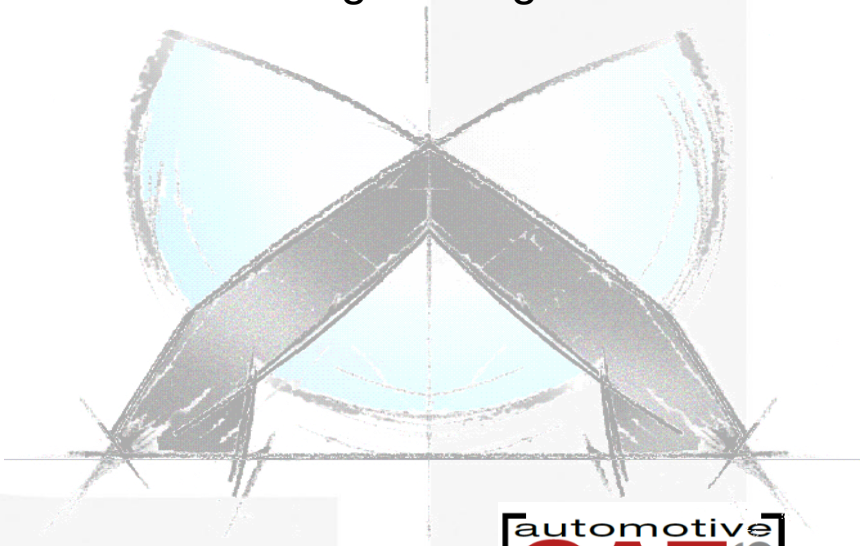
Interaction of solver settings / idealisation / material card for different explicit solvers on bending load cases

A. Fertschej, P. Reithofer, M. Rollant
4a engineering GmbH



4a engineering GmbH
Industriepark 1
A-8772 Traboch
fertschej@4a.co.at
++43 (0) 664 80106 619
http://impetus.4a.co.at/en/

automotive CAE Grand Challenge 2016
April 12 - 13, 2016
Congress Park Hanau, Germany

I N P H Y S I C S W E T R U S T

4a technology group

4a technology-group: founded in 2002

Location: Traboch, Austria

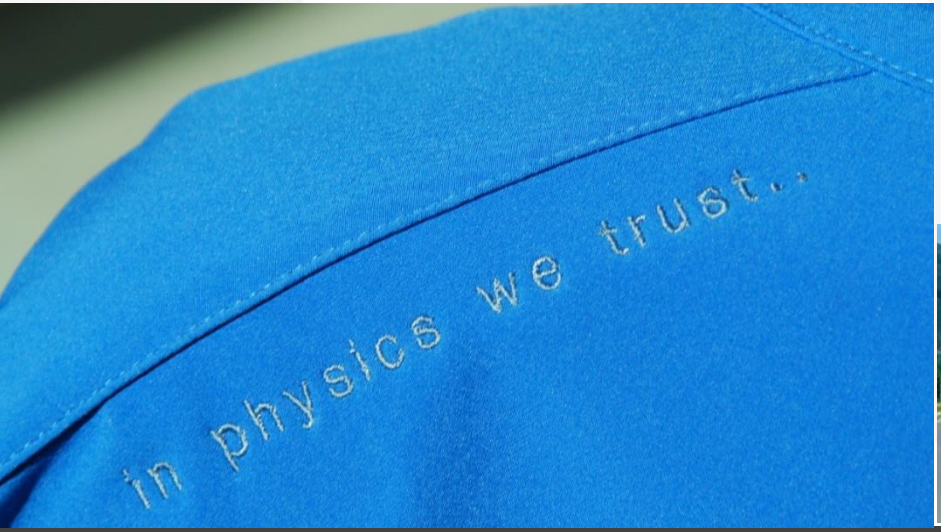
Number of employees > 80

Field of operation: global

Certificates: ISO 9001

more than 2000 projects

more than 400 customers



4a technology group

4a GROUP

Group of Companies

- 4a Group
- Philosophy
- People
- Products
- Press
- Contact
- Directions

>>> JOBS

Company details
Terms & Conditions

DE|EN

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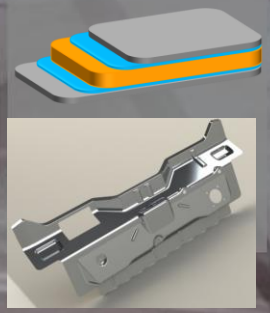
Business units

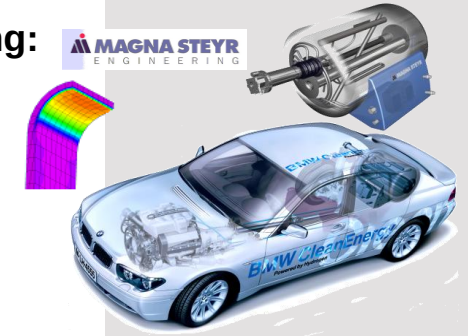
4a ENGINEERING	CIMERA	4a IMPETUS	4a active SYSTEMS
Engineering and simulation for plastic products and components	Multi-layer composites and sandwich materials for cost-efficient	Testing facilities generating material data suitable for the dynamic simulation of plastics	Dummies and testing facilities for active vehicle safety
to unit webpage		to unit webpage	

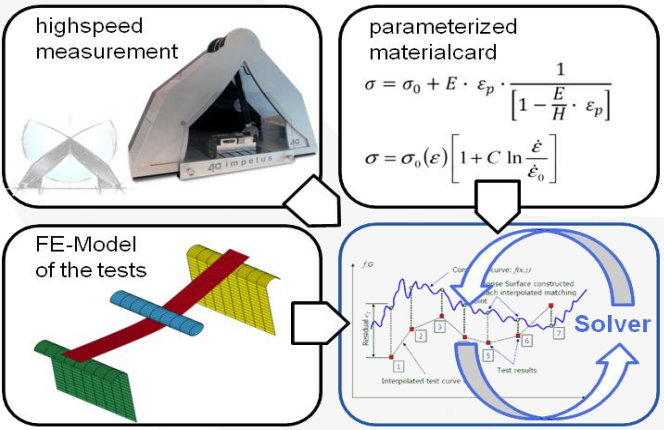
4a engineering GmbH

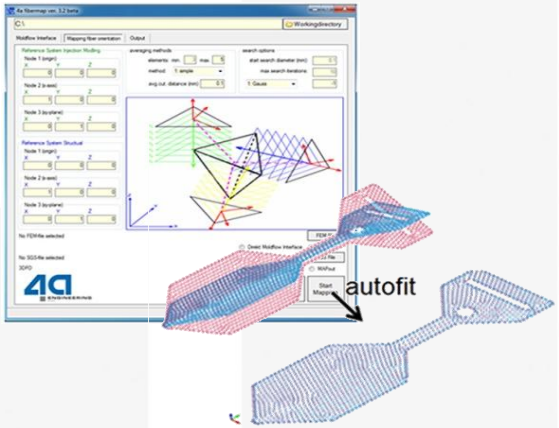
- polymer and materials science
- numerical simulation methods
- fiber reinforced plastics and composites
- method and software development
- material characterization
- product development

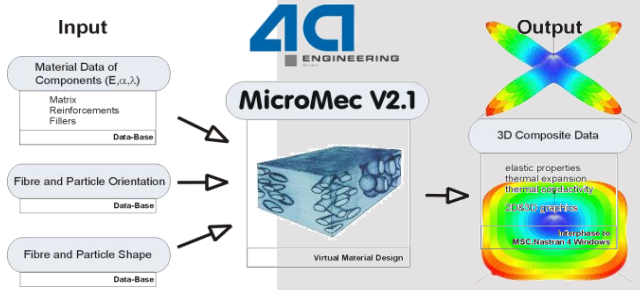
strut bar:

LH_2 – tank mounting:









4a impetus

Pendulum testing device
Numerical simulation
Automatic material card (LS-Dyna…)

4a fibermap

Consideration of the fiber orientation in the structural simulation of short or long fiber reinforced thermoplastics

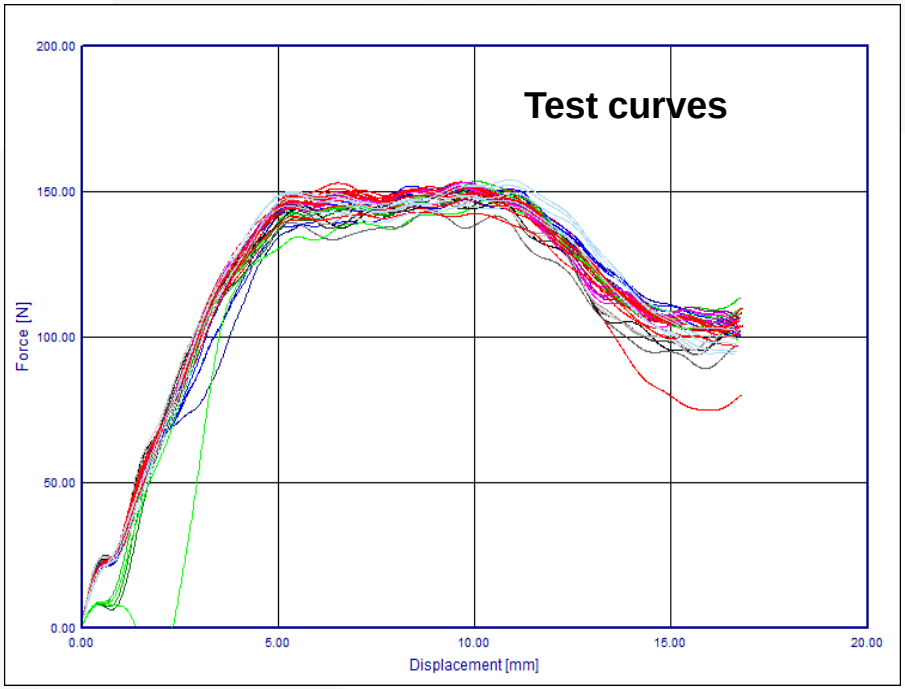
4a micromec

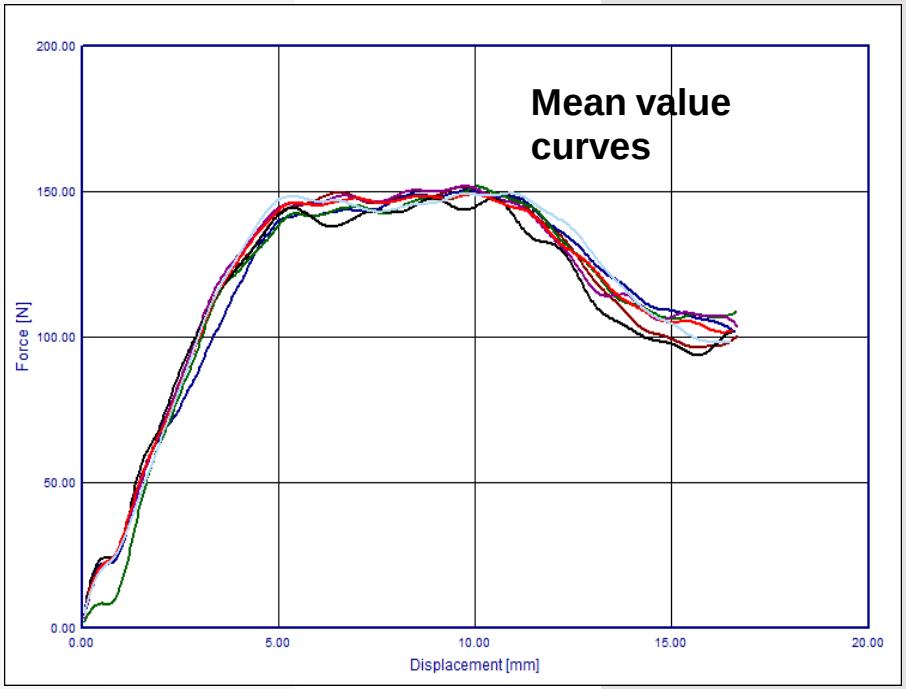
Micromechanical program
Calculation of the thermo-mechanical properties of composites

Content

- Introduction
- 4a impetus
- Tests – specimen preparation
- Simulation – influences
  - Solver, element size, integration points, settings, …
- Scattering in the tests - statistical evaluation in 4a impetus
- Summary

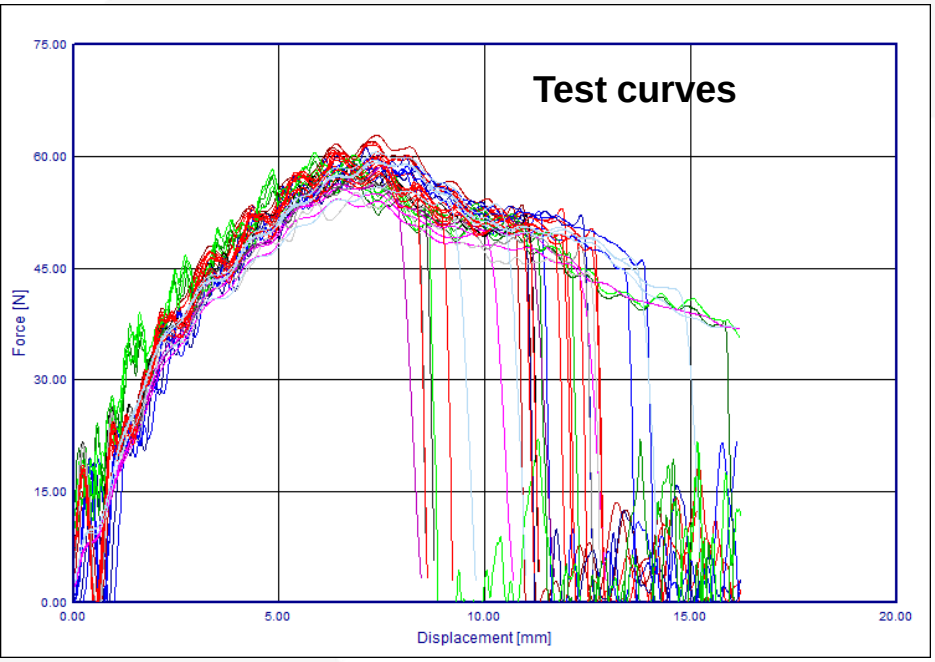
Introduction
Examples of measurement results PC/ABS

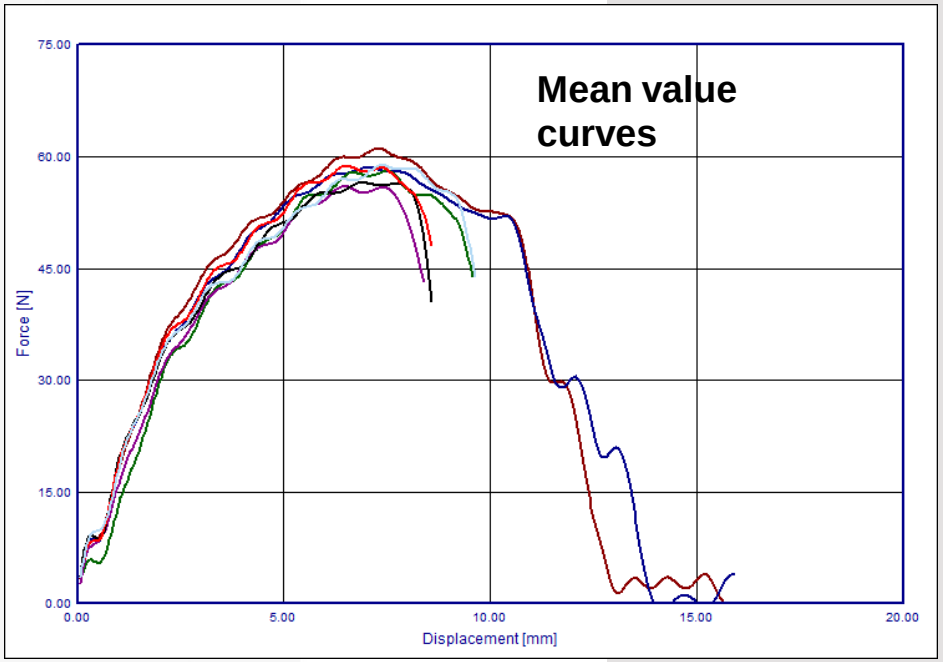




- Within a round robin test many materials were tested using the 4a impetus test systems of some customers.
- The results for the bending test of the material PC/ABS (thickness 3 mm) show a good conformity.

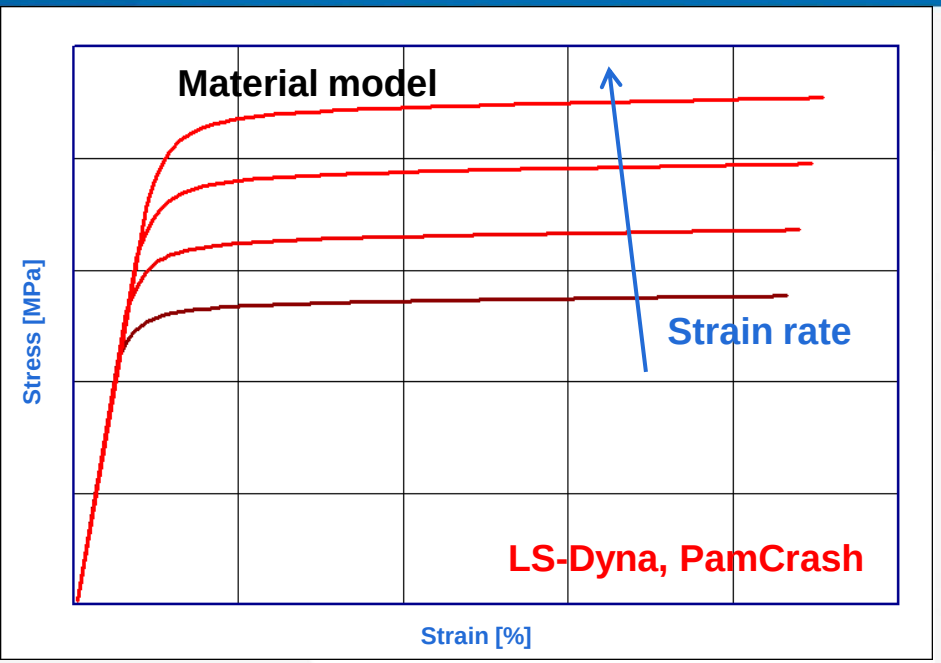
Introduction
Examples of measurement results PPT20

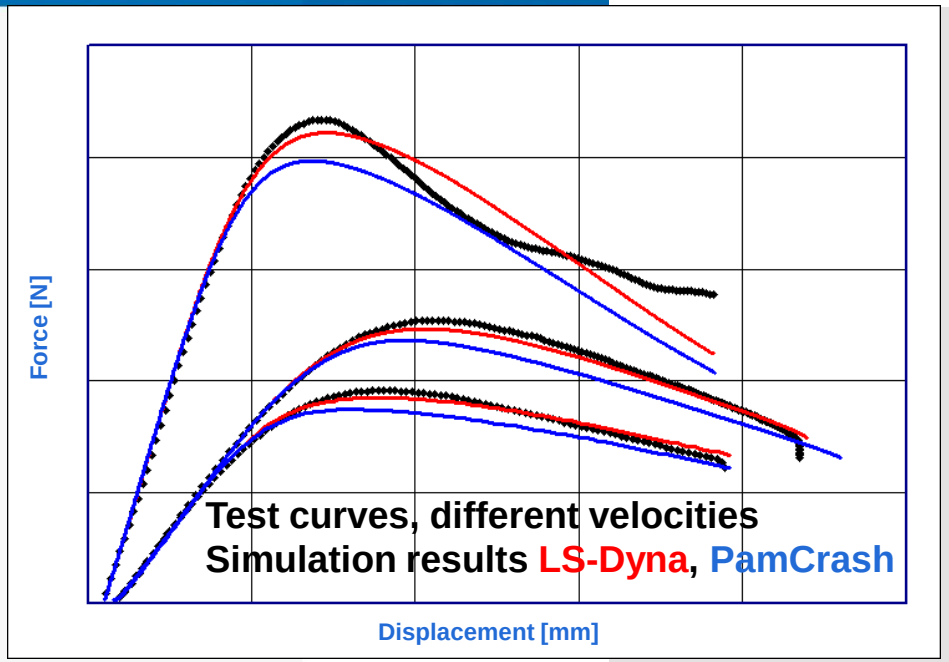




- The results for the bending test of the material PPT20 (thickness 2 mm) show a good conformity for the stiffness but a large scatter range for the failure displacement.

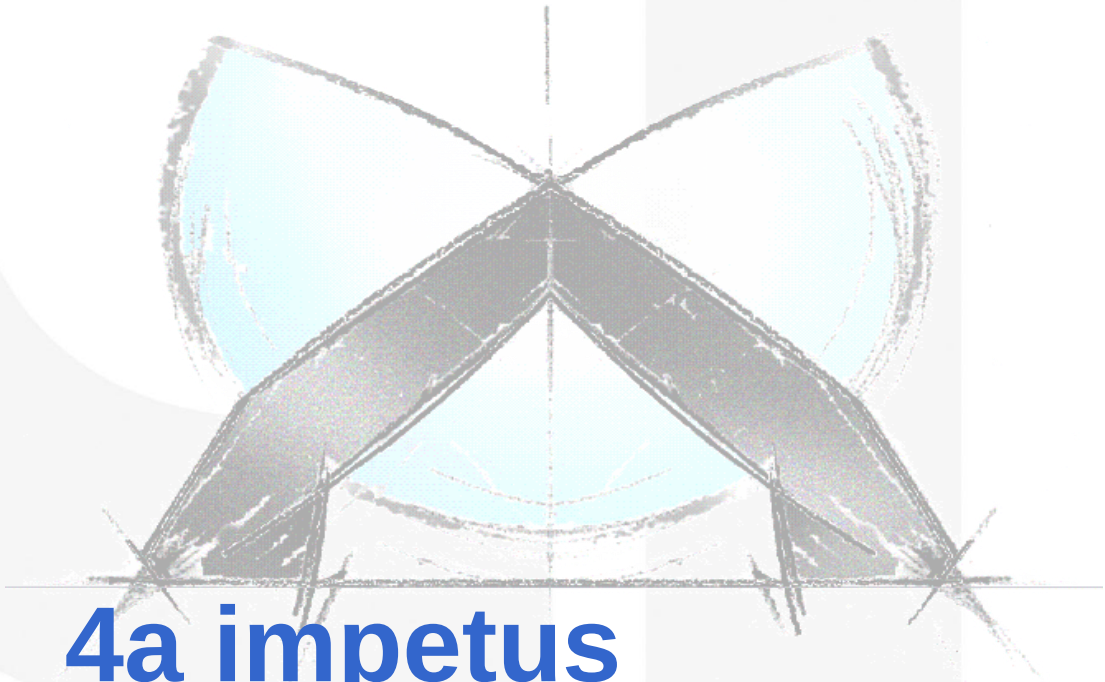
Introduction
Comparison LS-Dyna vs. PamCrash





- Using the same stress-strain curves in the material model for both solvers LS-Dyna and PamCrash results in different force-displacement curves (for obligatory settings in the control cards)

4a impetus ?



4a impetus

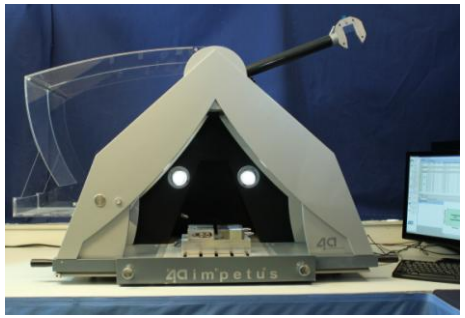
4a impetus
Current test machine

2015

4a impetus

Software solution from the test to the material card

4a impetus Hardware



directly linked

External Testing

gom Optical Measuring Techniques

Zwick / Roell

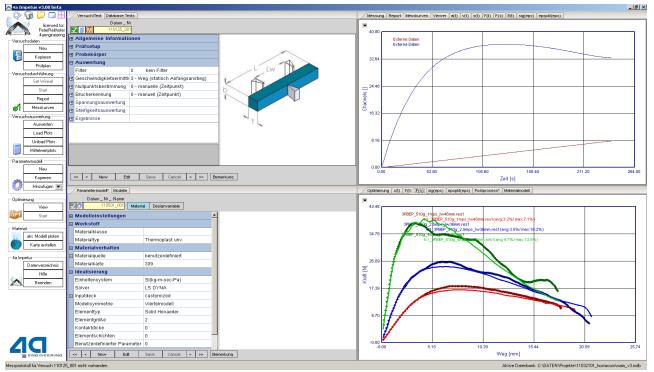
MTS®

INSTRON®

SHIMADZU

ASCII DATA

4a impetus Software



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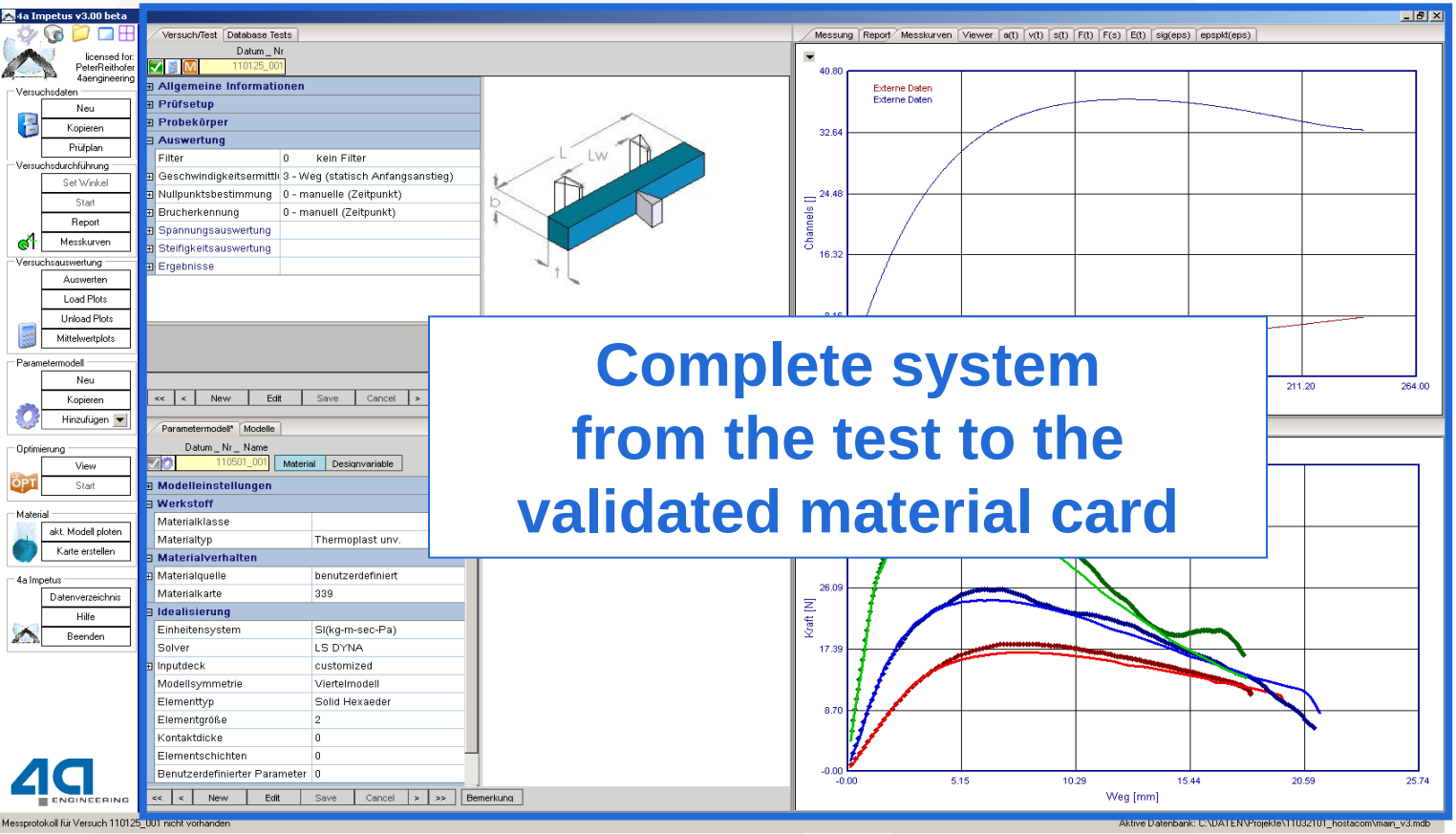
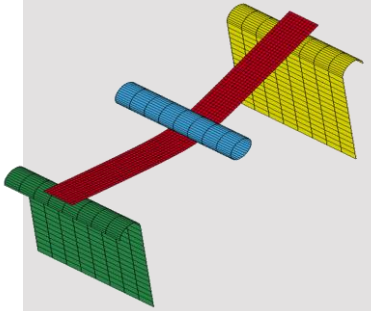
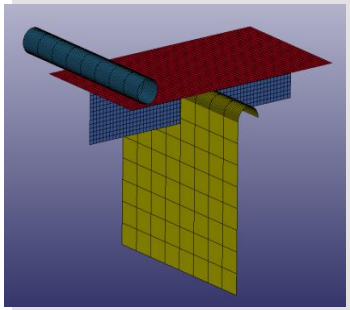
4a impetus

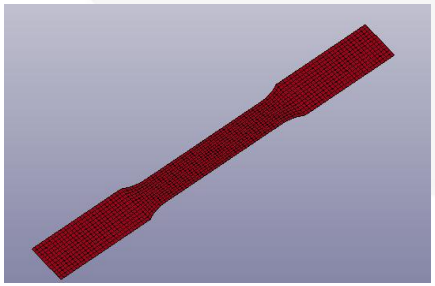
Software solution from the test to the material card

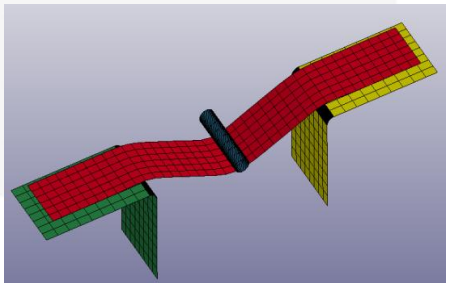
Complete system from the test to the validated material card

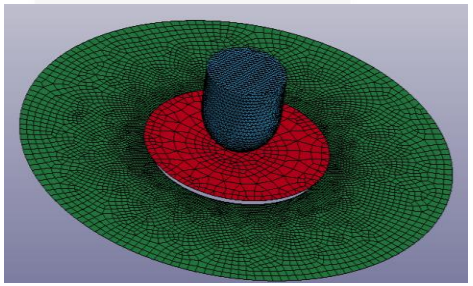


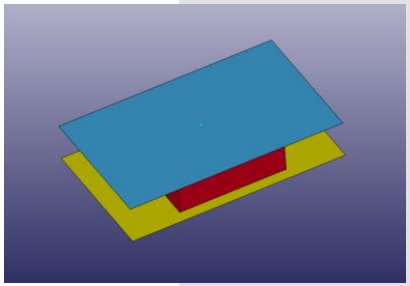






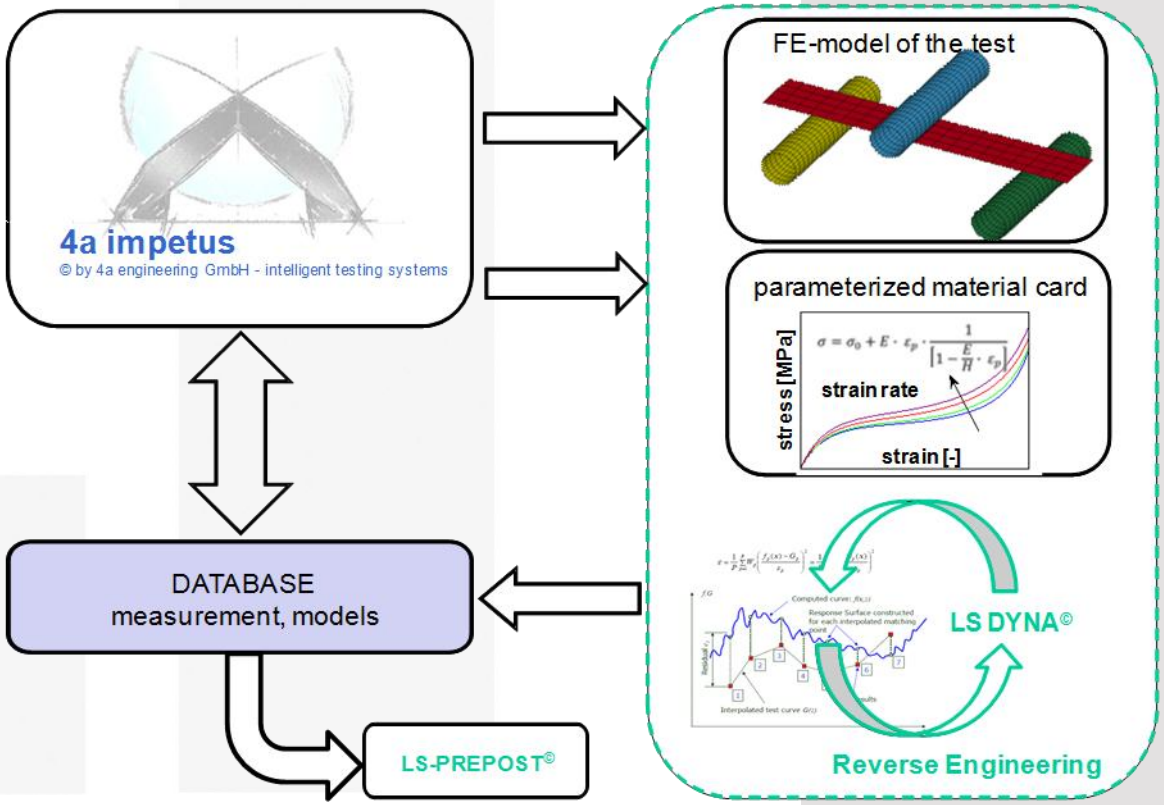




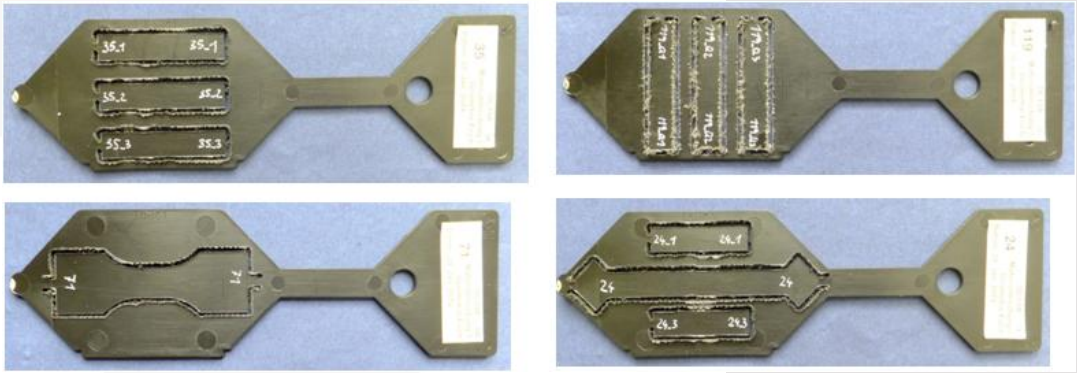


4a impetus
Process of material card generation

- Preparation of test specimen (injection molding / milling from plates / retrieving from parts …)
- Performing bending tests with different test setups using 4a impetus test device
- Evaluation of the tests
- Setting up the simulation
- Material card generation (reverse engineering using LS-OPT®)
- Validation of the material card

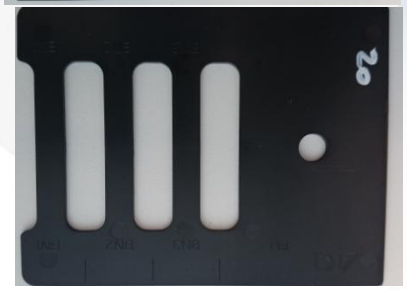


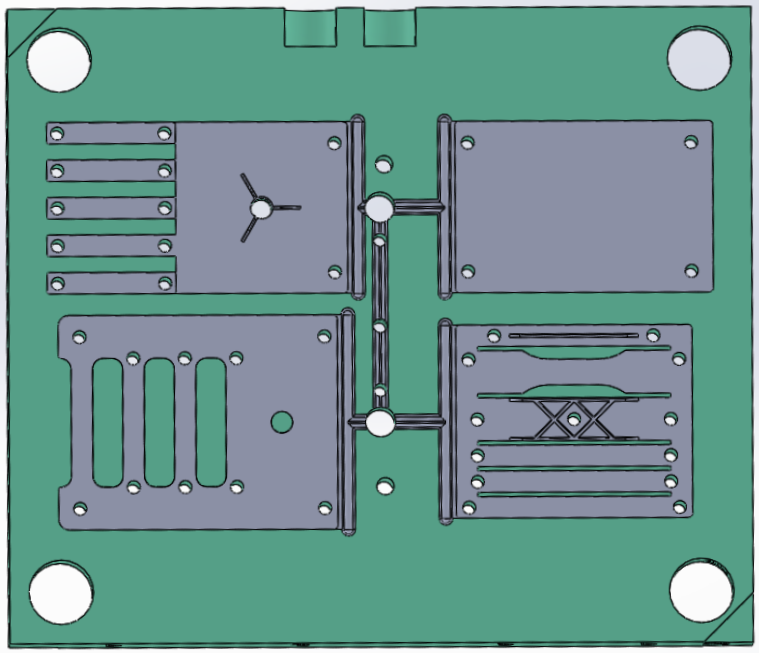
- Injection molding
  - „fish mold“



  - „4a plate mold“

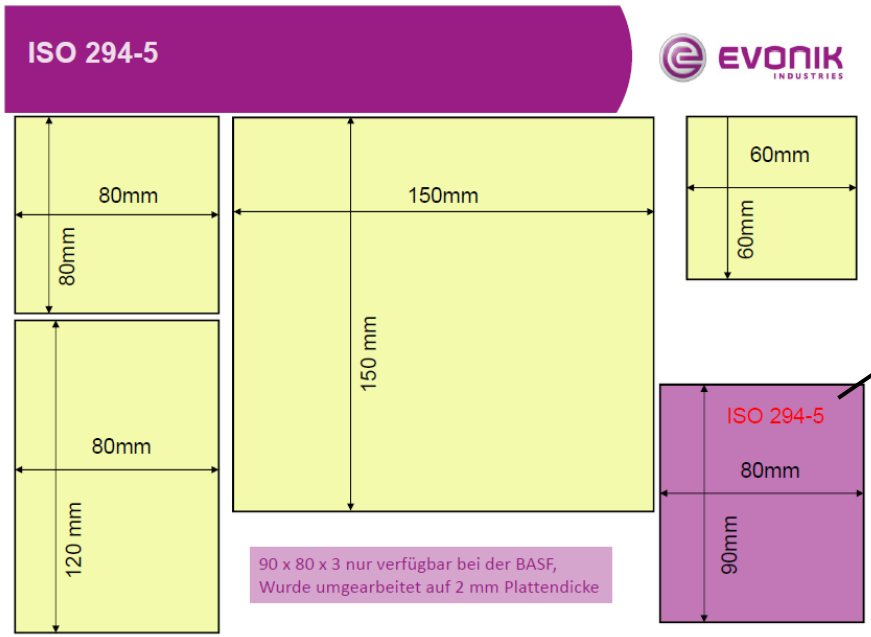
plate 120 x 80 x 2 mm

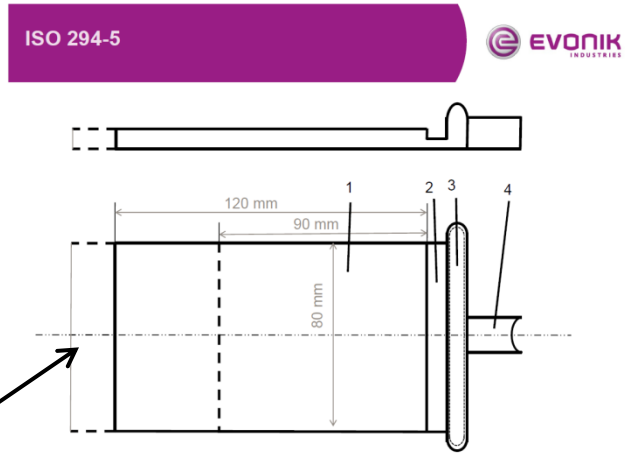




Tests – specimen preparation

- Test specimens taken from plates (ISO 294-5)

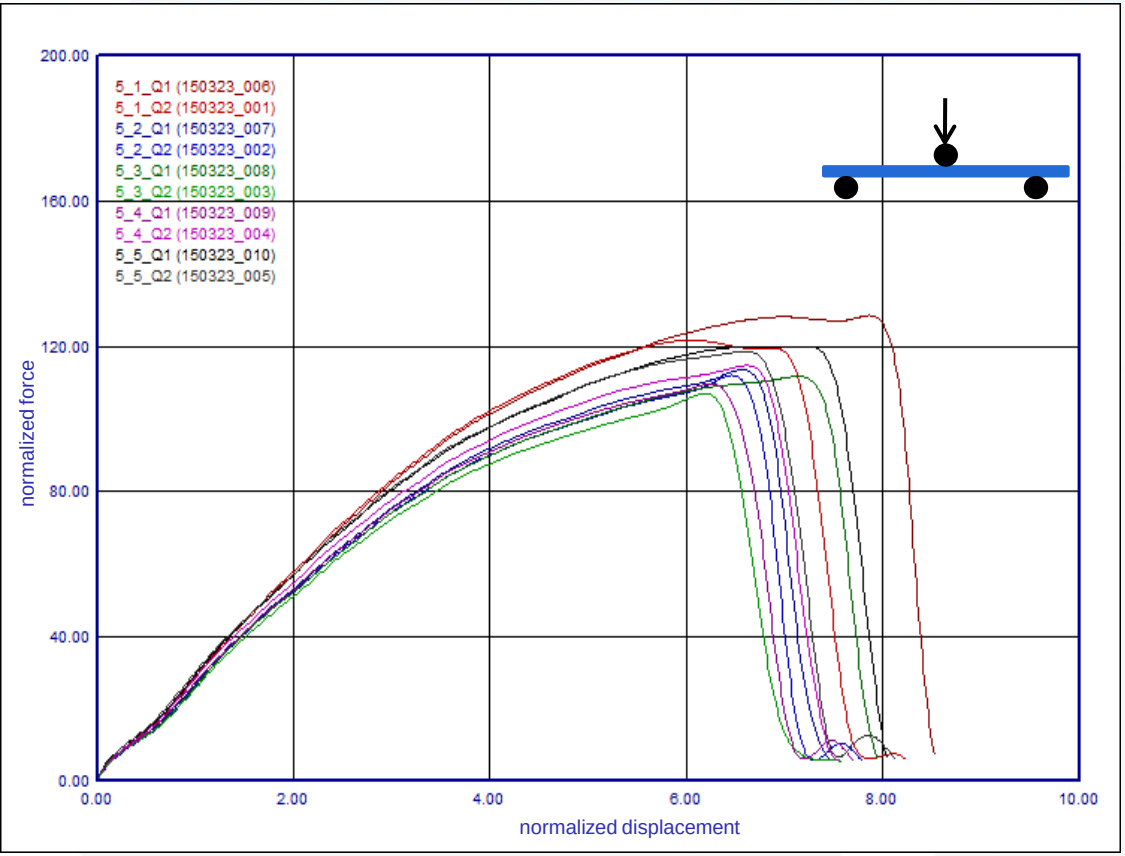




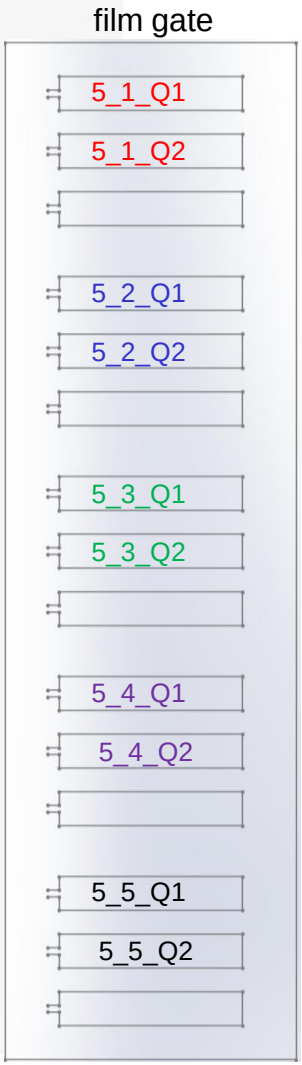
Revision ISO 294-5
CAMPUS anisotropic values based on plates 120 x 80 x 2 mm

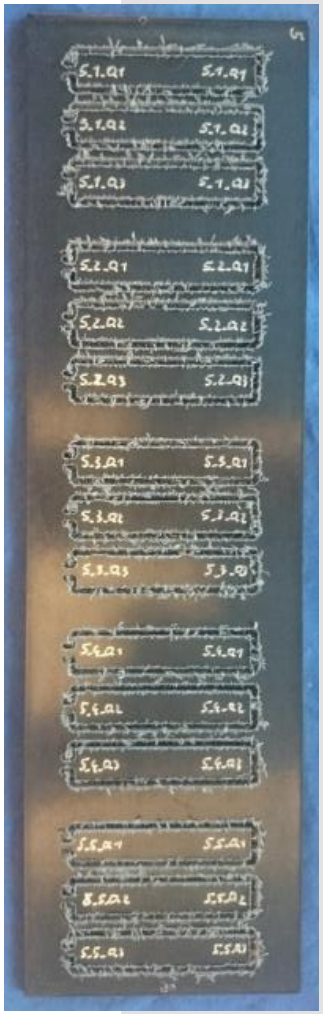
Source: Symposium Zwick/Ulm, R. Tuellmann: Anisotropie in ISO und CAMPUS

4a impetus
Tests – specimen preparation

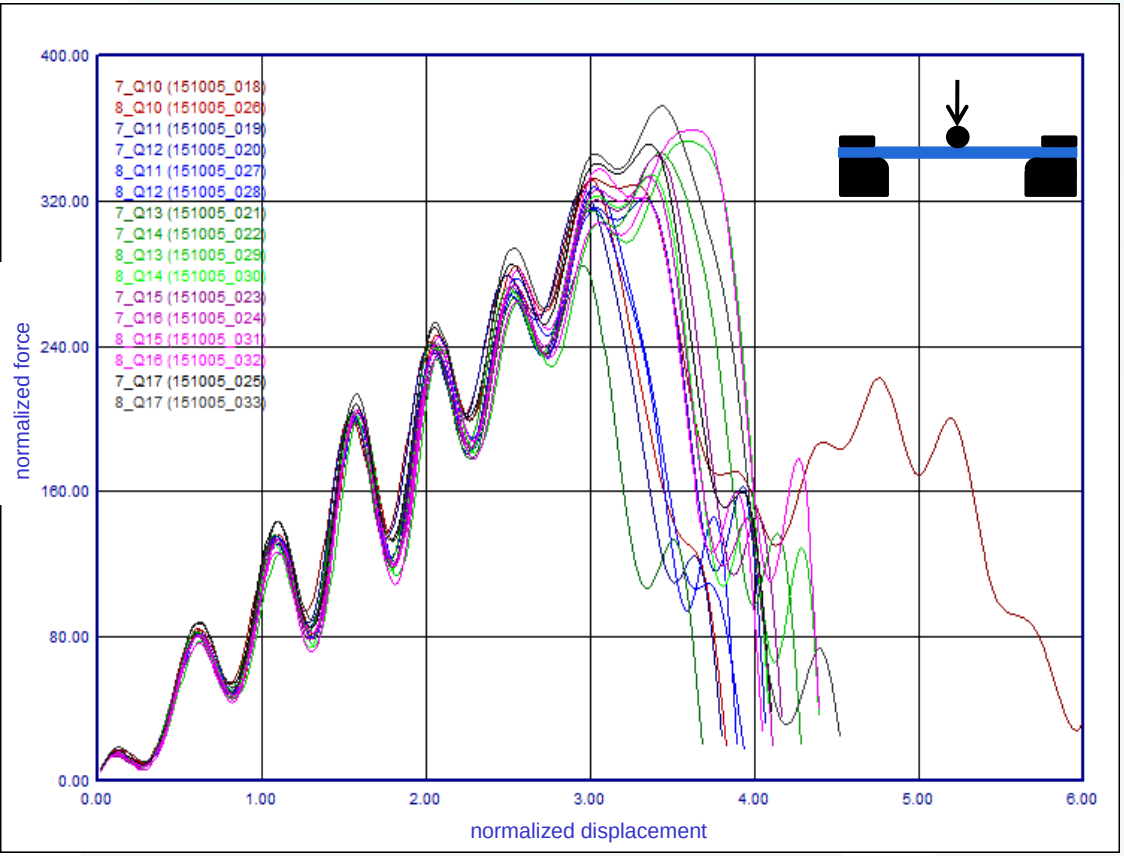


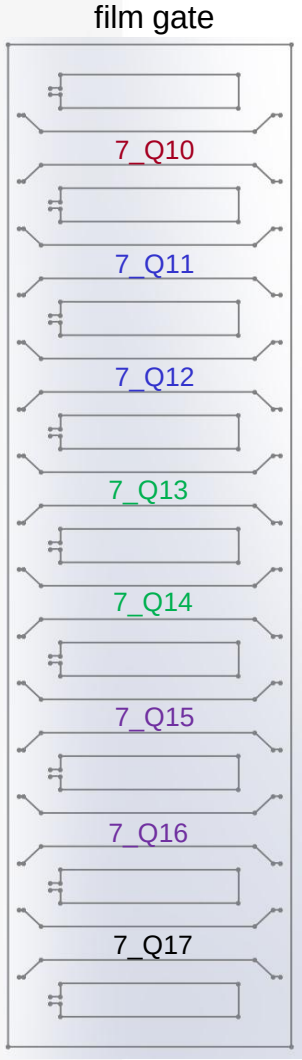
Scattering of stiffness and failure in dependence of the test specimen position for reinforced thermoplastics (PP GF30) in 3-point-bending

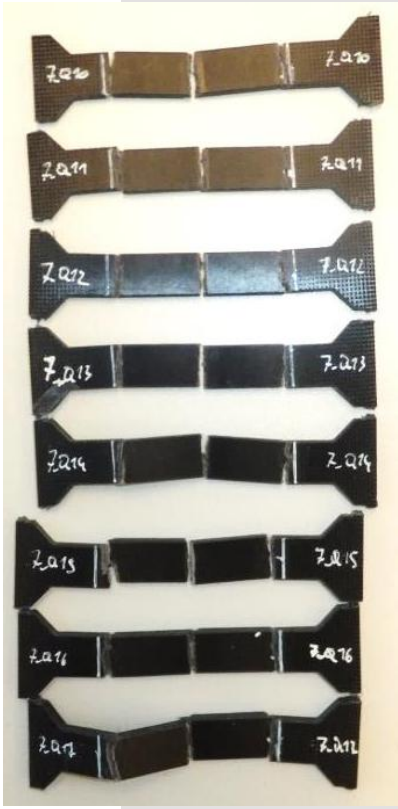




4a impetus
Tests – specimen preparation

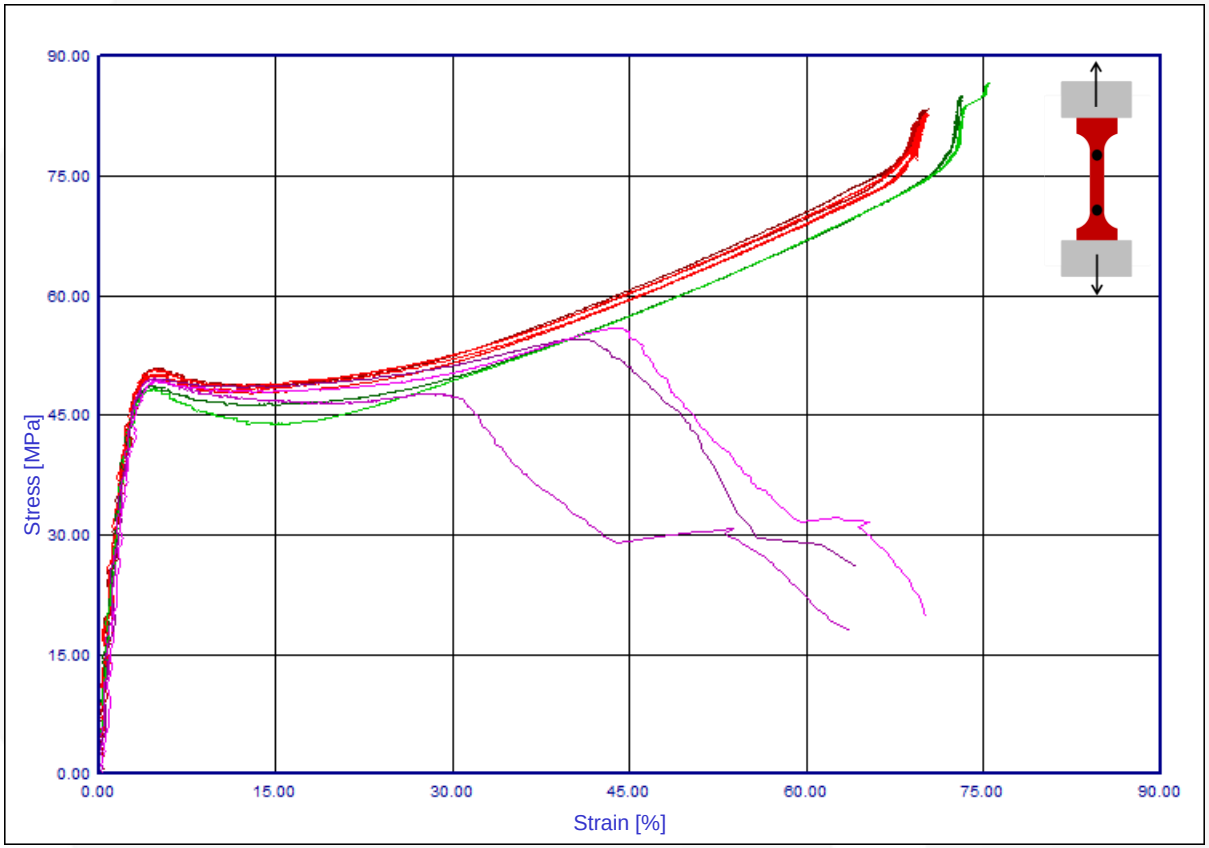






Scattering of failure for reinforced thermoplastics (PP GF30) in clamped 3-point-bending

Tests – specimen preparation



v_0 [m/s]	l_w [mm]	$m_{Pendular}$ [g]	b [mm]	t [mm]	l [mm]
0.0002	50	-	12	2,13	90
0.0002	40	-	10	1,9	75
0.0002	40	-	10	1,9	75

Tensile bar injection molded

Milled from plate

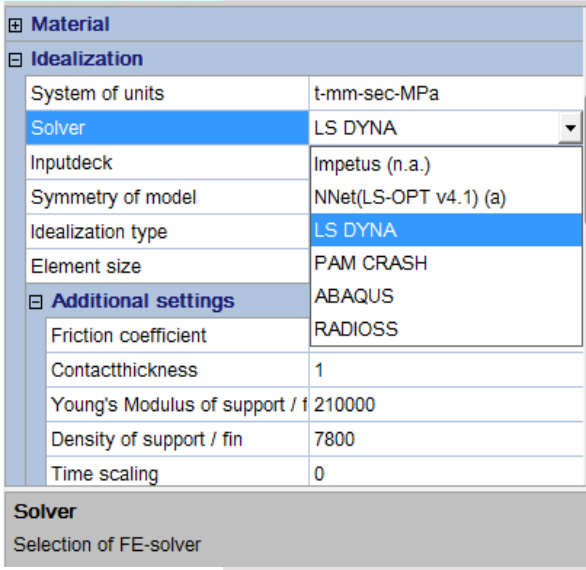
Water jet cut from plate

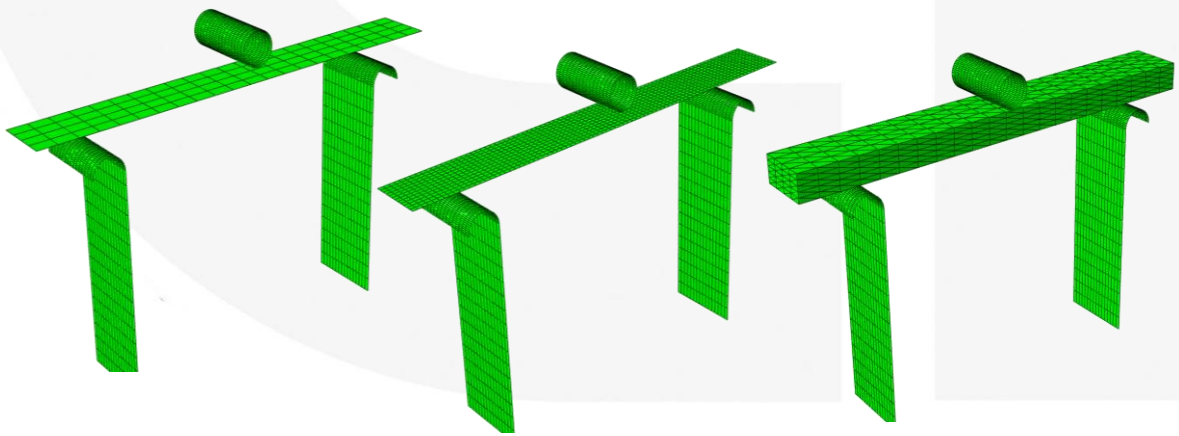
- Influence of retrieving the test specimens

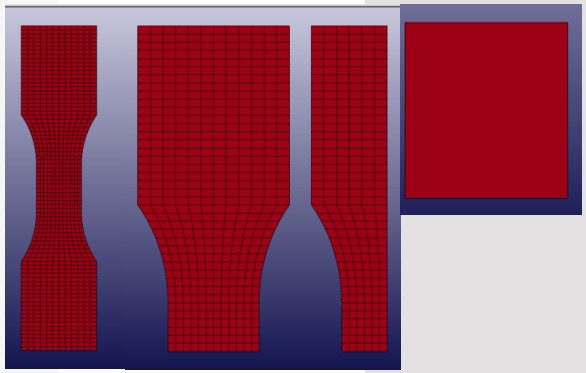
Consequences for testing

- The more tests are performed the better the range of scattering can be seen
- Standard: 5 tests per test setup
- If it is necessary much more tests can be done → bending test is easy and fast performed

- Supports LS-Dyna, Abaqus, PAM-Crash, Radioss
- Allows the idealization in shell or solid using the most popular element types and an arbitrary element size (of course it should be reasonable)
- Can consider symmetries – simplification down to 1-element





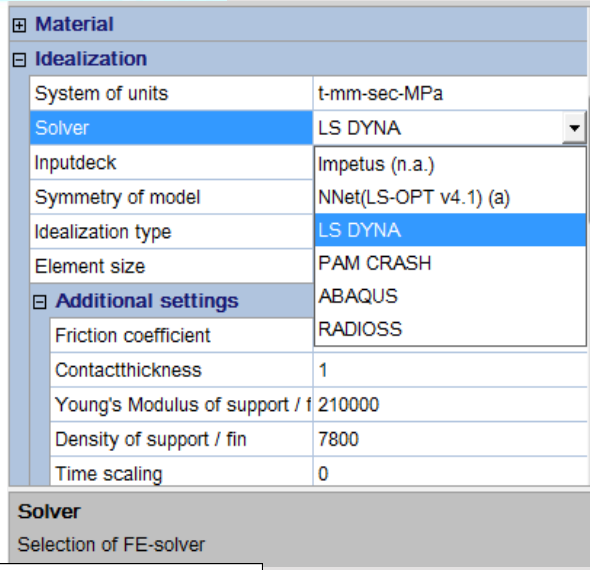


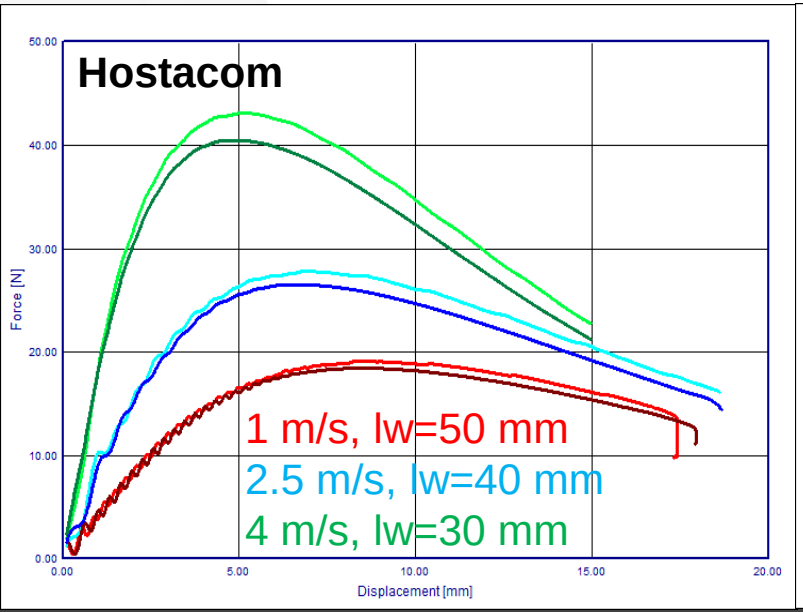
4a impetus
Influence of solver

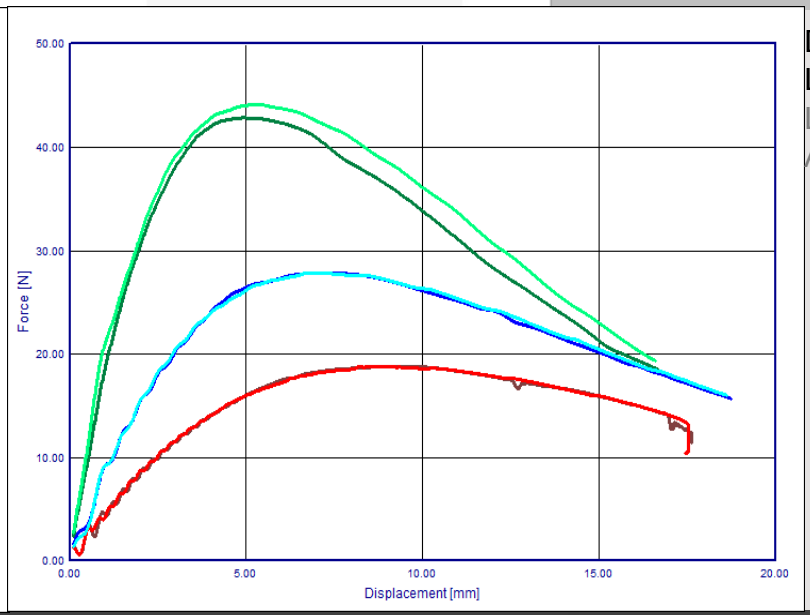
- Easy material cards transfer from one solver to another.
- 2 examples: 3-point-bending; LS-Dyna → Abaqus

  *MAT24 → *ELASTIC *PLASTIC (left)

  *MAT_SAMP-1 → *ABQ_MOLDED_PLASTIC (right)
- By One-Mouse-Click the differences can be researched: similar results, differences → distribution of the integration points



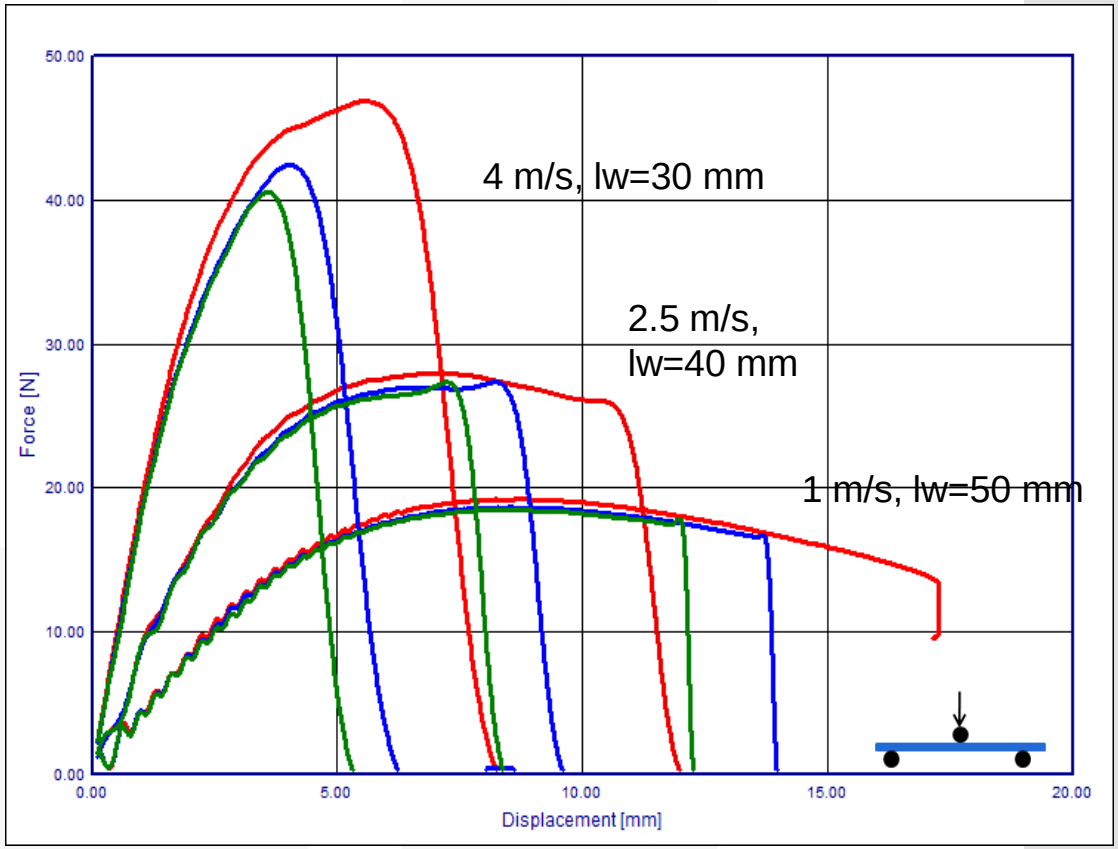




Dark color:
LS-Dyna, Shell type 16
Light color:
Abaqus, Shell S4

Influence of element size

- Example: 3-point-bending; *MAT_24 with plastic failure strain; shell-elements; 5 integration points



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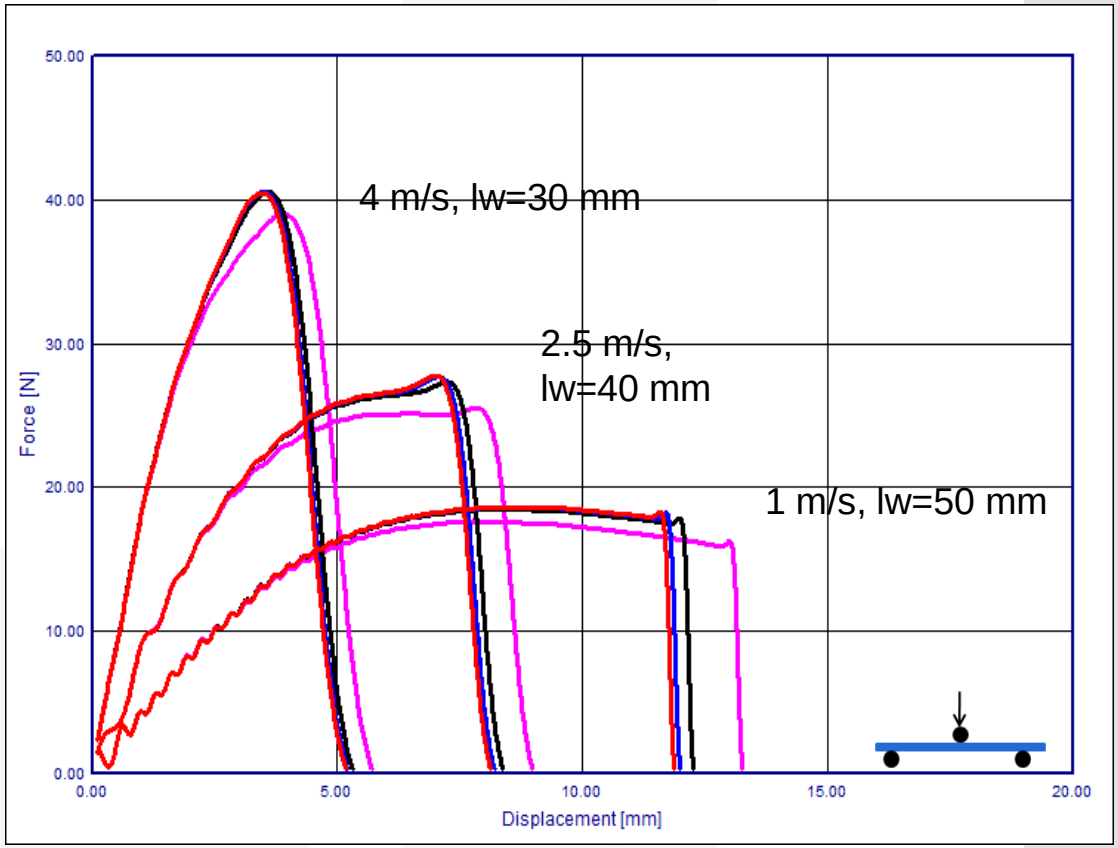
Element size 2 mm

Element size 4 mm

Element size 8 mm

Influence of integration points

- Example: 3-point-bending; *MAT_24 with plastic failure strain; shell-elements; element size 2 mm



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Element type 16; 3 IP

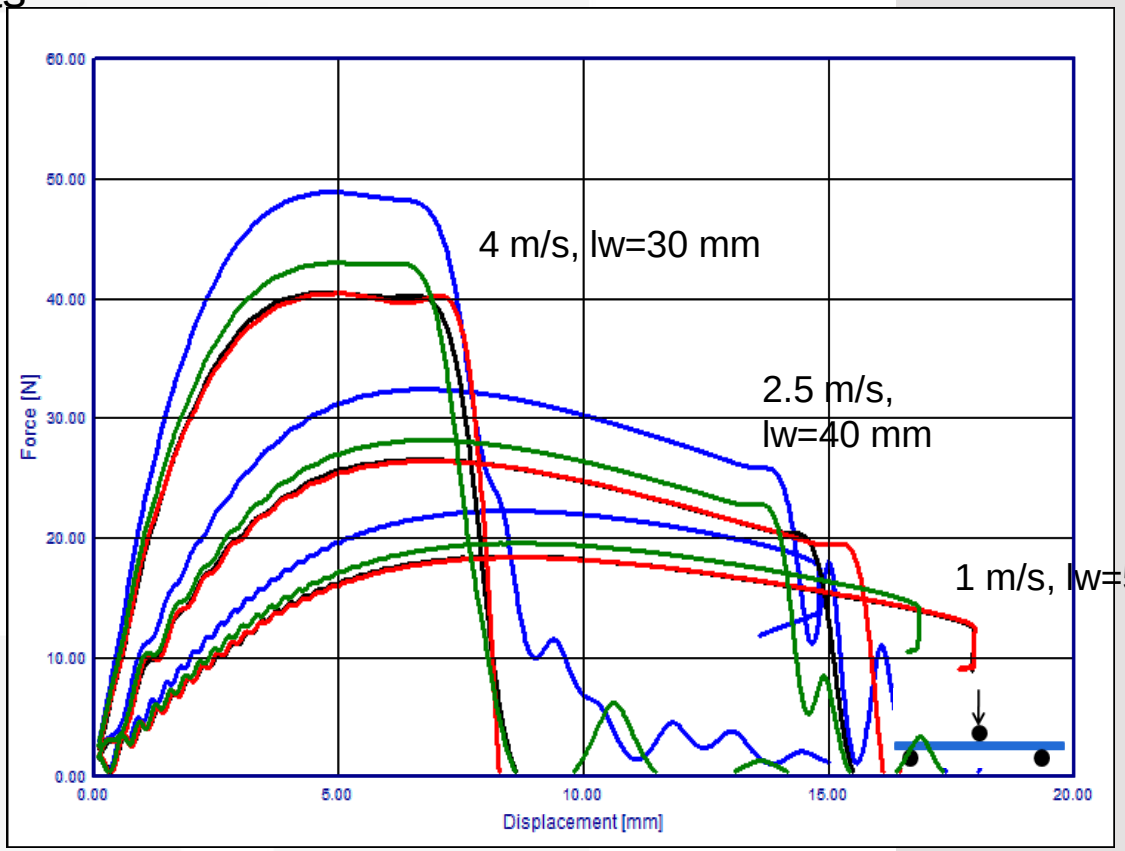
Element type 16; 5 IP

Element type 16; 7 IP

Element type 16, 9 IP

Influence of element type

- Example: 3-point-bending; *MAT_24; element size 2mm; shell elements vs. solid elements



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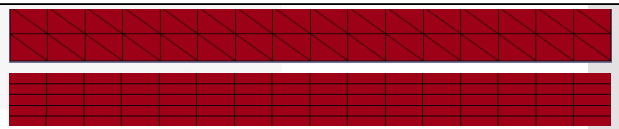
Shell-element type 16, 5 IP

Solid-element type 16; 2 elements over thickness

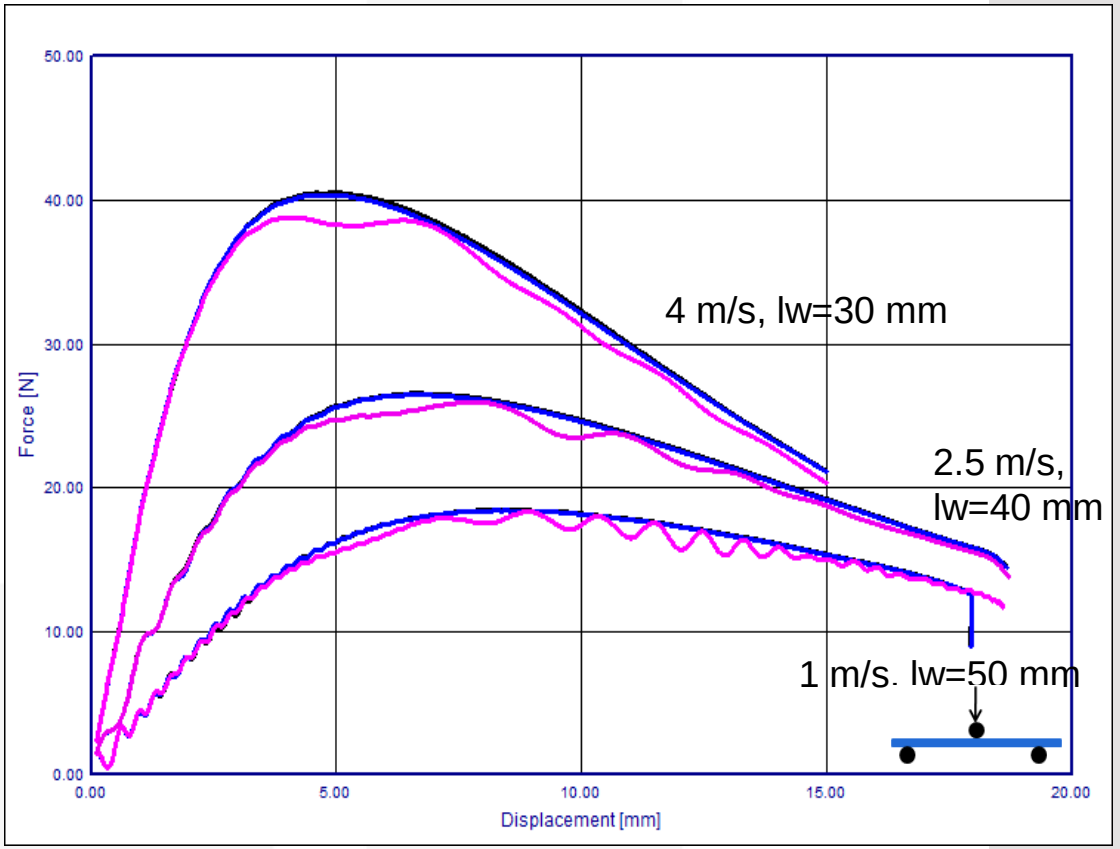
Solid-element type 2, 5 elements over thickness

Solid-element type 2, 5 elements over thickness, 1mm element size



Influence of element type / control card settings

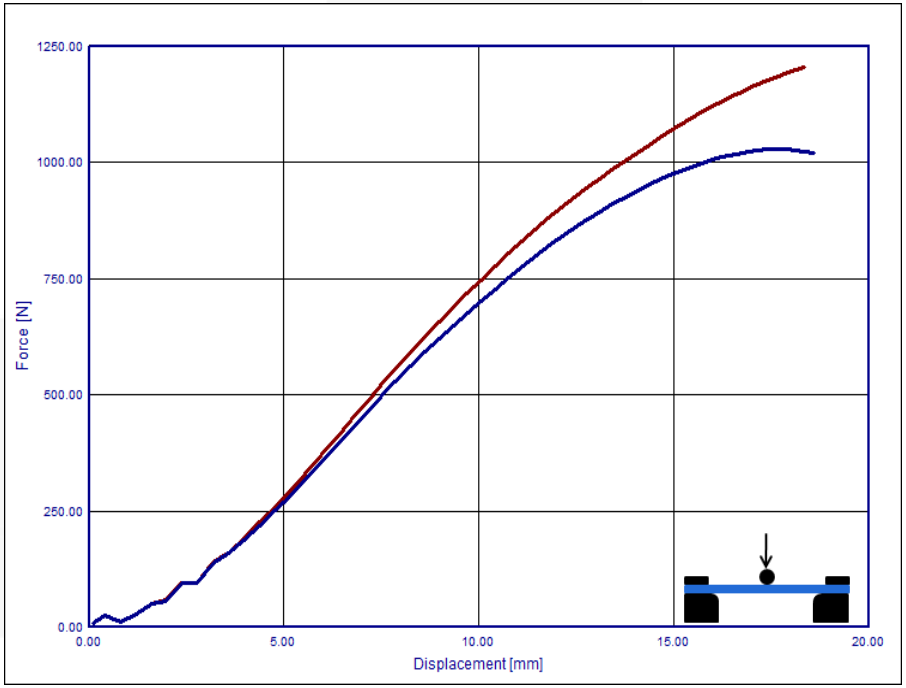
- Example: 3-point-bending; *MAT_24; shell-elements; 5 integration points, element size 2 mm



Hostacom
Element type 16
Element type 2
Element type 2, with contact damping and node drill rotation boundary

Influence of control card settings

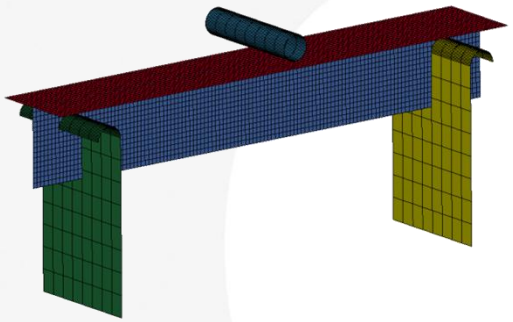
- Example: Clamped 3-point-bending; von Mises; LS-Dyna; settings ISTUPD in the control card *CONTROL_SHELL
- In the tension dominated area the shell thickness is changing (isochoric behavior). This is just possible if the setting ISTUPD=1 is activated (blue curve). In comparison to ISTUPD=0 (red curve) this results in a lower force.

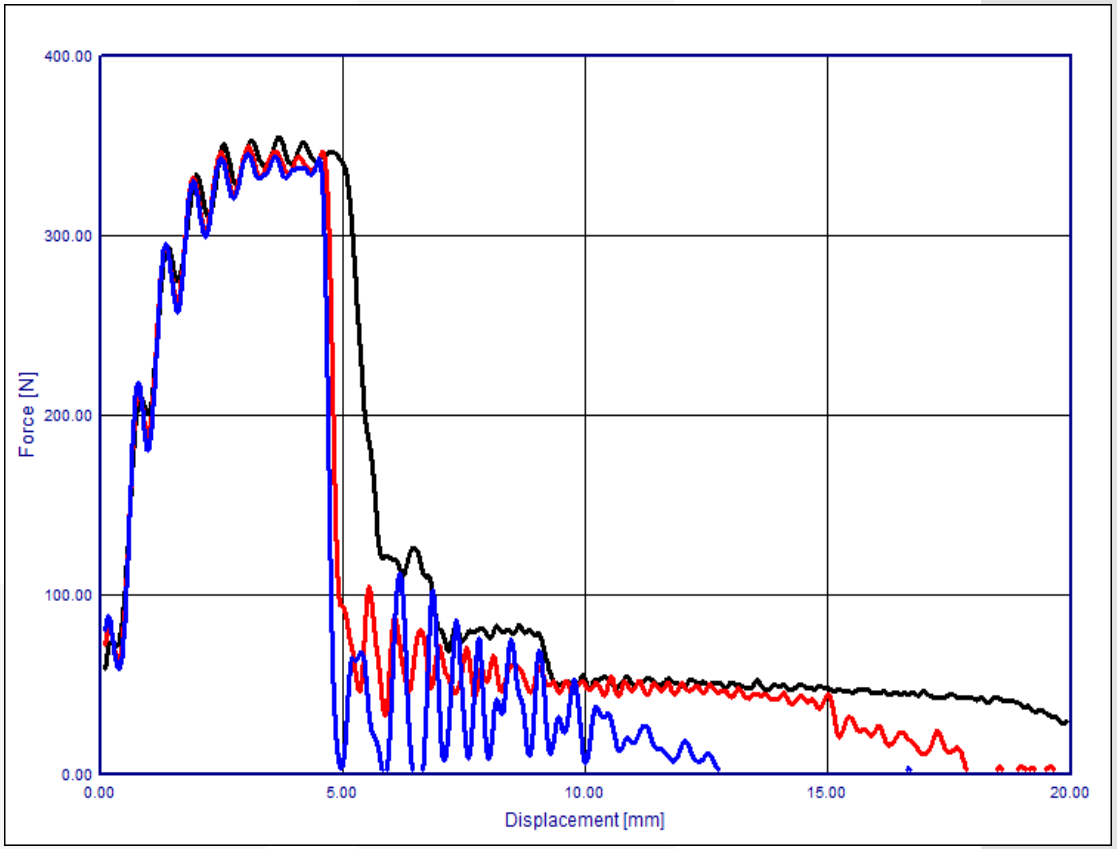


Hostacom
Element size 2 mm, 5 IP
ISTUPD=0
ISTUPD=1

Influence of element size on failure

- Example: 3-point-bending T-specimen; 2.5 m/s; *MAT_24 with plastic failure strain; shell-elements; 5 IP

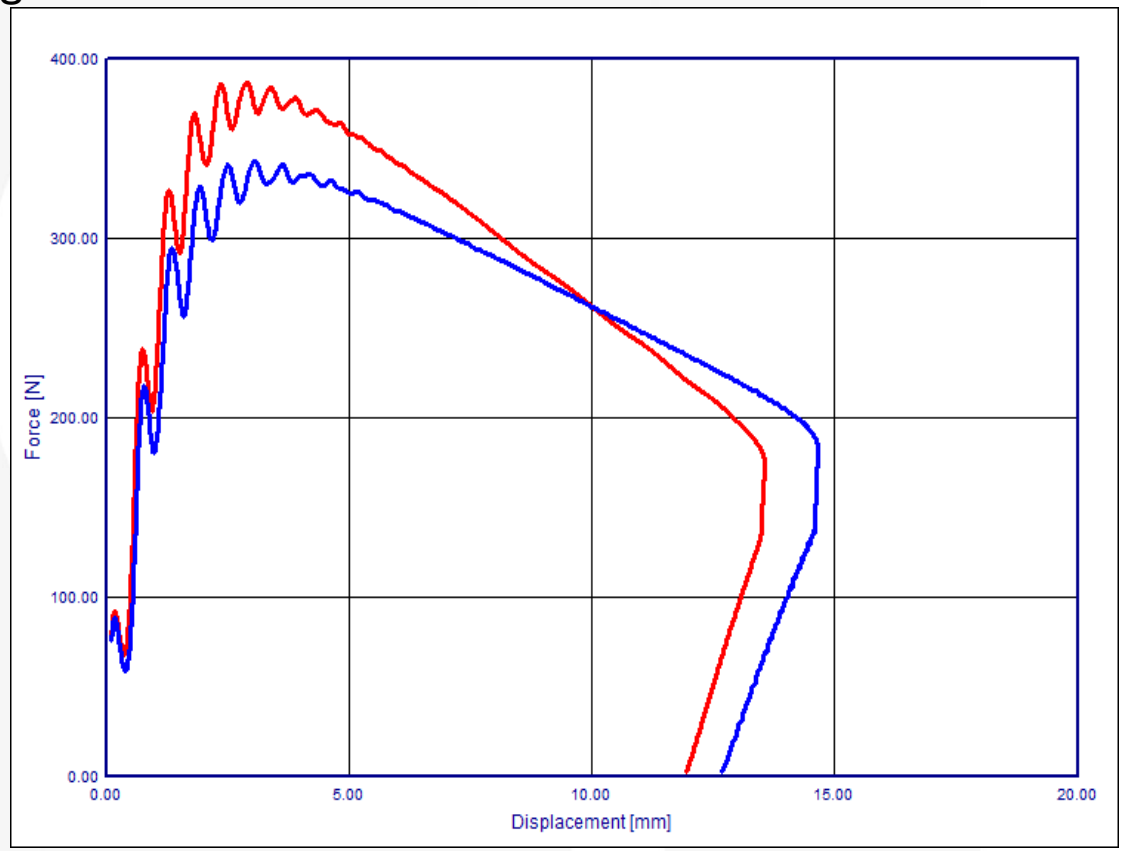


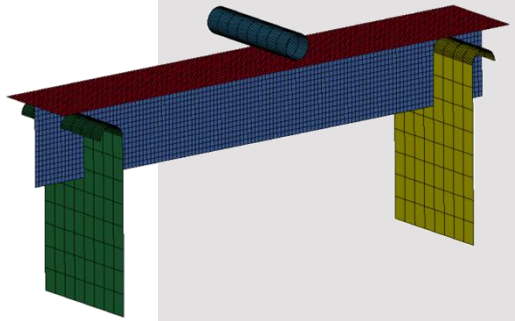


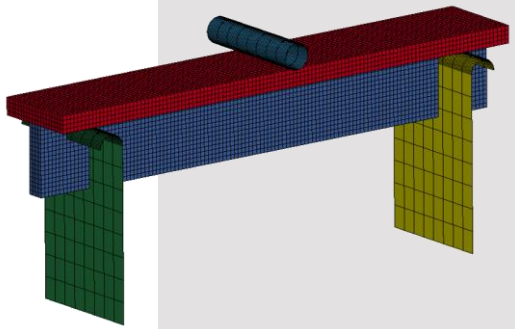
Hostacom
Element size 4 mm
Element size 2 mm
Element size 1 mm

Influence of idealization

- Example: 3-point-bending T-specimen; 2.5 m/s; *MAT_24; shell vs. solid elements







Hostacom

Element size 0.5 mm

Solid-elements, element type 2

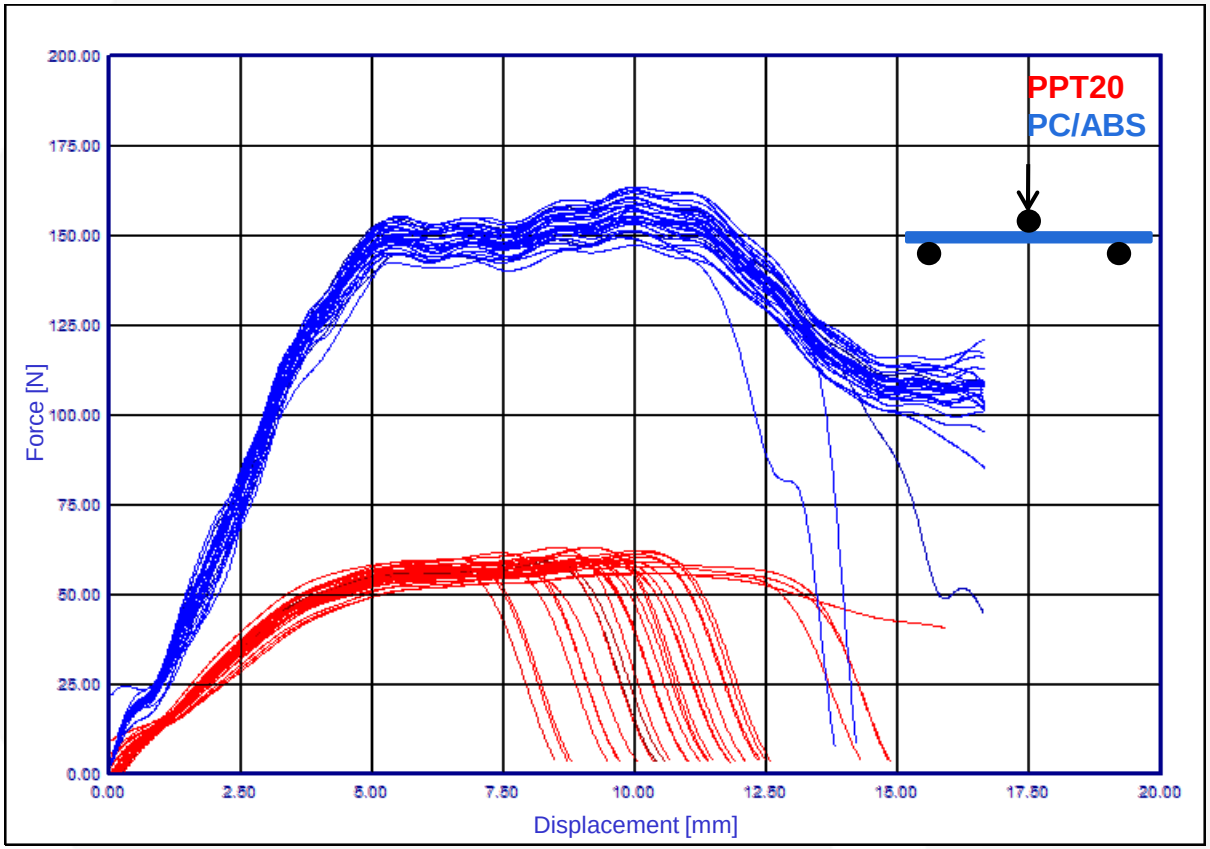
Shell-elements, element type 16

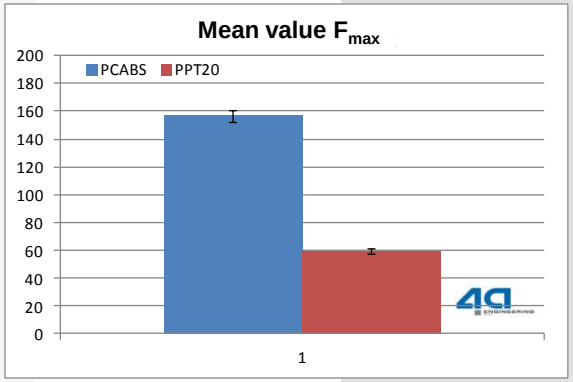
Consequences

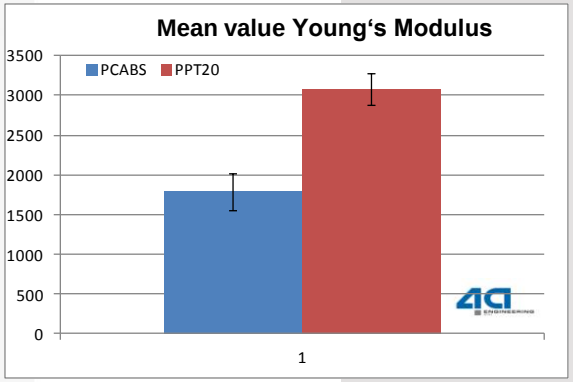
- For creating a material card it is essential to discuss with the customer about his needs to get these influences under control !
- The created material cards are only valid within the ranges specified with the customer !

4a impetus

Measurement results – statistical evaluation in 4a impetus

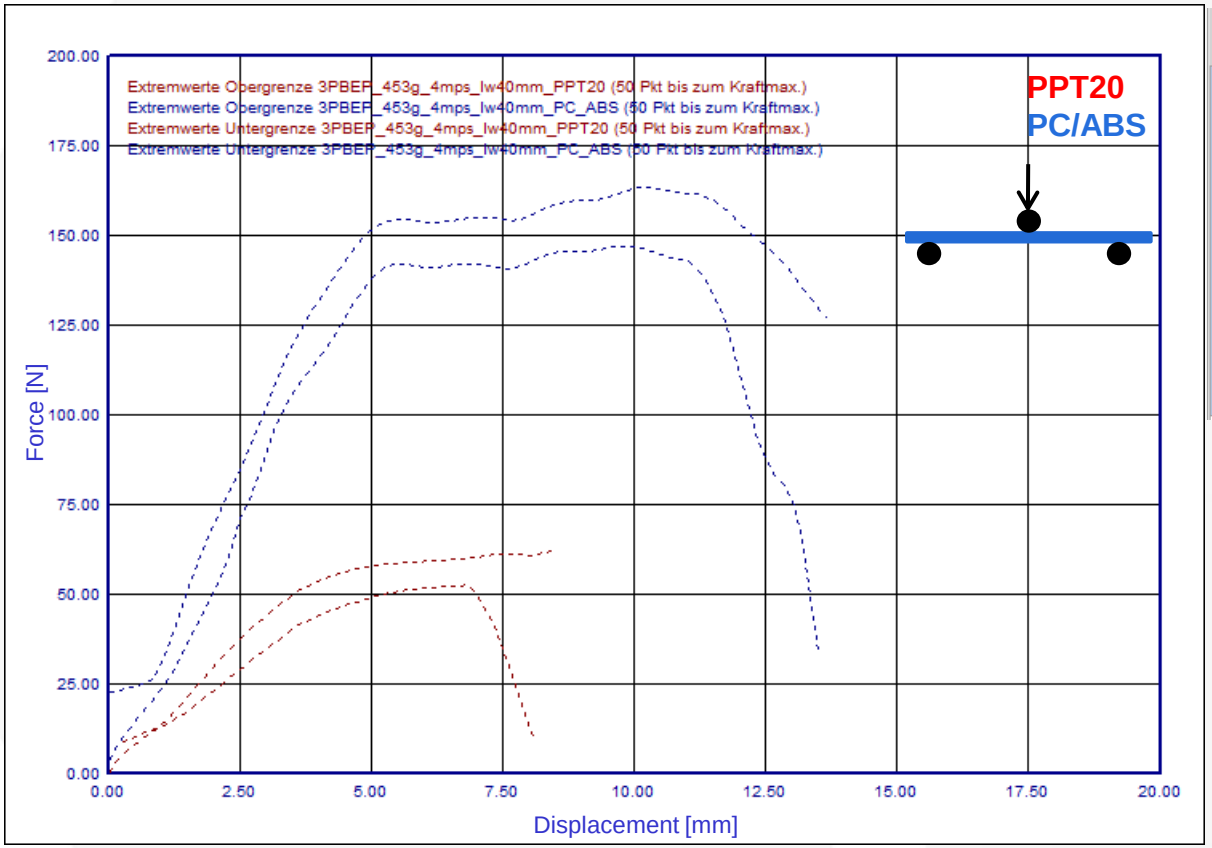


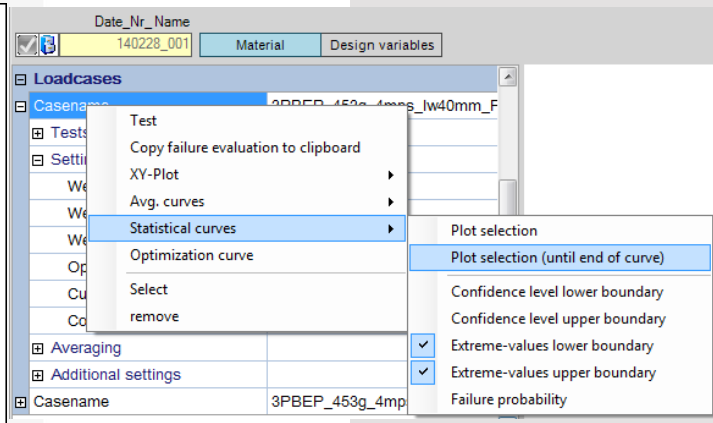




Example: 30 measurements for both materials (30 users)

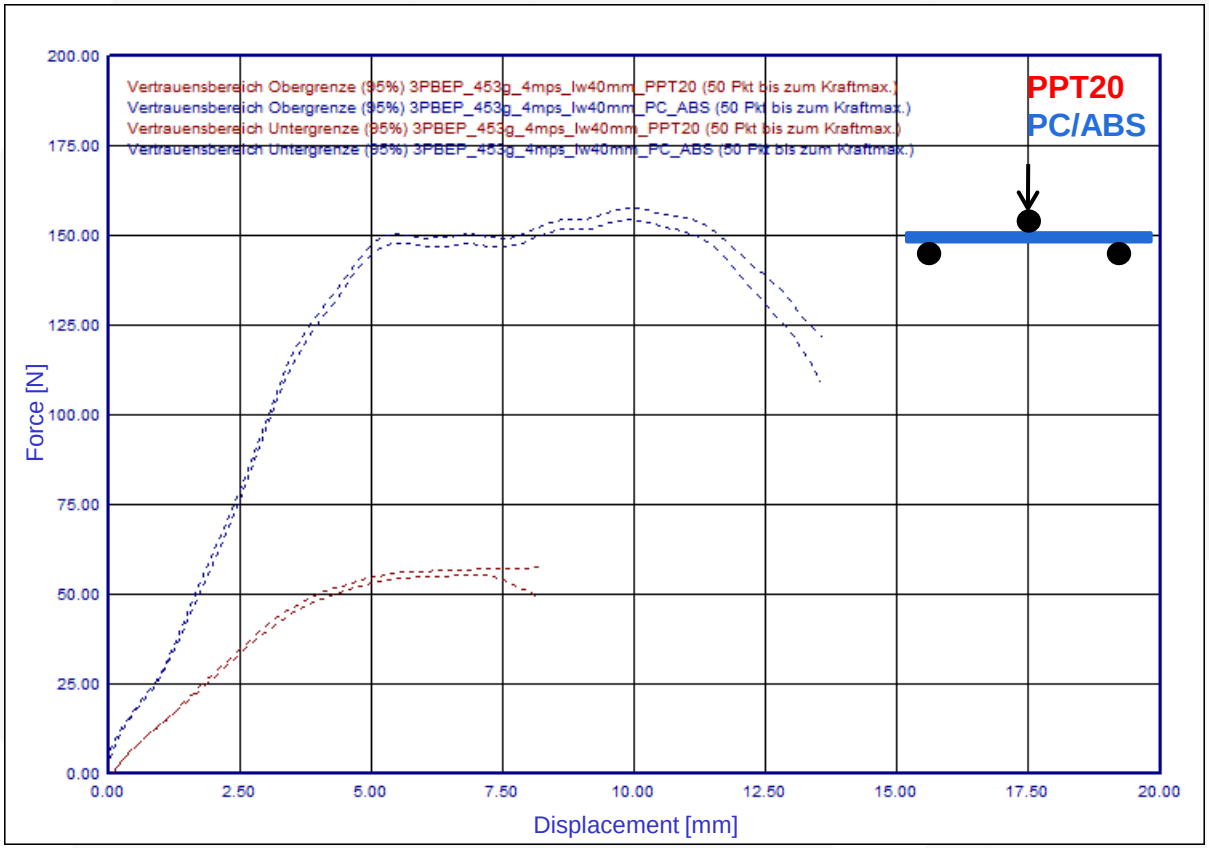
Measurement results – statistical evaluation in 4a impetus

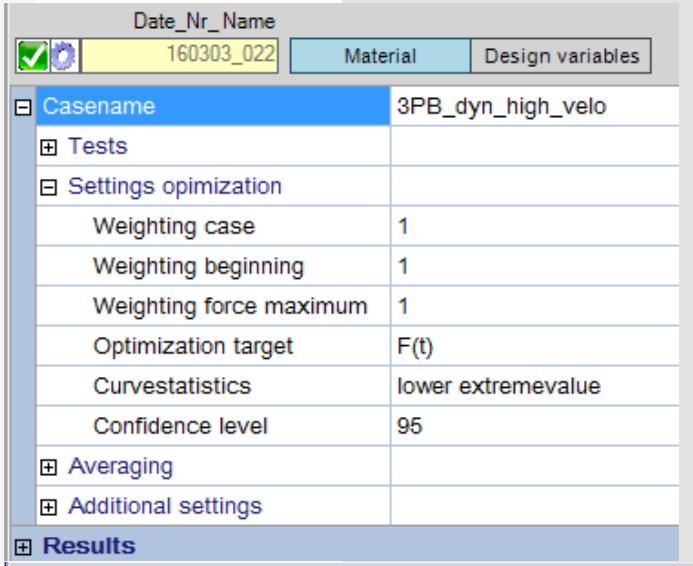




Extreme value curves of both materials (enveloping limit curves minimum and maximum)

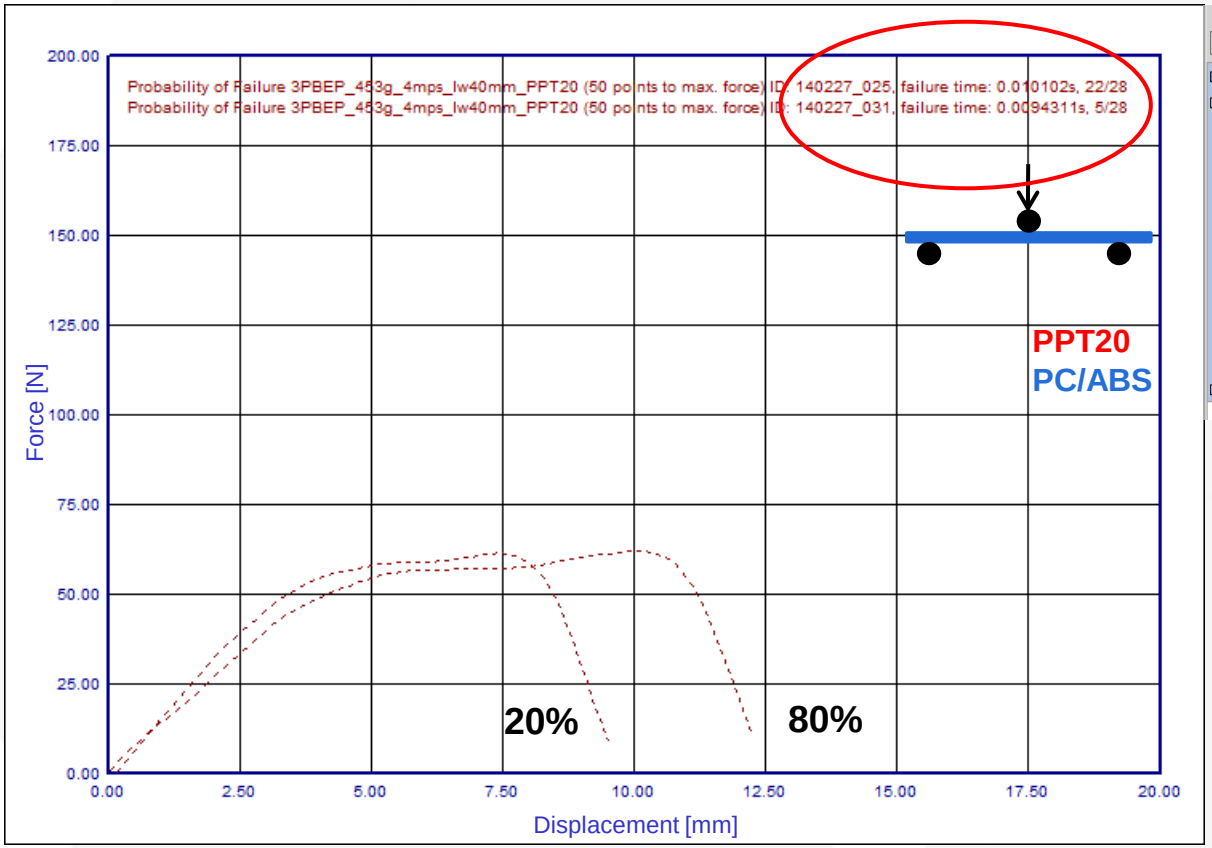
Measurement results – statistical evaluation in 4a impetus

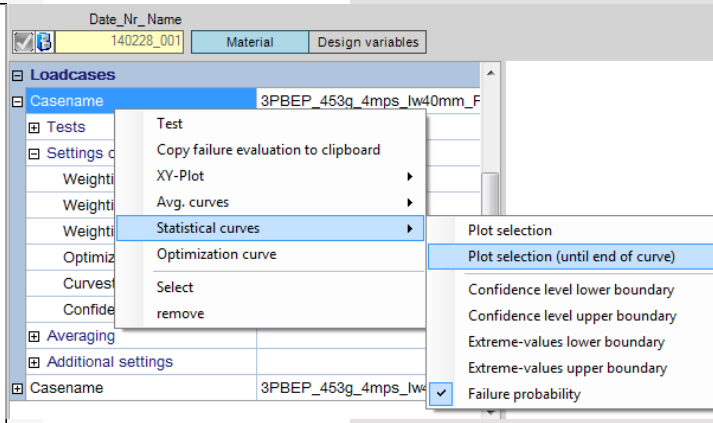




Confidence interval of both materials (confidence level 95%)

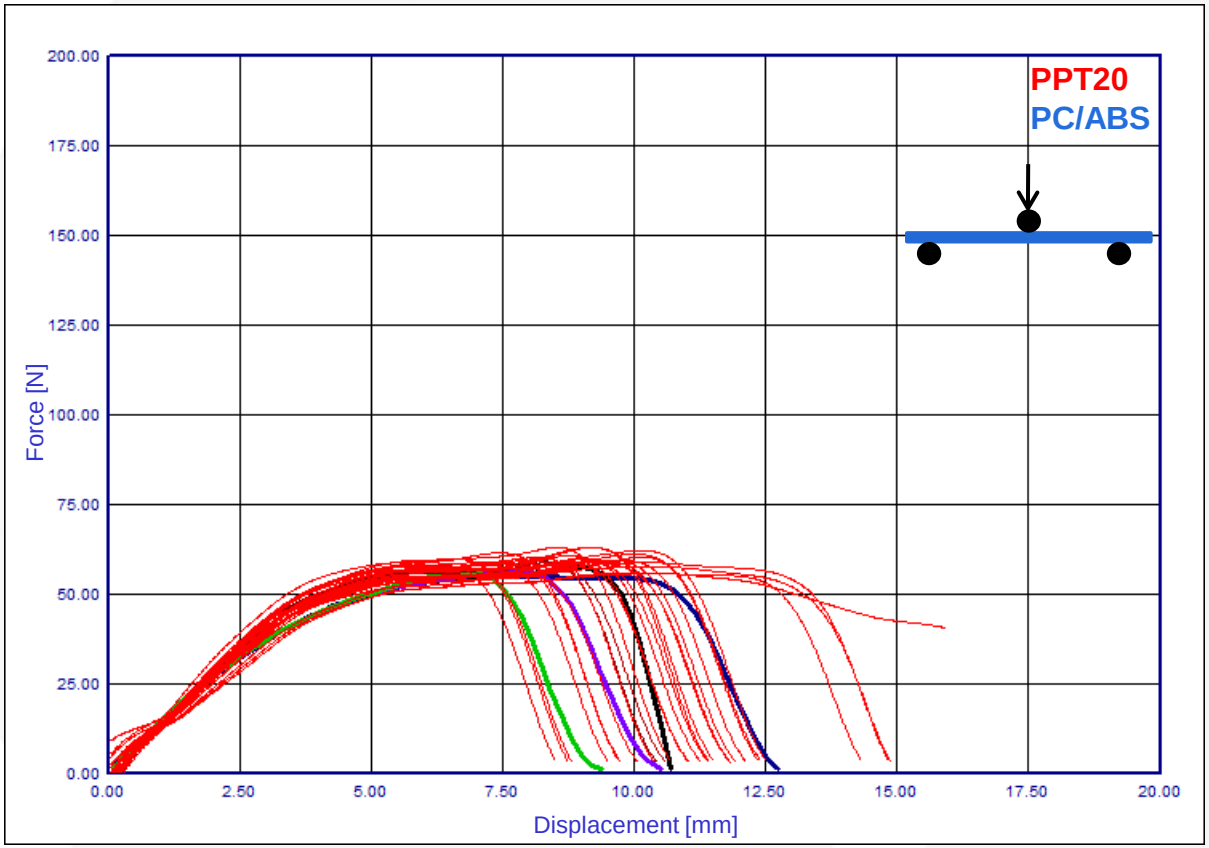
Measurement results – statistical evaluation in 4a impetus





Failure probability: 20% and 80%

4a impetus
Simulation results



Optimization of the failure strain to the desired failure percentage (colored curves) of the test curves (red curves)

Summary

- 4a impetus offers comprehensive and fast testing possibilities
- Using reverse engineering appropriate material models are generated in an efficient way for the simulation (LS-DYNA, PAM CRASH, ABAQUS, Radioss)
- Influences of the modeling process can be investigated in an easy way
- 4a impetus software offers a statistical evaluation of the tests, so considering of scattering of failure (often occurring) is possible

- 4a impetus is an outstanding system to generate material data bases for everyday simulations.

Thank you for your attention!