4a Summer School
Summary: Lessons learned, outlook and upcoming features

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Traboch, 10.07.2020

4a Summer School

1st week - Introduction and outlook


07. July - Introduction to VALIMAT® from test to material card


08. July - Efficient dynamic testing with IMPETUS®


09. July - Material card generation: vonMises plasticity (**MAT_024*), simple failure, setting up our Autofit


10. July - Summary: Lessons learned, outlook and upcoming features

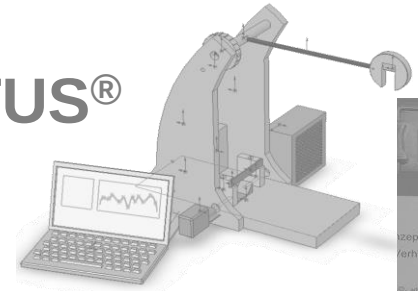
Content

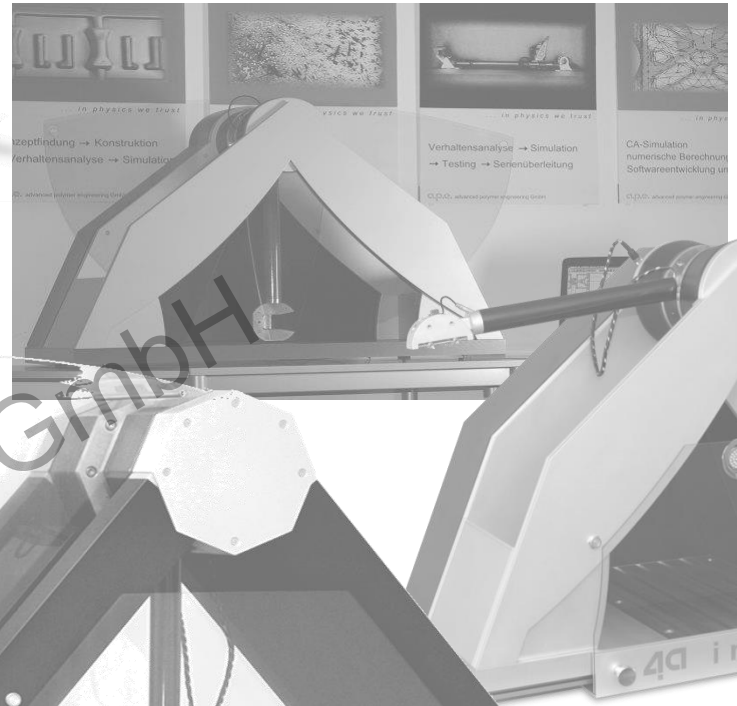
- Efficient dynamic testing with IMPETUS® summary
- Material card generation: vonMises plasticity (*MAT_024) with simple failure summary
- VALIMAT® 3.8 upcoming features
- Outlook on our advanced topics week
- Q&A

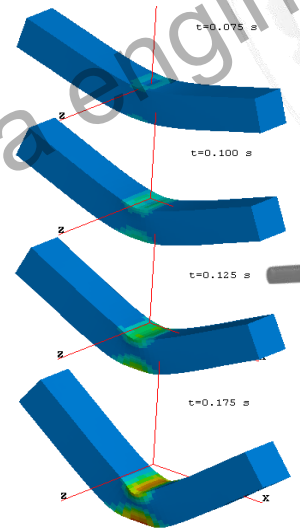
4a Summer School
Efficient dynamic testing with IMPETUS® summary

Efficient dynamic testing with IMPETUS®

- desktop testing device
- instrumented high-speed testing







IMPETUS® data specification

technical specifications

maximum energy	50J
length of swing arm	500mm
mass of swing arm	1.5 - 5.5kg
impact velocity	0.5 - 4.4m/s

weights and dimensions

L x W x H	1400 x 600 x 850mm
mass	165kg

desk load and dimensions minimum required

L x W x H	1500 x 800 x 800mm
minimum load	250kg

electrical supply data

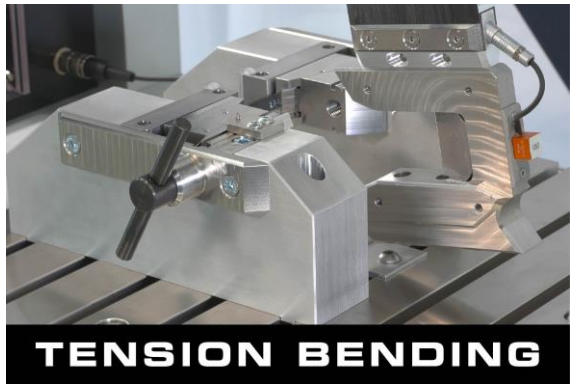
230 VAC 50 Hz	0.5A
115 VAC 60 Hz	1.0A

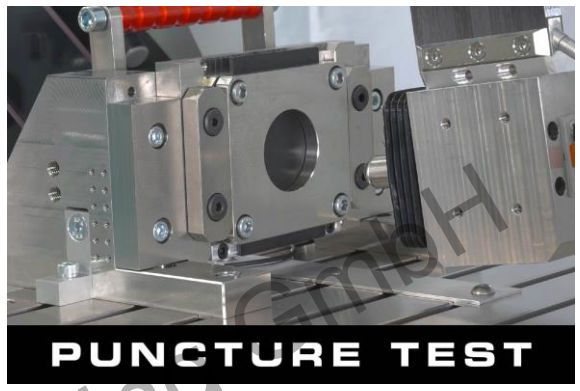
5V camera trigger

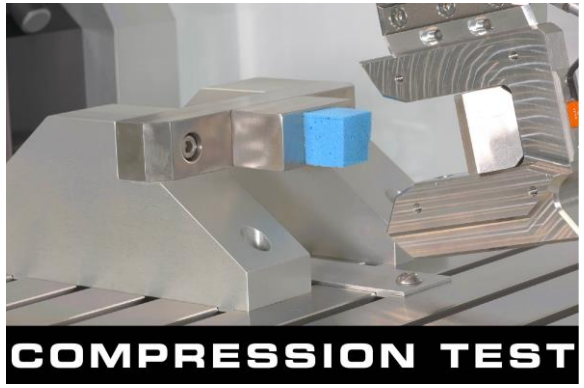
output level high	>2.5V
output level low	<0.5V

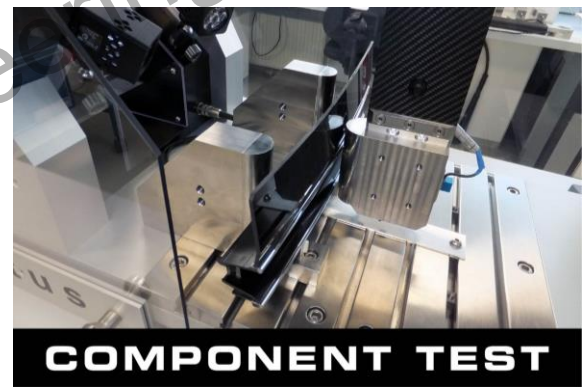
Highspeed camera is an optional equipment and can be ordered separately.

IMPETUS® - configurations







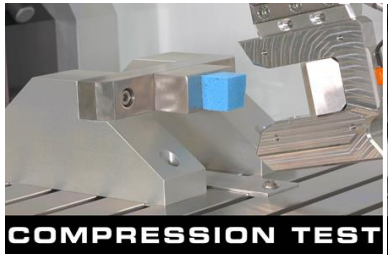
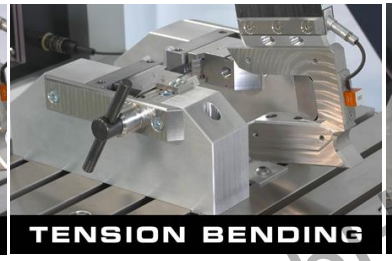
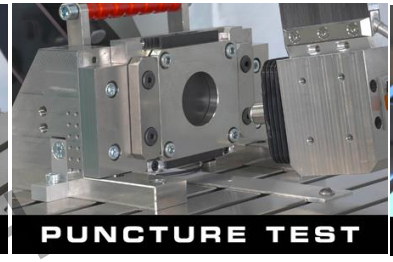


BASIC

STANDARD

PROFESSIONAL

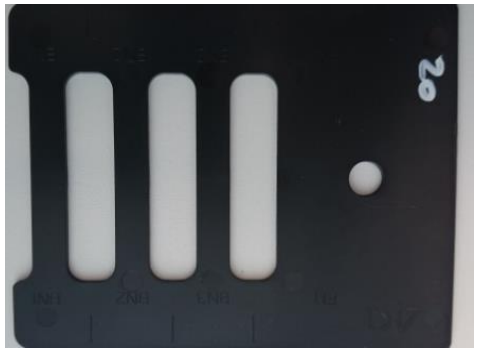
efficient dynamic testing

Material *(Typical thickness)*	 COMPRESSION TEST	 3 POINT BENDING	 TENSION BENDING	 PUNCTURE TEST	 TENSION TEST
Plastic *(1 - 4 mm)*		✓	✓	✓	✓
Foam *(20 - 30 mm)*	✓	~			
Composite *(1 - 4 mm)*		✓		✓	
Aluminum *(1 – 2.5 mm)*		✓	✓		✓
Metals *(0.5 – 1.5 mm)*		✓			

validated material cards - injection mold for plastics

Dom & Wall thickness

Melt- & Weldlines



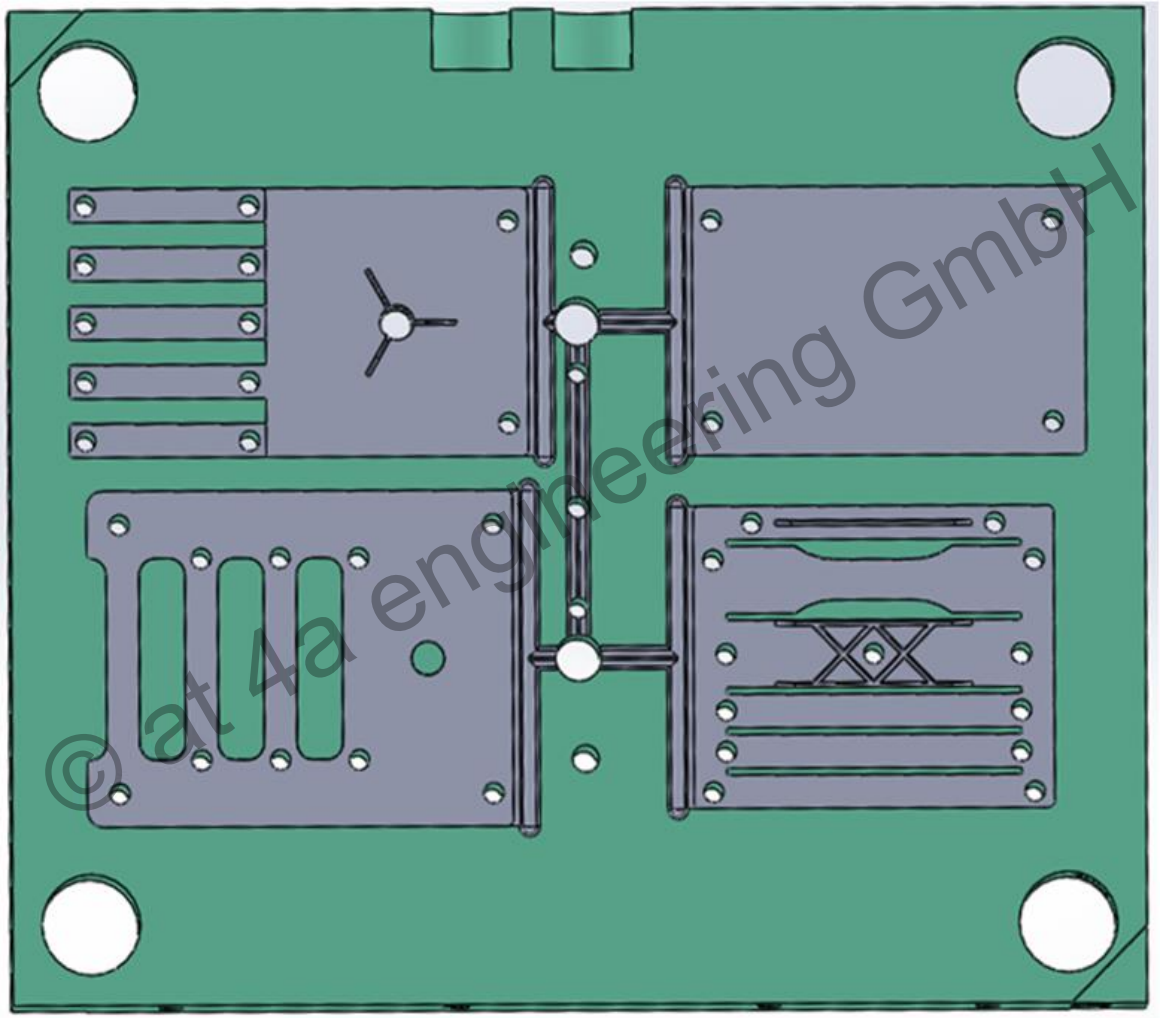
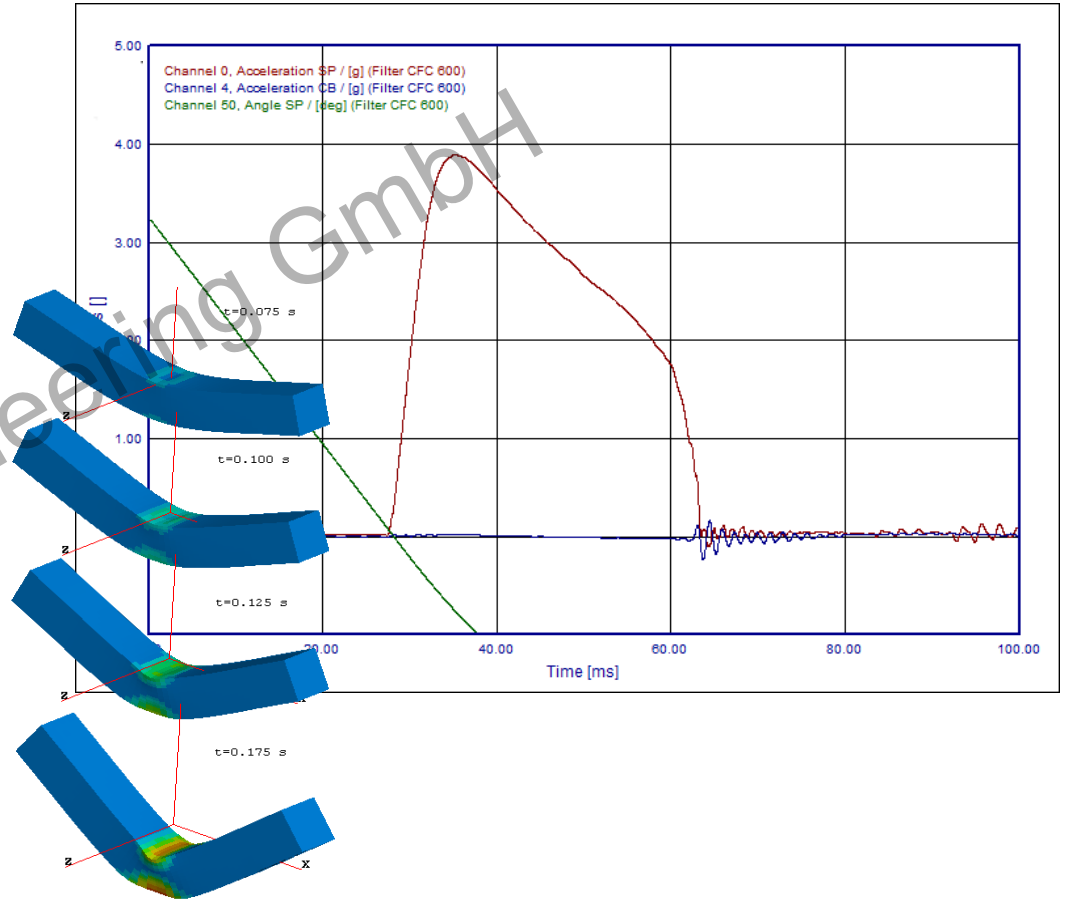


Plate 120 x 80 x 2 mm

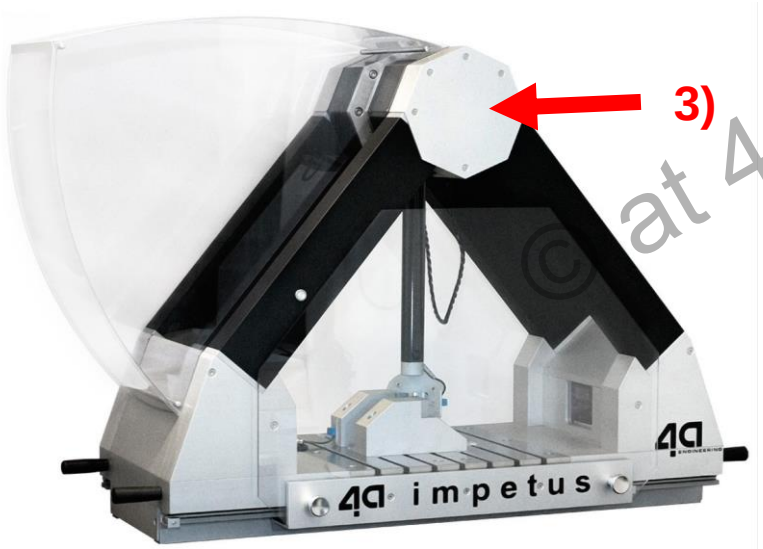
Multi-Specimen &
XX-Rib & Component

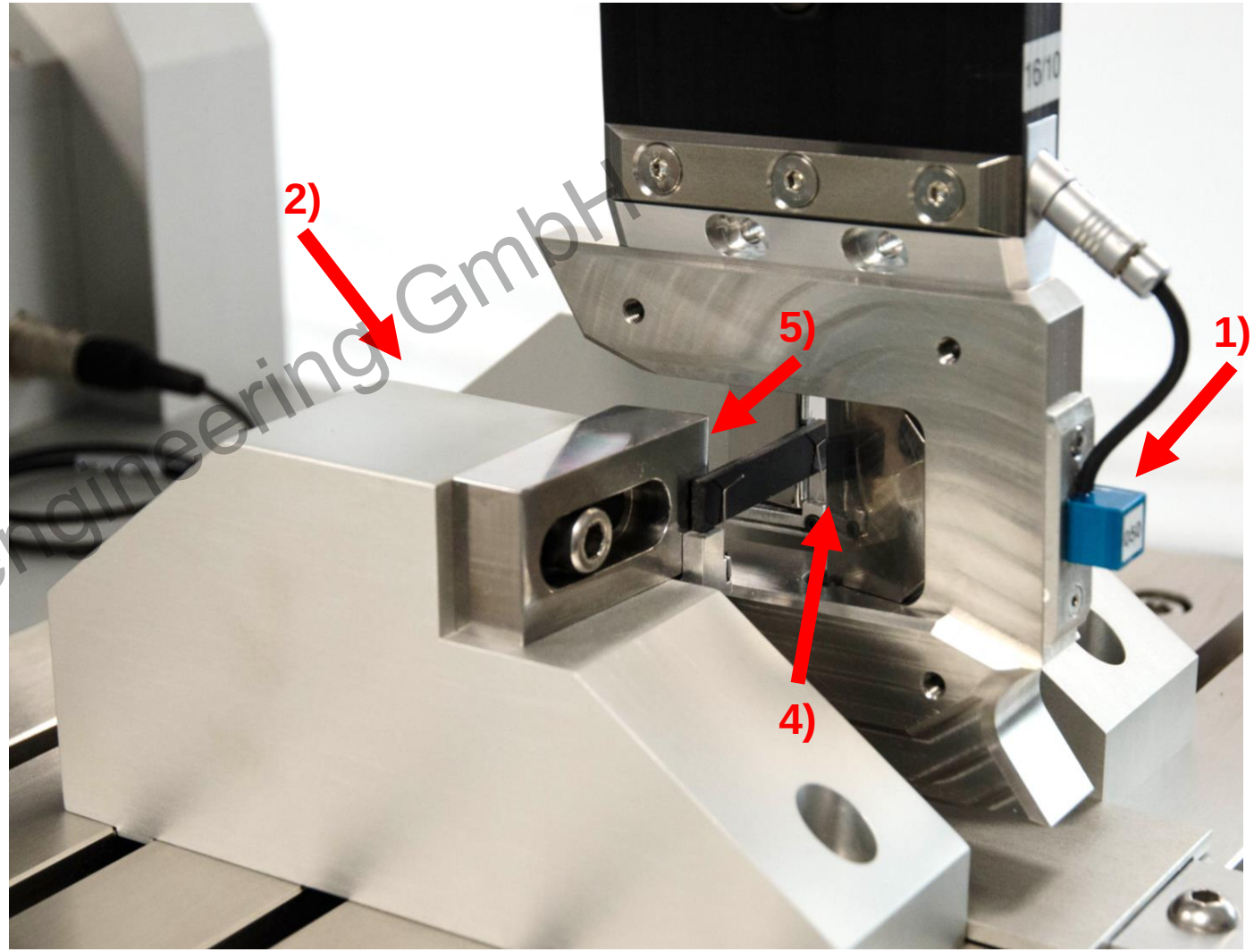
Measurement technique



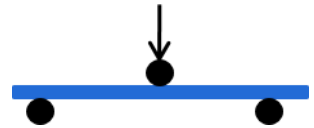
Test setup – IMPETUS® 3-Point-Bending

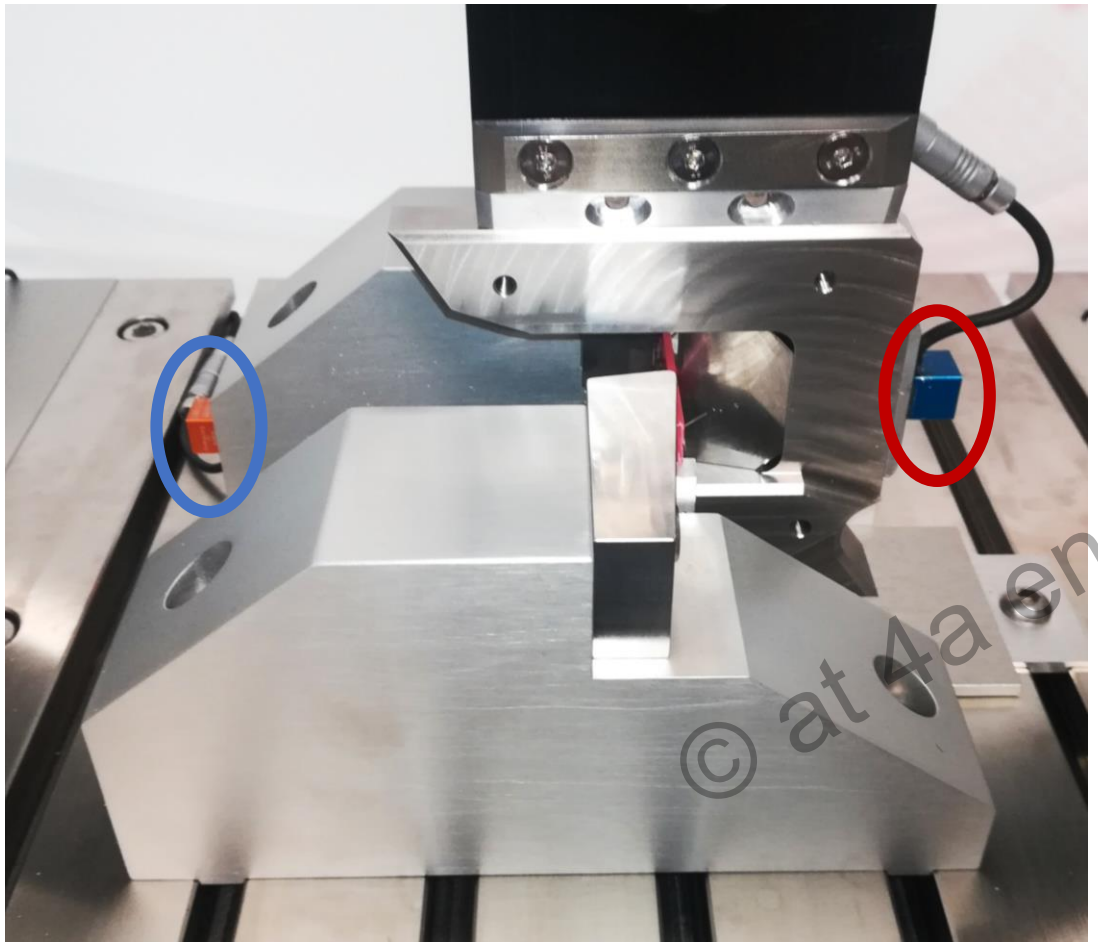
1) acceleration sensor on pendulum head
2) acceleration sensor on counter bearing
3) angle sensor
4) radius of the fin: 2 mm
5) support radius: 2 mm
6) swing hammer mass: 1580 g

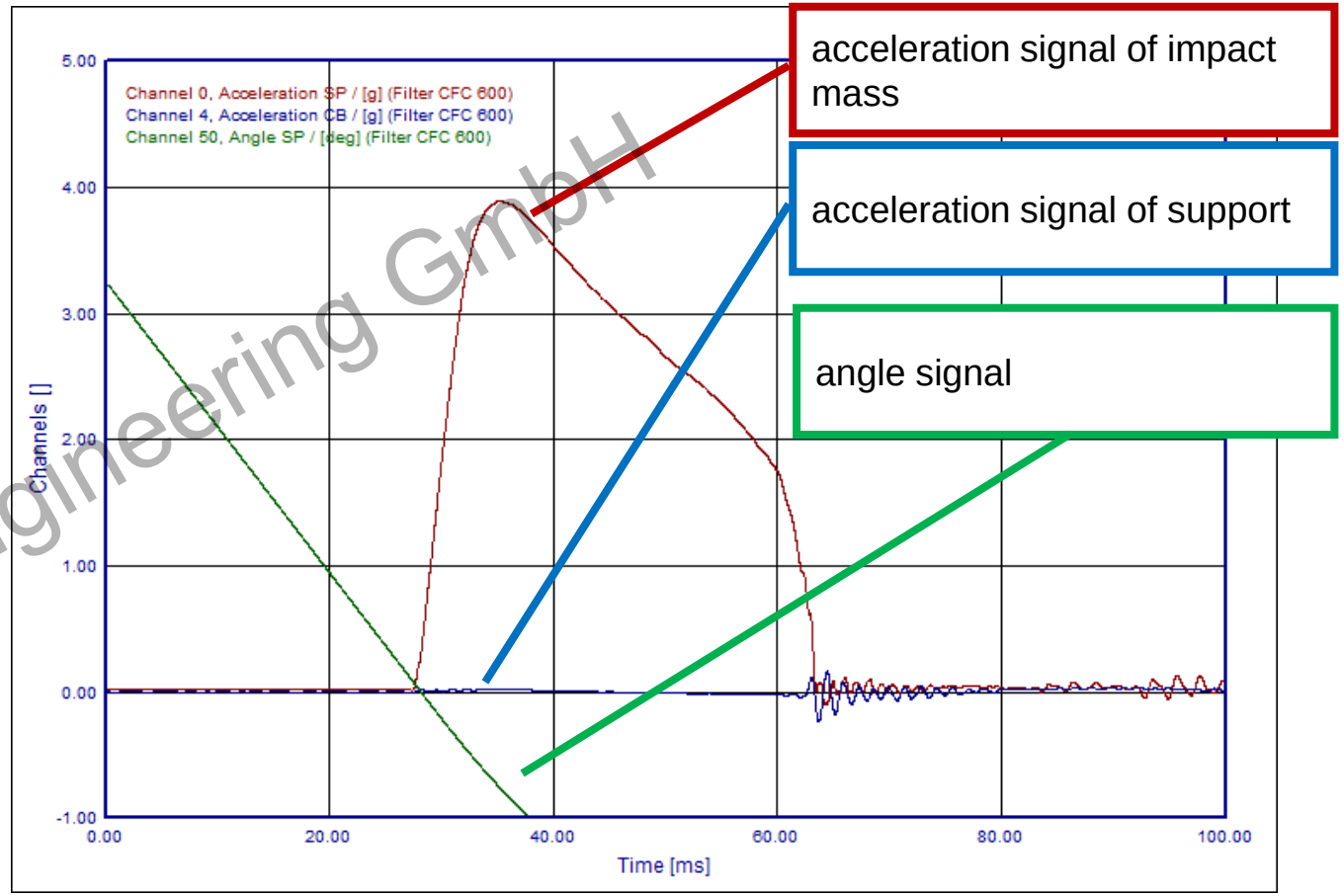




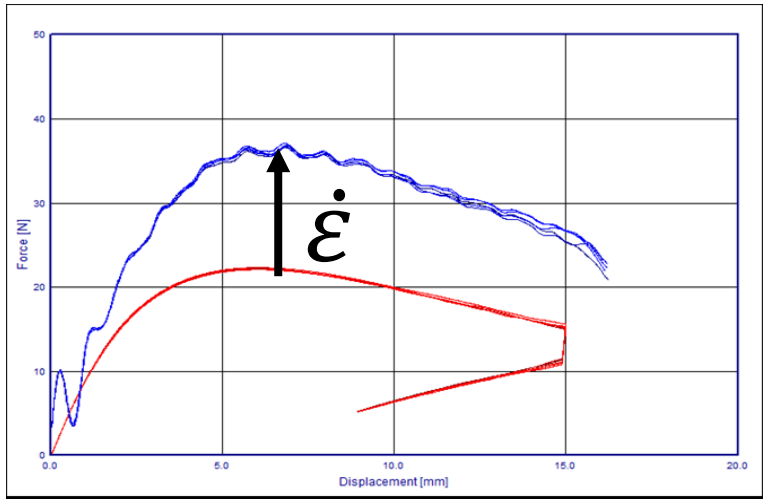
Measurement signals – IMPETUS® 3-Point-Bending



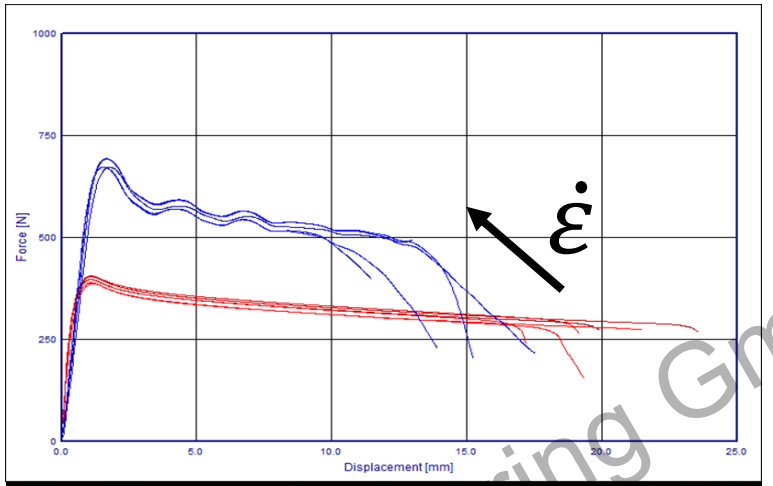




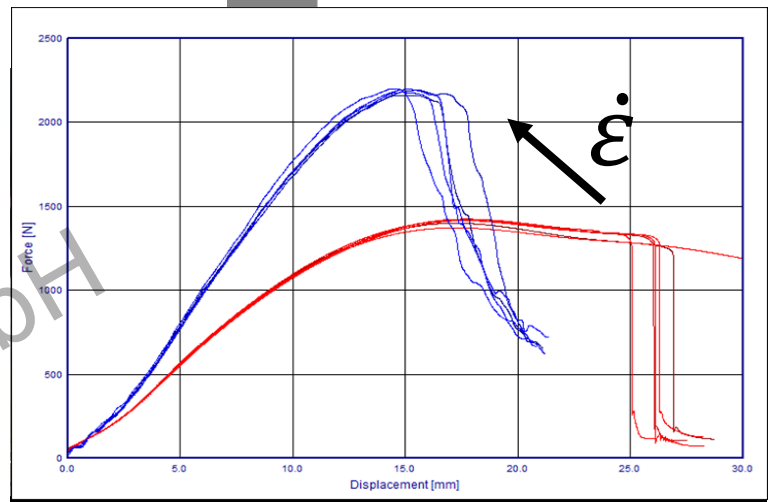
IMPETUS® - efficient dynamic testing



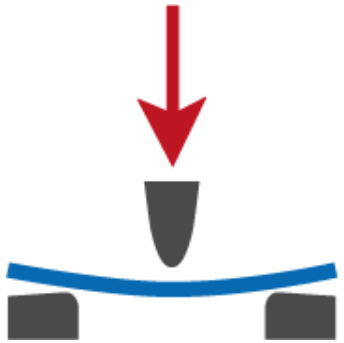
3 POINT BENDING

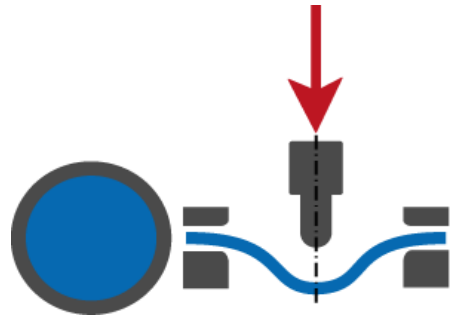


TENSION TEST



PUNCTURE TEST

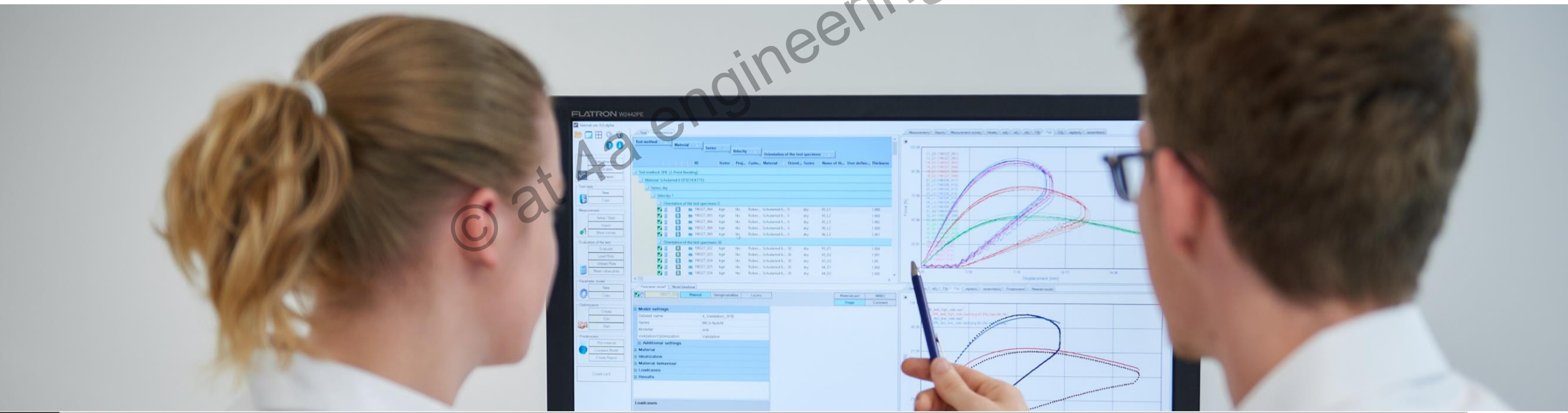




IMPETUS™ ~ 3 m/s

static ~ 1mm/s

Available material models!



Material Model Selection

LS-DYNA has many material models implemented
currently 265 materials (01.07.2020)
most of them won't fit in our use case

The most used material model is **`*MAT_024`**.

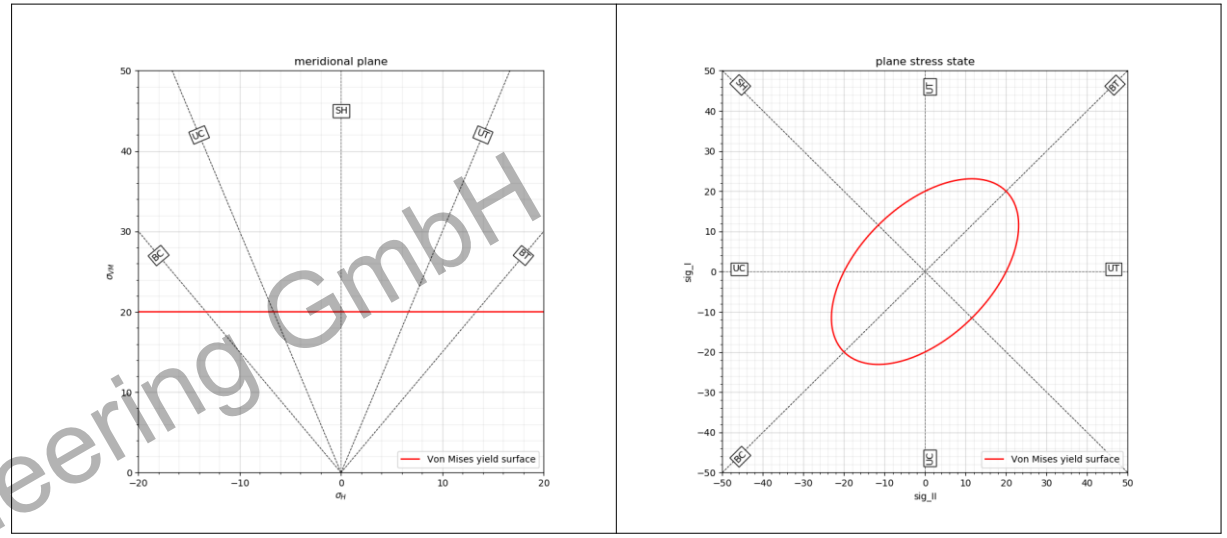
Other interesting material models for thermoplastic polymers are **`*MAT_124`** and **`*MAT_187`**.

Table: number of available material models for subset of filters
http://www.lstc.com/dynamat/ (01.7.2020)

Element	Material family	Nr. of material models
Any element	Any family	265
Shell element	Any family	23
Solid element	Any family	179
Any element	Plastics	33
Shell element	Plastics	23
Solid element	Plastics	29

Commonly Used Material Models For Plastics

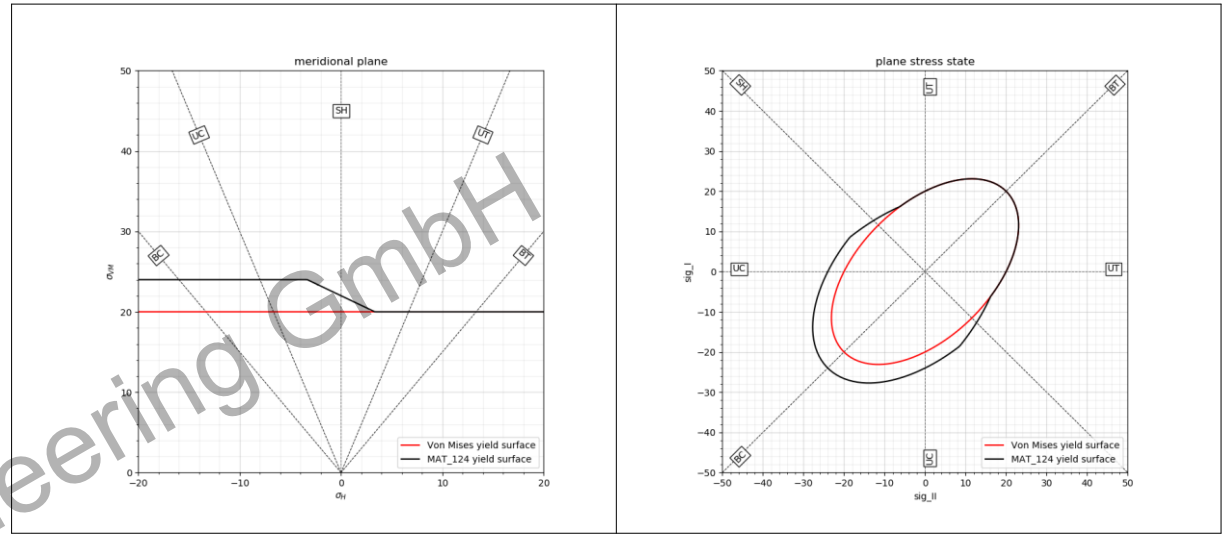
- ****MAT_024*** **- *The workhorse***
  (MAT_081*, **MAT_089*, **MAT_123*, …)**



Material model	yield surface	Visco-elasticity	Visco-plasticity	Comp./tension asymmetry	plastic Poisson's ratio
***MAT_024**	von Mises	✘	✓	✘	0.5

Commonly Used Material Models For Plastics

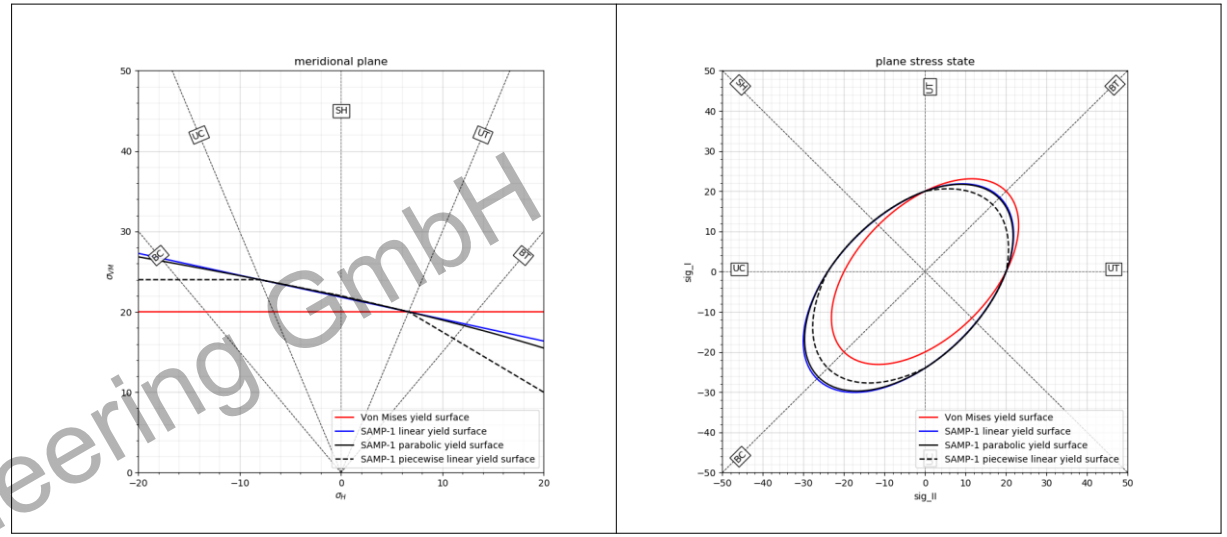
- ***MAT_024** - **The workhorse***
  (***MAT_081**, **MAT_089**, **MAT_123**, …)*
- ***MAT_124** - **The hidden***



Material model	yield surface	Visco-elasticity	Visco-plasticity	Comp./tension asymmetry	plastic Poisson's ratio
***MAT_024**	von Mises	✘	✓	✘	0.5
***MAT_124**	2x von Mises	✓ Pronyseries	✓	✓	0.5

Commonly Used Material Models For Plastics

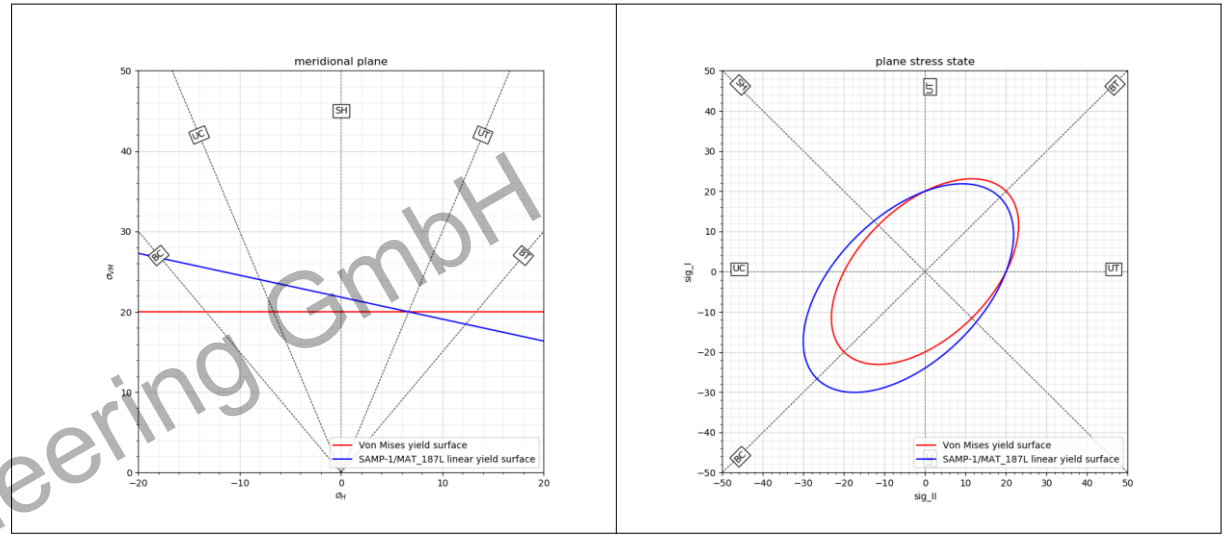
- ***MAT_024** - The workhorse*
  (***MAT_081**, **MAT_089**, **MAT_123**, …)*
- ***MAT_124** - The hidden*
- ***MAT_187** - The plastic expert*



Material model	yield surface	Visco-elasticity	Visco-plasticity	Comp./tension asymmetry	plastic Poisson's ratio
***MAT_024**	von Mises	✗	✓	✗	0.5
***MAT_124**	2x von Mises	✓ Pronyseries	✓	✓	0.5
***MAT_187**	linear; parabolic; piecewise linear	✓ $E(\dot{\varepsilon})$	✓	✓	✓ $\nu_p(\varepsilon)$

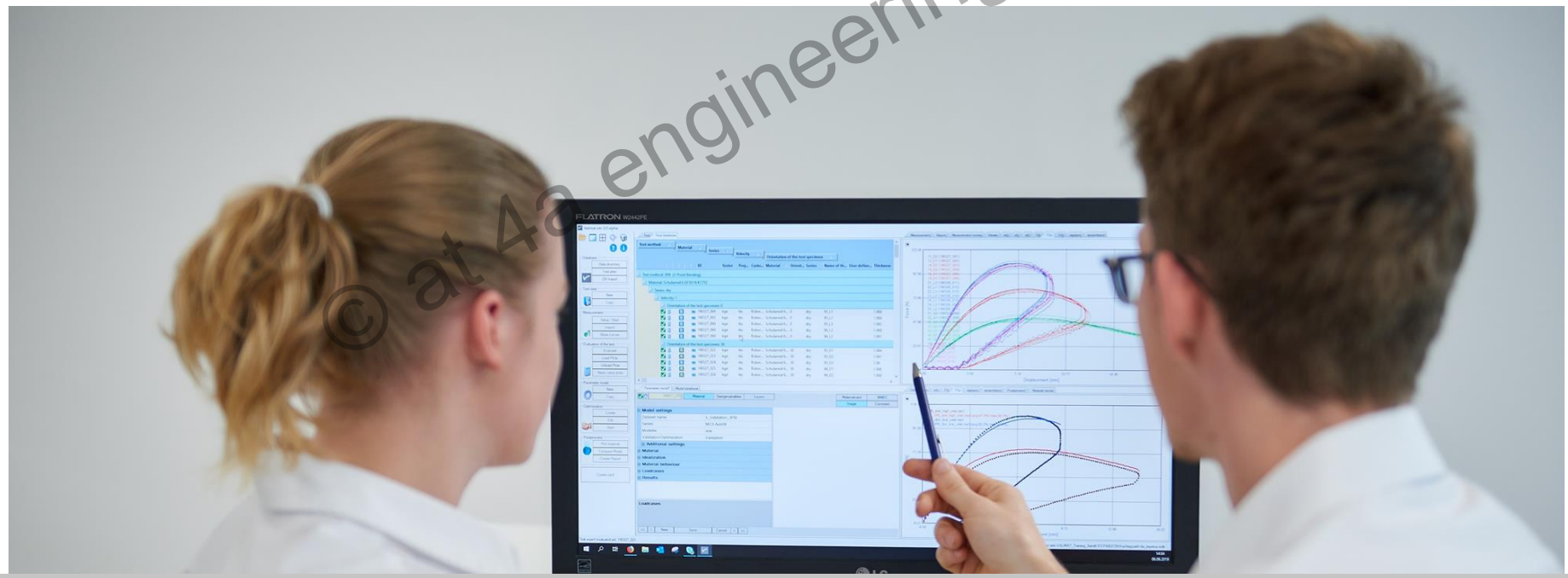
Commonly Used Material Models For Plastics

- ***MAT_024** - The workhorse*
  (***MAT_081**, **MAT_089**, **MAT_123**, …)*
- ***MAT_124** - The hidden*
- ***MAT_187** - The plastic expert*
- ***MAT_187L** – efficient version (R12)*



Material model	yield surface	Visco-elasticity	Visco-plasticity	Comp./tension asymmetry	plastic Poisson's ratio
***MAT_024**	von Mises	✗	✓	✗	0.5
***MAT_124**	2x von Mises	✓ Pronyseries	✓	✓	0.5
***MAT_187**	linear; parabolic; piecewise linear	✓ $E(\dot{\varepsilon})$	✓	✓	✓ $\nu_p(\varepsilon)$
***MAT_187L**	linear	✓ $E(\dot{\varepsilon})$	✓	✓	✓ $\nu_p(\varepsilon)$

*MAT_024 Summary



*MAT_024 introduction

VALIMAT

MAT_024 (*MAT_PIECEWISE_LINEAR_PLASTICITY) is the most commonly used material card for crash simulations in LS-DYNA.

- It is an elastic, viscoplastic material model
  - Von Mises yield surface
  - associated flow rule
- hardening curves can be defined arbitrarily for selected strain rates
- interpolation between the hardening curves of different strain rates can be performed either linear or logarithmic

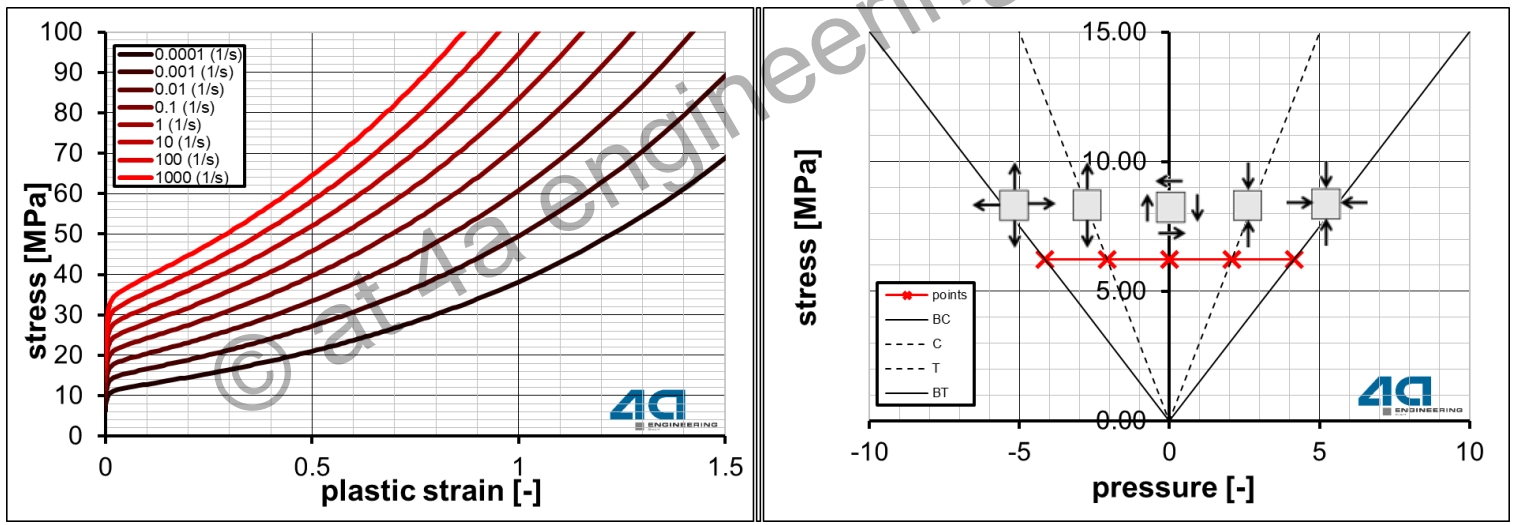
more information:

- "LS-DYNA_Manual_Volume_II_R11.pdf"

*MAT_024 introduction

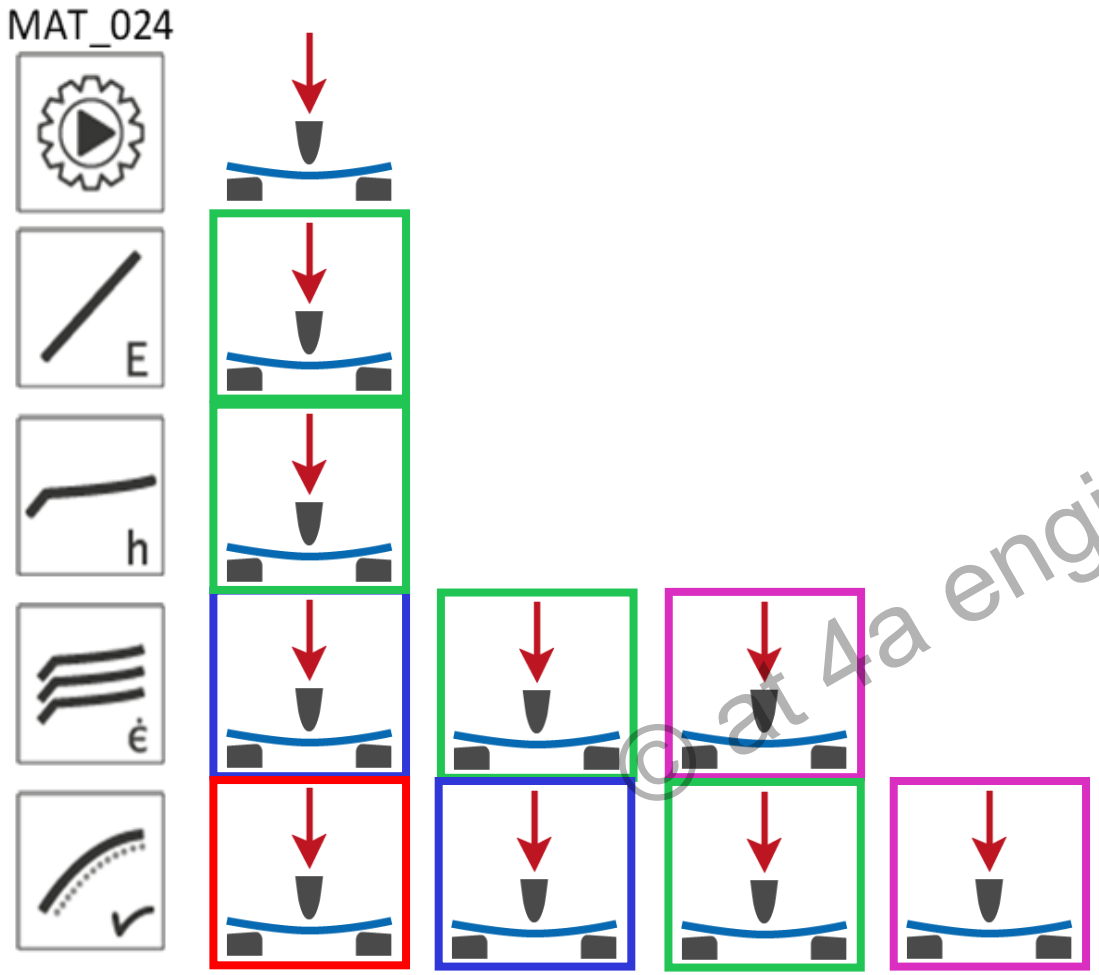
material card overview

- ***Material:*** PPEG107HP
- ***MAT_024** material card:
  - Deformation: elastic, viscoplastic
  - Von Mises yield surface
  - associated flow rule ➔ plastic deformation at constant volume

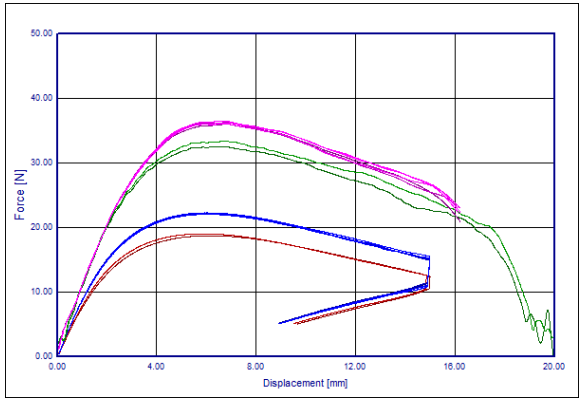


AutoFit

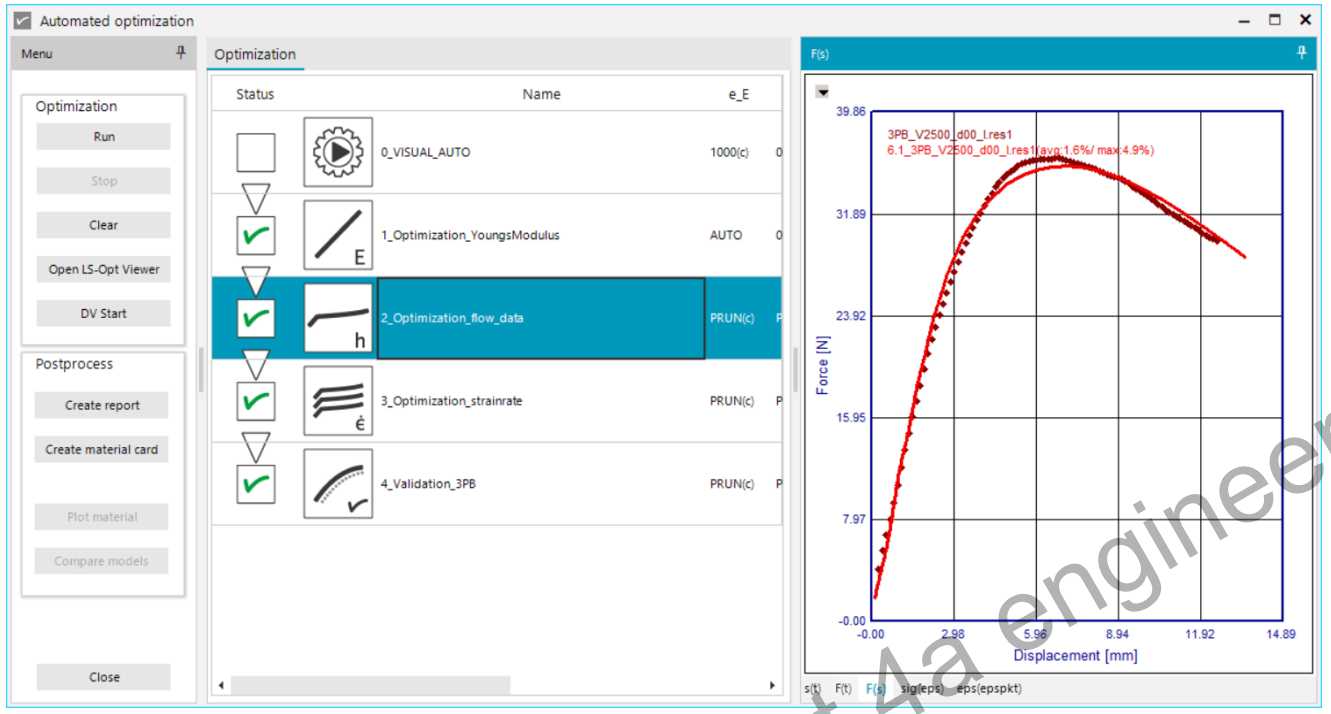
Strategy



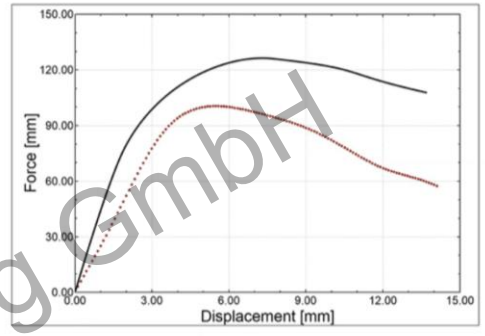
without border all velocities
quasistatic low velocity
quasistatic high velocity
dynamic low velocity
dynamic medium velocity

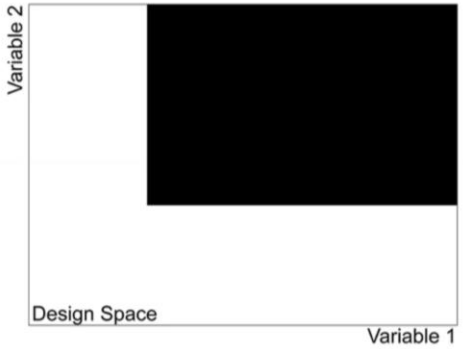


Workflow for Material Card Generation - AUTOFIT

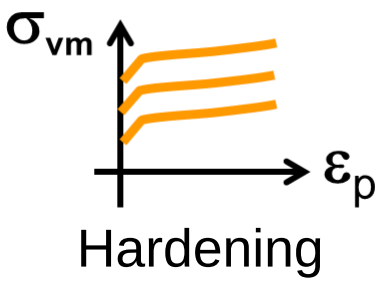


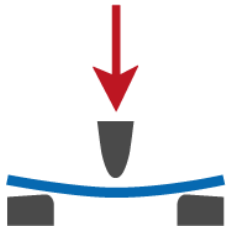
optimization – successive response surface method





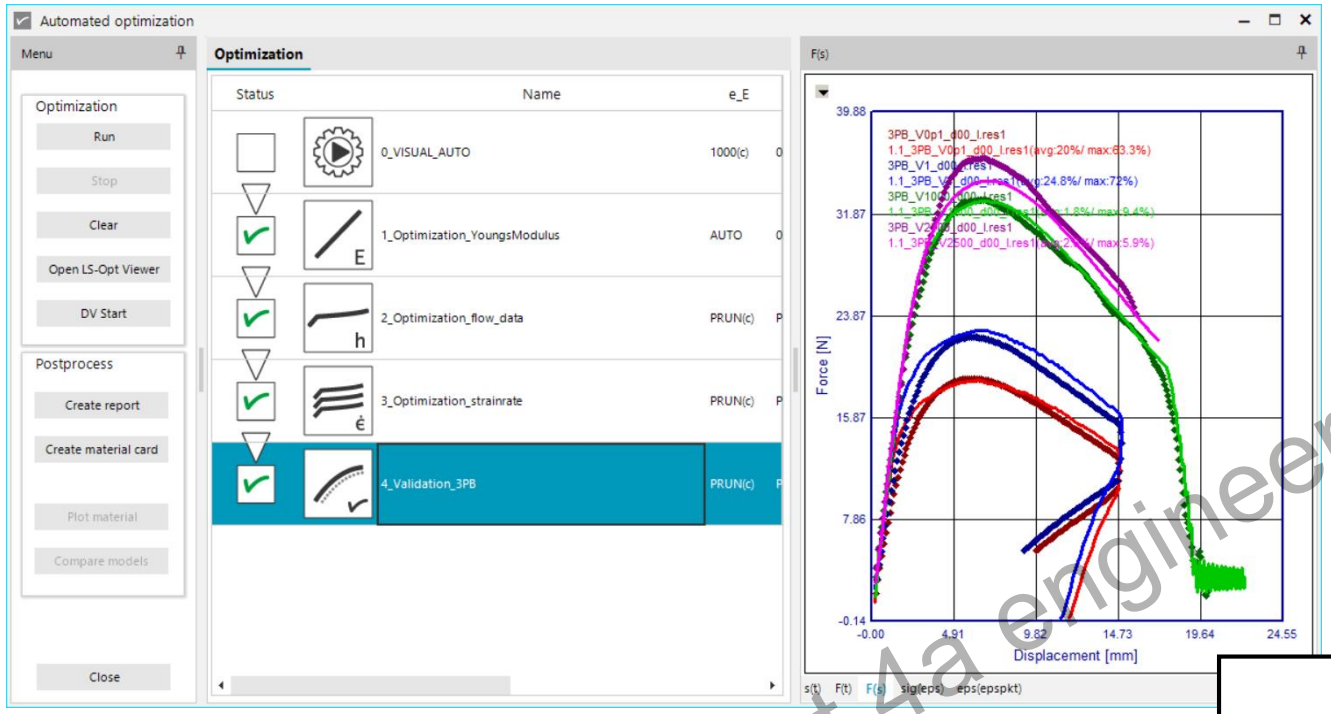
$$hardening\ function = f(Variable\ 1, Variable\ 2)$$

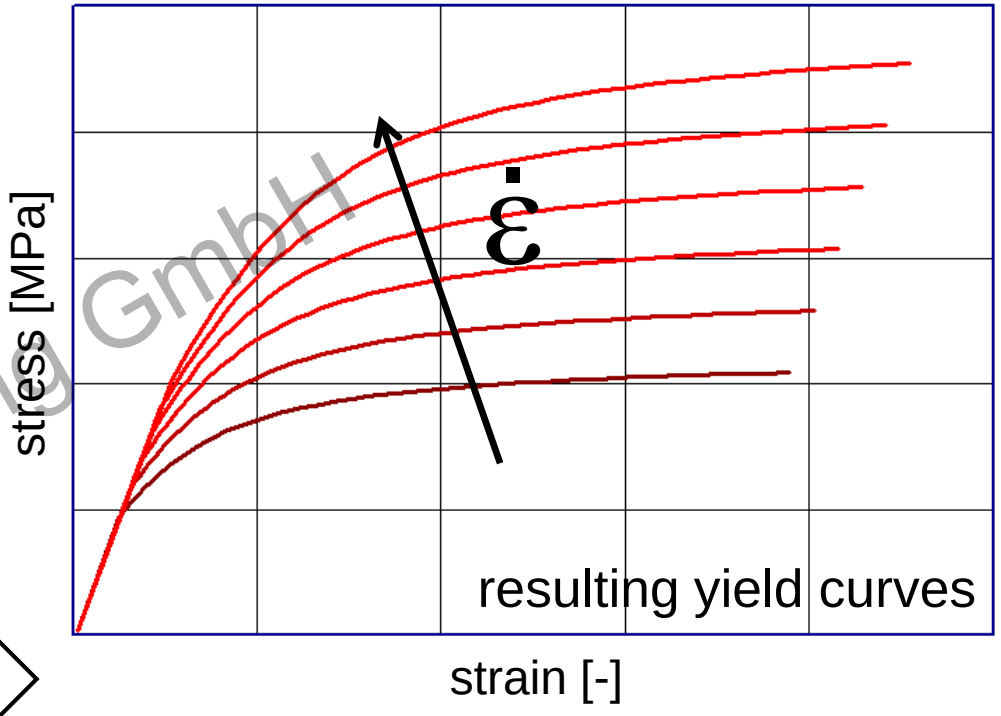


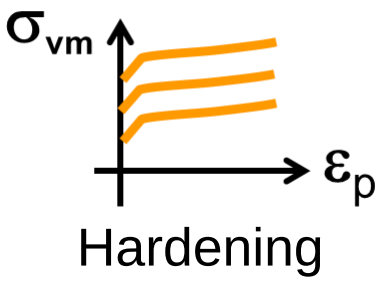


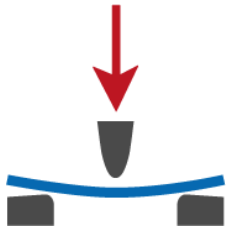
[redacted]

Workflow for Material Card Generation - AUTOFIT

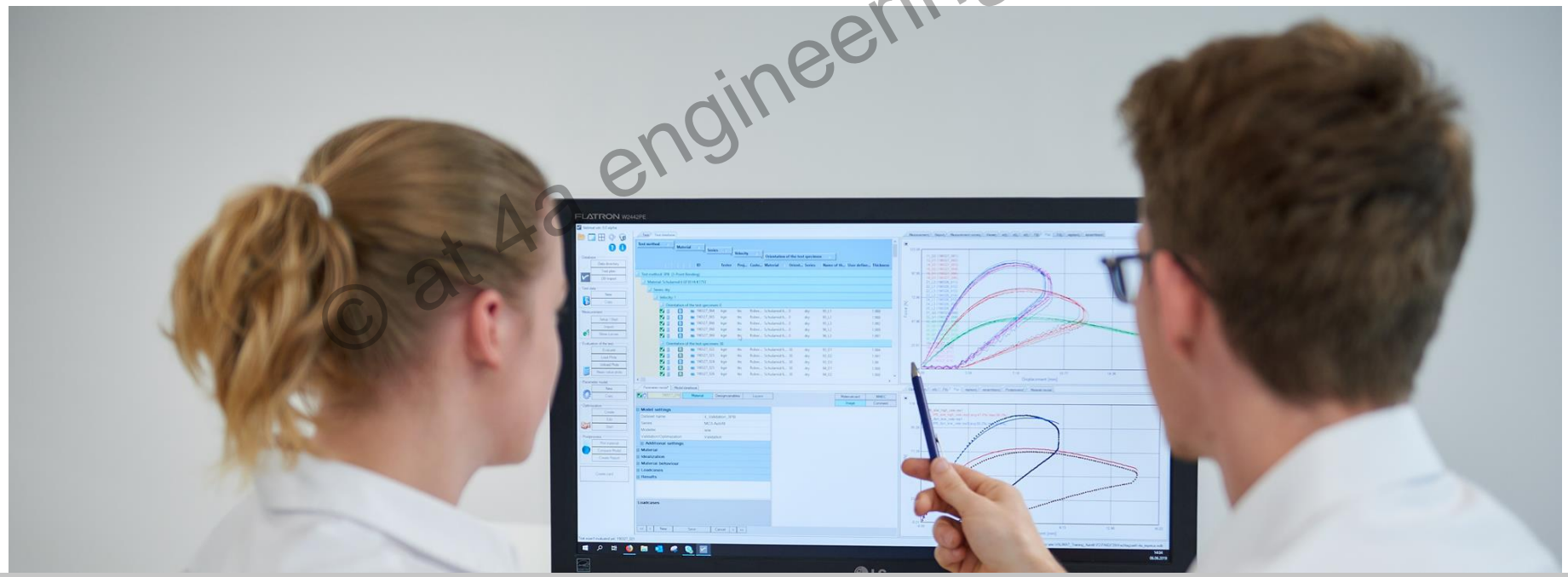




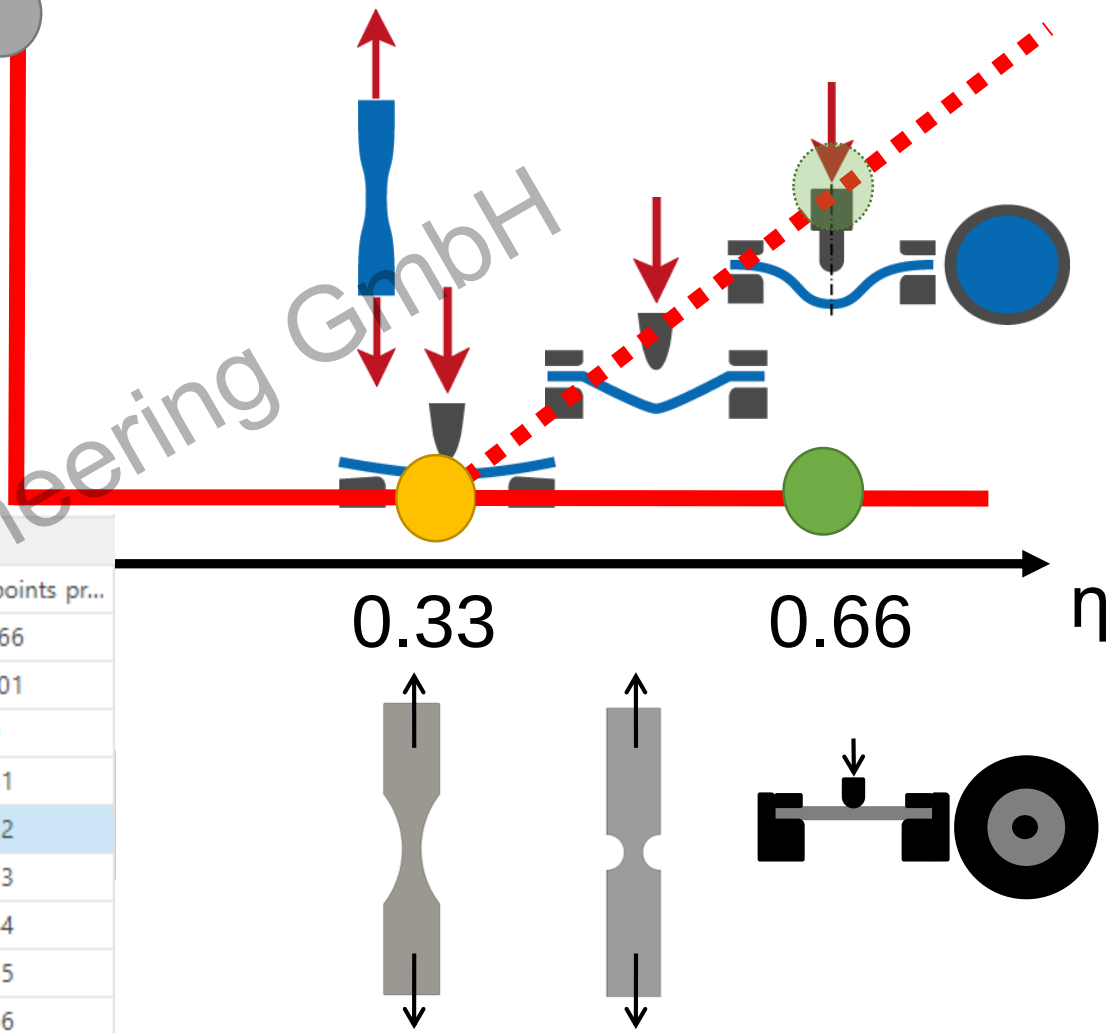




Simple Failure



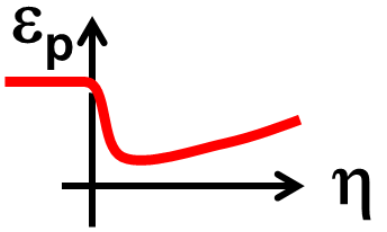
From test to material card



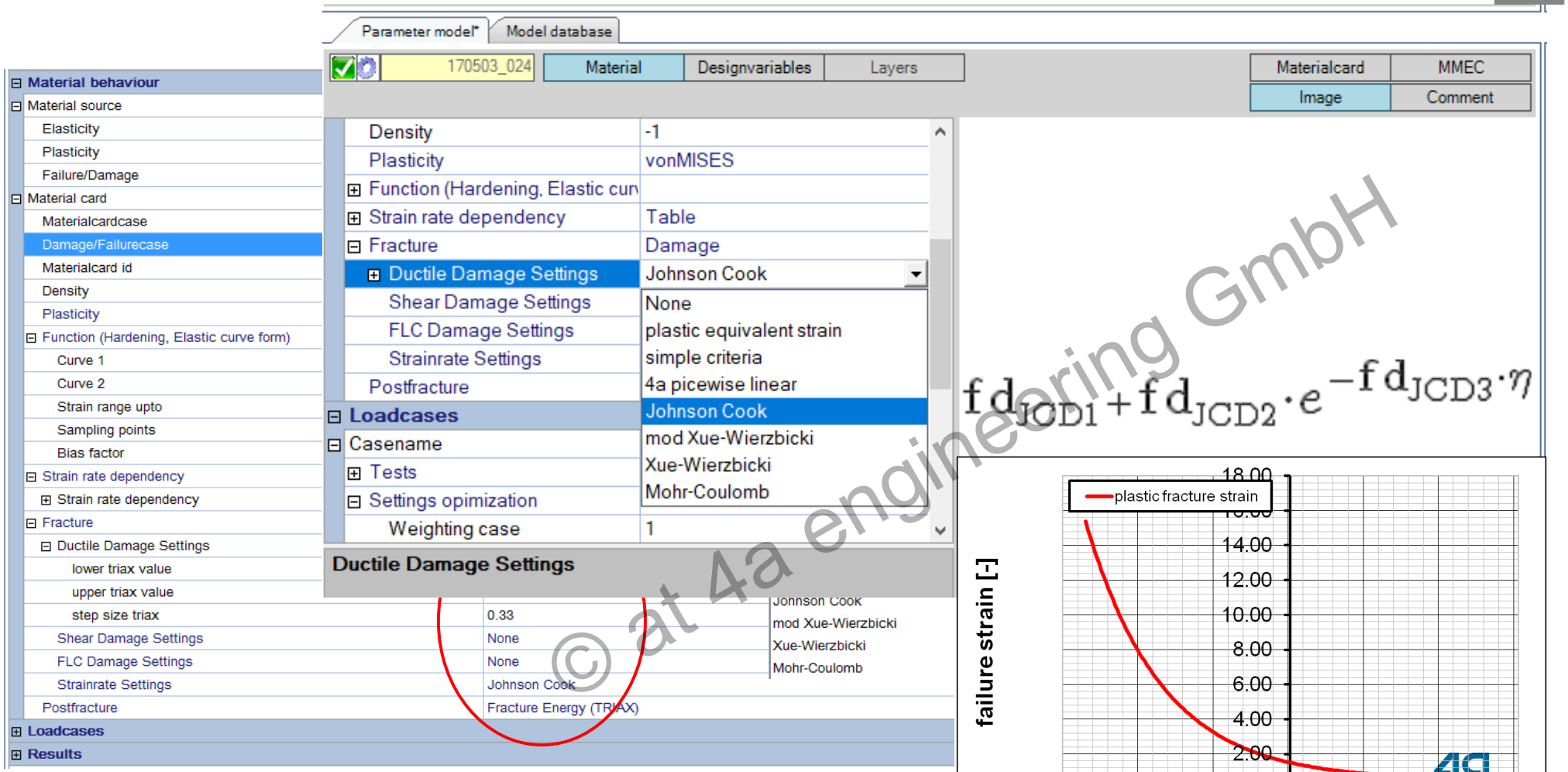
▲	GroupName: 51_failure							
	xf_NUMFIP	-75	☑	(NULL)	(NULL)	(NULL)		Number of failed integration points pr...
●	fd_FC_m0p66	2	☑	0.1	1	(NULL)		Failure curve point at TRIAX -0.66
●	fd_FC_m0p01	2	☑	0.1	1	(NULL)		Failure curve point at TRIAX -0.01
	fd_FC_0p0	0.4	☑	0.8	1.3	(NULL)	=fd_F...	Failure curve point at TRIAX 0.0
	fd_FC_0p11	0.4	☑	0.8	1.3	(NULL)	=fd_F...	Failure curve point at TRIAX 0.11
	fd_FC_0p22	0.4	☑	0.8	1.3	(NULL)	=fd_F...	Failure curve point at TRIAX 0.22
●	fd_FC_0p33	0.4	☐	10%	10%	(NULL)		Failure curve point at TRIAX 0.33
	fd_FC_0p44	0.4	☑	0.8	1.3	(NULL)	=(fd_F...	Failure curve point at TRIAX 0.44
	fd_FC_0p55	0.4	☑	0.1	1	(NULL)	=(fd_F...	Failure curve point at TRIAX 0.55
●	fd_FC_0p66	0.4	☑	0.1	1	(NULL)		Failure curve point at TRIAX 0.66
▲	GroupName: 52_failurestrainrate							

Fracture models → **MAT_ADD_EROSION*

VALIMAT

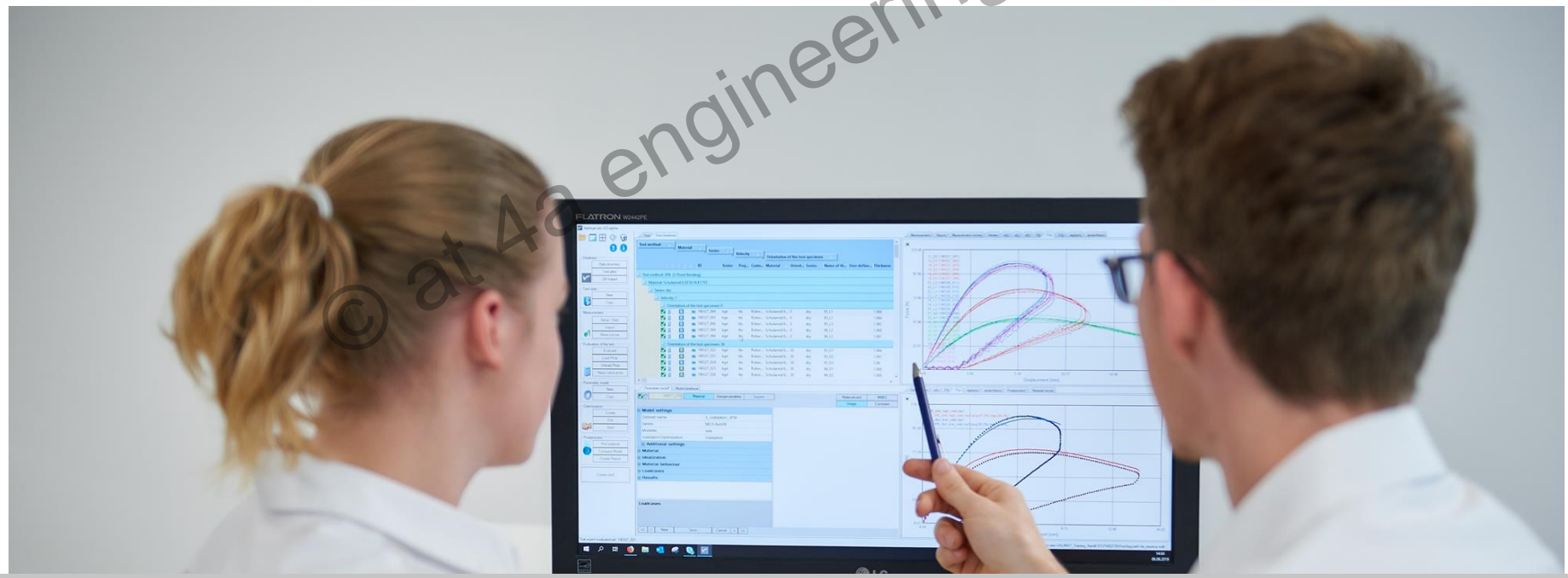


Damage/Failure



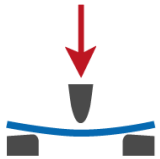
$$fd_{JCD1} + fd_{JCD2} \cdot e^{-fd_{JCD3} \cdot \eta}$$

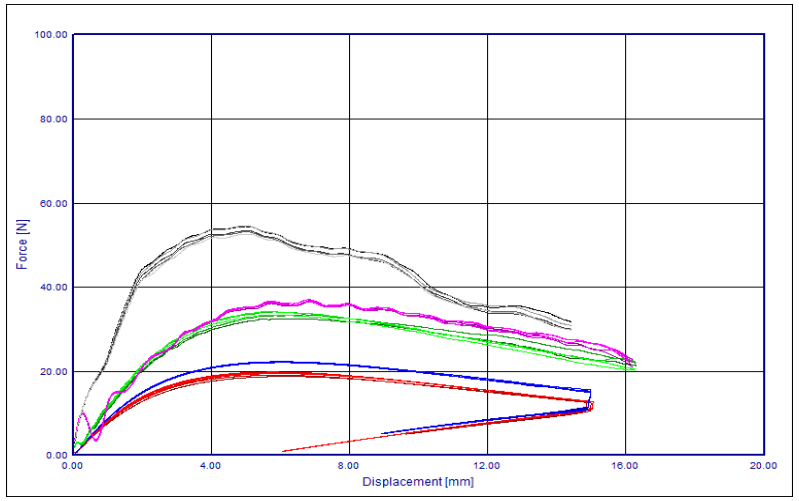
Autoreport

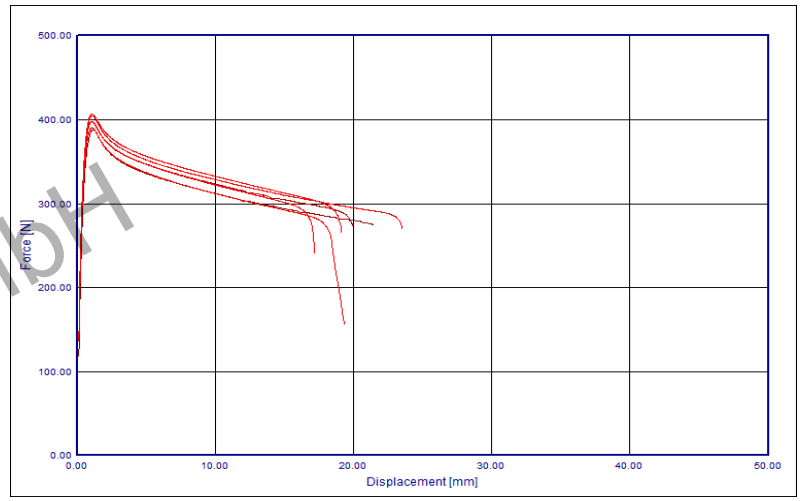


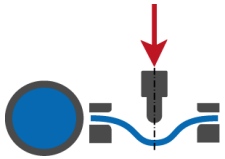
Measurement results, 23°C, PPEG107HP

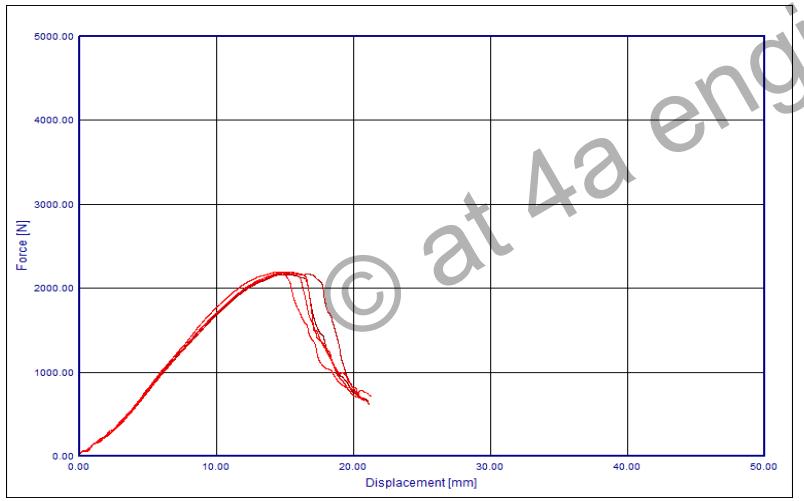
overview

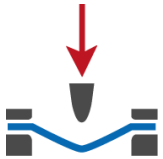


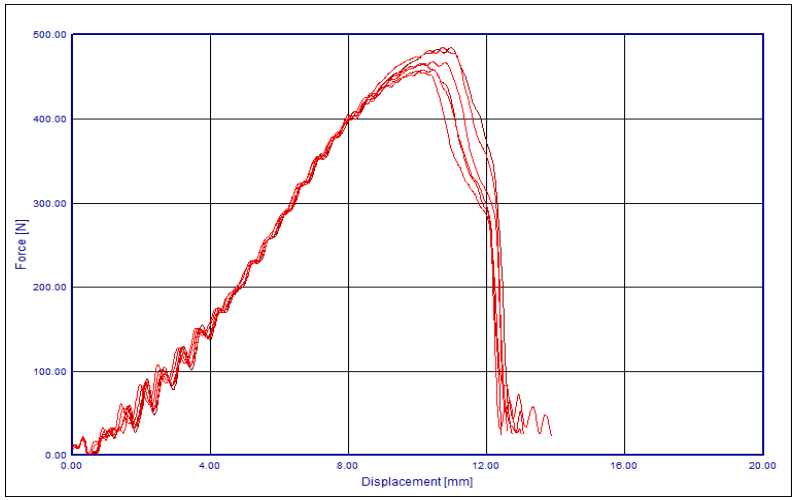






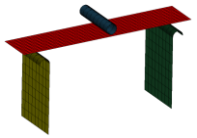


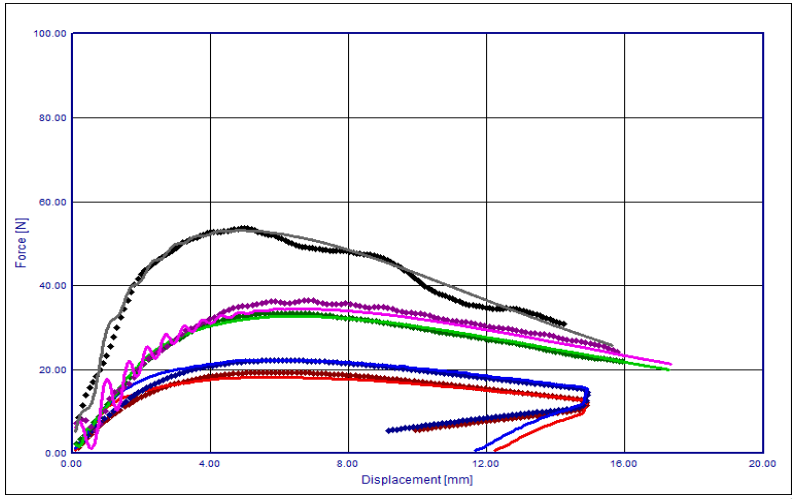


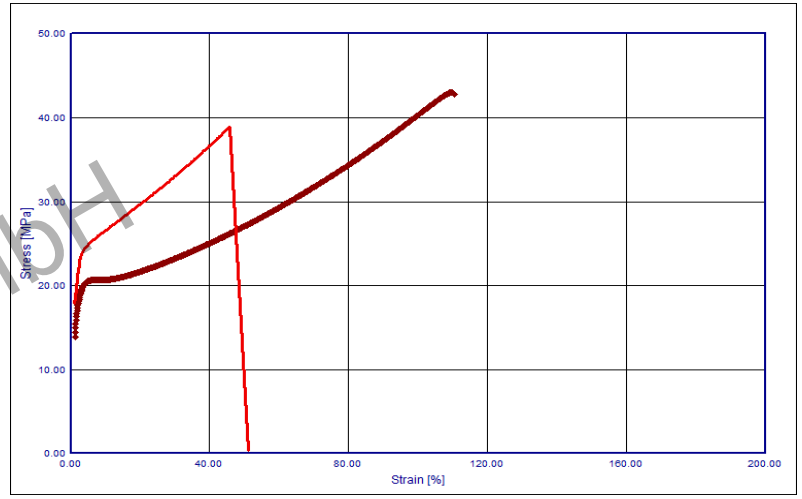


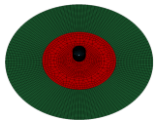
Validation results, 23°C, PPEG107HP

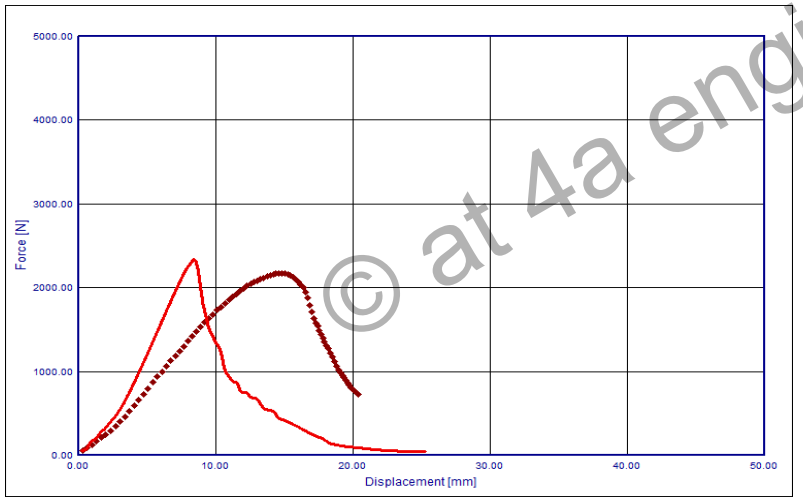
overview

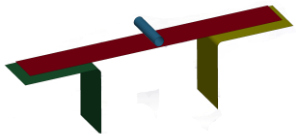


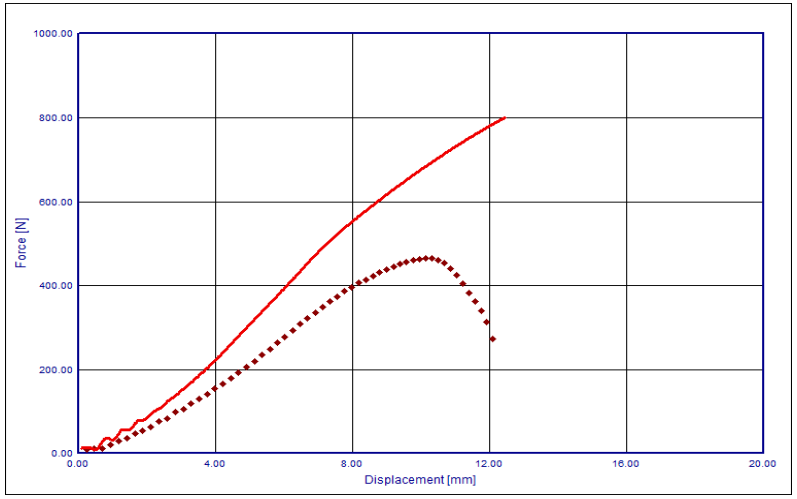












VALIMAT® 3.8

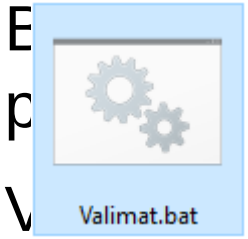
upcoming features

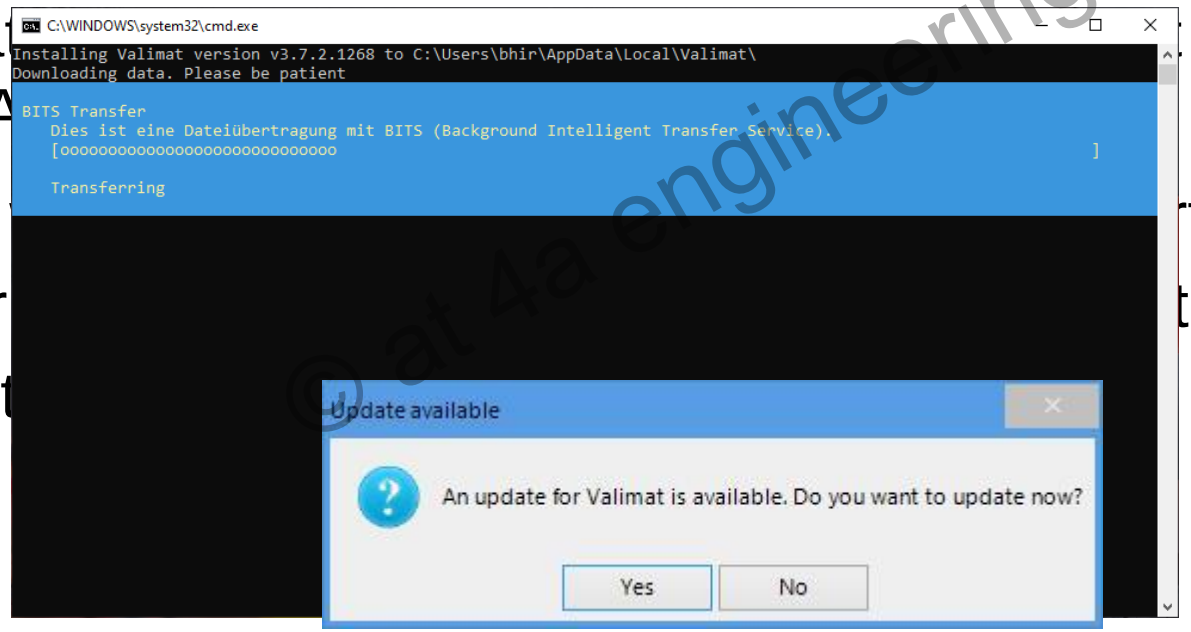
Content

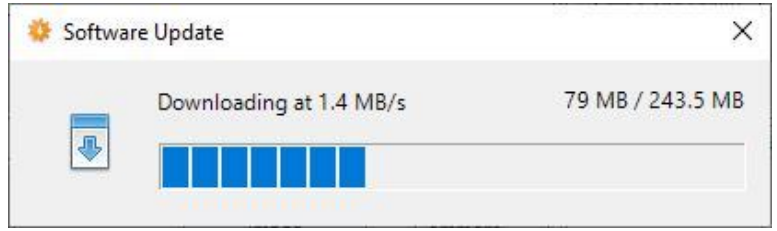
- New Software Installation and Automated Updates
- Included Python 3.8 with VALIMAT Python Module
- New Auto Report Features
- AutoFit Failure Parameter Evaluation
- Quick Filter Shortcut
- Reload Parameter Model Button
- Network changed warning
- Added non-scaled graphing on time-scaled simulations

VALIMAT® 3.8 - new Software installation and automated updates

- 4a will provide a batch script for the users
- This batch script is used to start the software and to install it (ex. place on desktop)
- Upon first call the installation of VALIMAT® starts.
  - installation directory: “C:\Users\username\AppData\Local\Valimat”
- E… tha… closes and that the start up p… VA…
- V… T® …rtup
  - the user … talled
  - If accept…

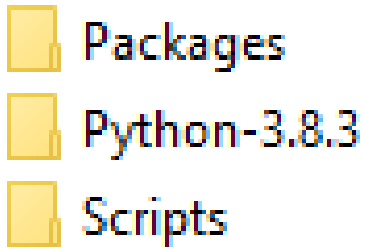






VALIMAT® 3.8 - Included Python 3.8 with VALIMAT python module

- VALIMAT installs with a Python 3 version
  - Located in C:\Users\username\AppData\Local\Valimat\Python
- There we have:
  - Packages: containing modules
  - Python-3.8.3: containing the python executable
  - Scripts: containing Internal Scripts and Test and Modell Scripts



- For better database access a python module “VALIMAT” is included.

VALIMAT® 3.8 – New Auto Report Features

- Auto Reporting Feature greatly enhanced.
- Allows indexing other model curves and data
  - In Tables: <<case_1;index:1>> or <<case_2;index_r:-1>>
  - In Textboxes: <<db_va;index:1>> or <<db_va;index_r:-1>>
  - In Images: <<img_tc_F(s);index:1>> or <<img_tc_F(s);index_r:-1>>
- Access to DV in Reports:
  - <<DV_e_E>>
- Formating the output
  - fx: Fixed number of decimal values (e.g. <<DV_e_E;f3>> yields 2341.342)
- Current Date
  - <<Date;Format>> (For detailed information about the possible values of “Format” see link1)

simulation results, <<db_mattyp>>, <<db_T_case_1>>°C

<<Date;d>>

AutoFit overview – MAT_024

<<img_tc_F(s);0;auto;0;auto;legend_off>>

<<img_sc_F(s);0;auto;0;auto;legend_off;index:2;0>>

<<img_sc_F(s);0;auto;0;auto;legend_off;index:3>>

<<img_sc_F(s);0;auto;0;auto;legend_off;index:4>>

<<img_sc_F(s);0;auto;0;auto;legend_off;index:5>>

Case	v_0 [m/s]	l_w [mm]	$m_{Pendulum}$ [g]
<<case_1;index:5>>	<<db_va>>	<<db_lw>>	<<db_mp>>
<<case_2;index:5>>			
<<case_3;index:5>>			
<<case_4;index:5>>			
<<case_5;index:5>>			

e_E e_nue

<<DV_e_E;f0;index:2>> <<DV_e_nue;f2;index:2>>

h_y h_h h_ET v_p v_epspkt

<<DV_e_E;f0;index:3>> <<DV_e_nue;f2;index:3>> <<DV_h_y;f2;index:3>>
<<DV_h_h;f2;index:3>> <<DV_h_ET;f0;index:3>> <<DV_v_p;f2;index:3>>
<<DV_v_epspkt;index:3>>

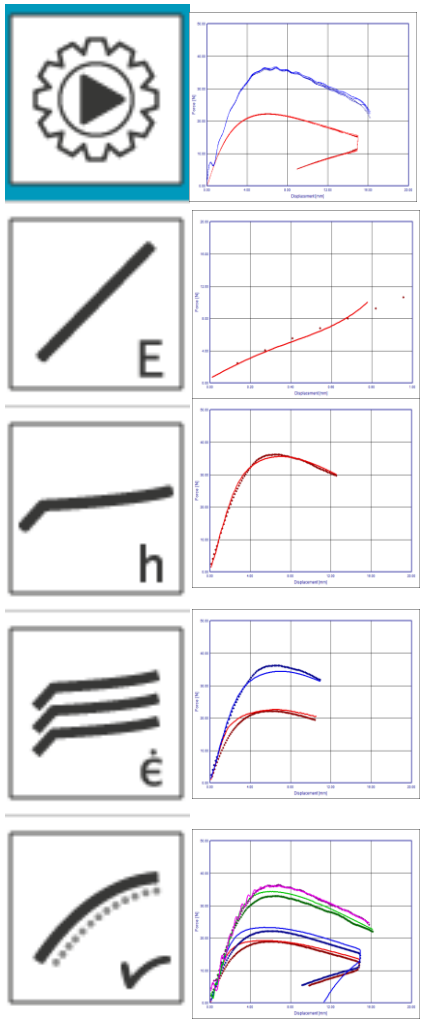
<<DV_e_E;f0;index:4>> <<DV_e_nue;f2;index:4>> <<DV_h_y;f2;index:4>>
<<DV_h_h;f2;index:4>> <<DV_h_ET;f0;index:4>> <<DV_v_p;f2;index:4>>
<<DV_v_epspkt;index:4>>

<<DV_e_E;f0;index:5>> <<DV_e_nue;f2;index:5>> <<DV_h_y;f2;index:5>>
<<DV_h_h;f2;index:5>> <<DV_h_ET;f0;index:5>> <<DV_v_p;f2;index:5>>
<<DV_v_epspkt;index:5>>

simulation results, PPEG107HP, 23°C

AutoFit overview – MAT_024

09.07.2020



e_E	e_nue
2193	0.30

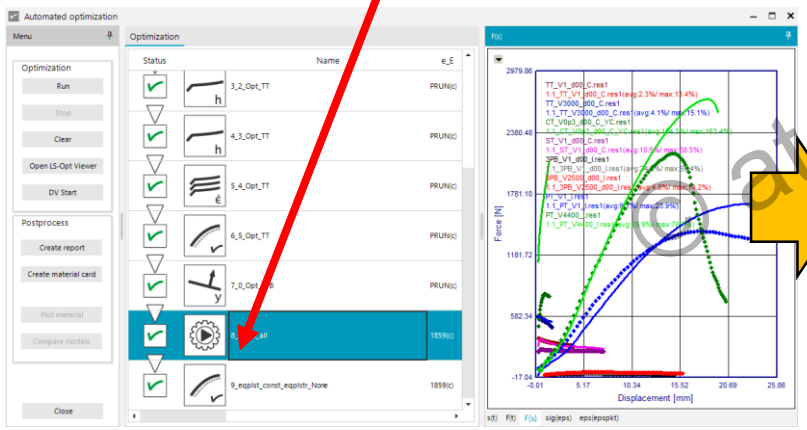
		h_y	h_h	h_ET	v_p	v_epspkt
2193	0.30	10.61	3.48	1096	7.89	0.0001
2193	0.30	10.61	3.48	1096	8.46	0.0001
2193	0.30	10.61	3.48	1096	8.46	0.0001

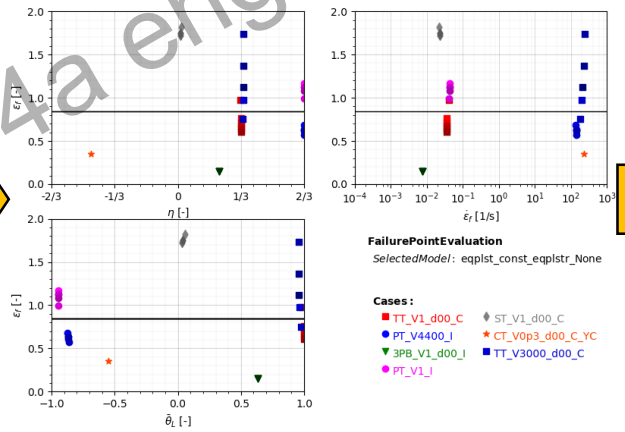
Case	v_0 [m/s]	l_w [mm]	$m_{Pendulum}$ [g]
3PB_V0p1_d00_l	0.0001	40.01	0
3PB_V1_d00_l	0.001	40.01	0
3PB_V1000_d00_l	1	40.01	1580
3PB_V2500_d00_l	2.5	40.01	1580

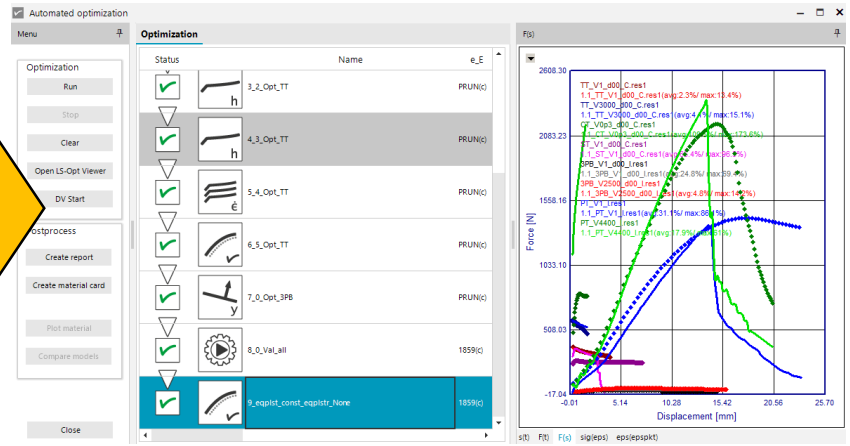
VALIMAT® 3.8 – AutoFit Failure Parameter Evaluation

- Added a Model setting for the AutoFit which evaluates failure model parameters on the model results
- The evaluated parameters are available for all following models in the AutoFit

Model settings	
Dataset name	8_0_Val_all
Series	TT_based_AutoFit_MAT_187
Modeller	bhir
Validation/Optimization	Failure evaluation

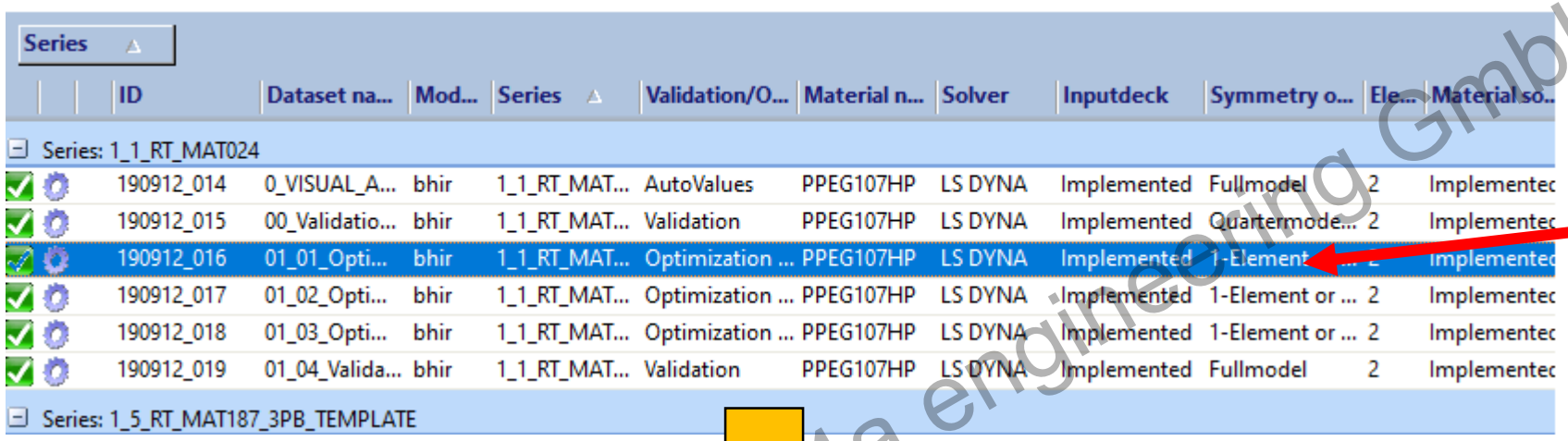


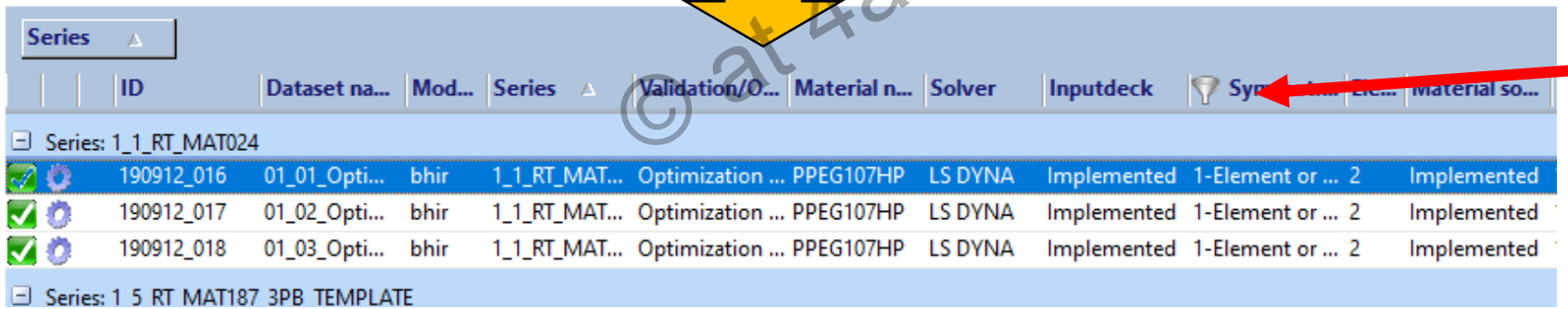


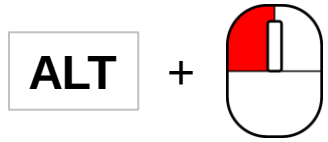


VALIMAT® 3.8 - Quick Filter Shortcut

- A Filter can be added by pressing **ALT+LMB** on an element in the table
- For example: select only 1-Element or more complex in Symmetry



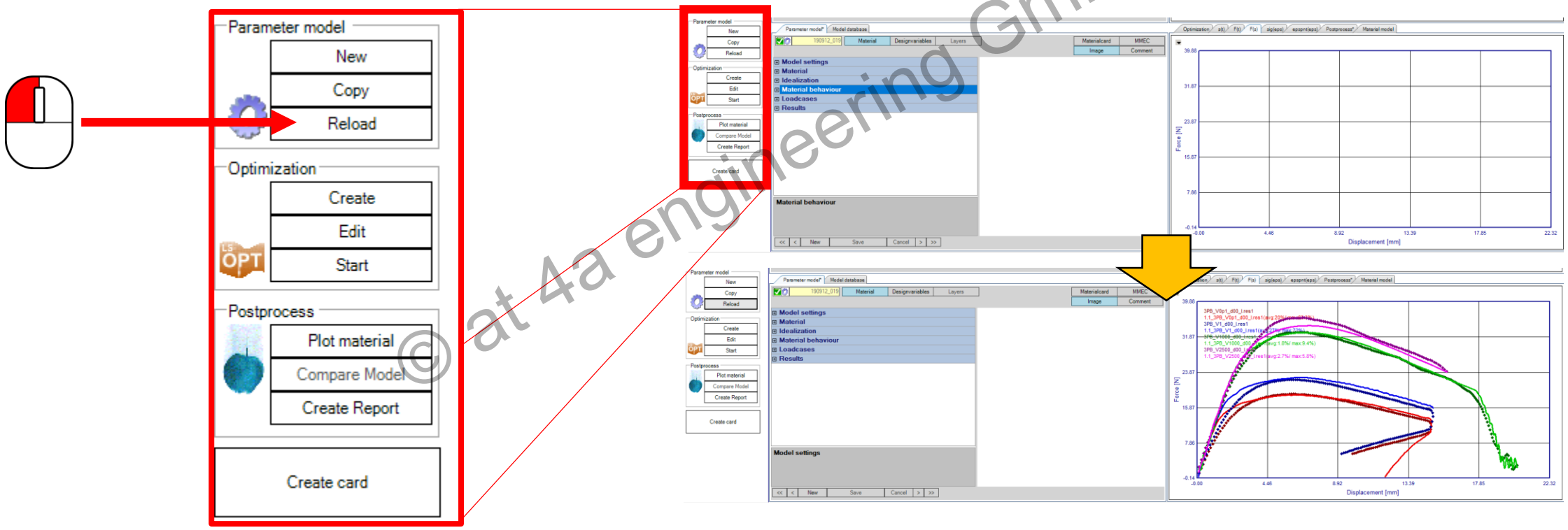




added Filter

VALIMAT® 3.8 - Reload Parameter Model Button

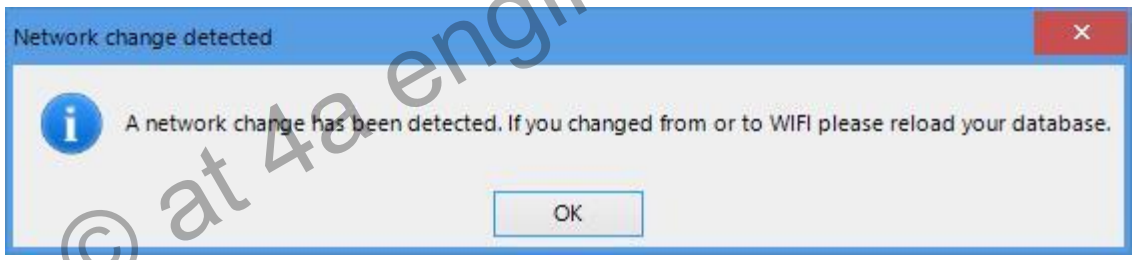
- Reloading the Model can now be done through the new Reload Button located in the Parameter model side view
- Example usage: cleared all curves ➔ want the model results displayed again



VALIMAT® 3.8 - Network changed warning

- In **some cases** if the user changes the network with a running instance of VALIMAT® and an open database on a **network drive**, the database **could be corrupted**.

- To avoid this VALIMAT now gives a warning message if the network is changed and **recommends to reopen** the database.

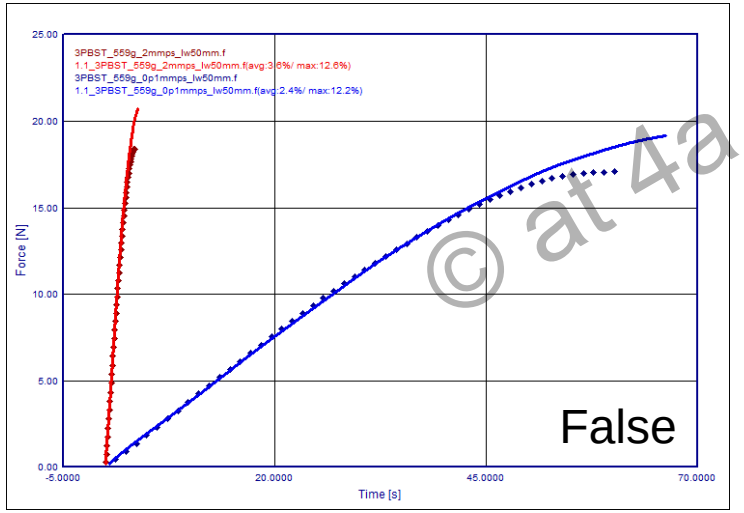


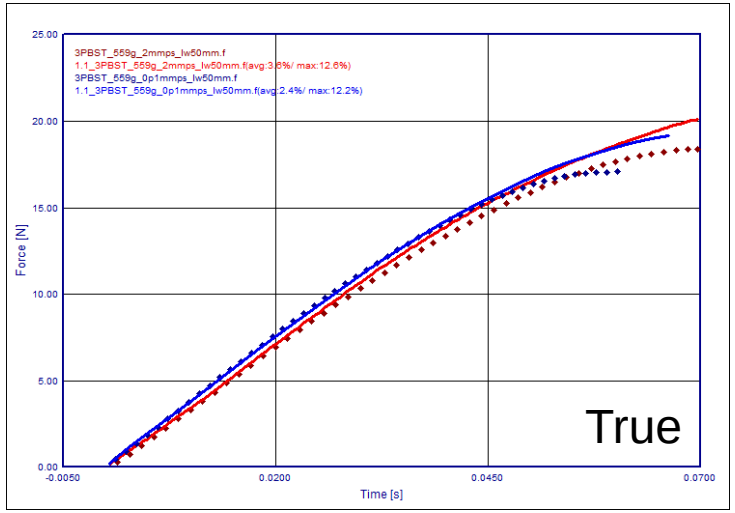
VALIMAT® 3.8 - Added non-scaled graphing on time-scaled simulations

Feature to use the **simulation time** of time-scaled models instead of actual time in the **graph**

An **improper**, but convenient method to compare time curves of static and dynamic tests

⊟ **Postprocessing**	
Deviation	1
Number of animation plots	10
Trim resultcurves?	False
Plot resultcurves timescaled?	True
⊞ **Averaging**	True
⊞ **4a Solver Settings**	False
⊞ **Links/references**	



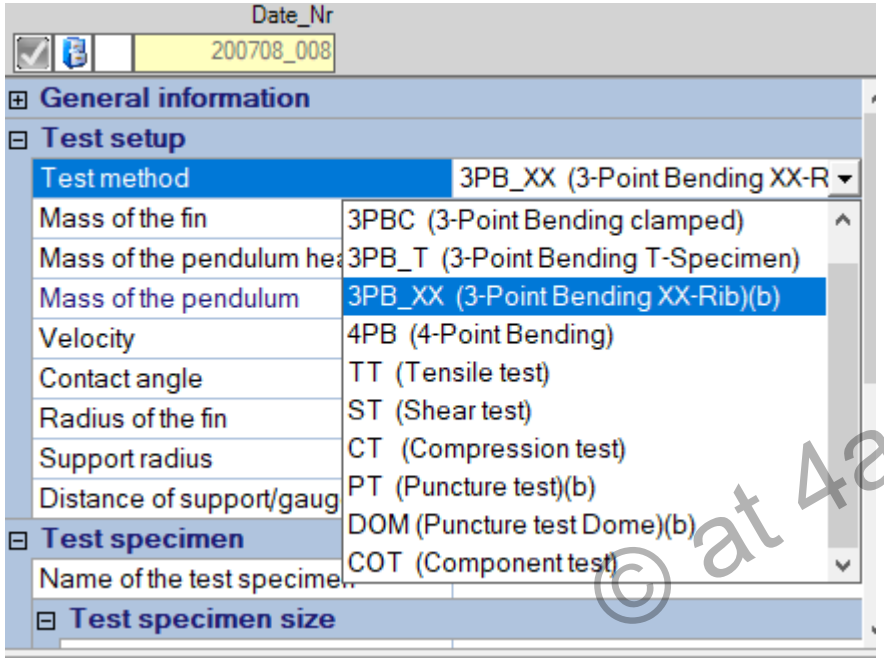


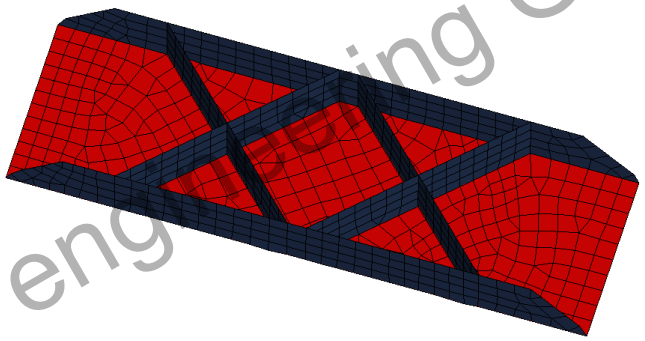
VALIMAT® 3.8 - Mesh Folder

- For the following test types the used mesh will be taken from the mesh folder in the VALIMAT directory
  - location: C:\Users\username\AppData\Local\Valimat\Mesh
- The subdirectories have the following structure:
  - Dome|Puncturetest|XX-Rib
    - ABAQUS|LSDYNA|PAMCRASH
      - HEX8|SHELL|TET4|TET10
        - sample_(elementsize)mm.inp
- Elementsize can be 0k5, 1, 2 or 4.

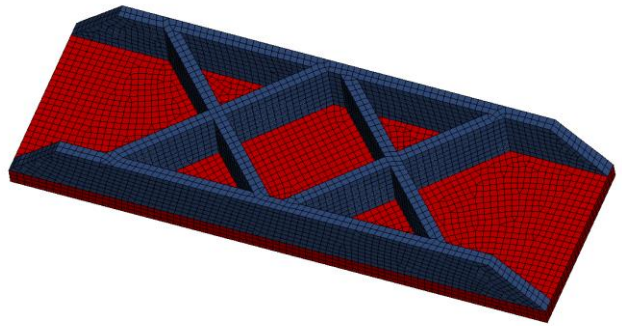
VALIMAT® 3.8 - New Test Type 3PB_XX

- The 3-point bending of the double XX rib reinforced specimen is included





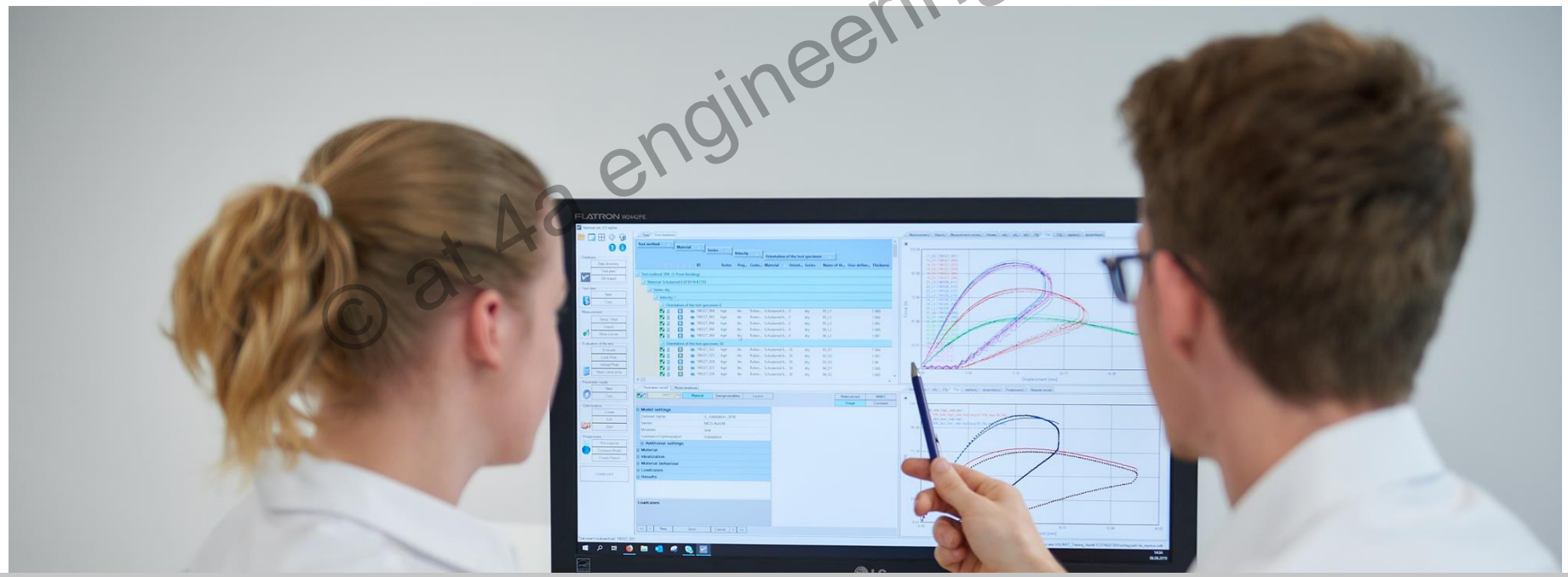
../ SHELL/sample_2mm.key



../HEX8/sample_0k5mm.key

VALIMAT

Outlook upcoming week
14.07. – 17.07.



Summer School

2nd week - Advanced topics

14. July - Evaluating and checking test data
interpretation of typical results

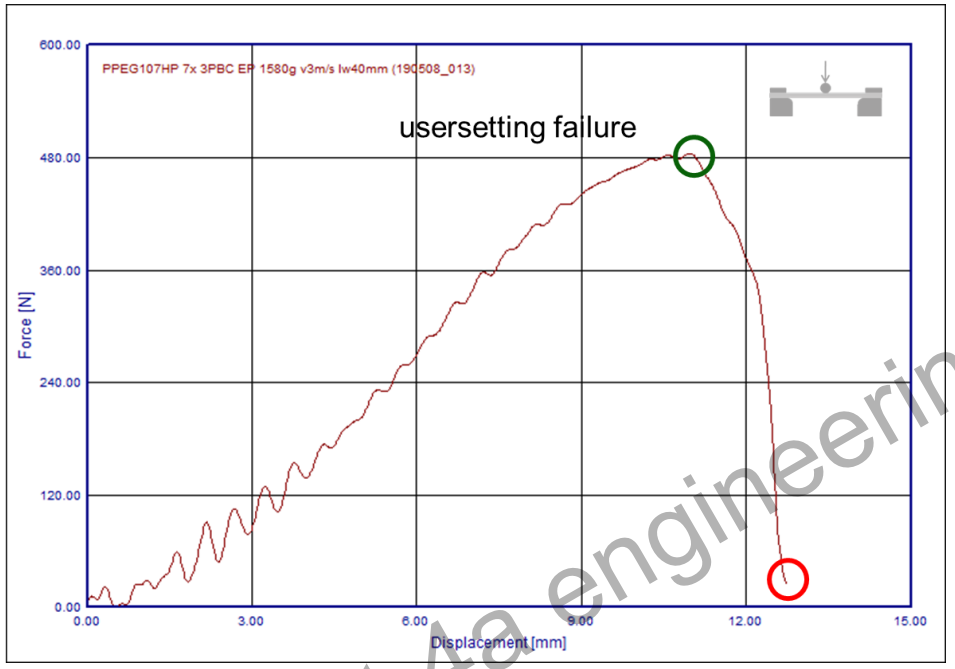
15. July - general yield surface (*MAT_187) and other material models,
failure approaches and comprehensive Autofit setup

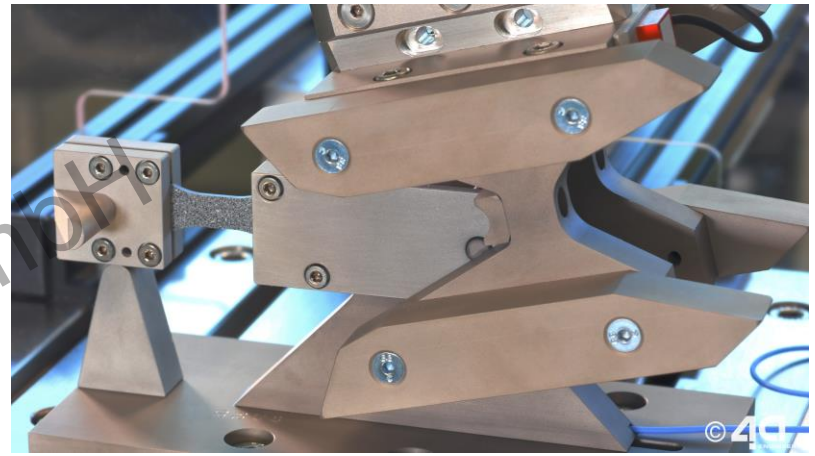
16. July - Fiber reinforced plastics and their modelling approach
an extensive guide

17. July - Python: a powerful tool with VALIMAT®,
user defined material cards/specimen

DAY 5 – 14th July 2020

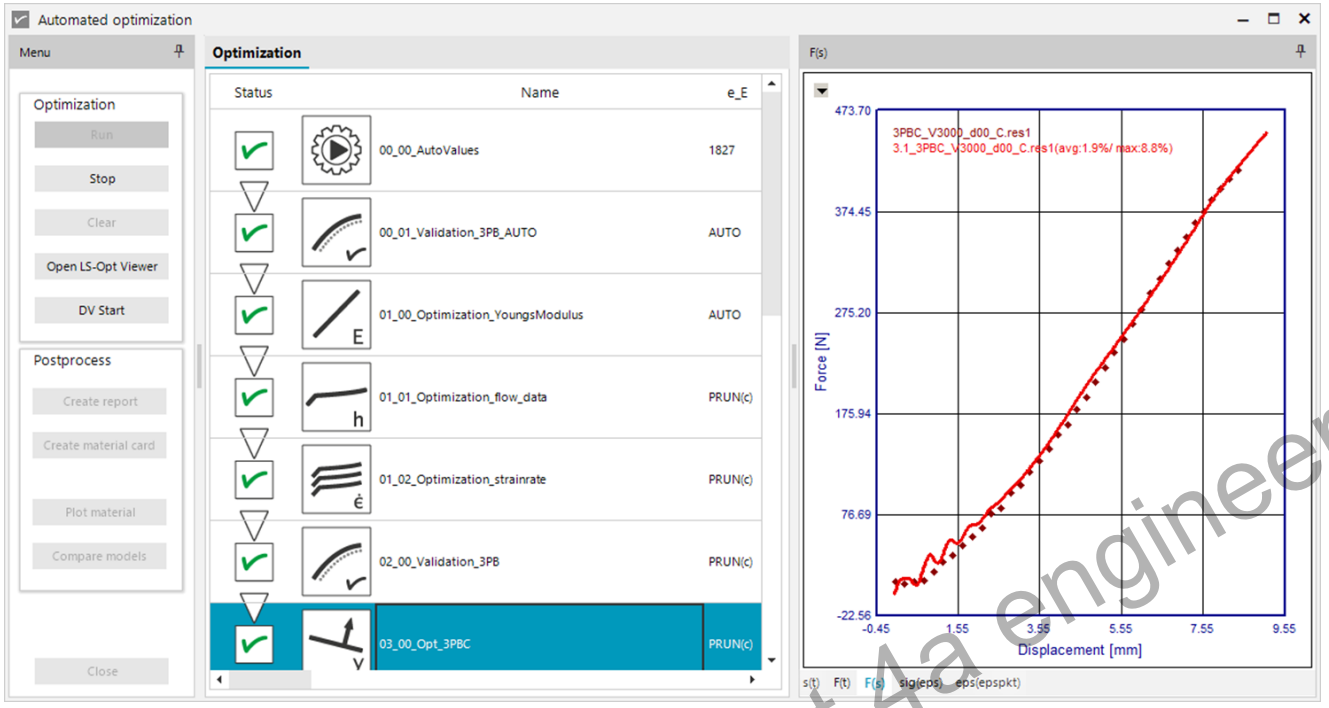
190508_013	
General information	
Test setup	
Test method	3PBC (3-Point Bending clamped)
Mass of the fin	104-SP16 3PB R2 steel
Mass of the pendulum head	128-EP16
Mass of the pendulum	1580
Velocity	3
Contact angle	0.59
Radius of the fin	2
Support radius	1
Distance of support/gauge length	40.02
Sensor SP	ASC 4211LN-400-0HB76 17-33677
Sensor Sup	ASC 4211LN-005-0HB76 15-17565
Test specimen	
Evaluation	
Filter	5 CFC SAE velocity optimum
Evaluation of displacement	Angle
Evaluation of the velocity	1 - Angle sensor
Zero-point evaluation	5 - Accelerationsignal (without filter)
Identification of failure	1 - automatic
tend	0.011793
tfail	0.011793
alphamax_ep	-5
alphamax_dp	-5
Ffail	0.05
tfailfac	10
Fperc	0.8
trecovfac	20
b_criterium	0
Stress evaluation	
Evaluation bending	No evaluation
Stiffness evaluation	
fperc_lo	0.1
fperc_up	0.3
Results	

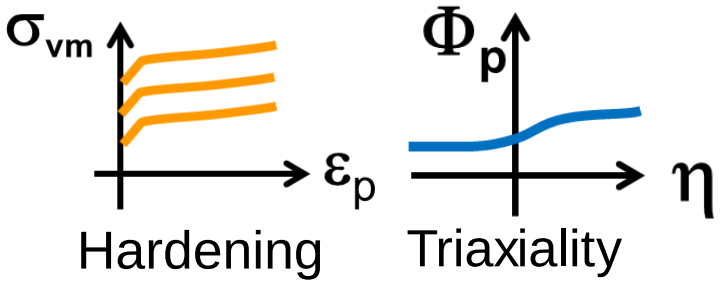


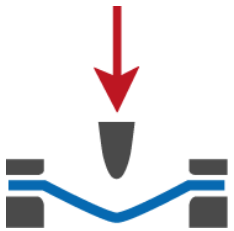


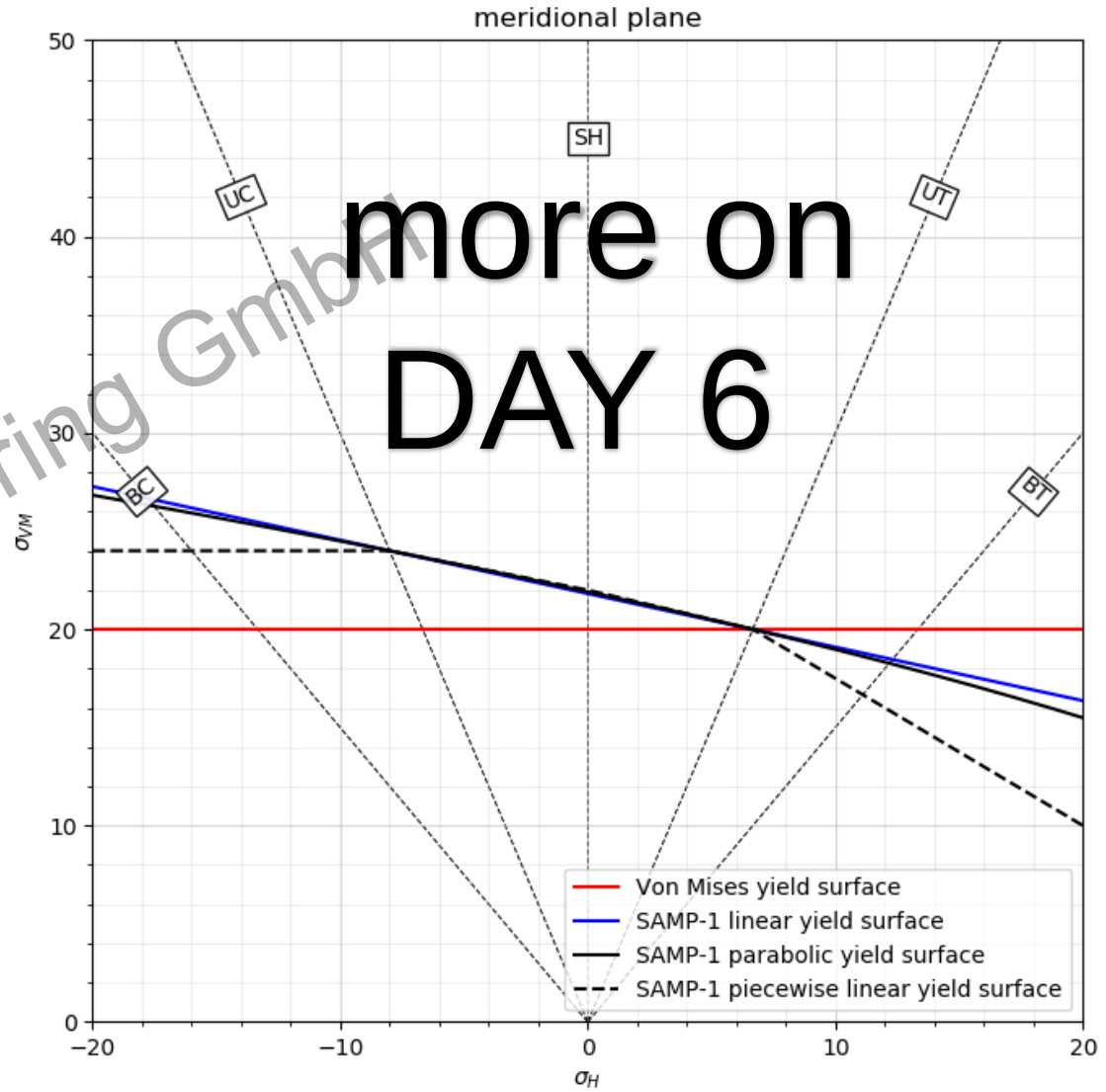
Evaluation methods and interpretation of typical test results

DAY 6 – 15th July 2020





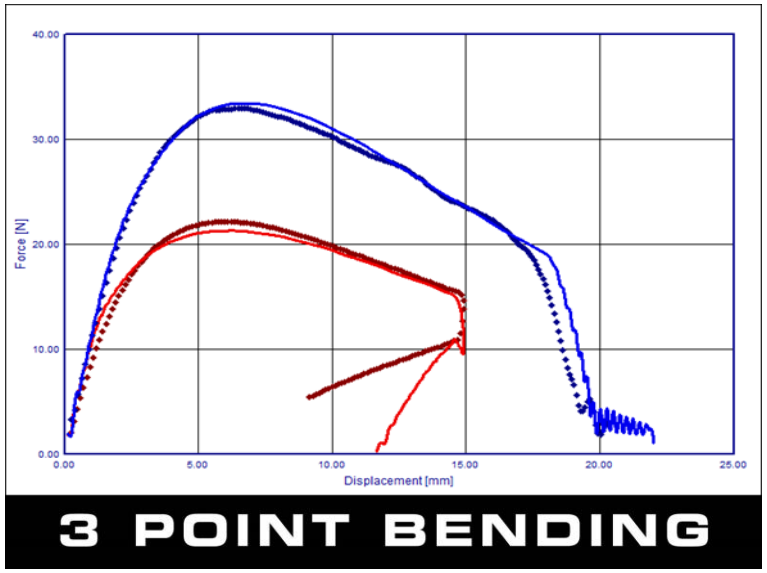




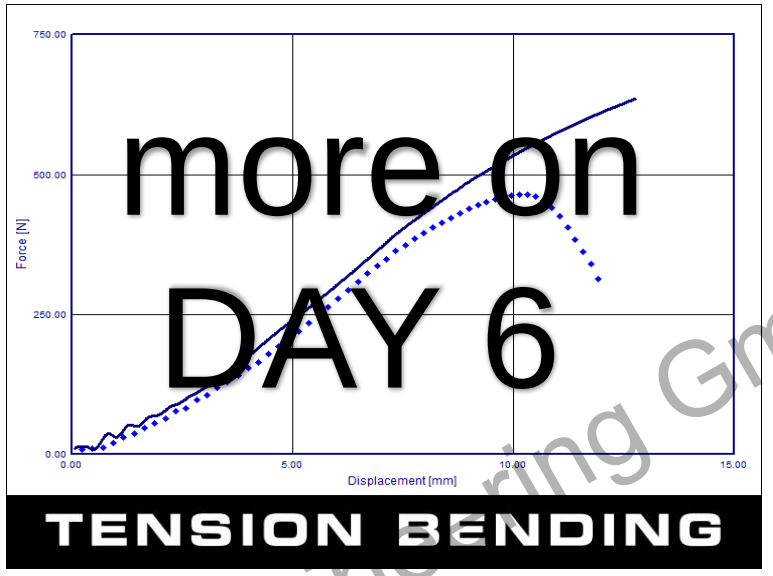
more on DAY 6

DAY 6 – 15th July 2020

VALIMAT

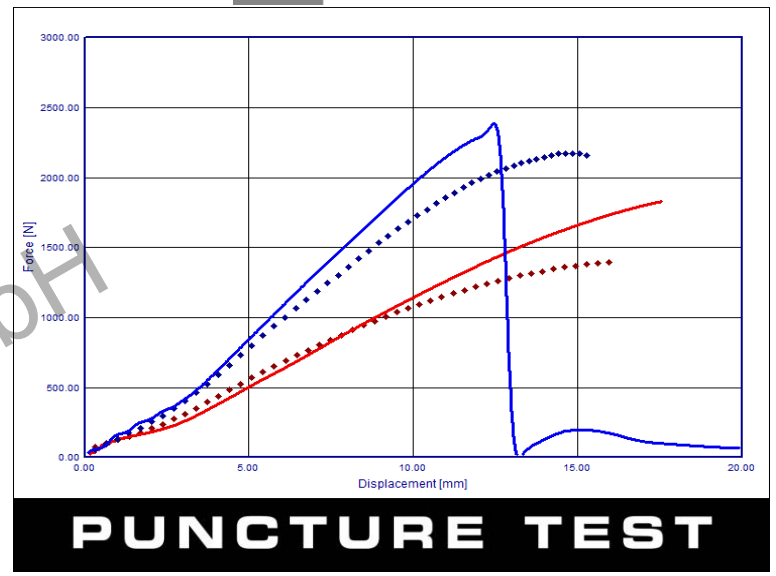


3 POINT BENDING

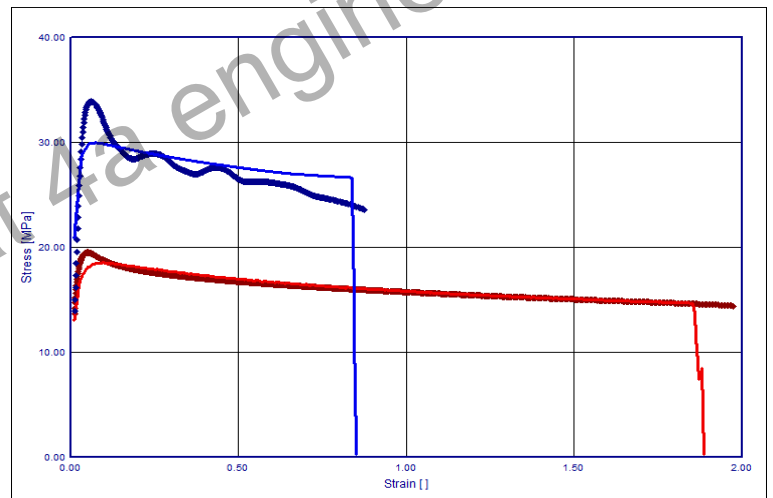


TENSION BENDING

more on DAY 6



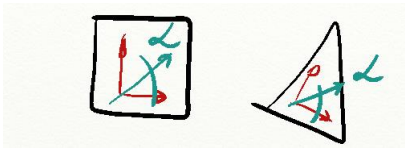
PUNCTURE TEST



TENSION TEST

IMPETUS® ~ 3 m/s

static ~ 1mm/s

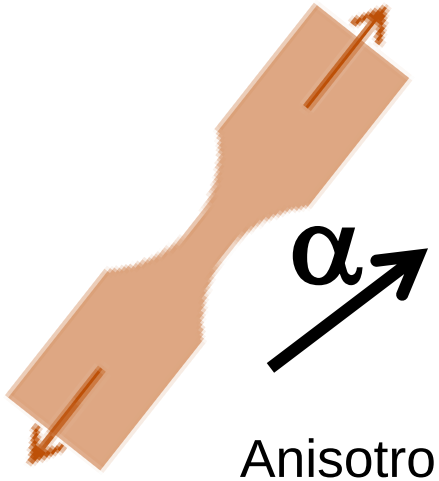


···· averaged test curves

— result of simulation

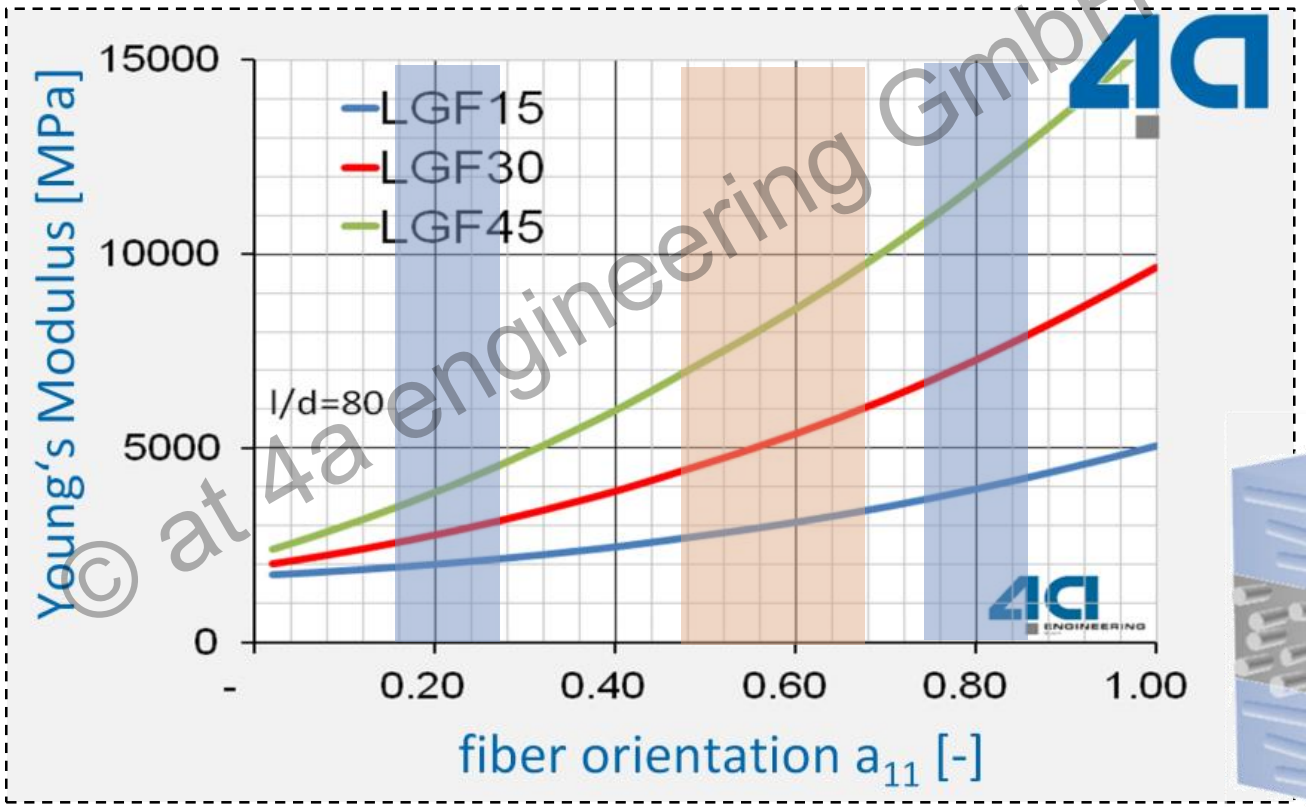
source: Benjamin Hirschmann, master thesis

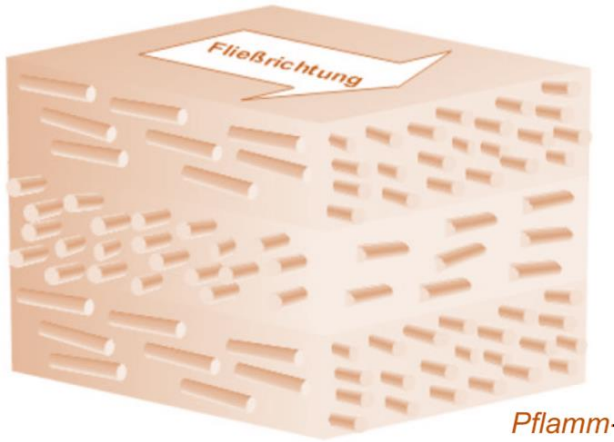
more on DAY 7



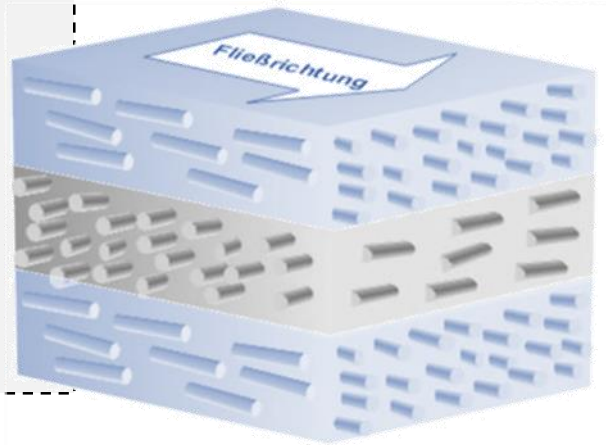
Anisotropic

Why not tension (only)?

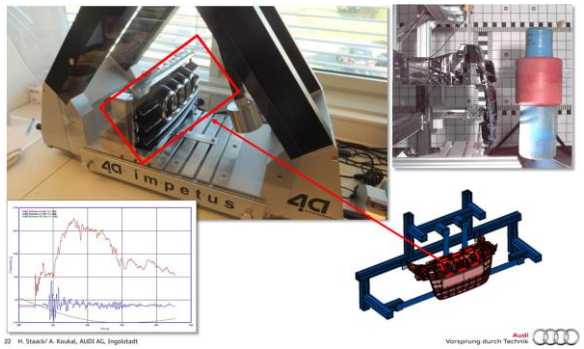




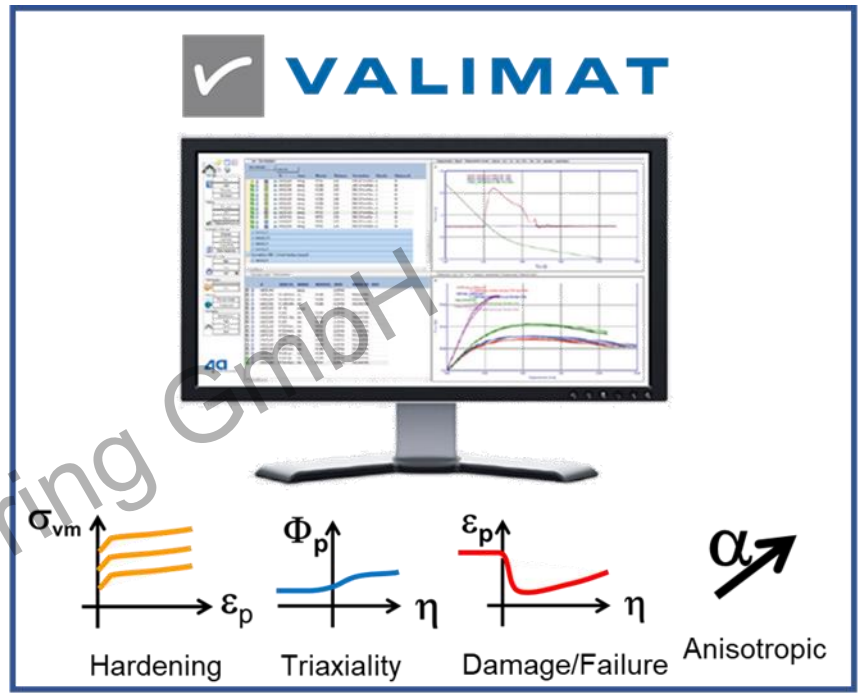
Pflamm-Jonas 2001



DAY 8 – 17th July 2020



User-defined specimen/input decks
User-defined material cards



Possibilities in VALIMAT® with Python

Thank you for your Attention!

4a summer-school - webinar and training
Material characterization with VALIMAT® and IMPETUS®

SAVE THE DATE

09. July - Material card generation:
vonMises plasticity (*MAT_024),
simple failure, setting up our Autofit

VALIMAT

IMPETUS