



VALIMAT



IMPETUS

4a Summer School

Introduction to VALIMAT® - from test to material card

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Traboch, 07.07.2020



Content

- 4a Summer School
 - Outlook on the upcoming week
 - Additional information
- Introduction 4a engineering GmbH
- Motivation and case studies
- IMPETUS[®] - short introduction in efficient dynamic testing
- VALIMAT[®] - from test to material card – a first look
- Summary

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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

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



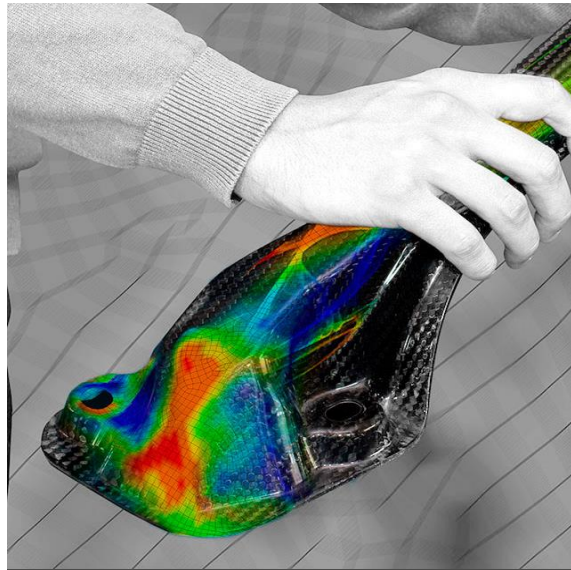
17. July - Python: a powerful tool with VALIMAT®,
user defined material cards/specimen



excellence in
plastics&simulation
testing equipment
lightweight products



4a business units



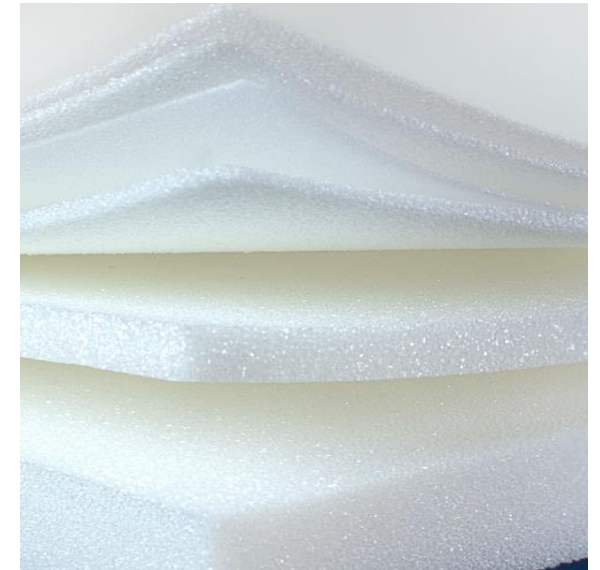
4a engineering
Engineering and simulation for plastic products and composites



Impetus
Testing equipment generating material data for the dynamic simulation of plastics



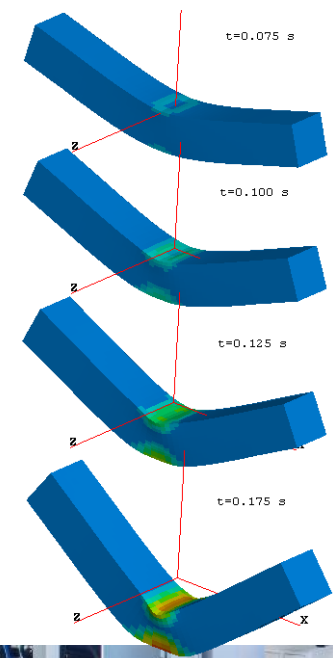
4activeSystems
Dummies and testing facilities for active vehicle safety



4a manufacturing
Specialized thin foams and multi layer materials

Material characterization - services

- efficient high-dynamic testing
- dynamic material behaviour
- plastics, foams, composites, ...
- **validated material cards ready to use for your crash-simulation**



validated material cards – packages

- isoP - isotropic Plastic
- frP – fibre reinforced Plastic
- comP - composite
- foam

Materialcard detail	basic	standard	prof.
strain rate/hardening	isoP & frP		
compression/tension asymmetry		isoP & frP	
damage/failure		isoP & frP	
validation on component			isoP & frP

Comprehensive overview



4a test packages

thermoplastic materials
setups & measurement definition



excellence in ..
from test to material card
efficient dynamic testing for
plastics, foams, composites, ...



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*Standard package optionally includes temperature-based measurements



validated material cards - injection mold for plastics

Dom & Wall thickness



Melt- & Weldlines

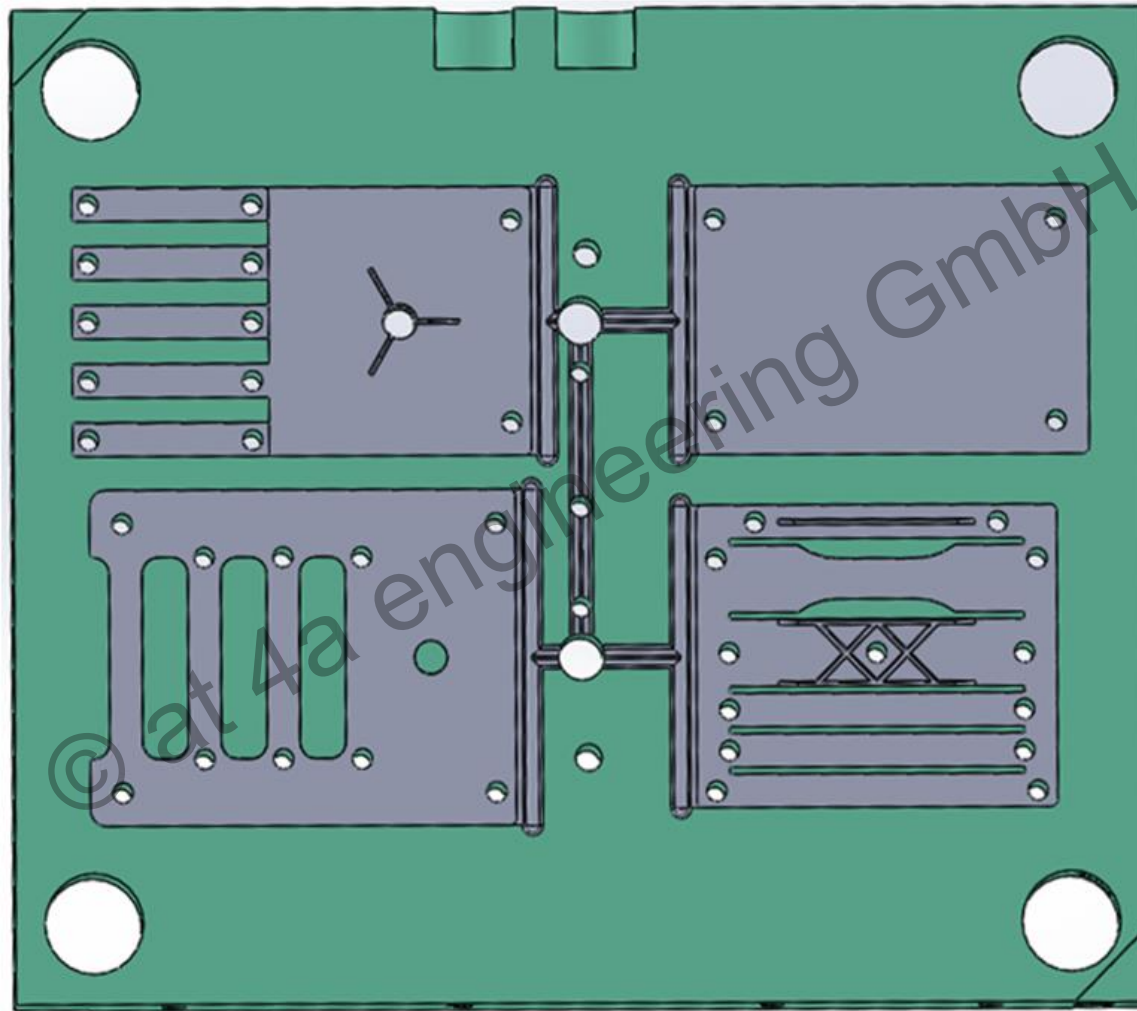
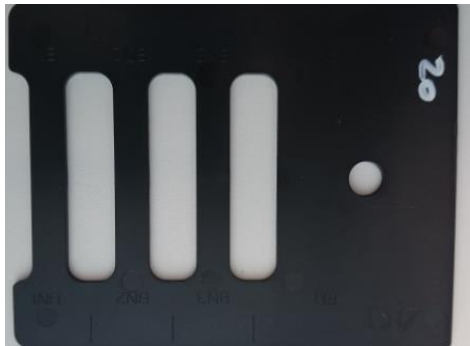


Plate 120 x 80 x 2 mm

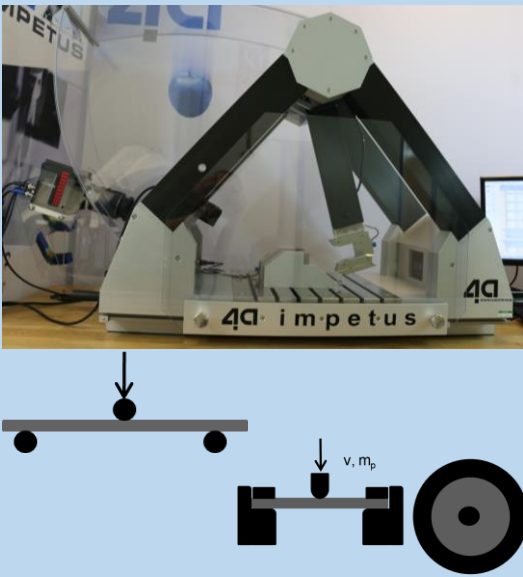


Multi-Specimen & XX-Rib & Component



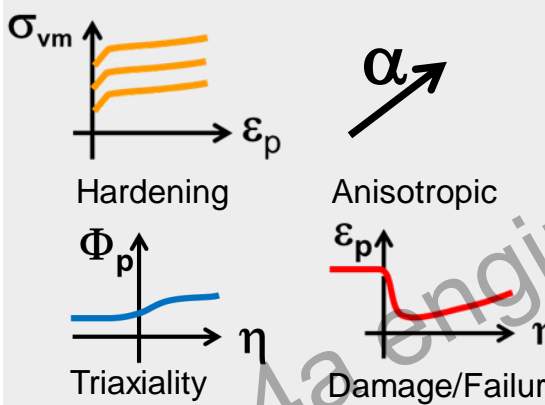
Intelligent reliable solutions for plastics, composites, metals, foams, ...

IMPETUS



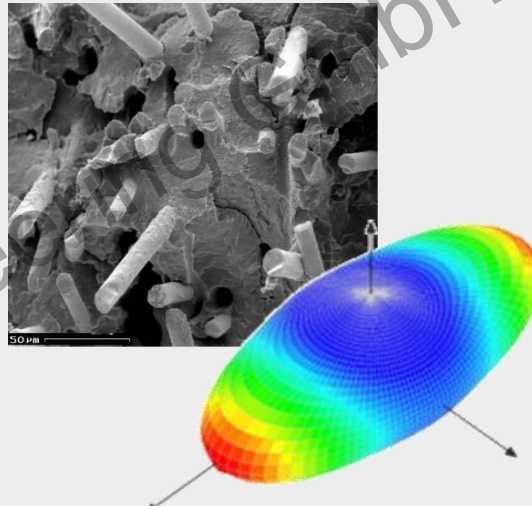
efficient dynamic testing

VALIMAT



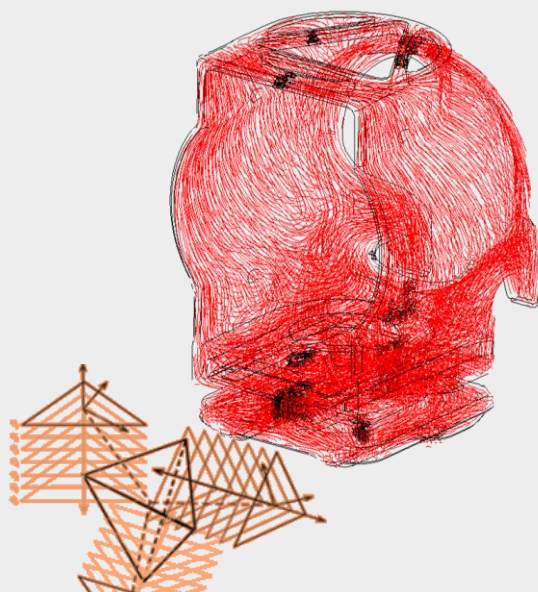
from test to validated material cards

MICROMECH



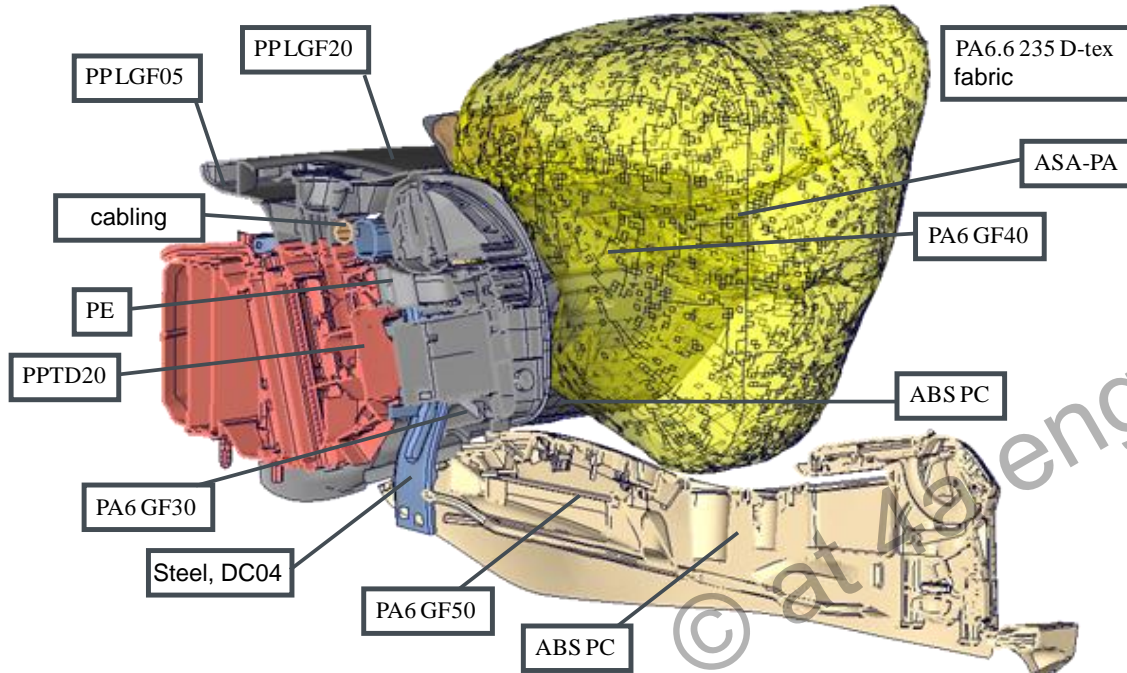
3D anisotropic material cards

FIBERMAP

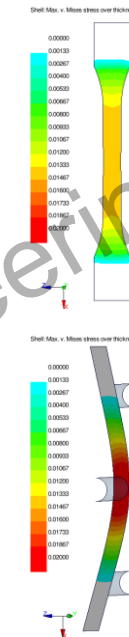


individual mapping process information

material variety

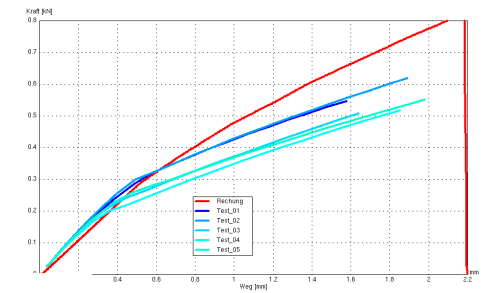
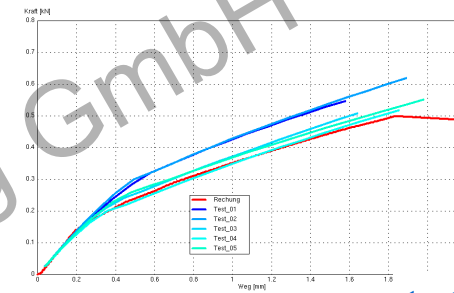


bending load case

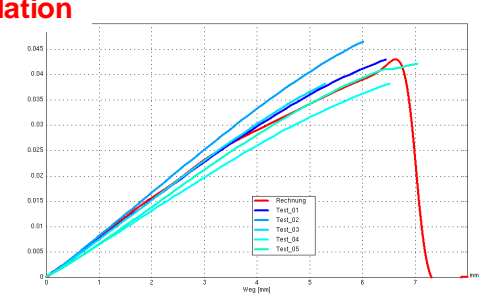
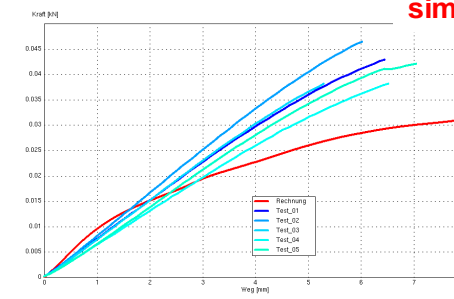


original test curve tension

scaling 1.25



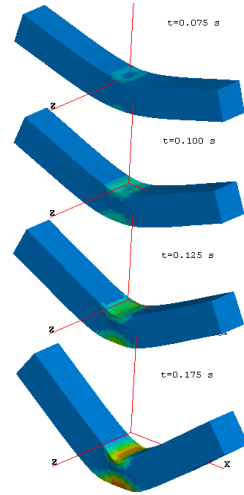
test simulation



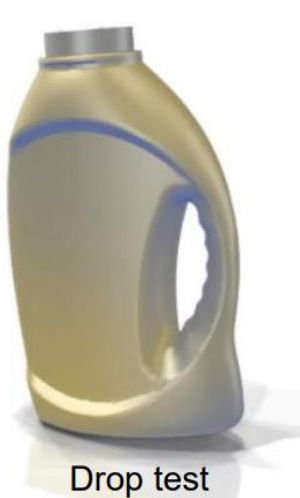
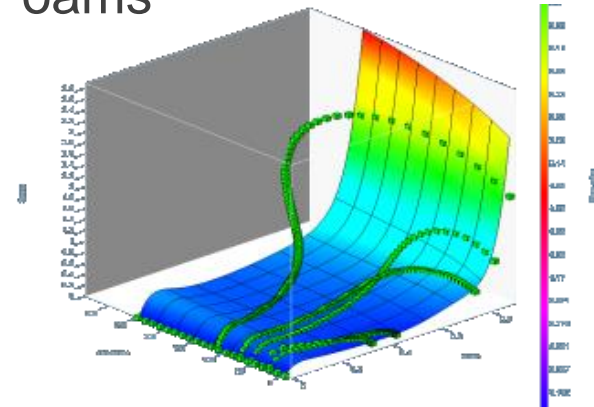
Source: R. Luijckx - Kunststoffmaterialien in der Interieur Funktionsauslegung bei Audi AG, 4a Technologietag 2010

Case study – drop test

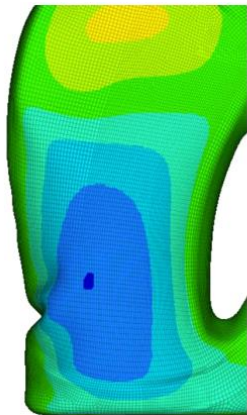
- Drop test of plastic bottle
- Easy to use material card
- **good prediction with new material card from 4a**



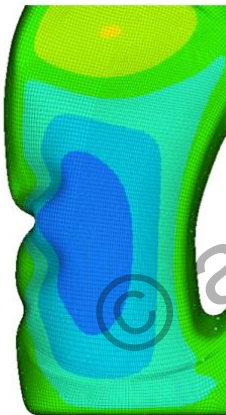
- Droptest of Beamer
- Packaging EPS/EPP Foams
- Energy absorption



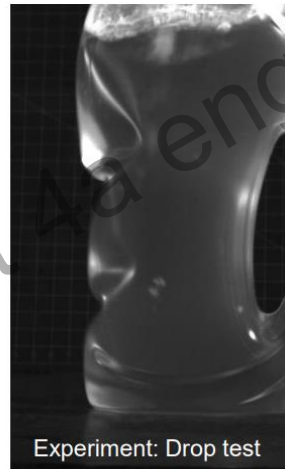
Drop test



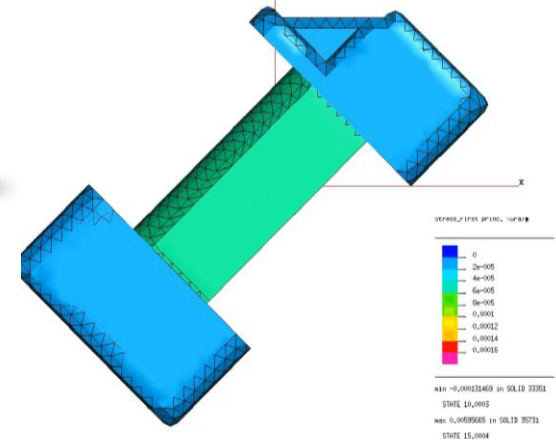
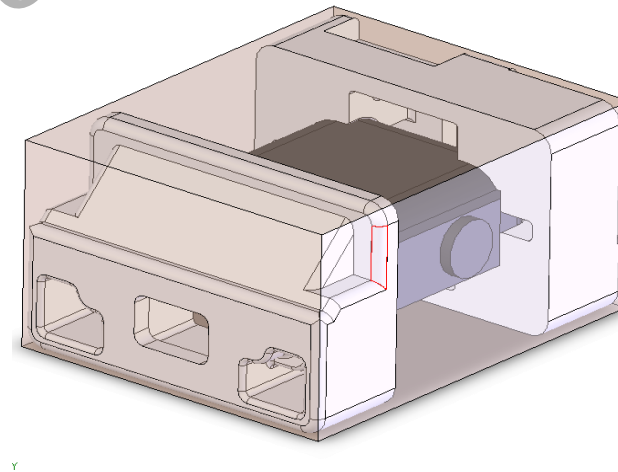
No rate dependency (old)



With rate dependency (new)



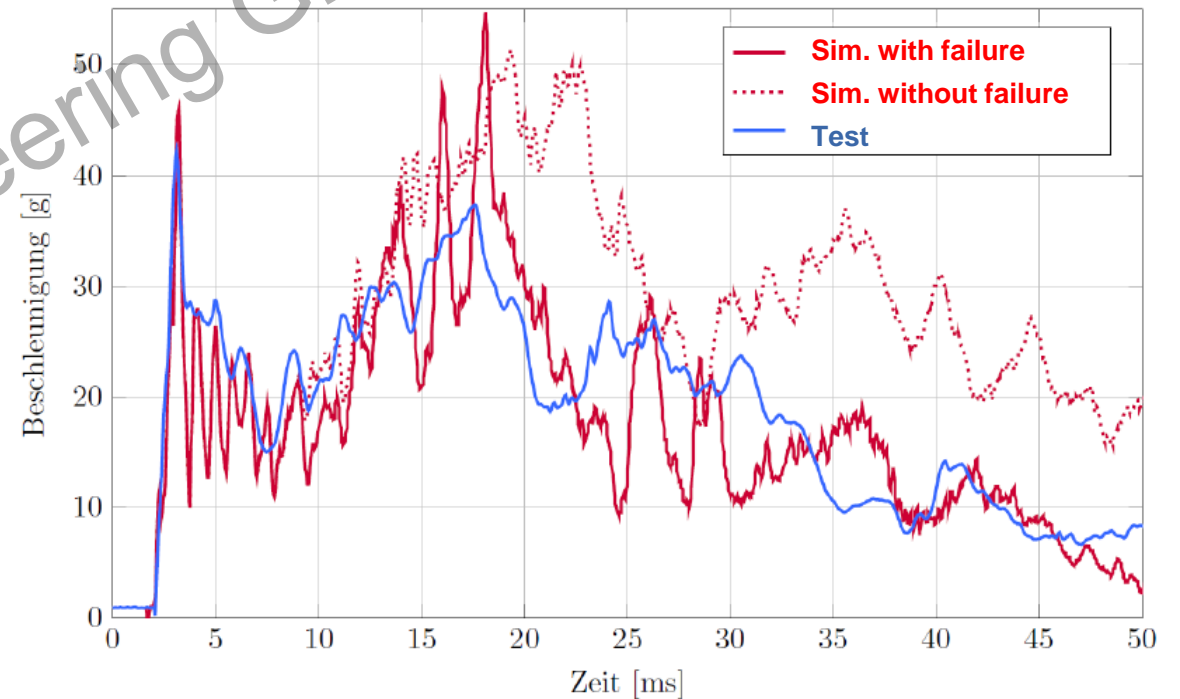
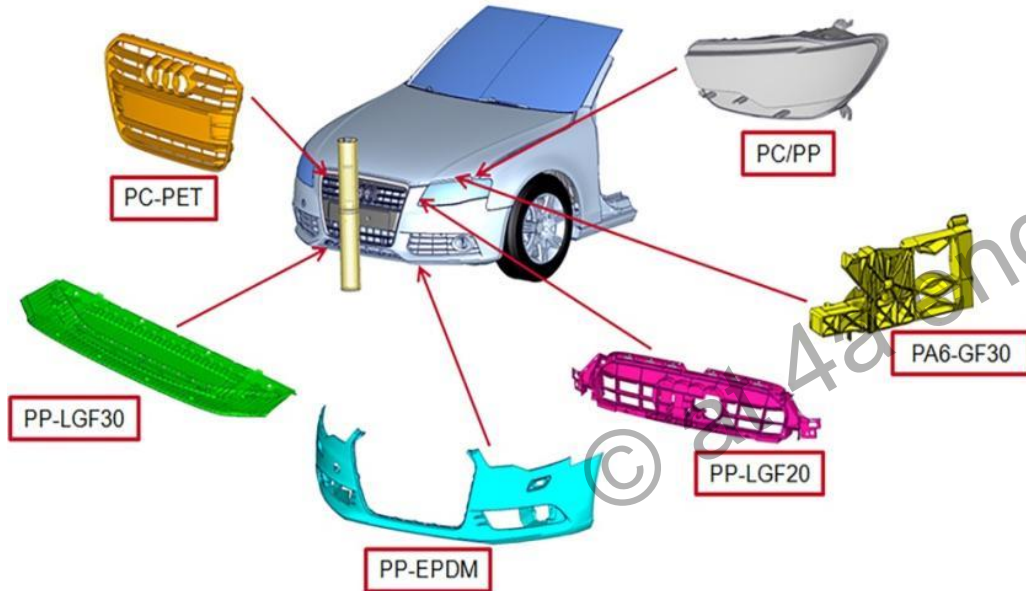
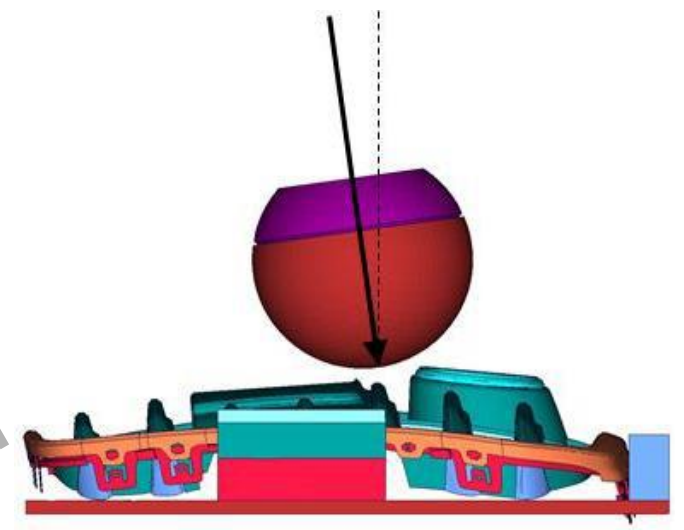
Experiment: Drop test



[SOURCE: LINK to PAPER](#)

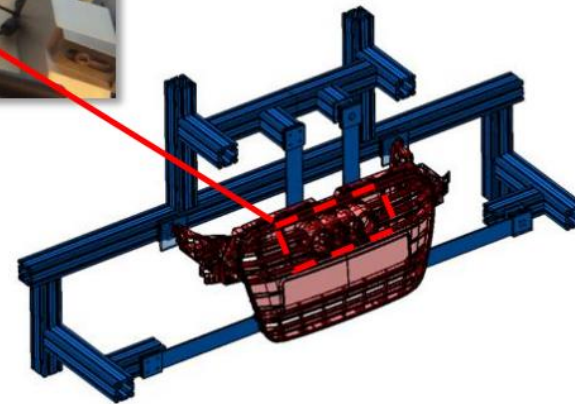
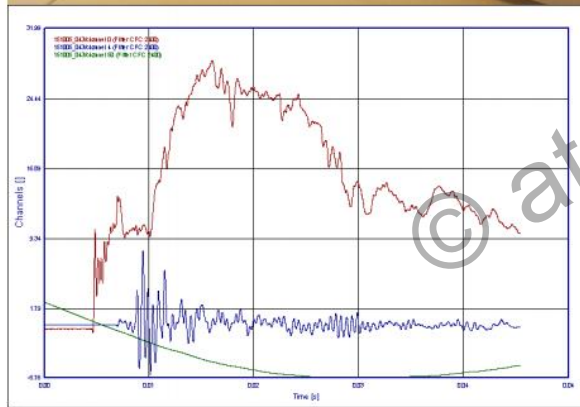
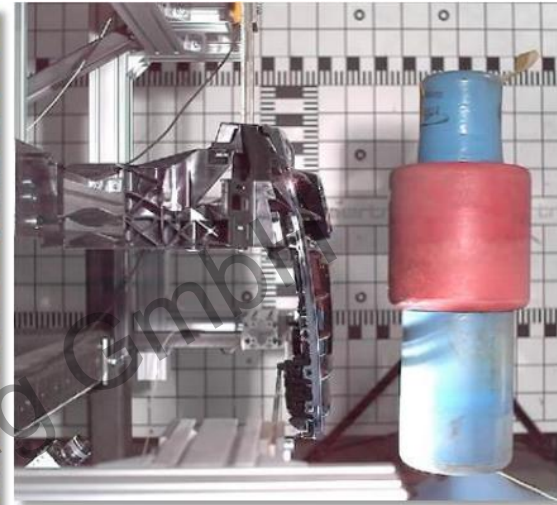
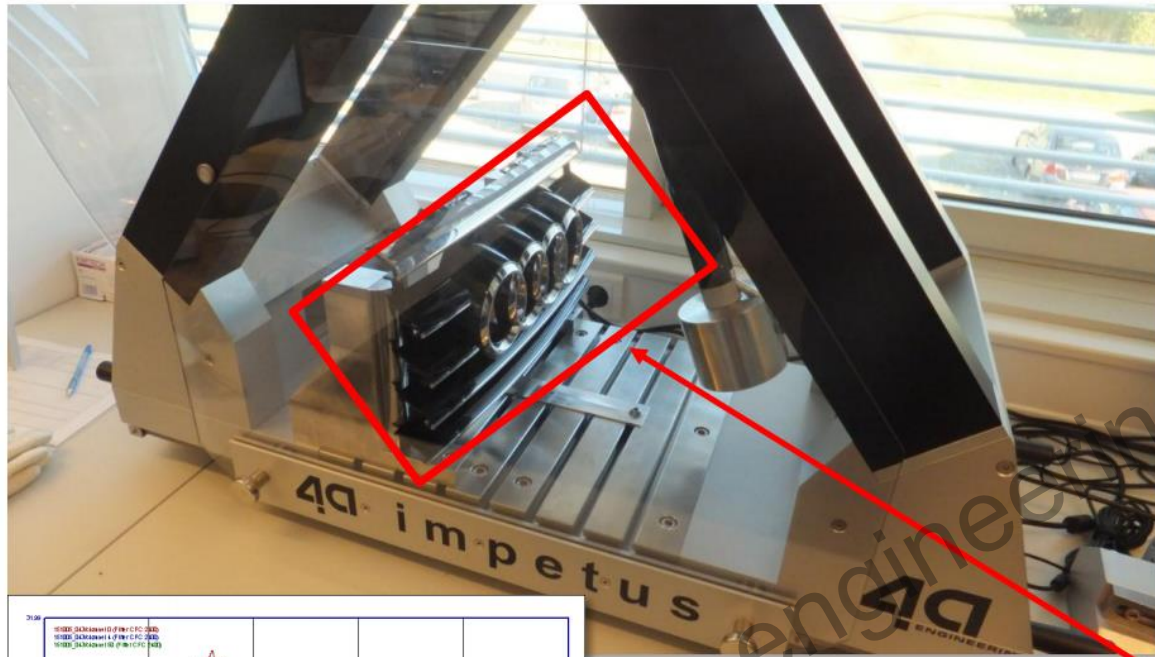
Case study - pedestrian safety

- Low Speed Impact behavior
- Plenty of different plastic grades
- Temperature influence -35°C up to 80°C



[SOURCE: LINK to PAPER](#)

Case study - pedestrian safety Component Testing



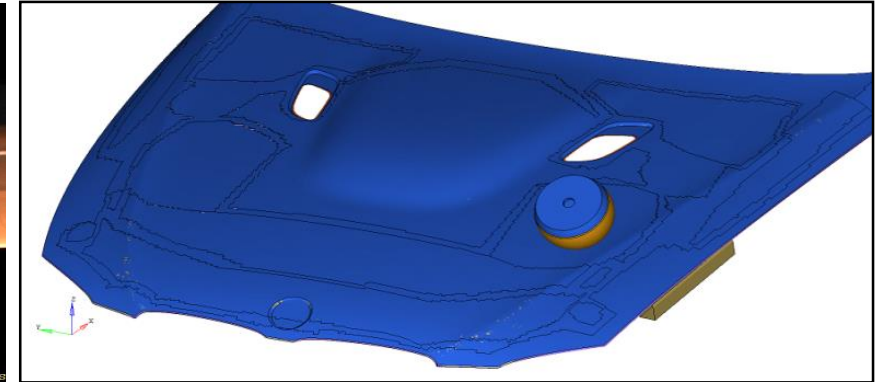
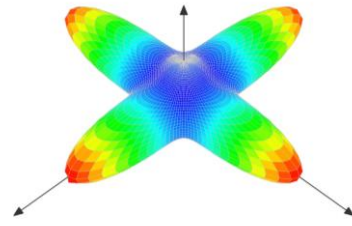
22 H. Staack/ A. Koukal, AUDI AG, Ingolstadt

Audi Vorsprung durch Technik 

[SOURCE: LINK to PAPER](#)

Case study - composite

- Front hood
 - Stiffness versus pedestrian safety
- Material card
 - Composite layup with anisotropic material behavior
 - Core material – Honeycomb different compression levels



[SOURCE: LINK to PAPER](#)

Intelligent reliable solutions for plastics, composites, metals, foams, ...

◀ **IMPETUS**

✓ **VALIMAT**

◉ **MICROMECH**

➤ **FIBERMAP**

Foams

Thermoplastics

Fiber reinforced Plastics (SFRT & LFRT)

Composites (Carbon)

Metals

efficient
dynamic testing

from test to validated
material cards

3D anisotropic
material cards

individual mapping
process information

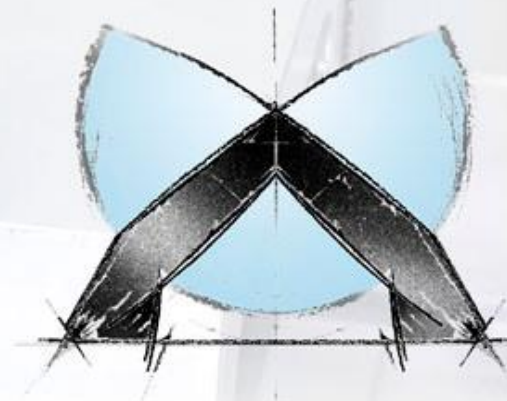
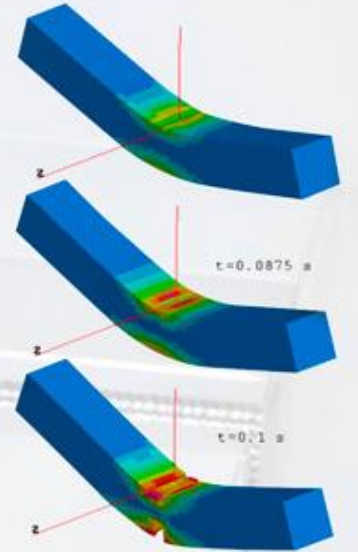
efficient dynamic testing



IMPETUS

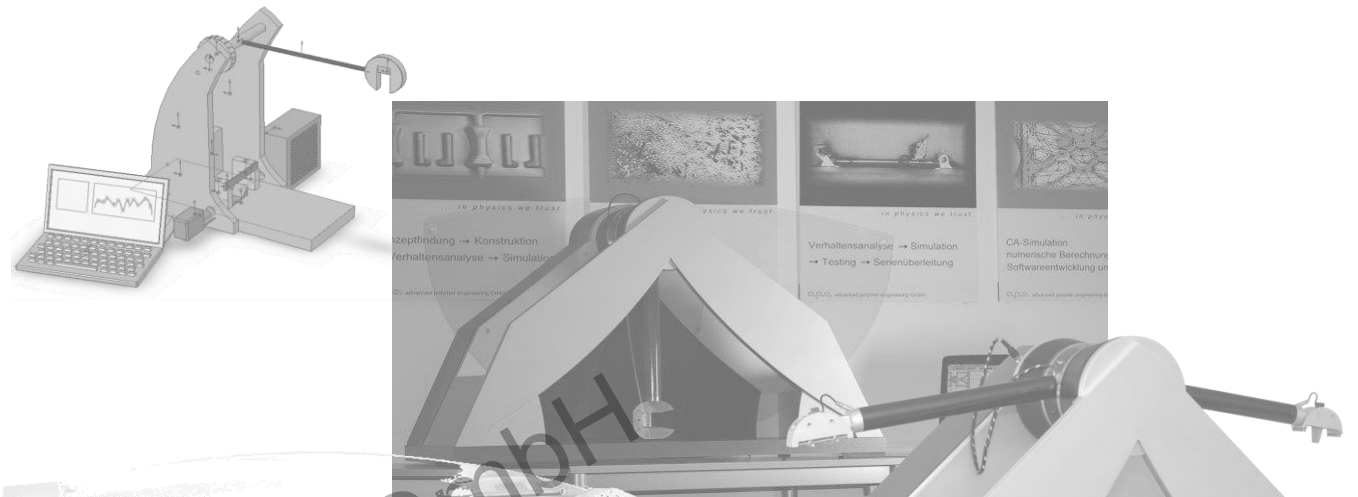
engineering plastics production
excellence in testing
concepts simulation
lightweight prototypes

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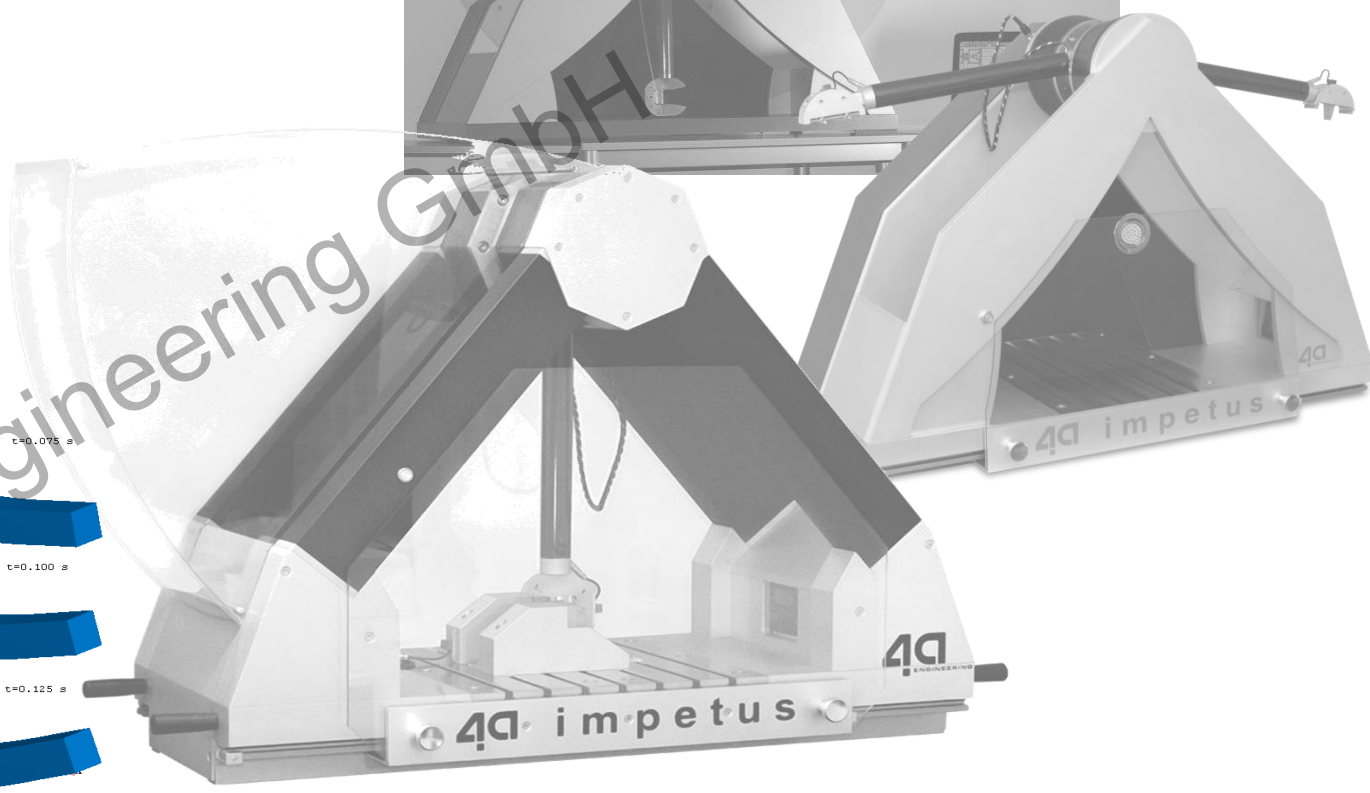
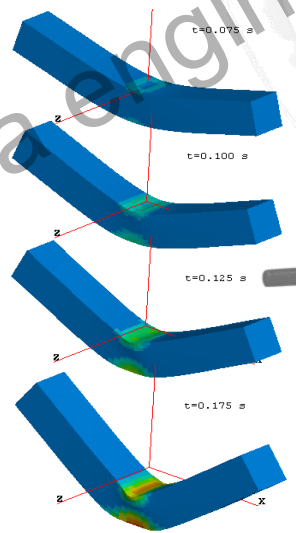


efficient dynamic testing

- desktop testing device
- instrumented high-speed testing
 - acceleration → force / displacement
- impact velocity 0.5 – 4.5 m/s



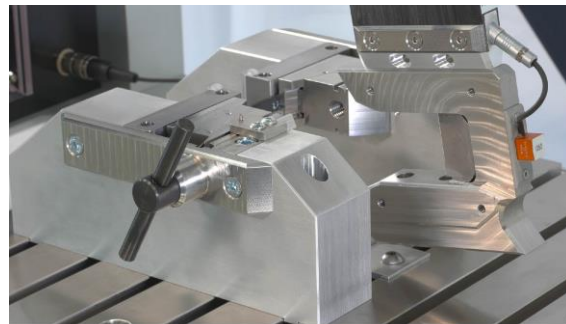
◀ IMPETUS



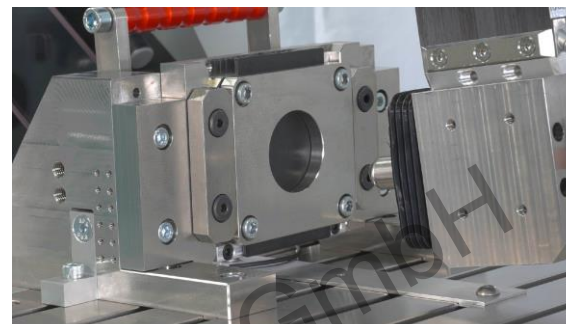
IMPETUS® - configurations



3 POINT BENDING



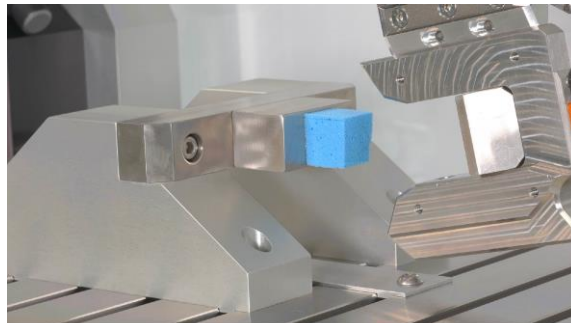
TENSION BENDING



PUNCTURE TEST



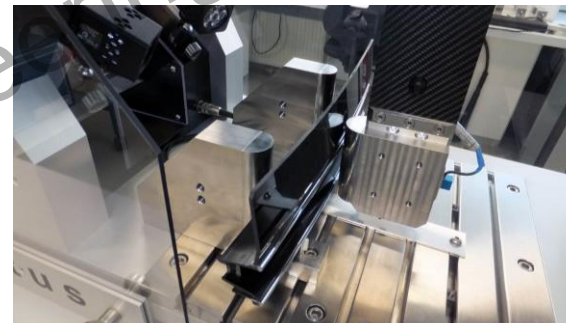
TENSION TEST



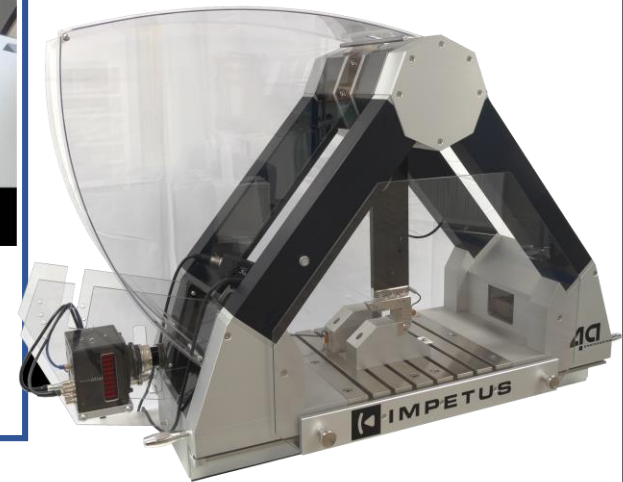
COMPRESSION TEST



SAMPLE MAGAZIN



COMPONENT TEST



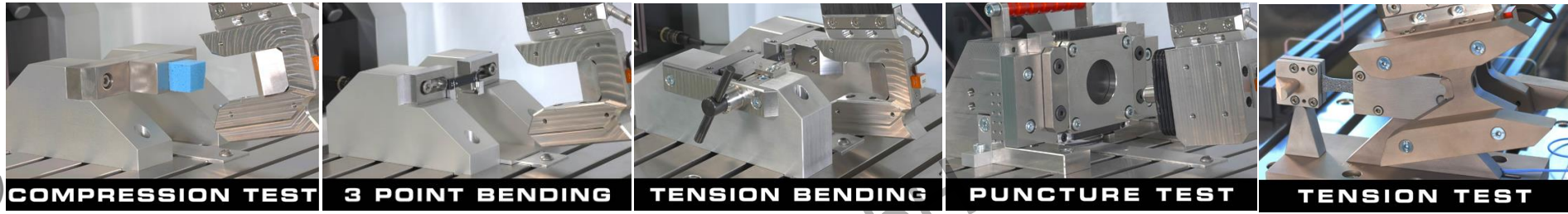
BASIC

STANDARD

PROFESSIONAL



efficient dynamic testing



Material (*Typical thickness*)

Plastic (*1 - 4 mm*)

Foam (*20 - 30 mm*)

Composite (*1 - 4 mm*)

Aluminum (*1 - 2.5 mm*)

Metals (*0.5 - 1.5 mm*)

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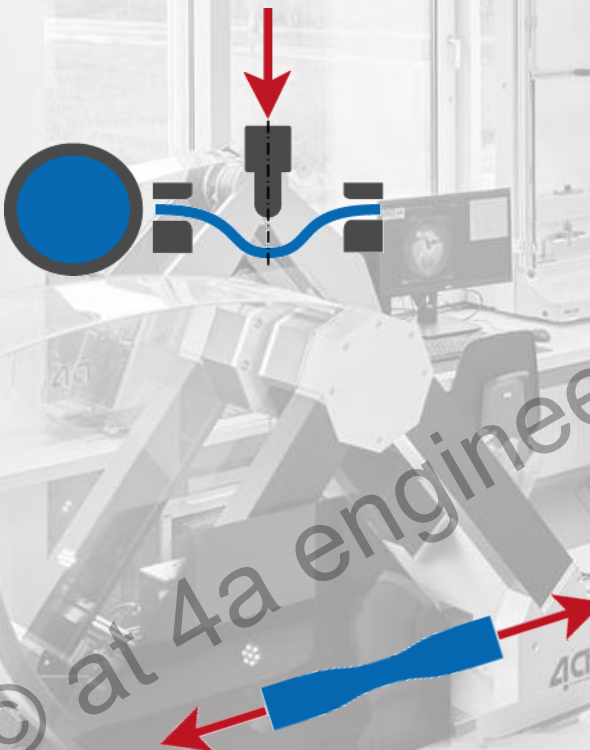
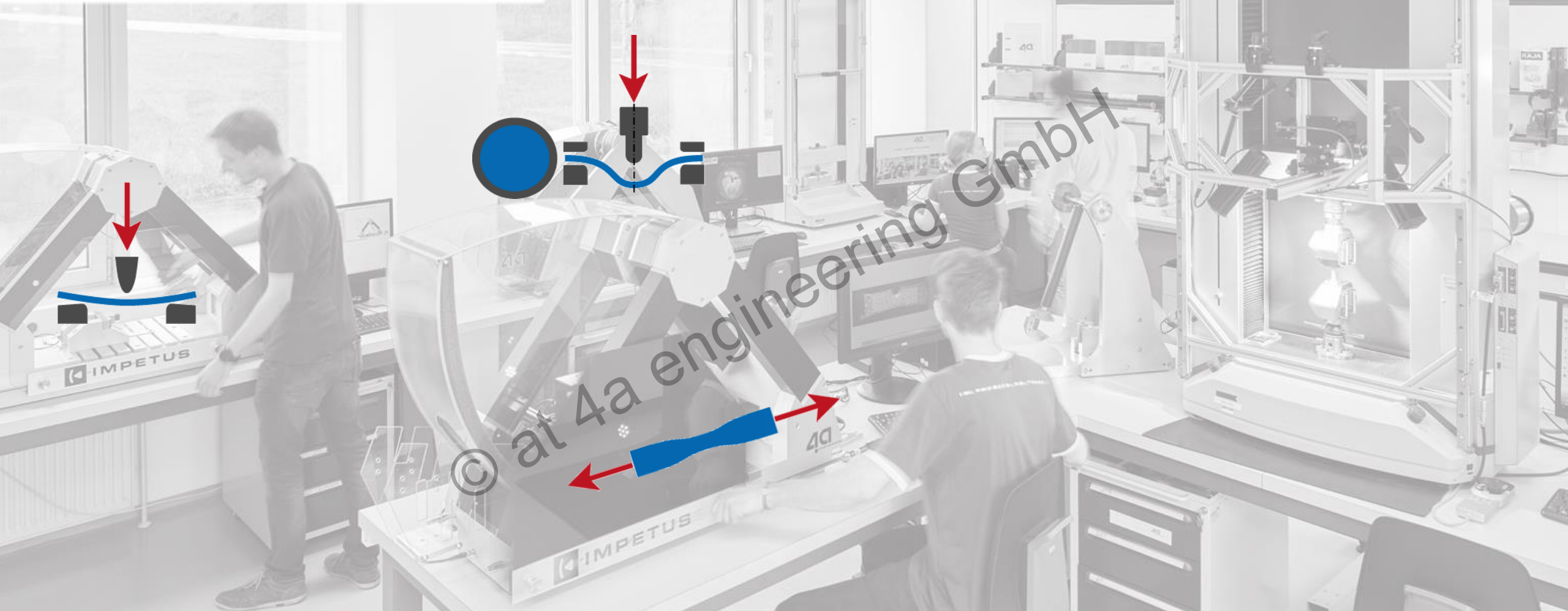


IMPETUS

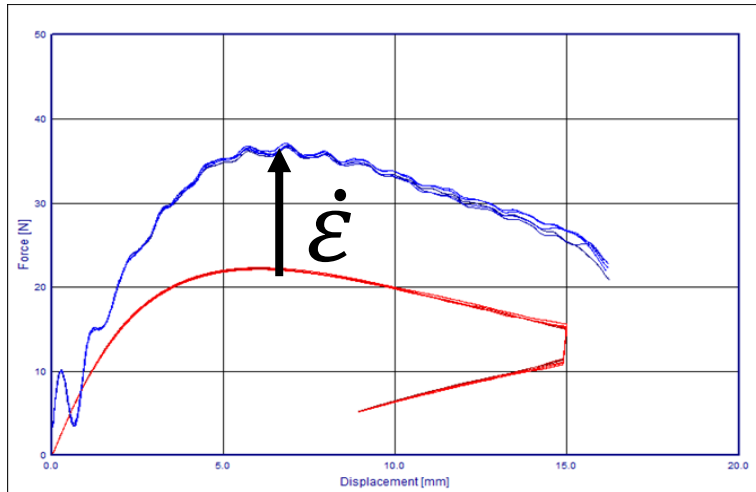
DAY2 – LIVE



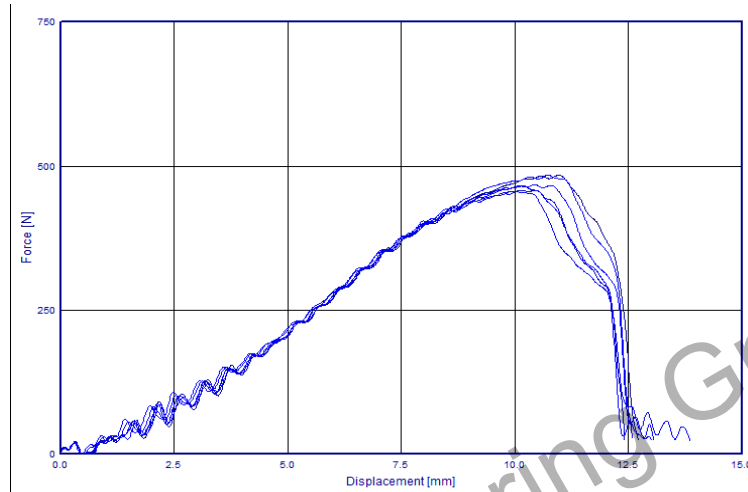
I N P H Y S I C S W E T R U S T



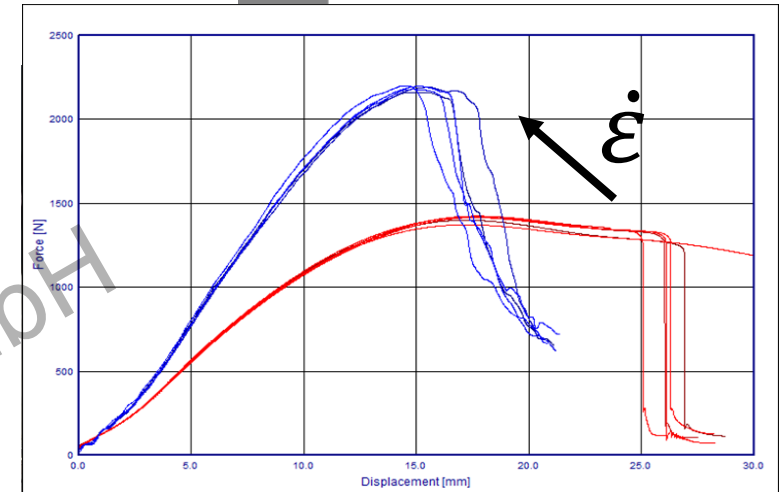
Measurement Results



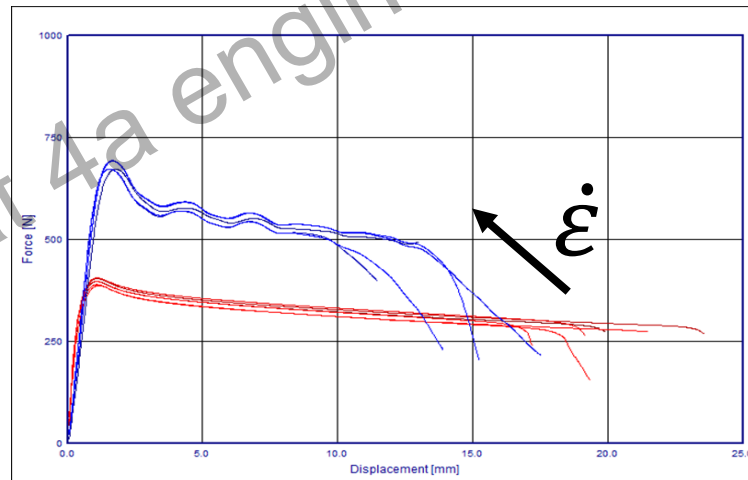
3 POINT BENDING



TENSION BENDING



PUNCTURE TEST



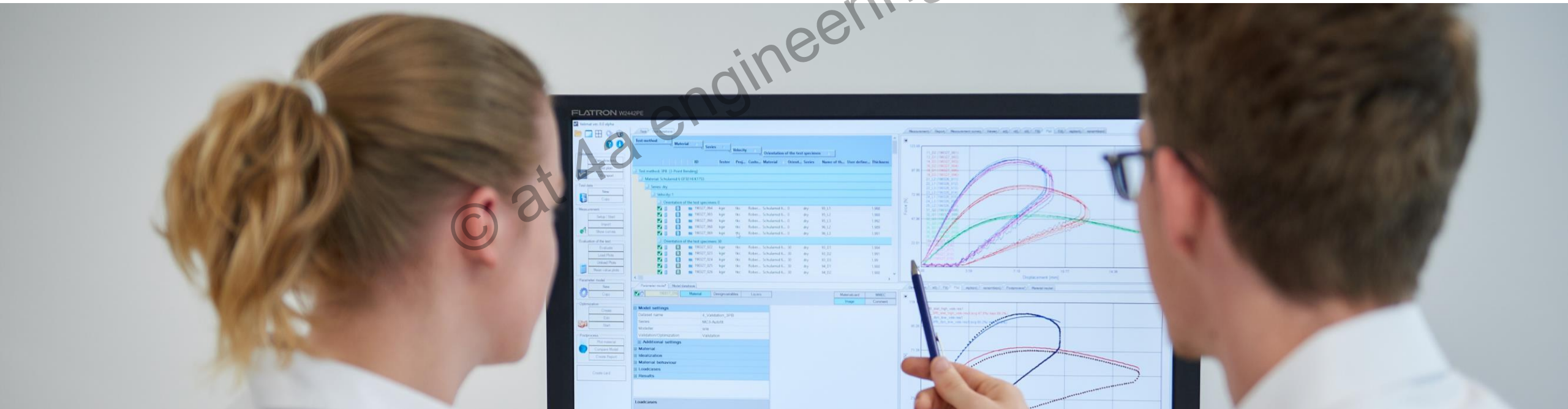
TENSION TEST

IMPETUS® ~ 3 m/s
static ~ 1 mm/s

©

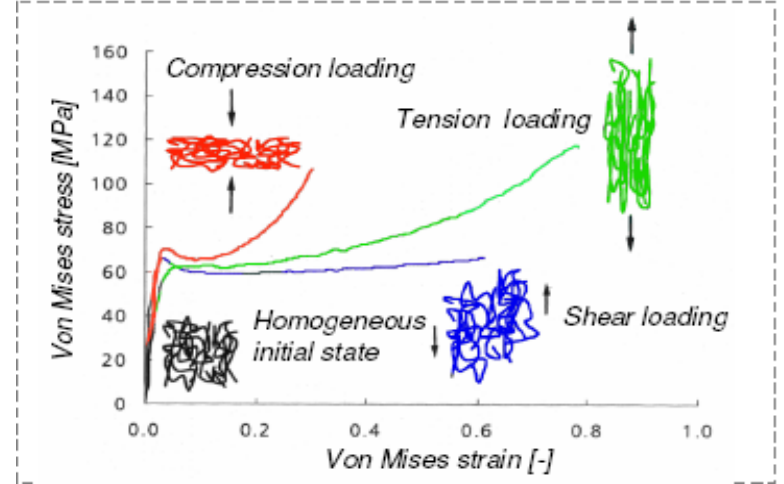
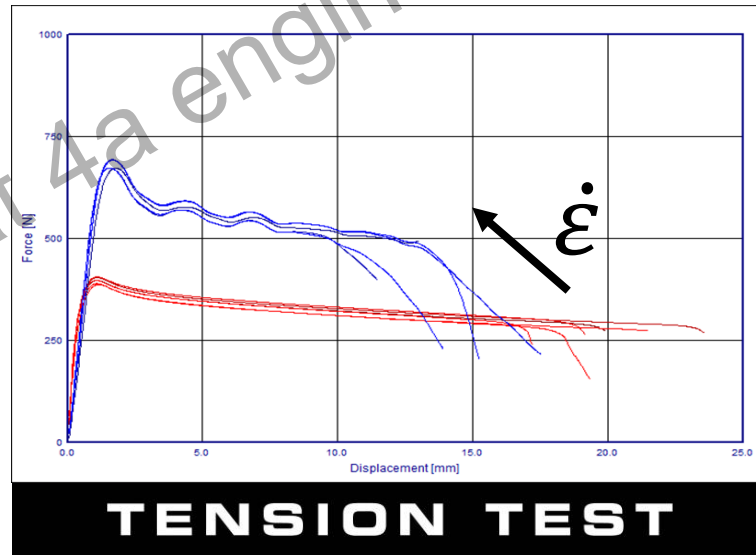
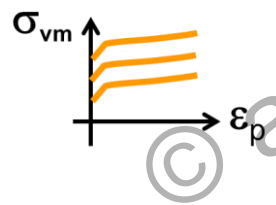
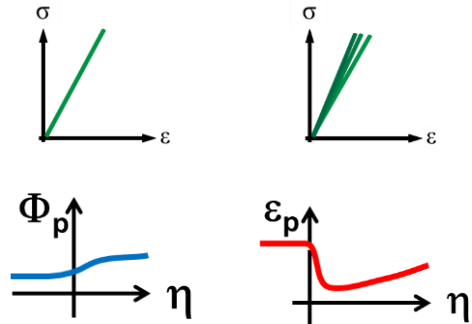
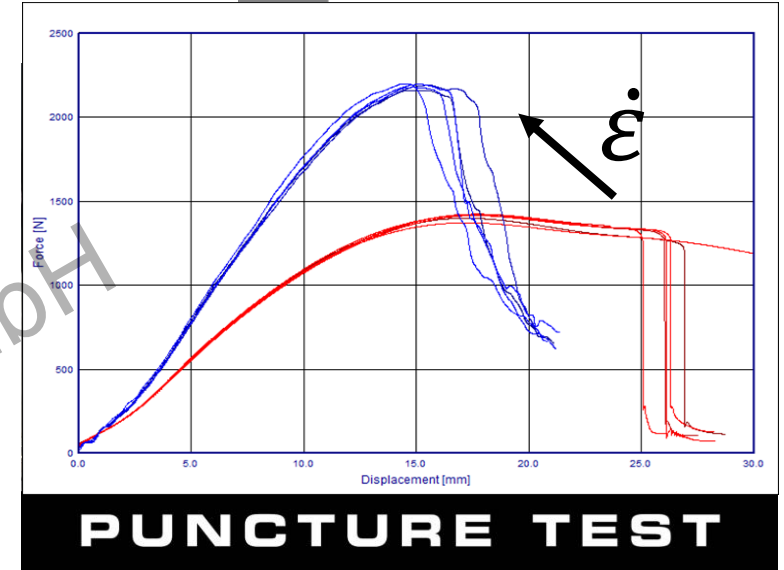
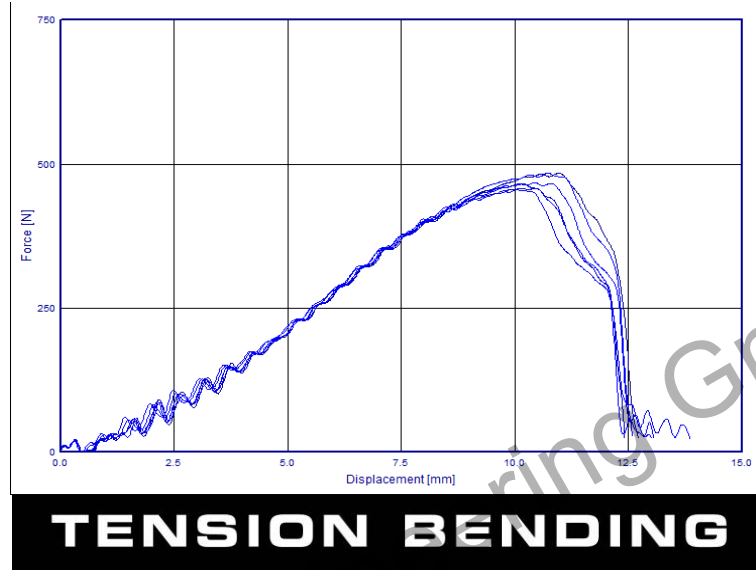
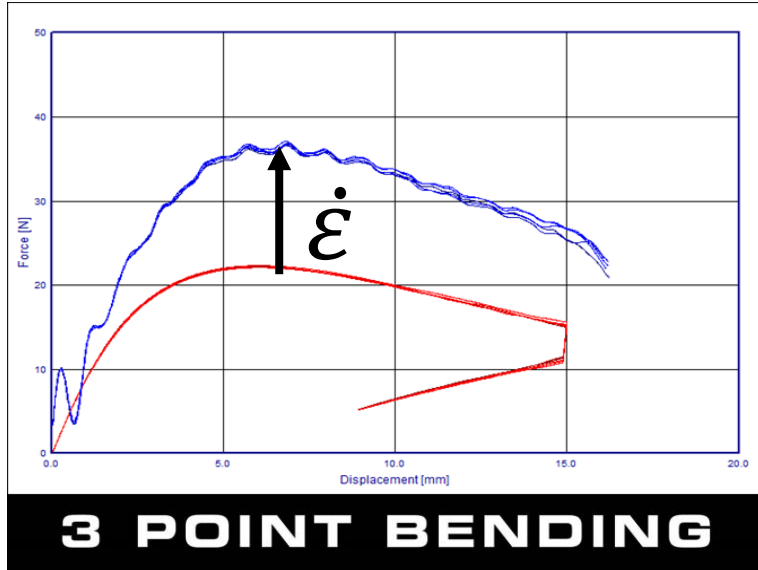
at 4a engineering GmbH

From test to material card



© at 4a engineering GmbH

from test to material card



Source: Mechanik der Kunststoffe W. Retting, Hanser Verlag 1991

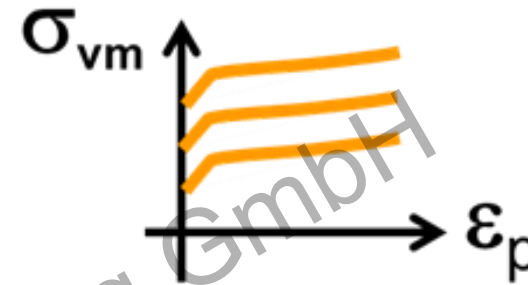
from test to material card

Current Situation

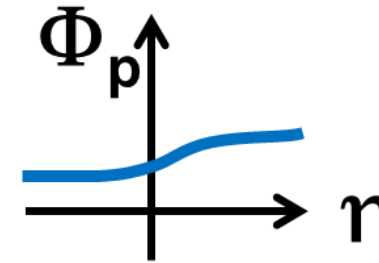
- more and more data
- Not only tension
 - Different loadcases (compression, shear,)
- More complex simulation models
- Investigations on failure

NEEDED

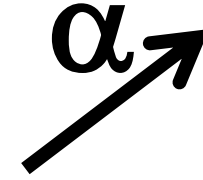
- Smart USER INTERFACE
- Optimization
- DATABASE handling data



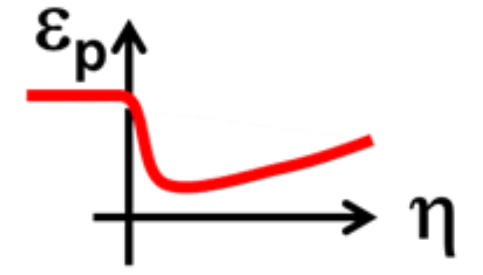
Hardening



Triaxiality



Anisotropic



Damage/Failure

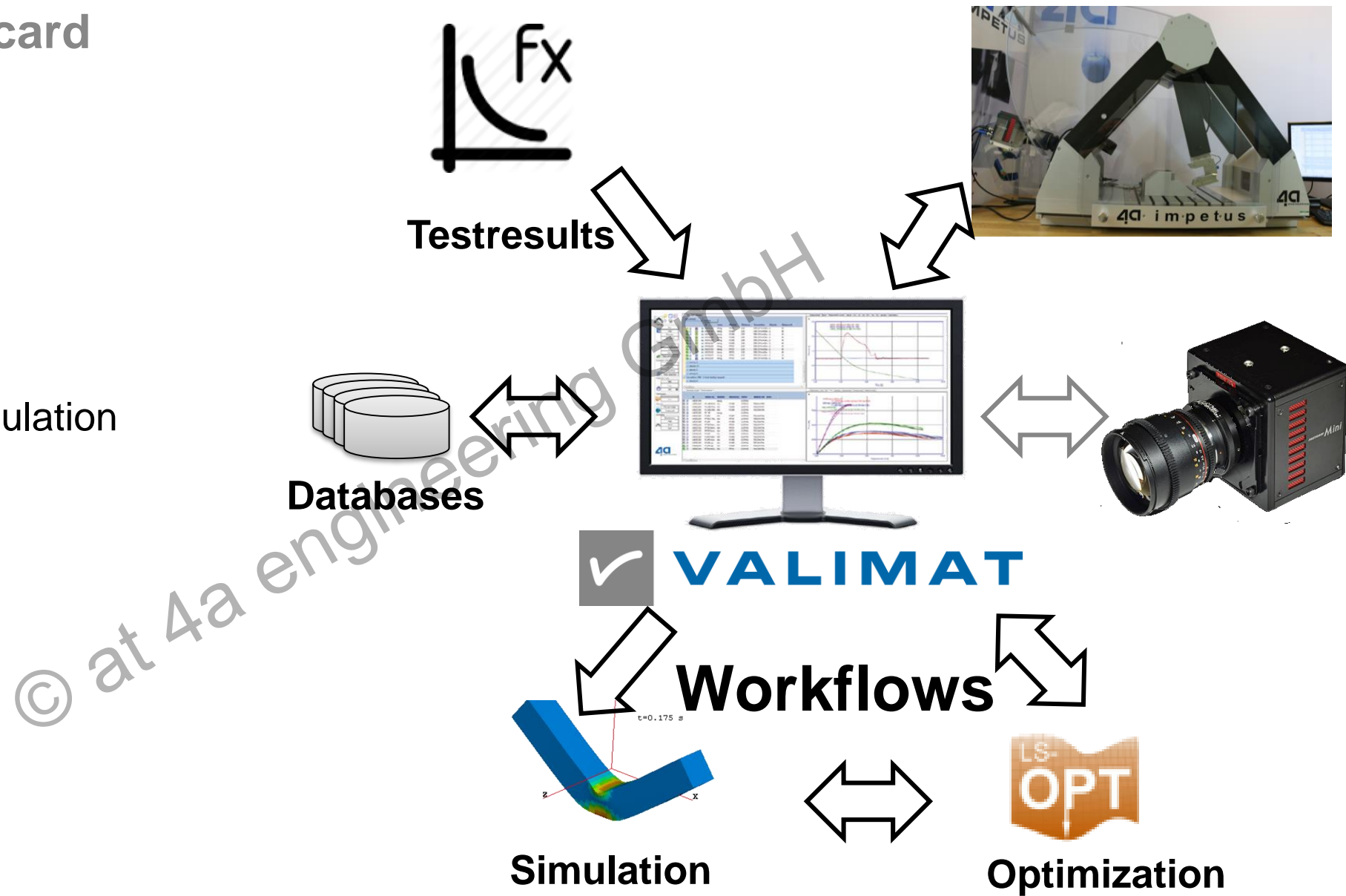
© at 4a engineering GmbH

from test to material card

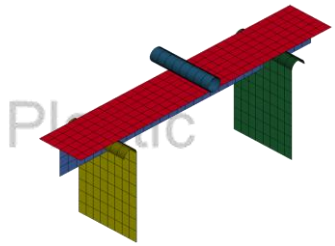
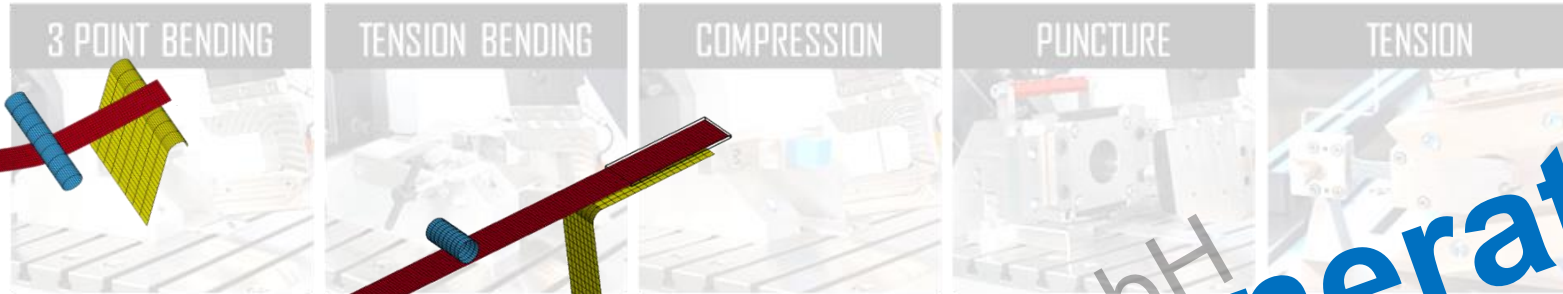
VALIMAT®

Advantage

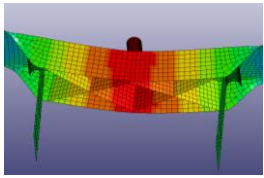
- Handling of bigdata
- Complex models
- Good correlation to simulation



from test to material card



Foam



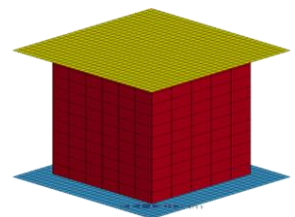
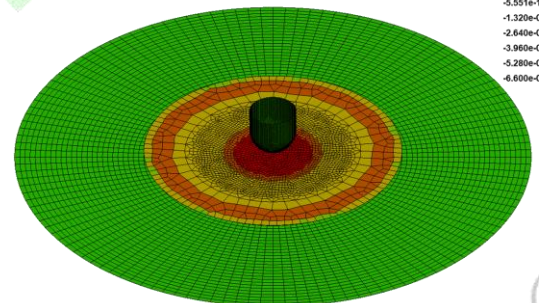
Aluminum

Metals

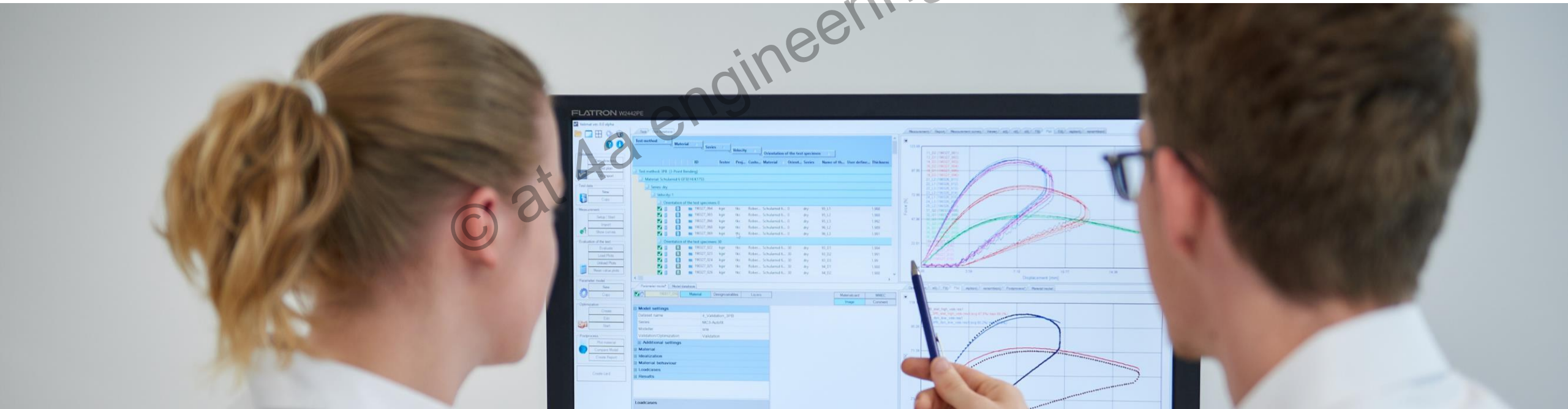
automated FE-model generation

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VALIMAT

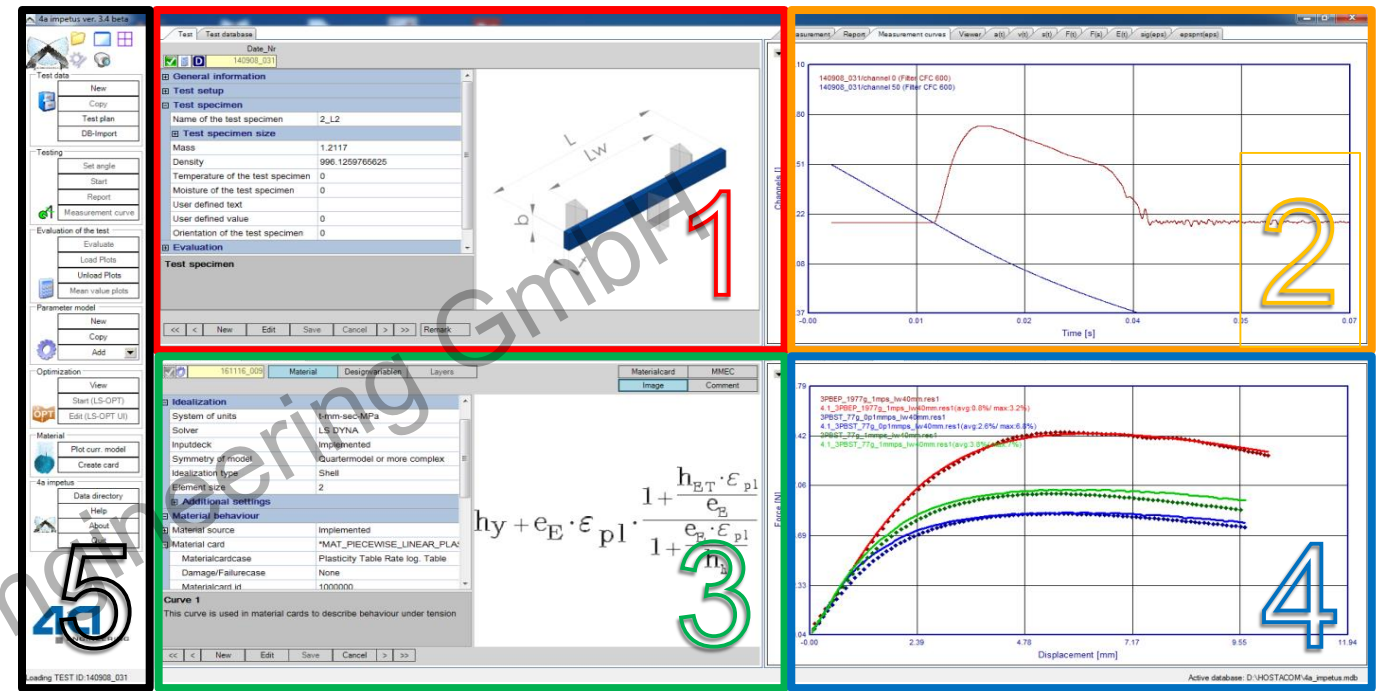


FIRST LOOK



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GUI - the graphic user interface is divided into five parts



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 **userdefined material cards**

from test to material card

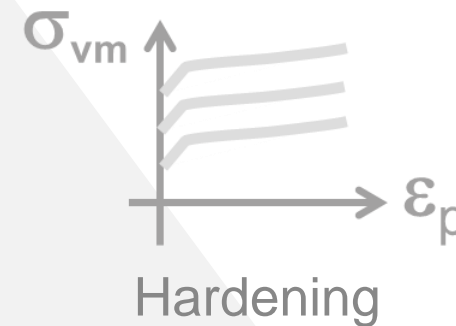
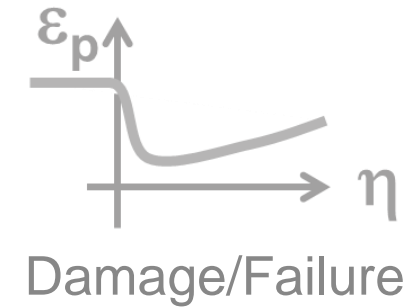
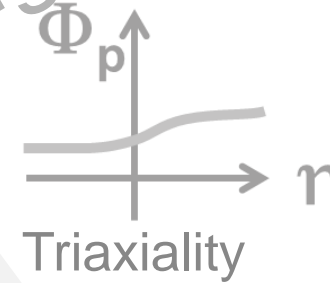
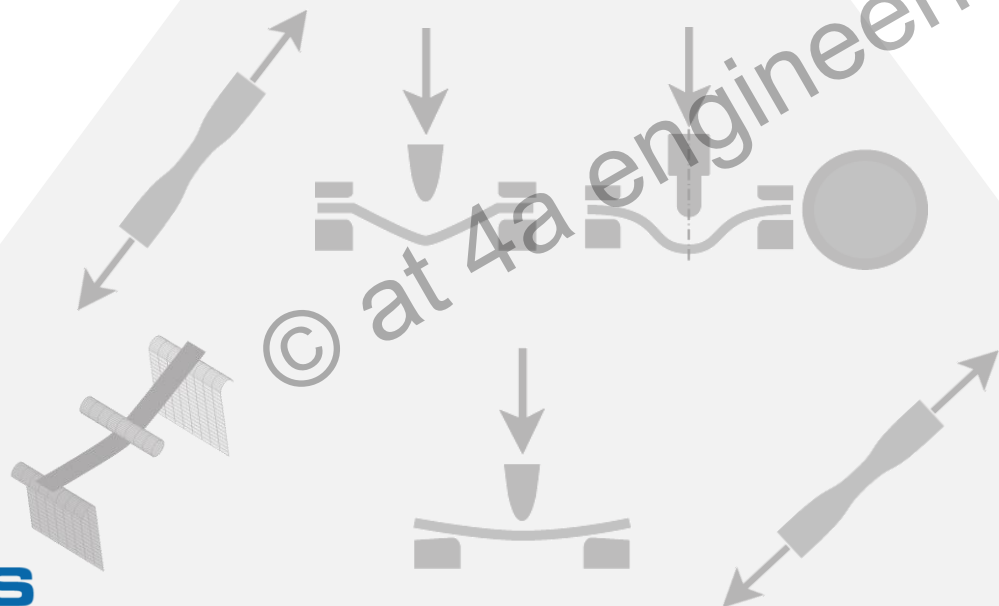
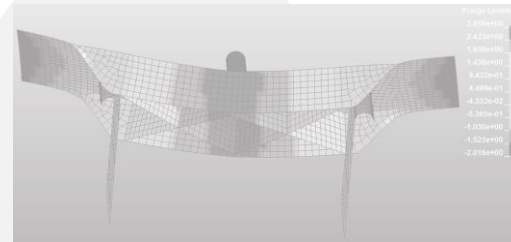
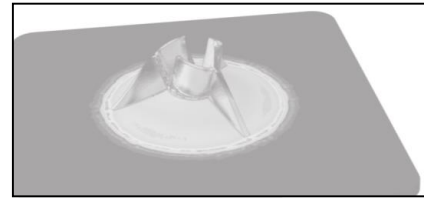


VALIMAT

Deformation → Failure

Creep → Static → Crash

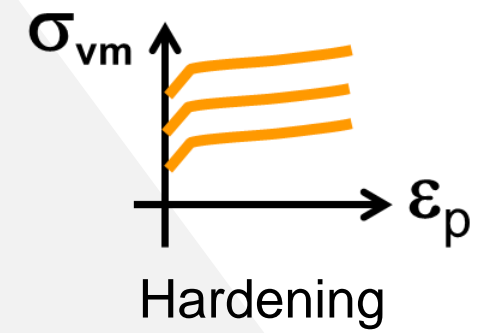
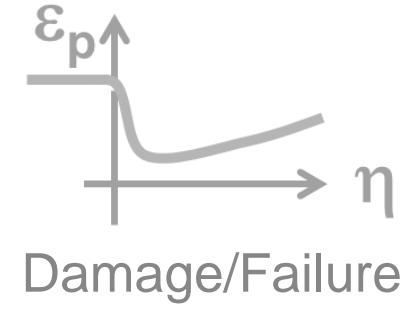
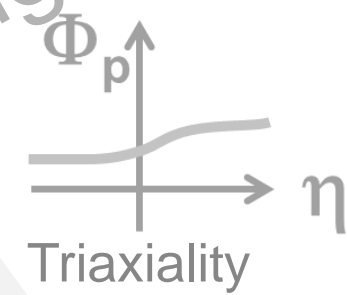
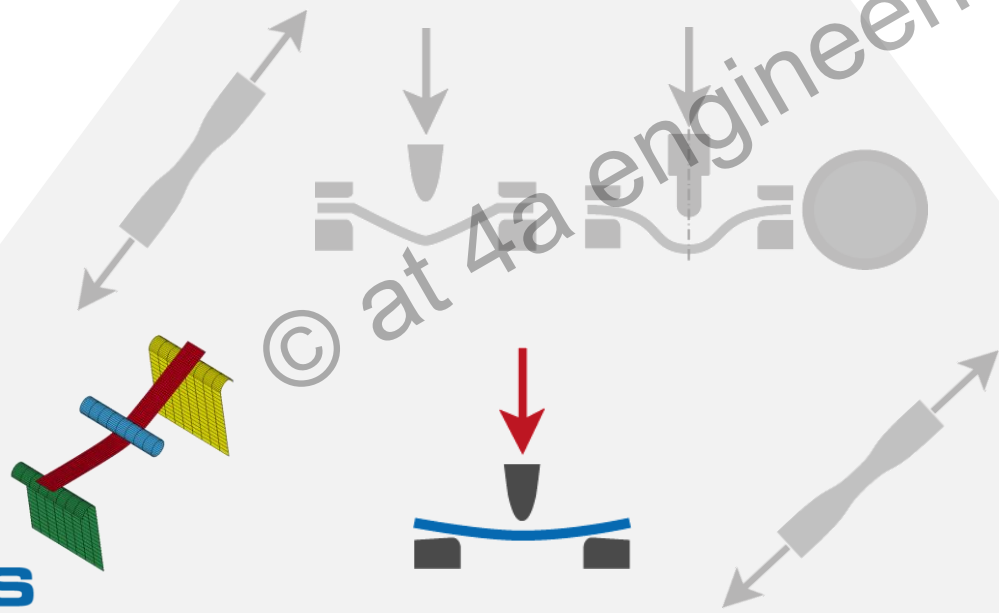
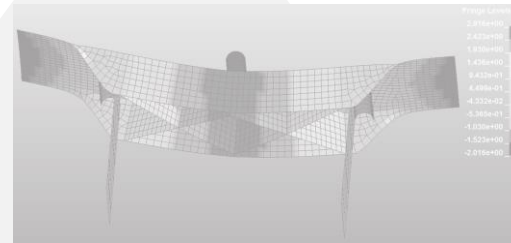
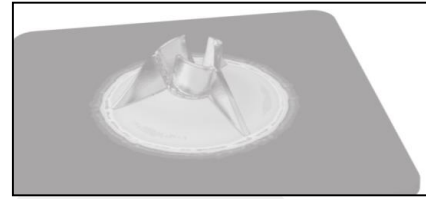
ISOTROPIC → ANISOTROPIC



IMPETUS



from test to material card



Workflow for Material Card Generation - AUTOFIT



Automated optimization

Menu

Optimization

Run

Stop

Clear

Open LS-Opt Viewer

DV Start

Postprocess

Create report

Create material card

Plot material

Compare models

Close

Status	Name	e_E
	0_VISUAL_AUTO	1000(c)
	1_Optimization_YoungsModulus	AUTO
	2_Optimization_flow_data	PRUN(c)
	3_Optimization_strainrate	PRUN(c)
	4_Validation_3PB	PRUN(c)

Force [N]

Displacement [mm]

39.88

31.87

23.87

15.87

7.86

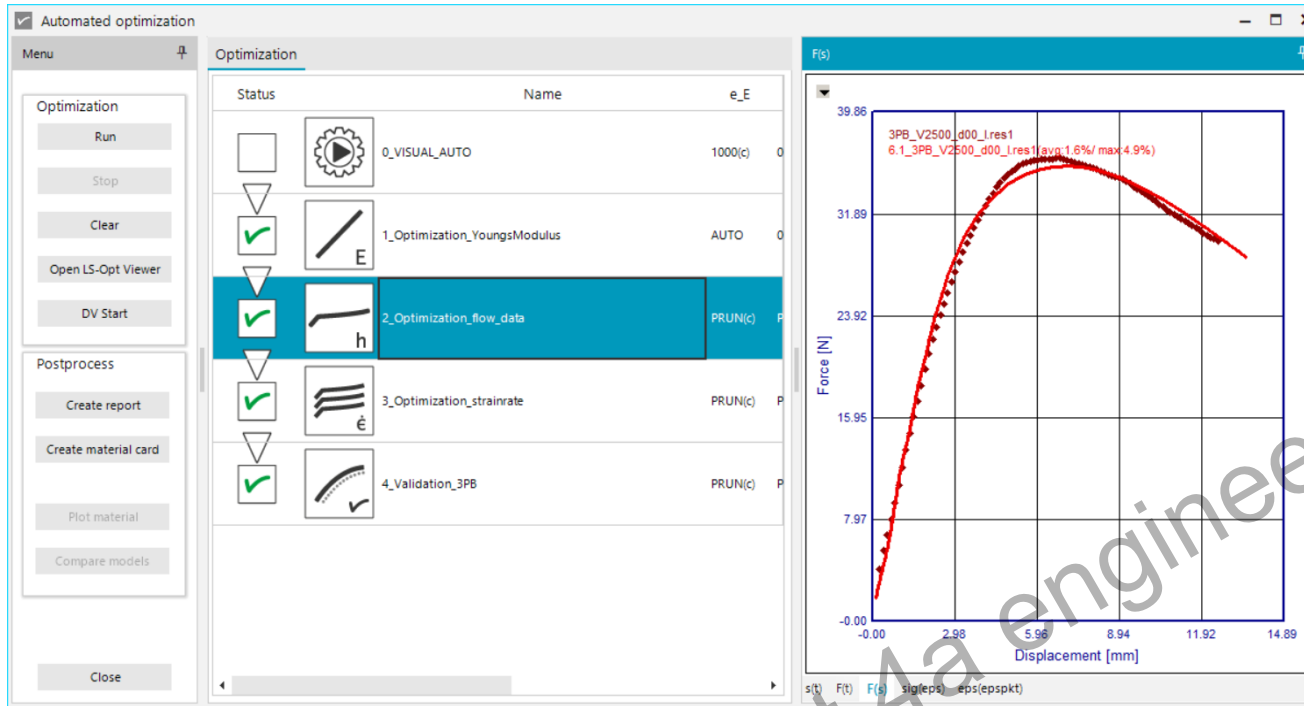
-0.14

-0.00 4.91 9.82 14.73 19.64 24.55

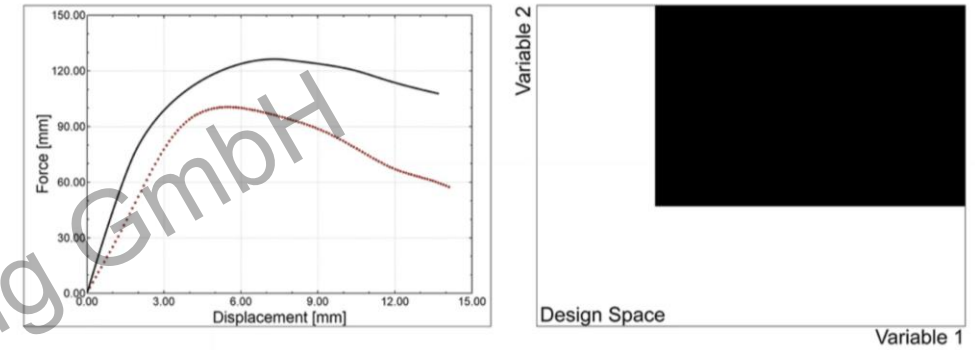
fenster ausschneiden

s(t) F(t) F(s) sig(eps) eps(epspkt)

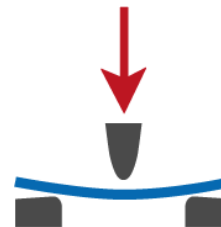
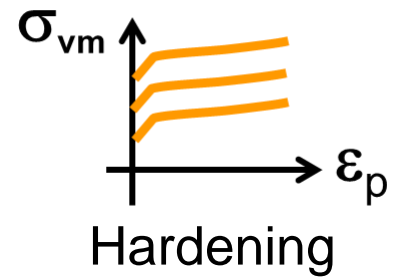
© at 4a engineering GmbH



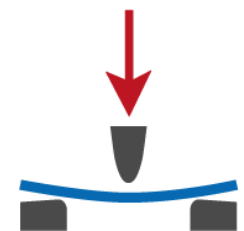
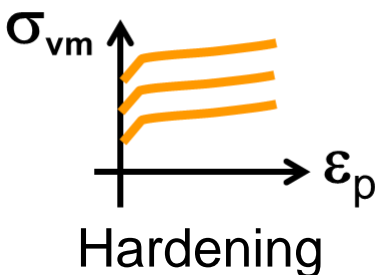
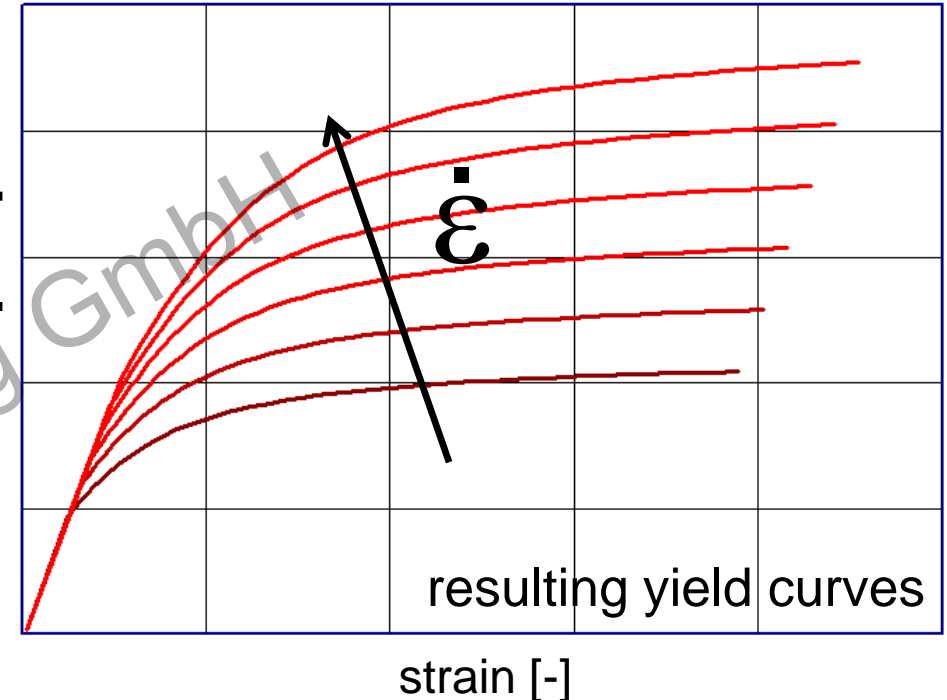
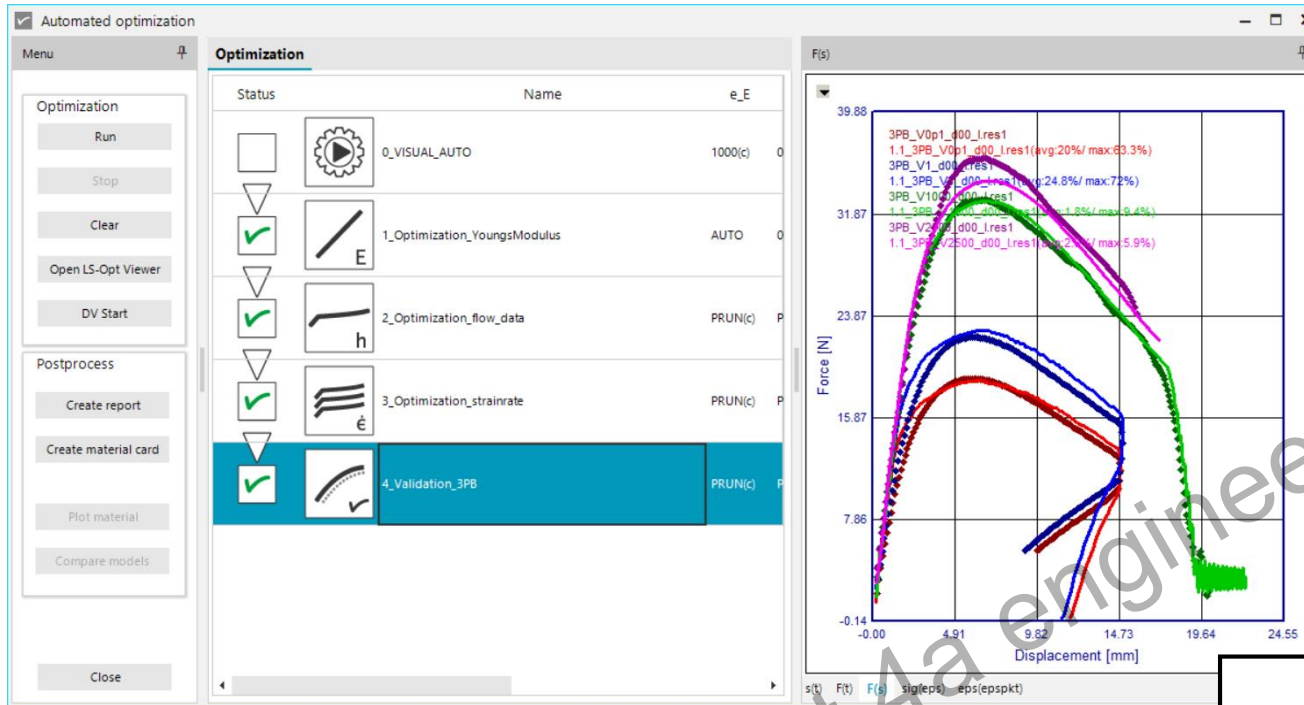
optimization – successive response surface method



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



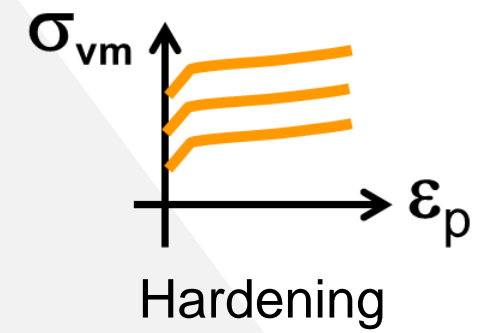
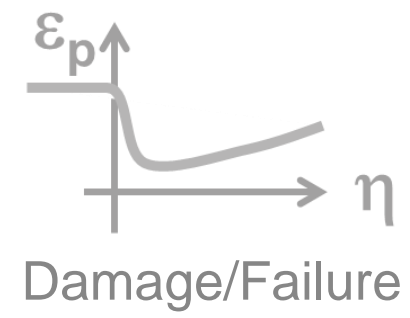
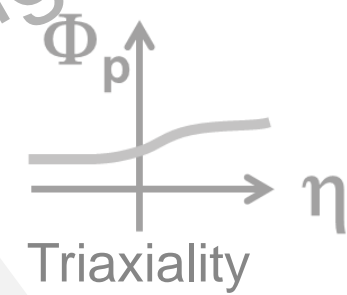
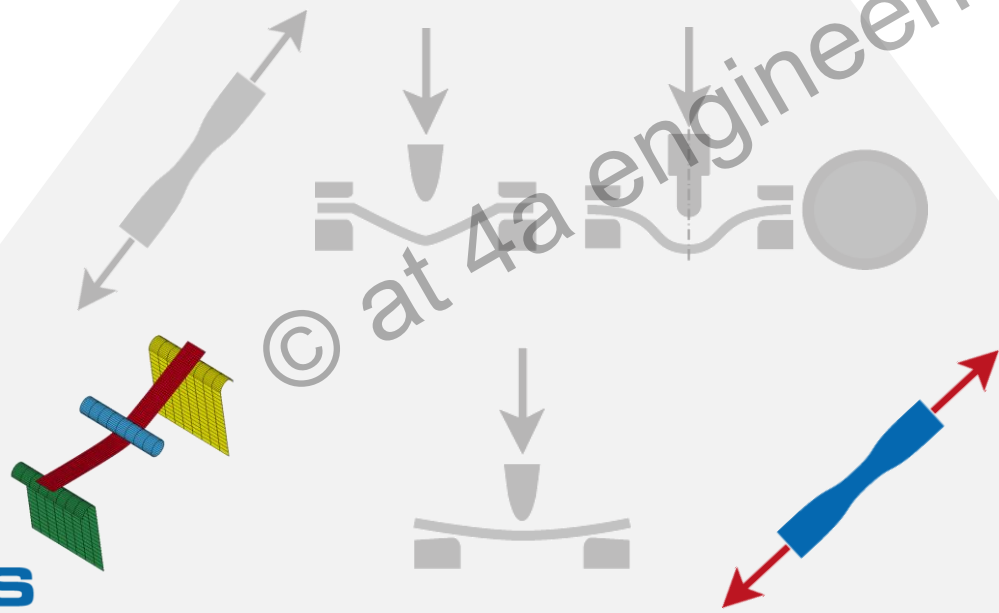
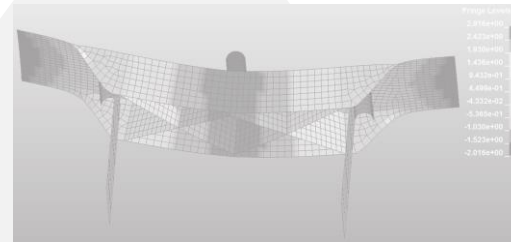
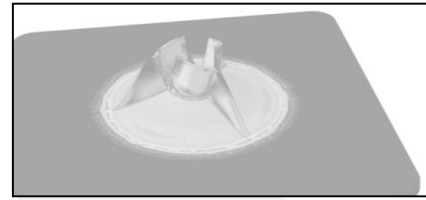
Workflow for Material Card Generation - AUTOFIT



more on
DAY 3



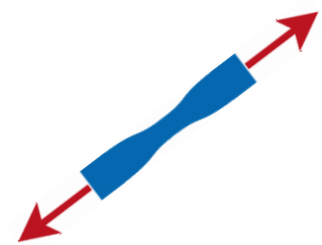
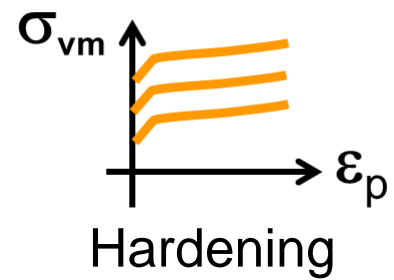
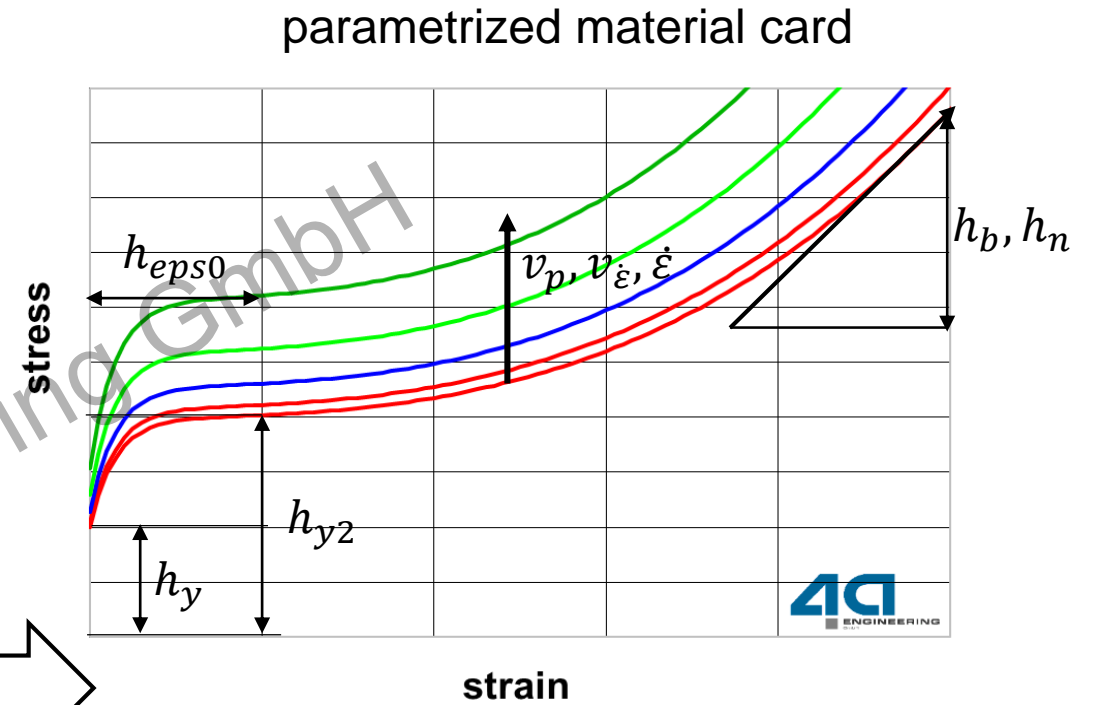
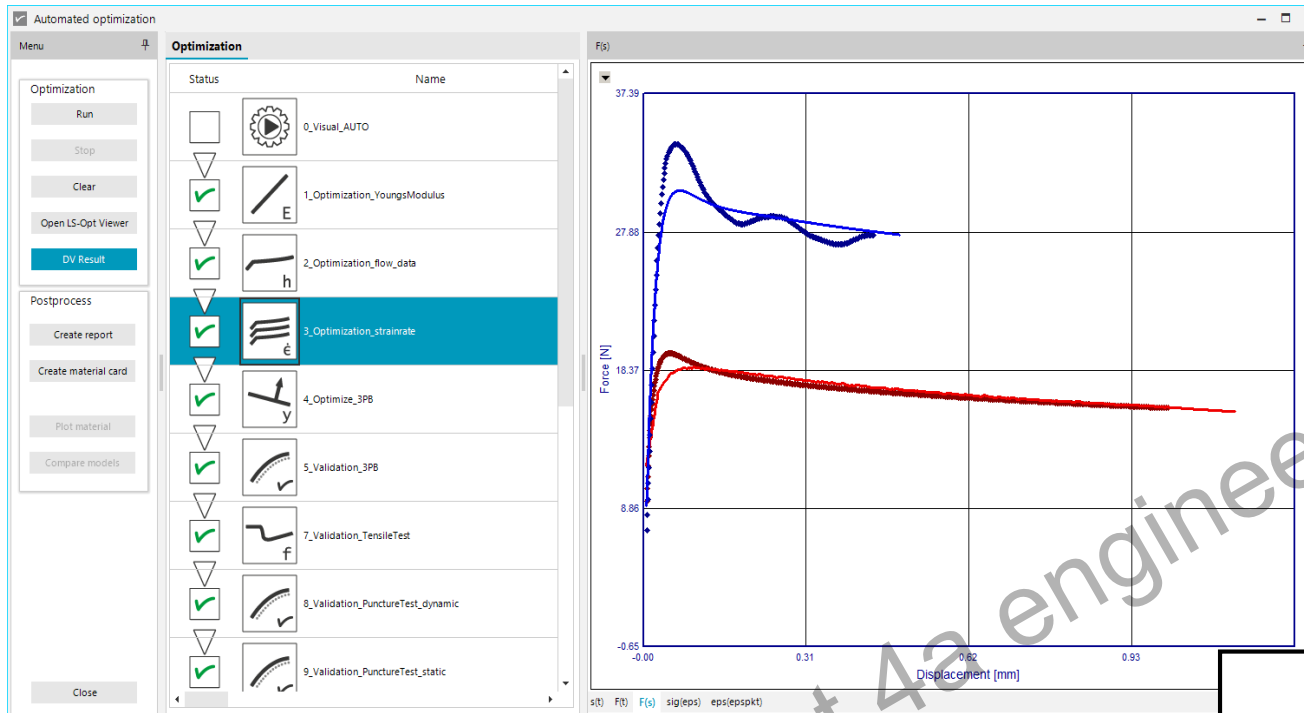
from test to material card



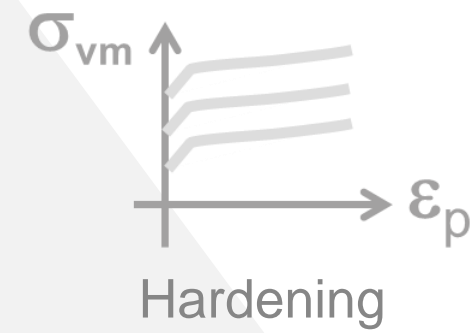
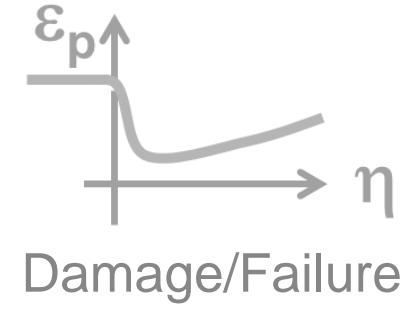
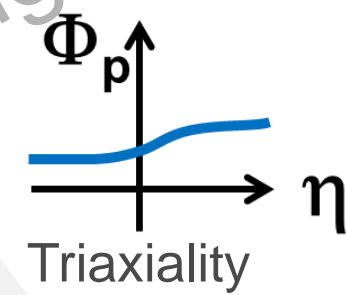
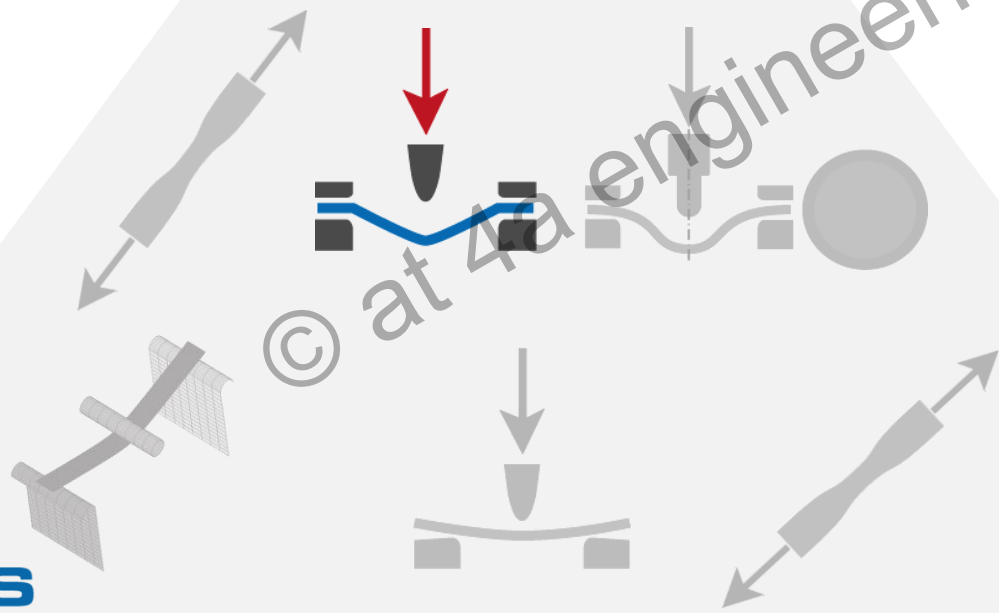
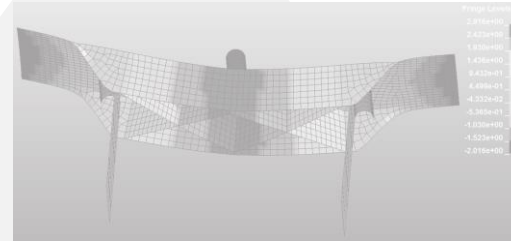
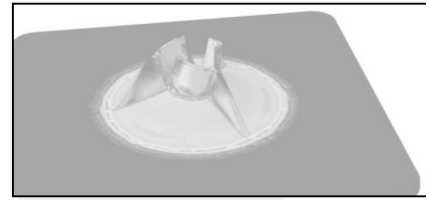
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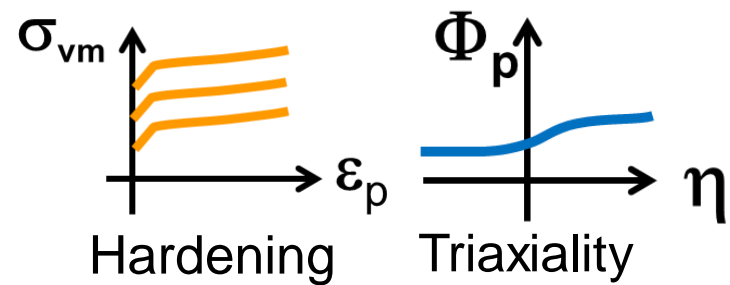
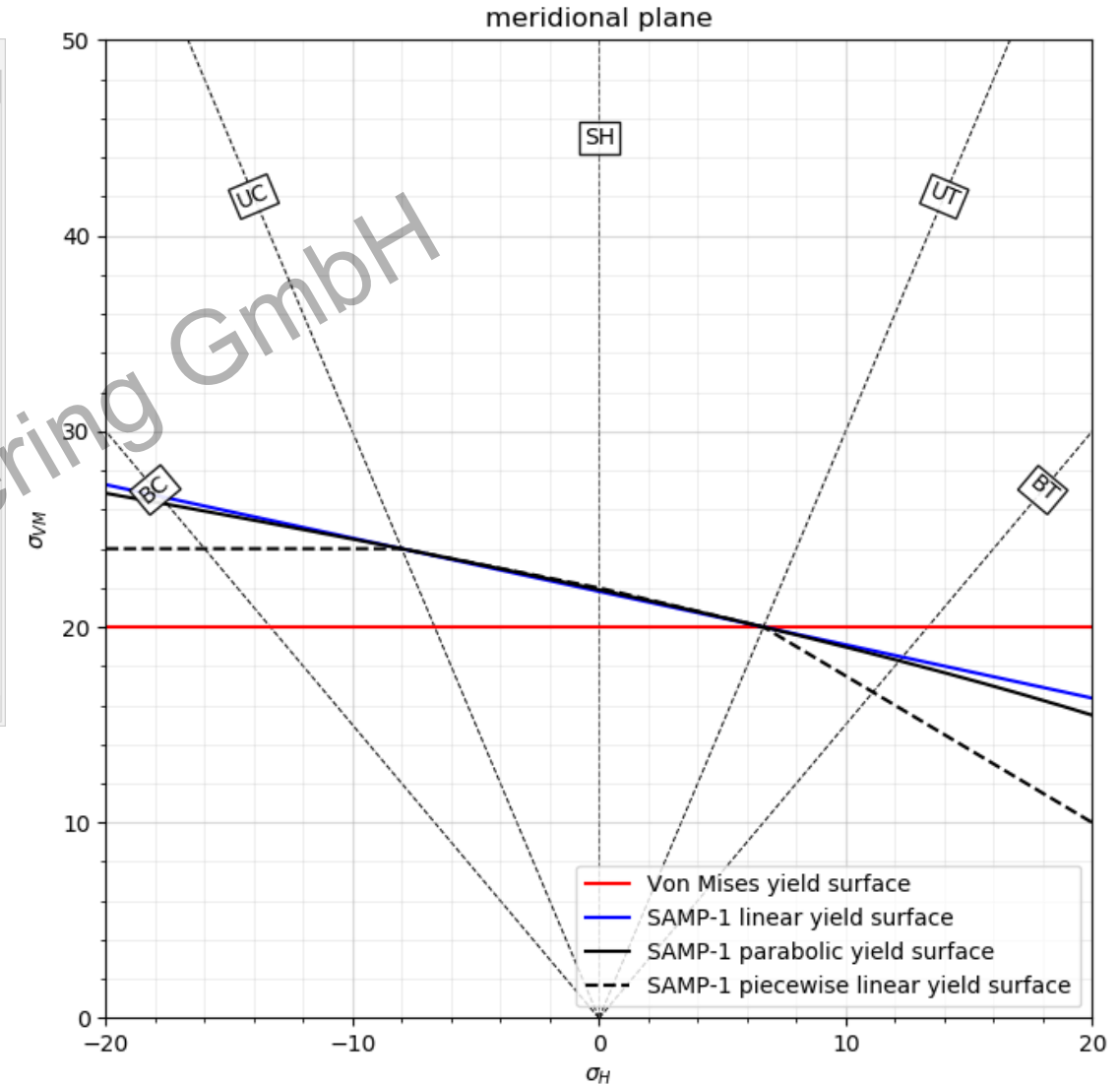
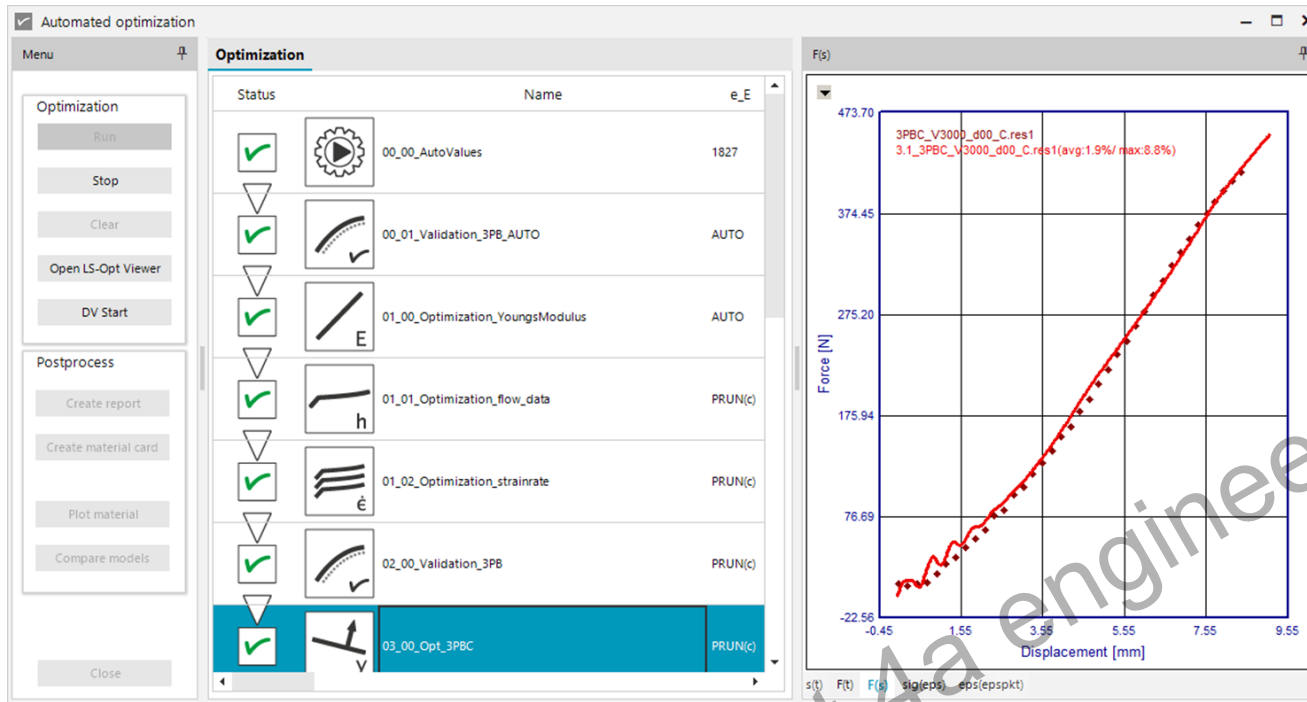
Workflow for Material Card Generation - AUTOFIT



from test to material card

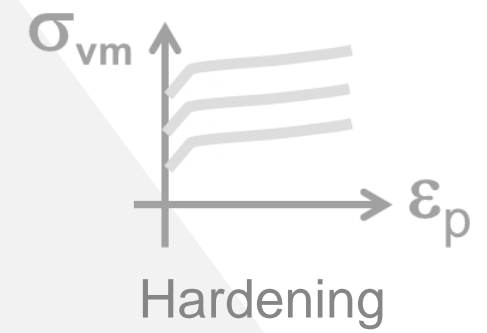
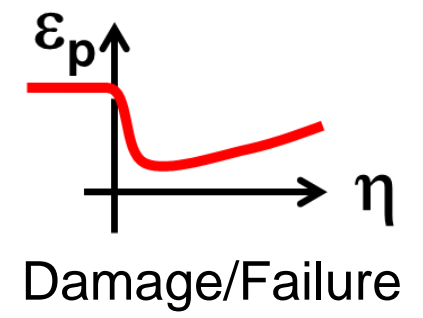
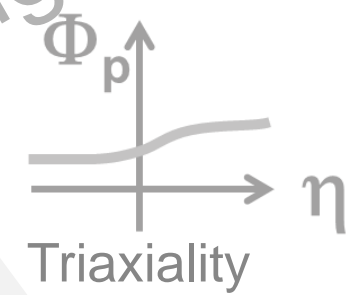
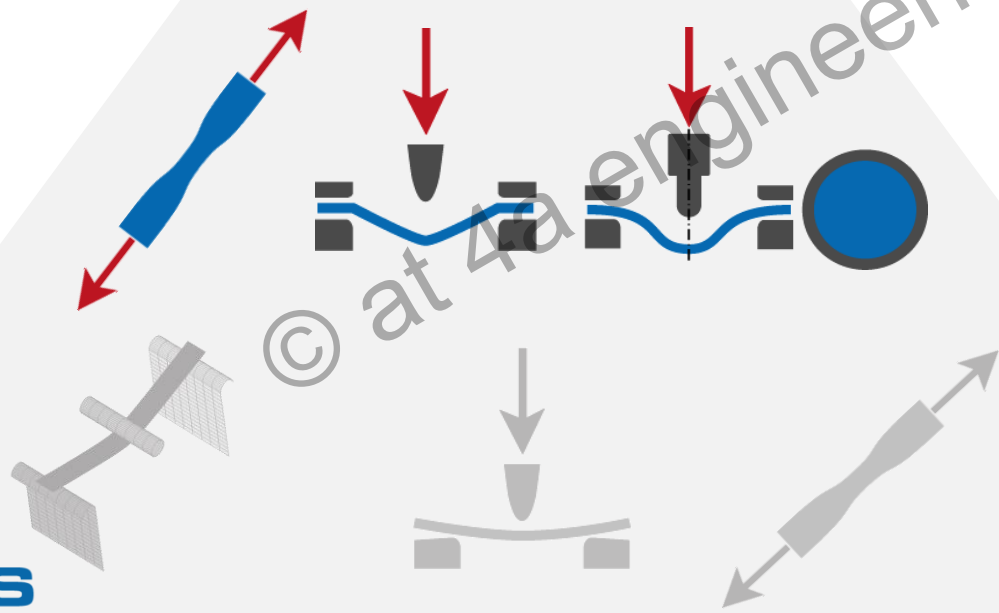
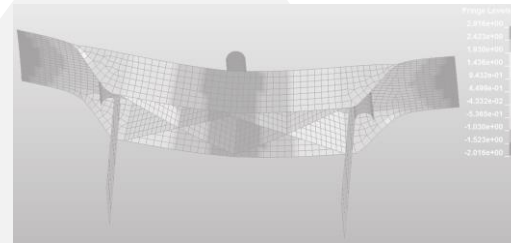
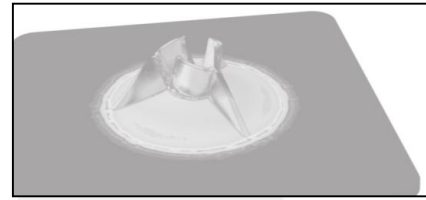


Workflow for Material Card Generation - AUTOFIT

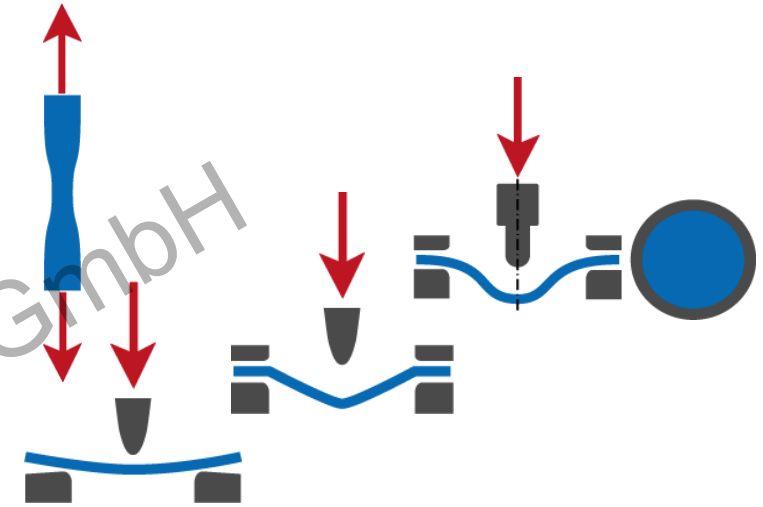
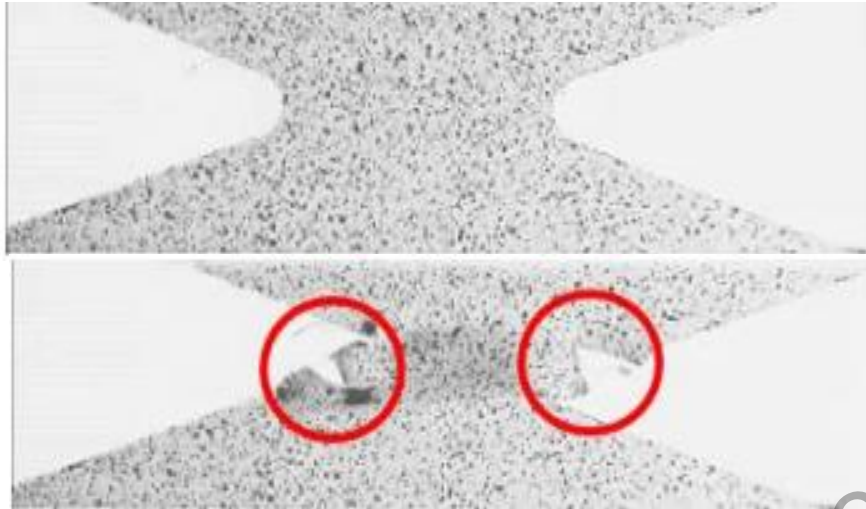


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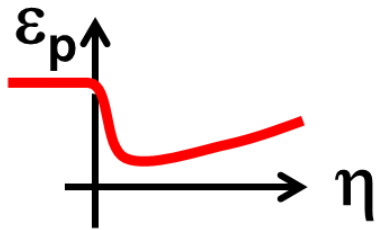
from test to material card



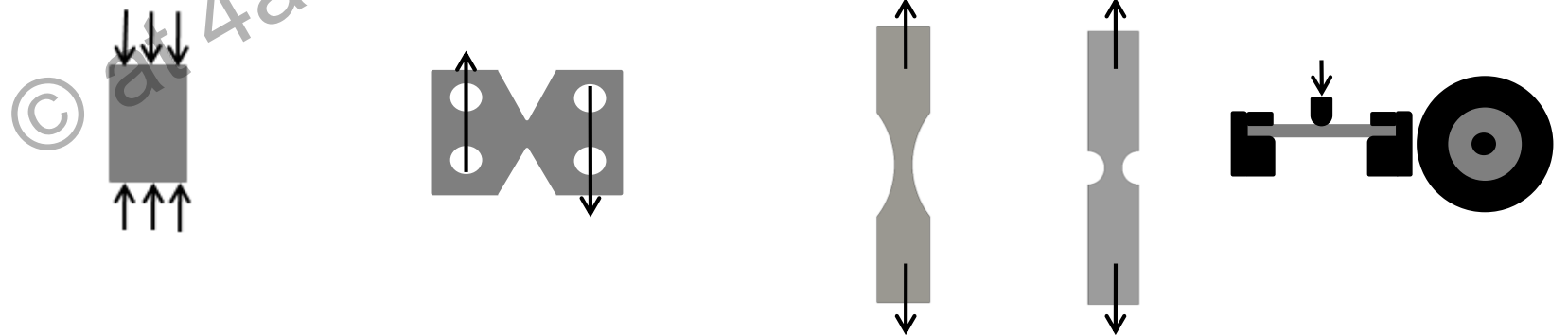
from test to material card



- 0.33 0 0.33 0.66 η



Damage/Failure



fracture models → *MAT_ADD_EROSION



Parameter model* Model database

170503_024 Material Designvariables Layers

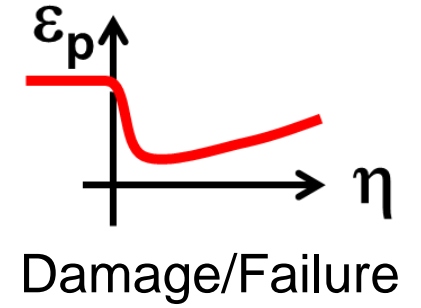
Materialcard MMEC
Image Comment

- 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
 - lower triax value
 - upper triax value
 - step size triax
 - Shear Damage Settings
 - FLC Damage Settings
 - Strainrate Settings
 - Postfracture
 - Loadcases
 - Results

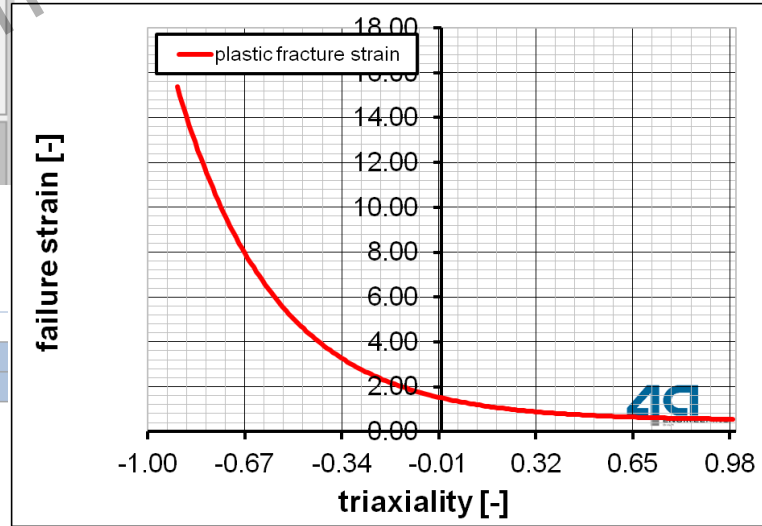
Density	-1
Plasticity	vonMISES
Function (Hardening, Elastic cur	
Strain rate dependency	Table
Fracture	Damage
Ductile Damage Settings	Johnson Cook
Shear Damage Settings	None
FLC Damage Settings	plastic equivalent strain
Strainrate Settings	simple criteria
Postfracture	4a picewise linear
Loadcases	Johnson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

Ductile Damage Settings

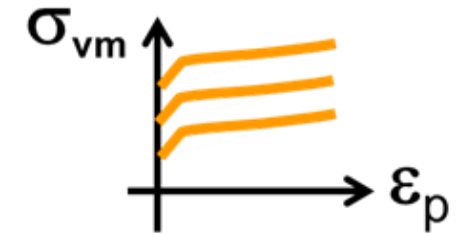
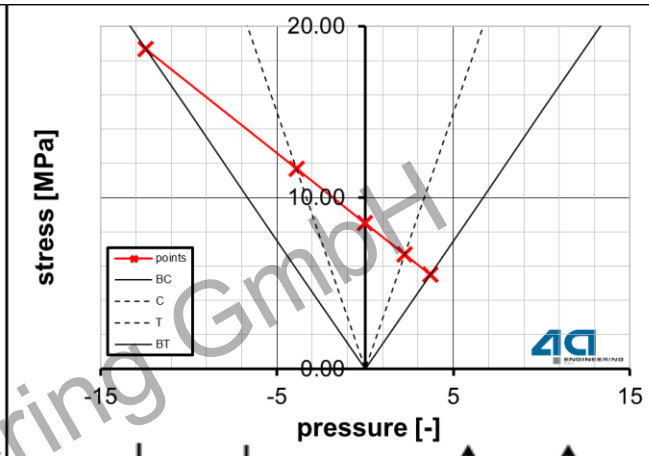
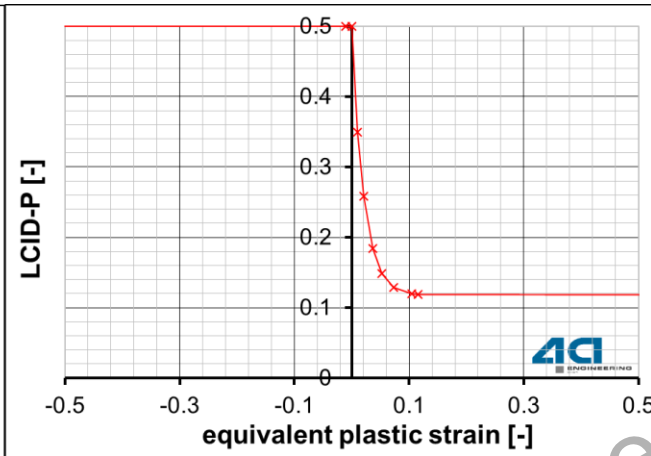
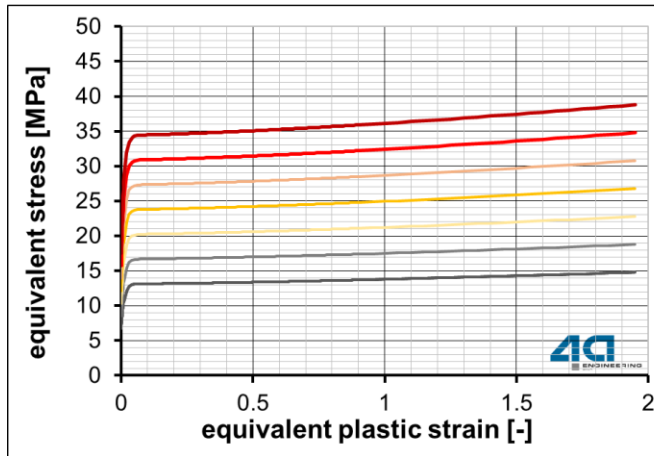
	0.33	Johnson Cook
	None	mod Xue-Wierzbicki
	None	Xue-Wierzbicki
	Johnson Cook	Mohr-Coulomb
	Fracture Energy (TRIAx)	



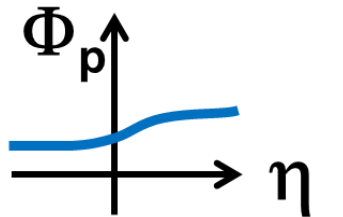
$$f_{dJCD1} + f_{dJCD2} \cdot e^{-f_{dJCD3} \cdot \eta}$$



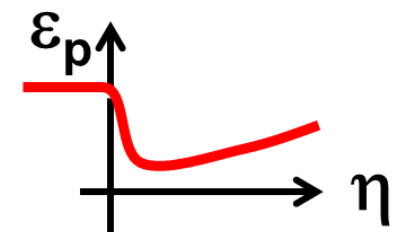
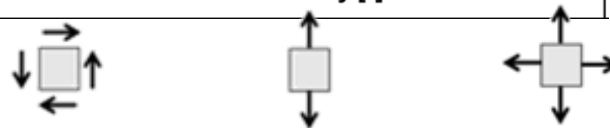
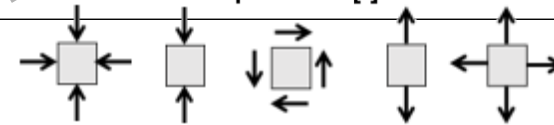
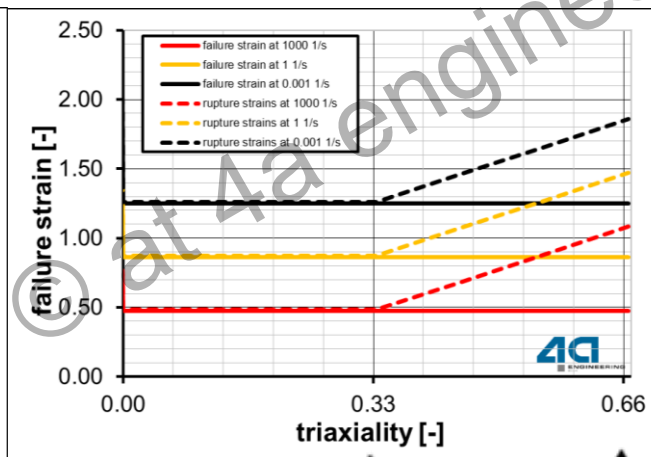
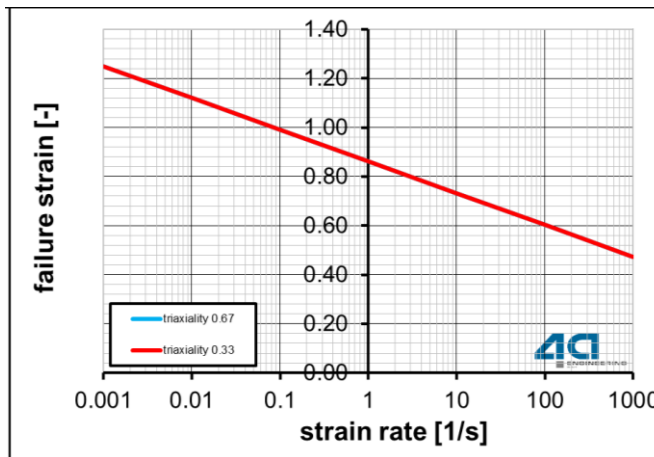
typical result - *MAT_SAMP-1 with failure



Hardening



Triaxiality

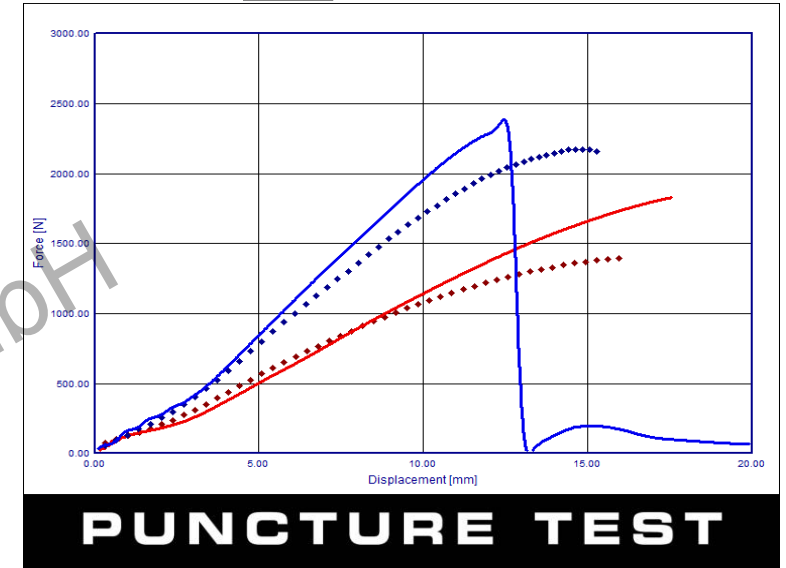
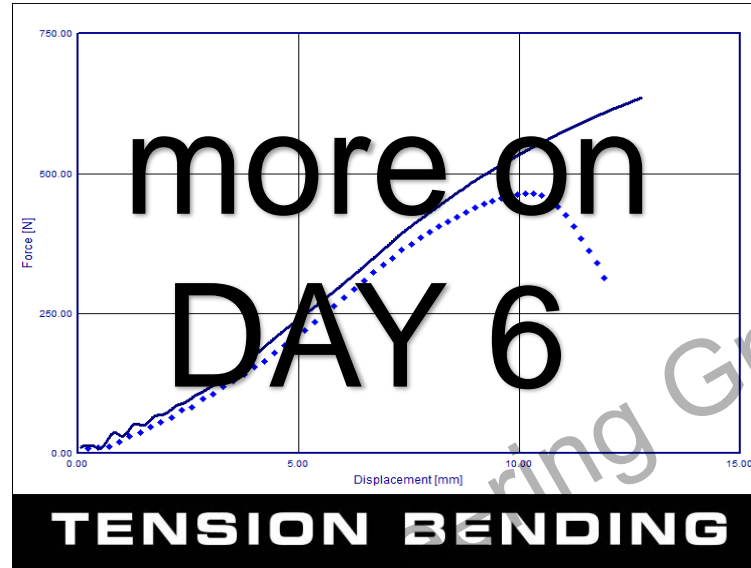
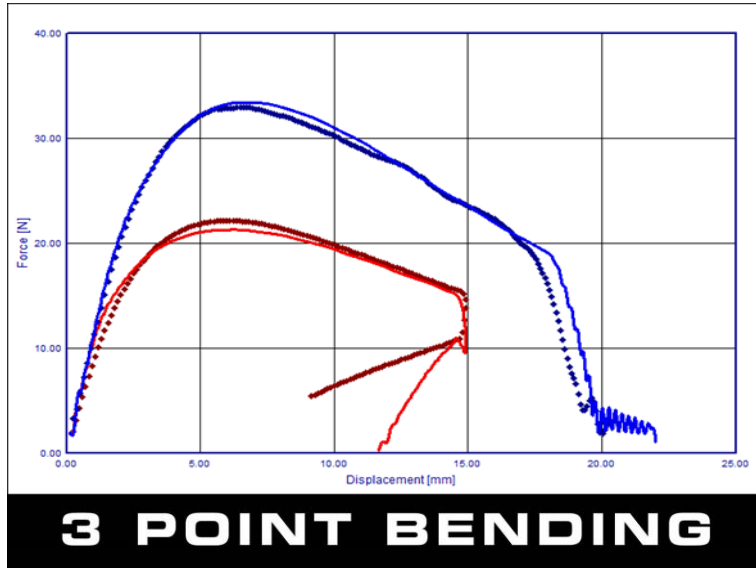


Damage/Failure

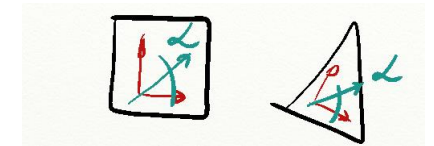
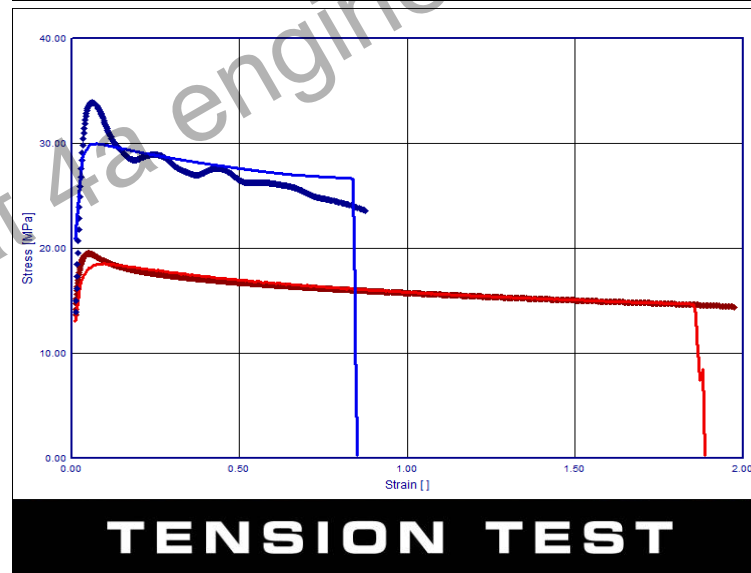
source: Benjamin Hirschmann, master thesis



typical result - *MAT_SAMP-1 with failure



IMPETUS® ~ 3 m/s
static ~ 1 mm/s



..... averaged test curves
— result of simulation

source: Benjamin Hirschmann, master thesis

Intelligent reliable solutions for plastics, composites, metals, foams, ...

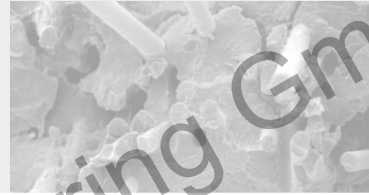
 **IMPETUS**



 **VALIMAT**



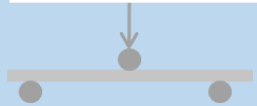
 **MICROMECH**



 **FIBERMAP**



Fiber reinforced Plastics (SFRT & LFRT)



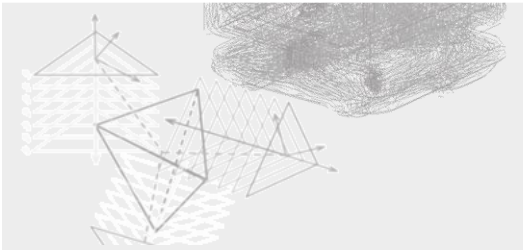
efficient
dynamic testing



from test to validated
material cards

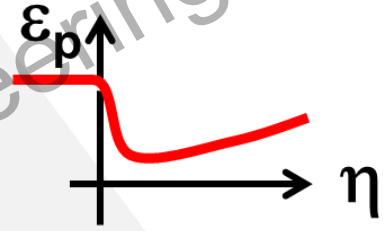
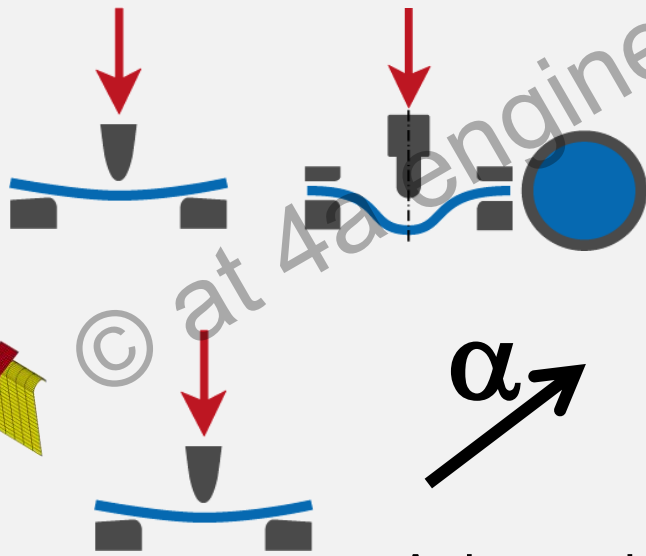
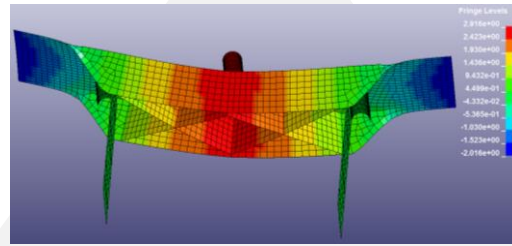


3D anisotropic
material cards

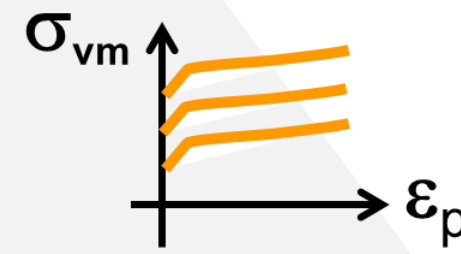


individual mapping
process information

from test to material card

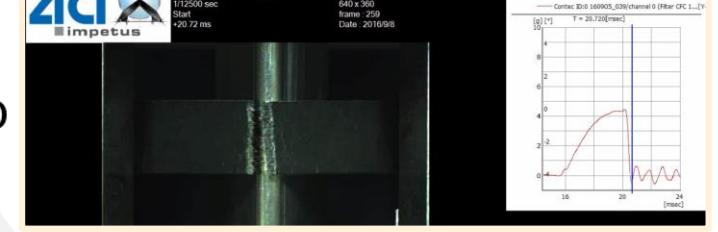
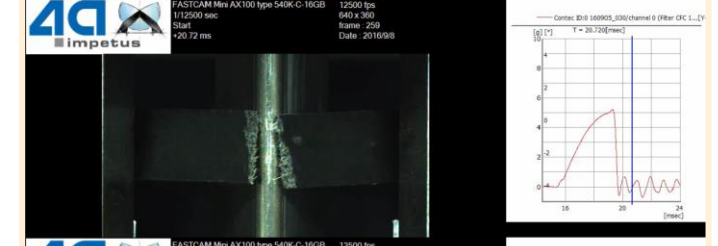
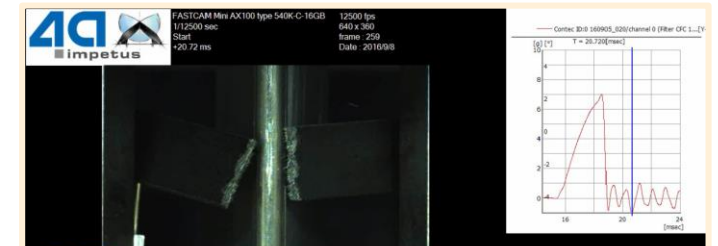
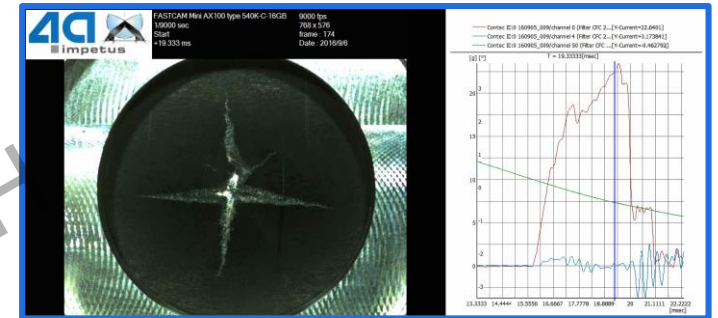


Damage/Failure

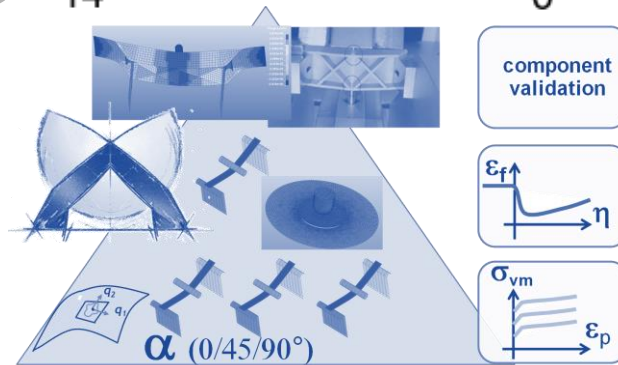
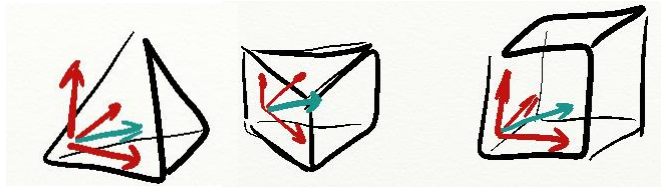
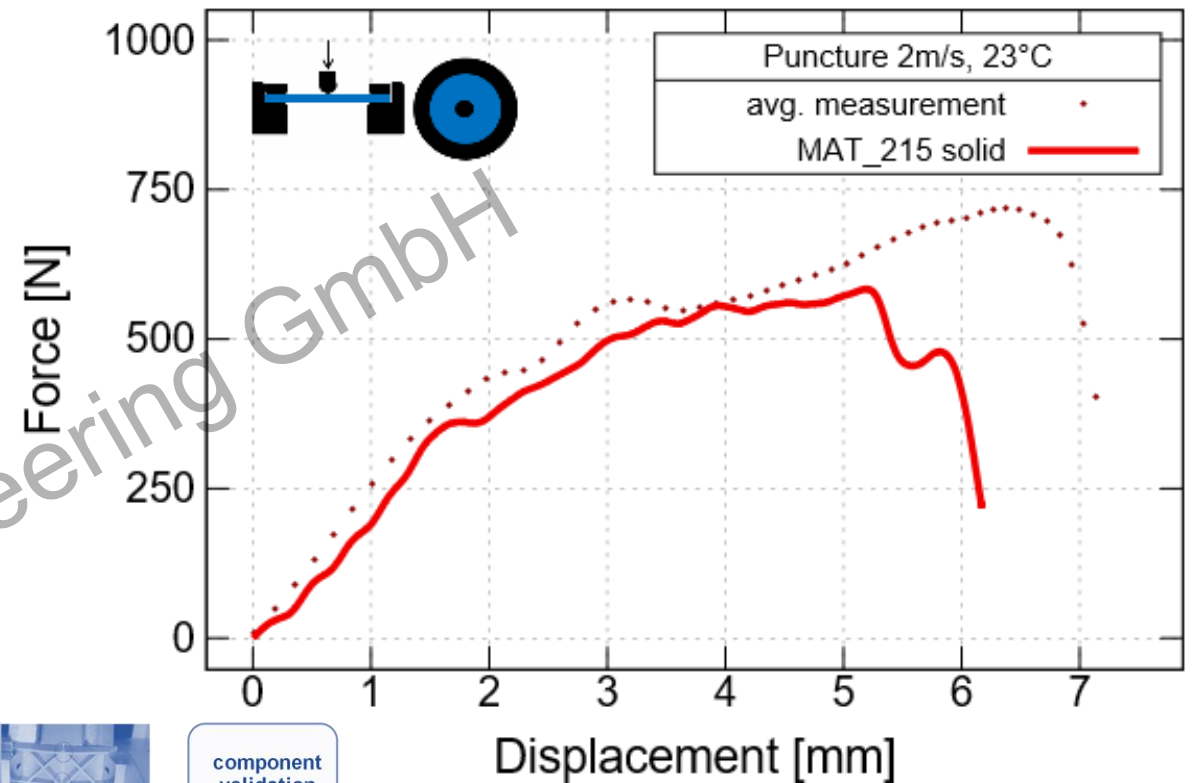
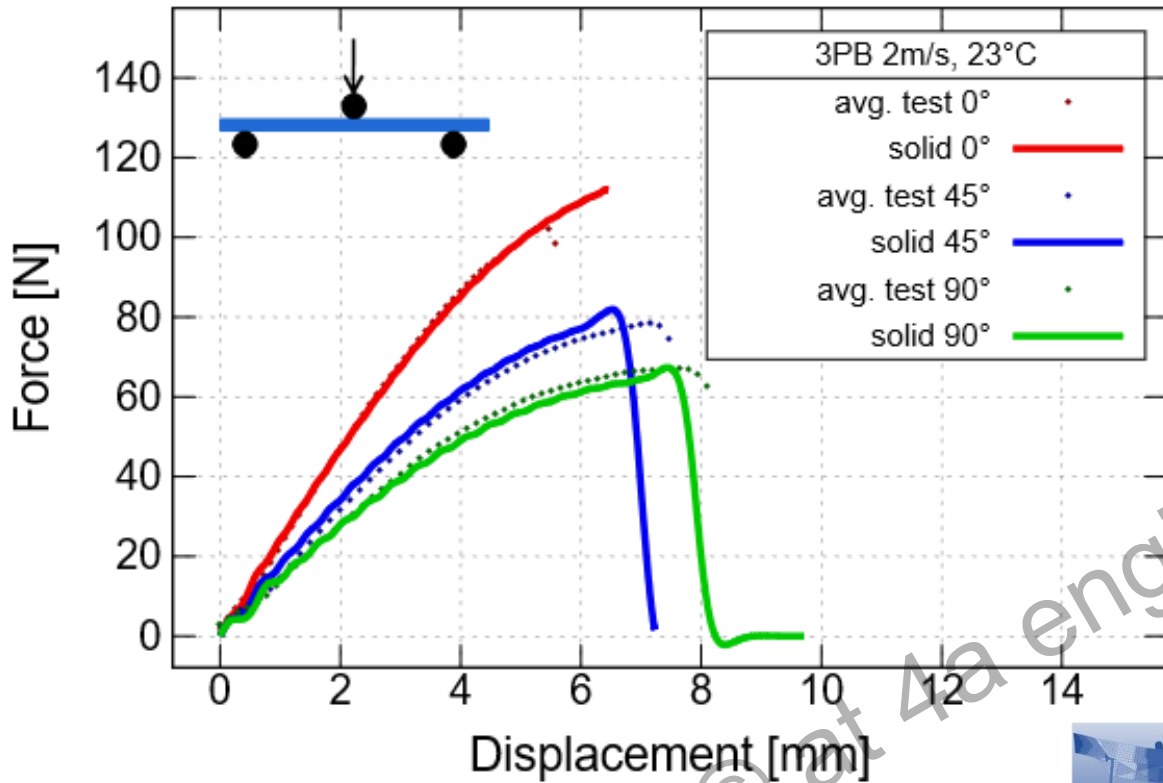


Hardening

Anisotropic



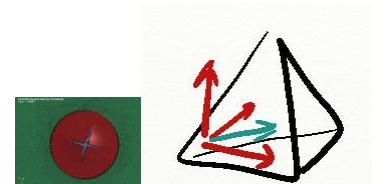
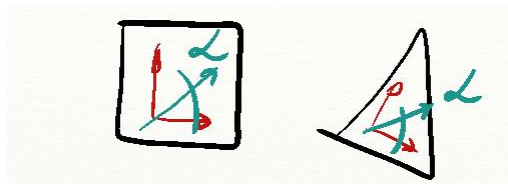
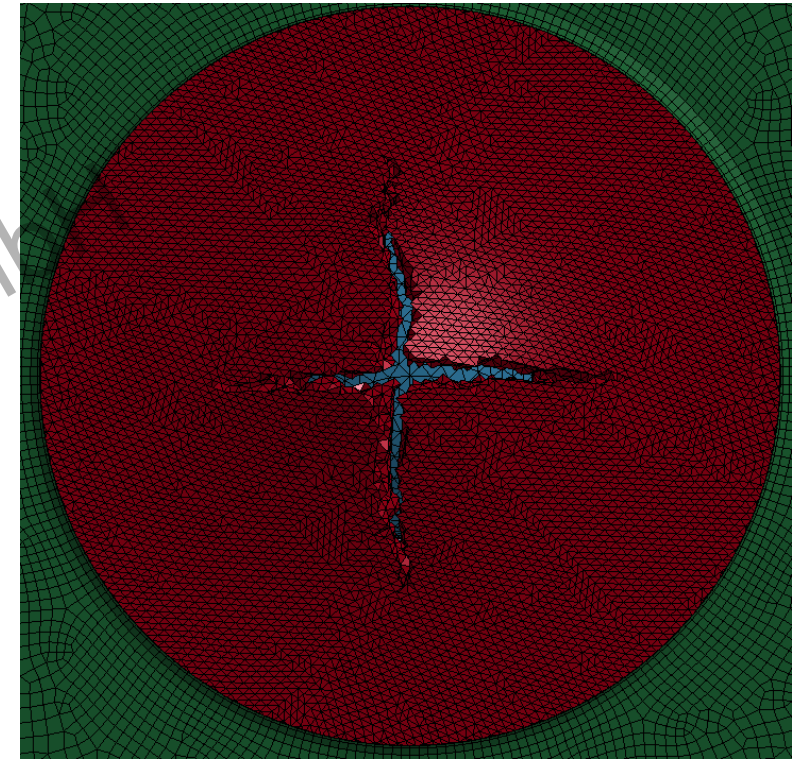
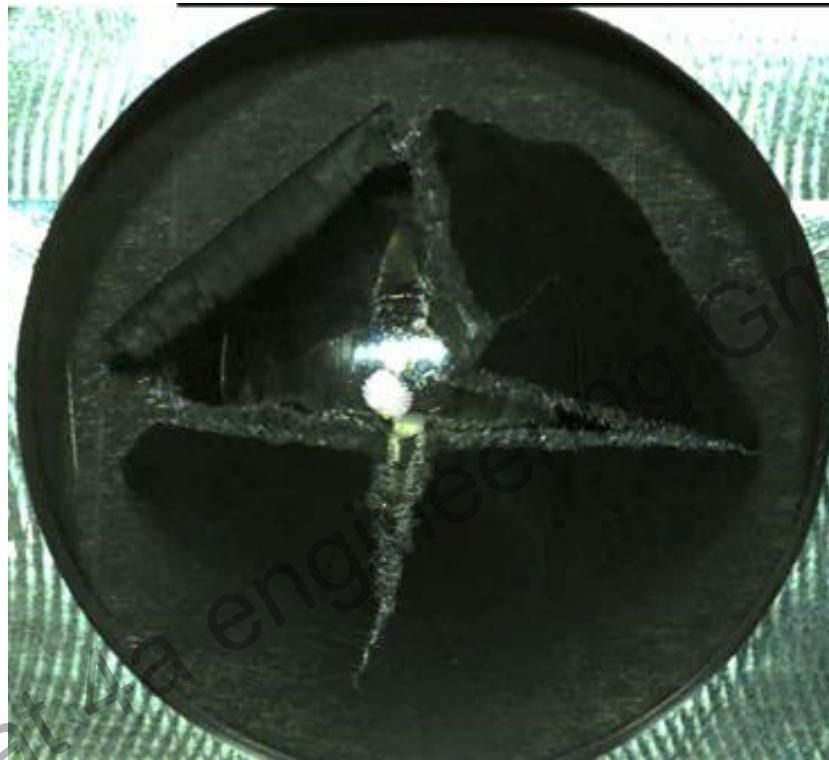
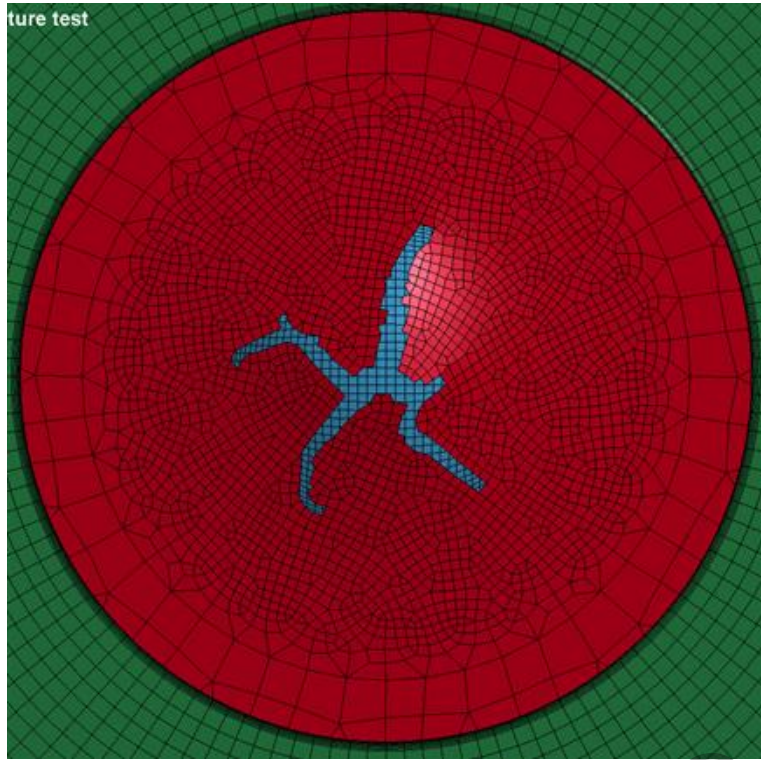
From test to material card – PP LGF30 **MAT_215*



..... averaged test curves
 — result of simulation

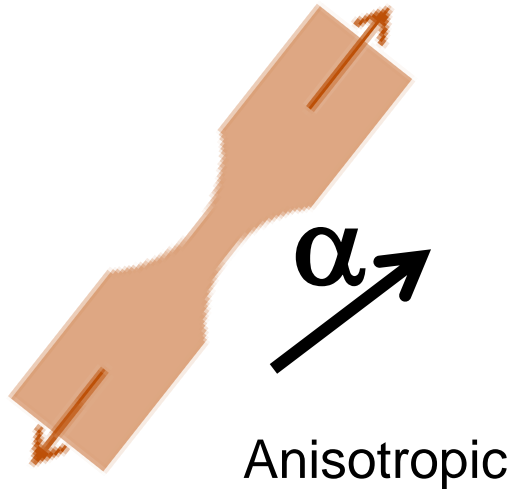
Source: P Reithofer, failure criteria SFRT and LFRT

From test to material card – PP LGF30 **MAT_215*



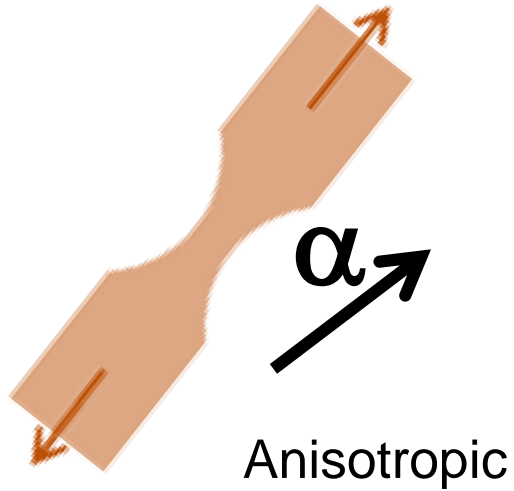
Source: P Reithofer, failure criteria SFRT and LFRT

From test to material card

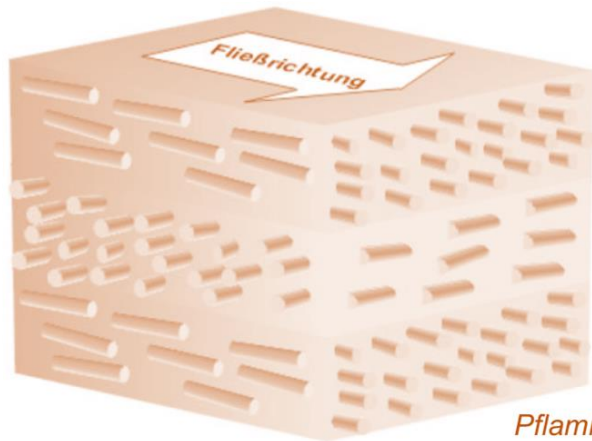
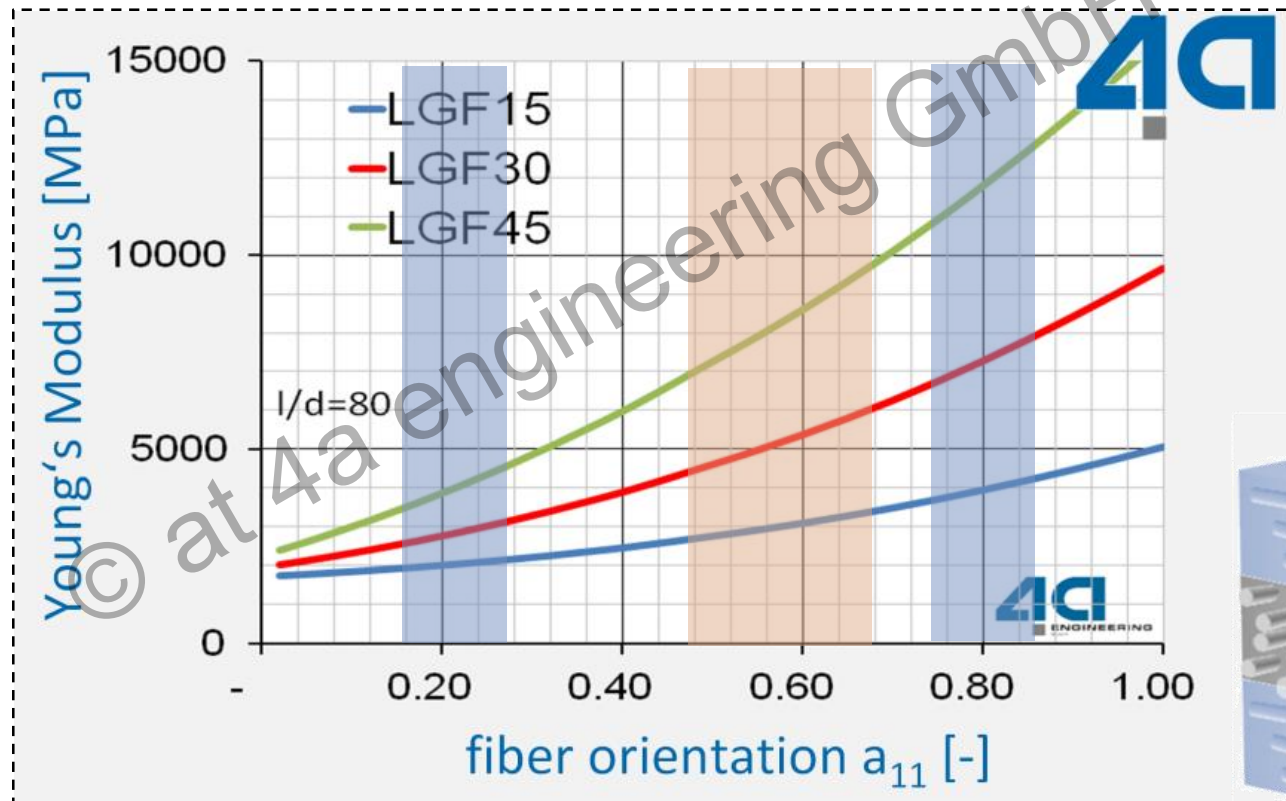


Why not tension (only)?

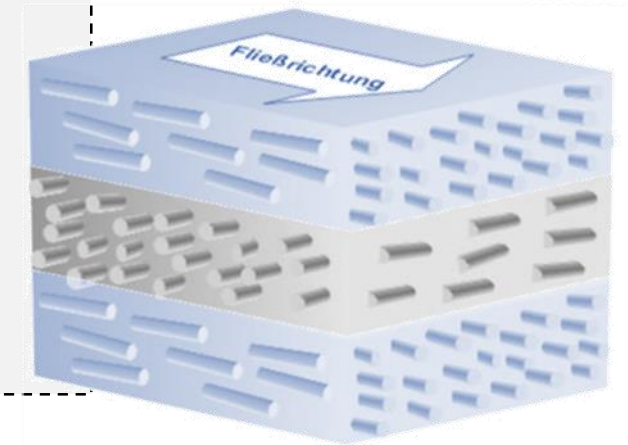
© at 4a engineering GmbH



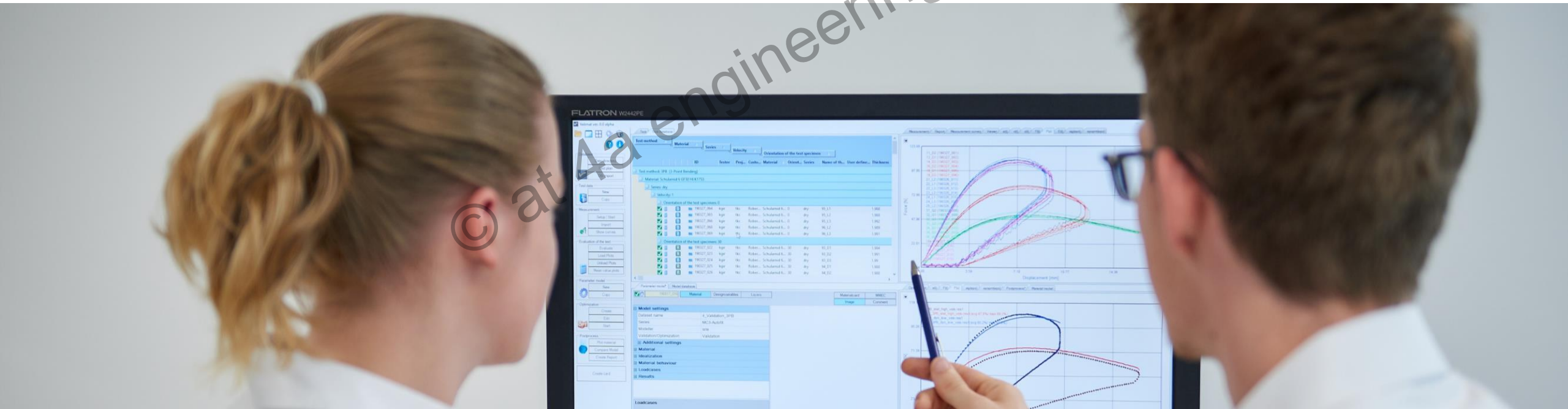
Why not tension (only)?



Pflamm-Jonas 2001



What else ?



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Summary

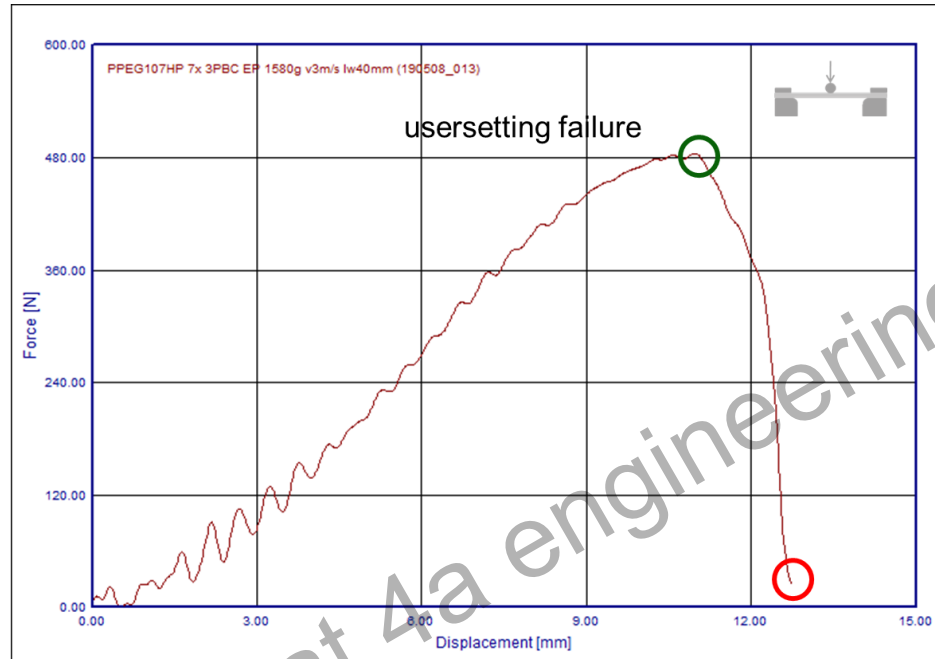
Lessons learned

Upcoming features in VALIMAT® 3.8

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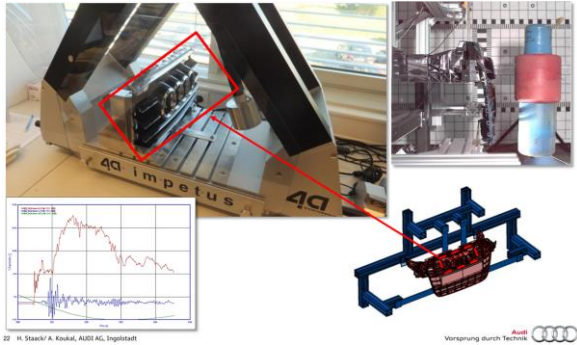
DAY 5 – 14th July 2020

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	
tend	0.011793
tfail	0.011793
alphamax_ep	-5
alphamax_dp	-5
Ffail	0.05
tfaifac	10
Fperc	0.8
trecovfac	20
b_criterion	0
Stress evaluation	
Evaluation bending	No evaluation
Stiffness evaluation	
fperc_lo	0.1
fperc_up	0.3
Results	



Interpretation of typical test results

DAY 8 – 17th July 2020



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



VALIMAT

Hardening: σ_{vm} vs ϵ_p

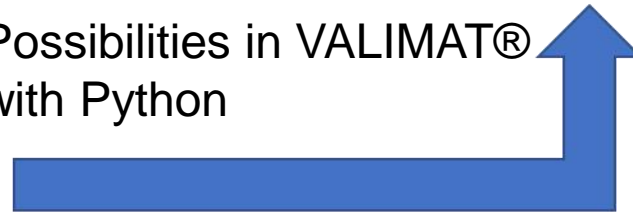
Triaxiality: Φ_p vs η

Damage/Failure: ϵ_p vs η

Anisotropic: α

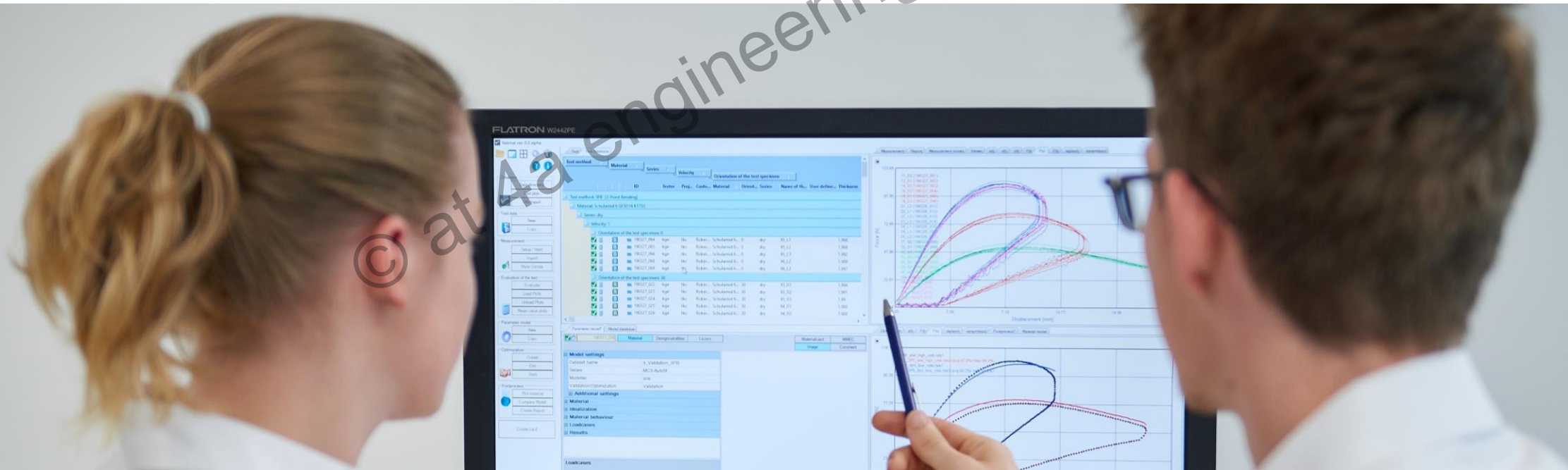


Possibilities in VALIMAT®
with Python



Summary

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Intelligent reliable solutions for plastics, composites, metals, foams, ...



VALIMAT

- manage test results
(import, export, filter, evaluation)
- statistics
- automatic report
- material card generation
- material card validation

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for all material types

from test to validated material cards



IMPETUS

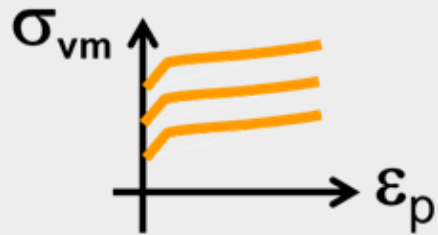
- single pendulum up to 4.5 m/s
- double pendulum up to 8 m/s
- standard test methods
- specialized test methods
- component testing
- advanced measurement

efficient dynamic testing

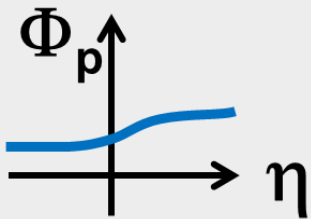
plastics and composites

Intelligent reliable solutions for plastics, composites, metals, foams, ...

✓ VALIMAT



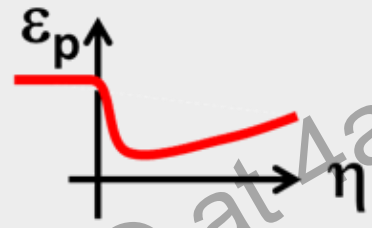
Hardening



Triaxiality



Anisotropic

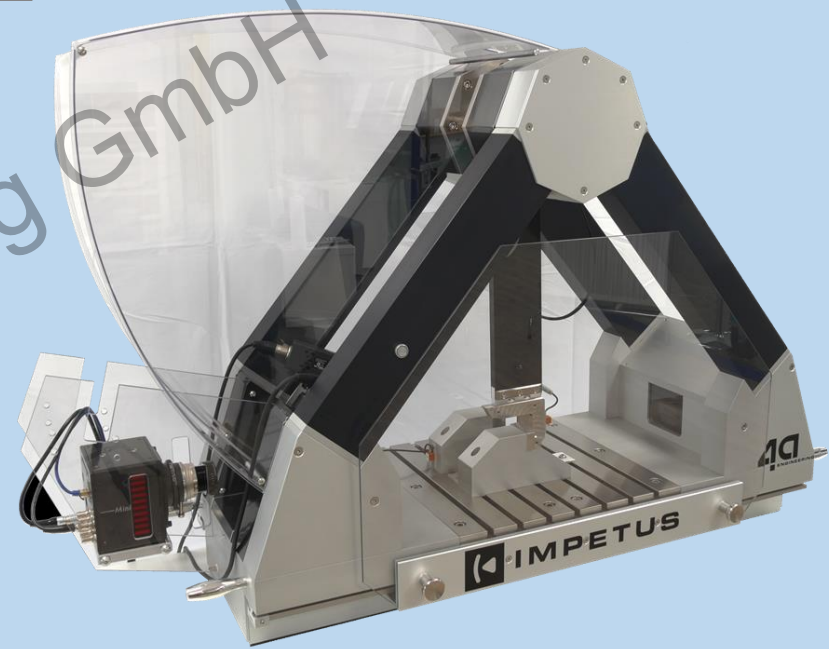


Damage/Failure

for all material types

from test to validated material cards

◀ IMPETUS



efficient dynamic testing

plastics and composites

Thank you for your Attention!

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

SAVE THE DATE

08. July - Efficient dynamic testing with IMPETUS®



more information on our software

α
Anisotropic

ϵ_p
Damage/Failure

Φ_p
Triaxiality

σ_{vm}
Hardening

η

ϵ_p

www.4a-engineering.at/valimat



comprehensive test package overview

www.4a-engineering.at/test-packages