



VALIMAT



IMPETUS

# 4a Summer School

## Material card generation: vonMises plasticity (\*MAT\_024), simple failure and how to set up our Autofit

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Traboch, 09.07.2020



## 1<sup>st</sup> week - Introduction and outlook



**07. July** - Introduction to VALIMAT<sup>®</sup> from test to material card



**08. July** - Efficient dynamic testing with IMPETUS<sup>®</sup>



**09. July** - Material card generation: vonMises plasticity (\*MAT\_024), simple failure, setting up our Autofit



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

## 2<sup>nd</sup> 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

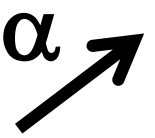
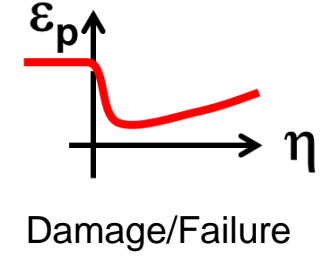
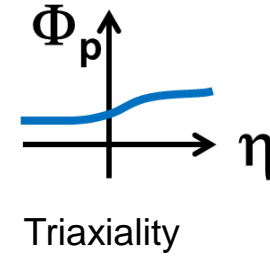
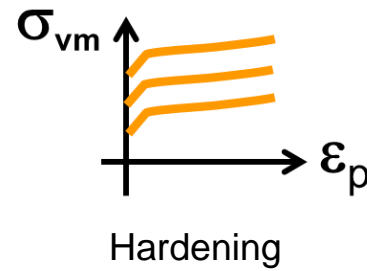
# from test to material card



# VALIMAT

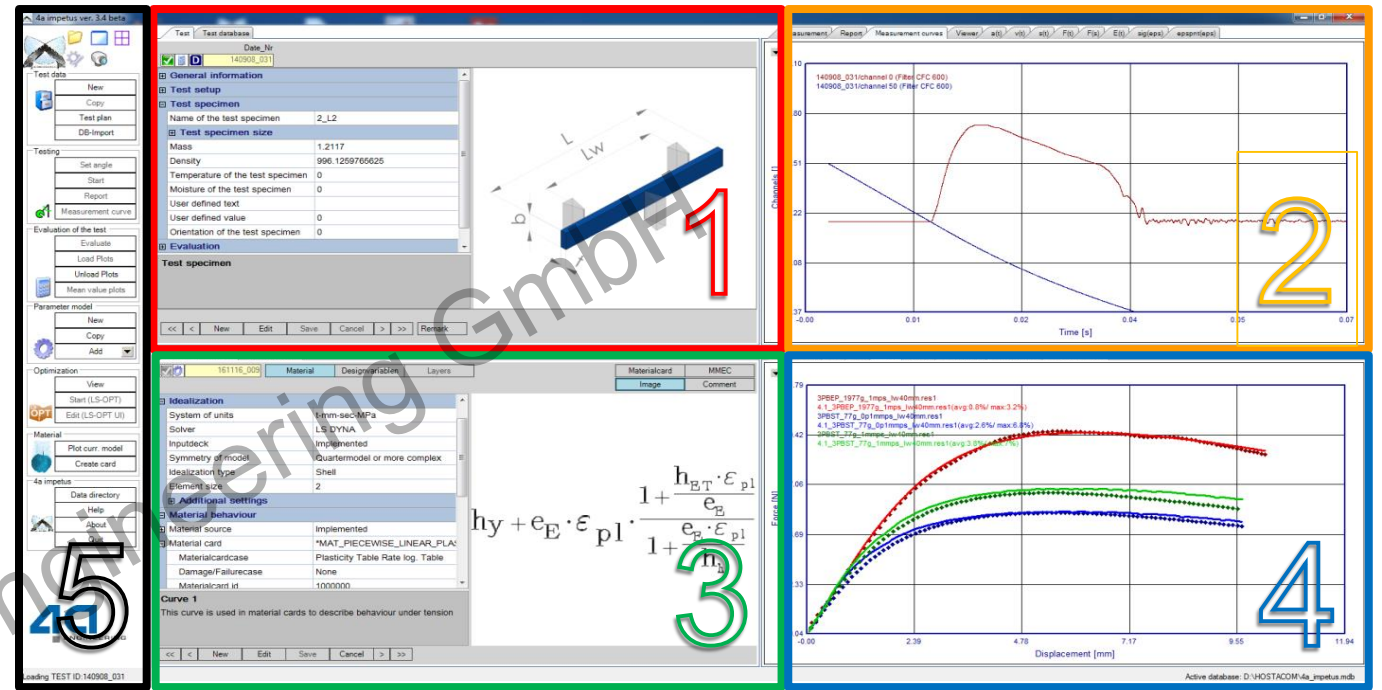
engineering plastics production  
concepts simulation  
lightweight prototypes

**excellence in validation**



Anisotropic

# GUI - the graphic user interface



basic menu (left margin, (5))

window top left (1) → test; data base

window top right (2) → measurements; info; measurement results

window bottom left (3) → model parameter; optimization settings

window bottom right (4) → optimization; results of the optimization

the basic menu describes the principal process from the test to the completed material model and allows a simple and fast access of the most important functions.

- Plenty of direct implemented **LS-Dyna** material models (*also Abaqus, PamCrash*)

Material card	
Materialcardcase	*MAT_ELASTIC (*MAT_001)
Damage/Failurecase	*MAT_PIECEWISE_LINEAR_PLASTICITY (*MAT_024)
Materialcard id	*MAT_PLASTICITY_COMPRESSION_TENSION (*MAT_124)
Density	*MAT_SAMP-1 (*MAT_187)
Plasticity	*MAT_FU_CHANG_FOAM (*MAT_083)
Function (Hardening, Elastic curve)	*MAT_COMPOSITE_DAMAGE (*MAT_022)
Strain rate dependency	*MAT_ENHANCED_COMPOSITE_DAMAGE (*MAT_054)
Micromec	*MAT_LAMINATED_COMPOSITE_FABRIC (*MAT_058)
Fracture	*MAT_RATE_SENSITIVE_COMPOSITE_FABRIC (*MAT_158)
Postfracture	*MAT_LAMINATED_FRACTURE_DAIMLER_PINHO (*MAT_261)
	*MAT_LAMINATED_FRACTURE_DAIMLER_CAMANHO (*MAT_262)
Loadcases	*MAT_ANISOTROPIC_ELASTIC_PLASTIC (*MAT_157)
Results	*MAT_MICROMECC (*MAT_215)
	*MAT_MICROMECC (*MAT_215)+Carbon

- Whole number** of LS-Dyna material models is available through **user defined material cards**

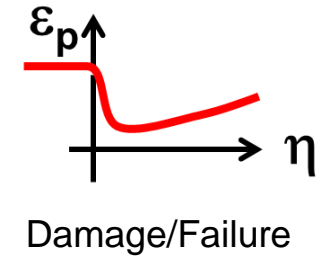
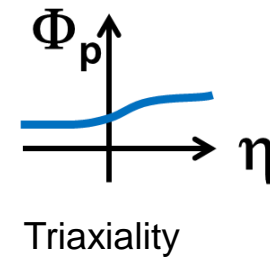
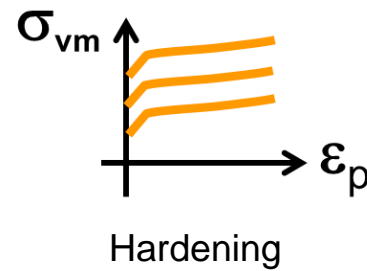
# HANDS ON SOFTWARE

\*MAT\_024 Autofit



## VALIMAT

engineering plastics  
production  
excellence in validation  
simulation  
concepts  
lightweight prototypes



Anisotropic

# Objective/requirements

Fit an elastic viscoplastic material model (\*MAT\_024) for SHELL's on 3-point bending measurements conducted by 4a IMPETUS®. Create an Auto-Report for the found material model.

## What one should know:

- VALIMAT® GUI overview & key functioning

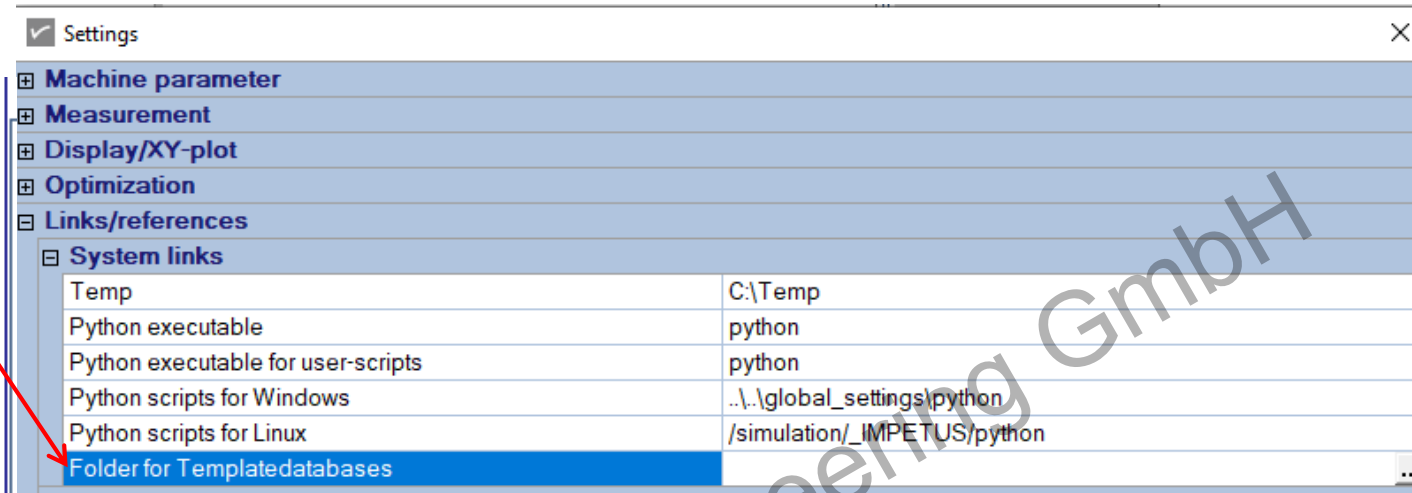
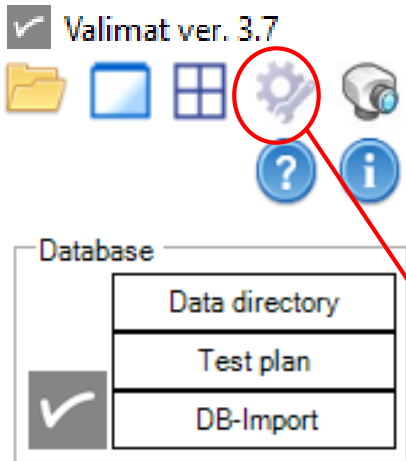
## Requirements:

- Installed VALIMAT® and Python
- VALIMAT® Training Database
- LS-DYNA license

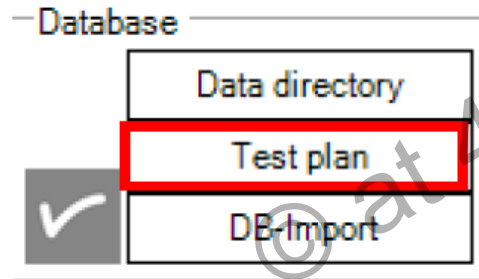
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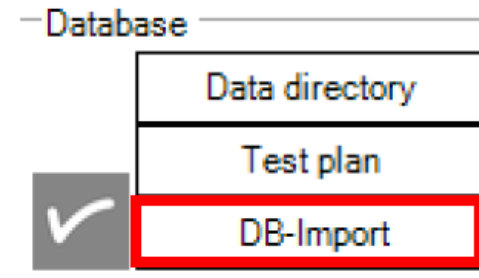
# VALIMAT® - Template database



Setup the folder containing the template database under the settings tab



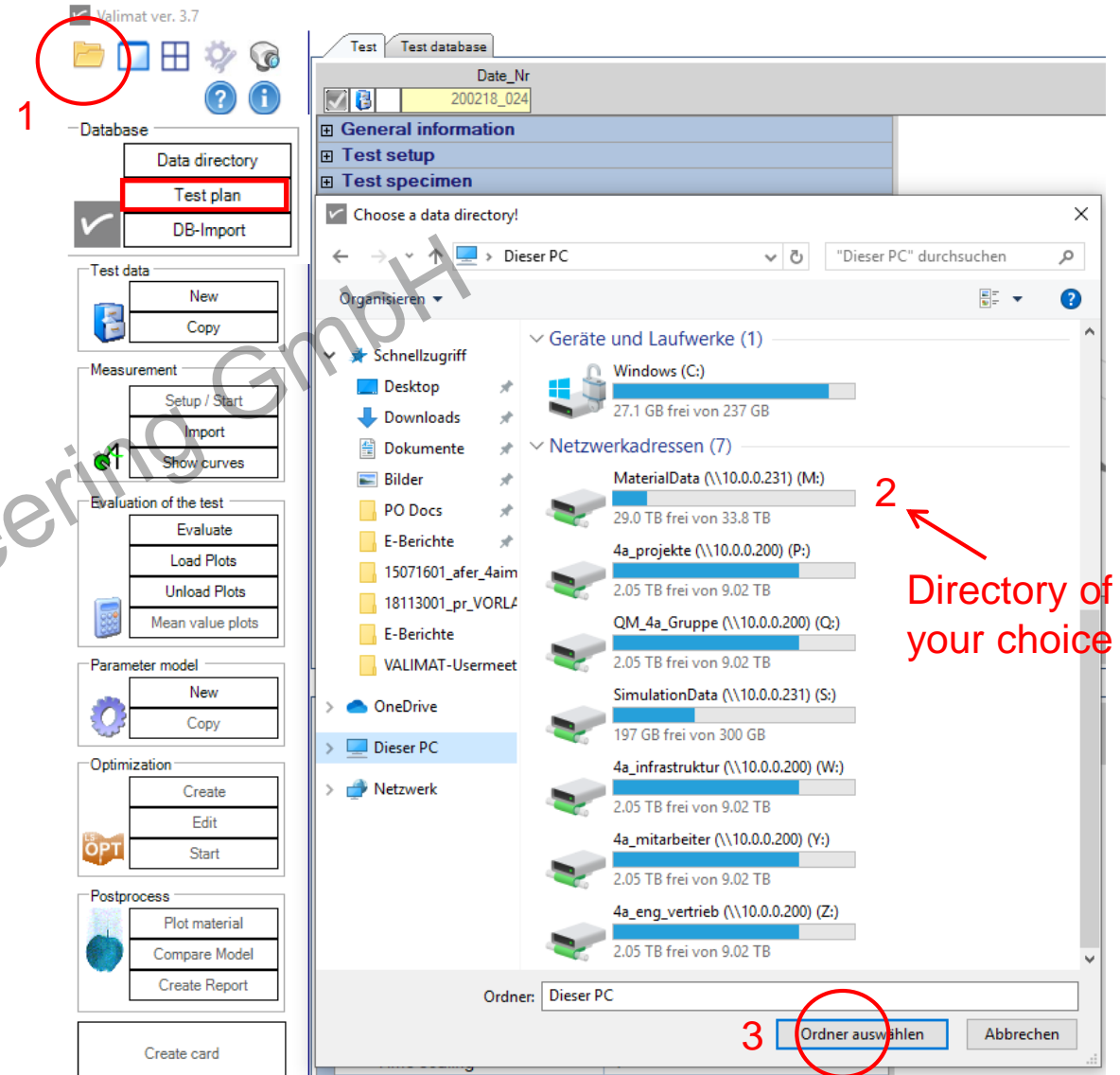
A template database can be imported using the `Test plan` button



An additional VALIMAT® can be imported in the already opened database

# VALIMAT® - Template database

- To use the template database, you have to create it once → 4a provides you with an example template database
- Important steps need to be performed
  - Create a directory where you store tests and models
  - Create a new (empty) database in this directory



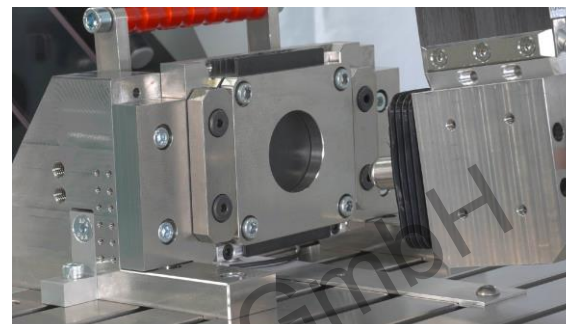
# IMPETUS® - configurations



**3 POINT BENDING**



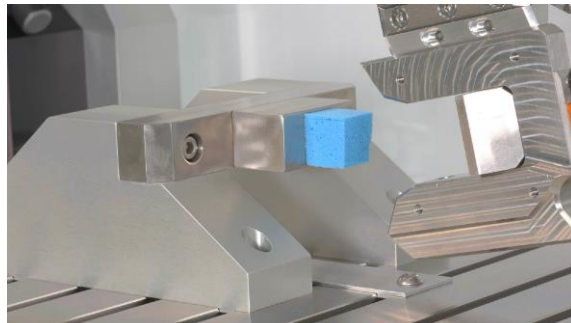
**TENSION BENDING**



**PUNCTURE TEST**



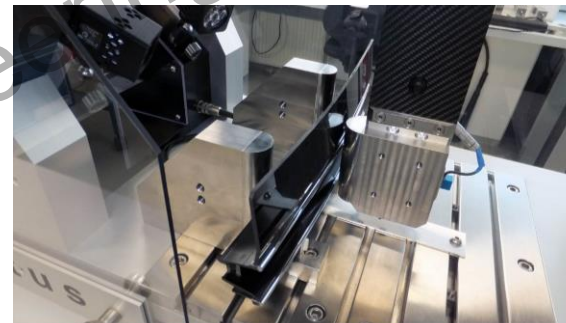
**TENSION TEST**



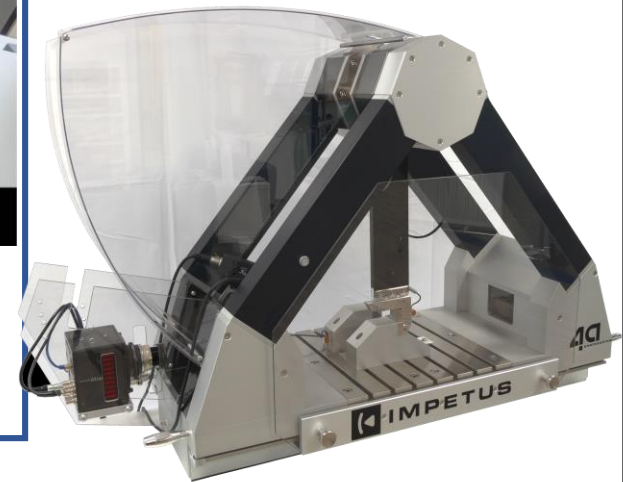
**COMPRESSION TEST**



**SAMPLE MAGAZIN**



**COMPONENT TEST**



BASIC

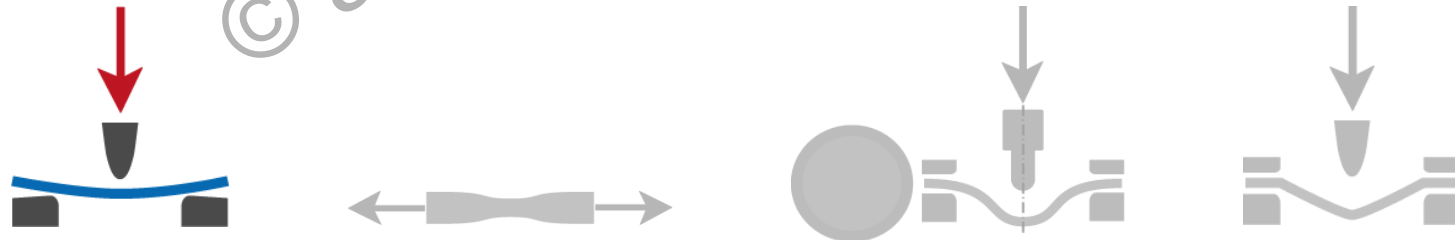
STANDARD

PROFESSIONAL



# VALIMAT® - Template database

- Using template database streamlines the workflow of generating material cards from the tests conducted under the different loading conditions
- It is especially useful, when the test setups for the optimization or validation of the material cards are the same, as shown in the test package overview in the previous slide
- As a demo, we will go through the template database for the material package **isoP standard**
  - The material package uses static and dynamic bending tests to generate the material card.
  - Dynamic puncture, clamped 3-point-bending and tensile tests to validate the material card.



# VALIMAT® - Template database

- Template database is available for all packages: basic, standard, professional

The screenshot shows the Valimat software interface. On the left is a sidebar menu with the following sections:

- Database: Data directory, Test plan, DB-Import
- Test data: New, Copy
- Measurement: Setup / Start, Import, Show curves
- Evaluation of the test: Evaluate, Load Plots, Unload Plots, Mean value plots
- Parameter model: New, Copy
- Optimization: Create, Edit, Start
- Postprocess: Plot material, Compare Model, Create Report
- Create card

The main window is split into two panes:

- Test database:** Shows a tree view with 'Material' selected. Under 'Material', there are four test methods: 3PB (3-Point Bending), 3PBC (3-Point Bending clamped), TT (Tensile test), and PT (Puncture test)(b). A white box labeled 'Tests' is overlaid on this list.
- Parameter model\* Model database:** Shows a table of series. A white box labeled 'Generation of the material card' is overlaid on the first few rows, and another white box labeled 'Validation of the material card' is overlaid on the last few rows.

Series	ID	Dataset name	Modeller	Series	Validation/...	Material na...
Series:						
Series: MC3-Autofit						
<input checked="" type="checkbox"/>	200224_171	0_VISUAL_AUTO	mr	MC3-Autofit	AutoValues	Kunststoff
<input checked="" type="checkbox"/>	200224_172	00_Validation_3PB_AUTO				
<input checked="" type="checkbox"/>	200224_160	1_Optimization_YoungsMod				
<input checked="" type="checkbox"/>	200224_161	2_Optimization_flow_data				
<input checked="" type="checkbox"/>	200224_162	3_Optimization_strainrate	mr	MC3-Autofit	Optimizatio...	Kunststoff
<input checked="" type="checkbox"/>	200224_163	4_Validation_3PB	mr	MC3-Autofit	Validation	Kunststoff
Series: MC5						
<input checked="" type="checkbox"/>	200224_164	5_Optimization_T/Bfactor_3PBC	mr	MC5	Optimization	Kunststoff
<input checked="" type="checkbox"/>	200224_165	6_Optimization_strainrate2_3				
<input checked="" type="checkbox"/>	200224_166	7_Validation_3PB_MAT187				
<input checked="" type="checkbox"/>	200224_167	7_Validation_3PBC_MAT187				
<input checked="" type="checkbox"/>	200224_170	7_Validation_PunctureTest_dynamic_MAT187	mr	MC5	Validation	Kunststoff
<input checked="" type="checkbox"/>	200224_169	7_Validation_PunctureTest_static_MAT187	mr	MC5	Validation	Kunststoff
<input checked="" type="checkbox"/>	200224_168	7_Validation_TensileTest_MAT187	mr	MC5	Validation	Kunststoff

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# VALIMAT® - Template database

- As an alternative, you can also import the template database in an already existing database by following these steps

1: DB-Import

2: Import

3: Öffnen

4: New ID's

5: ...

4: Check on this box so that all tests and models get a new ID !!!

Name	Änderungsdatum	Typ
curvestore	18.02.2020 17:23	Dateiordner
DatenShimadzu	15.01.2020 11:20	Dateiordner
Fotos	15.01.2020 11:20	Dateiordner
model	13.02.2020 15:28	Dateiordner
4a_impetus	19.02.2020 11:51	Microsoft Access ...

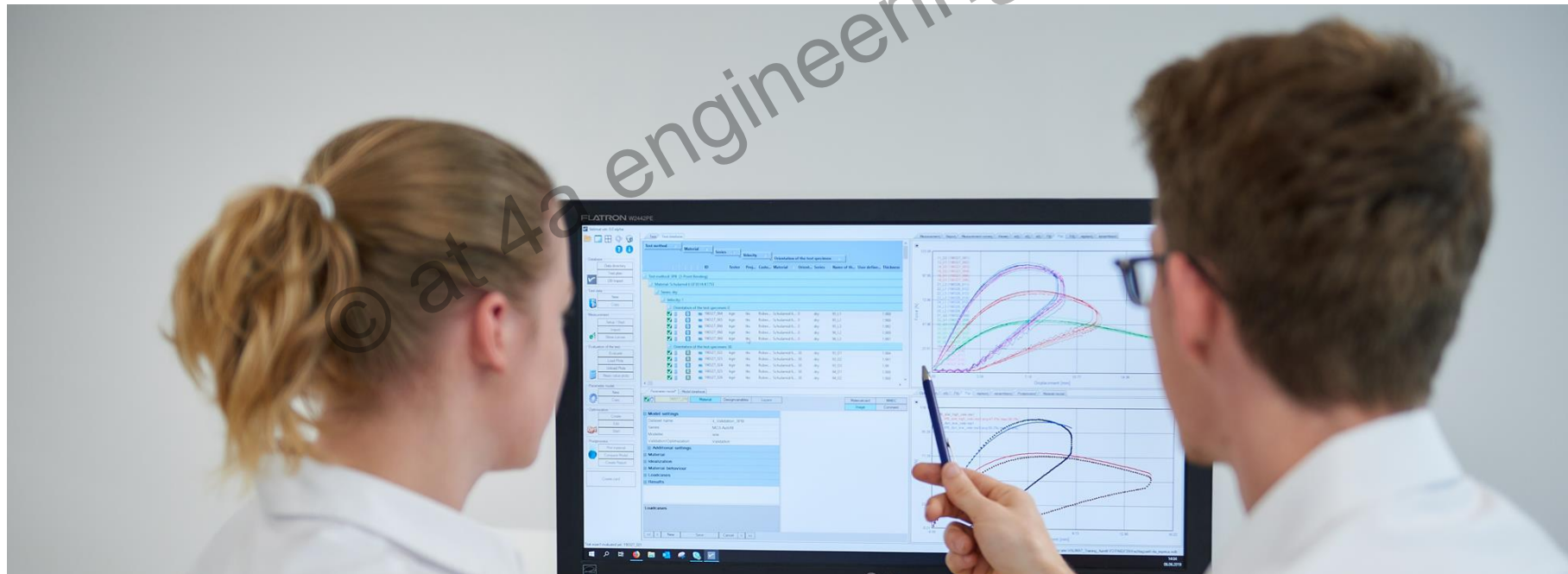
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# VALIMAT® - Template database

- Advantages of the template database
  - Test setup already pre-created
  - Parameter models for creating workflow already stored
  - Test IDs are linked in models
- Checks that need to be carried out:
  - Update test specimen **names** and **geometry** (e.g. pendulum mass, gauge length)
  - Check **length** of test curves
  - Optimization of Youngs modulus → **trim test curve** to obtain a suitable length for optimization
  - Optimization of plastic data and strain rate dependency → **optimization** curve should be a little **over the force maximum**
  - Check the **starting values** and **limits of design variables**
  - Check if the test IDs are **linked correctly** to the models

# Introduction MAT\_024 AutoFit

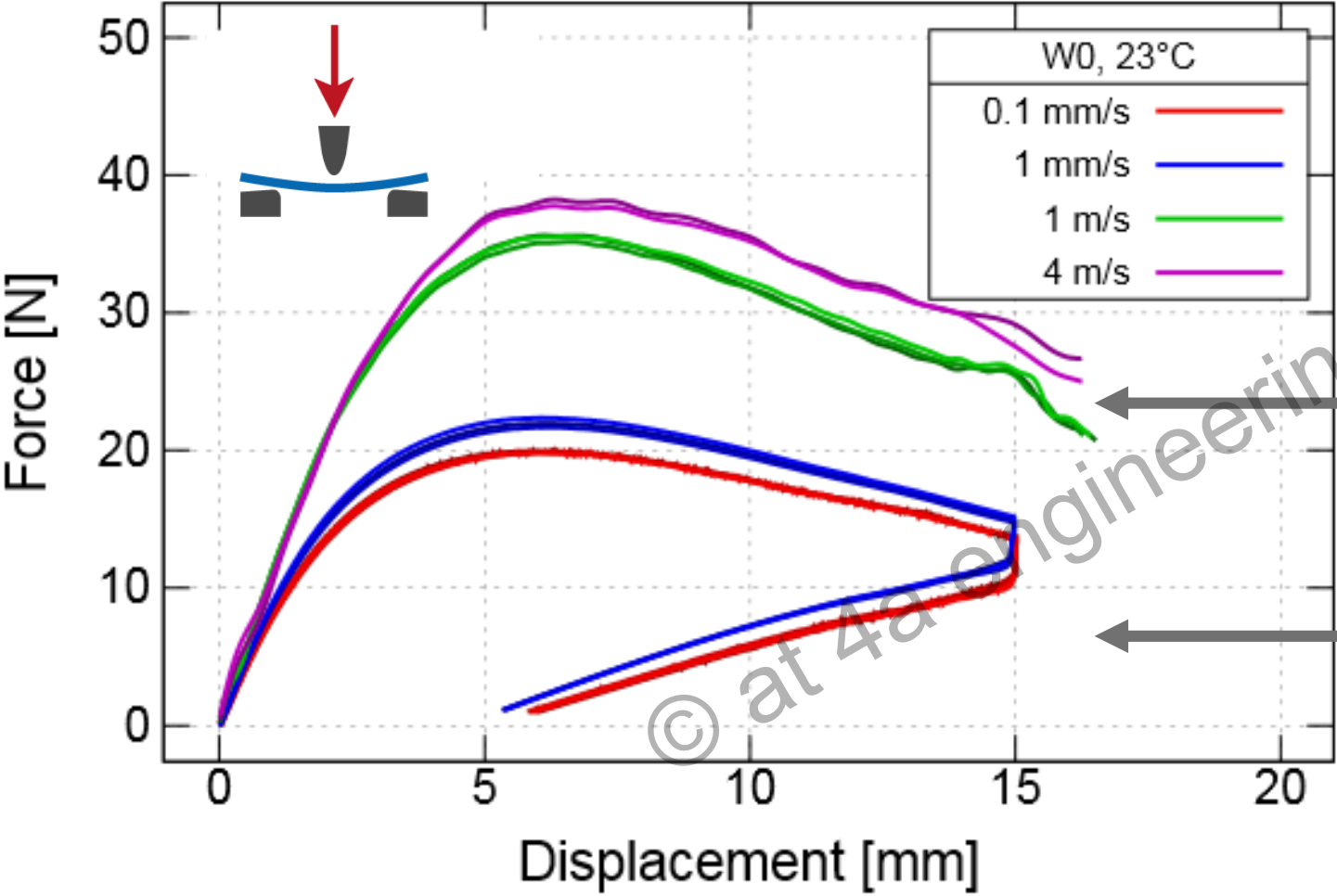
## Basis 3-Point-Bending



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# Efficient dynamic testing

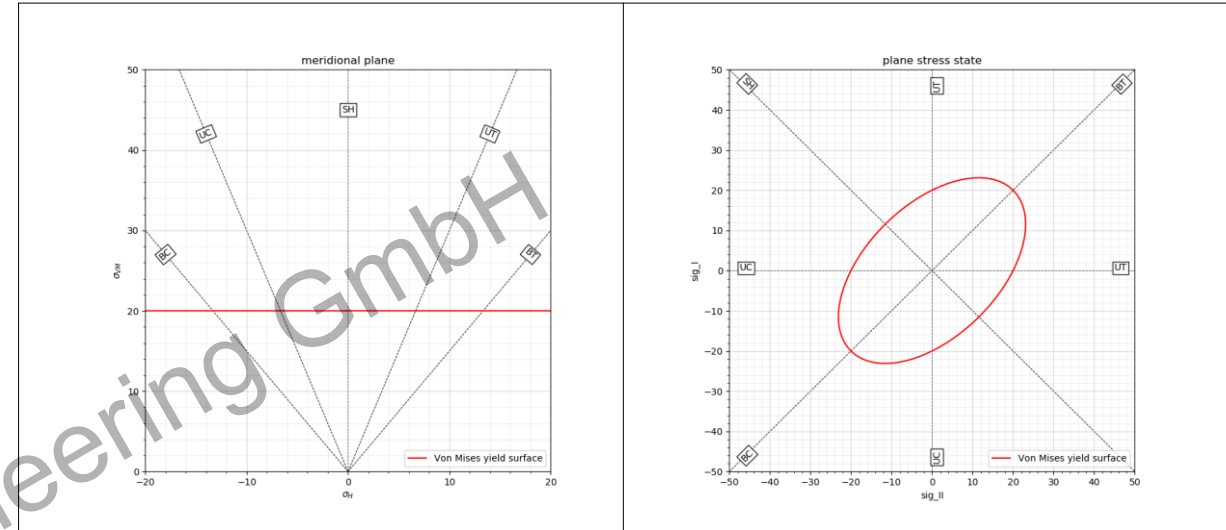


**IMPETUS**

Universal static testing

# 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	x	✓	x	0.5

**\*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

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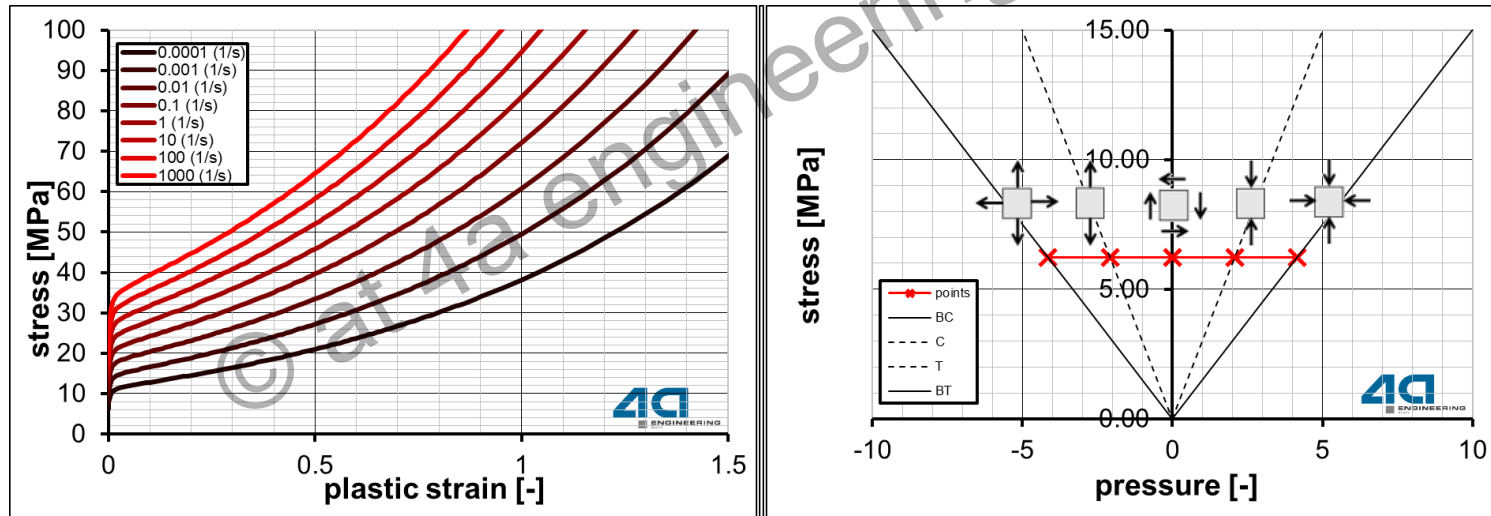
more information:

- "LS-DYNA\_Manual\_Volume\_II\_R11.pdf"

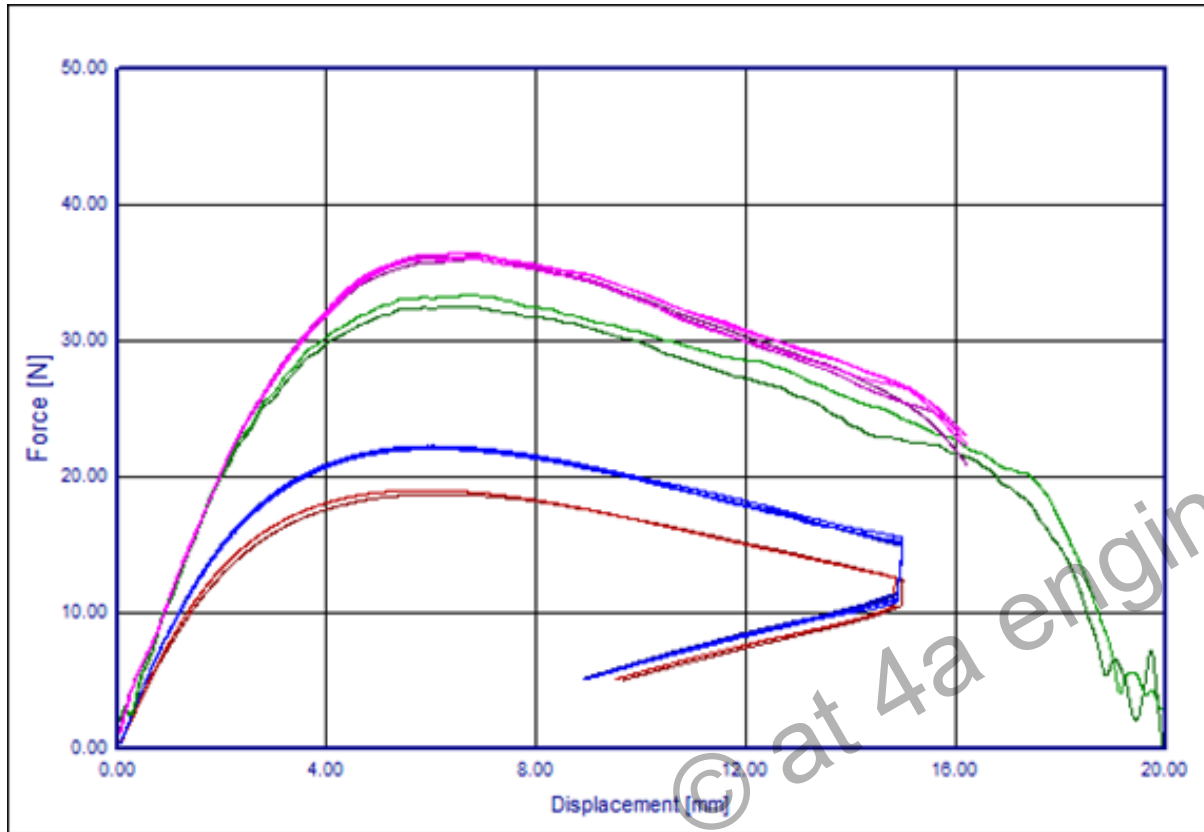
# MAT\_024 introduction

## material card overview

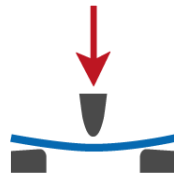
- **Material:** PPEG107HP
- **\*MAT\_024** material card:
  - Deformation: elastic, viscoplastic
  - Von Mises yield surface
  - associated flow rule → plastic deformation at constant volume



# AutoFit Data

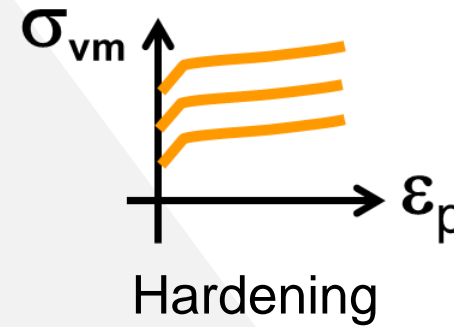
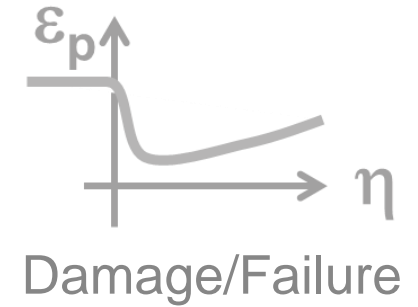
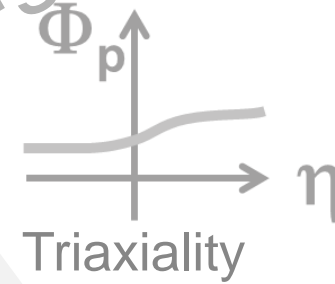
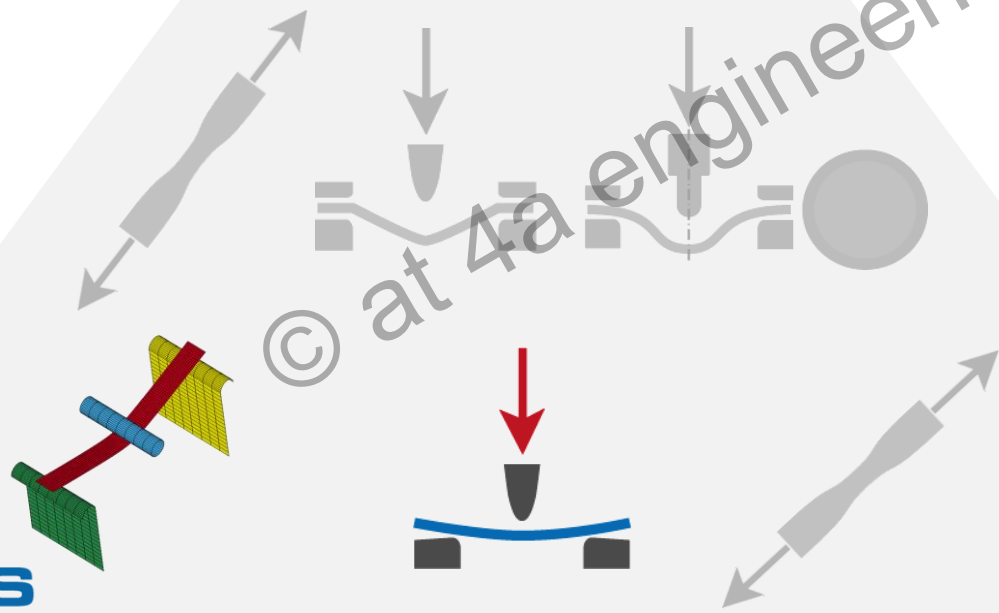
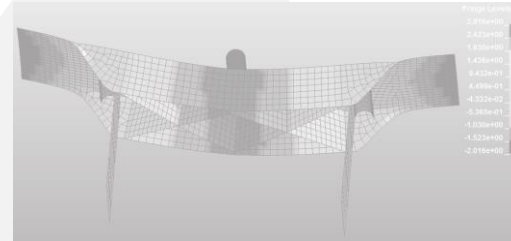
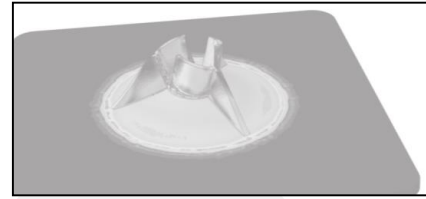


model 190912\_019



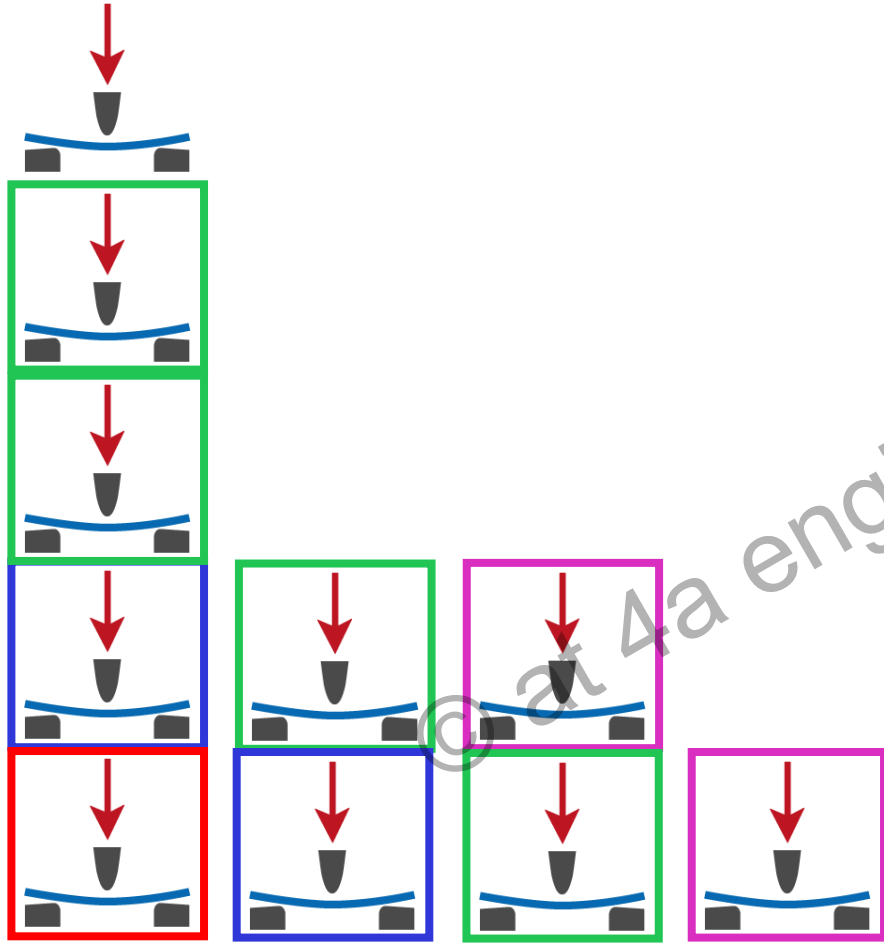
Case	$v_0$ [m/s]	$l_w$ [mm]	$m_{\text{Pendulum}}$ [g]	b [mm]	t [mm]	l [mm]
3PB_V0p1_d00_I	0.0001	40.01	0	9.93	1.99	49.75
3PB_V1_d00_I	0.001	40.01	0	9.91	2.00	50.06
3PB_V1000_d00_I	1	40.01	1580	9.91	1.99	50.10
3PB_V2500_d00_I	2.5	40.01	1580	9.91	1.99	49.94

# from test to material card

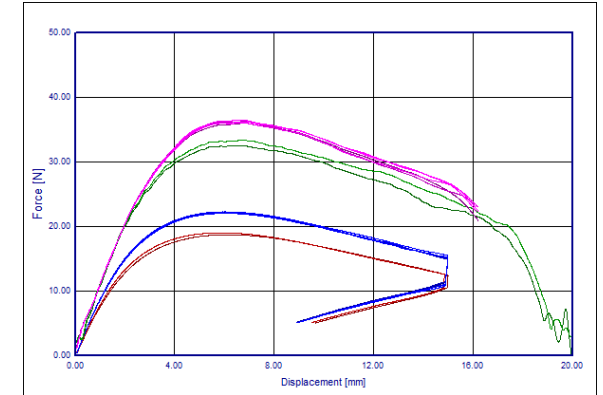


# AutoFit Strategy

MAT\_024



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



# Workflow for Material Card Generation - AUTOFIT



Automated optimization

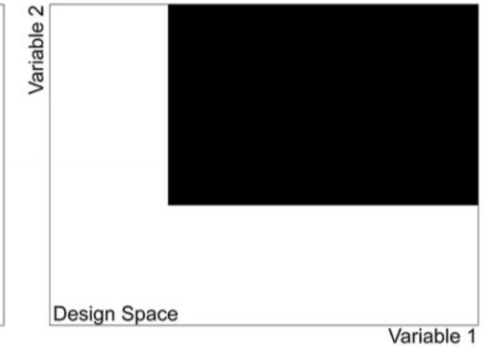
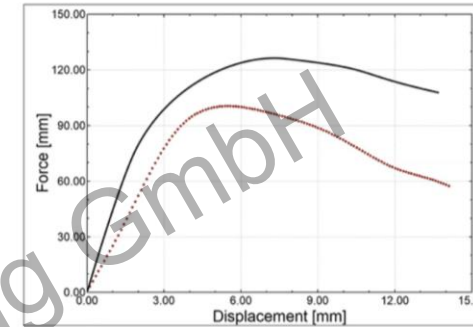
Optimization	Status	Name	e_E
Run		0_VISUAL_AUTO	1000(c)
Stop		1_Optimization_YoungsModulus	AUTO
Clear		2_Optimization_flow_data	PRUN(c)
Open LS-Opt Viewer		3_Optimization_strainrate	PRUN(c)
DV Start		4_Validation_3PB	PRUN(c)

Postprocess

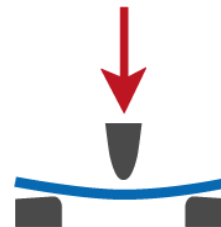
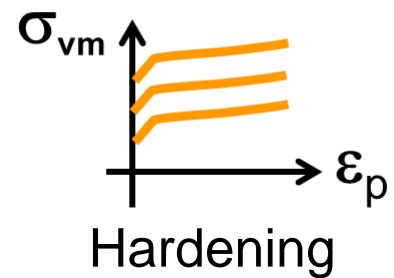
- Create report
- Create material card
- Plot material
- Compare models

Close

optimization – successive response surface method

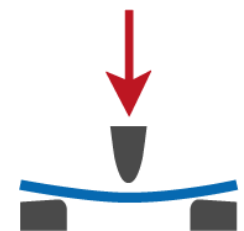
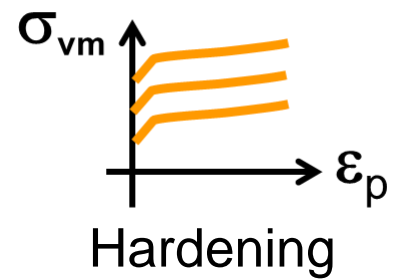
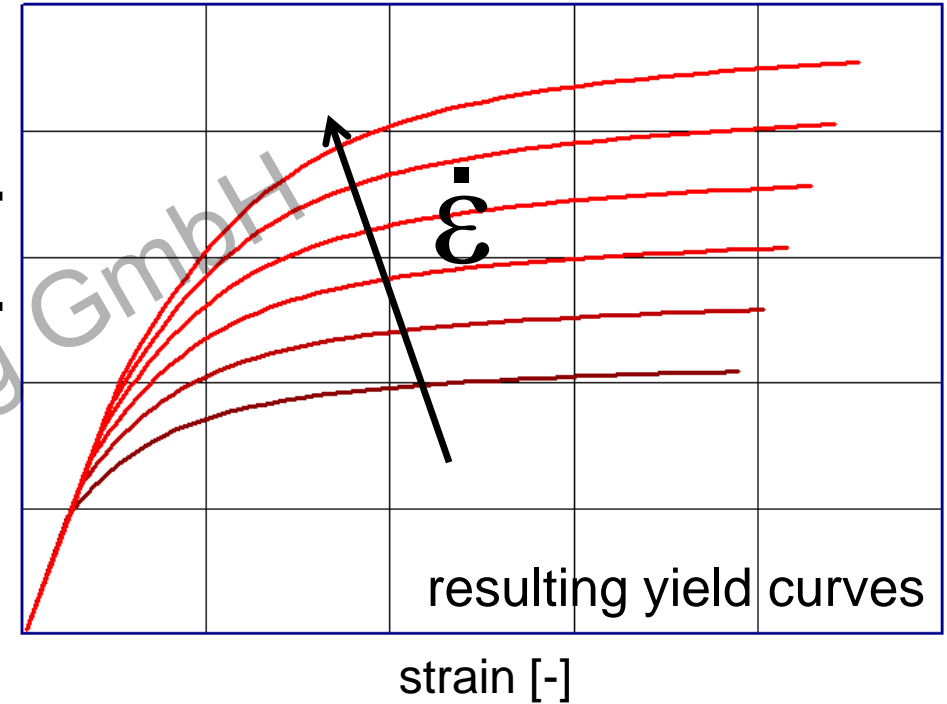
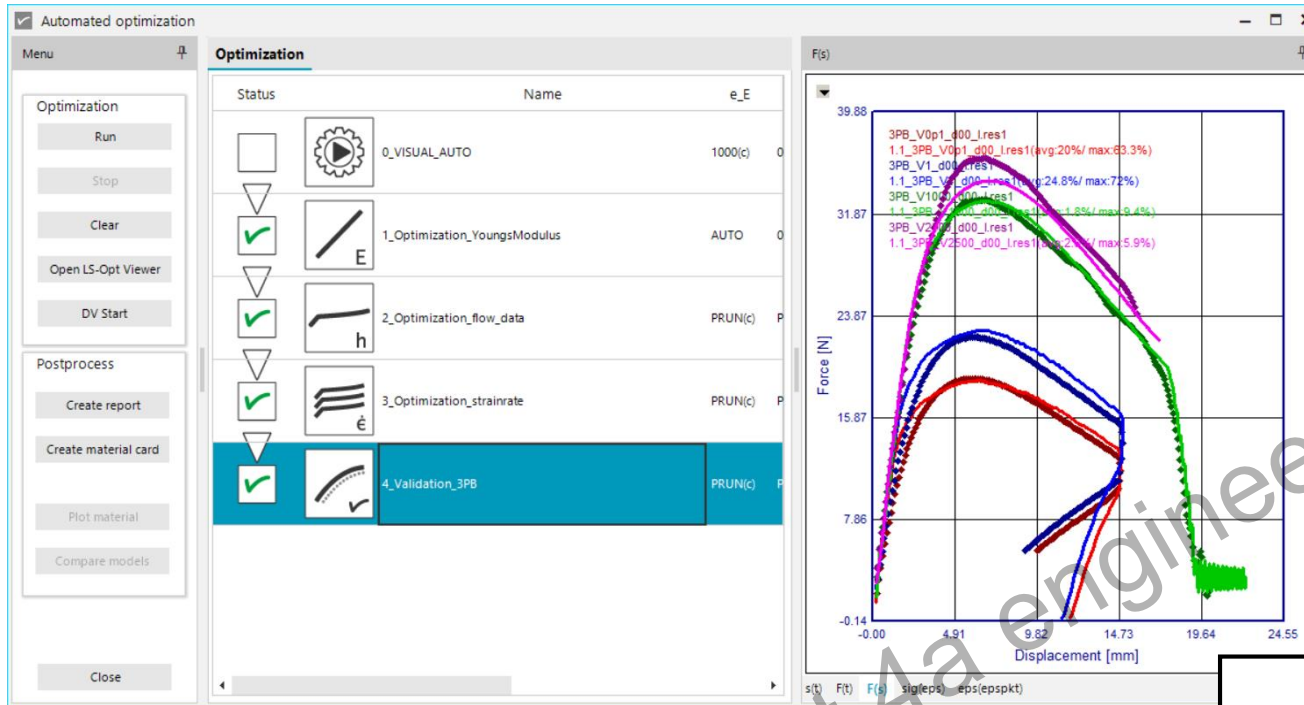


*hardening function*  
 $= f(\text{Variable 1}, \text{Variable 2})$





# Workflow for Material Card Generation - AUTOFIT



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# AutoFit

## Auto Values

Validation/Optimization: **AutoValues** → Model used for start value generation

- **\_EL** → Young's Modulus  $e_E$
- **\_HC** → hardening curve parameter estimation
- **\_VP** → to evaluate the strain rate dependency  $v_p$
- important **v\_espkt** will be taken from Designvariables

190912\_014 Material Designvariables Layers

Model settings

Dataset name	0_VISUAL_AUTO
Series	1_1_RT_MAT024
Modeller	bhir
Validation/Optimization	AutoValues

Loadcases

Casename	3PB_V1_d00_I_VP
Casename	3PB_V2500_d00_I_EL_HC_VP

Name	Start	const...	from	to	Variance	Condi...	Descri...
^ GroupName: 31_strainrate							
v_espkt	0.0001	<input checked="" type="checkbox"/>	0.001	1	(NULL)		initial...

Click here to add a new row

# AutoFit

## Auto Values

Auto Values Model → script get\_auto\_opt\_startvalues.py

Database-PPEG107HP > model > 190912\_014

Name

- auto\_opt\_copyvalues.txt
- auto\_opt\_startvalues.txt

Start parameters polymer\_law:

Name	Start	constant	from	to	Variance	Condition
e_E	1827.34	True	10%	10%	(NULL)	
h_y	7.38390510073361		True	50%	50%	(NULL)
h_y2	14.76781020146722		True	10%	20%	(NULL) >h_y
h_eps0	0.006771626753819869		True	10%	20%	(NULL) >h_y
h_n	1.1	True	0	5	(NULL)	
h_b	0.01	True	0	1	(NULL)	
h_nuep	-1.0	True	10%	20%	(NULL)	
v_p	7.893796663800692		True	50%	50	(NULL)
v_epspkt	0.0001	True	0.00001	1	(NULL)	
y_nuep=-1000050	True	(NULL)	(NULL)	(NULL)	(NULL)	
xm_nuep_plat=-1.0	True	(NULL)	(NULL)	(NULL)	(NULL)	

these values will be used in subsequent models

```
e_E=1827.34 CRIF
e_nue=0.35 CRIF
y_0=7.38390510073361 CRIF
y_T=7.38390510073361 CRIF
y_C=7.38390510073361 CRIF
y_SH=7.38390510073361 CRIF
y_B=22.381144501959284 CRIF
h_scale0=1.0 CRIF
h2_scale=1 CRIF
h3_scale=1 CRIF
h_y=7.38390510073361 CRIF
h_y2=14.76781020146722 CRIF
h_eps0=0.006771626753819869 CRIF
h_n=1.1 CRIF
h_b=0.1 CRIF
h_h=5.907124080586889 CRIF
h_ET=365.468 CRIF
y_nuep=-1000050 CRIF
xm_nuep_eps=0.2 CRIF
xm_nuep_plat=0.05 CRIF
xm_nuep_meps=0.3 CRIF
xm_nuep_pres=0.5 CRIF
h_nuep=0.5 CRIF
v_p=7.893796663800692 CRIF
v_epspkt=0.0001 CRIF
```



# AutoFit

Optimization Young's modulus

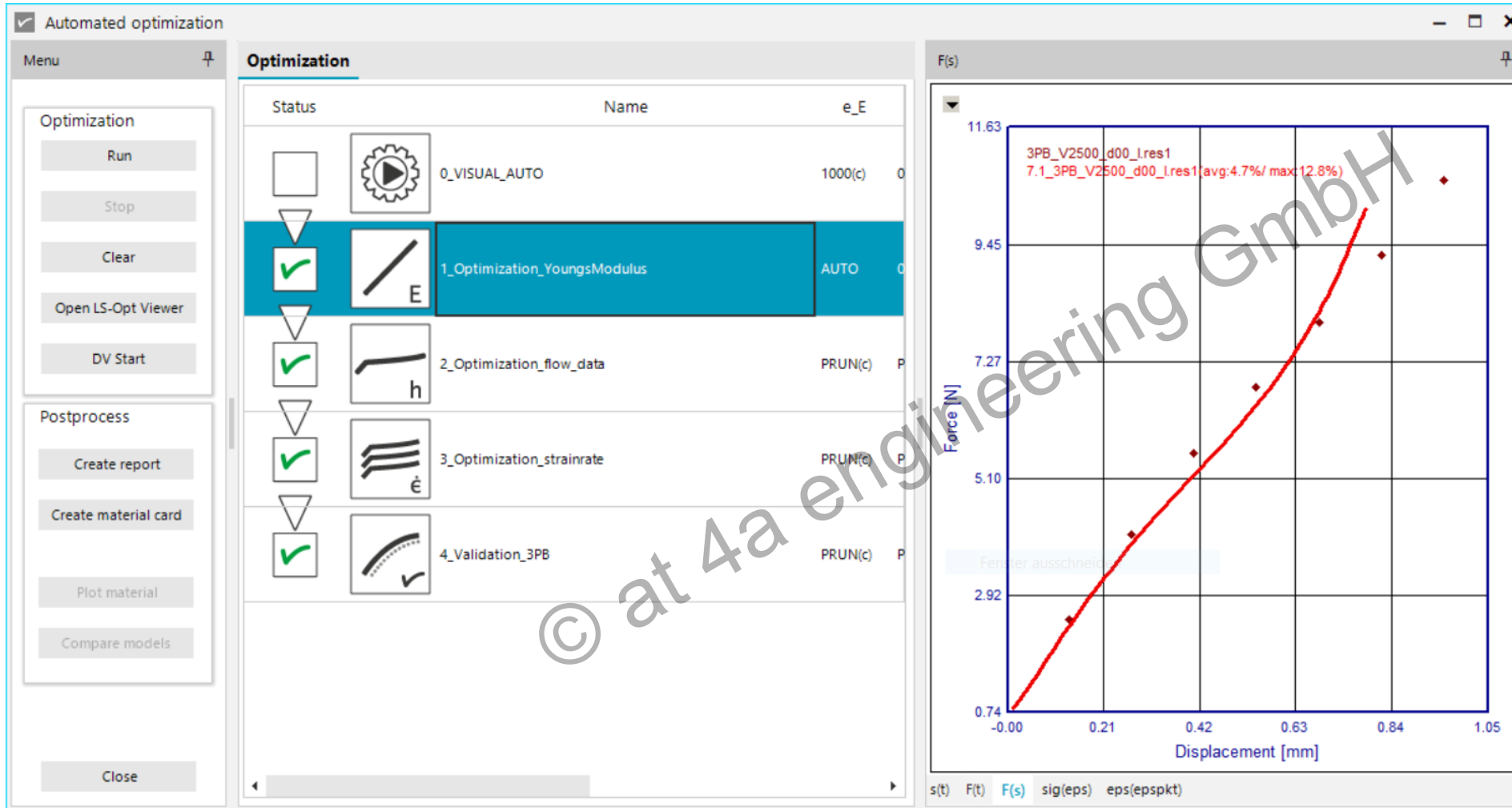
Validation/Optimization: **Optimization Young's modulus**

- MAT\_ELASTIC → to Fit Young's modulus
- In design variables e\_E → AUTO which will be replaced by script result of the Young's modulus

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# AutoFit

## Optimization Young's modulus



Checks:  
are oscillations too high?  
curve long enough?  
curve still linear elastic?

# AutoFit

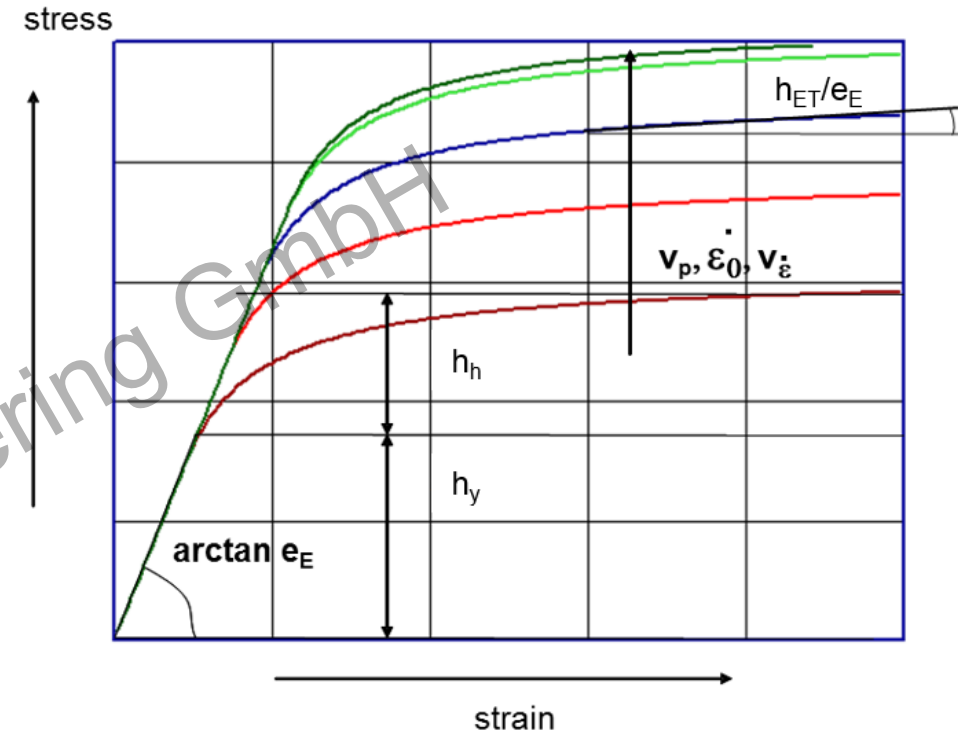
## Optimization hardening – 4a model

- LS Dyna - *\*MAT\_024*
- plastic behavior described using the meta model of Schmachtenberg

$$h_y + e_E \cdot \epsilon_{pl} \cdot \frac{1 + \frac{h_{ET} \cdot \epsilon_{pl}}{e_E}}{1 + \frac{e_E \cdot \epsilon_{pl}}{h_h}}$$

- hardening linear increased by coefficient  $h_{ET}/e_E$
- strain rate dependency based on Johnson- Cook.

$$1 + \frac{1}{v_p} \cdot \log\left(\frac{\max(\dot{\epsilon}, v_{\dot{\epsilon}})}{v_{\dot{\epsilon}}}\right)$$



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# AutoFit

## Optimization hardening

### Validation/Optimization: **Optimization hardening**

- a parametrized model is used for the hardening curve and the strain rate dependency
- Optimized Parameters are set to PRUN
- New Parameters are set to AUTO

Material behaviour	
Material source	Implemented
Elasticity	Linear isotropic elastic
Plasticity	Yes
Failure/Damage	Damage
Material card	*MAT_PIECEWISE_LINEAR_PLASTICITY (*MAT_024)
Deformation	Plasticity Table Rate log. Table
Damage/Failure	None
Materialcard ID	1000000
Density	1
Yield behavior	vonMISES
Function (Hardening, Elastic curve form)	
Curve 1	4a model (nue 0.5)
Strain range upto	2.5
Sampling points	100
Bias factor	1
Strain rate dependency	Table
Strain rate dependency curve	Johnson Cook
VP	Plastic strain
1st strain rate	0.0001
2nd strain rate	0.001
3rd strain rate	0.01
4th strain rate	0.1
5th strain rate	1
6th strain rate	10
7th strain rate	100
8th strain rate	1000

hardening model

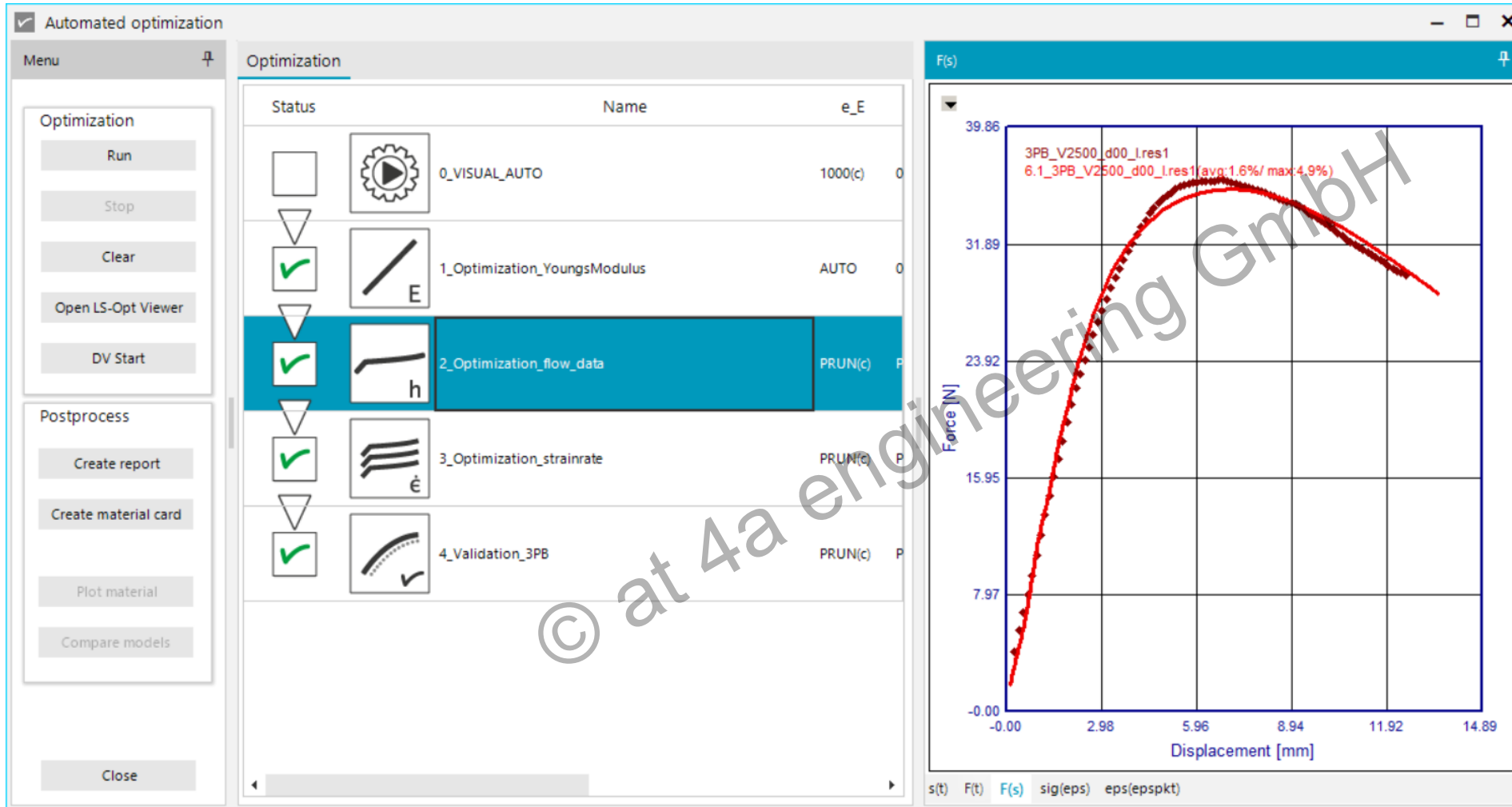
strain rate dependency model

strain rates for strain rate  
dependency used in the material  
card

Name	Start	const...	from	to	Variance	Condi...	Descri...
GroupName: 10_elasticity							
e_E	PRUN	<input checked="" type="checkbox"/>	100	10000	500		young...
e_nue	PRUN	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		poiss...
GroupName: 20_yield							
y_0	AUTO	<input type="checkbox"/>	50%	50%	(NULL)		yield s...
GroupName: 21_hardening							
h_scale0	1.0	<input checked="" type="checkbox"/>	0.5	1.0	(NULL)		scalef...
h_y	90	<input checked="" type="checkbox"/>	5	150	50	=y_0	harde...
h_ET	NaN	<input checked="" type="checkbox"/>	0	100	(NULL)	=e_E/2	tange...
h_h	AUTO	<input type="checkbox"/>	90%	50%	(NULL)		harde...
GroupName: 31_strainrate							
v_p	AUTO	<input checked="" type="checkbox"/>	5	50	(NULL)		strain...
v_epspkt	AUTO	<input checked="" type="checkbox"/>	0.0001	1	(NULL)		initial...

# AutoFit

## Optimization hardening



Checks:  
curve long enough?  
good fit?



# AutoFit

Optimization strain rate dependency

Validation/Optimization: **Optimization strainrate**

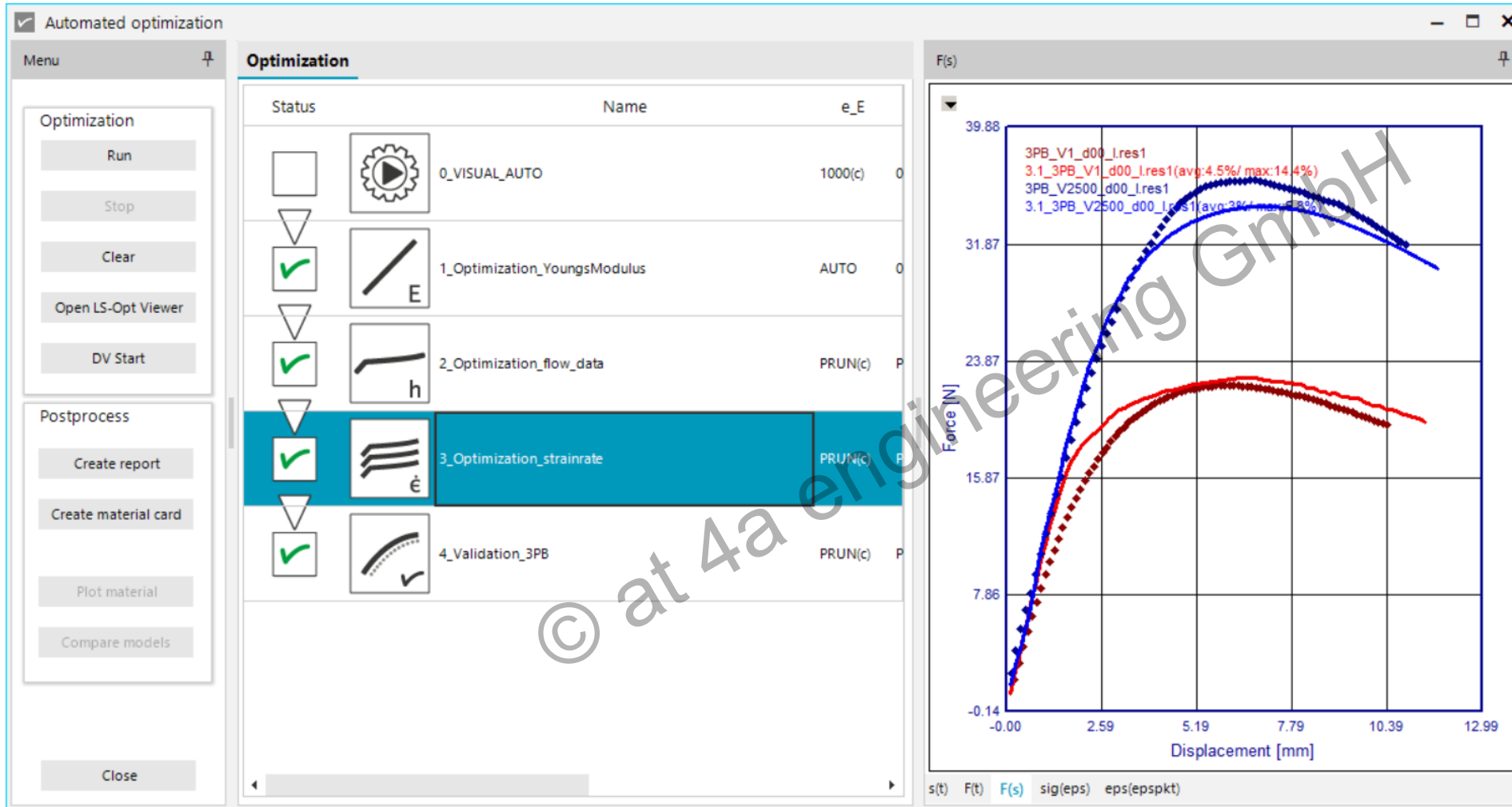
- a parametrized model is used for the hardening curve and the strain rate dependency
- Optimized Parameters are set to PRUN
- New Parameters are set to AUTO

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Name	Start	const...	from	to	Variance	Condi...
GroupName: 10_elasticity						
e_E	PRUN	<input checked="" type="checkbox"/>	100	10000	500	
e_nue	PRUN	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)	
GroupName: 20_yield						
y_0	PRUN	<input checked="" type="checkbox"/>	5	150	50	
GroupName: 21_hardening						
h_scale0	PRUN	<input checked="" type="checkbox"/>	0.5	1.0	(NULL)	
h_y	90	<input checked="" type="checkbox"/>	5	150	50	=y_0
h_ET	PRUN	<input checked="" type="checkbox"/>	0	100	(NULL)	<e_E
h_h	PRUN	<input checked="" type="checkbox"/>	5	200	(NULL)	
GroupName: 31_strainrate						
v_p	AUTO	<input type="checkbox"/>	20%	20%	(NULL)	
v_epspkt	PRUN	<input checked="" type="checkbox"/>	0.0001	1	(NULL)	

# AutoFit

## Optimization strain rate dependency



# AutoFit

## Validation

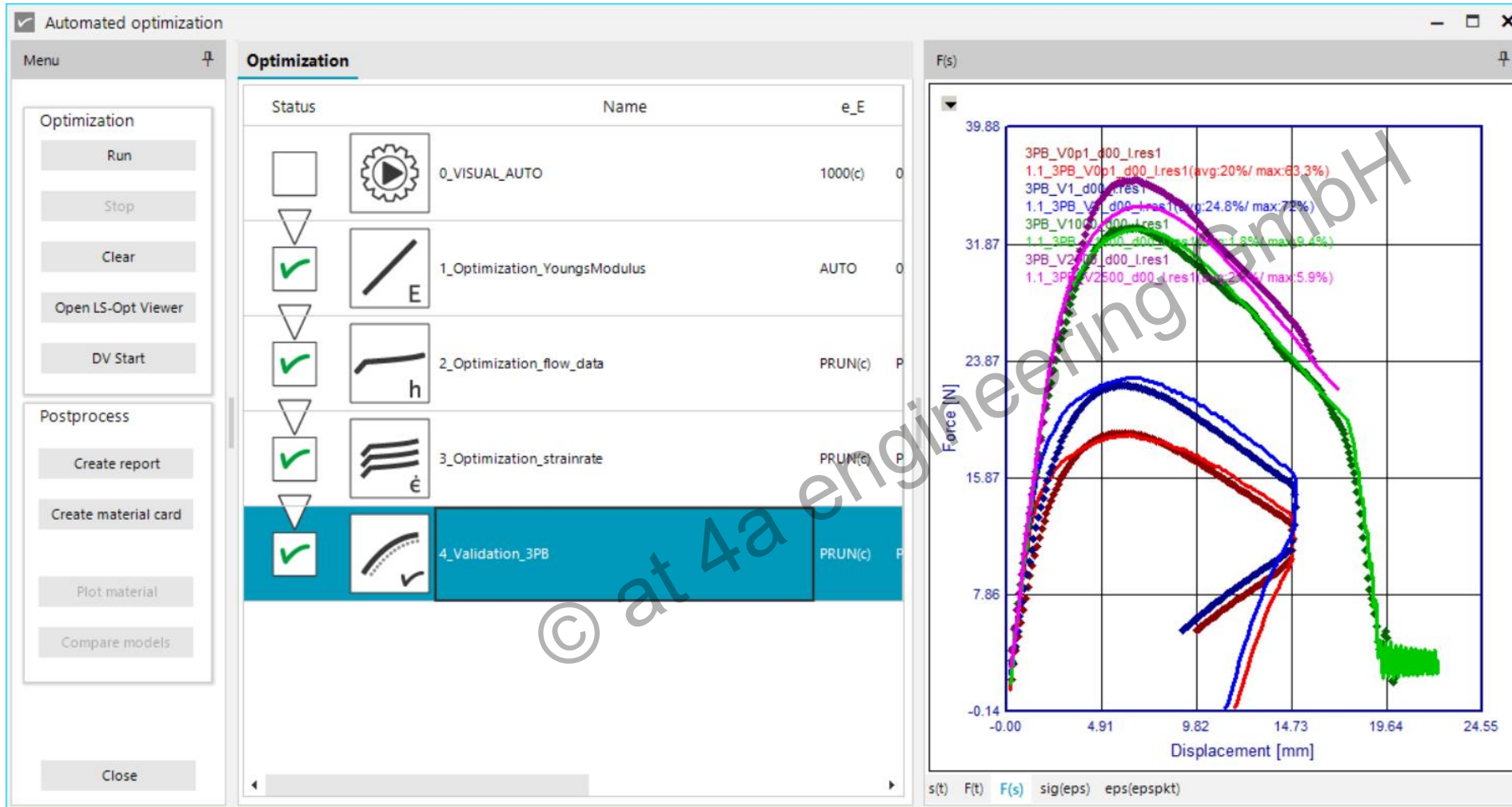
### Validation/Optimization: **Validation**

- All optimized Parameters are set to PRUN

© at 4a engineering GmbH

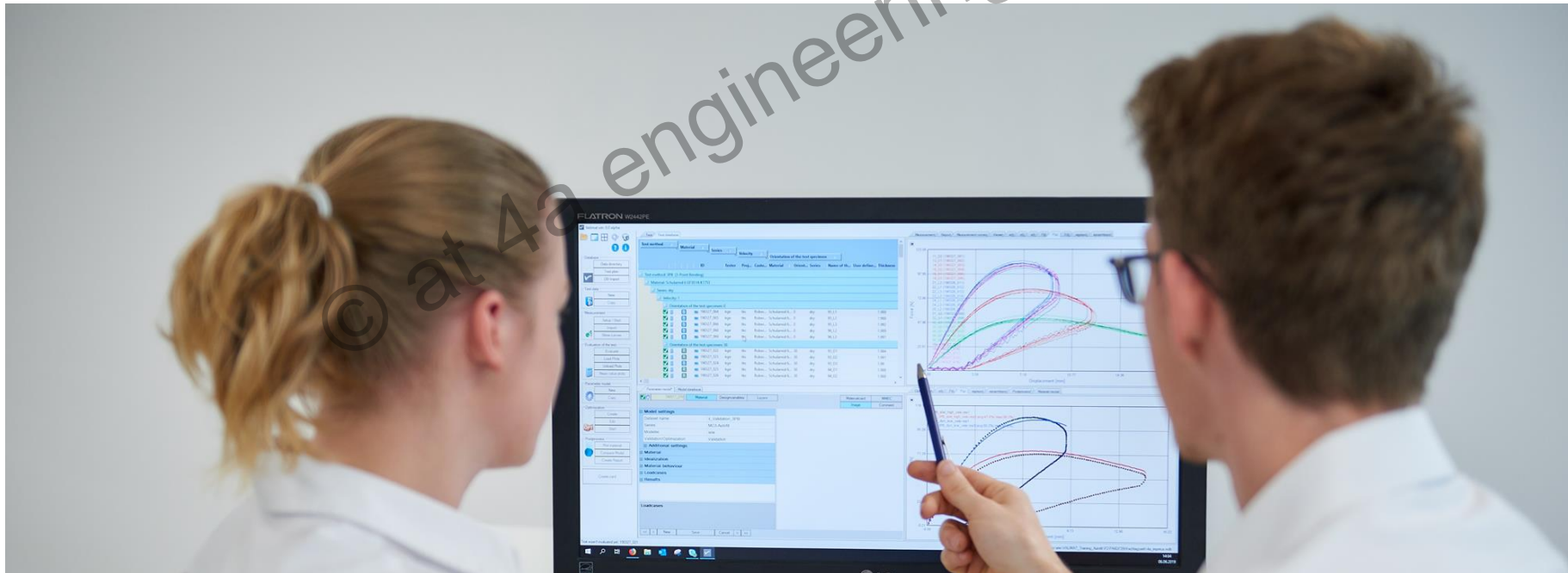
Name	Start	const...	from	to	Variance	Condi...
GroupName: 10_elasticity						
e_E	PRUN	<input checked="" type="checkbox"/>	100	10000	500	
e_nue	PRUN	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)	
GroupName: 20_yield						
y_0	PRUN	<input checked="" type="checkbox"/>	5	150	50	
GroupName: 21_hardening						
h_scale0	PRUN	<input checked="" type="checkbox"/>	0.5	1.0	(NULL)	
h_y	NaN	<input checked="" type="checkbox"/>	5	150	50	=y_0
h_ET	PRUN	<input checked="" type="checkbox"/>	0	100	(NULL)	<e_E
h_h	PRUN	<input checked="" type="checkbox"/>	5	200	(NULL)	
GroupName: 31_strainrate						
v_p	PRUN	<input type="checkbox"/>	20%	20%	(NULL)	
v_epspkt	PRUN	<input checked="" type="checkbox"/>	0.0001	1	(NULL)	

# AutoFit Validation

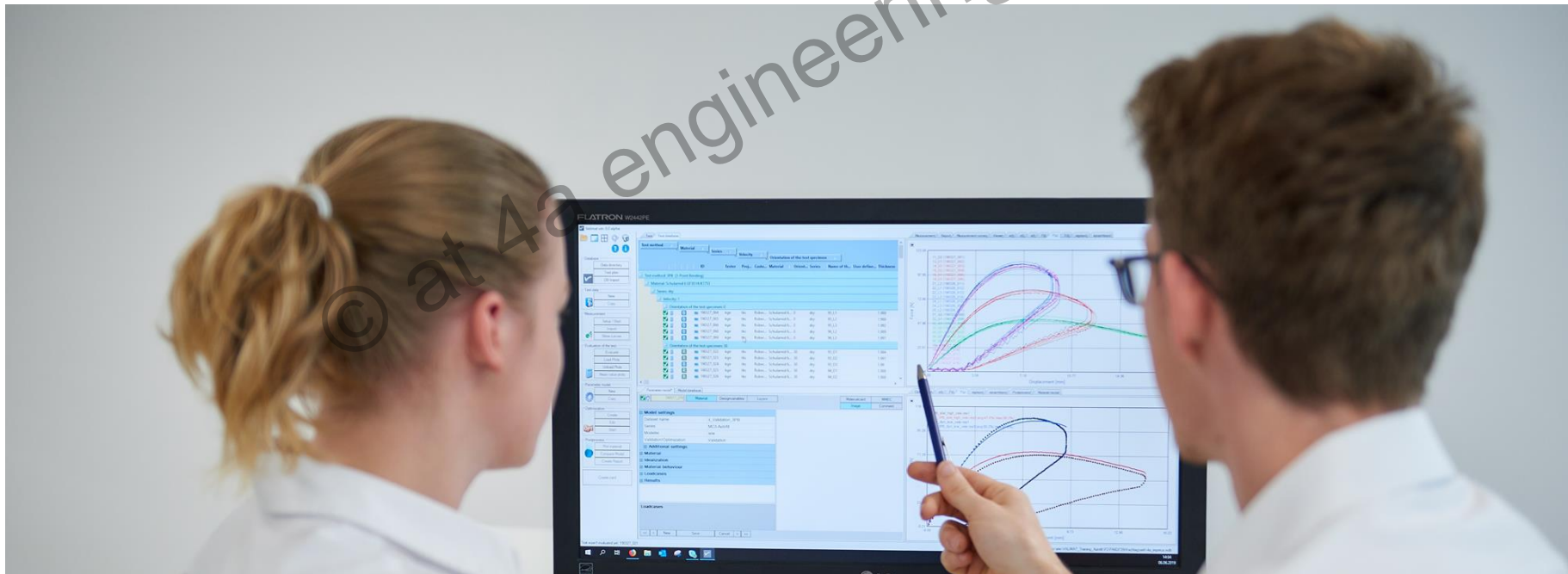


# MAT\_024 AutoFit - Live

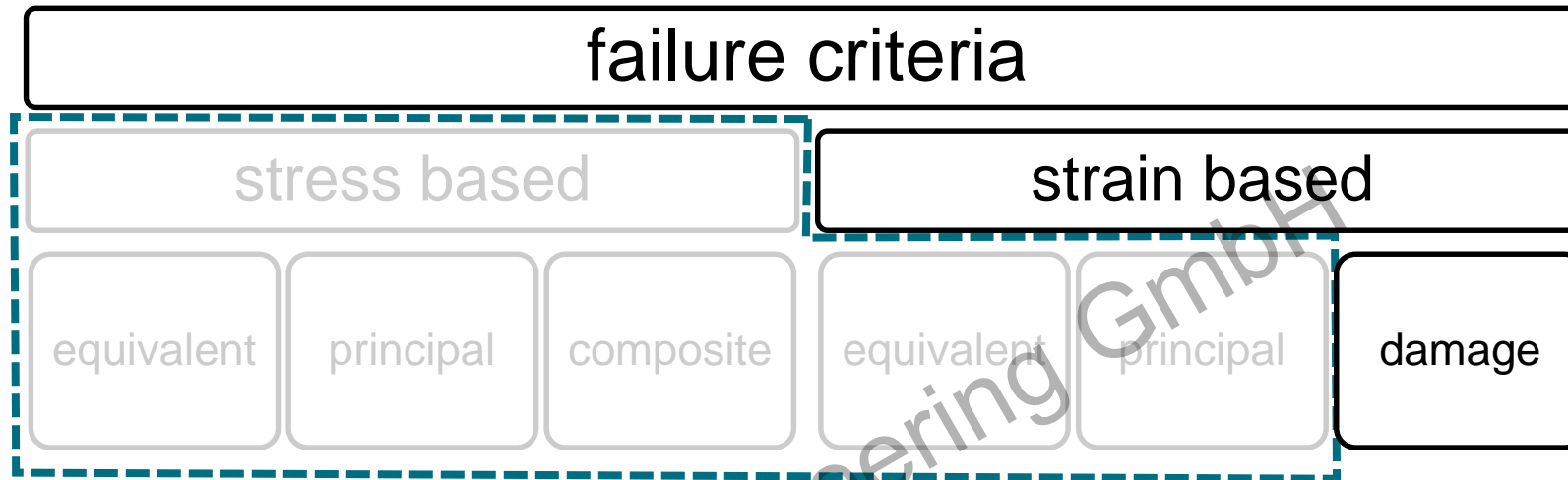
## Basis 3-Point-Bending



# Simple Failure



# Available failure models in LS-DYNA®



## **additional failure models**

### **\*MAT\_ADD\_EROSION**

### **strain damage based**

- *before R11 optional DIEM / GISSMO*
- *since R11 \*MAT\_ADD\_DAMAGE\_DIEM*
- *since R11 \*MAT\_ADD\_DAMAGE\_GISSMO*

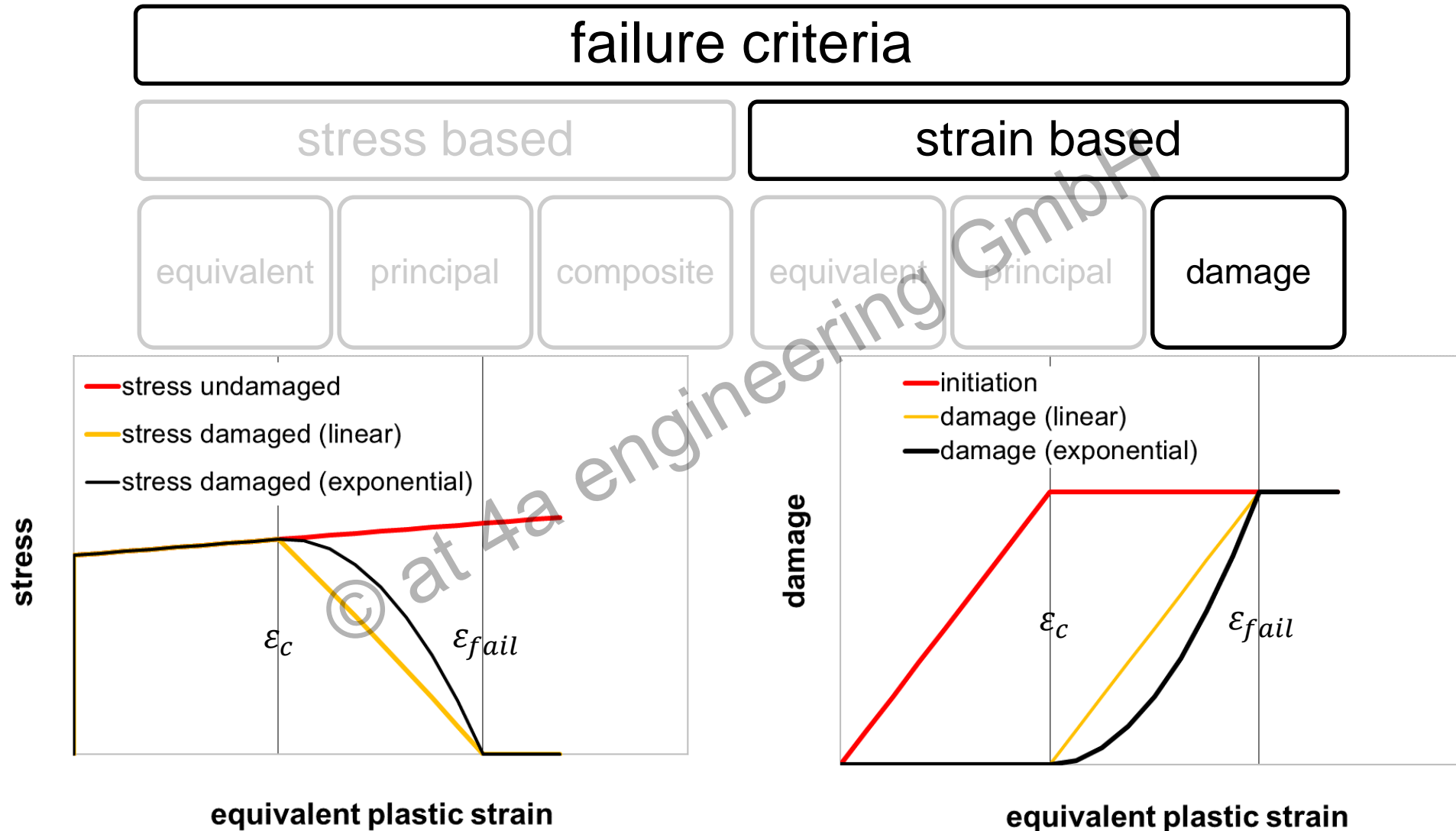
### **Included eq. pl. strain**

### **\*MAT\_024**

### **included damage model in**

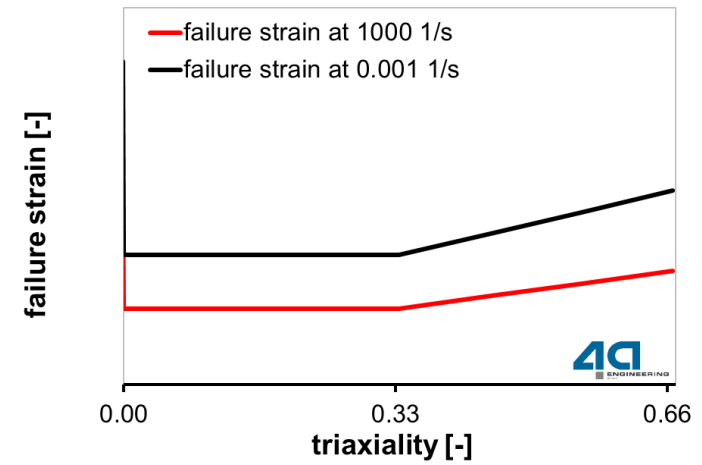
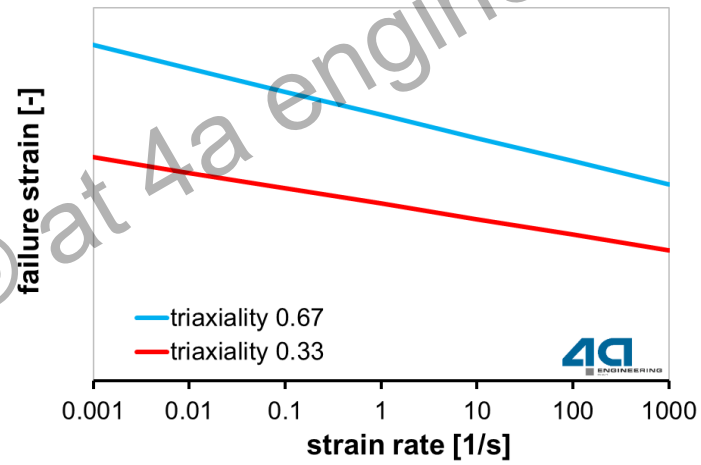
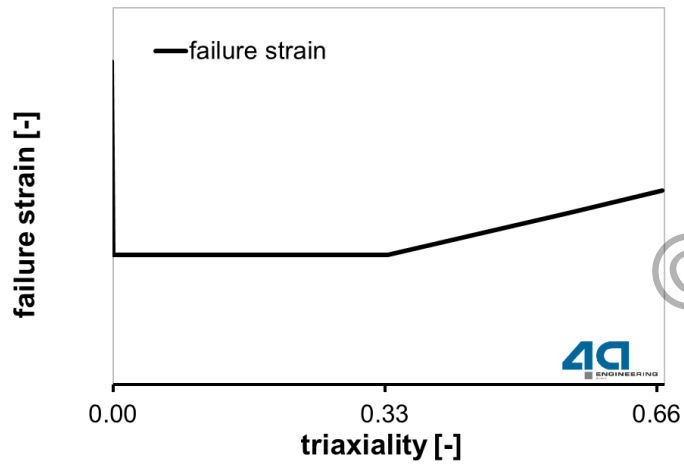
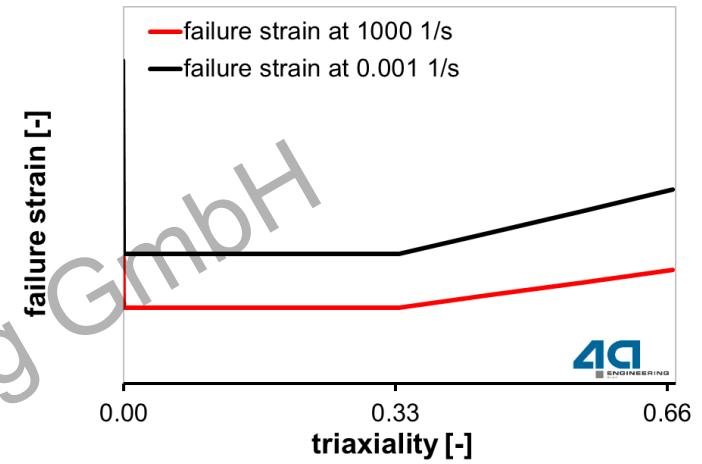
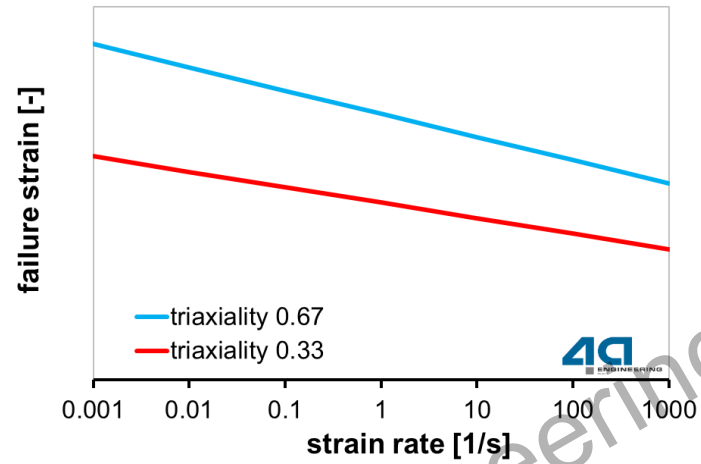
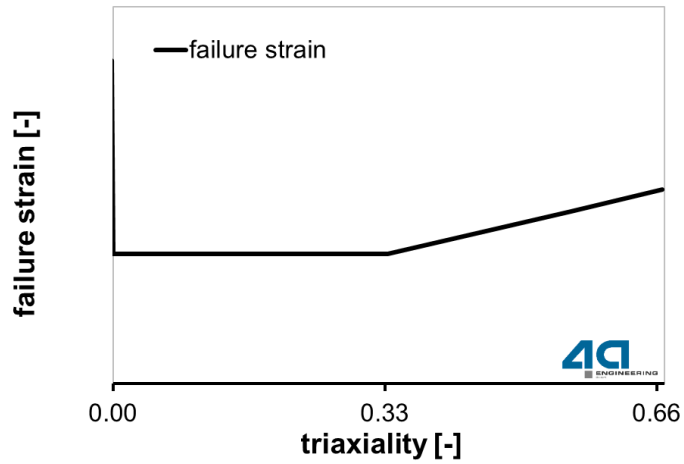
### **\*MAT\_SAMP-1(GISSMO like)**

# Available failure models – incremental damage formulation





# Comparison DIEM-GISSMO visualized



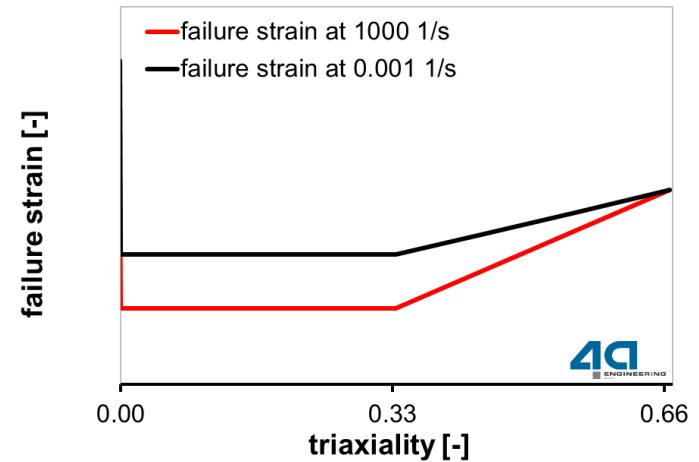
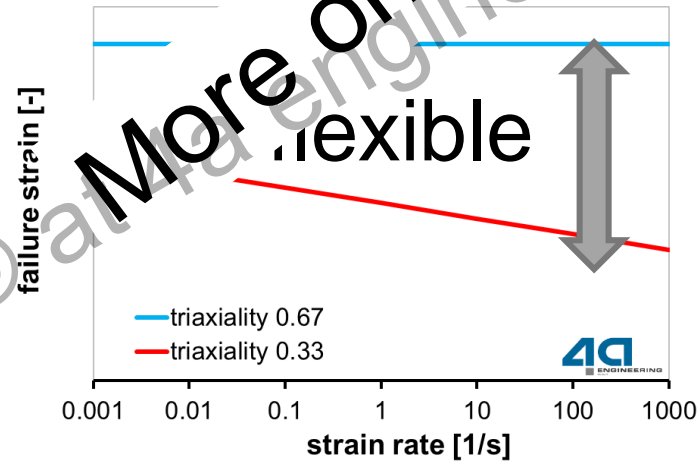
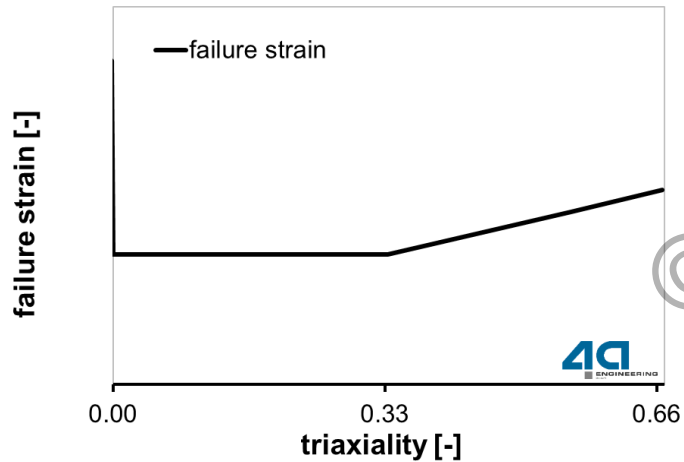
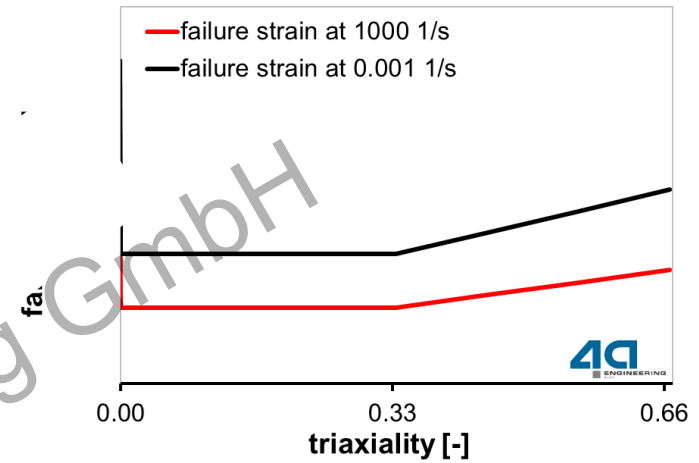
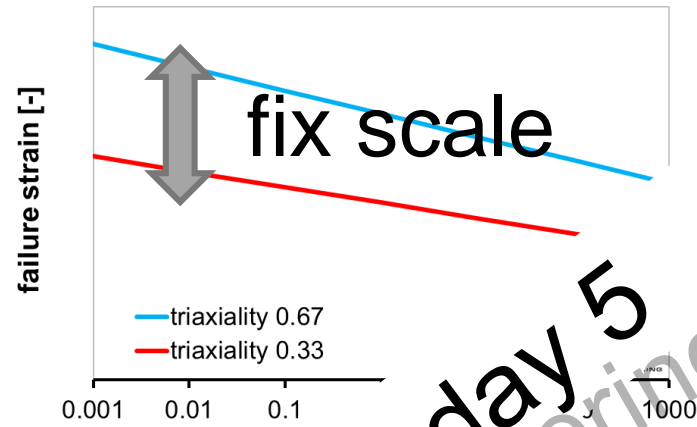
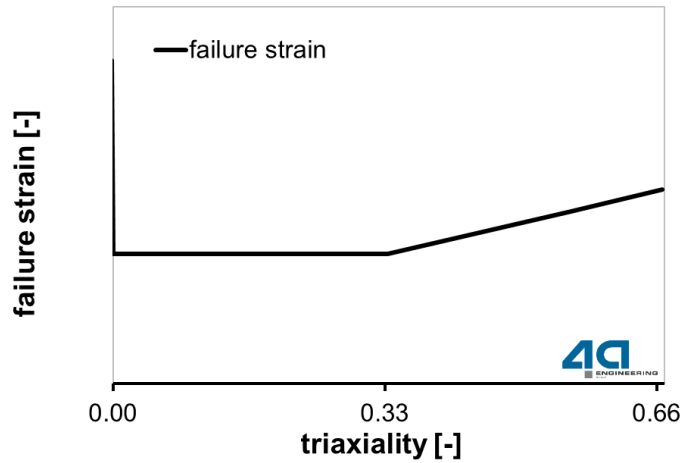
GISSMO

DIEM

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# Comparison DIEM-GISSMO visualized



GISSMO

DIEM

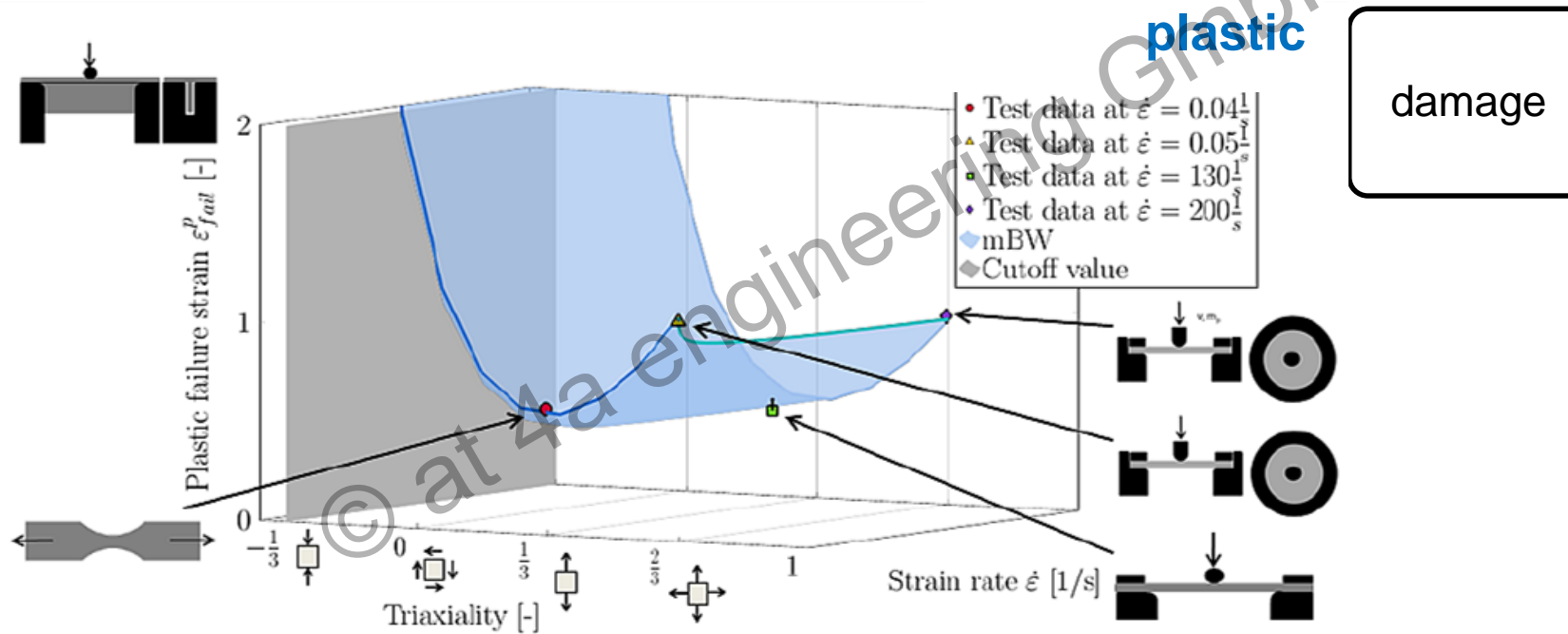
More on day 5  
© 4a engineering GmbH

# Available failure models – typical curves

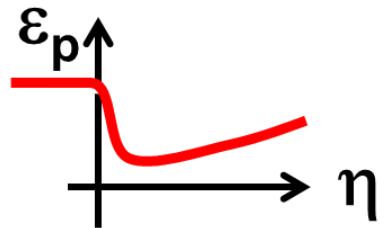
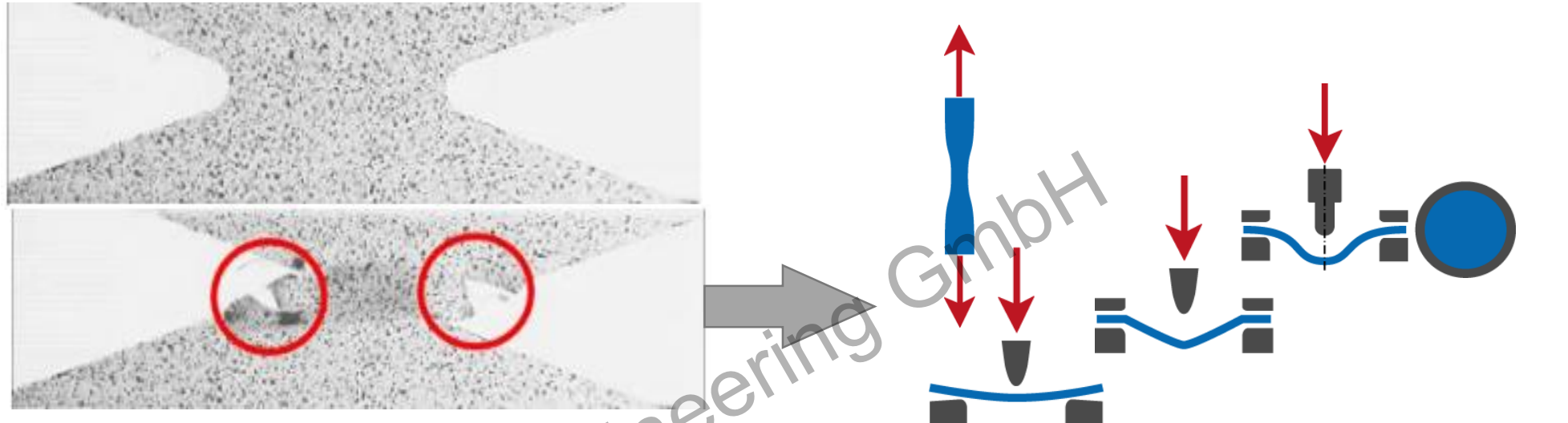
## failure criteria

stress based

strain based



# From test to material card



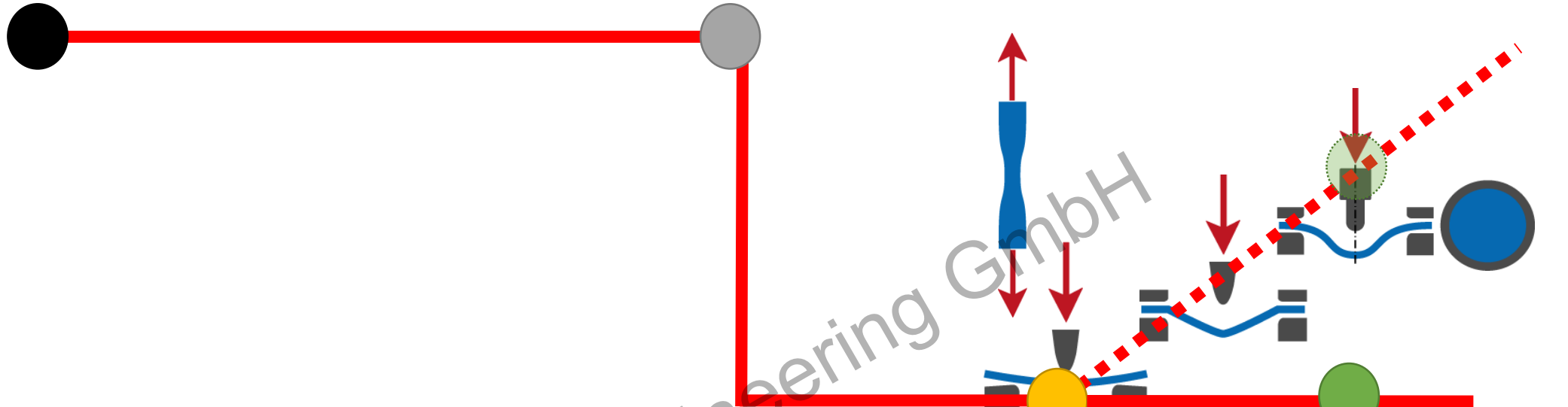
Damage/Failure

©

4a engineering GmbH

# From test to material card

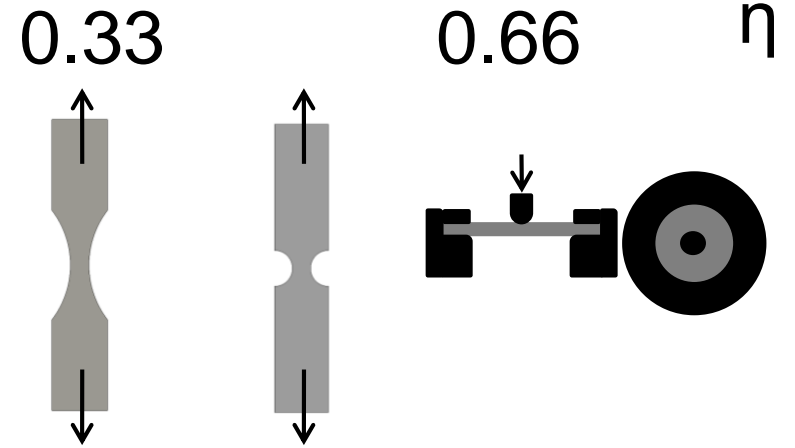
DIEM



GroupName: 51\_failure

xf_NUMFIP	-75	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)	Number of failed integration points pr...
fd_FC_m0p66	2	<input checked="" type="checkbox"/>	0.1	1	(NULL)	Failure curve point at TRIAX -0.66
fd_FC_m0p01	2	<input checked="" type="checkbox"/>	0.1	1	(NULL)	Failure curve point at TRIAX -0.01
fd_FC_0p0	0.4	<input checked="" type="checkbox"/>	0.8	1.3	(NULL)	Failure curve point at TRIAX 0.0
fd_FC_0p11	0.4	<input checked="" type="checkbox"/>	0.8	1.3	(NULL)	Failure curve point at TRIAX 0.11
fd_FC_0p22	0.4	<input checked="" type="checkbox"/>	0.8	1.3	(NULL)	Failure curve point at TRIAX 0.22
fd_FC_0p33	0.4	<input type="checkbox"/>	10%	10%	(NULL)	Failure curve point at TRIAX 0.33
fd_FC_0p44	0.4	<input checked="" type="checkbox"/>	0.8	1.3	(NULL)	Failure curve point at TRIAX 0.44
fd_FC_0p55	0.4	<input checked="" type="checkbox"/>	0.1	1	(NULL)	Failure curve point at TRIAX 0.55
fd_FC_0p66	0.4	<input checked="" type="checkbox"/>	0.1	1	(NULL)	Failure curve point at TRIAX 0.66

GroupName: 52\_failurerstrainrate



# Fracture models → \*MAT\_ADD\_EROSION



Parameter model\* Model database

170503\_024 Material Designvariables Layers

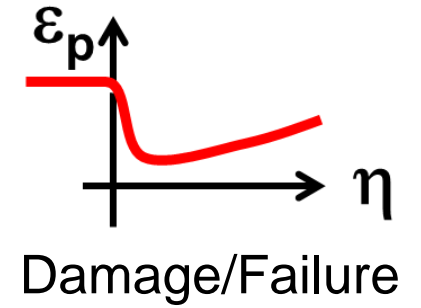
Materialcard MMEC  
Image Comment

- Material behaviour
  - Material source
    - Elasticity
    - Plasticity
    - Failure/Damage
  - Material card
    - Materialcardcase
    - Damage/Failurecase
    - Materialcard id
    - Density
    - Plasticity
  - Function (Hardening, Elastic curve form)
    - Curve 1
    - Curve 2
    - Strain range upto
    - Sampling points
    - Bias factor
  - Strain rate dependency
    - Strain rate dependency
  - Fracture
    - Ductile Damage Settings
    - Shear Damage Settings
    - FLC Damage Settings
    - Strainrate Settings
    - Postfracture
  - Loadcases
  - Results

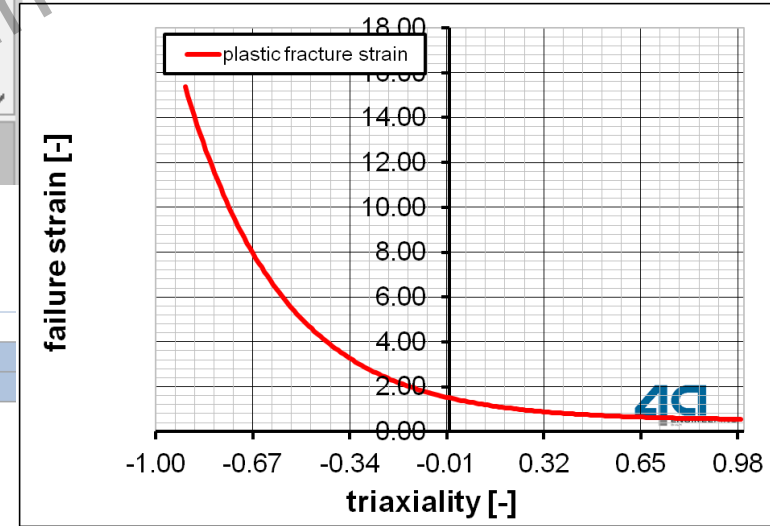
Density	-1
Plasticity	vonMISES
Function (Hardening, Elastic cur	
Strain rate dependency	Table
Fracture	Damage
Ductile Damage Settings	Johnson Cook
Shear Damage Settings	None
FLC Damage Settings	plastic equivalent strain
Strainrate Settings	simple criteria
Postfracture	4a picewise linear
Loadcases	Johnson Cook
Casename	mod Xue-Wierzbicki
Tests	Xue-Wierzbicki
Settings optimization	Mohr-Coulomb
Weighting case	1

**Ductile Damage Settings**

lower triax value	0.33	Johnson Cook
upper triax value	None	mod Xue-Wierzbicki
step size triax	None	Xue-Wierzbicki
Shear Damage Settings	None	Mohr-Coulomb
FLC Damage Settings	None	
Strainrate Settings	Johnson Cook	
Postfracture	Fracture Energy (TRIAX)	



$$f_{dJCD1} + f_{dJCD2} \cdot e^{-f_{dJCD3} \cdot \eta}$$



# Automatic report generation

- Requirements

- A testing database with correct values in the following fields

			ID	Project name	Customer	Material	Series	Thickness	Width	Length	Temperatu...	Mass of the pendulum	Velocity	Distance of support...
✓		B	140313_001	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.8	10	50	23	1466	1	39.89
✓		B	140313_002	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.81	9.97	50	23	1466	1	39.89
✓		B	140313_003	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.82	9.99	50	23	1466	1	39.89
✓		B	140313_004	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.82	9.98	50	23	1466	1	39.89
✓		B	140313_005	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.8	9.99	50	23	1466	1	39.89
✓		B	140313_006	Ringversuch	4a engineering GmbH	PP LGF30	longitudinal	1.82	10	50	23	1466	1	39.89
✓		B	140313_007	Ringversuch	4a engineering GmbH	PP LGF30	perpendicular	1.82	9.97	50	23	1466	1	39.89
✓		B	140313_008	Ringversuch	4a engineering GmbH	PP LGF30	perpendicular	1.81	9.97	50	23	1466	1	39.89
✓		B	140313_009	Ringversuch	4a engineering GmbH	PP LGF30	perpendicular	1.83	9.98	50	23	1466	1	39.89
✓		B	140313_010	Ringversuch	4a engineering GmbH	PP LGF30	perpendicular	1.82	9.99	50	23	1466	1	39.89

- A model database with correct values in the following fields

	ID	Dataset name	Material name	Series
Material name:				
Material name: PPLGF30				
Series: longitudinal				
✓	140318_002	Young's Modulus	PPLGF30	longitudinal
✓	140318_003	Plastic Data	PPLGF30	longitudinal
✓	140318_004	Strain Rate Dependency	PPLGF30	longitudinal
✓	140318_005	Validation	PPLGF30	longitudinal

- Powerpoint templates

# Automatic report generation

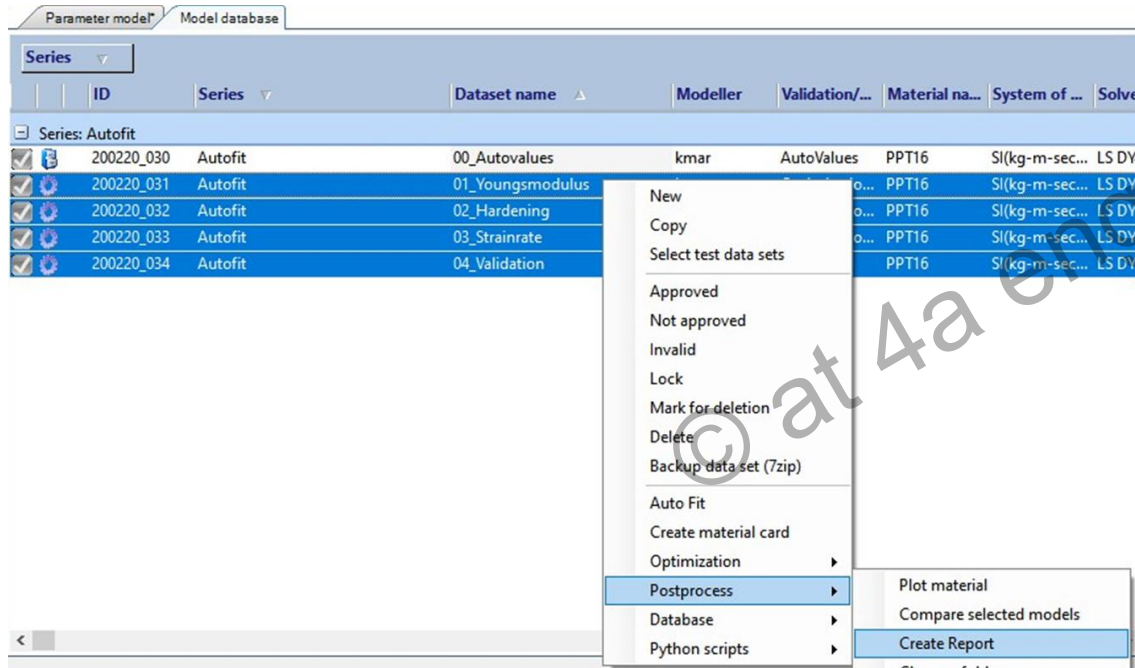
- Generation of a template
  - One can generate customized .PPTX template
  - There are several possibilities to choose from
    - `<<img_sc_F(s);auto;legend_off>>` : image of the simulation curve force vs. displacement with auto scaling and without a legend
    - `<<img_sc_F(s);0;0.002;0;1000>>` : image of the simulation curve force vs. displacement with scaling from 0 to 0.002 m and from 0 to 1000 N
    - `<<img_sc_sig(eps);auto;legend_off;sc_only>>` : image of the simulation curve stress vs. strain with auto scaling and without a legend; just the simulation curves are displayed
    - `<<img_tc_v(t)>>` : image of the test curve(s) velocity vs. time with auto scaling
    - `<<img_tc_F(t);xmin;xmax;ymin;ymax>>` : image of the test curve(s) force vs. time with the scaling xmin to xmax for time and ymin to ymax for force; values have to be replaced



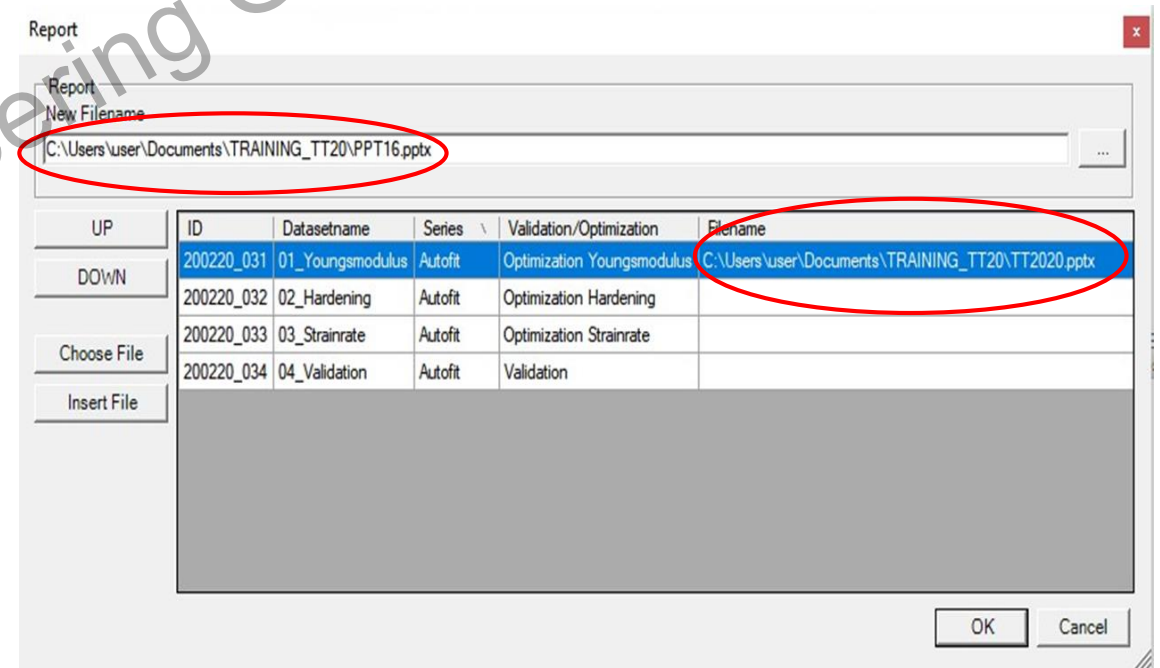
# Automatic report generation

- Export using Template

## Template



## Generated report



# Automatic report generation

## Template

measurement results, <<db\_T\_case\_1>>°C, <<db\_mattyp>>  
overview



E moduli



Hardening



<<img\_sc\_F(s);auto;legen  
d\_off;index:1>>

<<img\_sc\_F(s);auto;legen  
d\_off;index:2>>

3-point bending



Strain rate dependency



Validation of curves



<<img\_sc\_F(s);auto;legen  
d\_off;index:3>>

<<img\_sc\_F(s);auto;legen  
d\_off;index:4>>

## Generated report

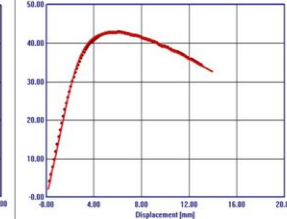
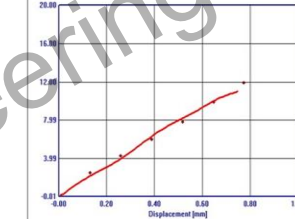
measurement results, 23°C, PPT16  
overview



E moduli



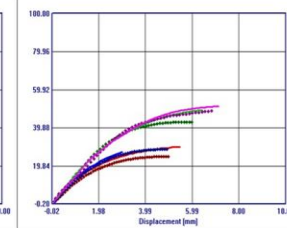
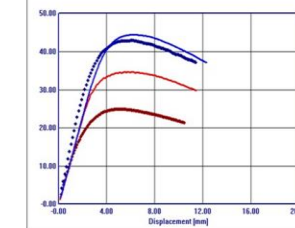
Hardening



Strain rate dependency



Validation of curves



3-point bending



# Automatic report generation

- Tests are exported to a Powerpoint

## Template

Reverse engineering, <<db\_mattyp>>, <<db\_T\_case\_1>>°C  
3-point-bending tests



<<img\_sc\_F(s);auto;legend\_off>>

Case	V <sub>0</sub> [m/s]	l <sub>w</sub> [mm]	m <sub>Pendulum</sub> [g]	b [mm]	t [mm]	l [mm]
<<case_1>>	<<db_v_a>>	<<db_l_w>>	<<db_mp>>	<<db_b1>>	<<db_h1>>	<<db_l1>>
<<case_2>>						
<<case_3>>						
<<case_4>>						
<<case_5>>						

◆◆◆ Mean value curves testing  
— optimization curves simulation

model <<db\_model\_id>>  
solver <<db\_solver>>, material card: <<db\_mat\_file>>, element size: <<db\_esize>>mm,  
element type: <<db\_eltype>>, through thickness integration points: <<db\_nlayers>>  
assumptions: Poisson's ratio: <<db\_nu>>, friction coefficient: <<db\_fr>>

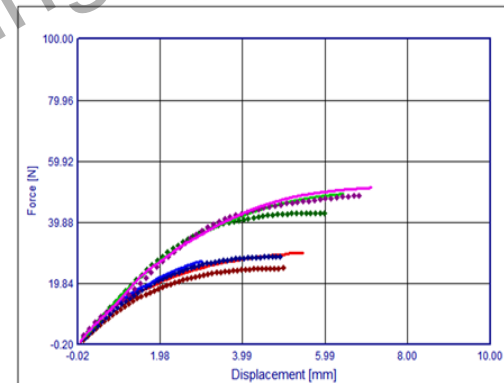


## Generated report

Reverse engineering, PPT16, 23°C  
3-point-bending tests



Case	V <sub>0</sub> [m/s]	l <sub>w</sub> [mm]	m <sub>Pendulum</sub> [g]	b [mm]	t [mm]	l [mm]
stat_low_vel_VP	0.0001	40.01	0	10.02	2.42	50.19
stat_high_vel	0.001	40.01	0	10.03	2.42	50.20
dyn_low_vel_EL_HC_VP	1	40.03	1580	10.03	2.42	50.18
dyn_high_vel	4	40.03	1580	10.02	2.42	50.20



model 200220\_034  
solver LS DYNA, material card: MAT\_PIECEWISE\_LINEAR\_PLASTICITY (MAT\_024), element size: 2mm,  
element type: 16, Fully integrated shell element (very fast), through thickness integration points: -1  
assumptions: Poisson's ratio: 0.3, friction coefficient: 0.1



# Thank you for your Attention!

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

SAVE THE DATE

10. July - Summary, lessons learned, outlook and  
upcoming features

✓ **VALIMAT**

more information on our software



$\alpha$   
Anisotropic

$\epsilon_p$   
Damage/Failure

$\Phi_p$   
Triaxiality

$\sigma_{vm}$   
Hardening

$\eta$

$\epsilon_p$

[www.4a-engineering.at/valimat](http://www.4a-engineering.at/valimat)

◀ **IMPETUS**

comprehensive test package overview



**4a**  
ENGINEERING

[www.4a-engineering.at/test-packages](http://www.4a-engineering.at/test-packages)