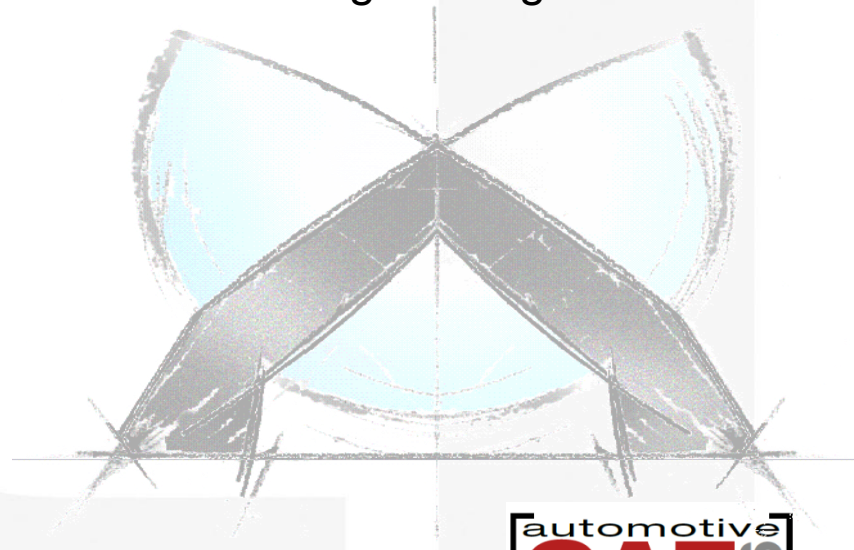


Interaction of solver settings / idealisation / material card for different explicit solvers on bending load cases

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

4a technology-group: founded in 2002

Location: Traboch, Austria

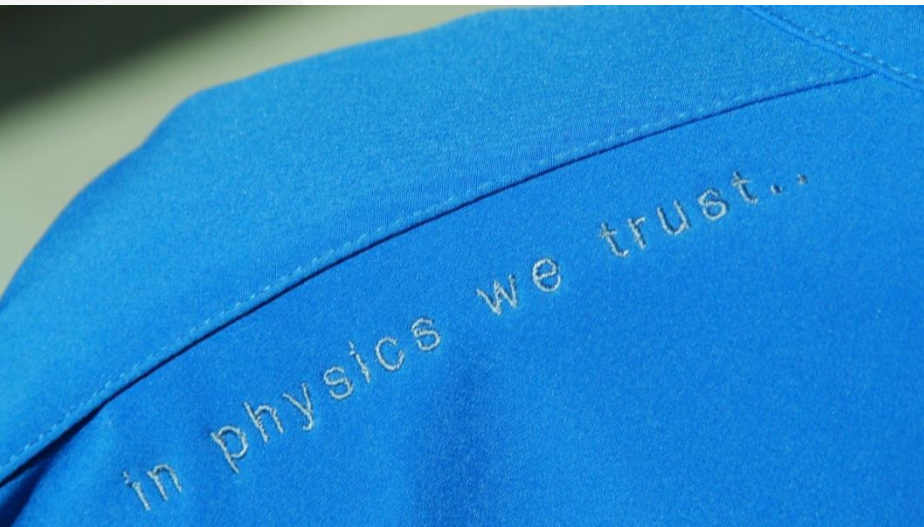
Number of employees > 80

Field of operation: global

Certificates: ISO 9001

more than 2000 projects

more than 400 customers





Group of Companies

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

>>> [JOBS](#)

[Company details](#)
[Terms & Conditions](#)

DE|EN



IN PHYSICS WE TRUST

Business units



Engineering and simulation for plastic products and components



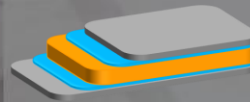
Multi-layer composites and sandwich materials for cost-efficient



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](#)

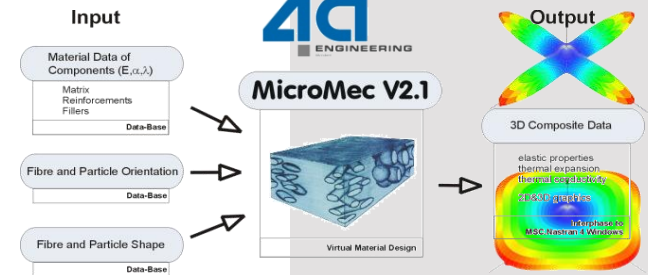
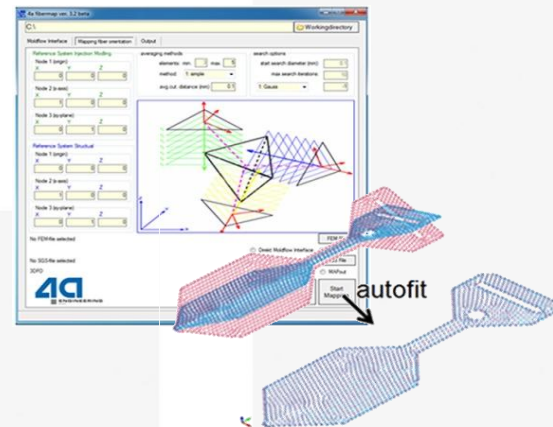
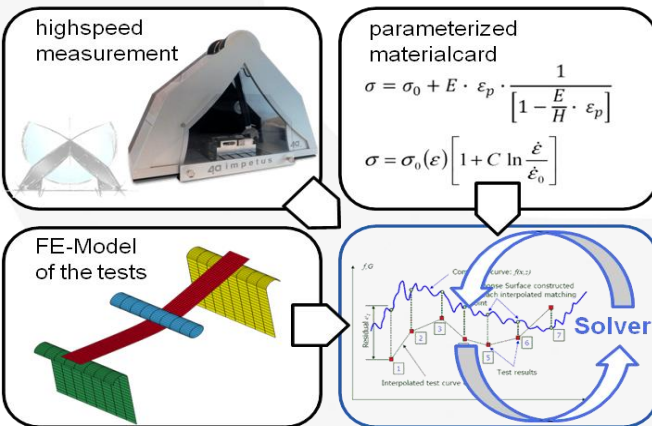
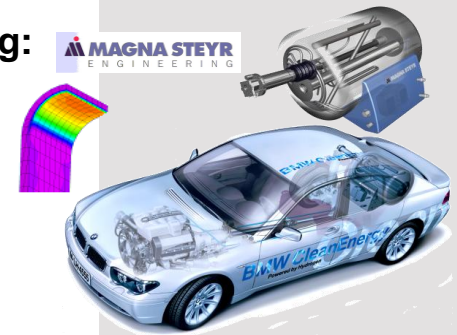


[to unit webpage](#)

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



LH₂ – tank mounting:



4a impetus

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

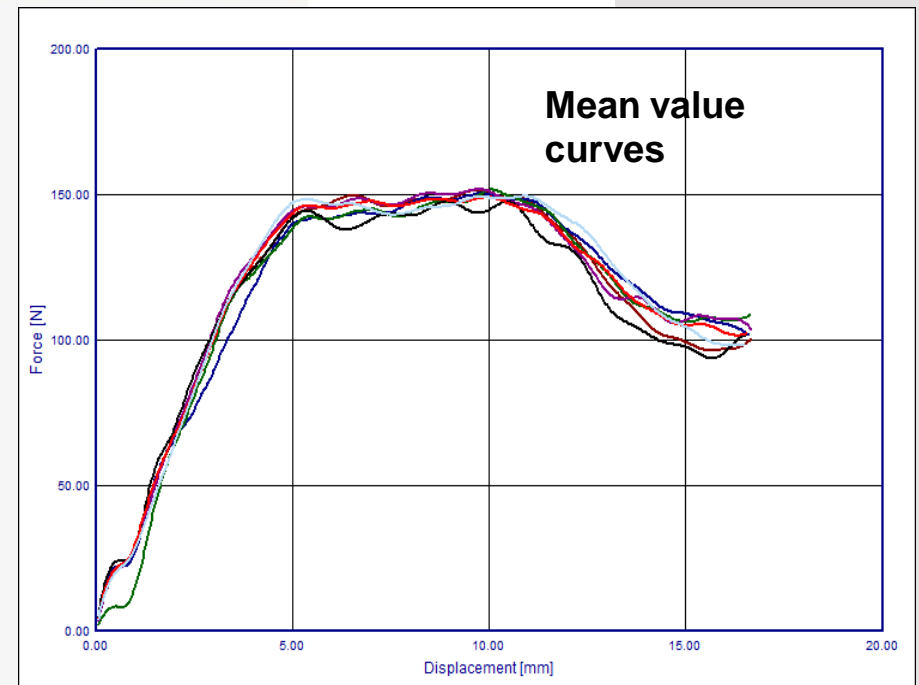
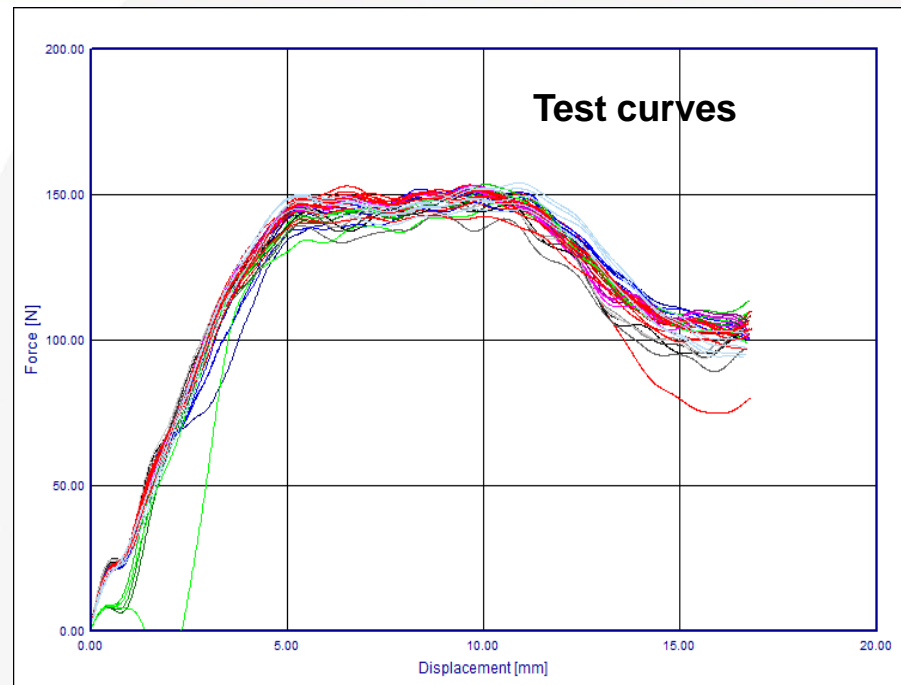
4a fibermap

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

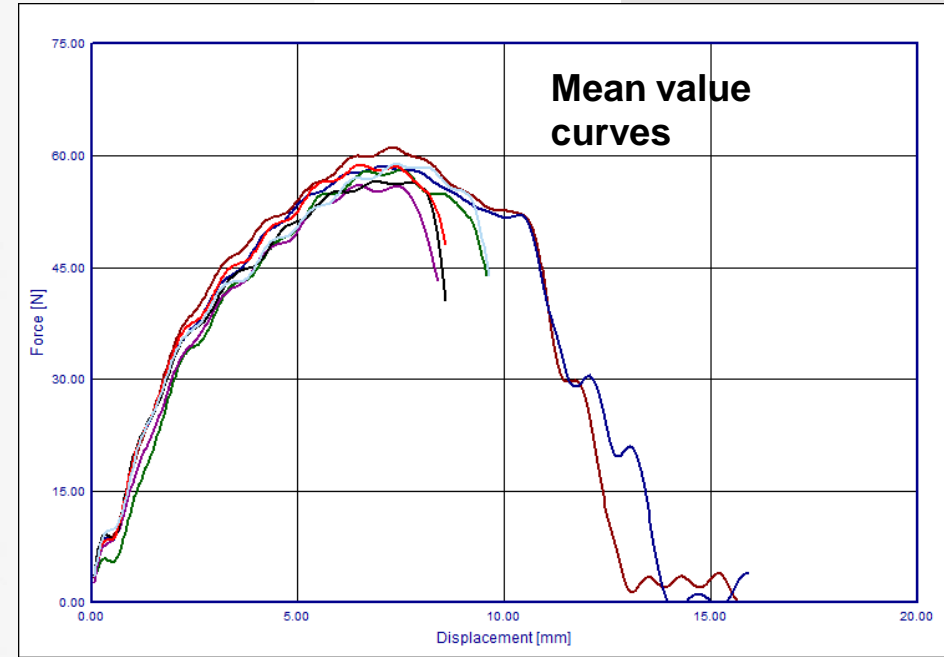
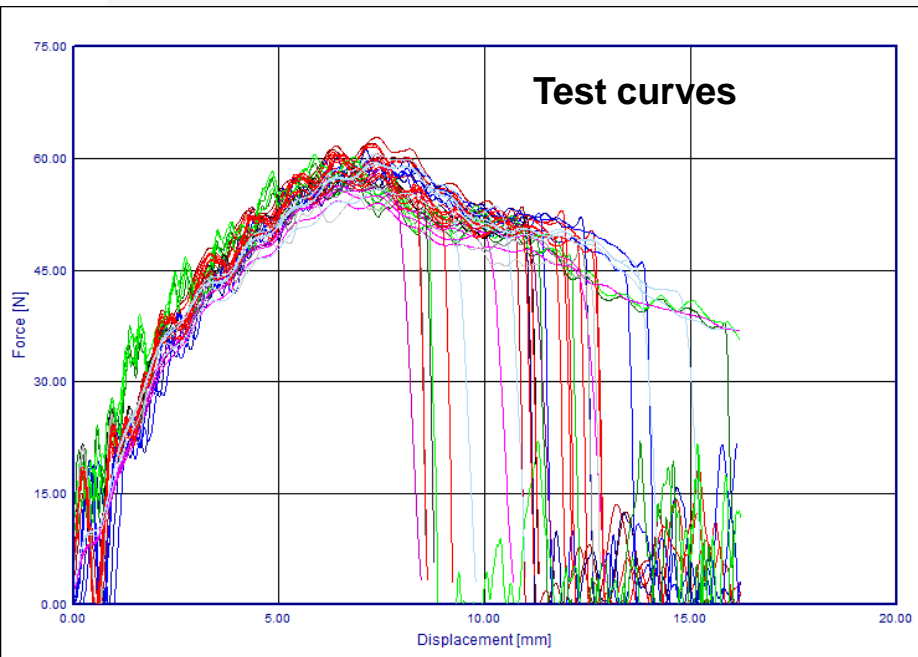
4a micromec

Micromechanical program
Calculation of the thermo-mechanical properties of composites

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



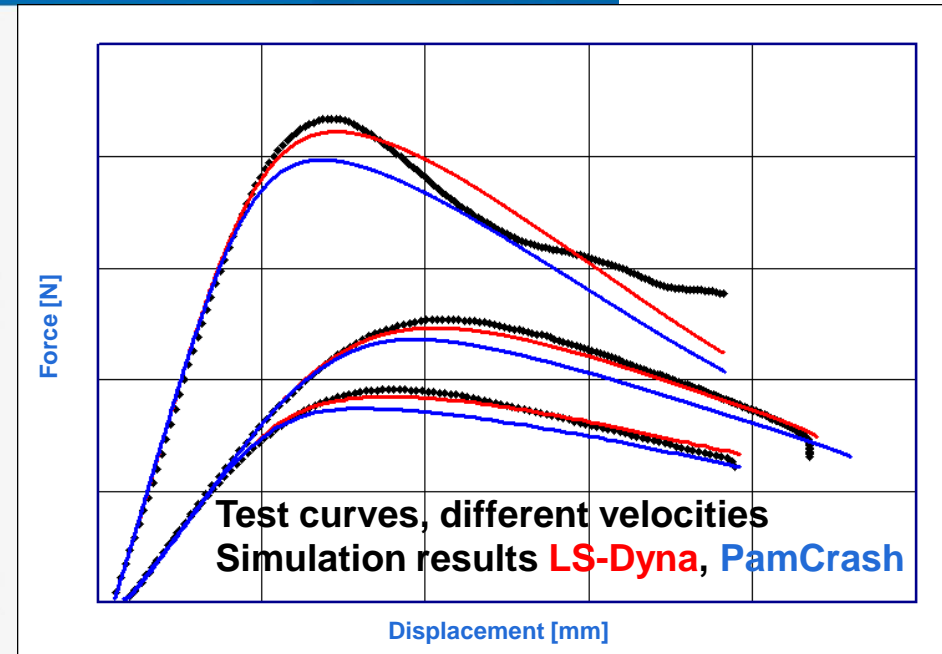
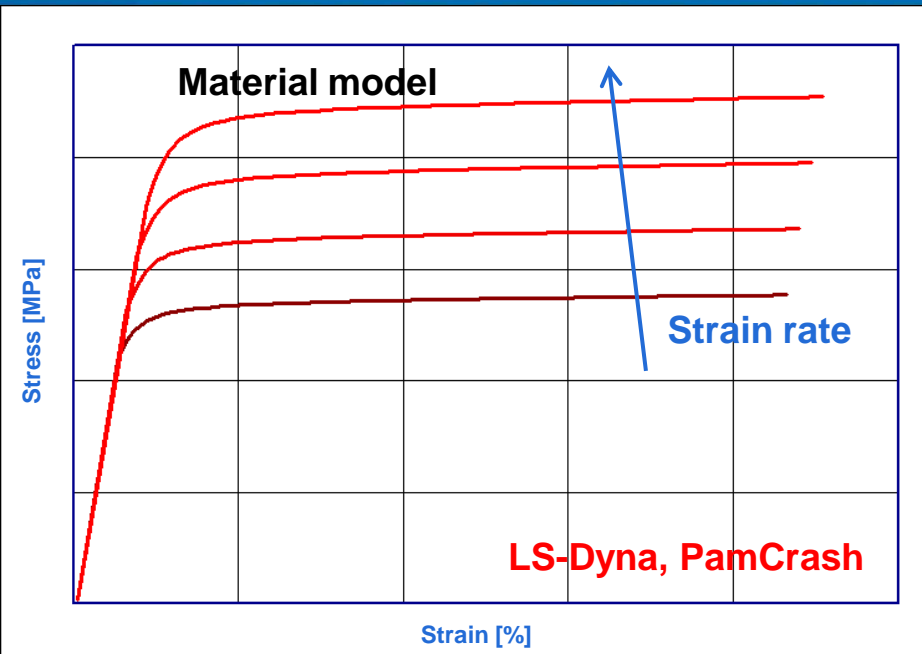
- Within a round robin test many materials were tested using the 4a impetus test systems of some customers.
- The results for the bending test of the material PC/ABS (thickness 3 mm) show a good conformity.



- 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.

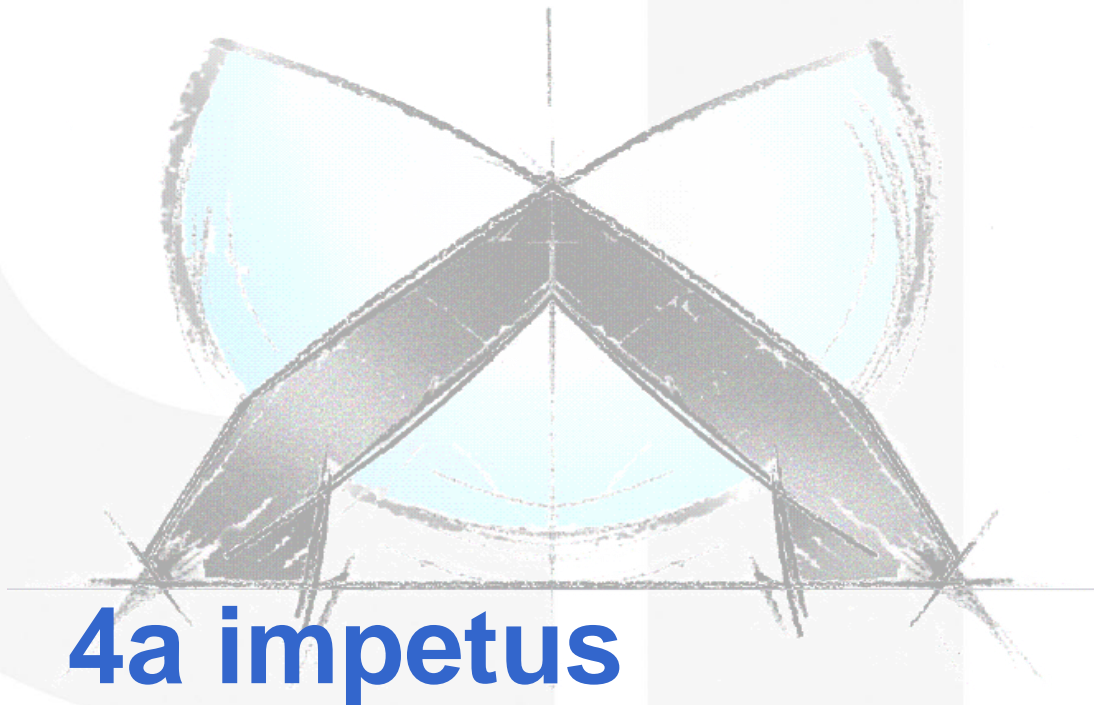
Introduction

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

© by 4a engineering GmbH - intelligent testing systems

4a impetus

Current test machine

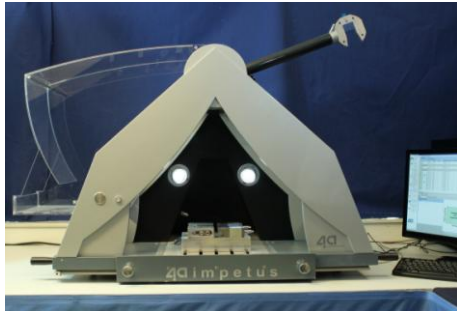
2015



4a impetus

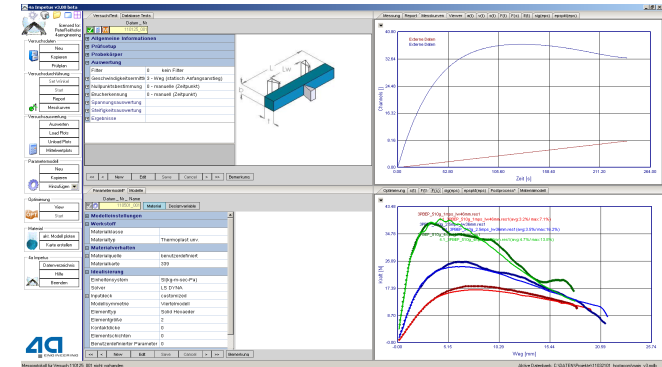
Software solution from the test to the material card

4a impetus Hardware



directly linked

4a impetus Software



External Testing



gom
Optical Measuring Techniques

Zwick / Roell

MTS
INSTRON

ASCII DATA

SHIMADZU

4a Impetus v3.00 beta

licensed for Peter Reithofer @engineering

Versuchsdaten

- Neu
- Kopieren
- Prüfplan

Versuchsdurchführung

- Set Winkel
- Start
- Report
- Messkurven

Versuchsauswertung

- Auswerten
- Load Plots
- Unload Plots
- Mittelwertplots

Parametermodell

- Neu
- Kopieren
- Hinzufügen

Optimierung

- View
- Start

Material

- akt. Modell plotten
- Karte erstellen

4a Impetus

- Datenverzeichnis
- Hilfe
- Beenden

Versuch/Test Database Tests

Datum_Nr 110125_001

Allgemeine Informationen

Prüfsetup

Probekörper

Auswertung

- Filter 0 kein Filter
- Geschwindigkeitsermittl 3 - Weg (statisch Anfangsanstieg)
- Nullpunktsbestimmung 0 - manuelle (Zeitpunkt)
- Brucherkenntung 0 - manuell (Zeitpunkt)
- Spannungsauswertung
- Steifigkeitsauswertung
- Ergebnisse

Channels []

Externe Daten

Externe Daten

211.20 264.00

Parametermodell

Datum_Nr_Name 110501_001

Material Designvariable

Modelleinstellungen

Werkstoff

- Materialklasse
- Materialtyp Thermoplast unv.

Materialverhalten

- Materialquelle benutzerdefiniert
- Materialkarte 339

Idealisierung

- Einheitensystem SI(kg-m-sec-Pa)
- Solver LS DYNA
- Inputdeck customized
- Modellsymmetrie Viertelmodell
- Elementtyp Solid Hexaeder
- Elementgröße 2
- Kontaktstärke 0
- Elementschichten 0
- Benutzerdefinierter Parameter 0

Kraft [N]

Weg [mm]

26.09

17.38

8.70

-0.00

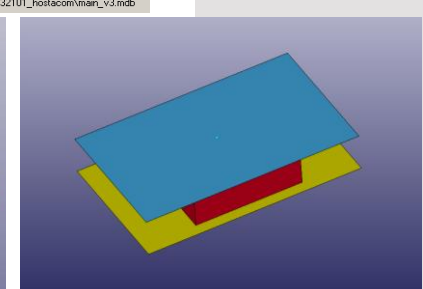
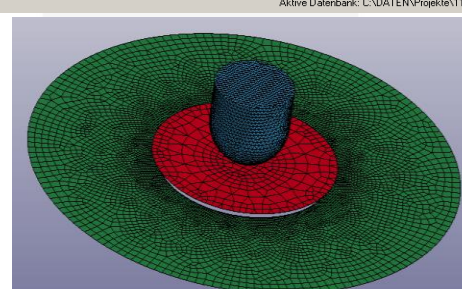
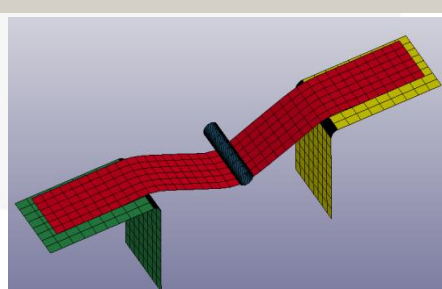
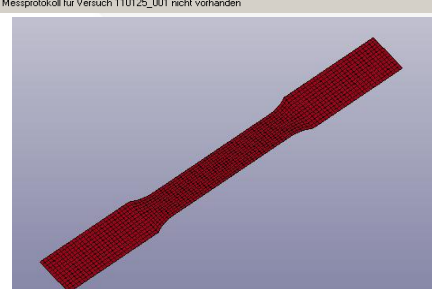
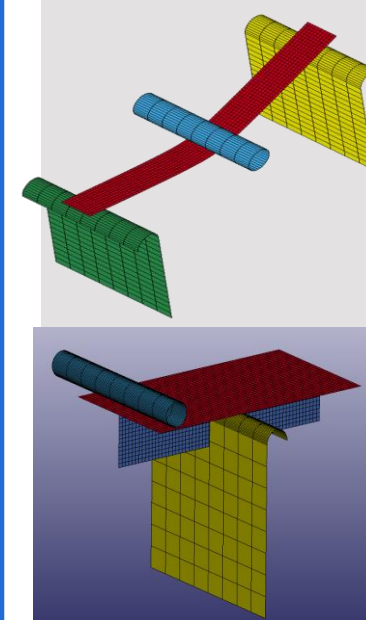
-0.00 5.15 10.29 15.44 20.59 25.74

4a ENGINEERING

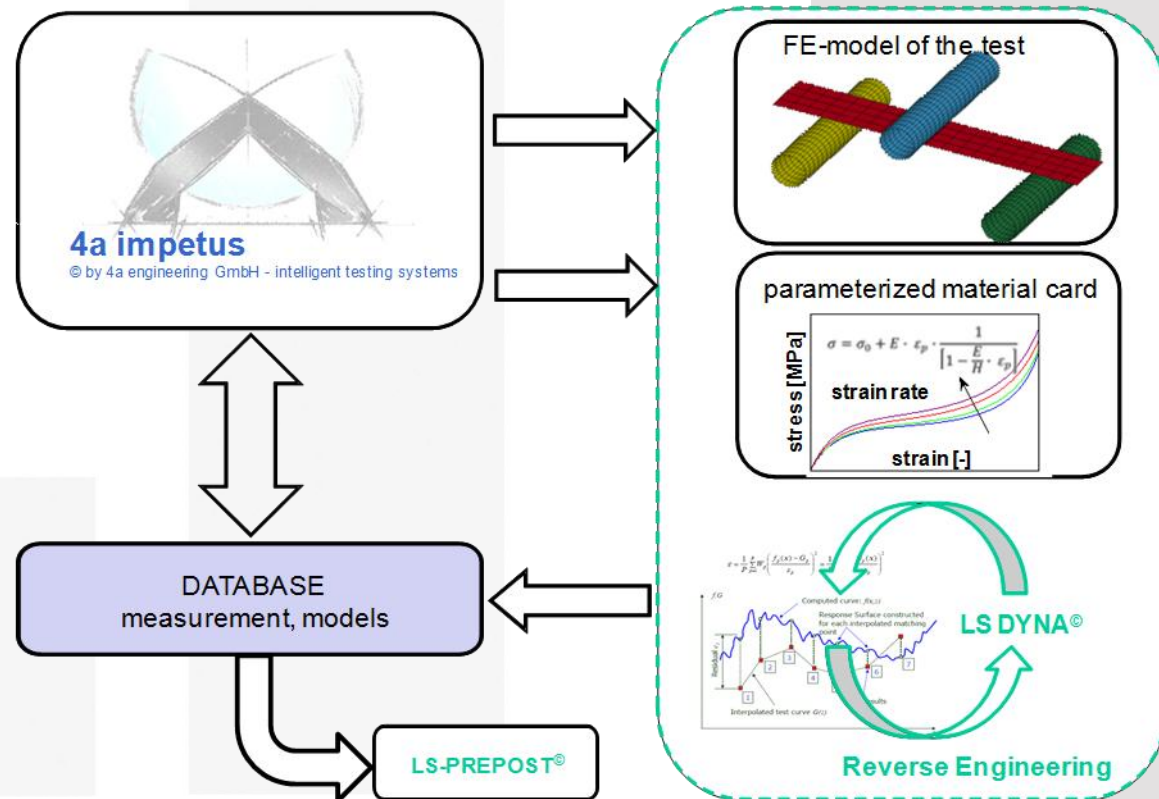
Messprotokoll für Versuch 110125_001 nicht vorhanden

Aktive Datenbank: C:\DATA\ENV\Projekte\11052101_hostacom\vmam_v3.mdb

**Complete system
from the test to the
validated material card**



- 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

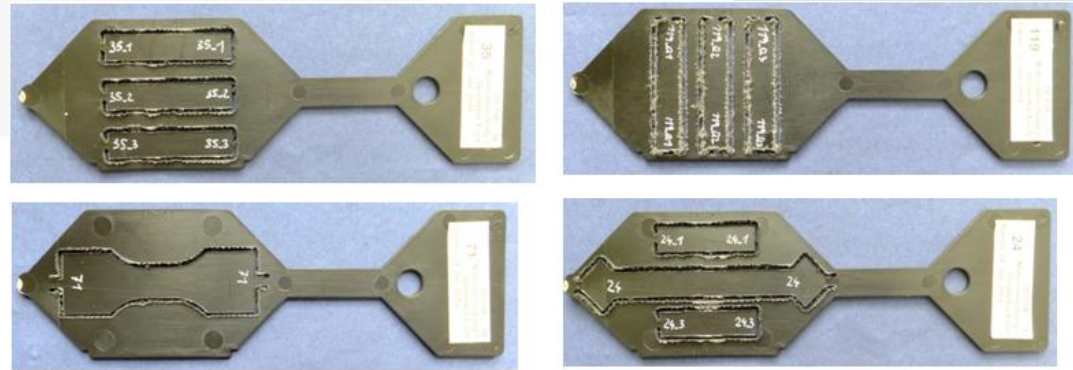


4a impetus

Tests – specimen preparation

- Injection molding

- „fish mold“



- „4a plate mold“

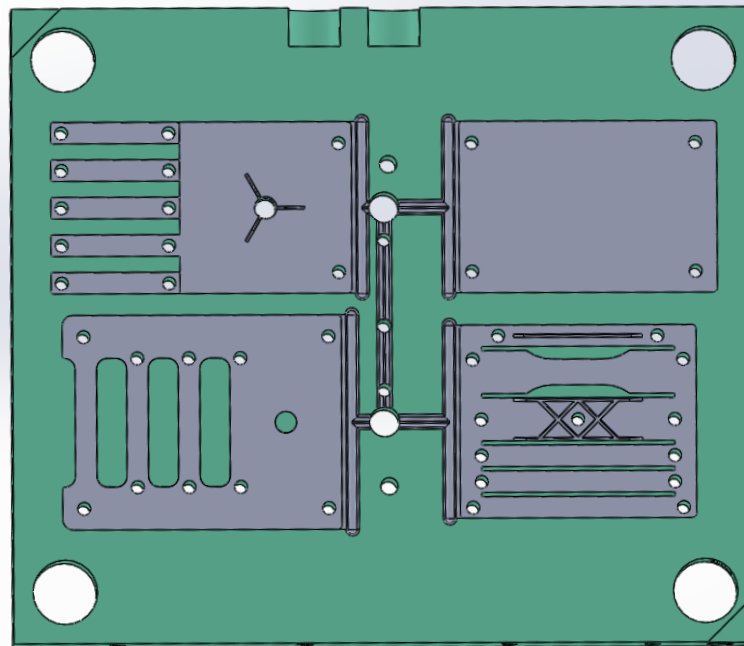
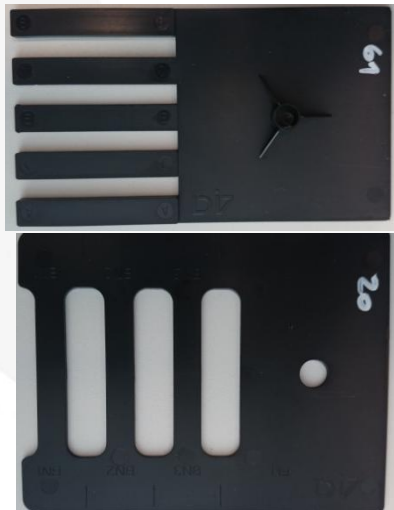
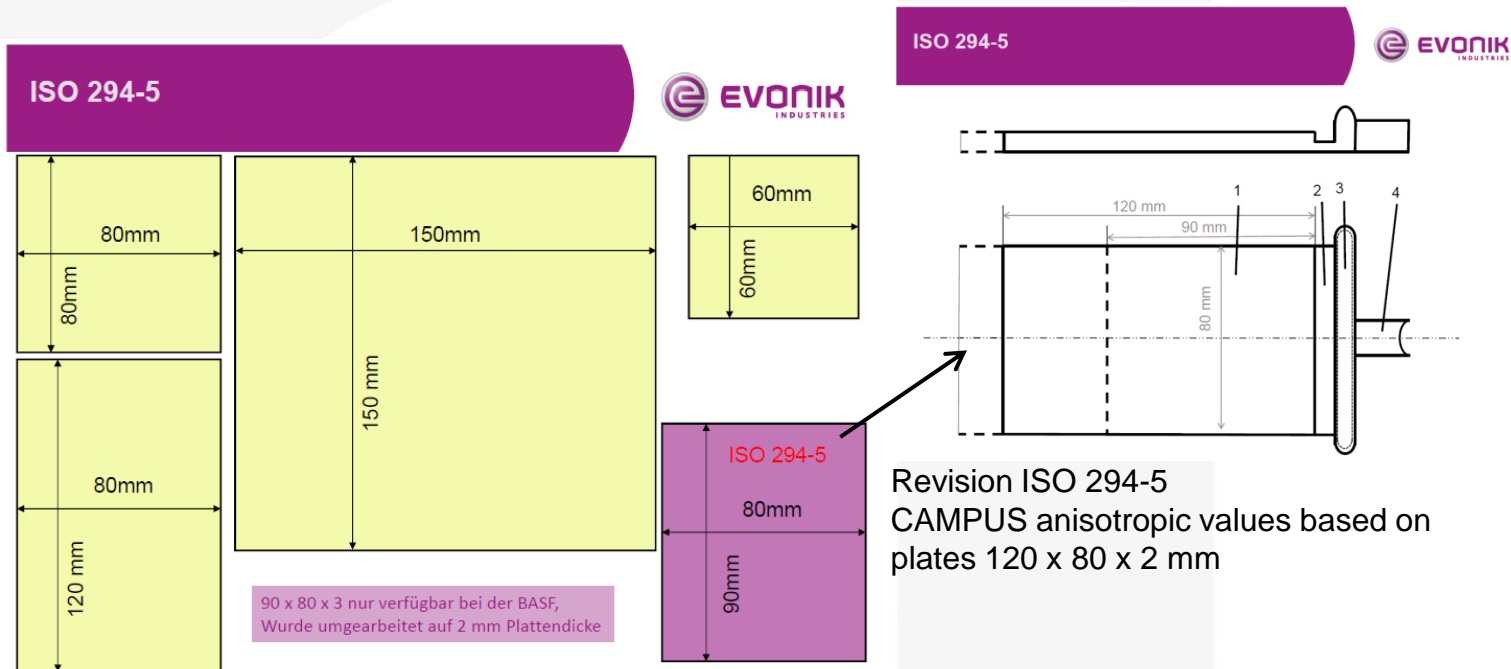


plate 120 x 80 x 2 mm



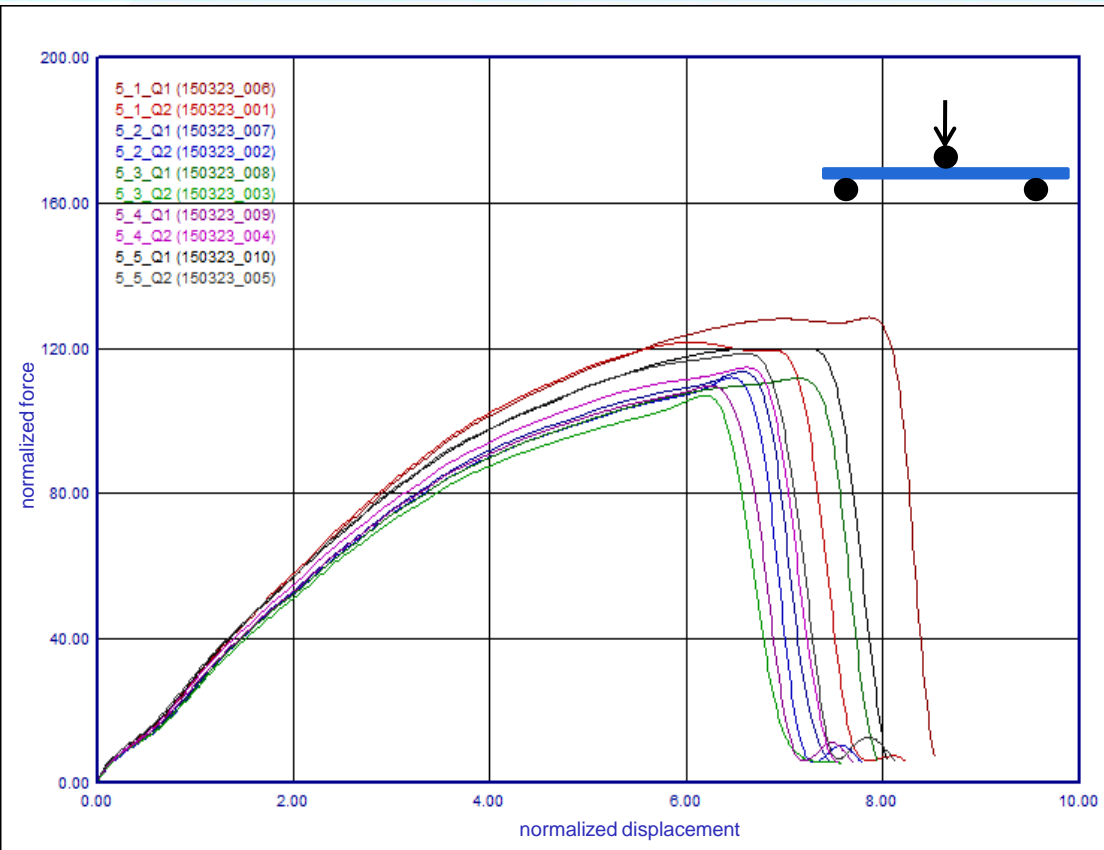
- Test specimens taken from plates (ISO 294-5)



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

4a impetus

Tests – specimen preparation



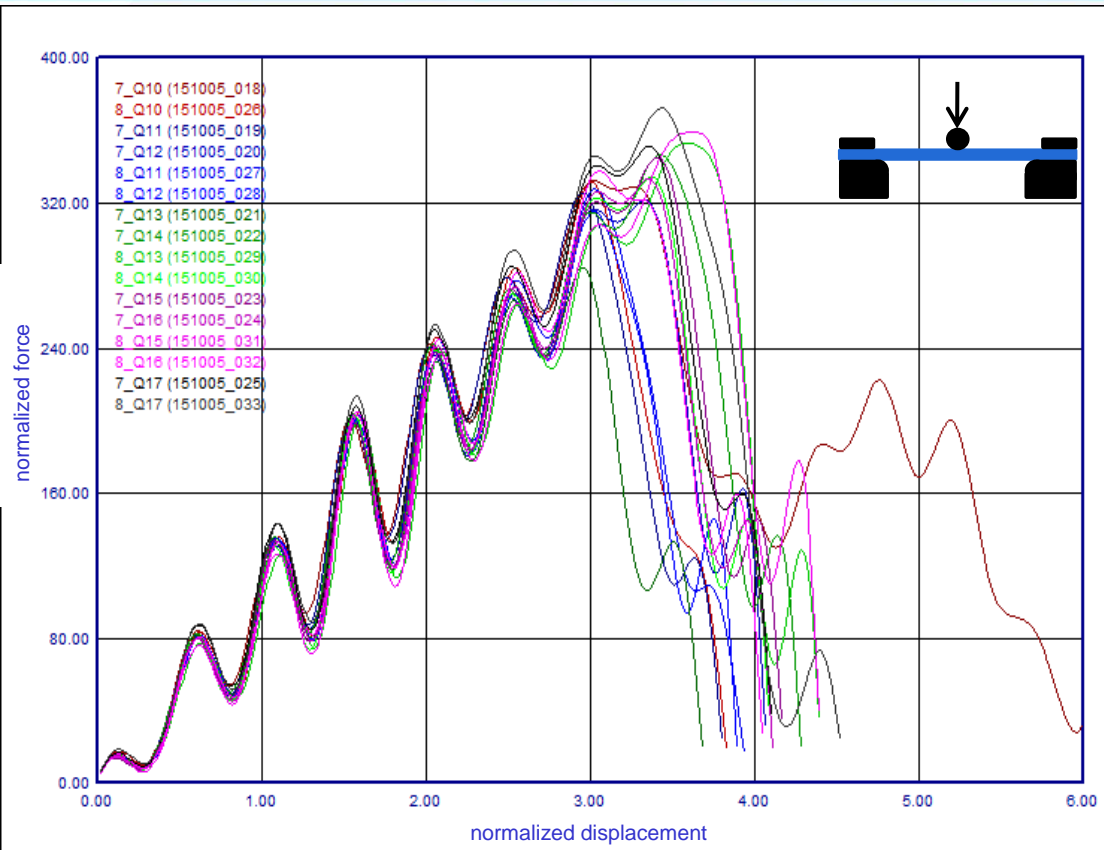
- film gate
- 5_1_Q1
 - 5_1_Q2
 - 5_2_Q1
 - 5_2_Q2
 - 5_3_Q1
 - 5_3_Q2
 - 5_4_Q1
 - 5_4_Q2
 - 5_5_Q1
 - 5_5_Q2



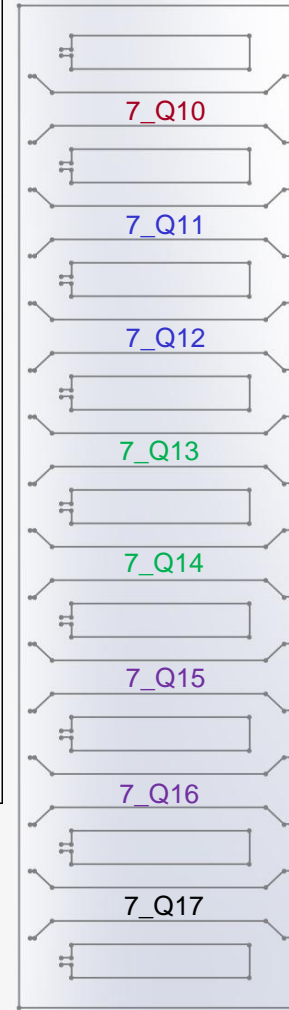
Scattering of stiffness and failure in dependence of the test specimen position for reinforced thermoplastics (PP GF30) in 3-point-bending

4a impetus

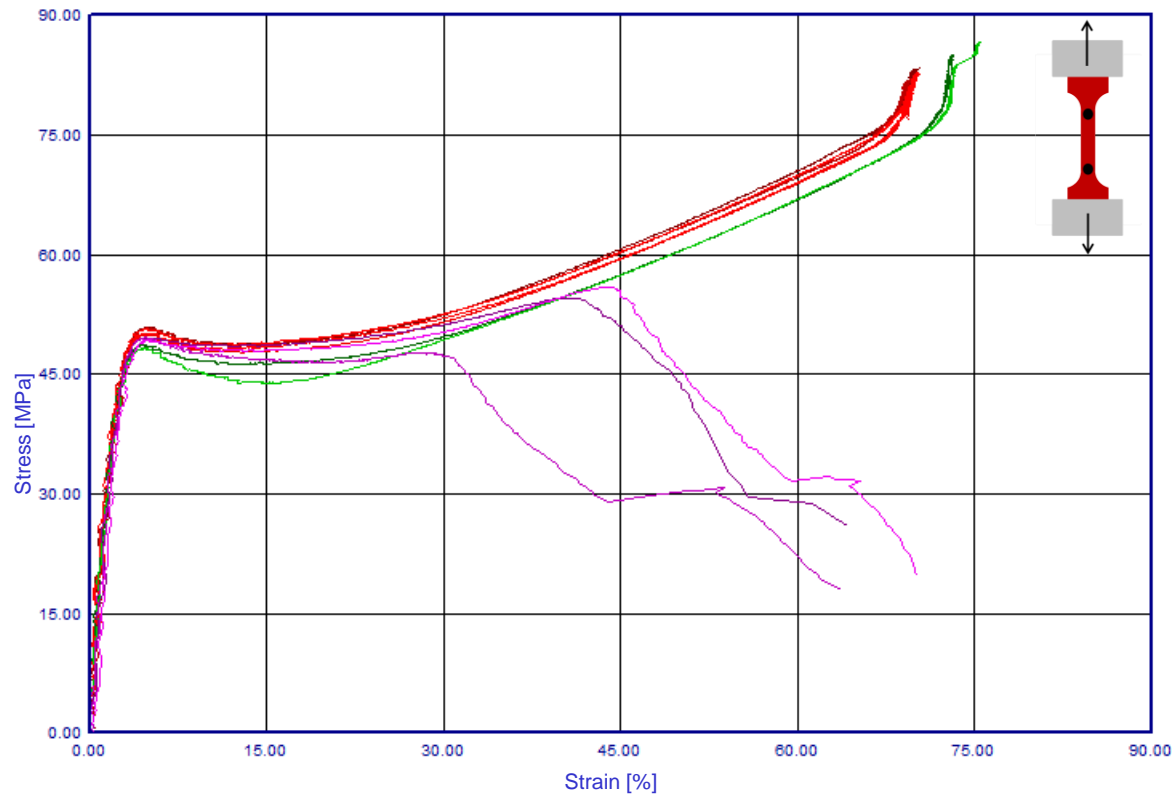
Tests – specimen preparation



film gate



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



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

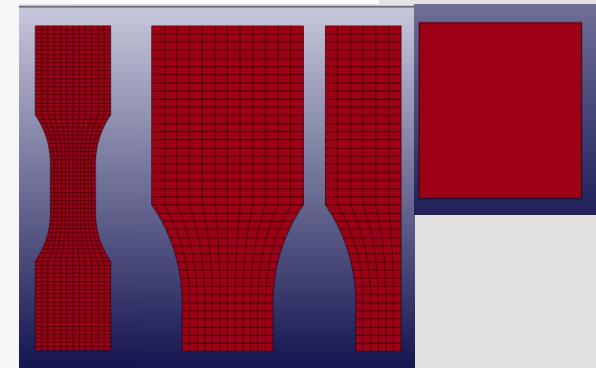
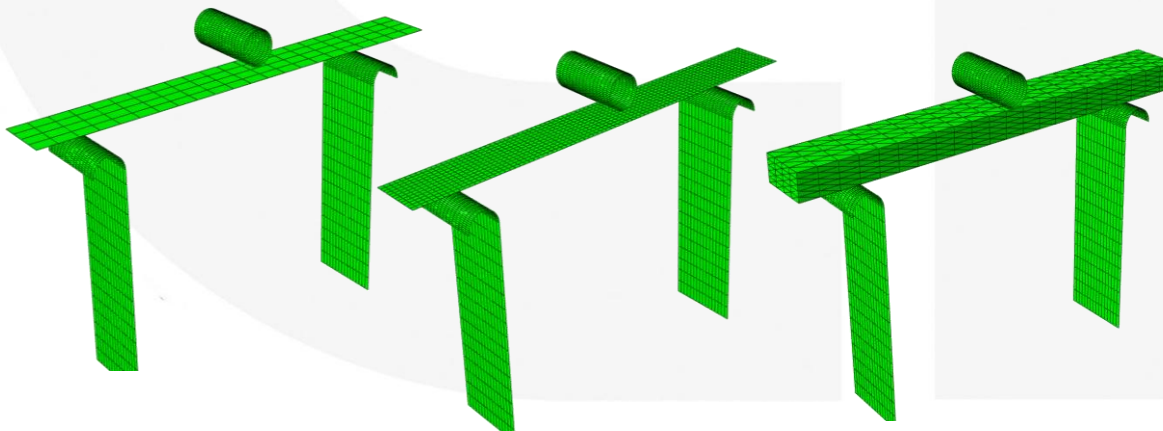
Water jet cut from plate

- Influence of retrieving the test specimens

- 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

Material	
Idealization	
System of units	t-mm-sec-MPa
Solver	LS DYNA
Inputdeck	Impetus (n.a.)
Symmetry of model	NNet(LS-OPT v4.1) (a)
Idealization type	LS DYNA
Element size	PAM CRASH
Additional settings	
Friction coefficient	ABAQUS
Contactthickness	RADIOSS
Young's Modulus of support / f	1
Density of support / fin	210000
Time scaling	7800
	0
Solver	
Selection of FE-solver	



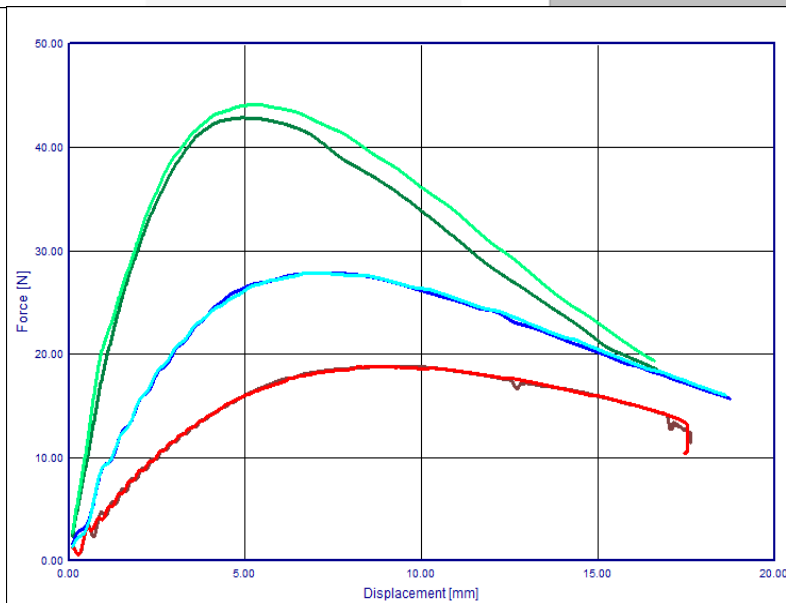
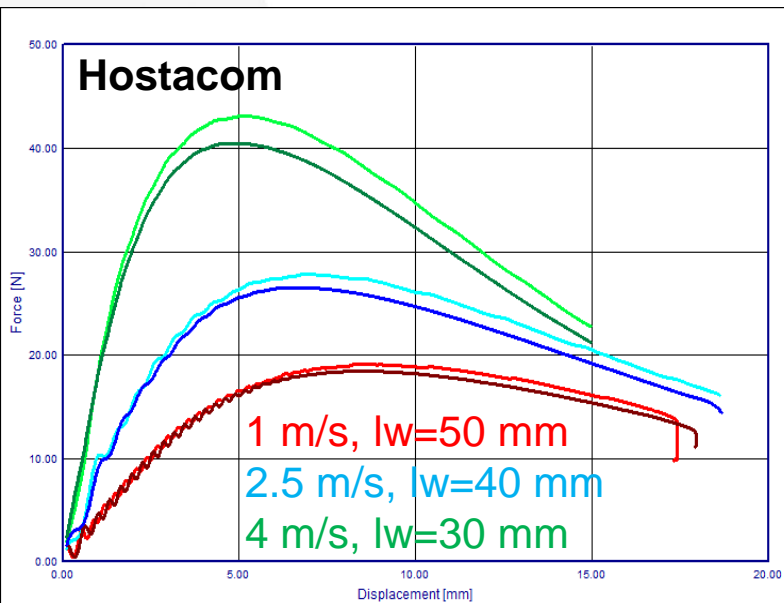
4a impetus

Influence of solver

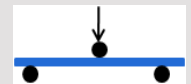
- Easy material cards transfer from one solver to another.
- 2 examples: 3-point-bending; LS-Dyna → Abaqus
 - *MAT24 → *ELASTIC *PLASTIC (left)
 - *MAT_SAMP-1 → *ABQ_MOLDED_PLASTIC (right)
- By One-Mouse-Click the differences can be researched: similar results, differences → distribution of the integration points

Material	
Idealization	
System of units	t-mm-sec-MPa
Solver	LS DYNA
Inputdeck	Impetus (n.a.)
Symmetry of model	NNet(LS-OPT v4.1) (a)
Idealization type	LS DYNA
Element size	PAM CRASH
Additional settings	
Friction coefficient	RADIOSS
Contactthickness	1
Young's Modulus of support / f	210000
Density of support / fin	7800
Time scaling	0

Solver
Selection of FE-solver



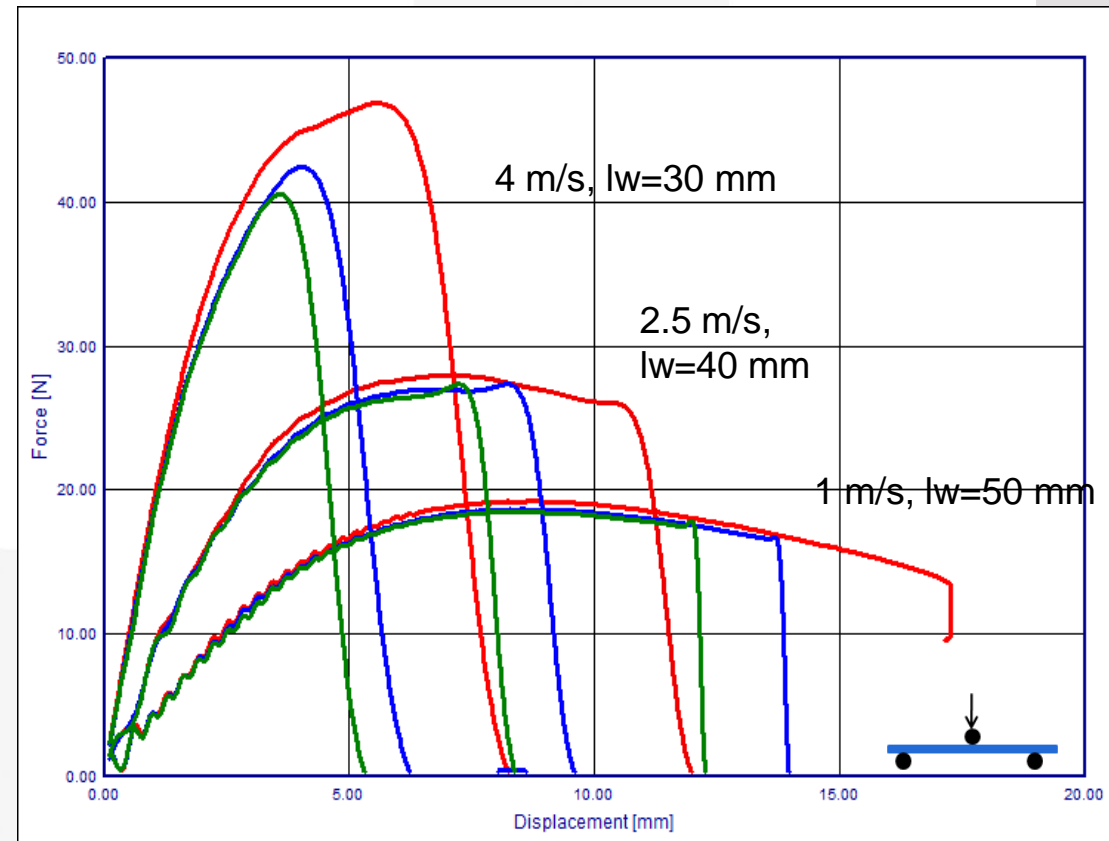
Dark color:
LS-Dyna, Shell type 16
Light color:
Abaqus, Shell S4



4a impetus

Influence of element size

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



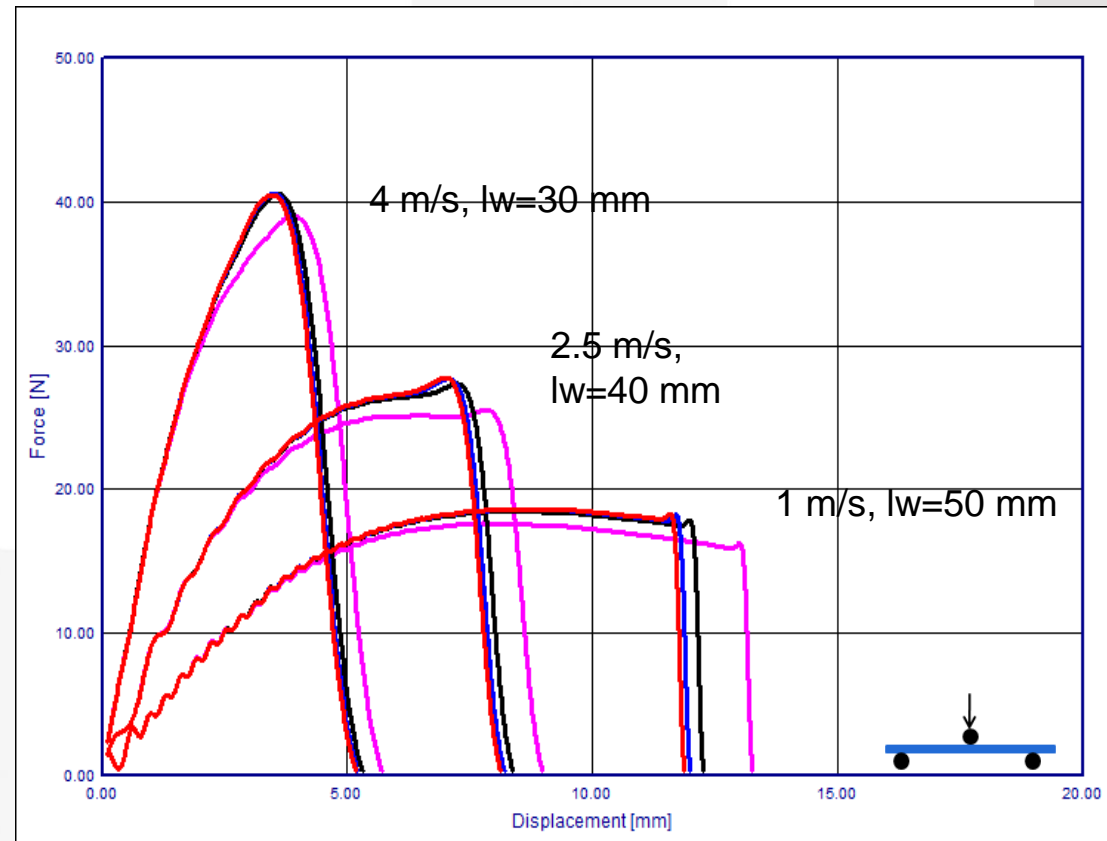
Hostacom

Element size 2 mm

Element size 4 mm

Element size 8 mm

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



Hostacom

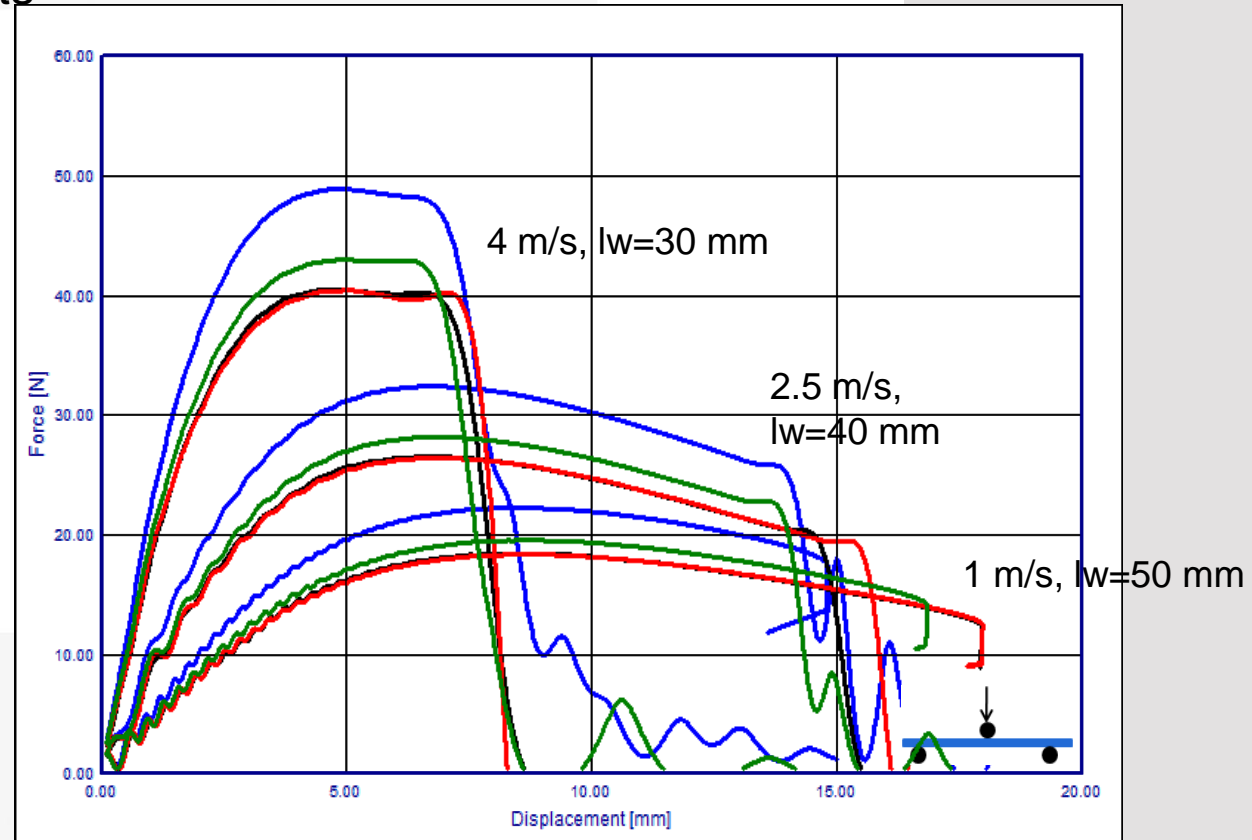
Element type 16; 3 IP

Element type 16; 5 IP

Element type 16; 7 IP

Element type 16, 9 IP

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



Hostacom

Shell-element type 16, 5 IP

Solid-element type 16; 2 elements over thickness

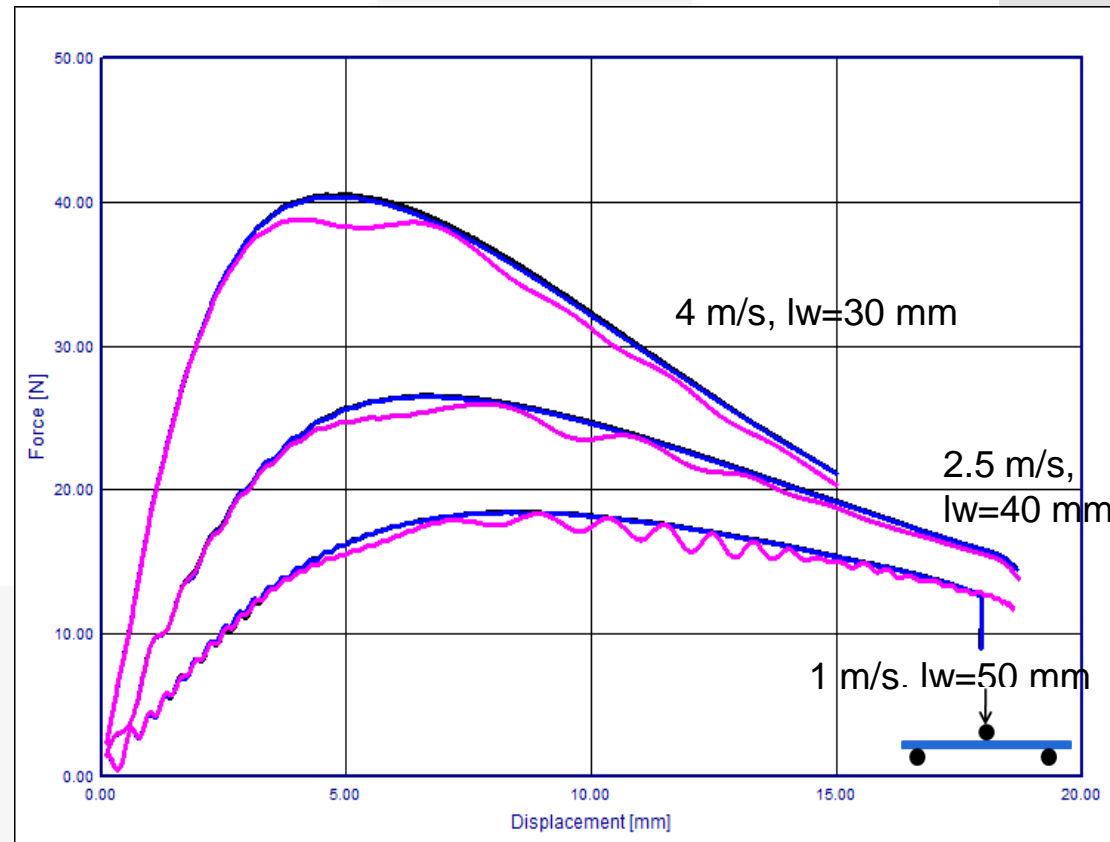
Solid-element type 2, 5 elements over thickness

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

4a impetus

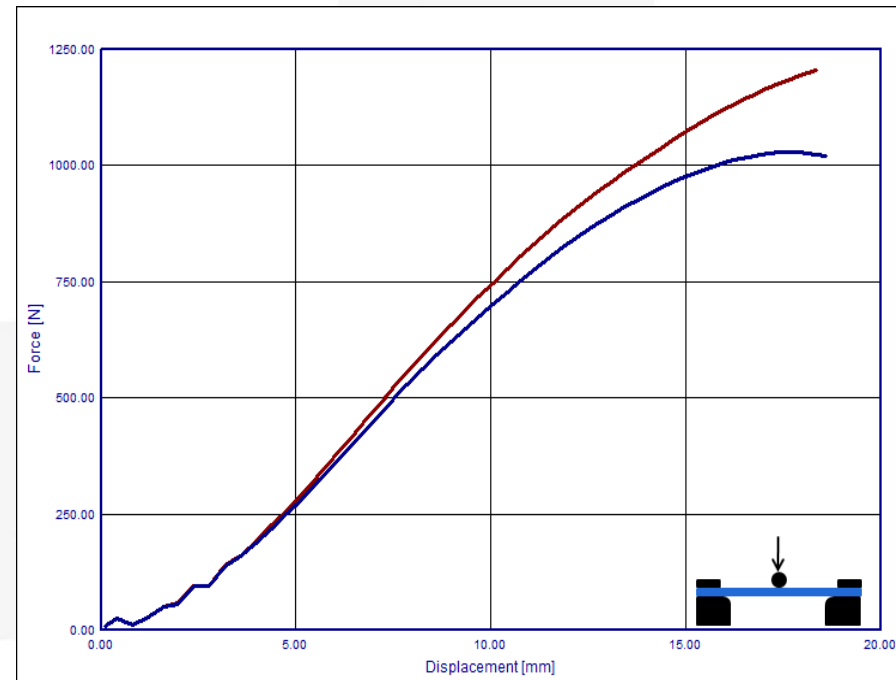
Influence of element type / control card settings

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



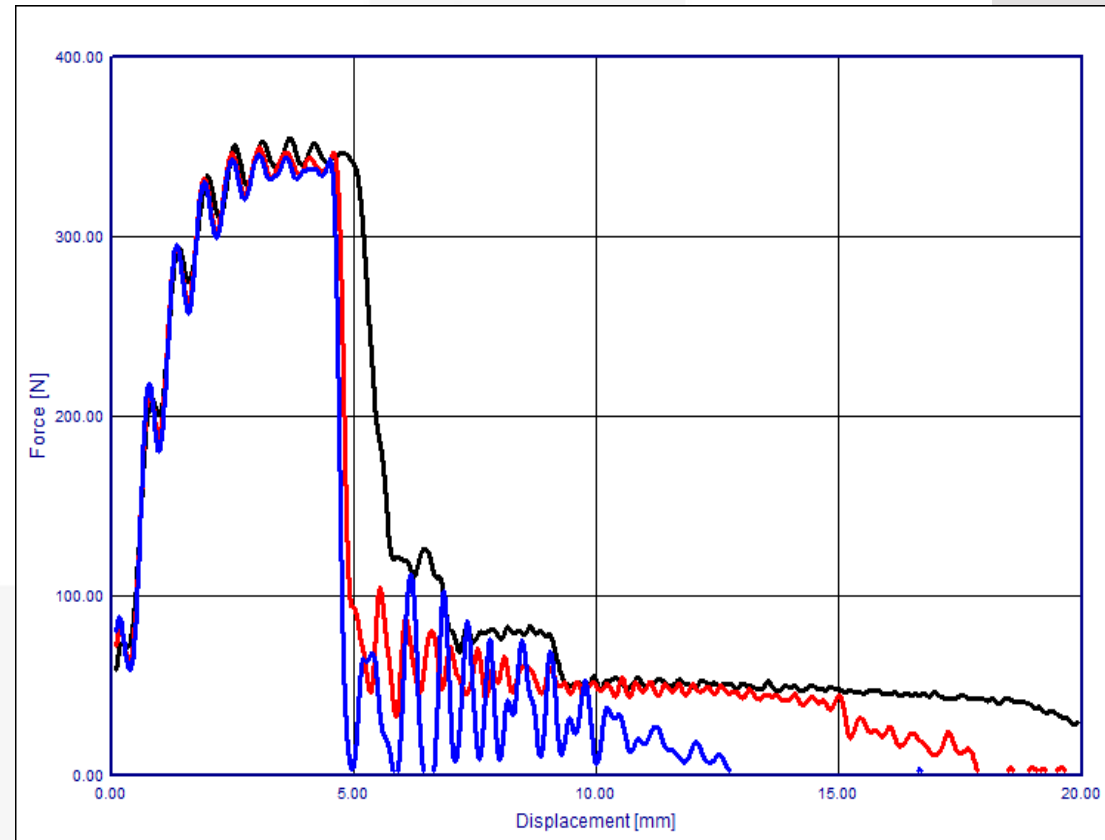
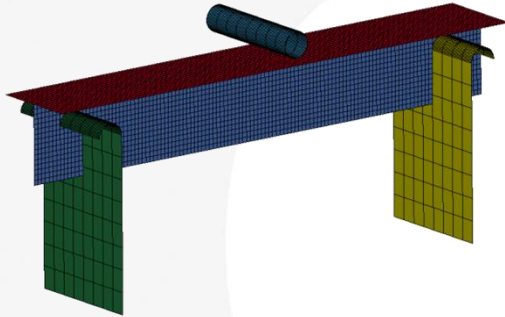
Hostacom
Element type 16
Element type 2
Element type 2, with contact damping and node drill rotation
boundary

- 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

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



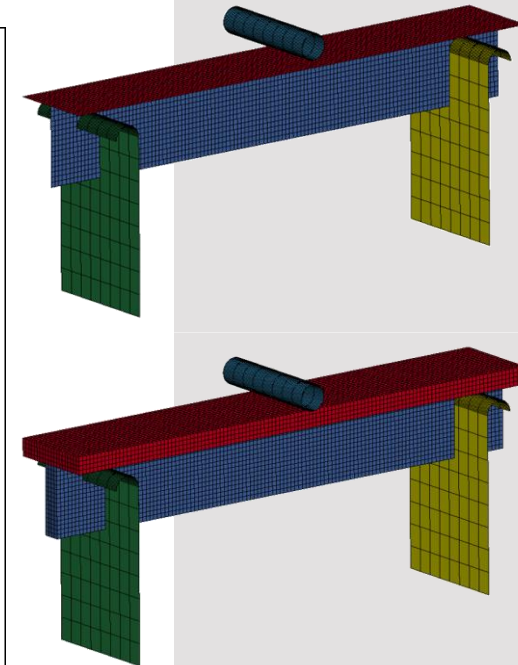
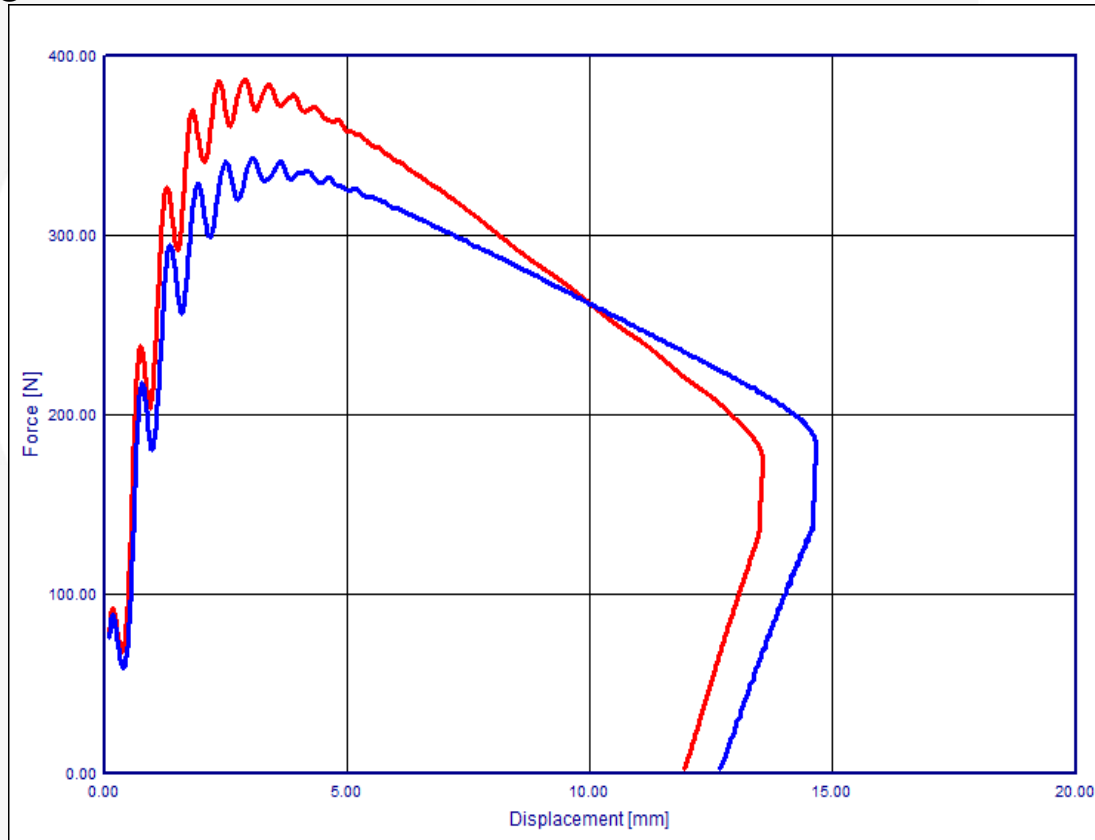
Hostacom

Element size 4 mm

Element size 2 mm

Element size 1 mm

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



Hostacom

Element size 0.5 mm

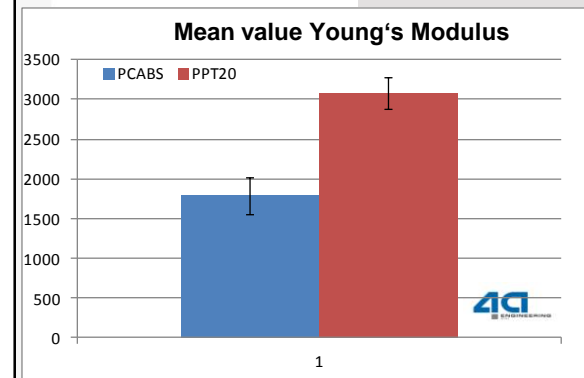
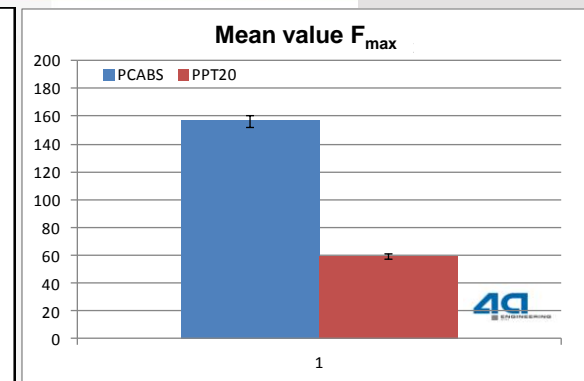
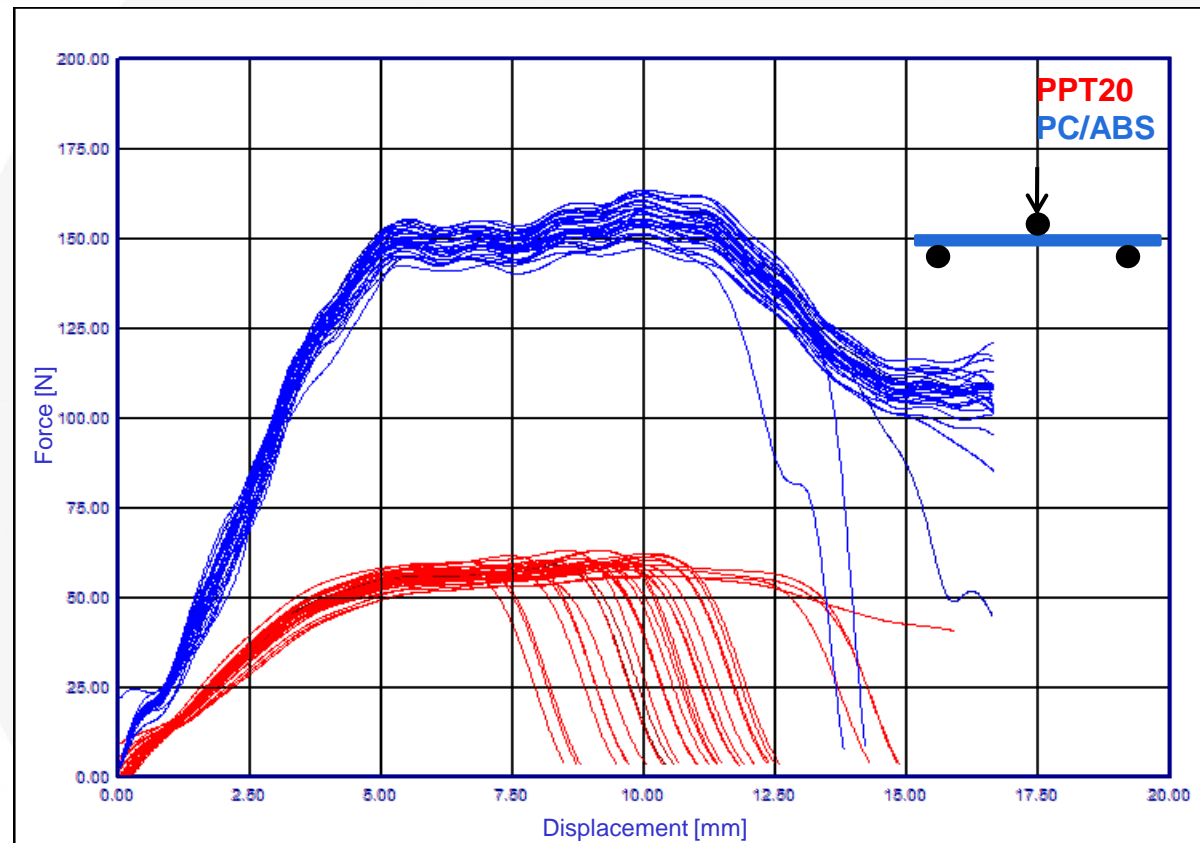
Solid-elements, element type 2

Shell-elements, element type 16

- 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

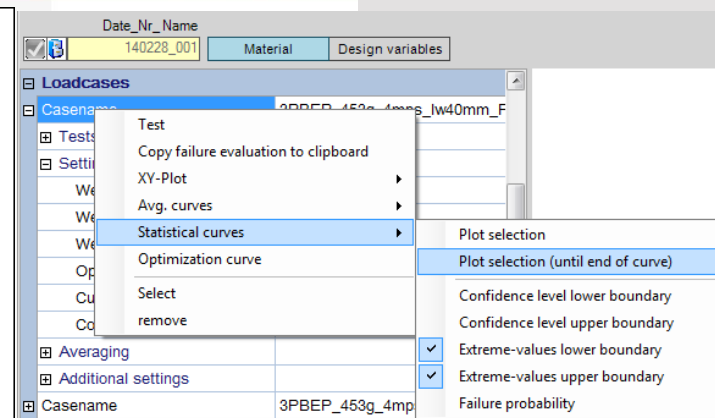
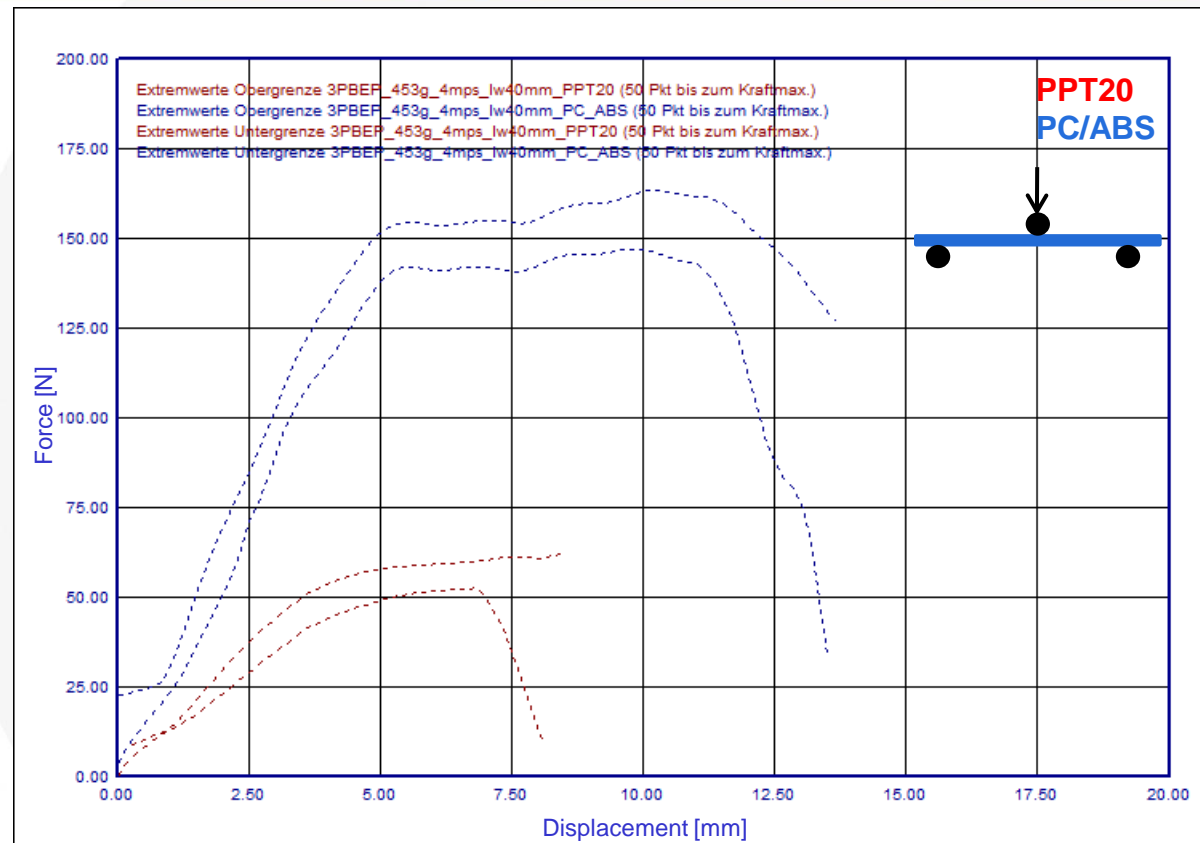
Measurement results – statistical evaluation in 4a impetus



Example: 30 measurements for both materials (30 users)

4a impetus

Measurement results – statistical evaluation in 4a impetus

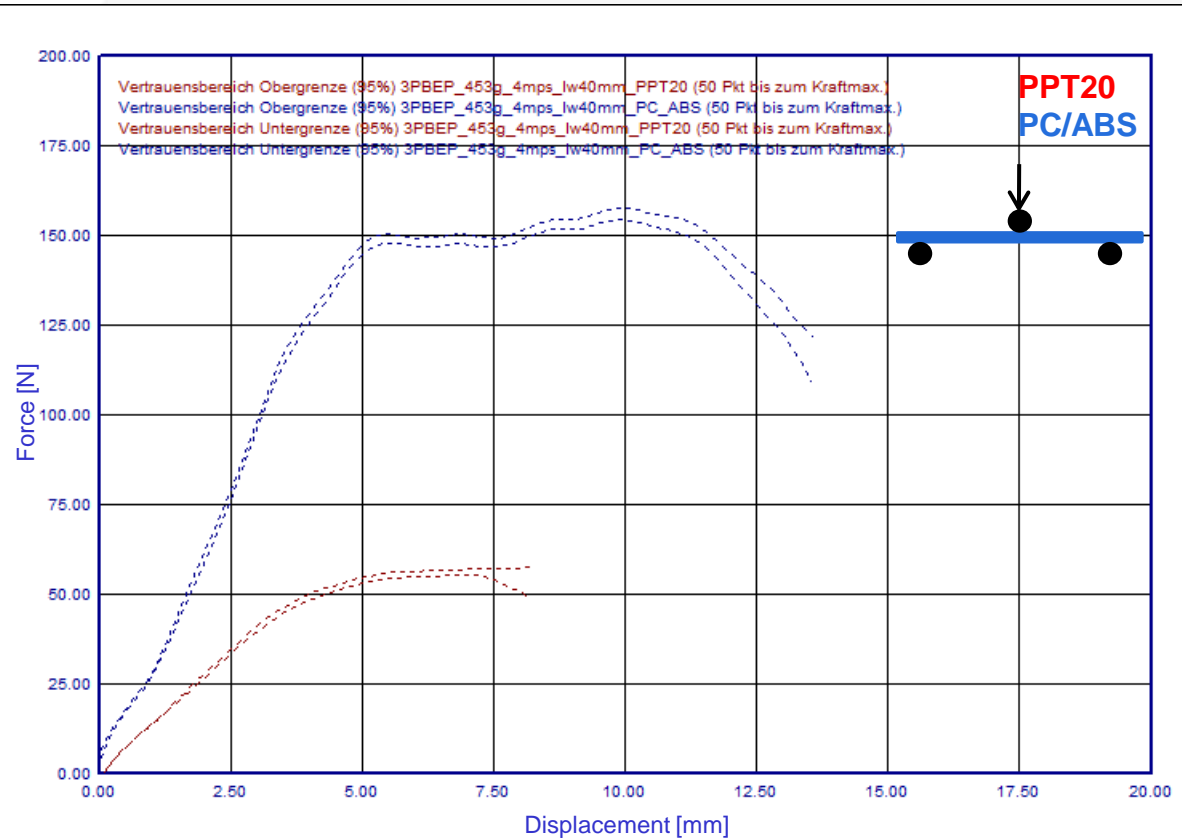


The screenshot shows the software interface with a context menu open over the 'Statistical curves' option. The menu includes options like 'Copy failure evaluation to clipboard', 'XY-Plot', 'Avg. curves', 'Statistical curves', 'Optimization curve', 'Select', and 'remove'. The 'Statistical curves' submenu is also visible, showing options for 'Plot selection', 'Plot selection (until end of curve)', 'Confidence level lower boundary', 'Confidence level upper boundary', 'Extreme-values lower boundary', 'Extreme-values upper boundary', and 'Failure probability'. The 'Casename' field is set to '3PBEP_453g_4mp'.

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

4a impetus

Measurement results – statistical evaluation in 4a impetus



Date_Nr_Name: 160303_022 | Material | Design variables

Casename	3PB_dyn_high_velo
Tests	
Settings optimization	
Weighting case	1
Weighting beginning	1
Weighting force maximum	1
Optimization target	F(t)
Curvestatistics	lower extremevalue
Confidence level	95
Averaging	
Additional settings	

Results

Date_Nr_Name: 140228_001 | Material | Design variables

Loadcases	
Casename	3PBEP_453g_4mps_lw40mm_F
Tests	
Settings optimization	
Weighting case	
Weighting beginning	
Weighting force maximum	
Optimization target	
Curvestatistics	
Confidence level	
Averaging	
Additional settings	
Casename	3PBEP_453g_4mps_lw40mm_F

- Test
- Copy failure evaluation to clipboard
- XY-Plot
- Avg. curves
- Statistical curves
- Optimization curve
- Select
- remove

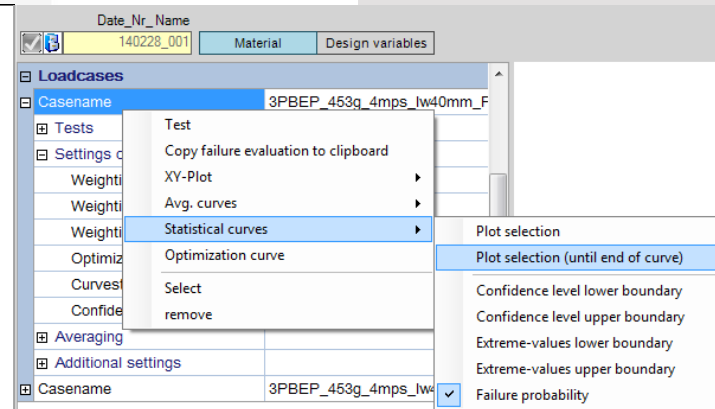
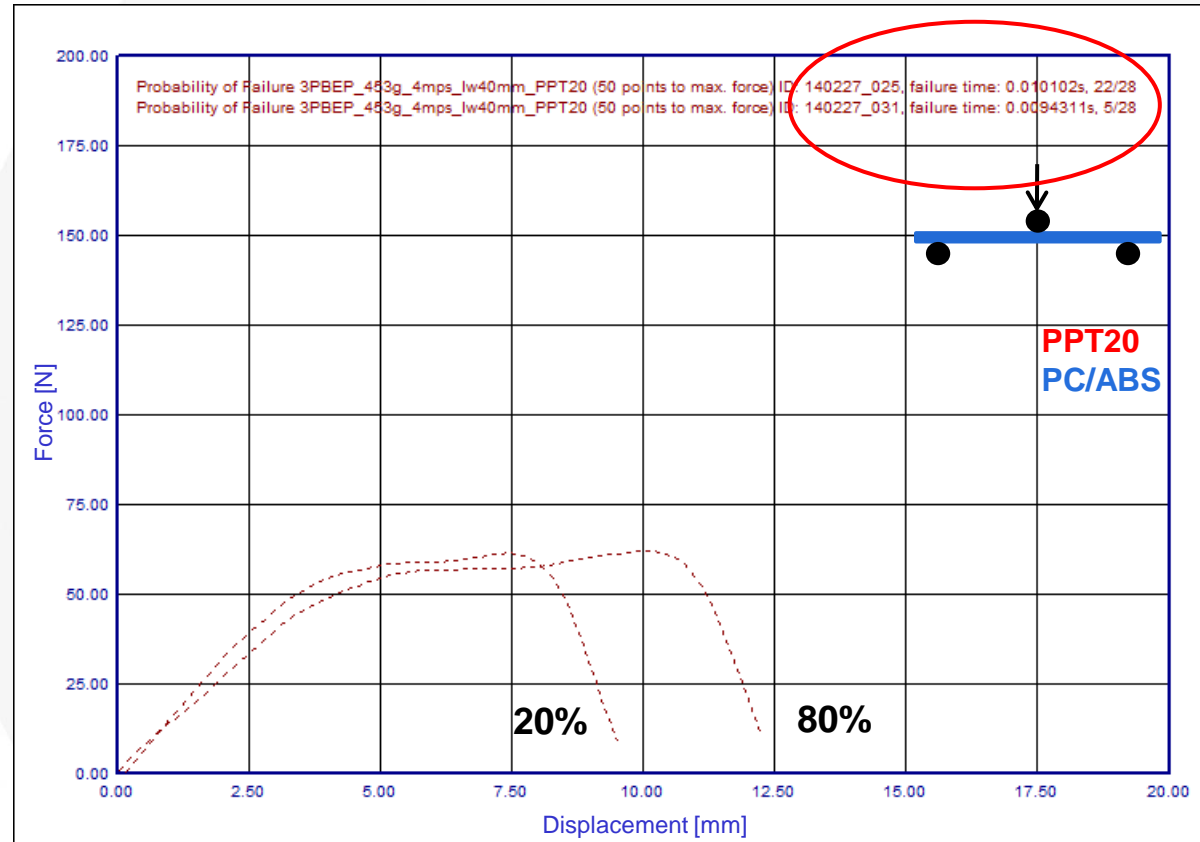
Plot selection

- Plot selection (until end of curve)
- Confidence level lower boundary
- Confidence level upper boundary
- Extreme-values lower boundary
- Extreme-values upper boundary
- Failure probability

Confidence interval of both materials (confidence level 95%)

4a impetus

Measurement results – statistical evaluation in 4a impetus



Date_Nr_Name
140228_001

Material Design variables

Loadcases

Casename 3PBEP_453g_4mps_lw40mm_F

- Tests
- Settings
- Weighting
- Weighting
- Optimization
- Curves
- Confidence
- Averaging
- Additional settings
- Casename 3PBEP_453g_4mps_lw40mm_F

Test

- Copy failure evaluation to clipboard
- XY-Plot
- Avg. curves
- Statistical curves
- Optimization curve
- Select
- remove

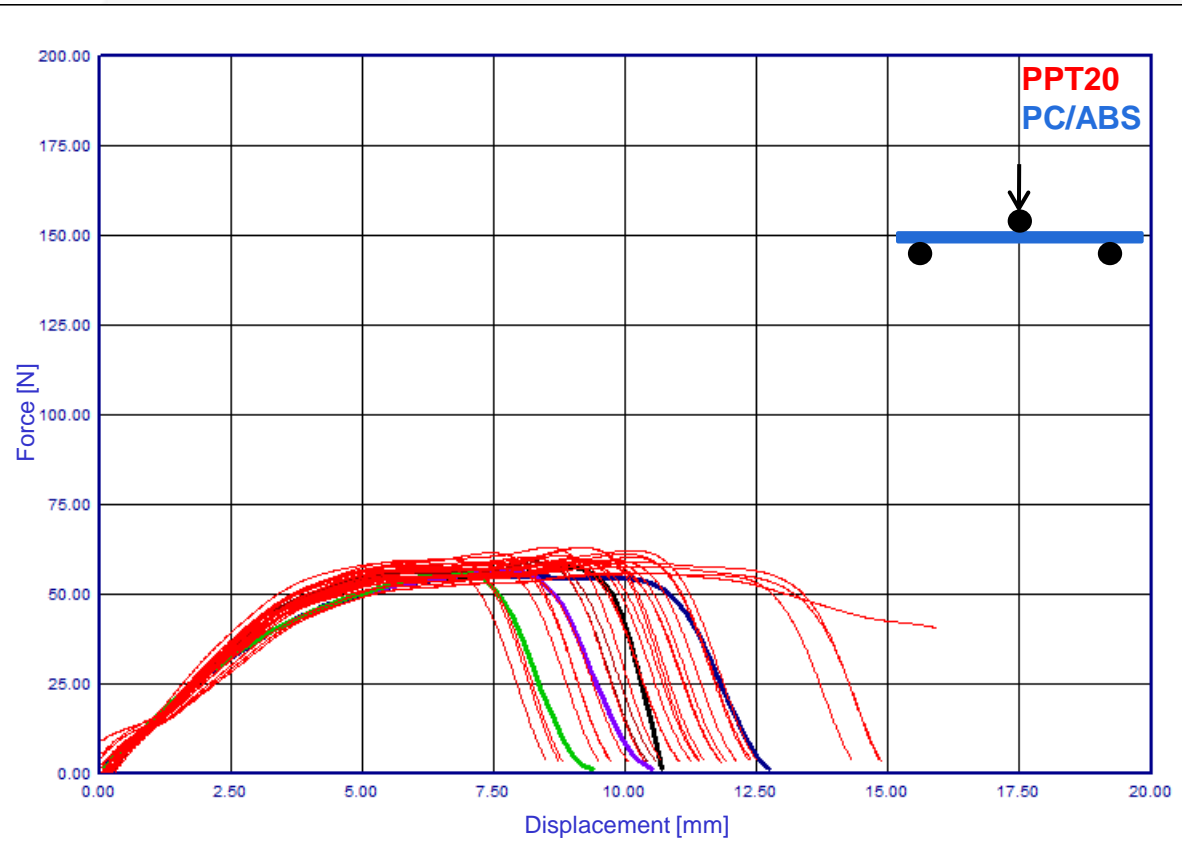
Plot selection

- Plot selection (until end of curve)
- Confidence level lower boundary
- Confidence level upper boundary
- Extreme-values lower boundary
- Extreme-values upper boundary
- Failure probability

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)

- 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!

