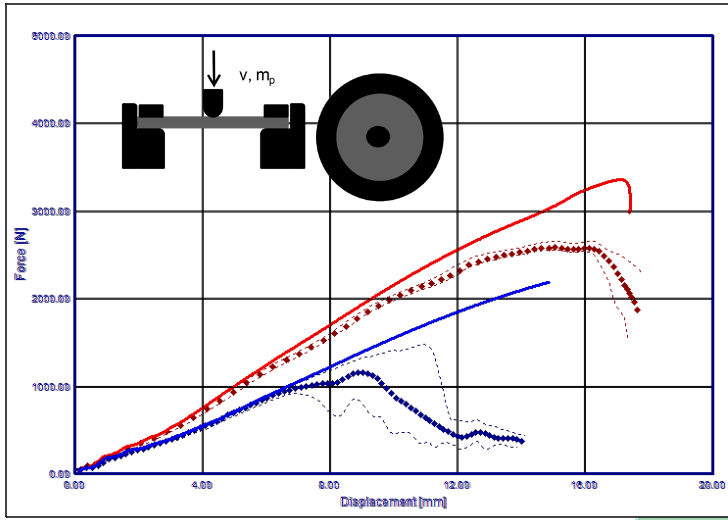
static tensile



dynamic bending



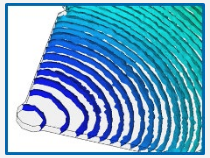
dynamic puncture test



USE CASE - radio mask structural foaming

process simulation

filling

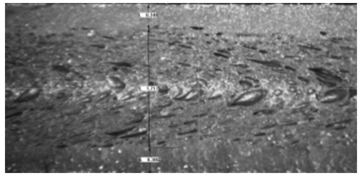


foam distribution
cell volume

CADMOULD® 3D-F SIMULATION

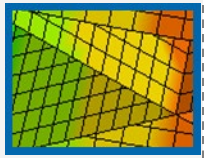
FIBERMAP

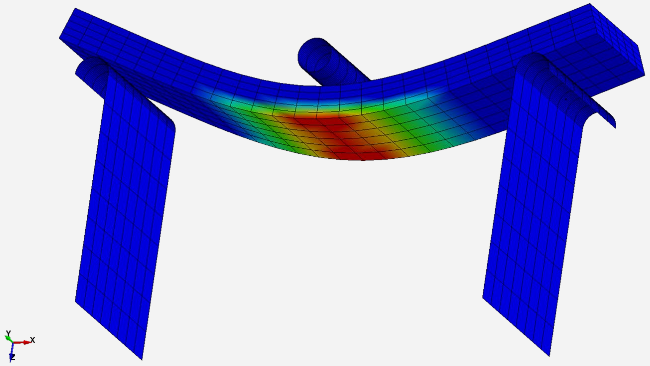
VMAP



structural simulation

coupon level





damaged material

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Virtual Performance Solution

USE CASE - radio mask structural foaming

structural foaming

- *simple scale rough estimation*
- *local distribution → local strength and failure strain*

challenges for future

- *machine ↔ process sim. ↔ virt. material ↔ structural sim.*
- *material transfer models / material model*
- *simplification*

→ defining a new CAE standard VMAP

Thank you for your attention

With kind assistance

ITEA3: Defining Standards for Material Data Transfer in Manufacturing Virtual Simulation